Portage Lakes Management Plan:

A Balanced Approach to Sustaining the Lakes and their Activities

DRAFT October 2021

Note: This version of the Portage Lakes Management Plan has all the chapters. In some chapters, images have been compressed further to lower resolution, and the title page has fewer photographs, to allow the plan to be displayed online as a single document (without appendices). The individual chapters have higher-resolution images.

Northeast Ohio Four County Regional Planning and Development Organization (NEFCO) October, 2021

NORTHEAST OHIO FOUR COUNTY REGIONAL PLANNING AND DEVELOPMENT ORGANIZATION

Draft

Portage Lakes Management Plan

October 2021

This product or publication was financed in part or totally through a grant from the Ohio Environmental Protection Agency and United States Environmental Protection Agency, with funds from the State of Ohio; and with funds from NEFCO's dues-paying members. The contents and views, including any opinions, findings, or conclusions or recommendations, contained in this product or publication are those of the authors and have not been subject to any Ohio Environmental Protection Agency or United States Environmental Protection Agency peer or administrative review and may not necessarily reflect the views of either Agency, and no official endorsement should be inferred.

This report is submitted in fulfillment of Portage Lakes Management Study Task 1, from Appendix 1 of NEFCO's water quality management contract with the Ohio EPA. The scope calls for NEFCO to address comments received from the PLMS Technical Advisory Committee on its **technical** review of the draft FY2021 Portage Lakes Management Study (PLMS) Plan.

Acknowledgement

This effort has benefited from the participation and support of members, partners, volunteers, agencies, and the Technical Advisory Committee (TAC), which represented many interests. Over five years, the TAC shared their diverse perspectives to develop a mutual understanding of Portage Lakes conditions, processes, priorities, and possible management approaches. The TAC continues to collaborate in exploring and carrying out management measures. Lynn Stamp, of the Portage Lakes Advisory Council, was a driving force that got this effort started. We miss her enthusiasm, insatiable interest in learning, and commitment to a broad-based lakes management effort. She was a great friend of the Portage Lakes. We hope to carry out her legacy in developing a collaborative program to sustain the health and uses of the lakes.

Partners in the field working together to identify priorities and possible management measures in the lakes. The diverse partnership represented many perspectives and fields of expertise. This trip included a lake scientist, citizen activist/Chair of Portage Lakes Advisory Council, ODNR Canal Lands Hydraulics Engineer, and the Mayor of Green. During several such trips, various partners met to observe and discuss conditions in the lakes, causes, and potential management measures. Lynn Stamp is in the stern.

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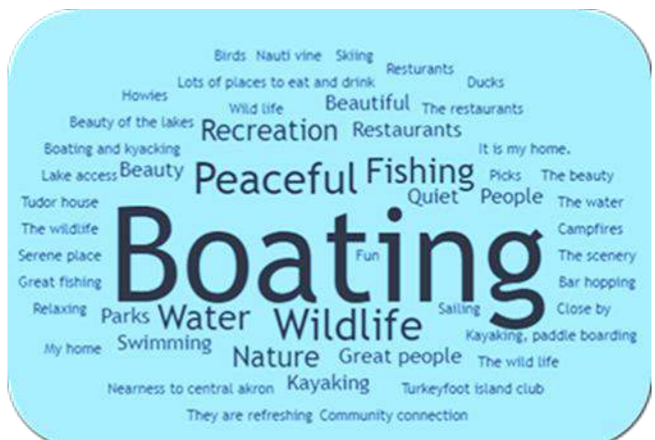
1. Introduction

The Portage Lakes - Many Things to Many…Users

The Portage Lakes is a natural system that is many things to many people, the “lakers,” who live and work by the lakes, visit them, take care of them.

- ***For residents it is home***, the back (or front) yard, a refuge on the water, where children learn to swim, a community linked by water, the change of seasons in a natural setting.
- ***A group of state and other parks***, managed to provide people with opportunities to experience the lakes and woods.
- ***A vibrant community and economic engine*** drawing hundreds of thousands of visitors per year, supporting businesses and tax revenues in nearby communities.
- ***Part of a carefully managed flood control/flow diversion system***.
- ***Important habitat*** for plants, fish, and other wildlife.
- ***A great place*** for fishing, boating, paddling, water skiing, swimming, nature watching, festivals.



Comments from a 2019 public focus group illustrate how lakers value recreation, nature, and the community.

Good water quality is essential for the present and future quality of life on the lakes: recreation, natural scenery, wildlife, property values, visitor and resident experiences.

Interconnected, Multi-Use System

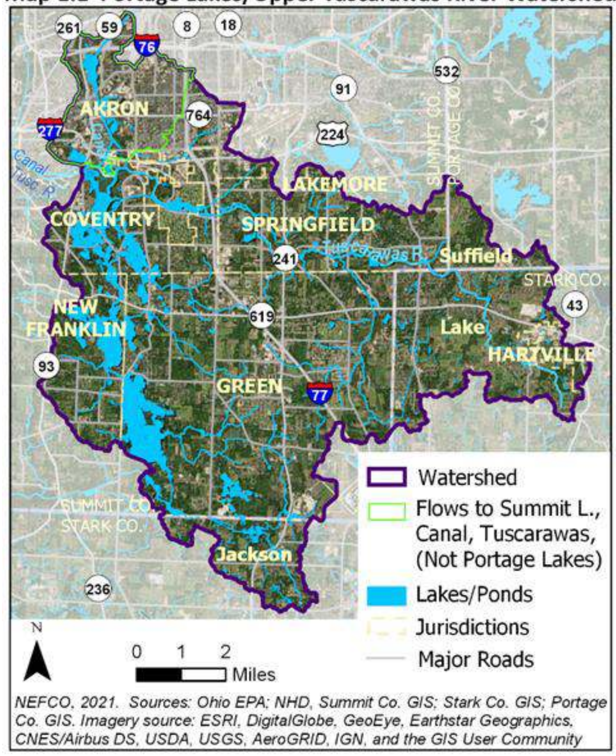
The Portage Lakes is a natural system and multi-use resource. It draws hundreds of thousands of visitors each year and is surrounded by thousands of homes and businesses. The lakes get their water from a 74-square mile watershed and are influenced by that landscape (Map 1.1).[1]

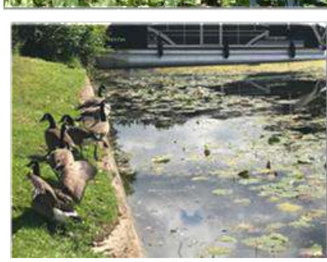
The use and enjoyment of the lakes is intertwined with the water quality and health of the lakes. The intense activities affect the lake system, and the natural lake processes affect activities.

The residents, boaters, swimmers, anglers, and others who use the lakes are connected by the lakes system, part of the lakes system:

- Water
- Sediment
- Plants and animals
- Substances in the water
- Activities on the lakes or surrounding watershed

Map 1.1 Portage Lakes/Upper Tuscarawas River Watershed





Changes to part of the system affect the rest of it, for good or bad. They can be sudden or gradual.

Portage Lakes by the Numbers

- 2,200 acres of state-managed lakes
- 500 acres of state park land
- 900-foot swim beach, 2 boat swim areas
- 2 metro parks
- ~300,000 visitors to the State Park per year
- 8 boat launch ramps, 10 courtesy docks
- 19,320 boats on the lakes, twice as many arriving by trailer
- ~1,400 lakeside homes
- ~1,200 residential or commercial docks
- ~20,000 properties within a mile of the lakes

[1] Map source: Summit Co. GIS; Stark Co. GIS; Portage Co. GIS; National Hydrologic Database, 2016. Base map: ESRI; DigitalGlobe; GeoEye; EarthStar Geographics; CNES/AirBus DS; USDA; USGS; AeroGRID; IGN; GIS user community.

Aquatic Plants – Essential Elements in Lake Systems

Plants are crucial to the functioning and health of lakes:

- Provide habitat, food, cover for fish, birds, and a host of other animals;
- Generate oxygen;
- Stabilize sediment, prevent erosion;
- *Improve* water quality, process nutrients help keep the lake system in balance, and thus
- Protect against Harmful Algal Blooms (HABs).

Nutrients Drive Plant Growth – and HABs

Nutrients washing in from the landscape fuel growth of aquatic plants, just as fertilizer feeds growth of lush lawns and gardens.

- The nutrients recycle within the lake, build up, spurring more growth.
- In lakes that have become over-enriched (eutrophic), the high nutrient load causes excessive plant growth.
- The same nutrients that drive plant growth support cyanobacteria, which can release toxins and cause HABs when they grow rapidly. If a lake becomes too nutrient-rich, the HABs take over, shading out the plants. The lake becomes unusable and is very difficult and expensive to restore.

➢ ***Plants and algae protect the lake by using nutrients that would otherwise support cyanobacteria/HABs.***

Too much of a Good Thing in the Portage Lakes

– *Impacts from Intense Use Shift the Balance*

Concentrated human activity in a natural system is likely to cause impacts. In the Portage Lakes, years of intense use of the lakes and watershed have led to high levels of nutrients. The nutrients produce dense growth of aquatic vegetation, which causes conflicts with residents, businesses, boaters, and visitors.

Problem: Dense Plant Growth Interferes with Uses

1. **Cause: Over-enriched, Eutrophic Lakes and Invasive Plants**.
   The balance in the lakes has shifted toward over-enrichment. Over years and decades, nutrients (phosphorus and nitrogen) have been washing in and building up from the altered, developed landscape - runoff, septic systems, lawn chemicals, cleared land, agricultural use, and animal waste.
   - ***The lakes have become over-enriched over time and continue to do so***.

2. **The eutrophic lakes feed excessive plant growth, possibly HABs, creating a nuisance.** Dense growth has become a nuisance for residents and boaters and clogs flow control structures. Cyanobacteria blooms hint at a potential future with HABs.

   Invasive plants, accidentally brought in on boats or fishing gear, create tangled mats that spread rapidly in the nutrient-rich waters.

3. **Conflicting priorities.** The plants grow in shallow water where people live, swim, boat, and fish, causing conflicts between the natural system and uses. But it would be much worse if these images showed lakes covered with HABs, instead of shallows full of plants. The plants provide essential benefits to the Portage Lakes system, *especially because the lakes are over enriched.* Something will grow in all those nutrients ***– plants are better, and more manageable, than HABs***.

"Just Clear the Stuff Out" Is Not an Option

Property owners and organizations try their own individual approaches to control vegetation.

However, piecemeal plant control doesn't work in a complex, intercon-nected lakes system. The plants, the conditions that cause them, and impacts from management approaches are lakes-wide.

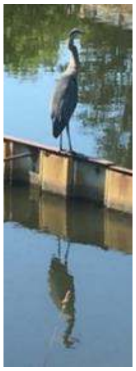
The wrong method may not work at all and may cause more harm than good: spreading invasive plants, creating hazards with toxic chemicals, clogging flow gates, causing massive die-offs or decaying mats of plants, or – worse - tipping the system further toward eutrophication and HABs.

Source: J. Garretson, 2021.

Currently, there is no organization or individual with the scope, resources, time, staff, or background to systematically manage the aquatic plants or consider the context of the lakes.

- *The current method of dealing with the plants is not working. So what is to be done?*

Achieving Balance with an Aquatic Plant Management Program



An aquatic plant management (APM) program is necessary to allow people to use and enjoy the lakes while protecting the health of the lakes at the same time. This approach devotes efforts and resources to systematic management of the plants and lakes system. It is used successfully in other areas to provide for activities in balance with sustaining the lakes:

- Provides for access, use, and aesthetics;
- Protects the important benefits provide for habitat, water quality, and lake health.

  - ***Aquatic plants must be managed systematically, in a balanced way that supports access, use, and aesthetics, and protect the habitats and health of the lakes.***

There are many tools that can be used to manage aquatic plants, each with different strengths and concerns. An aquatic plant management (APM) program will work with the lakers and partners to:

- Identify priority areas for use, conservation, and management;
- Identify types of plants, and problem areas;
- *Selectively* use methods that can address the need and improve conditions effectively in each area with minimal impacts;
- Provide assurance that problem areas will be addressed in a safe, systematic, consistent way that protects the lakes; and
- Be part of technically-based, coordinated management of the lakes system: health and habitats, impacts and changes, in-lake conditions and watershed inputs that promote plant/HABs growth.
- Systematic management of aquatic plants and the lakes requires adequate staff and resources.

Pieces in a Puzzle

Taking care of a lake system is like putting together a puzzle.

The system has so many parts that lakers, visitors, agencies, organizations, volunteers can each focus on a piece or two that reduce impacts and improve lake conditions.

But individual pieces are only part of the entire picture. All pieces are essential, affect the others, and are affected by the others.
The individual elements must be connected and viewed as part of a whole in order to understand the context and for measures to be effective.

- Without context, the pieces may not be the appropriate ones.
- Without all the pieces, there are gaps.

People and organizations are part of the lakes system and can help take care of the lakes with individual actions in the context of the interconnected lakes system.

Managing the Lakes System

Plants are driven by and affect the lakes system. It is essential to understand and address conditions in the lakes and watershed. There are many dedicated organizations, communities, and individuals working in and around the Portage Lakes, each focusing on individual aspects of the lakes and watershed.









Some are land-based, some work in the lakes or along the shore. Each contributes something important to the well-being of the lakes, but their work and resources are narrowly focused.


- *They cannot manage the lakes and aquatic plants on their own.*

A New Approach: Lakes Management

Sustaining the health and activities of eutrophic multi-use lakes is challenging. With many uses on the lakes and in the watershed, many interconnections, there is great potential for conflicting interests and priorities, for impacts that tip the balance toward more problems. Lakes management, which includes the plants, is necessary to sustain the system and the activities it supports. This involves:

- ***Commitment*** by lakers and partners to manage activities on the lakes, reduce impacts improve conditions, make choices to balance use and protection of the lakes and coexist with the natural system;
- ***Collaborative, coordinated management*** among partners and lakers, sharing information, perspectives, and resources;
- ***Building a shared understanding*** about lake conditions, changes, processes, concerns, priorities, management practices, impacts;
- ***Increasing awareness, stewardship, involvement, and support for lake management,*** among lakers, agencies, other organizations, and communities; and
- ***Increased organization focus, coordination, monitoring, and resources for lake management,*** including adequate staff, funding, equipment, resources, lakes management expertise, technical background, and systematic monitoring of lake conditions and plants.

While such a coordinated, focused approach is new for the Portage Lakes, lake management programs are used successfully in many other areas, demonstrating that lakes can be managed in a way that supports uses and lake health together. A lake management program, with well-understood guidelines, processes, roles, and responsibilities allows lake residents, visitors, and participating organizations to understand what is expected of them, what will be managed, when, and how.

The Portage Lakes Management Plan

In order to develop an approach to protect the lakes' ecosystem while supporting their uses, Ohio Environmental Protection Agency (Ohio EPA) provided funding for five years of studies and planning to NEFCO. NEFCO staff have worked closely with representatives from the Portage Lakes Advisory Council (PLAC), community members, and a Technical Advisory Committee (TAC), which included agency staff, community representatives, lake scientists, and volunteers. (See Appendix A for a list of TAC members and meetings.)

Over the past five years the TAC members have worked together and built a partnership to better understand the lakes conditions and processes, concerns, current lake management, and potential approaches to improve conditions. The TAC and other community members have shared information, ideas, and perspectives about the lake system, identified needs and steps forward, shaping this plan.

Continuing this collaborative approach is essential. It is already changing the partners' understanding of lake conditions and possible approaches. The partners are starting to define roles and tasks to help carry out the recommendations. The partnership will evolve as the recommendations are carried out, and will seek more community involvement in setting priorities, decision-making stewardship, and advocacy.

Development of the Portage Lakes Watershed Plan

- Year 1 – Watershed characteristics, updating the 2000 Upper Tuscarawas Watershed Plan.
- Year 2 – Study of aquatic plants in the lakes, generally identifying types and extent from boat trips and shoreline visits, noting conflicts with the lake users, and exploring management strategies.
- Year 3 – Public and community engagement to help identify priorities and concerns, including focus groups, a lake monitoring workshop, boat tours of the lakes with community representatives, and various meetings and discussion groups. Appendix A lists public engagement activities, Appendix B summarizes the focus groups.
- Years 4 and 5– Compiling information from the first three years, additional information about lake processes and conditions, and results of numerous, in-depth discussions with the TAC and others, into a cohesive framework for managing aquatic plants and the lakes.

Plan Overview

The plan compiles existing information about the Portage Lakes conditions to provide the background for understanding and managing the lakes system, including:

- Lake characteristics and processes;
- How the water is managed;
- Uses, community, and watershed;
- Aquatic plants, habitats, fish and other wildlife;
- Preliminary plant management priorities and approaches;
- Organizations currently working on and around the lakes;
- Recommendations; and
- Opportunities for organizations and individuals to help improve conditions and sustain the lakes.

Some of the background (specifically plants, lake chemistry/processes, and aquatic plant management strategies) is general, based on limited data. Important tasks include systematic inventory and monitoring of aquatic plants and lake conditions, developing roles and resources, and identifying priority management zones and approaches with involvement of the lakes community.

The plan and recommendations encompass the lakes, surrounding land, and the contributing watershed. There are many practices on land, along the shoreline, and in the water that will improve lake conditions. There is a great need and many opportunities for organizations and individuals to increase awareness of the lakes system and practice good stewardship.

The new approach involves more effort, coordination, and systematic management of the lake system and activities within it. It provides a lakes-wide context for managing this important resource in a balanced way, setting priorities, addressing concerns, and improving conditions for the users, community, and health of the lakes.

The plan is organized as follows:

1. Introduction
2. Portage Lakes Setting
3. The Portage Lakes and their People: Community; Uses and Users; Balancing Priorities; Caretakers
4. Limnological Characteristics, Productivity and Eutrophication of Portage Lakes
5. Habitat, Wildlife, and Aquatic Plants
6. Water Quality and Portage Lakes Watershed
7. Recommendations and Management

Overall Goal:

Manage the Portage Lakes in a way that protects the natural lakes system in balance with the priorities of lake users, communities, and management organizations.

Important Note on Recent Occurrences – Highlighting the Need for Coordinated, Supported, Systematic Lakes Management

Several recent events in 2020-2021 affect – and emphasize - the findings and recommendations of the plan. Some have been addressed in the plan, but some occurred too occurred recently to be included.

- Dense growth throughout North Reservoir
- *Floating vegetation clogging the Long Lake Feeder outlet* to the Ohio and Erie Canal and other water control facilities
- *Occurrence of the cyanobacteria, anabaena, in Nimisila Reservoir* early in the season. Cyanobacteria blooms occasionally occur, but this bloom early in the season, along with changing climate and increasing nutrients, highlights the potential for future HABs and the need to understand existing and changing conditions, so appropriate measures can be developed.
- *Recent research on Harmful Algal Blooms* changes our understanding of the nutrients and lake temperature conditions that affect the severity and toxicity of HABs.
- *Recent discovery in Mosquito Lake of hydrilla*, a highly invasive, easily spread plant. It is easily spread by fragments on boats or fishing gear traveling between Mosquito Lake and the Portage Lakes, including the shared harvester, and it is very difficult to eradicate.

These occurrences emphasize these urgent needs identified in the plan:

- The critical importance of inventory and monitoring programs to characterize lake conditions and plant communities, changes, and impacts. Without understanding the aquatic plant community and lake characteristics, management measures cannot be targeted, and their impacts could make conditions worse. Early identification and eradication of hydrilla may prevent an infestation in the Portage Lakes and Lake Erie drainage, which receives water from Long Lake.
- Need to move forward developing management measures that improve conditions for residents, boaters, and the lakes.
- The need for technical expertise and coordination to bring new developments into the decision-making process, to build understanding of causes, effects, and management implications.

Conditions and understanding of the lakes will continue to evolve, often rapidly, in this heavily used eutrophic system. The collaborative partnership and lake managers will need to and will be able to address these, with technical support, in developing management measures and monitoring lake conditions.

Chapter 2 – Overview
The Portage Lakes in the Landscape

This chapter discusses the lakes, watershed, and the canal that connects the lakes across the drainage divide between the Ohio River and Lake Erie basin. Lake levels are managed by dams for flood control, and some flow is diverted north across the drainage divide. Understanding how water is controlled and moves into and through the lakes is important in determining how to manage them.

- Originally a collection of kettle lakes, the Portage lakes were modified and enlarged as a water supply for the Ohio and Erie Canal. Similar to the ancient portage, the canal crosses the Lake Erie-Ohio River drainage divide.
- The Portage Lakes are within the Upper Tuscarawas watershed, receiving water and influenced by 74 square miles of communities within the watershed.
- With dams and the canal, the lakes are used for flood control and for diverting flow from the Ohio River Basin north to the Lake Erie basin. A small staff maintains lake levels and flow into the canal by manipulating lake drains and gates and removing obstructions.
- The highest of the lakes and southernmost, Nimisila Reservoir, mostly flows south but occasionally is released to Turkeyfoot Lake to partially refill the other Portage Lakes.
- North of Nimisila, the other lakes descend to Long Lake, beginning with Turkeyfoot Lake and the other “Main Chain” lakes, which are connected by channels. The other lakes are lower than the Main Chain, separated by dams.
- Long Lake, the northernmost and lowest in elevation, discharges to the Tuscarawas River and the Ohio and Erie Canal, where the water is moved north to the Lake Erie Basin at Lock 1 in Akron.

Chapter Organization

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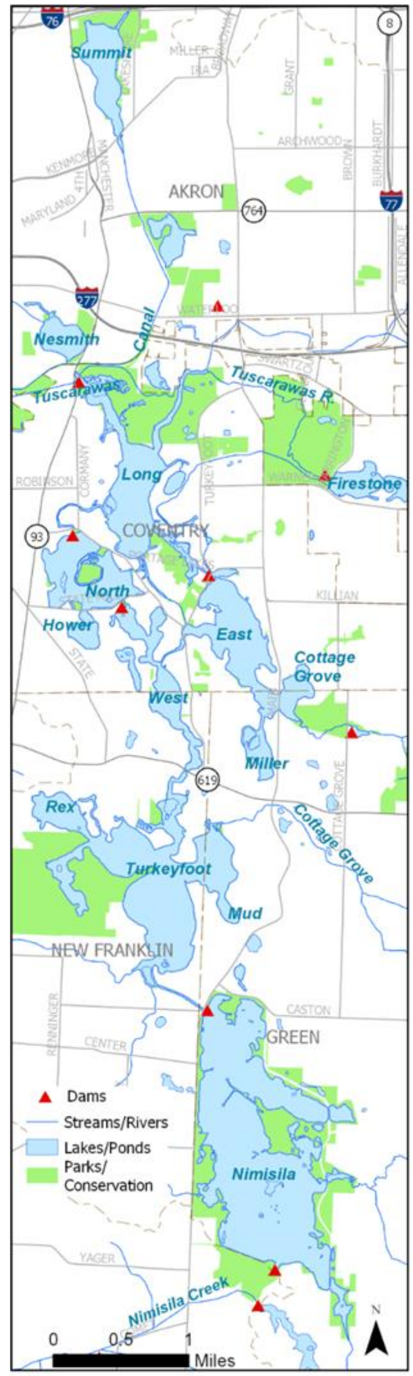
2. The Portage Lakes in the Landscape

The Portage Lakes – Location

The Portage Lakes is a series of connected lakes in Akron, Coventry Township, the Village of New Franklin, and the City of Green in southern Summit County, Ohio (See Maps 2.1 and 2.2).[1] The lakes are part of the Portage Lakes State Park. Two parks on the lakes are managed by Summit County Metro Parks.

The Portage Lakes are an unusual combination of natural lakes, dams, canals, reservoirs, and an intensely managed waterway. The reservoirs were originally built to provide water for the nearby Ohio and Erie Canal. Today, the dams, augmented by lake drains, are used for flood control and regulating flow between the Ohio River basin (the Tuscarawas River) and the Lake Erie basin (the Cuyahoga River).

Map 2.1 – The Portage Lakes



Map 2.2 Portage Lakes Location

NEFCO, 2020. Map Sources Maps 2.1, 2.2: ODNR GIS; Summit County GIS; National Hydrologic Database (NHD) 2016; AMATS; Western Reserve Land Conservancy.

The Lakes and the Divide

Map 2.4 Canal and Drainage Divide

Map Sources Maps 2.3, 2.4: ODNR GIS; National Hydrologic Database (NHD) 2016

Map 2.3 Tuscarawas River Watershed

The Portage Lakes are in the upper Tuscarawas River watershed just south of the Lake Erie-Ohio River drainage divide (Map 2.3).[2] Water north of the divide naturally flows to Lake Erie, while water south of the divide flows to the Ohio River. Water from the lakes enters the Tuscarawas River from Long Lake in the north and from the Nimisila Reservoir (via Nimisila Creek) at the southern end, then flows south to the Ohio River via the Muskingum River.

Ohio & Erie Canal and the Portage Lakes

The Portage Lakes are unusual, because they have been connected to both Ohio and Erie drainage areas by the Ohio Canal (Map 2.4). Water from the Portage Lakes mostly flows south to the Ohio River, but some is diverted north to Lake Erie. Canal construction and operation shaped the lakes today.

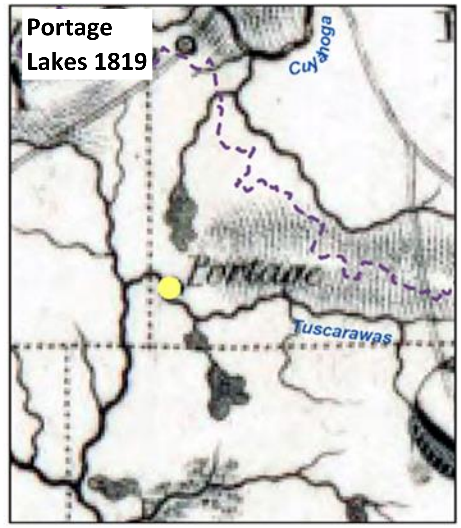
Early inhabitants of this area portaged between the Lake Erie and Ohio River basins south of where Akron is now. Settlers and surveyors (including George Washington) noted the importance of a potential trade route connecting the Ohio River/Mississippi drainage to Lake Erie. Following development of the Erie Canal, the Ohio and Erie Canal was begun in 1825 and finished in 1832, spanning the divide and creating a transportation system between the Great Lakes and the Gulf of Mexico.

Fig. 2.1 Shape of the Lakes[3]

Before the Canal was built

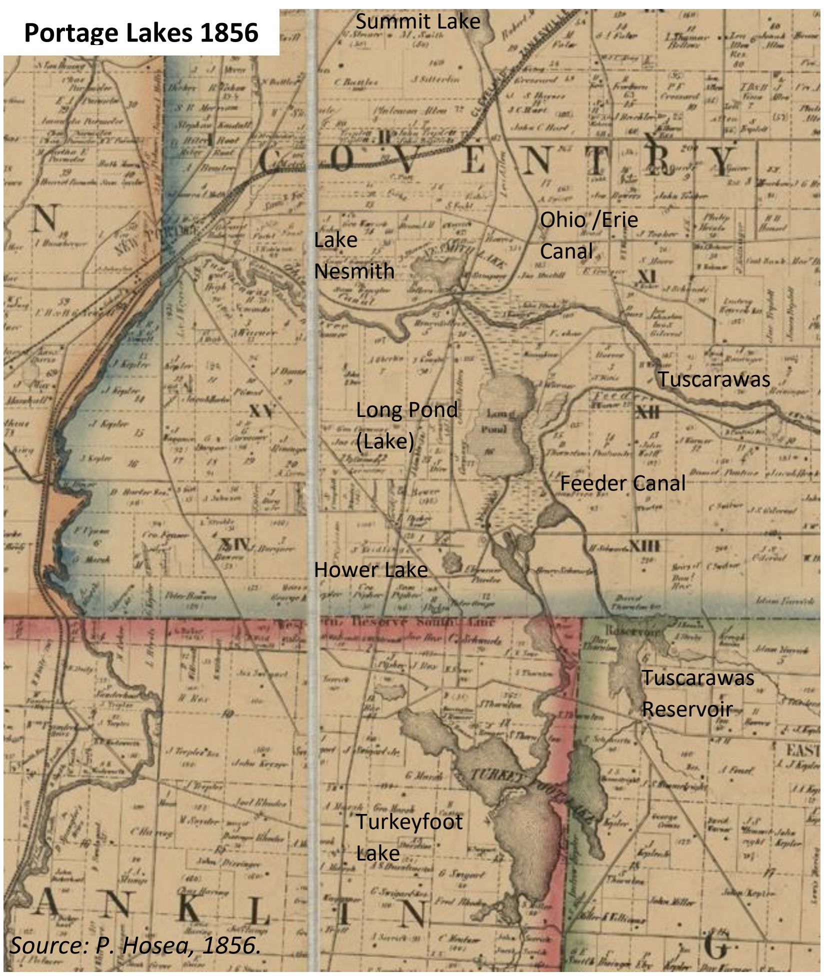
Early maps show small lakes south of the drainage divide (added to map on right) that were precursors to the Portage Lakes, and the close proximity of the Cuyahoga and Tuscarawas Rivers. Portage (yellow dot) is on the Tuscarawas, south of the drainage divide and present-day Akron.

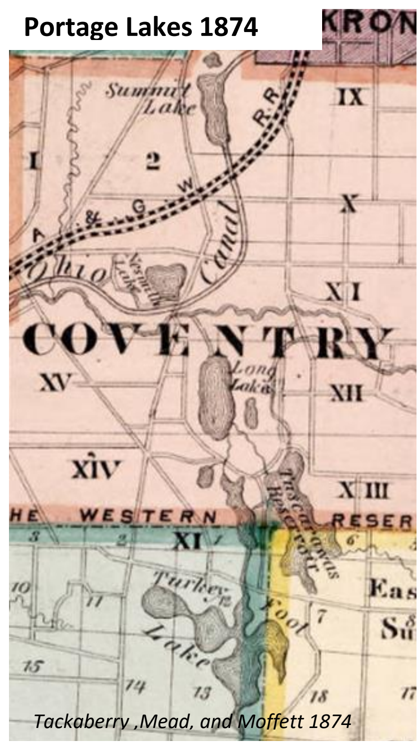
Source: R. Putnam, T. Wightman, T. Harris, 1805



Lake Erie-Ohio River Drainage Divide (approx.) Map Source: R. Tanner, 1819

After the Canal was built. *The Tuscarawas (East and West) Reservoir was built in 1840 to supply canal water, fed by a feeder canal. Turkeyfoot and Long Lakes were deepened. Hower Lake existed, likely as a natural kettle lake. New Reservoir (North Res.) was built in 1909, and Nimisila Reservoir was built in the 1930 to augment the industrial water supply in the canal.*



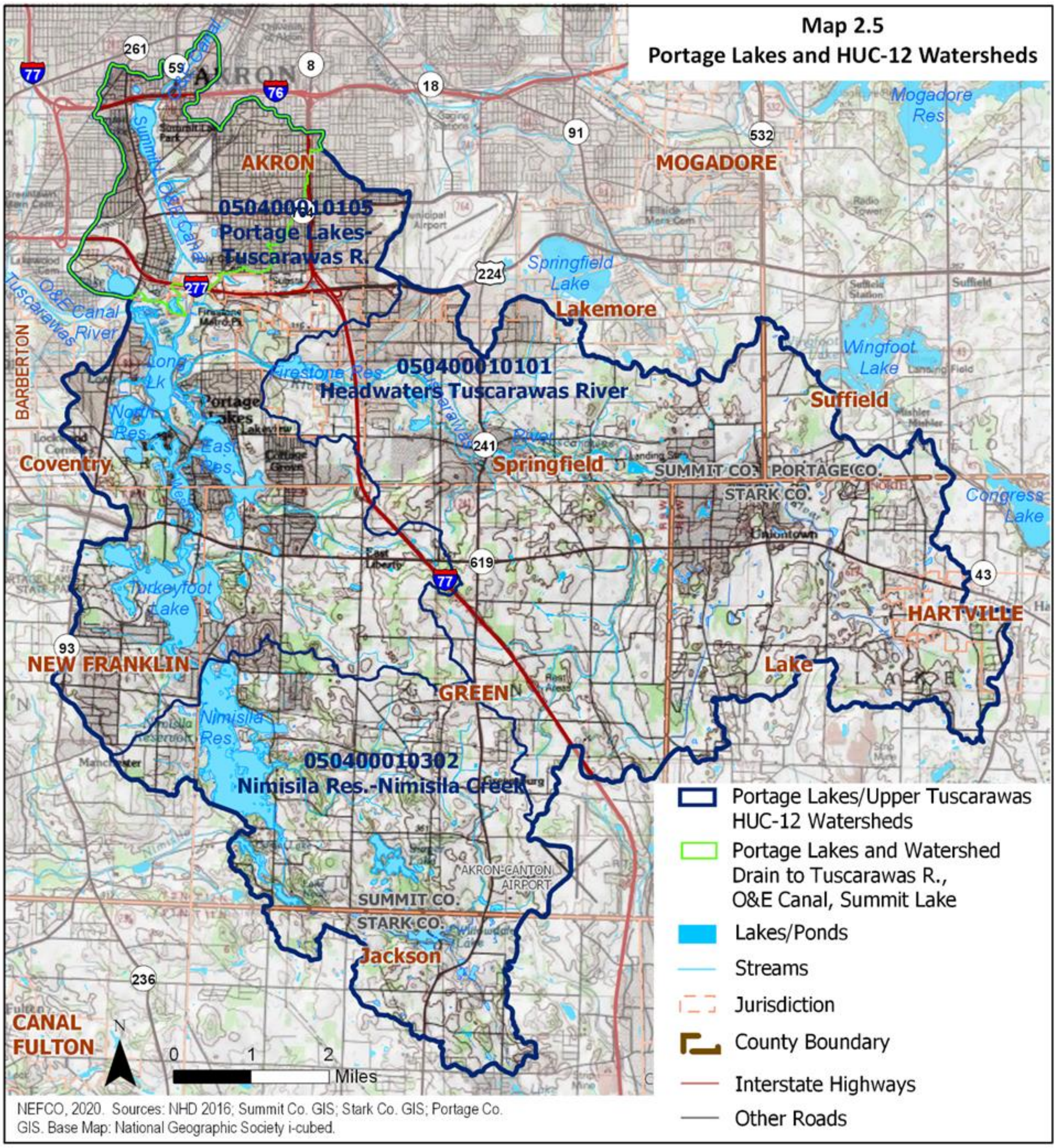


These 1856 and 1874 maps show the Tuscarawas (East and West) Reservoirs taking shape, fed by a feeder canal from the Tuscarawas River, which flows to a canal north of Long Pond. The Nimisila and North Reservoirs had not been built.

Water Flows Downhill…Portage Lakes and Upper Tuscarawas Watersheds[4]

The land that drains to the Portage Lakes, its watershed, is part of the three HUC-12 designated watersheds of the Upper Tuscarawas River (See Map 2.5).

> Watersheds are designated by nested Hydrologic Unit Codes (HUCs). The HUCS of the largest watersheds have the fewest digits. HUCs of smaller subdivisions have more digits. The Ohio River basin, HUC 0504, contains many smaller watersheds, including the 12-digit HUC watersheds draining to the Portage Lakes, e.g., 050400010105.



Water flows downhill across the landscape of the watershed (See Map 2.6), entering the lakes through streams, ditches, storm drains, and as stormwater runoff from the land. About 74 square miles of the 80-square mile Upper Tuscarawas watershed feeds the Portage Lakes, through three sub-watersheds and portions of nine communities. Each subwatershed affects specific lake areas: Long Lake and Tuscarawas River; Turkeyfoot Lake to North Reservoir; and Nimisila Reservoir.

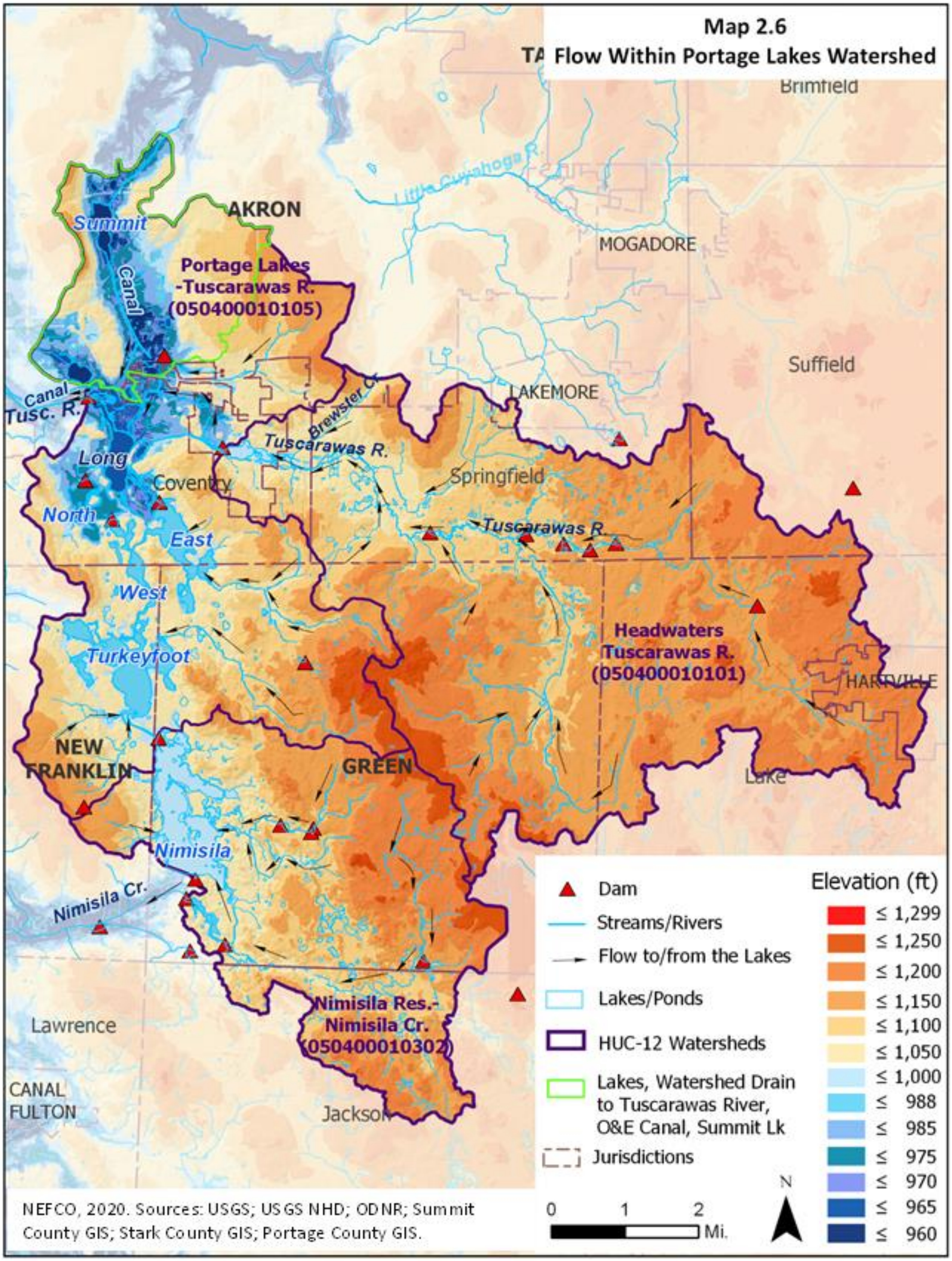
As shown on Map 2.6, the Portage Lakes are on a high area between river valleys, with the Tuscarawas River at both north and south ends of the lakes. Long Lake, the lowest of the lakes and one of the original, natural lakes, is at the end of a lowland that extends north, which contains Summit Lake and connects with the Cuyahoga River valley. This lowland, with its lakes and streams, is the location of the ancient portage and the present-day Ohio and Erie Canal.

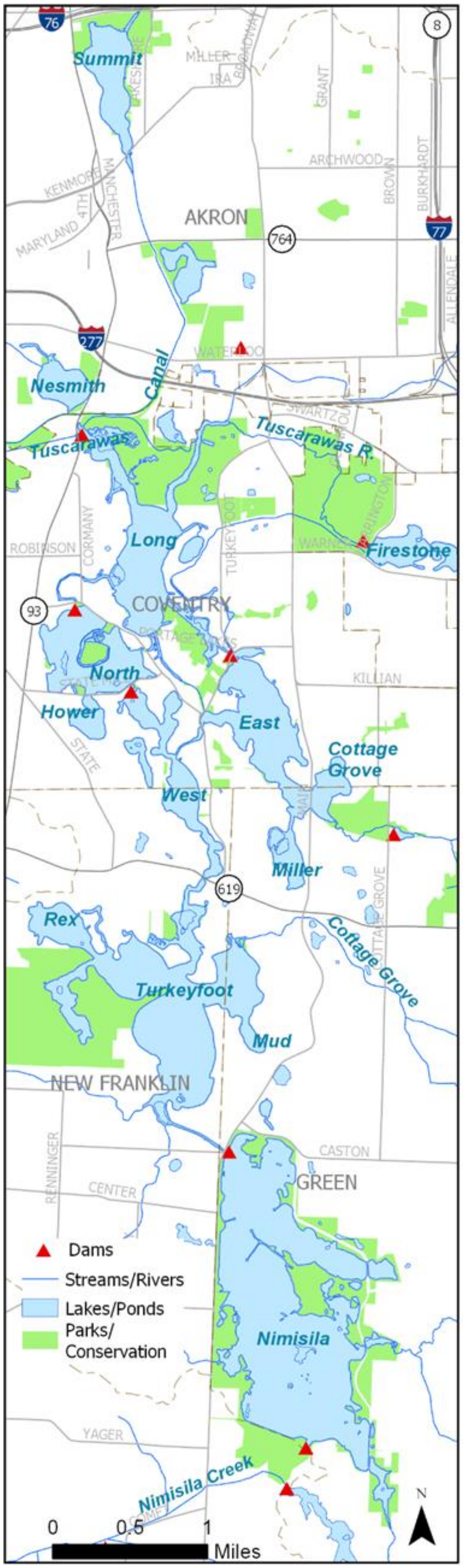
Watersheds Affecting the Portage Lakes and Waterways

The sub-watersheds of the Portage Lakes (Maps 2.5 and 2.6) drain to the Tuscarawas River and Portage Lakes. The size and landscape of the watersheds affects the amount and quality of water entering the lakes.

The canal-lakes system is bounded by Firestone Reservoir, Lock 1 north of Summit Lake, the Canal at Wolf Creek, and Nimisila Reservoir. Flow in this system is managed with dams, flow-control gates, channels, and the canal. (J. Garretson, pers. commun., 2020)

- Nimisila Reservoir is fed by the Nimisila Creek/ Reservoir subwatershed (…0302). It empties to Nimisila Creek south of the lakes and also is used to recharge the other lakes occasionally.
- The “Main Chain” (Turkeyfoot Lake, East and West Reservoir, and their associated lakes) are fed by the upstream (southern) 13.5 square miles of the Portage Lakes watershed (…0105).
- Small areas of the Portage Lakes watershed feed Hower Lake and North Reservoir (0.7 and 1.1 square miles, respectively), which also receive flow from the Main Chain lakes.
- Long Lake receives water from the other Portage Lakes, Brewster Creek, the southeastern 17.3 square miles of HUC …0105, the Tuscarawas River, and its 37 square mile watershed (HUC …0101).
- The Tuscarawas River west of Long Lake receives water from the entire Tuscarawas Headwaters and Portage Lakes watersheds (…0105 and …0101) as well as occasional recharge from Nimisila Reservoir via the other lakes.
- The Ohio and Erie Canal receives discharge from Long Lake and thus, the Tuscarawas and other lakes. Some flows south to the Tuscarawas River at Barberton, some is directed north to the Cuyahoga River and Lake Erie basin.


Map 2.6
Flow Within Portage Lakes Watershed
Brimfield
AKRON
MOGADORE
Summit
Canal
Portage Lakes
-Tuscarawas R.
(050400010105)
Suffield
LAKEMORE
Canal
Tusc. R.
Brewster Cr.
Tuscarawas R.
Long
Coventry
Springfield
North
East
Tuscarawas R.
West
Headwaters
Tuscarawas R.
(050400010101)
Turkeyfoot
HARTVILLE
NEW
FRANKLIN
GREEN
Lake
Nimisila
Nimisila Cr.
Nimisila Res.-
Nimisila Cr.
(050400010302)
Lawrence
CANAL
FULTON
Jackson
Dam
Streams/Rivers
Flow to/from the Lakes
Lakes/Ponds
HUC-12 Watersheds
Lakes, Watershed Drain
to Tuscarawas River,
O&E Canal, Summit Lk
Jurisdictions
Elevation (ft)
≤ 1,299
≤ 1,250
≤ 1,200
≤ 1,150
≤ 1,100
≤ 1,050
≤ 1,000
≤ 988
≤ 985
≤ 975
≤ 970
≤ 965
≤ 960
N
0 1 2 Mi.
NEFCO, 2020. Sources: USGS; USGS NHD; ODNR; Summit County GIS; Stark County GIS; Portage County GIS.



Managing the Water

Staff from The Ohio Department of Natural Resources (ODNR) Division of Parks and Watercraft, O&E Canal Lands and Reservoirs, manages water level and flow in the canal-lakes system. ODNR generally maintains the water in the lakes at nearly constant levels, to provide adequate water for boaters and waterways, minimize flooding on nearby roads, and prevent flooding Akron from the Portage Lakes during high flow. ODNR also maintains flow into the canal and Tuscarawas River and diverts water into the Lake Erie Basin.[5]

The dams, lakes and canal are part of a complex system of flood control structures, in an area of historical flooding:

- Water from the lakes inundated Akron in 1913 after the dams at East and North Reservoirs failed.
- Akron experienced flooding for decades before the Firestone Reservoir was impounded.

The Main Chain lakes feed into North Reservoir and Long Lake. The dam spillways control flow by elevation and size. Designed in the 1800s and early 1900s, the spillways in East and West Reservoirs are inadequate to handle storm flow. A rise of four inches in water elevation in East or West Reservoirs causes flooding.

The historical spillway design cannot be enlarged. Flow release at the dams has been augmented by lake drains and gates, which are manually adjusted to alter flow. A small ODNR staff monitors water elevations remotely, then manually adjusts gates or removes obstructions to ensure safe water levels during storms. The period before, during, and after storms involves intense activity throughout the system to maintain safe water levels.

In addition to flood control, ODNR is responsible for diverting water from the Ohio River basin to the Great Lakes basin to balance out the water diverted across the divide for water or sewer service. The federal Water Resources Development Act of 1986 was enacted to protect the Great Lakes Basin from export of water. The Governors Accord of the Great Lakes approved Akron's Water Diversion Plan in 1998. The first of its kind, it allowed water to be sold and diverted outside of the Great Lakes Basin. This allowed water supplies and wastewater treatment to operate across the divide, if an equal amount of water is returned to the Great Lakes basin. The Canal and feeder reservoirs are the mechanism to provide fresh water into the Great Lakes basin to offset water that Akron sells outside of the basin. ODNR discharges 17 to 21 cubic feet per second (cfs) to the Ohio and Erie Canal. This pushes 6-13 million gallons per day (mgd) to Lock 1 north of Summit Lake, which is released north to the Lake Erie Basin. The rest waters the canal.

Every two years in autumn, the ODNR draws down the Main Chain lakes by about 18 inches partially refilling them from Nimisila Reservoir. This allows maintenance of docks and boats. The ODNR Wingfoot Lakes and Portage Lakes park manager coordinates dredging and repairs/improvements to shoreline structures.

ODNR Dam Safety staff inspects and maintains the dams, which were built from 1840 to 1930. Recent reconstructions include:

- West Reservoir, 2011
- Tuscarawas Diversion Dam (Firestone) 2014-2018
- Long Lake and East Reservoir, 2018-2019
- North Reservoir – the northern embankment failed in the 1913 flood and is being reconstructed, 2020
- Nimisila Reservoir - risk reduction study scheduled, 2020-2021
- The Portage Lakes canal-lakes system will be evaluated in 2021.

East Reservoir dam, 2020

Elevation of the Lakes and Associated Waterways

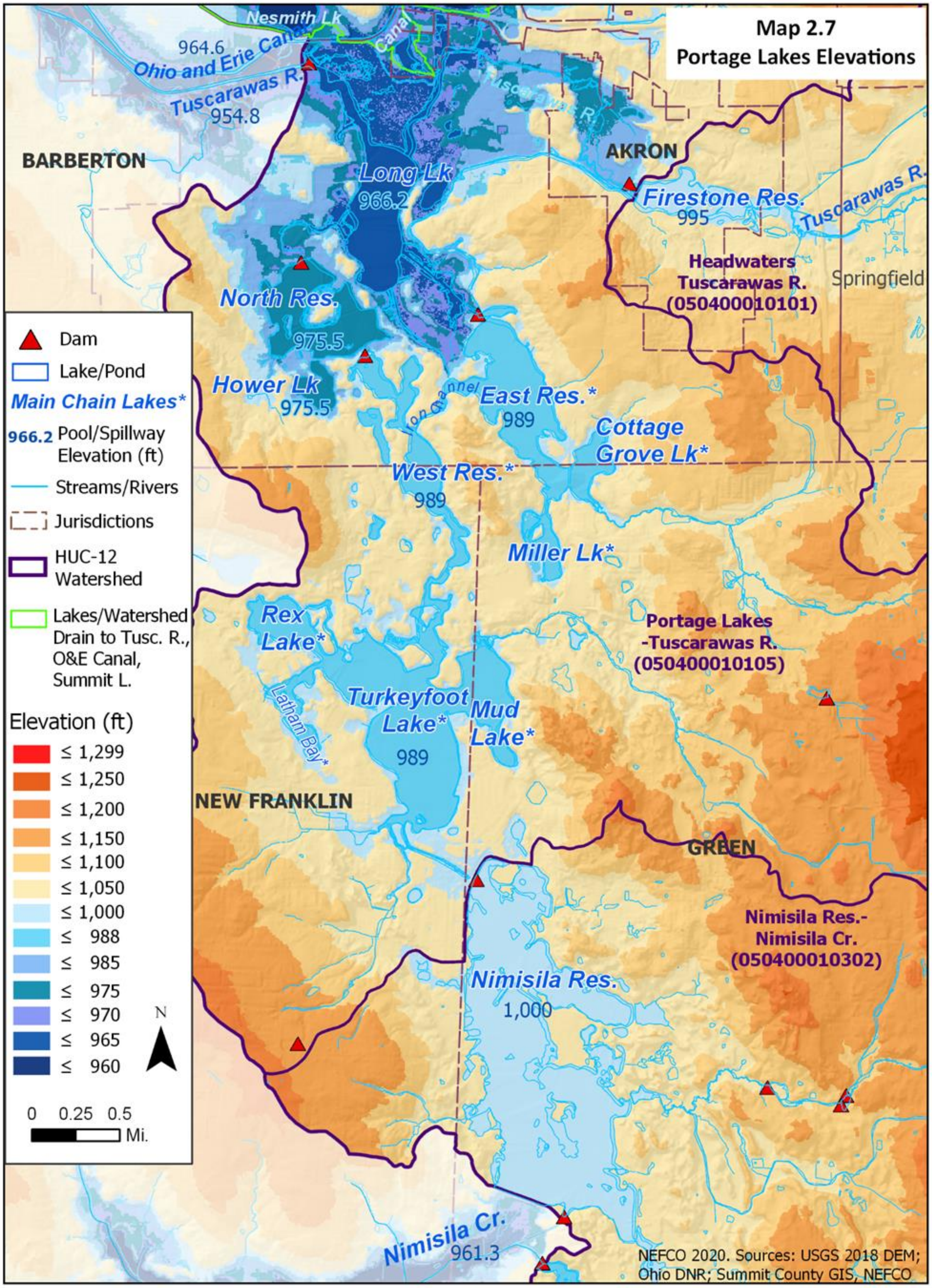
As shown on Table 2.1 and Map 2.7, the lakes descend from Nimisila Reservoir to Long Lake.

- Nimisila has the highest elevation of the Portage Lakes.
- Turkeyfoot, East, and West Reservoirs, and their associated lakes, known as the "Main Chain" are all at the same elevation and are connected by channels, allowing water and boats to travel between the lakes.
- North Reservoir and Hower Lake are at the same elevation and connected by a culvert. Both lakes are lower than the "Main Chain."
- Long Lake is lower than North Reservoir, Hower Lake, and the Main Chain.
- Summit Lake and the canal are lower than Long Lake. The Tuscarawas River north of the lakes, and Nimisila Creek at the southern end, are lower than the lakes.

East Reservoir, one of the "Main Chain lakes. Looking toward the Iron Channel, which connects East and West Reservoirs. View is from the East Reservoir dam, which separates East Reservoir from Long Lake.

Table 2.1 Portage Lakes Elevations and Watershed Information

Lake/River	Elev. (ft)[6]	Water Flows	Watershed 05040001-
Nimisila Cr.	961.3	to Tuscarawas	Fed by -0302, Green
Nimisila Res. spillway	1,000	Mostly to Nimisila Cr. over dam. Occasionally released to Turkeyfoot	-0302 – 17.4 sq mi. Green
Main Chain			-0105 – 17.3 sq mi affects Portage Lakes upstream of Long Lake, from Green, New Franklin, Coventry. Feeder canal diverts minimal flow to East Res. The lakes are occasionally recharged from Nimisila Res., -0302 via Turkeyfoot.
Turkeyfoot Lk	989	To/from East Res. through a channel	
East Res.		To/from West Res. by Iron Channel Main outflow to Long Lake	
West Res.		Flows into East Res. by Iron Channel Some flow to North Res. over dam	
Hower Lake	975.5	To North Res., through culvert	
North Res.		To Long Lake over dam	
Long Lake	966.2	To Tusc. River over dam; some diverted to Ohio and Erie Canal	Receives water from 56.9 sq. mi of -0101, -0105, plus recharge from -0302.
Firestone Reservoir	995	Diversion dam directs flow to Tusc. R, small amounts to Feeder Canal	-0101 - 35.8 sq mi
Tuscarawas R.	954.8	Muskingum River, then Ohio River	Receives water from -0105 and -0101 (63.6 sq. mi); occasional recharge from -0302 via the lakes (17.4 sq mi)
Canal, Summit Lk	964.8	N to Lake Erie or S to Ohio River	Cuyahoga, Tuscarawas watersheds.
Nesmith Lake	964.8	Canal to Tuscarawas at Wolf Cr.	Watered by canal


Map 2.7
Portage Lakes Elevations
Nesmith Lk
964.6
Ohio and Erie Canal
Tuscarawas R.
954.8
BARBERTON
AKRON
Long Lk
966.2
Firestone Res.
995
Tuscarawas R.
Headwaters
Tuscarawas R.
(050400010101)
Springfield
North Res.
975.5
Hower Lk
975.5
East Res.*
989
Cottage
Grove Lk*
West Res.*
989
Miller Lk*
Rex
Lake*
Portage Lakes
-Tuscarawas R.
(050400010105)
Latham Bay*
Turkeyfoot
Lake*
989
Mud
Lake*
NEW FRANKLIN
GREEN
Nimisila Res.-
Nimisila Cr.
(050400010302)
Nimisila Res.
1,000
Nimisila Cr.
961.3
Dam
Lake/Pond
Main Chain Lakes*
966.2 Pool/Spillway Elevation (ft)
Streams/Rivers
Jurisdictions
HUC-12 Watershed
Lakes/Watershed Drain to Tusc. R., O&E Canal, Summit L.
Elevation (ft)
≤ 1,299
≤ 1,250
≤ 1,200
≤ 1,150
≤ 1,100
≤ 1,050
≤ 1,000
≤ 988
≤ 985
≤ 975
≤ 970
≤ 965
≤ 960
N
0 0.25 0.5
Mi.
NEFCO 2020. Sources: USGS 2018 DEM; Ohio DNR; Summit County GIS, NEFCO

Tour of the Lakes

This management plan focuses on the lakes south of the Tuscarawas River. Figs. 2.2-2.5 is a tour of how water moves through the lakes, from highest (Nimisila) to lowest (Long Lake). Map 2.8 shows flow through the lake system.

Nimisila Reservoir - the highest of the lakes in this plan, was created in 1930 to augment the canal as an industrial water supply. Dams at both ends control flow. Most water leaves the reservoir at the southern dam, falling about 39 feet to Nimisila Creek and then the Tuscarawas River. Occasionally, water is released to Turkeyfoot Lake through gates at the northern end, to replenish the other lakes. A past practice was also to pump water into the reservoir for storage.

Turkeyfoot Lake - the one of the original, natural lakes. Latham Bay was dredged out. Turkeyfoot Lake, one of the three "Main Chain" lakes, is connected to West Reservoir by a channel.

West Reservoir - the middle of the three "Main Chain" lakes, was impounded by dams, along with East Reservoir in 1840 to provide canal water. The two reservoirs were known as the Tuscarawas Reservoir. West Reservoir is connected to Turkeyfoot Lake and East Reservoir by channels. At the northern end of West Reservoir, a dam with gates controls flow to the North Reservoir, discharging small amounts.

East Reservoir - East Reservoir is the third of the "Main Chain" lakes, impounded with West Reservoir in 1840 as the "Tuscarawas Reservoir" to supply canal water. Water and boats move between West and East Reservoirs through the Iron Channel. Water enters from West Reservoir, minimal inflow from the Feeder Race, and as runoff and streams from Coventry and Green. The East Reservoir is the primary lakes feeder to Long Lake. Flow out of the East Reservoir to Long Lake, 23 feet below, is controlled by a dam and gates. A spillway relieves excess flow. The dam and spillway were recently reconstructed. "Cat Swamp" is where the 1913 flood breached, causing Long Lake to overflow and flood Akron.

Hower Lake and North Reservoir - Hower Lake, one of the smallest lakes, is one of the original kettle lakes. It is connected to North Reservoir by a culvert under State Mill Road. North Reservoir was built in 1909 as "New Reservoir." It is isolated from all other lakes, controlled by a dam on the northern side (Long Lake). Water enters from Coventry, Green and New Franklin.

Long Lake - shown on early maps is the southern terminus of the ancient portage. The dam built in 1936 impounded and altered the lake as an industrial water supply for the canal. It is the lowest of the Portage Lakes, receiving inflow from all the other Portage Lakes and the Tuscarawas River. Its watershed is 74.3 square miles. It is critical for flood control. If it overflows during the severe rain events it could flood Akron, which occurred in 1913.

The Tuscarawas enters at the northeast, and the lake discharges to the Tuscarawas and canal at the northwest, Long Lakes Feeder. Water from Long Lake drops ten feet to the Tuscarawas River through flood gates in a newly reconstructed dam. Under international agreement, the ODNR diverts 6-13 million gallons of water per day to the Lake Erie basin via the canal to offset wastewater that leaves the Lake Erie basin for treatment south of the divide.

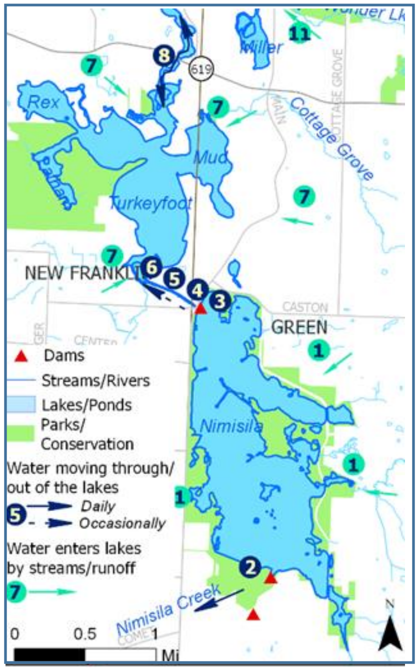


Figure 2.2 Nimisila Reservoir Flow

1. Water enters from a portion of Green and New Franklin via streams and runoff.

2. *Most* water flows over southern dam, drops 35 feet to Nimisila Creek, (and then enters the Tusc.)

3, 4, 5, 6 Occasionally, water from the reservoir is released into Turkeyfoot Lake.

3. Water is released from Nimisila Reservoir at the control structure by the berm.

4. Water enters the channel via a control structure. Berm (background) hides view of reservoir.

5. Water flows northwest through the channel to Turkeyfoot Lake.

Turkeyfoot Lake

6. Water enters Turkeyfoot Lake. Photos show channel and outlet into Turkeyfoot Lake.

7. Streams/runoff enter from Green, New Franklin. ***Photos:*** 7a Cottage Grove Cr.; 7b Mud Lk near Cottage Grove Cr.

8. Water flows between Turkeyfoot Lake and West Reservoir via the channel. ***Photo*: L**ooking north toward West Res. from Rte 619.

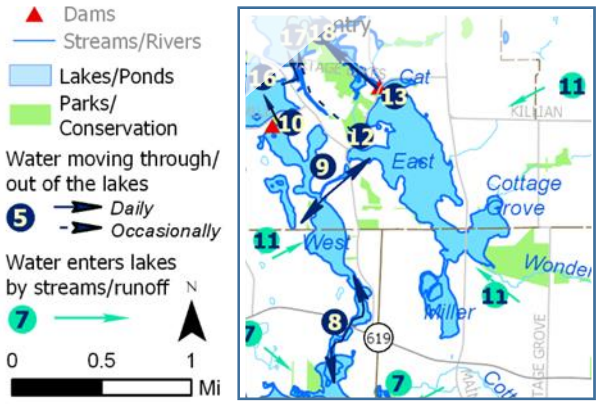


Figure 2.3 West and East Reservoir Flow

8. Water and boats move between West Reservoir and Turkeyfoot Lake through a channel.

9. Water flows between West and Easts Reservoirs through the Iron Channel. ***Photos:*** Views of the Iron Channel. 9a looking toward East Reservoir; 9b looking into Iron Channel from East Reservoir.

10. Dam/gates at north end of West Reservoir releases low volumes into North Reservoir, 13.5 feet lower.

11. Water enters the reservoirs from Coventry, New Franklin, and Green via runoff and streams.

Photos: 11a Wonder Lake Creek; 11b view of Wonder Lake Creek where it enters Cottage Grove Lake.

12. Secondary spillway (el. 989.1) E. Reservoir is a high-water release to Long Lake, 23 feet below.

13. Water primarily leaves East Res. at a recently reconstructed dam with gates, falling 23 feet to Long Lk.

Photos: 13a Upstream (E. Res.), 13b downstream (Snakey River/Heimz Ditch) of dam outlet; 13c Cat Swamp.

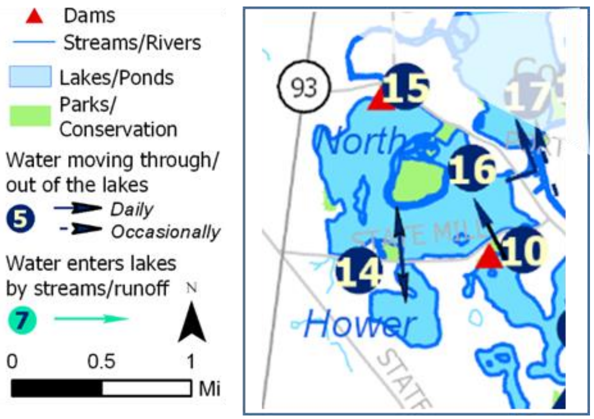


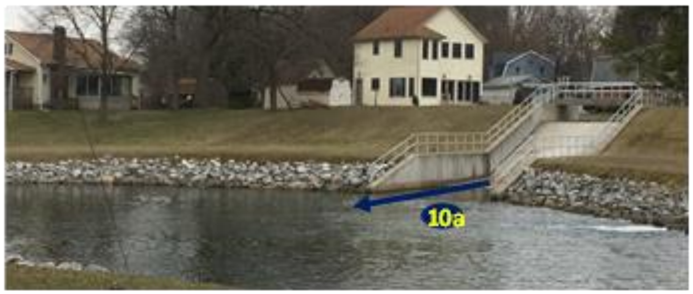
Figure 2.4 Hower Lake and North Reservoir Flow

10. Small volumes enter North Reservoir from dam/gates on West Reservoir via a stilling basin.
Photos: 10a enters stilling basin from W. Reservoir 10b enters North Res. from stilling basin.

14. Hower Lake and North Reservoir are connected by a culvert under State Mill Rd.
Photo: View of culvert under State Mill Rd. from North Reservoir

15. The North Reservoir embankment, which failed in 1913, is being reconstructed.
Photo: 15 North Reservoir embankment.

16. Water leaves North Reservoir through a spillway, dropping 11 feet to the Long Lake channel.



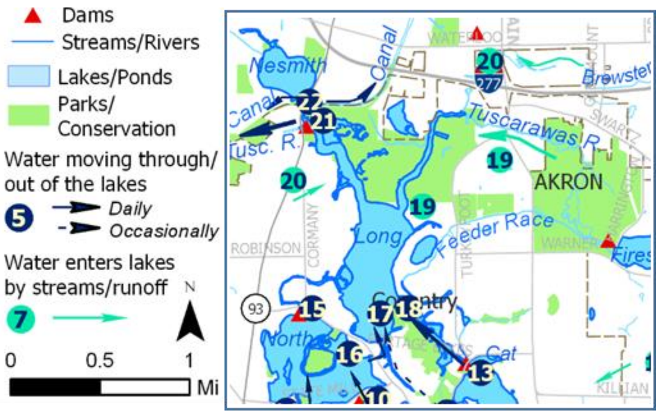


Figure 2.5 Long Lake Flow

17. Water enters from E. Res. secondary spillway and North Res. ***Photo***: Inflow from E. and North Res.

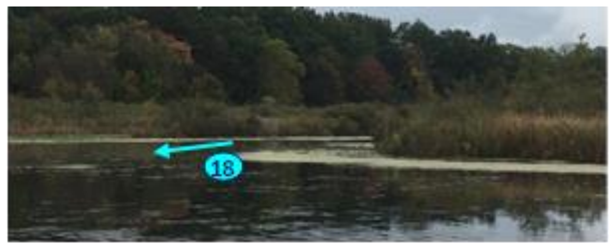
18. Water enters from the East Res. dam/gates. ***Photo:*** Long Lk, inflow from East Res. dam.

19. The Tuscarawas River enters Long Lake. ***Photos:*** 19a Tuscarawas River at S. Main St. looking east. 19b The Tuscarawas River enters Long Lake through the channel joining the body of the lake here.

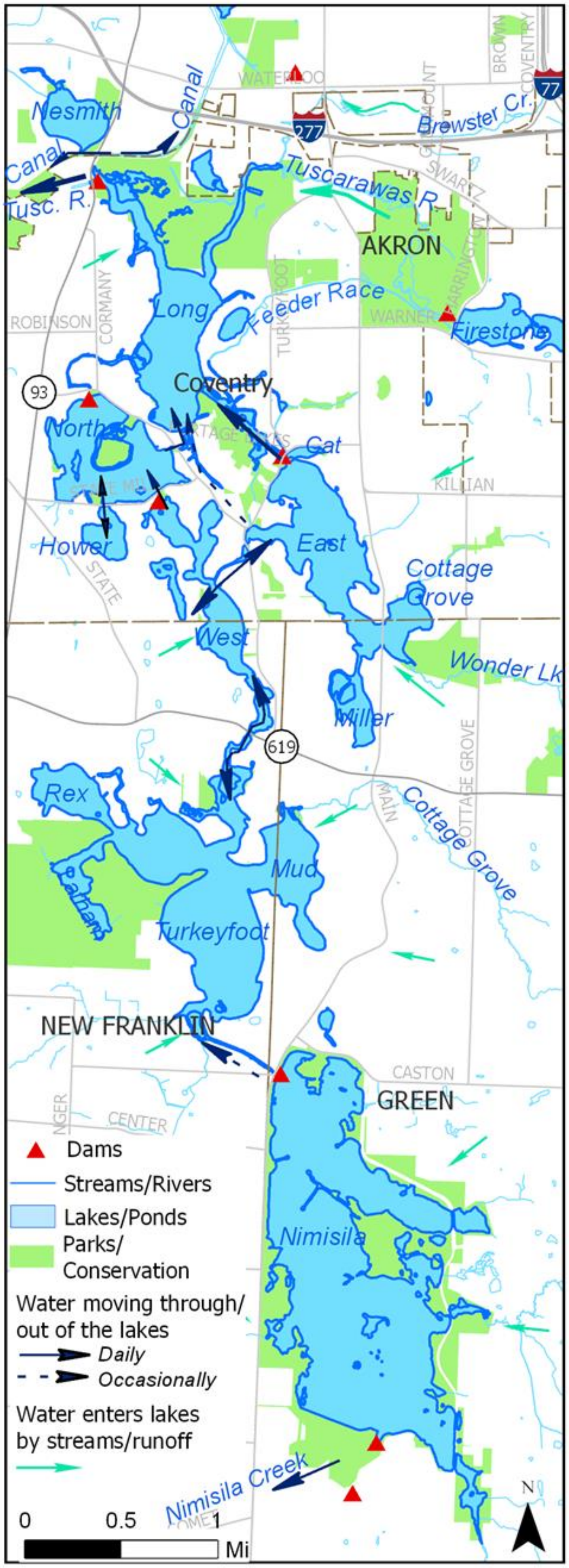
20. Water enters Long Lake via streams and runoff. ***Photo:*** Brewster Creek at S. Main St, view north.

21. Water flows through gates to the Tuscarawas River, dropping 7 feet to the river. ***Photos:*** 21a Dam (foreground) and outlet to canal (background) from Long Lake; 21b dam viewed from Tuscarawas R.

22. A flow control structure directs flow to the canal and the Lake Erie Basin. ***Photo:*** Outlet to canal.



Map 2.8 Flow in Portage Lakes



Key Considerations

The Portage Lakes began as a few small kettle lakes left by glaciers. The lakes were transformed during the 1800s and early 1900s into an interconnected system controlled by dams, supplying the canal water for transportation and industrial water supply.

Today, the lakes:

- Support thriving communities, and a regional recreational and economic resource
- Are crucial for flood control
- Are used to comply with requirements to maintain water levels in the Great Lakes
- Receive water from 67 miles of developed

Managing – and protecting – the lakes for multiple uses will require understanding where the water comes from that enters the lakes, how it moves through the system, and how it is controlled.

Watershed – The watershed affects the quantity and quality of the water entering the lakes. Protecting water quality requires understanding which areas contribute to each lake and taking care of the upstream lands of the watershed that feed the lakes. Best management practices, reducing non-point source pollution and protecting or restoring certain landscape features helps reduce the amount of runoff and the pollutants, and improves the quality of the water entering the lakes. This is discussed further in Chapters 5 and 6.

Dams – The dams and their control structures provide flood control, are necessary for maintaining flow to the Great Lakes Basin, and are used to change lake levels. Dams are engineered and maintained for safety and longevity. Most have been or will be reconstructed. Certain uses may not be allowed on the dams for safety, e.g., structures or trees.

A small ODNR staff maintains lake levels and flow as required. This critical, labor-intensive task involves monitoring water levels, adjusting gates, and clearing vegetation and debris from waterways and drains.

Management Concerns - Later chapters of this plan recommend additional management measures in the lakes to better understand current and changing conditions, manage aquatic plants in a balanced way with residents' and visitors' concerns, and protect the lakes from further eutrophication. The current small, dedicated staff that manages the waterways does what they can to also manage the aquatic plant growth and provide for navigation. However, they lack the time, technical resources, staff, and funding to adequately take on the complex task of managing the lakes as a multi-use resource and ecosystem. Protecting the lakes and accommodating the uses will require a coordinated, concerted effort, consistent management, and adequate resources.

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[1] Map Sources Maps 2.1, 2.2: NEFCO, 2020. Map Sources Maps 2.1, 2.2: ODNR GIS Ohio Dams database, https://gis.ohiodnr.gov/arcgis/rest/services/DSW_Services/Ohio_Dams/MapServer; Summit County GIS roads, streams, jurisdictions, parcels databases, retrieved from https://data-summitgis.opendata.arcgis.com/ 2018-2020.

National Hydrologic Database (NHD) 2016, retrieved from nationalmap.gov Jan. 2017. Parks data layers from AMATS; Western Reserve Land Conservancy, parcel data.

[2] Map Sources Maps 2.3, 2.4: ODNR GIS 2017; NHD 2016 ibid.

[3] Map Sources Fig. 2.1 All historic maps retrieved April, 2020.

Friend, N.; Smith, C.L.; Hunter, Thomas;, 1874. 1874 Combined Atlas of Summit County. Tackaberry, Mead, and Moffett, Philadelphia, PA. Obtained from Summit Memory Online Map Room. https://www.summitmemory.org/digital/collection/new-maproom/id/625/rec/5; Paul, Hosea. *Map of Summit Co., Ohio*. Philada.: Matthews & Taintor, 1856. Map. https://www.loc.gov/item/2012592394/.; Putnam, Rufus, Thomas Wightman, and Thaddeus Mason Harris. *Map of the state of Ohio*. [Boston: Printed by Manning & Loring, 1804] Map. https://www.loc.gov/item/90682167/.Tanner, Henry Schenck. *Ohio and Indiana*. [Philadelphia: Tanner, Vallance, Kearny & Co, 1819] Map. https://www.loc.gov/item/2011585893/.;

J. Garretson 2020. Parks and Watercraft, Canal Lands and Reservoirs, pers. commun. 2020;

Carolyn Vogenitz 1999. Portage Lakes Then and Now. Waterside Publishing, Akron, OH.

[4] Map sources Map 2.5: NHD 2016; Summit Co. GIS; Portage Co. GIS; Stark Co. GIS. ESRI base map: National Geographic I-cubed. Maps 2.6 and 2.7 USGS, 2018. The National Map. U.S. Geological Survey, 20180212, USGS 13 arc-second n41w082 1 x 1 degree; n42w082 1 x 1 degree.: U.S. Geological Survey. Retrieved from thenationalmap.gov April, 2020.

[5] The discussions of water elevation, flow, dams, connections, and managing the reservoir system relies heavily on communication with Josh Garretson, ODNR Parks and Watercraft, Canal Lands office, from 2017-2021.

[6] Spillway elevations from J. Garretson, 2020; other elevations from USGS, 2018, ibid. digital elevation model data.

Chapter 3 – Overview
The Portage Lakes and their People:
Community, Uses and Users, Balancing Priorities, and Caretakers

The Portage Lakes are a regional economic driver and recreational resource, and the center of a community. Thousands of people live along the lakes, and hundreds of thousands of visitors use it for recreation. A management plan for a multi-use resource like the lakes must protect the lakes, while taking into account effects, priorities, and impacts of the community, the resources available, the uses and users, and the organizations tasked with managing the resource. Chapter 3 discusses these.

Priorities of users include access and water that is not choked with nuisance aquatic plants. A healthy habitat and clean, safe water are priorities for maintaining the uses of the lakes. Impacts from uses include stormwater runoff, septic system discharge, habitat and sediment disturbance, nutrients, use of toxic chemicals, and changing the landscape, which increases runoff and attracts geese. Managing the lakes will mean balancing resource use and protection. Education and programs to develop an understanding of the lakes and encourage stewardship is an important part of protecting the lakes.

Chapter Organization

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3. The Portage Lakes and their People: Community, Uses and Users, Balancing Priorities, and Caretakers

The Need for Balance on a Multi-Use Resource

The Portage Lakes is where a nature and the human environment interact closely:

- The lakes act as a natural system, but the flow of water is manipulated and controlled.
- This lakes and parks are a regional outdoor recreational resource.
- The lakes support a vibrant community and intensive use by residents, visitors, and businesses.
- The natural lake process, alterations, and uses affect each other.

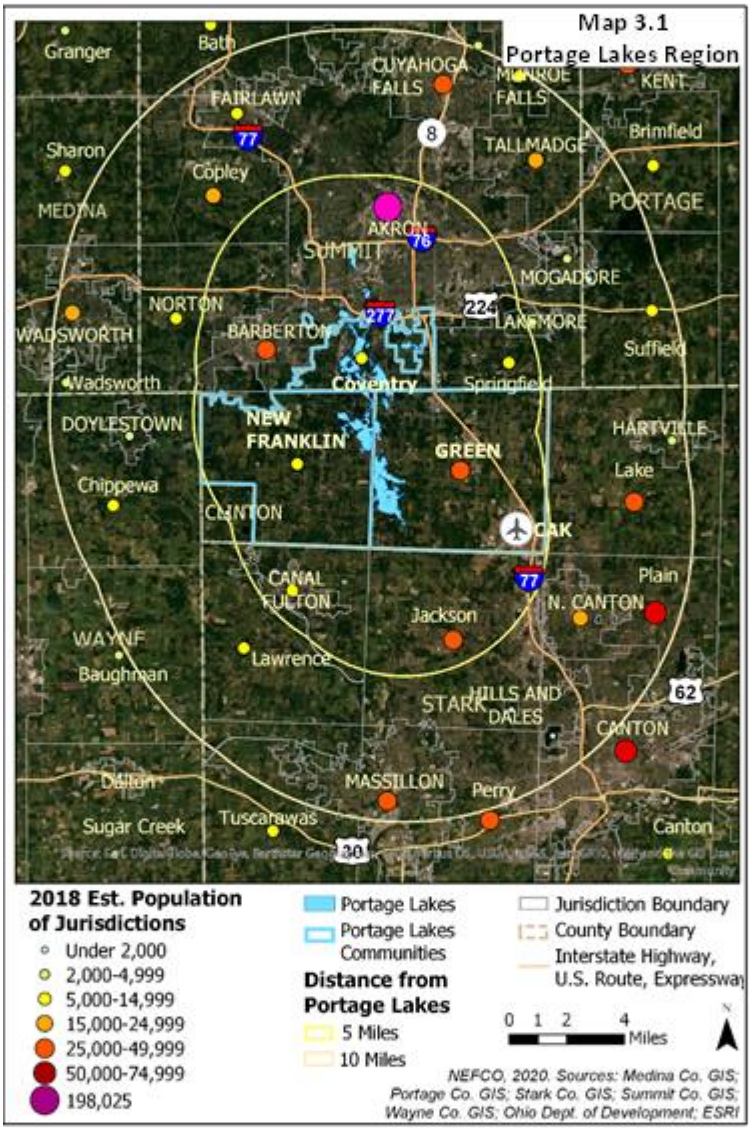
Supporting these activities while maintaining the health of the lakes on which all these activities depend, requires actively managing and supporting the lakes as a multi-use resource, balancing:

- Priorities, practices, needs, capabilities and impacts of many types of uses, users, the communities, and managers, and
- Protection of the water quality and ecosystem on which all the users depend.

This chapter portrays one of the key elements of the management plan – the people side of the equation, briefly describing:

- the regional setting of the lakes;
- the lakes themselves, the community;
- the uses, users, and some conflict areas involving plants; and
- the caretakers.

Priorities and recommendations presented in this chapter are combined with ecological and watershed concerns (Chapters 4-6) into the recommended goals, policies, and actions presented in Chapter 7.



The Portage Lakes Region

The Portage Lakes are between two heavily populated urban areas– the historically industrial areas of Akron-Barberton in southern Summit County, and Canton-Massillon in northern Stark County (Map 3.1.)[1] Canton and Akron are both county seats with County offices, as well as universities and major cultural institutions. Their neighboring communities grew as suburban outgrowth from the cities. Many of the highest-population communities are along the Route 8-Interstate 77 corridor.

Interstate highways and SR-8 provide regional access to Portage Lakes from the north and east. The Portage Lakes are connected to the nearby communities by major roads.

The Portage Lakes are in Coventry Township and the cities of New Franklin and Green. Akron is adjacent to the lakes, and is at the northern entrance to the Portage Lakes area via highways and other major roads. Southern Akron is also in the Portage Lakes watershed.

The Portage Lakes are part of a parks complex that includes the Portage Lakes State Park, two Summit Metro Parks adjacent to the lakes, and the Ohio and Erie Canalway bike-hike path north of Long Lake. These provide an important outdoor recreational resource for the region, with its densely developed urban areas, suburbs, and rural communities:[2] The parks support a wide variety of popular recreation.

- Nationally, about two-thirds of outdoor recreation trips are within ten miles of home.
- Popular types of recreation include jogging/running, fishing, biking, hiking, camping, nature viewing/nature-based activities, swimming, family gathering/picnicking, paddling, and boating.
- About 30 percent of Ohio households participate in boating. Over 28,000 boats were registered within 10 miles of the Portage Lakes in 2018, with equal amounts motorized or non-motorized.
- The Portage Lakes State Park, Summit Metro Parks, and nearby Ohio and Erie Canalway towpath trial provide opportunities for the most popular recreation categories, as well as others.
- Approximately 293,000 people live within ten miles of the Portage Lakes.[3]
- An estimated 300,000 people visit the Portage Lakes State Park per year.[4]

Portrait of the Lakes

The natural and recreational resources of the Portage Lakes draw visitors, residents, and businesses to the area. In addition to numerous existing uses, a potential water trail route for paddlers goes through the lakes. This portrait of the lakes is presented from north to south in Maps 3.2- 3.5[5] and Figures 3.1 and 3.2. Activities shown on the maps will be discussed more specifically later in the chapter.

Long Lake, North Reservoir, and Hower Lake, Map 3.2. These lakes are not accessible by boat from the "Main Chain." Long Lake is over 40 feet deep, with extensive shallows and dense aquatic vegetation at the margins, especially by the wetlands at the ends. Summit Metro Parks is developing Confluence Park, spanning from the Tuscarawas inlet to the floodgates outletting back to the Tuscarawas. Two boat launch ramps and fishing areas are at the north, and an access is on the southern shore. The Ohio and Erie Canal and Towpath Trail are accessible from Manchester Road near the Metro Park. This lake has residential development and a farm along the margins. Conservation areas protect wetlands at either end, and the Coventry Middle School has a wetland observation station.

Hower Lake is the smallest lake, an original kettle lake over 30 feet deep. It is surrounded by residential development. North Reservoir is a very shallow reservoir, with two fishing areas and a boat launch ramp on State Mill Road. The ODNR District 3 Division of Wildlife headquarters is on Meyers Island.

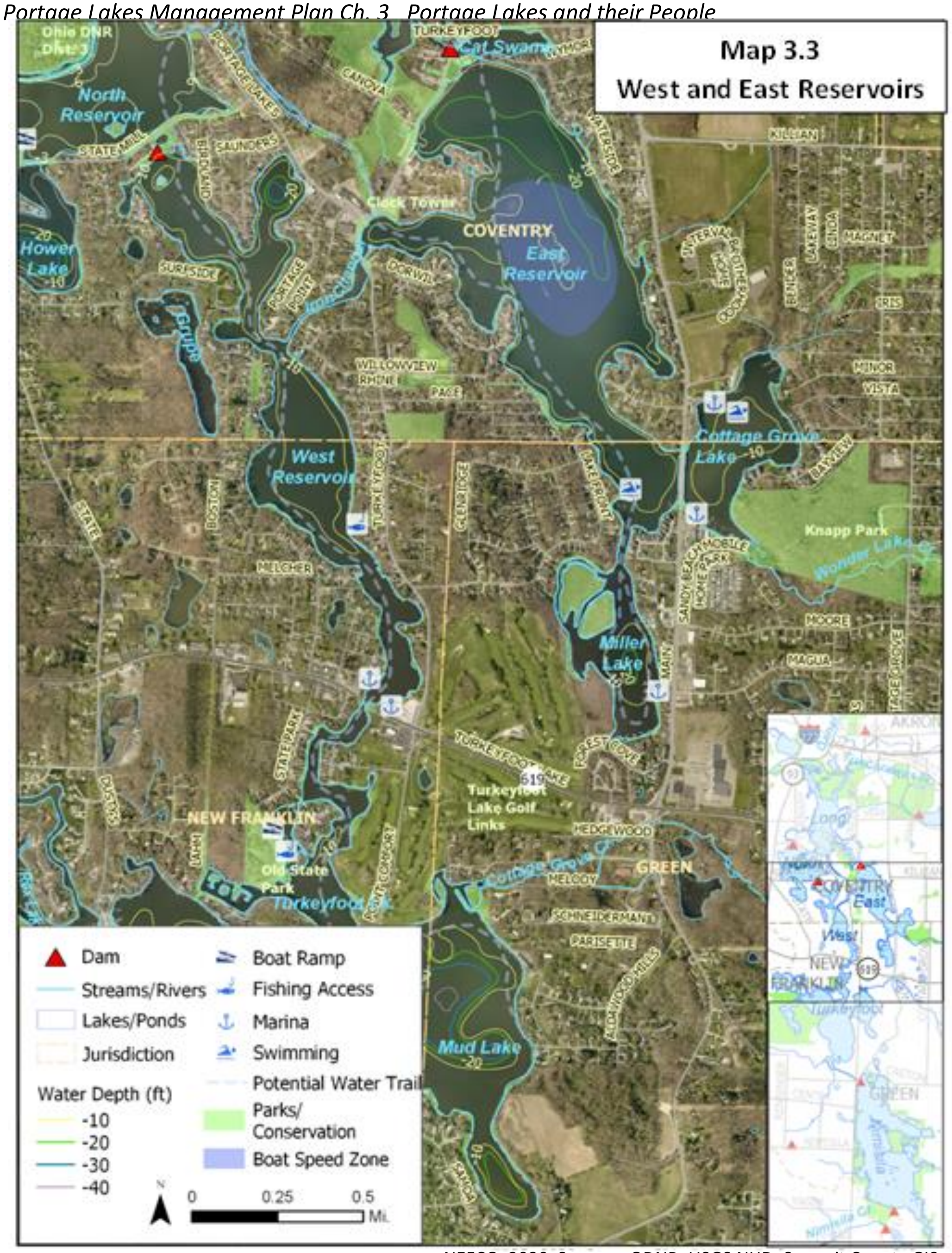
West and East Reservoirs, Map 3.3. These are "Main Chain" lakes, connected by channels. West Reservoir, also connected to Turkeyfoot Lake, is generally less than 20 feet deep, except for a basin in the northwestern lobe. It has a fishing site and access to marinas and a boat launch ramp along the channel between the reservoir and Turkeyfoot Lake. East Reservoir is over 20 feet deep in parts and has a speed zone. It has two swimming areas, boat clubs, a marina on Cottage Grove Lake, and a marina on Miller Lake. Both reservoirs are largely surrounded by dense residential development, many with docks, and have aquatic vegetation along the margins and coves. The Turkeyfoot Golf Links abut both reservoirs. The channel between West Reservoir and Turkeyfoot lake has marinas, a tour boat, and restaurants/bars with courtesy docks on W. Turkeyfoot Road, one of the business centers of the lakes.

Turkeyfoot Lake, **Map 3.4** – This is part of the "Main Chain" and potential water trail route. Depths range from less than 20 feet to over 60 feet. It is the most heavily used lake complex because of the boating, swimming, fishing, and other recreational opportunities of the State Park lands, its size and depth, speed/sailing zone, festivals, marinas and boat clubs, and residences with docks. Rex Lake has two camps – Rotary Camp and Craftsmen Park, a camping area with courtesy slips, and which also hosts the Portage Lakes Rowing Association and Dragon Dream Team dragon boat team. The lake is surrounded by the State Park, Golf Links, agricultural land, and residences. The channel West Reservoir passes through the business center along Turkeyfoot Road, with marinas and restaurants. The margins, shallows and coves have areas of dense aquatic plants.

Nimisila – Map 3.5 is not accessible by boat from the other lakes. It is used less intensively than other lakes due to electric motor requirements, its more remote location, and lack of private docks or marinas. There are several Metro Park areas with boat launch ramps, fishing access, hiking, and camping. There is dense aquatic vegetation in the shallows and coves.

NEFCO, 2020. Sources: ODNR; USGS NHD; Summit County GIS

Long Lake, North Reservoir, Hower Lake	
Size (acres):	Long Lk 194; North Res. 141; Hower Lk 26
Depth (ft)	Long <10-40+; North 3-9; Hower: <10-30+;
Management	Summit Metro Parks manages Confluence Park. ODNR manages the lakes, shoreline, park lands, dock permits, and dams. Cleveland Museum of Natural History owns the Portage Lakes Wetland Preserve. ODNR maintains channels, clear passages for navigation, dams, canals, water levels for flood control, and flow to Lake Erie basin.
Recreational Opportunities	Boating; fishing; hike/bike trail (Canal Towpath) Boat launch ramps and fishing areas on North Reservoir and Long lake provide access. ODNR Dist. 3 office has a visitor's center. Coventry Middle School has a wetland observation station. The Long Lake and North Res. boat ramps have purple martin houses.
Land Use	The shoreline of North Reservoir and Hower Lake are largely residential. Business areas are along Portage Lakes Dr., Manchester Rd., and S. Main St. Some of the land around Long Lake is residential and agricultural, but there are large areas of wetland conservation lands. Two schools and a shopping area are along Cormany/Manchester Roads.
Aquatic Plants	North Reservoir and the shallow margins and northern end of Long Lake have dense growth.

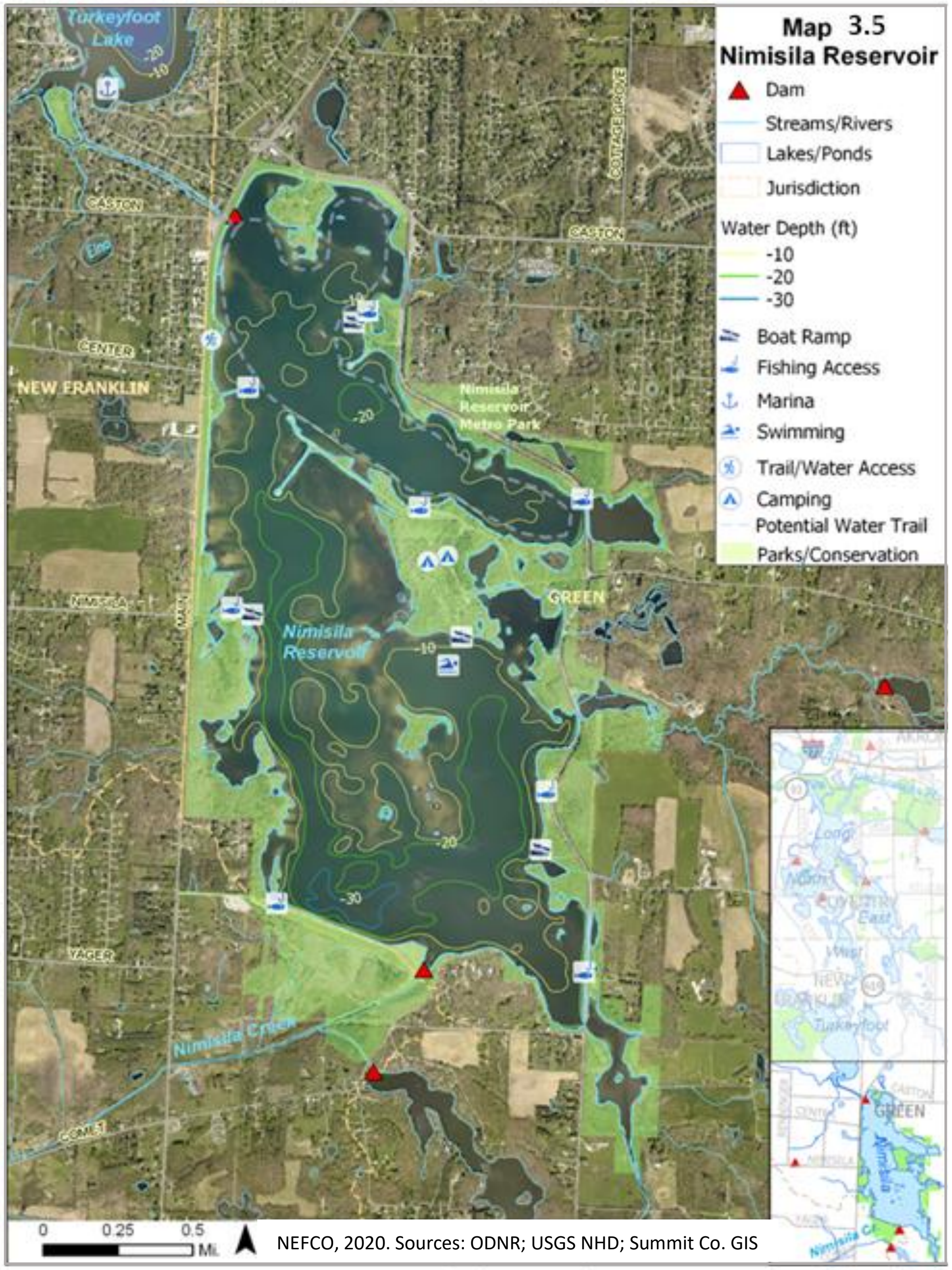


NEFCO, 2020. Sources: ODNR; USGS NHD; Summit County GIS

West and East Reservoirs	
Size (acres):	West Res.104 East Res 248 total; Miller 27; Cottage Grove 37
Depth (ft)	10-20+
Management	ODNR manages the lakes, shoreline, dock permits; and park lands, and dams. Cleveland Museum of Natural History protects the Portage Lakes Wetland Preserve, northwest of Cat Swamp. ODNR maintains passageways, channels, water levels, flow, and dams.
Recreational Opportunities	Boating, swimming, fishing, hiking in Knapp Park (water enhanced). East Reservoir has a speed zone. Private marinas provide water access. West Reservoir is accessible from the State Park boat launch ramps via a channel. Other Rec. Business Turkeyfoot Lake Golf Links
Land Use	The shoreline and areas near the lakes is predominantly residential, with woods, parks, a golf course, businesses along South Main St. and Portage Lakes Rd. near the Clock Tower. Restaurants, bars, and marinas are along Turkeyfoot Lake Rd. (SR 619) where it crosses the channel between Turkeyfoot Lake and West Reservoir.
Aquatic Plants	Miller Lake, the lake margins, shallows, and coves have dense vegetation growth.

NEFCO, 2020. Sources: ODNR; USGS NHD; Summit County GIS

Turkeyfoot Lake	
Size (acres):	503 total; Mud Lk 88; Rex 53; Latham Bay 35
Depth (ft)	10-20 in NW; <10-60 center; <10-40 Mud Lk
Management	ODNR manages lake, lake margin, state park lands: Dock permits; maintains channels; harvests plants in high-traffic areas, manages water levels for flood control, draws down lakes occasionally, refills them from Nimisila.
Recreational Opportunities	Two State Park areas with boat launch ramps, picnic areas. The State Park also has swimming beach, fishing area, boat camp area in the wooded Latham Bay cove, and numerous landside (water enhanced) activities, including disc golf, hiking trails, pavilions, beach volleyball. The lake has a designated speed zone for water skiing Recreation businesses/organizations (water dependent and water-enhanced) include the golf course; marinas/yacht club, camping, team rowing, special needs summer camp. The New Franklin Tudor House is used for gatherings. The lake is the site of fireworks and festivals like the Dragon Boat races.
Land Use	The shoreline and nearby land is largely, park, residential, recreational businesses, and some agriculture. Businesses along Rte 619 include a marina, tour boat, restaurants/bars.
Aquatic Plants	Latham Bay, coves, shallow margins, and some passageways have dense vegetation.



Nimisila Reservoir	
Size (acres):	769 acres
Depth (ft)	<10-20 feet north; <10-30 feet south
Management	The parks around the reservoir are managed by Summit Metro Parks. ODNR currently does not manage vegetation in Nimisila. ODNR occasionally refills the other lakes from Nimisila Res.
Recreational Opportunities	Camping, hiking, fishing, and access for electric boats and paddling Fishing is prohibited from the dam (south) and the utility access road.
Land Use	Very few residences abut the lake, but the lake is within a residential area.
Aquatic Plants	Coves and extensive shallows have dense stands of aquatic plants

Figure 3.1 Lakes Photos – Long Lake, North Reservoir, Hower Reservoir, East Reservoir


Long Lake northern end (left), view from south (right)

Hower Lake, below left *North Res. above North Res. Boat Launch Ramp, State Mill Rd. below right*

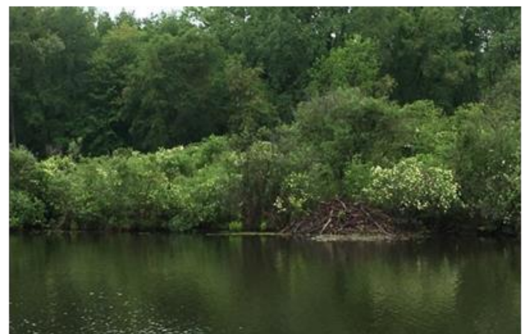


East Reservoir *Miller Lake*

Figure 3.2 Lakes Photos – West Reservoir, Turkeyfoot Lake, Nimisila Reservoir

Iron Channel at entrance to East Reservoir

West Reservoir



Turkeyfoot Lake above right – Latham Bay boat camp

Turkeyfoot Lake - Above left – boaters, anglers, rowers, birds, and homes
Below left – State Park beach

Below, right, Rex Lake Craftsmen Park

Nimisila Reservoir from east side

The Lakes Community: Land Use in the Portage Lakes Vicinity

Map 3.6[6] depicts land use in the Portage Lakes area, mapped from parcel-based tax land use codes, providing insight into how communities are structured and relate to each other. The land use patterns are strongly linked the transportation network and wastewater treatment facilities.

The lakes are largely within the state park, and several other parks, conservation areas, and outdoor recreation opportunities are located along the lakes. The northern portion of the lakes, close to the highways and Akron, is the most intensively developed. The greatest density of housing is in the cities of Akron and, to the west, Barberton, but small parcels are also clustered around the northern lakes. Agricultural use, low-density development, and "vacant" lands are more prevalent in the southern portion of the lakes area.

The major access roads to the Portage Lakes are apparent on Map 3.6:

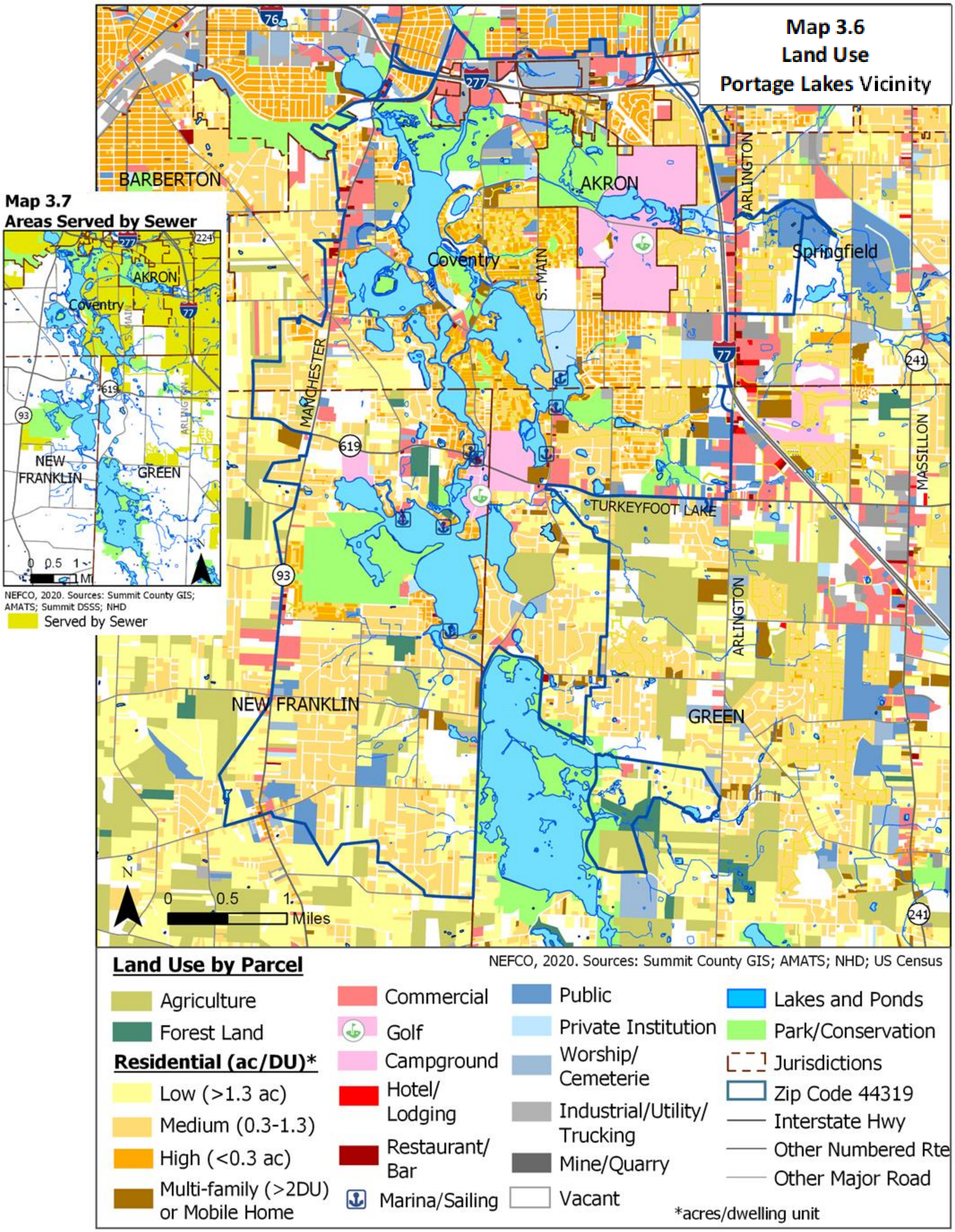
- Arlington Road is one of the areas of recent commercial development along Route I-77 between Akron, the Akron-Canton Airport, and Canton.
- South Main St. provides access from downtown Akron and Route I-277.
- Manchester Road is the main access to the Portage Lakes State Park and provides access from Akron and Route I-277.
- Turkeyfoot Road is the east-west connector from Manchester and Arlington Roads to the lakes.

Businesses line these gateway roads, contributing to the lakes communities and benefiting from the visitors to the lakes and parks. Map 3.6 highlights businesses along the gateway roads that are directly related to outdoor recreation and visitors (lodging, restaurants and bars, marinas, golf, and camping).

Marina and restaurant on Turkeyfoot Rd.

The Census of Businesses reports that within the 44319 zip code (Map 3.6) are: three boat dealers (out of five in Summit County); 10 drinking establishments; 51 restaurants; and six "other recreation," which includes both marinas and bowling.[7]

The availability of sanitary sewer service affects the types and intensity of land use that can be developed. The inset Map 3.7 shows areas designated by wastewater treatment Management Agencies as served by sewers. (Other wastewater treatment prescriptions are on the NEFCO website.) Proposed uses must have wastewater treatment measures approved by Ohio EPA in sewered areas or the Summit County Health Dept. in unsewered areas. Most of the areas around the lakes are not currently served by sanitary sewers. Some unsewered areas have concentrations of small-lot residences built prior to the wastewater treatment regulations, which pose an increased risk of poorly functioning septic systems and discharge of nutrients and bacteria to the lakes. The wastewater treatment Management Agencies work with the communities to identify potential areas for future sewer service based on need and feasibility, discussed further in later chapters.

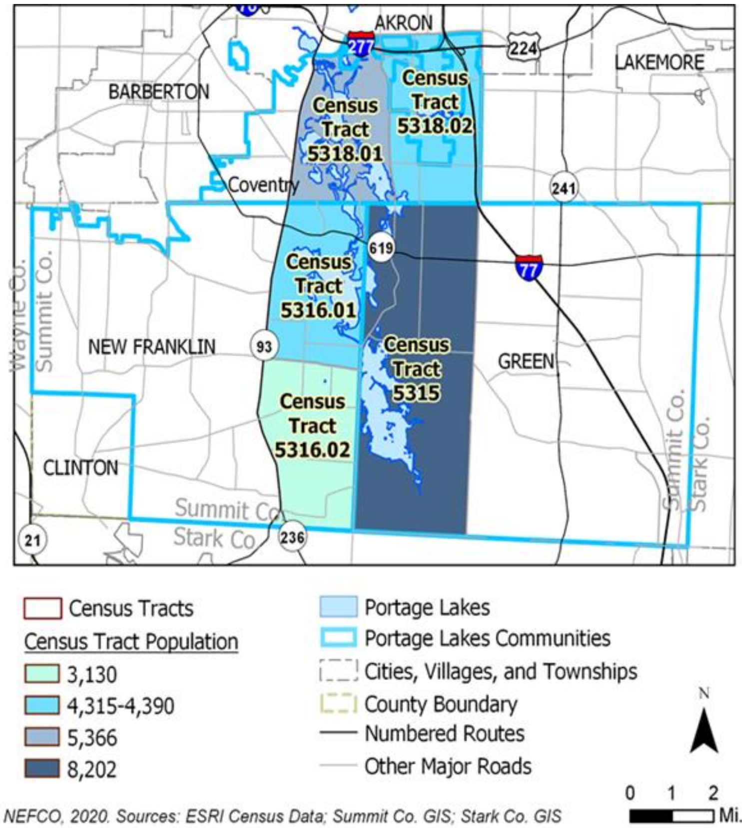

Map 3.6
Land Use
Portage Lakes Vicinity
Map 3.7
Areas Served by Sewer
BARBERTON
AKRON
Coventry
Springfield
NEW FRANKLIN
GREEN
TURKEYFOOT LAKE
MANCHESTER
S. MAIN
ARLINGTON
MASSILLON
76
277
77
224
619
93
241
0 0.5 1 Miles
NEFCO, 2020. Sources: Summit County GIS; AMATS; Summit DSSS; NHD
Served by Sewer
Land Use by Parcel
NEFCO, 2020. Sources: Summit County GIS; AMATS; NHD; US Census
Agriculture
Forest Land
Residential (ac/DU)*
Low (>1.3 ac)
Medium (0.3-1.3)
High (<0.3 ac)
Multi-family (>2DU) or Mobile Home
Commercial
Golf
Campground
Hotel/ Lodging
Restaurant/ Bar
Marina/Sailing
Public
Private Institution
Worship/ Cemeterie
Industrial/Utility/ Trucking
Mine/Quarry
Vacant
Lakes and Ponds
Park/Conservation
Jurisdictions
Zip Code 44319
Interstate Hwy
Other Numbered Rte
Other Major Road
*acres/dwelling unit

Community Profile

It is helpful to characterize the communities that most affect the lakes and are affected by them. A review of data from the 2018 U.S. Census (estimates, 5-year averages) and the Summit County parcel databases is summarized here.[8] The full profile and data tables are in Appendix C.

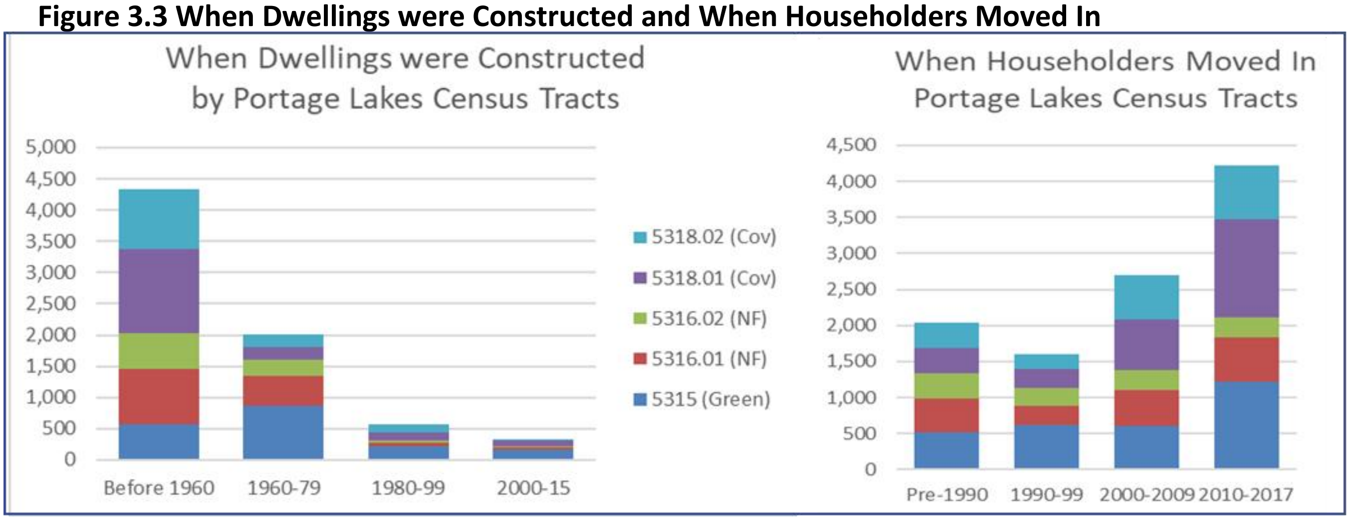
- Overall, the Portage Lakes census tracts are similar to the lakes communities and Summit County.
- Most homes were constructed before 1980; over half before 1960.
- Most householders moved in after 2000, with an increase after 2010.
- Homes built recently in the area tend to have more bedrooms (three or four), compared to the homes built earlier (two or three). New householders moving into older communities may be upgrading the older homes by adding bedrooms.

Map 3.8
Population by Portage Lakes Census Tracts (2018 est.)



Shoreline homes, West Reservoir

Figure 3.3 When Dwellings were Constructed and When Householders Moved In



Characteristics such as age, when householders moved in, income, percentage of rentals versus owner-occupied housing, and household size varies between the census tracts. Some census tracts have more families, some have residents who have been there longer, some have a high percentage of rentals. The data support many of the observations by lake residents and partners.

5315, Green, population 8,202, has a younger population, more families with children, larger households with more bedrooms, high home-ownership, higher income/house prices, and a high proportion of college-educated people. This area was most heavily developed in the 1960s-80s, more recently than other tracts. People have been moving in steadily, with a substantial increase since 2000.

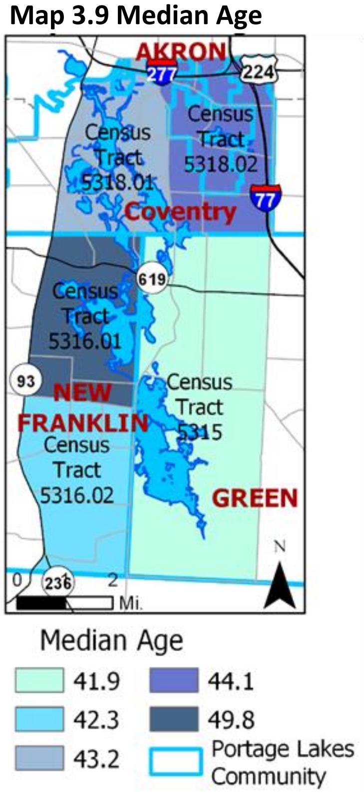
5316.01, New Franklin, population 4,316, has an older population, moderate-sized households, high home-ownership, high income, and higher educational attainment. Most homes were built before 1960. People have been moving to the area steadily, but a more moved in before 1990.

5316.02, New Franklin, population 3,130, has a large proportion of families with children. It has the highest home-ownership, larger households, more bedrooms, moderate income, and a high proportion of children. Like the other New Franklin census tract, the homes were mostly built in the in the two periods before 1980, and more people moved in before 1990, with people moving in steadily afterward.

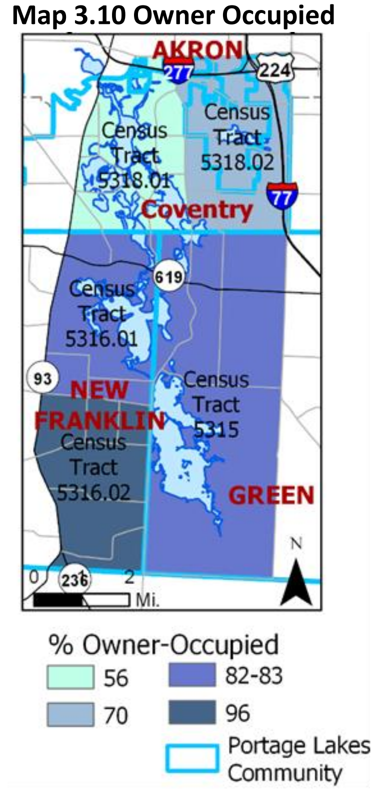
5318.01, Coventry, population 5,366, has the largest proportion of renter-occupied homes (lowest owner-occupied), smallest average household size, fewest bedrooms, relatively low income, and a high percentage of college-educated householders. The homes were mostly built before 1960. Most residents moved in after 2000, with the greatest growth after 2010.

5318.02, Coventry, population 4,348, has an older population (higher median age), low average household size, low household income, and a high number of renters. Most homes were built before 1960. People have moved in relatively steadily, but most moved in after 2000.

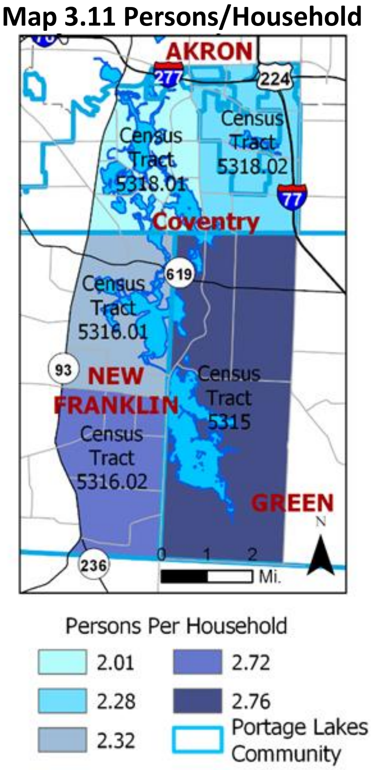
Map 3.9 Median Age



Map 3.10 Owner Occupied



Map 3.11 Persons/Household



Lakers Express Interests and Concerns – Focus Group

While census and parcel data provide a general profile of the Portage Lakes area, of greater value are the comments, observations, and insights provided by Portage Lakes community members during numerous meetings, gatherings, boat trips, and other discussions. These have helped shape the understanding of the community's interests and concerns, and potential management alternatives.

During Spring, 2019, 60 community members participated in a focus group that was targeted to lakeshore residents but open to the public. Their poll responses, questions, and comments about interests and concerns are summarized here and in Appendix B. The poll is not a representative sample of the residents, but the answers provide an idea of the interests and priorities of lake residents. Some of the responses were to open-ended questions, some questions provided as a list of responses to rank or highlight. Participants were allowed to provide more than one answer.

- Responses highlighted the importance of boating and other water-based recreation, an appreciation of the natural beauty of the lakes, and the social aspects of the lakes – the people, restaurants, bars, festivals, and gatherings.
- The participants were very concerned about water quality, managing aquatic plants, bacteria/ algae, and lake management.
- Other questions amplified these concerns, and some pointed to a need for further education about lake ecology.

"It's home."

Table 3.1 Resident Focus Group Poll Summary

Values/Concerns of Lake Residents	**% of Responses**
- Lakeshore resident	80
- Boating/sailing/water skiing	83
- Paddling/kayaking/paddleboard	57
- Swimming	46
- Fishing	57
- Water*	15
- Quiet/serene/beauty*	18
- Wildlife/nature	66
- Parks/recreation*	15
- Restaurants/Bars	77
- Going on tours	17
- People*	12
- Volunteering/PLAC	26
- Educator	11
- Fireworks/festivals	74
Concerns (% High/Very High Concern)	
- Water quality, runoff, nutrients, watershed, litter	87-100
- Managing aquatic plants	77
- Invasive plants	84
- Bacteria/algae	87
- Coordination among lake management groups	77
- Lack of funding for lake management	87
- Public access	48
- Water craft safety	51
Question Topics	
- Geese, cormorants	
- Water clarity	
- Nuisance "weeds," control	
- Septic Systems	
- Lakescaping/trees	
- Water flow	
- Zebra mussels	
- Stormwater runoff	

**Responses to open-ended questions only. (Others involved selecting from/ranking responses.)*

Activities and Participants (Uses and Users)

Who is using, benefiting from, and affecting the lakes? How can the different priorities of each be accommodated in a way that does not interfere with other uses and priorities? It is important to understand the types of uses that occur on and around the lakes, identify the priorities and impacts of each, in order to maintain the lakes as a multi-use resource.

Boating in the Region – an Economic Driver

Nationally, boating is one of the most popular outdoor recreation activities. On the Portage Lakes boating is one of the most prominent forms of recreation, and a driving force of the local economy. This profile summarizes NFFCO's economic study of boating (Appendix D) and other boating surveys.

- There are 19,320 boats on the Portage Lakes, but the number of boats using the lakes over time could be triple that.
- Surveys of Ohio boaters found that while 8-10 percent of people own boats, 30 percent of Ohio households participate in boating - for every boat owner, there are two to three participants.[9] The average boat-owning household in Ohio has 2.13 boats.

- Only 31% of the boats are kept at private docks, marinas, or clubs.
- The average respondent made 15.6 trips to Ohio boating sites, of which 4.3 were to Lake Erie sites.
- The typical boat owner is between 52 and 55 years old with an annual household income of $81,700 and 26.5 years of boating experience. In 2011, boaters in the Midwest participated primarily in cruising, socializing, or nature watching (64-79%); fishing, swimming, sunbathing, or waterskiing (35-48%); rowing or paddling, (18-25%). Most time boating was spent in power boats.[10]

- There are approximately 700,000 people within a 30-minute drive of the Portage Lakes, potentially 200,000 boaters.
- Tourism is Ohio's 3rd largest industry at $40 billion per year, supporting the full-time equivalent of approximately 443,000 Ohio jobs, generating nearly $10 billion in direct earnings.[11] More than half of all Ohioans are employed by the hospitality industry.
- Average spending per boat per day trip varied from $76, for boats less than 16 feet in length, to $275 per day for boats larger than 40 feet.
- The greatest trip expenses were for fuel (22%), restaurants and bars (17%) and groceries (14%). The majority of annual boat-related expenses are for equipment (39%), maintenance and repairs (29%) and insurance (14%).[12] (See Table 3.2)

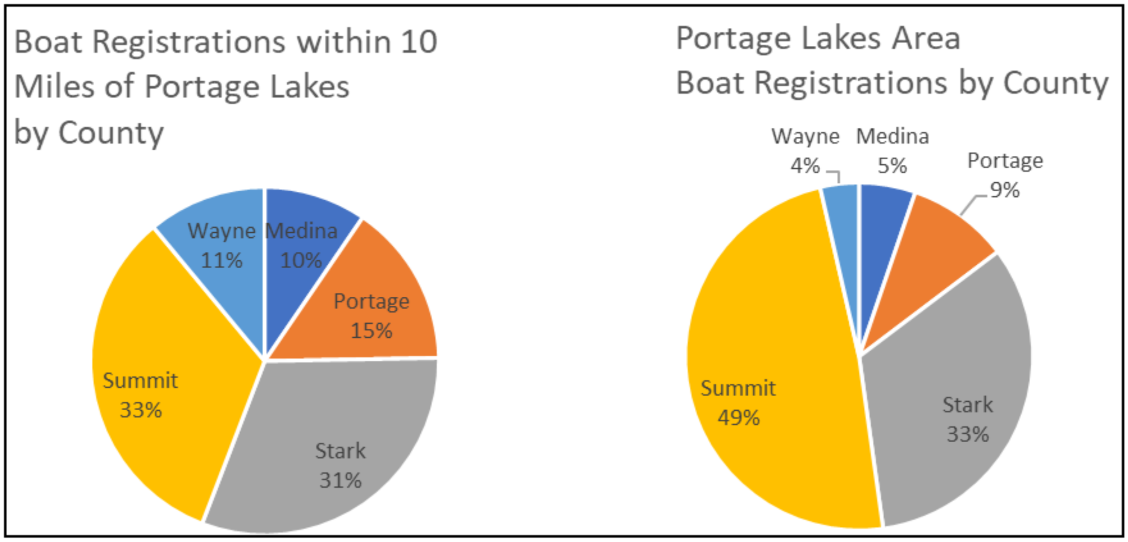
Table 3.2: Trip Expenditures by Boat-Owning Households	
Total trip related expenditures	$2,104
Typical trip related expenditures	$134
Food and lodging per trip	$55
Fuel, transient docking, etc.	$37
Other	$42
Annual Maintenance, fees, repairs	$920
Equipment purchases	$293

Registered Boats within the Portage Lakes Region

The area within ten miles of the Portage Lakes (Fig. 3.1) includes portions of five counties (Medina, Portage, Stark, Summit, and Wayne). Boating registration records were used to determine the proportion from each county and the characteristics of registered boats in the region.[13]

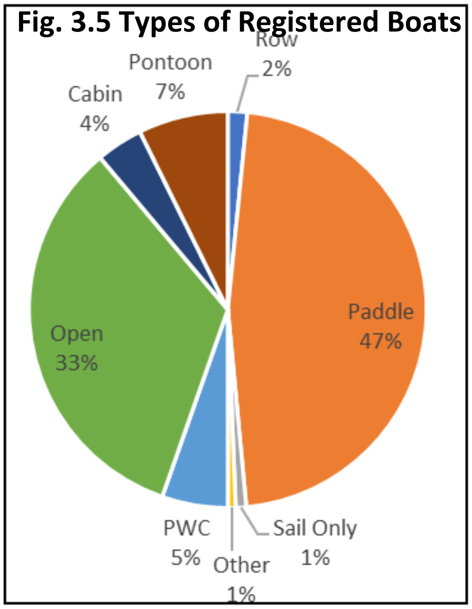
- The number of registered boats in the five counties grew from 59,584 in 2015 to 71,655 in 2018.
- Approximately 28,875 registered boats (10 to 33 percent from each of the five counties) are within 10 miles of the Portage Lakes. Some boats are not registered, and boaters may travel up to 36 miles for boating, increasing the potential number of visiting boaters. Nearly half of the Portage Lakes region boats are in Summit County. (Fig. 3.4), one-third are in Stark County.

Fig. 3.4 Boat Registrations of Portage Lakes Region by County



- Paddling boats are the most common registered, then open power boats, pontoon boats, and cabin boats. About half of the registered boats are manually powered. (Fig 3.5)
- Power boats range from 8 feet long to a few over 50 feet. 90% are between 10 and 24 feet long; the most common power boat length in the region was 16 feet.

Fig. 3.5 Types of Registered Boats



Portage Lakes Boating

Boating a major part of lake life – and the community economy - with over 19,000 boats on the lakes, 1,200 residential and commercial docks, often multiple boats per household, and tens (or hundreds) of thousands of visiting boaters. Boating is why many live near or visit the lakes. Boaters on the lakes participate in solitary and social activities, including fishing, cruising, paddling, sailing, water-skiing, camping, tours, visiting restaurants and other destinations, wildlife-viewing, teams, and community events. The lakes link neighborhoods, restaurants, the open lake, quiet natural areas and fishing spots.

Facilities/Access

- Docks – 700 residential docks, 10 state park courtesy docks, over 500 commercial docks.
- Every lake has or is accessible by boat launch ramps
- Speed zone that is also periodically closed to power boats to allow sailing races
- Electric-only (or paddling) on Nimisila Reservoir
- Potential water trail

Priorities, Needs, Expectations:

- Access and passage and within/between lakes and destinations (boat launches, marinas, courtesy docks, residences) – dense vegetation and shallow depths may impede travel.
- Safe areas for different intensities of use (paddling, sailing, swimming, water skiing)
- Good water quality

Potential Impacts/Concerns:

- Clearing vegetation, dredging, propellers can harm habitat. There is a need to balance access with protecting habitat and water quality.
- Certain chemicals used on boats or vegetation can harm water quality, swimmers, wildlife.
- Boats can spread invasive species.
- Impacts of many individuals – litter, waste disposal, boat maintenance practices, spills, etc.

Responsibilities:

- Practice and promote good stewardship - cleaning up litter, reducing spills, protecting habitat
- Clean-drain-dry practices, avoid dense plant growth, to minimize spread of invasive species.
- Safeguard lake users (other boaters, swimmers, property owners), respecting property owners' rights, following posted guidelines, leave natural areas undisturbed.

Helping visitors be stewards

Fishing

Fishing is one of the most popular recreation categories nationally, appealing to a wide range of ages. The number of fishing permits in Ohio has risen to 1,150,000 in 2019, with the Portage Lakes Counties representing 10 percent of fishing license sales in 2010.[14] The lakes are popular for fishing, from shore and boats. Based on the most recent creel surveys across the Portage Lakes, conducted during 2009 to 2016, weekend fishing pressure exceeds 1,850 hours per day. Several fishing tournaments occur weekly, while the weather permits.[15]

Facilities/Access – Most of the lakes have fishing access at boat launch ramps, other public access points.

Priorities, Needs, Expectations:

- Access by boat or shore
- Diverse fishing opportunities, including various fish species and habitats
- Good fisheries habitat, including aquatic vegetation
- Stable aquatic communities where aquatic vegetation control is appropriately paced
- Good water quality

Potential Impacts/Concerns:

- Impacts of boating
- Potential vectors for aquatic nuisance species
- Impacts of many individuals, e.g., litter, disposal of bait and fishing line.

Responsibilities and Opportunities to Help Protect the Lakes:

- Practice and promote good stewardship - cleaning up litter, protecting habitat, and avoid practices that spread invasive species.

Swimming

The Portage Lakes provide swimming opportunities for residents and visitors from the region. It is especially an important resource for cooling off during hot weather.

Facilities/Access:

- Public swimming beach at the State Park
- Designated swimming areas on East Reservoir, Cottage Grove Lake, and Nimisila Reservoir
- Shoreline residents speak of their children and grandchildren swimming near their houses.

Priorities, Needs, Expectations:

- Good water quality is essential, free from harmful organisms and chemicals (oil, pesticides)
- Swimming areas need to be safe from boaters and entangling aquatic plants
- Application of chemicals can affect swimmers

Potential Impacts/Concerns: Impacts of many individuals, e.g., litter

Responsibilities, Opportunities: Practice and promote good stewardship - cleaning up litter

Other Outdoor Recreation (Public)

Nationally, nature-based activities, hiking, and family gatherings are more popular than boating.[16] The Portage Lakes offer many popular recreational opportunities, and has room to expand opportunities as well. The Portage Lakes State Park, Summit Metro Parks, and nearby Towpath Trail, offer opportunities for hiking, biking, jogging, archery, picnicking, camping, nature viewing/photography, disk golf. Development of playgrounds in the State Park increases the opportunities for families. The Tudor House, owned by the City of Green, is a gathering-space available for events.

Purple martin houses throughout the parks and lake provide refuge for the birds. Each year, volunteers help educate hundreds of visiting schoolchildren about the martins.

These other outdoor activities have little direct use of the lakes or impact themselves, but contribute to the recreational appeal of the parks, and increase visitors' and residents' connection to the natural world, and benefit from the natural setting and clean, healthy lakes.

Priorities/Needs/Expectations –

- Clean, well-maintained facilities,
- Good water quality

Impacts – associated with large numbers of participants

<u>*Responsibilities/Opportunities to Help Protect the Lakes*</u>

- Respect, protect property rights
- Minimize impacts – stay on trails, park in parking lots, take care of litter and pet waste
- Promote good stewardship and an understanding of natural systems through signage, volunteer opportunities, wildlife watching

Homes

The residents of the shore and nearby neighborhoods enjoy great benefits of lake life - views, boating, swimming, and water-enhanced outdoor activity, and the opportunity to learn about the lakes from close up throughout the year. There are approximately 1,400 homes adjacent to the lakes, with nearly 700 residential docks along the lakes. Certain homeowners' associations also have water access available to residents for boating and/or swimming. The lakes connect the communities to the rest of the lakes and provide a "main street," where neighbors and visitors pass by in boats. Water access affects property values, with property values per square foot significantly higher in certain areas along the lake than in nearby neighborhoods.

The homeowners along the lakes have similar priorities and considerations to homeowners elsewhere, e.g., maintaining property and property values, but some that are also unique to their situation. They live at the edge of a public park that happens to be a lake. Their homes and activities are affected by their proximity to the Portage Lakes State Park, and the needs to be good stewards are increased.

<u>*Priorities, Needs, Expectations*</u>

- Access to the water and the passages through the lakes.
- Property maintenance – wastewater disposal, homes, yards, docks, boats, lakewalls, and shore.
- Aquatic vegetation is often perceived as a detraction, nuisance, hindering boating, lowering property values, and creating a distasteful back (or front) yard environment.
- Good water quality – because of the proximity of houses to the water and the potential for water-based recreation from the "back yard" or neighborhood "street," water quality is an important consideration. Poor water quality, toxic chemicals, and harmful organisms (e.g.,

bacteria, Harmful Algal Blooms) place swimmers and boaters at risk, create unpleasant conditions, and harm property values. Note: Harmful Algal Blooms come from cyanobacteria and are different from aquatic vegetation, which is important for good water quality.

Impacts/Concerns

Because the residences are right at the edge of the lakes, occupied for much or all of the year, there is a high potential for impacts to the lakes with common activities.

- Maintenance activities that affect water quality have especially high impacts and risks right next to the water, e.g., lake-specific activities (boat maintenance) as well as typical residential property management (maintaining lawns, automobiles; wastewater treatment, yard waste).
- Any chemical applied off a dock enters the water, potentially affecting other properties, placing swimmers at risk, and harming the animals and habitat, off-property as well.
- Stormwater runoff may directly enter the lakes.
- Nuisance wastewater treatment systems could discharge bacteria and nutrients to lakes.
- Proximity to the water may limit options for household waste management due to small lot size, setback requirements, and limitations of soils and high water table.

- Visitors, renters, or new residents who do not understand how commonplace activities affect the lakes, the need or means to reduce their impacts on the lakes, their front yards. They may overload or inappropriately maintain septic systems, allow chemicals or pet waste to run off into the lakes, or put harmful chemicals in the water to remove aquatic plants.
- Sod is attractive to geese. Goose waste adds nutrients and bacteria to the water.

- Organic material, such as yard waste or animal waste increases nutrients and possibly harmful organisms in the water. Runoff from the property goes directly into the lake.

Responsibilities/Opportunities to Help Protect the Lakes

- Understanding and stewardship is especially important in the fragile lakeshore environment.
- Many lakeside yards are at the edge of or within the State Park. Modifying lakeside properties – e.g., docks and seawalls – requires permits and following ODNR standards.
- Chemical treatment of aquatic plants must be done by licensed professionals, who use permitted chemicals and industry-approved measures to protect water quality, habitat, and the health of people using the water.
- Certain lakescaping is more beneficial than others. Tall vegetation, with deep roots, improves water quality by absorbing excess rain water and nutrients. Homeowners can develop alternative landscaping that preserves views of the lakes, absorbs rain water, and reduces the likelihood of geese. Natural shorelines are better for the lakes than hardened lakewalls.
- Follow maintenance requirements for wastewater management systems.

Composting yard waste, instead of dumping it in the lakes, and planting tall (deep-rooted) native plants are good lake stewardship.

Businesses and Organizations

Water dependent and water-enhanced businesses benefit from location by the lakes and in the lakes community. Water-dependent businesses and organizations on the lakes include marinas, boat clubs (sailing, powerboat, rowing), boat rentals, bait shops, and the tour boat. The boat dealerships also benefit from being near the lakes.

Residents and visitors view the restaurants and bars as an important part of the lakes communities. Several restaurants offer courtesy docks, encouraging boaters to dine out during a day (or evening) on the lakes. Restaurants benefit from water views, as does the Turkeyfoot Lake Golf Links.

Priorities/Needs/Expectations

- Water views, access, passage, lack of nuisance plants.
- Good water quality.
- Adequate wastewater treatment.

Impacts/Concerns

- Chemicals used on lawns and at marinas can harm water quality if they are not controlled carefully.
- Maintenance activities – e.g., boats, property, and waste management can also affect water quality.
- Stormwater runoff enters lakes directly.
- Nuisance wastewater treatment systems can harm water quality with bacteria and nutrients.
- Visitors may be careless with trash and pet waste.
- Geese, attracted to sod, leave waste by the water.

Responsibilities. Opportunities to Help Protect the Lakes

- Certain activities such as docks and aquatic plant management require permits.
- Careful control of chemicals, runoff, and wastewater management systems.
- Businesses have an opportunity to educate residents and visitors about the lakes, water quality, stewardship.
- Lakescaping to reduce runoff and discourage geese. LEED design, Audubon ASCP for Golf, and Ohio Clean Marinas programs encourage landscape practices with benefits like reduced runoff.[17]

Camps

Craftsmen Park, run by the Masons of Summit County, is a campground on Rex Lake with cabins, RV and tent camping, and boat slips. The lake and lakeshore are important to the campground's appeal. Craftsmen Park also hosts the Portage Lakes Rowing Association and the Dragon Dream Team breast cancer survivors' dragon boat team.[18]

The Akron Rotary Camp for developmentally disabled children and young adult is also on Rex Lakes. It offers typical activities of summer camps, such as crafts, swimming, and canoeing.

Priorities/Needs/Expectations

- Good water quality for contact recreation
- Passage, access, area free of nuisance vegetation.
- Safe swimming areas.

Impacts

- Chemicals used in lawn maintenance or controlling aquatic plants could affect water quality.
- Stormwater runoff directly enters lakes
- The potential impacts are typical of areas where people gather.

Responsibilities/Opportunities to Help Protect the Lakes

- The organizations can promote good stewardship with information and activities.
- Docks, shoreline alteration, and use of chemicals for aquatic plant control require permits, specialized knowledge, to protect water quality, habitat, and public safety.
- Maintain wastewater management systems to minimize impacts to water quality.
- Use of stormwater management best management practices and tall native plants for lakescaping can reduce stormwater runoff and may discourage geese.

Special Events on the Lakes

Special events throughout the year around the lakes bring thousands of participants to the lakes and surrounding areas to enjoy the lakes, shared interests, and often to support special causes:

- Run to the Beach 5k race and egg hunt
- Polar Bear Leap
- Fourth of July Fireworks
- Pirate Day
- Dragon Boat Festival
- Boat Parade
- Antique Boat Show

These gatherings are part of the lakes community life and bring visitors and residents together. With so many people, it is important to minimize the impacts of each participant on the lake. These events provide good opportunities to educate residents and visitors about the lake.

Shared – And Conflicting – Priorities; the Dilemma of Aquatic Plant Management

The wide spectrum of participants in the Portage Lakes system has certain priorities in common:

- The community and users all rely on good water quality, "fishable-swimmable," and free from harmful organisms like bacteria and Harmful Algal Blooms (HABs), chemicals, odors.
- Homeowners, water-dependent businesses, and people using the lakes all need access from the water and the ability to travel through the lakes.
- Uses need to be kept safe from hazards, more intensive uses, harmful chemicals, e.g., through no-wake zones, protected swim areas, using only safe (permitted) chemicals near/in the water.
- Each of the hundreds of thousands of people using the lakes can affect them:
  –*Negative impacts* can include littering, spilling, leaving pet waste, or mis-using harmful chemicals, harming habitat or property, adding to runoff pollution.
  -*Positive impacts* – To protect the resource that everyone values and uses, everyone should also learn about the lakes, become aware of and minimize impacts, practice and promote good stewardship, and encourage others – lakers and managers – to take steps to protect the lakes.

Conflicting Priorities – Nuisance "Weeds," Habitat, Essential for Water Quality, or "All of The Above?"

The answer is "all of the above," depending on one's perspective. Managing aquatic plants is a challenge of balancing conflicting priorities: supporting use of the lakes and surrounding areas, while protecting water quality and habitat, which are so important to the lake users and communities. Sustaining the lakes may require to designating areas for conservation or management. The Portage Lakes offer a lot of space for both.

- ***The aquatic plants (not necessarily "weeds"), are essential for a healthy lake system***, (discussed in Chapters 4 and 5). Among other things, they protect water quality by taking up stores of nutrients in the lakes, thus limiting nutrients available to fuel eutrophication and HABs.
- While aquatic plants are crucial for water quality, they hinder property access and passage in the lakes, and cause nuisance growth near homes and businesses.
- ***Indiscriminate use of chemical controls can harm water quality and habitat, and pose risks to swimmers***.
- Many areas are free from aquatic plants. Even dense growth does not have to be controlled or removed everywhere. ***Where feasible, aquatic plant growth should be allowed to flourish*** to take up nutrients and provide habitat and other benefits for the lake ecosystem and community of lake users.

Achieving the balance is central to managing a multi-use resource. Areas may be designated for certain uses or protections. It will require concerted effort by those involved - State Park, Metro Park, Portage Lakes Advisory Council, communities, and other management agencies, residents, business owners, and visitors. Strategies and recommendations are discussed in Chapter 7.

Residents Express their Opinions about Aquatic Plants

The public focus group poll included questions about aquatic plants. The residents' answers are summarized below and shown in Appendix B. There were about 30-35 responses per question.

The focus group poll should not be regarded as a statistically valid sample, but it highlights certain views among the participants:

- Managing aquatic plants in passages and by docks is important.
- There is recognition that aquatic plants are important for the lakes.
- It is important to designated for protected areas for habitat.
- There is a need for education about aquatic plants, invasive species, and best management practices.
- People recognized the value of licensed aquatic plant management versus do-it-yourself approaches.

Summary of Focus Group Questions and Comments About Aquatic Plants

77 percent considered managing aquatic plants by docks or in passageways to be concerns or big concerns

When asked about how they considered aquatic plants,

- 20-25 percent said they were a nuisance, good for habitat, or affected by water quality
- 45-50 percent said they were important for water quality or "all of the above"

When asked what to do about the plants, the most popular responses (47-55 percent) were:

- Protect certain areas for management
- Increase education about plants and best management practices
- Increase awareness of invasive plants and clean-drain-dry practices
- Improve water quality

Between 25 and 40 percent of the responses were

- Harvest plants for access
- Conduct a detailed plant survey
- Learn to live with them
- Hire someone to keep the docks clear

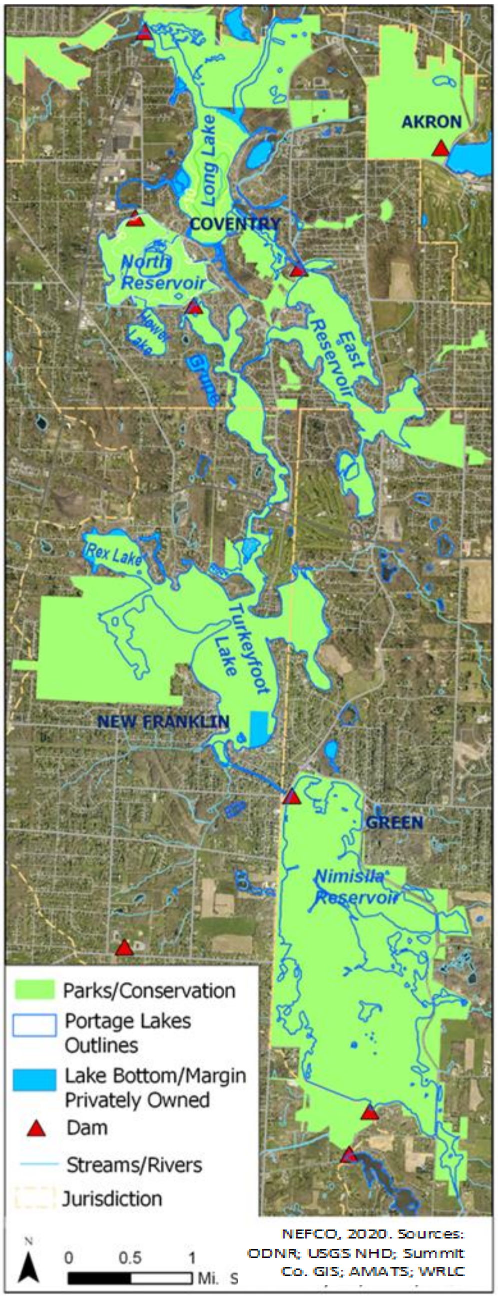
Nobody thought removing all the plants was a good idea, and only one person thought do-it-yourself treatments were a solution.

As discussed further in Chapter 5, the ideas that were expressed by the focus group are supportive of best management practices generally used for managing aquatic plants.

- ***A primary focus of this plan is how to manage aquatic plants to allow use, provide passage and access, reduce nuisance growth, while protecting water quality and habitat.***

- ***Managing the lakes will require land-based efforts on the shoreline and in the watershed, as well as water-based efforts to understand and manage the lake system.***

Map 3.12
Parks and Conservation Lands

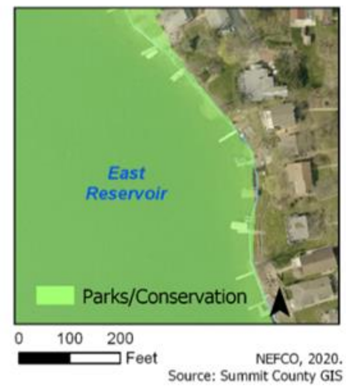


Caretakers of the Lakes

The ODNR and Portage Lakes Advisory Council are the primary contacts for overall coordination and management of the lakes. Many other agencies and organizations have important roles in managing the lakes and watershed, as highlighted below. The Information below summarizes numerous discussions with TAC members, other participants and interested parties, and organization websites.

Ohio Department of Natural Resources (ODNR)

Map 3.13
Public Land at the Shoreline



The Portage Lakes are waters of the state, owned by the State of Ohio. Most of the conservation (green) areas shown on Maps 3.12 and 3.13 are state-owned, including the bottoms of the lakes. (Summit Metro Parks manages two parks on state land, Confluence Metro Park and Nimisila Reservoir Metro Park.) The ODNR, State Parks and Watercraft, manages 500 acres of park land (State Park, Old State Park, and Knapp Park), canals, and 2,200 acres of lakes up to and including the shoreline, including buoys and docks.[19]

ODNR State Parks and Watercraft, O&E Canal Lands and Reservoirs, is responsible for controlling water levels and flow in the lakes and canals, for flood control and maintaining flow diversion to the Lake Erie basin. The staff currently consists of a manager and two other field staff. This small staff keeps canals and waterways clear of obstructions, maintains safe water levels to reduce flooding risk during storm events by monitoring and manually adjusting gates, and draws the lakes down every two years in the autumn. The staff has also been tasked with cutting aquatic vegetation in the Portage lakes and elsewhere for navigation.

ODNR Dam Safety inspects and maintains the dams used to store the lake water and provide flood control. As noted in Chapter 2, dam reconstruction has been under way since 2011.

ODNR Division of Wildlife staff maintain a visitor center on Meyers Island on North Reservoir, monitors fish populations and stocks fish in the lakes. During seasonal field work, the staff collects basic limnological data (temperature, depth, oxygen). The staff collects full chemistry profiles, during the summer, once every three years.

ODNR Parks and Watercraft, Wingfoot Lakes and Portage Lakes. The focus of this staff is to provide a positive experience for visitors, including maintenance of park facilities and water access and opportunities for visitors to increase their knowledge of the parks and park activities. A small staff manages facilities, maintenance, permitting, projects, and activities including: fishing access, beaches and swimming areas, boat ramps, navigation/cautionary buoys, buildings, grounds, restrooms, and hiking trails. The staff currently includes a parks manager, one full-time maintenance supervisor, two part-time maintenance staff, two seasonal maintenance staff, and a naturalist. The parks have benefited from interns in recent years, with the potential for three in 2021 to assist the naturalist, maintenance staff, and law enforcement. However, the staff is considerably reduced compared to 20 years ago.

- The park manager issues permits for residents to alter the shoreline or bottom of the lake, e.g., install docks or modify the lake shore/lake walls.
- The manager also coordinates and works on maintenance and improvement projects in the parks, such as improvements to fishing access and dredging.
- The Park naturalist conducts community outreach and activities in the parks to build engagement, such as hikes, fishing events, and Paddle-palooza, an introduction to kayaking. The naturalist also assists with efforts in other parks.
- The parks are also staffed by ODNR Law Enforcement officers, who inspect boats and monitor for compliance with state laws and park rules.
- ODNR staff coordinate with Portage Lakes Advisory Council to make sure there is two-way communication between the agency and the community, often collaborating on efforts.

Upcoming projects and opportunities in the Portage Lakes parks include:

- Adoption of a dock and shoreline management plan
- Funding for controlling aquatic vegetation
- Dredging - The dredging effort is expected to go for seven to ten years, to clear sediment from navigation channels and coves. The effort will begin in Turkeyfoot Lake, with disposal at the 20-acre dredge material facility on Latham Bay. In following years, locations will be established to receive and dewater dredged sediment.

Summit Metro Parks

Summit Metro Parks has two parks on the lakes, Confluence Park on Long Lake, and Nimisila Reservoir Park, state land managed by the Metro Park. Summit Metro Parks is actively engaged in protecting and restoring important natural resources. The parks contribute to the value of the recreation complex along the Portage Lakes. Summit Metro Parks maintains the park facilities, has planted native vegetation at Confluence Park, and is engaged with outreach and education throughout the county.

Portage Lakes Advisory Council

The Portage Lakes Advisory Council (PLAC) has a 12-member Board of Directors, with representatives from each of the three lakes communities. Members can be residents, lake users, representatives of organizations or local businesses.[20] The PLAC holds monthly meetings, among other things, to:

- Coordinate with ODNR staff and other organizations,
- Share news, information, updates, and events,
- Provide informational forums about topics of interest to lakers, and
- Organize activities and events.

The PLAC plays an important role as the primary contact for lakers and visitors to learn about topics related to living at or visiting the lakes and the surrounding area. Their mission is to be an informational and educational resource about the lakes, promote active and passive recreation and protection of the lakes habitats and watershed. The PLAC and PLAC members are involved in numerous efforts, large and small, to contribute to the community, improve the quality of the lakes experience, promote awareness about the lakes, involvement and stewardship. Some examples include:

- Litter Clean-up
- Polar Bear Leap fundraiser
- 5k Run to the Lakes
- Candidates Night
- Informational flyers
- PLAC recently established a scholarship for high school students with an interest in the lakes.

PLAC has partnered with the State Park on efforts including:

- Develop two playgrounds, most recently, an inclusive playground at the Old State Park
- Have speed zones designated on the lakes
- Have solar lighting installed on the Iron Channel
- Establish beach volleyball courts at the State Park beach

The PLAC Informational website, covers various lakes topics, including:

- Conservation,
- Aquatic plant control
- Dock permits,
- Safety,
- Dams, drawdowns, and dredging,
- Good stewardship practices for property owners, boaters, and other visitors
- Upcoming events

PLAC members volunteer with PLAC or on their own, in activities such as trash pick-up, water quality monitoring, and purple martin educational tours. Members have a wide range of expertise and great interest in working on behalf of the lakes and their community.

Other Caretakers

The ODNR, Metro Parks, and PLAC have the most immediate and pervasive contact with the lakes, but many other organizations play a significant role in protecting and managing the lakes and their watershed. They are highlighted in Table 3.3 and discussed further in Chapter 7. All lakers will be carrying out recommendations of the plan and should participate in developing a shared understanding of the lakes system and priorities for management.

Table 3.3 Other Organizations Taking Care of the Lakes

Organization	Topic	Role
Ohio EPA	Water Quality	• Monitors water quality attainment, determines standards, establishes priorities to restore waters (and watersheds) • Requires permits for discharges into waters of the state, including: - Wastewater and industrial discharges - Stormwater management - Use of chemicals in the water, e.g., herbicides - Wetland alteration • Spill response, clean-up • Responses to water quality complaints • Funding, research, technical assistance, outreach and grants/loans for stream/wetland restoration, wastewater management, research, environmental education • Responding agency to Harmful Algal Blooms, along with Ohio Department of Health and ODNR
Summit County Soil and Water Conservation District	Stormwater management, technical support, outreach	• Stormwater management/erosion control permits and inspections • Watershed management, watershed coordinator, erosion control technical assistance • Outreach about stormwater best management practices, erosion control, rain gardens, native plants • One of three agencies implementing stormwater permit for Municipal Separate Storm Sewer Systems, along with Summit Dept. of Public Health and Summit Co. Engineering
Summit County Public Health	Septic systems Beach monitoring Other	• Inspect and permit septic systems; • Document illicit discharges to stormwater systems • Test water supplies; regulate camps, motels, food service
Wastewater Management Agencies	Wastewater treatment	Summit Department of Sanitary Sewer Services and City of Akron provide wastewater treatment service in the lakes area. They work with local communities and the Health Dept. to identify areas that should be served by sanitary sewer based on need and feasibility.
Local Communities	Zoning Subdivisions Conservation/parks Stormwater	• Regulate land use, subdivision procedures • Obtain and manage parks and conservation lands • Identify and implement stormwater management measures, often including stream/wetland restoration
Volunteers and groups	Various	Through outreach, education, research increase awareness and stewardship of lakes; develop lakes amenities Coventry Middle School has a wetland observation station and a science teacher dedicated to the lakes
Businesses, visitors and residents	Stewardship	Increase awareness, reduce impacts, support management efforts

Key Considerations

The Portage Lakes system is a natural system within a state park and community that supports multiple uses by hundreds of thousands of residents and visitors. The lakes provide a home, natural refuge, recreational resource, community focus, and economic opportunities, that all depend on good water quality and a healthy lakes system. Each participant has priorities and expectations and can affect lakes' health. Protecting the lakes' health requires everyone's help in managing the different priorities, increasing understanding of the lake system, and minimizing impacts. These are highlighted below and discussed further in Chapter 7.

- The lakes provide an economic and recreational resource for the region.
- All the uses of the lakes require good water quality, free from harmful chemicals, bacteria or viruses, and HABs. Aquatic vegetation is essential for good water quality and habitat.
- The lakes are affected by the communities and land uses surrounding them, including older and on-going development, conservation and natural areas, and agriculture.
- All users can affect the lakes and reduce impacts by practicing and encouraging stewardship.
- Clear access to properties and destinations within the lakes is important for lake uses.
- Aquatic vegetation, in addition to its value for water quality, habitat, and lake uses, hinders travel and access in certain areas and may be unappealing for residents, businesses, and visitors.
- Aquatic plants can -and should be managed to allow access, passage, activities, but protect habitat and water quality, in ways that are safe for swimmers, property owners, and recreational uses. This may involve establishing maintenance procedures, zones of more intensive use and maintenance, and areas to leave undisturbed.
- It is important that management be implemented with professional expertise, rather than do-it-yourself approaches, to protect water quality for users and wildlife.
- Small staffs at ODNR Parks and Watercraft (O&E Canal Lands, Wingfoot and Portage Lakes) are responsible for managing the lakes, park facilities and experience, including:
    - Flood control,
    - Maintaining flow
    - Maintaining navigation channels
    - Maintaining facilities in the parks
    - Deploying buoys
    - Maintaining beaches, fishing accesses, and boat ramps
    - Coordinating and implementing maintenance or improvement projects in the water and on land
    - Providing naturalist services for hikes, nature education, fishing and paddling instruction
    - Assisting at other parks
- Initiatives planned for the Portage Lakes park include:
    - Dredging areas in the lakes
    - Managing aquatic plants
    - Completion of the docks and shoreline management plan for the lakes
- Summit Metro Parks manages parks on state land on Long Lake and Nimisila Reservoir.
- PLAC is the primary point of contact for residents interested in the lakes, representing the three communities surrounding the lakes and lake matters with residents and visitor, fielding

questions, coordinating with ODNR, promoting recreation, environmental protection, safety, and education.

- The level of resources available to ODNR and others (staff, funding, equipment, outreach technical support, materials), should be appropriate to an increased level of management of the lake resources.
- Many other organizations serve as caretakers of the lakes and surrounding lands. Other partner organizations can provide valuable roles within their mandates or mission. Lake management needs to be coordinated, build and include participation among lakers, have a decision-making authority, and have adequate staff, funding, technical support, and other resources to manage a complex ecological and multi-use system.
- Managing the lakes to sustain uses will require land-based and lake-based efforts, and making choices to maintain certain areas for use versus conservation.
- It is important for residents and visiting lakers, communities, and lake managers to build awareness of lake systems, participation, stewardship, and advocacy to encourage others – lakers, communities, agencies - to take steps to protect the lakes.
- The lakers will be carrying out the recommendations of the plan and should contribute to determining priorities.

Aquatic plants should be managed to provide access and passage, reduce nuisance growth, in a way that is safe for swimmers and recreational uses and protects water quality and habitat essential for healthy lakes and the community of people using them.

Managing the lakes will require raising awarness and participation among lakers, visitors, communities, and managers.

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[1] Map Sources: OGRIP, 2012; Portage Co. GIS; Summit Co. GIS, 2017; Stark Co. GIS, 2016; Wayne Co. GIS, 2016; USGS NHD, 2016; AMATS 2017 parks data shapefile; Western Reserve Land Conservancy 2015 parks data shapefile; Ohio Dept. of Development, 2019. 2018 Population Estimates by City, Village, and Township by County, May 2019; USDA https://development.ohio.gov/files/research/P5027.pdf; Base Map: ESRI, MAXAR, GeoEYE, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGrid, IGN, and the GIS User Community.

[2]Studies and data sources indicate the importance and popularity of outdoor recreation include:
Outdoor Recreation (general):

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Outdoor Foundation, 2020. Outdoor Participation Report 2019. Outdoor Foundation, Boulder, CO, pp. 1-10; https://outdoorindustry.org/resource/2019-outdoor-participation-report/ Retrieved April, 2020.

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Boat Registrations:

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[3] Ohio Dept. of Development, 2019. Op. cit.

[4] M. Studeny, 2020. ODNR Parks and Watercraft, Wingfoot and Portage Lakes Parks Manager. Suffield, OH. Pers. comm.

[5] Map sources, Maps 3.2-3.5: OGRIP, 2012. (aerial photos); ODNR GIS, 2017 (bathymetry, dams); ODNR fishing maps Portage Lakes.

[6] Map sources 3.6 and inset 3.7: Summit County GIS, 2020 (parcels); Summit County GIS 2017 (roads); NEFCO, 2021 (sewered areas); U.S. Census, 2020, Zip Code shape file.

[7] U.S. Census, 2017. Census of Businesses. https://www.census.gov/data/developers/data-sets/cbp-nonemp-zbp/zbp-api.2017.html Retrieved April, 2020.

[8] U.S. Census, 2020. American Community Survey. U.S. Census 2018. Housing Summary, filtered by Summit County, Green, New Franklin, and Coventry; Summit County GIS, 2020. Parcels.

[9] USCGboating.org, n.d., op. cit., p. 23

[10] Ibid, pp. 37, 42

[11] ODNR 2021. Ohio Boating Registrations. Op. cit.

[12] US Army Corps of Engineers 2008. Great Lakes regional boating In response to Public Law 106-53, Water Resources Development Act of 1999, Section 455(c), John Glenn Great Lakes Basin Program, Great Lakes Recreational Boating. Main Report - Final. Obtained Sept., 2017 from https://www.lre.usace.army.mil/portals/69/docs/pppm/planningandstudies/johnglenn/boating.pdf

[13] ODNR 2021. Ohio Boating Registrations, ibid. ODNR CSC 2021. Op. cit.

[14] ODNR, 2021. Historical Wildlife License Information. Searched by year. https://ohiodnr.gov/wps/portal/gov/odnr/business-and-industry/services-to-business-industry/data-records/historic-wildlife-licenses Retrieved Feb., 2021. In 2010, the five counties within 10 miles of the Portage Lakes (Medina, Portage, Stark, Summit, and Wayne) represented 9.6 percent of fishing license sales. However, as internet sales have increased, fewer license sales are tracked by county. If the percentage has remained the same, the five counties would represent 111,200 licenses.

[15] C. Aman, 2021. ODNR Div. of Wildlife, pers. commun.

[16] K. Cordell., 2012. Op. cit.; Outdoor Foundation, 2020. Op. cit; White, et al., 2016. Op. cit.

[17] US Green Building Council, This is LEED. http://leed.usgbc.org/leed.html; Audubon International ACSP for Golf. https://auduboninternational.org/acsp-for-golf/ ; Ohio Seagrant, Ohio Clean Program. https://ohioseagrant.osu.edu/clean

[18] Craftsman Park.com, 2016. https://craftsmenpark.com/ Accessed April, 2020.

[19] Information about ODNR involvement from a series of discussions with ODNR staff:

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Park management: M. Studeny, 2021, op cit.

Fish stocking and monitoring: C. Wagner, 2020. ODNR Division of Wildlife Div. 3, Akron, OH.

[20] Information about the Portage Lakes Advisory Council is from discussions with TAC participants and PLAC website: https://portagelakesadvisorycouncil.com/

Chapter 4 – Overview
Limnological Characteristics, Productivity and Eutrophication of Portage Lakes

Lakes are affected by – and affect - complex interactions of biological, chemical, and meteorological conditions, landscape, and physical lake characteristics, at scales ranging from microscopic to lake- and watershed-wide. This chapter presents background on lake processes and discusses the limnological characteristics of the Portage Lakes.

The Portage Lakes are predominantly in the shallow littoral zone, where rooted plants grow, an ecologically important area, where people interact with the lakes. The lakes are eutrophic: Excessive phosphorus drives dense plant growth and could fuel Harmful Algal Blooms. Reducing the phosphorus loading from the watershed and within the lakes is crucial to protecting the health of the lakes. Plant management is key to reducing internal phosphorus loading.

Chapter Organization

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4. Limnological Characteristics, Productivity and Eutrophication of Portage Lakes

Limnology is the study of inland freshwater ecosystems:

- Physical, chemical, biological, geological, meteorological factors affecting the ecosystems
- Dynamics and interaction between them
- Productivity, the amount of plant or animal material (biomass) a lake can support

The volume and location of plants is what lake residents and visitors experience from homes, boats, beaches, fishing access points, and businesses. The abundance of aquatic plants in the Portage Lakes is a measure of their productivity. The productivity of the lakes is *affected by* lake characteristics, and in turn, *affects* certain aspects of the lakes.

- Plants and algae are at the base of the food web of the lakes, producing oxygen and providing food and habitat for fish and other animals.
- Productivity ⟸ *reflects* lake environments, inputs, conditions, health, and disturbances.
- Productivity *affects* ⟹ lake conditions - water clarity, oxygen, nutrients, water quality.

The uses and value of the lakes depend on good lake health and water quality, which depend in large part on the lake ecosystem and productivity. This chapter looks at some of the components of the lakes ecology. Chapter 5 focuses on aquatic plants.

Life in Lake Systems – Producers, Consumers, Decomposers, and Building Blocks[1]

In order to address Portage Lakes aquatic plants and productivity, it is necessary to understand the factors affecting how the lakes work and the plants and animals living there. Lakes are complex systems, affected by combinations of many characteristics - physical, geological, biological, and chemical - operating at vastly different scales. Examples include:

- Factors operating at a lake or watershed-wide scale include wind, sunlight, basin shape and depth, lakewide nutrient availability, and watershed inputs.
- Factors operating at a minute scale include invertebrates foraging and burrowing among aquatic plants, algae generating oxygen, or nutrients being released from pore water in the sediment.

The Portage Lakes – and their health - are the result of interactions of these systems.

Photosynthesizers (Primary Producers), Consumers, Decomposers

Plants, algae, diatoms, and cyanobacteria are *primary producers*. They can be rooted or floating, microscopic (phytoplankton) or macroscopic (macrophytes). Photosynthesizers convert light energy and chemicals- nutrients- into organic material – fats, starches, sugars, proteins - which is the base of the food web and makes up living things. At excessive levels of nutrients, plant, algae, or cyanobacteria ("blue-green algae") growth can become a nuisance.

Consumers are those that feed on the primary producers or animals higher up the food web. *Decomposers* feed on decaying organic material, breaking it down again into available nutrients.

Building Blocks of Life – Energy and Chemicals

Light and temperature (heat)– Plants and algae need light for photosynthesis. The depth that light penetrates determines how deep photosynthesizers can grow (down to one percent of light at the surface) and also affects water temperature. Cloudy (turbid) water reduces light penetration but increases the temperature in the surface, as the particles absorb and release heat. Water temperature affects density and stratification, dissolved oxygen, and animal metabolism.

Tall plants can live in deeper water, as they can reach up toward the light. Light penetrates deeper in clear water, so plants can grow deeper. Left, short lily pads; center, tall Eurasian watermilfoil; right, eel grass. Portage Lakes examples.

Nutrients (*phosphorus*)- The primary nutrients that plants need are carbon, nitrogen, and phosphorus.

- In freshwater systems, carbon and nitrogen are plentiful.
- Phosphorus is the *limiting nutrient* – adding phosphorus increases plant and algae growth. Algae blooms occur after an input of dissolved phosphorus, from bottom waters or stormwater runoff.
- Most phosphorus comes from decomposed organic matter –animal waste or dead plants, algae, animals (or pieces cast off from them)- and added chemicals. Some comes from soil or rock.
- Phosphorus enters the lakes *externally*, through streams, discharge, or runoff, or is released *internally*, within the lakes, during decomposition of organic material or from phosphorus stored in sediment. Particulate phosphorus is not readily available for growth, but in low oxygen (anoxic) conditions, it is released as dissolved phosphorus, which photosynthesizers can use.
- Phosphorus is recycled many times and builds up in the sediment over time. One pound of phosphorus input can yield hundreds of pounds of biomass.
- Phosphorus is recycled from sediment in deep oxygen-poor water or by disturbance, zebra mussels, and plant growth in shallow water.

Note: recent research shows that nitrogen availability affects growth and toxicity of Harmful Algal Blooms.[2] This will be further studied in later lakes work.

Photosynthesis at work – oxygen bubbles under mats of filamentous green algae.

Oxygen –is essential for living things, which take in oxygen and give off carbon dioxide when they respire. Certain bacteria live in anoxic conditions.

- Plants generate oxygen during photosynthesis (daylight) but use oxygen in respiration all the time.
- Decay of organic material, a biological process, uses oxygen.
- Concentrations of dissolved oxygen (DO) in water are very low compared to air. Well-saturated water has 10 parts per *million* (ppm or milligrams per liter, mg/l). Air has 21 percent (parts per *hundred*) of oxygen.
- Cold water holds more dissolved oxygen than warm water.
- Coldwater species of fish, salmonids, require the highest amounts of dissolved oxygen to survive and are very sensitive to changes in temperature or dissolved oxygen levels.
- Most game fish need from 5 to 8 ppm of oxygen. Few fish can survive less than that, and when the levels reach 1 or 2 ppm, no fish can survive.

Physical Setting: Lake Morphometry (Study of Form), Depth, Location, Watershed

Morphometry is the measurement of lakes' external form. The size, shape, watershed, and connection to other water bodies affects what inputs – characteristics and amount of water, energy, and materials - that enter and move through the lakes.

Lake size and depth affect:

- The amount of water and substrate with enough light to support plant and algae growth
- Temperature differences throughout the water column, which influences water mixing, availability of oxygen and nutrients, plant and algae growth and the biological communities.

The shape of the lakes and location in the watershed also affect how lakes work:

- The shape affects how much of the lakes is margin, the productive area where shallow plant communities can live, and the area most susceptible to influence from the landscape.
- Kettle lakes are isolated and often small, and lakes in the headwaters have small watersheds. There is little input from the surrounding landscape, greater influence by groundwater, and little opportunity to flush the system. They are very susceptible to changes in the landscape.
- Reservoirs and lakes along rivers are affected by the flow of water and materials from a larger watershed. The inputs are greater, but with small lakes like the Portage Lakes, there is more opportunity for flushing. There may be more shallow areas than kettle lakes. The water levels may fluctuate greatly during flood season, which affects plant growth and nearshore habitats.
- Lakes with complex shapes and longer shorelines are more affected by influences from the land.
- How much of the shoreline or watershed are natural or altered affects inputs to the lakes and shoreline habitat. (Chapter 5 - shoreline habitat; Chapter 6 - watershed characteristics.)

Depth, Light, and Substrate - Zones of Lakes

Lake zones influence the kind of communities supported in each area, depending on available light and substrate. The numbers refer to Figure 4.1.

1 - Littoral Zone, the nearshore, is the where rooted plants live. In this productive area of the lake, rooted plants provide habitat, substrate, food, shelter, spawning area, flowers that attract insects. It is also where people's activities directly contact a fragile, important lake habitat.

2 - Limnetic Zone– open water - light does not reach the bottom of the lake.

3 - Euphotic/photic zone, penetrating light supports photosynthesis –both littoral and limnetic zones. Primary producers in the open-water photic zone are phytoplankton (microscopic floating photosynthesizers).

4 – Aphotic/profundal zone, the deepest areas where not enough light penetrates for photosynthesis. Some fish here have barbels to feel for food.

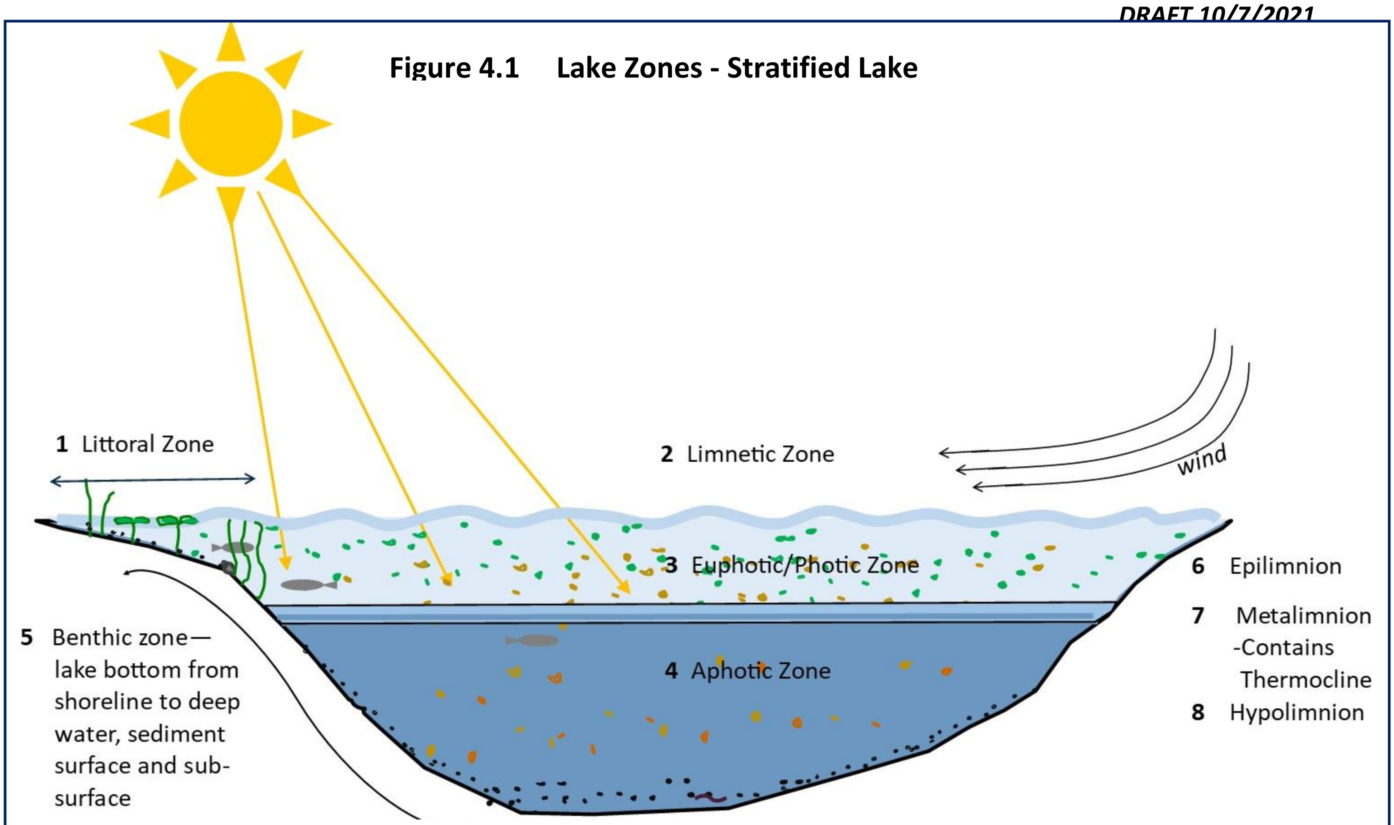
5 - Benthic Zone – the bottom of the lake and substrate, from shoreline to the deepest water. In the shallow water, the benthic zone provides habitat for many species of benthos (bottom-dwellers), spawning ground, and, because of the plants, a complex substrate supporting various invertebrates. In the deep waters, the benthos are mostly burrowers, feeding on material falling from the euphotic zone. The benthic zone is where decomposers consume dead organisms, releasing nutrients to be re-used.

Top- Littoral zone with floating-leaved and submerged plants. Middle - Limnetic, photic zone (photosynthesis by algae here). Bottom, shallow, sandy benthic. habitat. Many benthic areas are covered with decaying plants. Examples from Portage Lakes

Vertical Zones - Stratification and Turnover– Interaction of Depth, Light, Temperature, Density

Lake stratification is the layering of the lake by density. It affects what nutrients are available. The density of water changes with temperature. Water of less density floats on top of water of higher density, and there is little mixing between the layers. The density of lake water is affected by sunlight, air temperature, and mixing by wind and waves. Figure 4.1 shows layers in a stratified lake.

Figure 4.1 Lake Zones - Stratified Lake



6. - Epilimnion - During the summer, the upper layers of the lake, are warmed by the sun and mixed by wind and waves and may be around 75 degrees F or more. As the sun warms the layer, it becomes less dense. This layer often coincides with the depth that enough light penetrates to support plants. Rooted plants grow in the littoral zone, but floating algae lives in the epilimnion throughout the lake.

7. - Metalimnion - In between the upper and lower waters is a zone of temperature change. It contains the thermocline, the zone of greatest temperature change. Many swimmers have experienced the thermocline, the sudden coldness at depth.

8. - Hypolimnion - The lowest, coldest water, perhaps around 45 degrees F, is densest. Decomposition of dead organisms in the hypolimnion releases nutrients that remain there until conditions change.

During the summer, the temperature and density differences between the upper and lower layers become so great that there is almost no mixing through the thermocline.

Low Oxygen and Phosphorus Release

Decomposition of dead organisms at the bottom uses oxygen and releases phosphorus. Dissolved phosphorus released to the water is immediately available for use. Particulate phosphorus is stored in the sediment, but in anoxic conditions, particulate phosphorus is dissolved and can fuel growth.

- Stratified lakes may develop an anoxic hypolimnion, because oxygen-rich surface waters do not mix with the deeper water where decomposition uses oxygen. In these anoxic zones, the particulate phosphorus is dissolved and enters the water, reaching the surface waters if mixed. .
- Water between sediment particles (pore water) is also often anoxic, even in shallow lakes. Sediment disturbance and mixing often brings dissolved phosphorus from the sediment into the water column, where it can fuel growth. Weakly stratified lakes are more likely to mix.

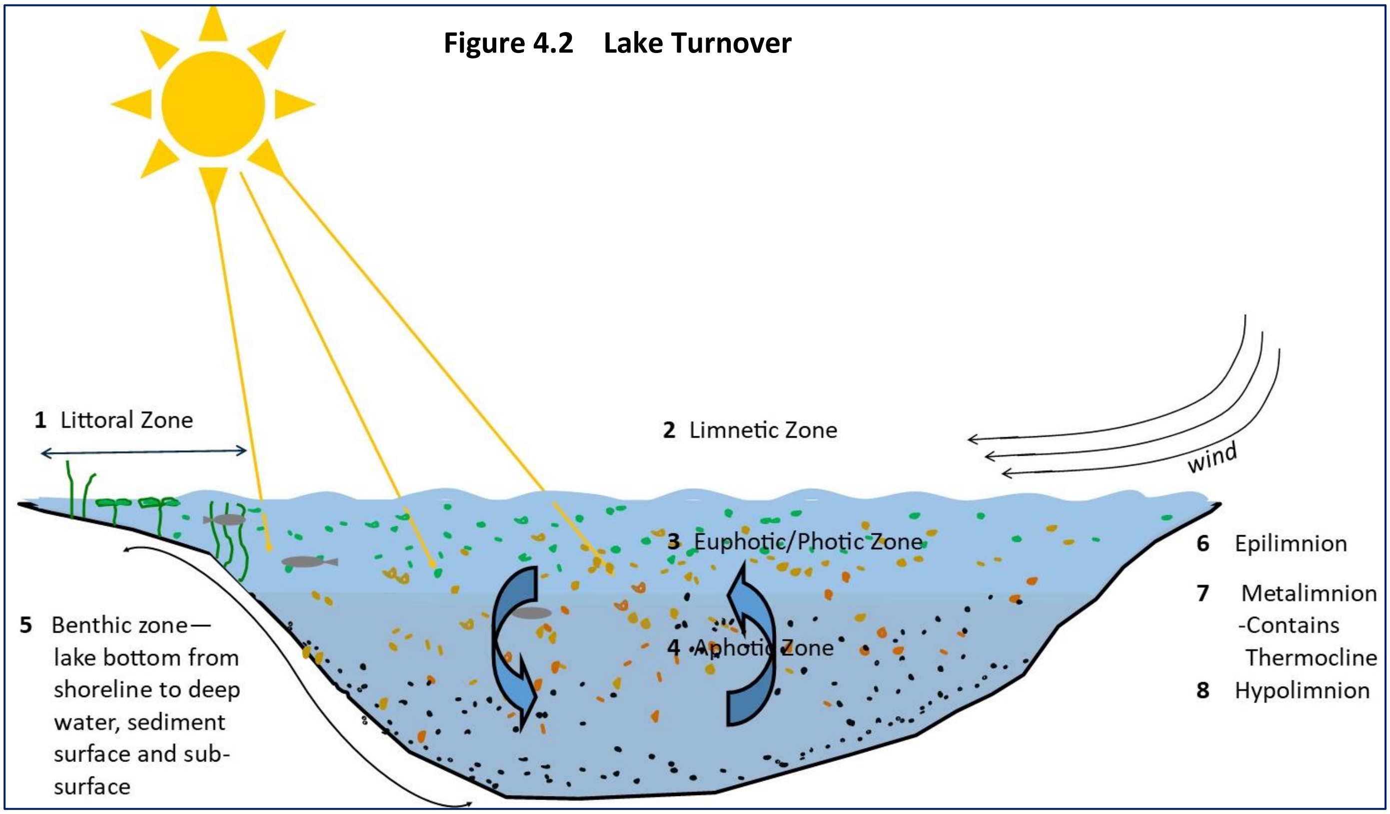
Anoxic zones are typical of deep basins in many lakes. Fish that tolerate warmer surface waters migrate to where the oxygen is. However, if the surface is too warm, or too much of the lake volume becomes anoxic, fisheries may be affected, as in the "Dead Zones" of Lake Erie or the Gulf of Mexico.

Other Seasons and Turnover

During the winter, the lake is essentially stratified if it is covered with ice. Water is densest at 39° F (4°C); water at or near the freezing point floats. The dense water near the bottom is close to 40 degrees Fahrenheit, and the less dense ice and melt water is at the surface.

In spring and fall, changes in the air temperature and amount of sunlight warm or cool the water from the surface down. With less difference in temperature and density between the surface and bottom waters, the wind, waves, and changing density gradually mix the water deeper. (Figure 4.2) This mixing allows the nutrient-rich bottom waters to rise to the surface, and the oxygen-rich upper water to be mixed in at depth, known as turnover. The influx of nutrients supports new growth of plants and algae.

Figure 4.2 Lake Turnover

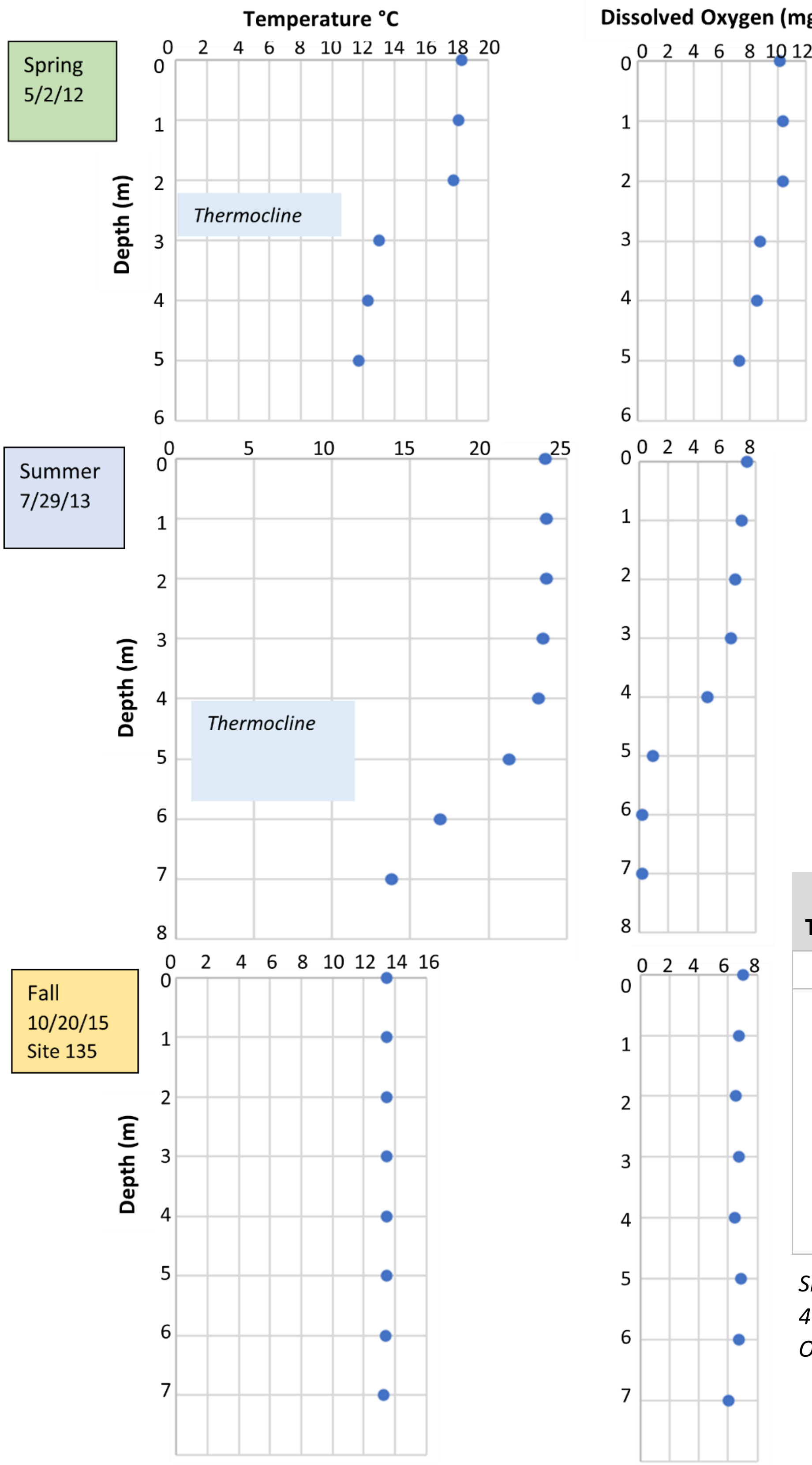


Limnological Profiles – Measuring and Depicting Conditions through the Lake Depths

Lake stratification, turnover, and oxygen levels are determined by measuring lake characteristics by depth during different seasons. The example limnological profiles in Figure 4.3, from locations in Turkeyfoot Lake, show typical seasonal conditions of temperature, oxygen, and thermocline:[3]

- Spring – Warming water, thermocline developing, oxygen decreases at depth but still high
- Summer – Surface much warmer than bottom, oxygen depletion below thermocline
- Fall – Thoroughly mixed

Figure 4.3 Example Limnological Profiles Showing Stratification and Mixing, Turkeyfoot Lake



Conversions			
Temperature		**Length**	
°C	**°F**	**m**	**ft**
0	32	1	3.3
5	41	2	6.6
10	50	3	9.8.
15	59	4	13.1
20	68	5	16.4
25	77	6	19.7
30	86	7	23.0

Site numbers refer to Map 4.3. Data source: C. Wagner, ODNR Div. of Wildlife, 2020

Portage Lakes Morphometry (Form) Related to Depth, Lake Zones, and Watershed

This section discusses the morphometry of the Portage Lakes and how it relates to various aspects of the lakes. Table 4.1 and Map 4.1 present the characteristics for each lake.[4] Figures 4.4 and 4.5 summarize the characteristics of the Portage Lakes system.

Depth

Depth influences littoral and photic zones, stratification, and influence by waves.

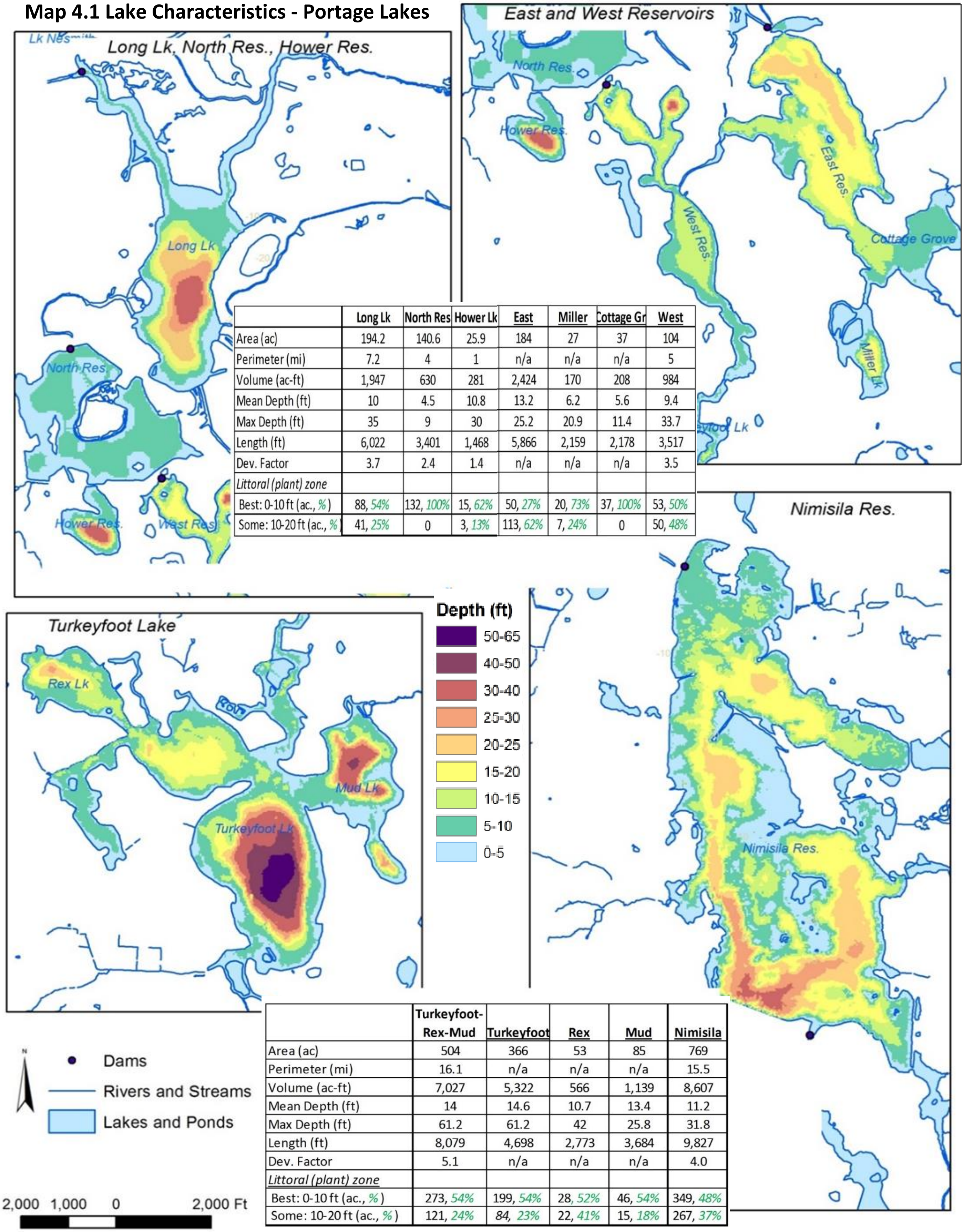
- The Portage Lakes are relatively shallow, with an overall mean depth of 11.2 feet, and mean depths ranging from 4.5 feet in North Reservoir, to 14.6 feet in Turkeyfoot Lake.
- From 70 to 100 percent of each lake is in the shallow littoral zone, where aquatic plants grow.
- Several lakes have extensive shallow areas that will be more affected by waves and mixing.
- The deepest areas are in Turkeyfoot, Long, Hower, and Mud Lakes, and West Reservoir. In these basins, water at depth may not circulate and mix with water from other areas in the lakes. They may become anoxic at depth: The large epilimnion generates a great deal of algae, which uses up oxygen at depth during decomposition, and the small basins have limited oxygen stored.

Table 4.1 Lake Morphology Characteristics

	Long Lk	North Res	Hower Lk	East	Miller	Cottage Gr.	West
Area (ac)	194.2	140.6	25.9	184	27	37	104
Perimeter (mi)	7.2	4	1	n/a	n/a	n/a	5
Volume (ac-ft)	1,947	630	281	2,424	170	208	984
Mean Depth (ft)	10	4.5	10.8	13.2	6.2	5.6	9.4
Max Depth (ft)	35	9	30	25.2	20.9	11.4	33.7
Length (ft)	6,022	3,401	1,468	5,866	2,159	2,178	3,517
Dev. Factor	3.7	2.4	1.4	n/a	n/a	n/a	3.5
Littoral (plant) zone							
Best: 0-10 ft (ac., *%*)	88, *54%*	132, *100%*	15, *62%*	50, *27%*	20, *73%*	37, *100%*	53, *50%*
Some: 10-20 ft (ac., *%*)	41, *25%*	0	3, *13%*	113, *62%*	7, *24%*	0	50, *48%*

	Turkeyfoot-Rex-Mud	Turkeyfoot	Rex	Mud	Nimisila
Area (ac)	504	366	53	85	769
Perimeter (mi)	16.1	n/a	n/a	n/a	15.5
Volume (ac-ft)	7,027	5,322	566	1,139	8,607
Mean Depth (ft)	14	14.6	10.7	13.4	11.2
Max Depth (ft)	61.2	61.2	42	25.8	31.8
Length (ft)	8,079	4,698	2,773	3,684	9,827
Dev. Factor	5.1	n/a	n/a	n/a	4.0
Littoral (plant) zone					
Best: 0-10 ft (ac., *%*)	273, *54%*	199, *54%*	28, *52%*	46, *54%*	349, *48%*
Some: 10-20 ft (ac., *%*)	121, *24%*	*84, 23%*	22, *41%*	15, *18%*	267, *37%*

Map 4.1 Lake Characteristics - Portage Lakes



	Long Lk	North Res	Hower Lk	East	Miller	Cottage Gr	West
Area (ac)	194.2	140.6	25.9	184	27	37	104
Perimeter (mi)	7.2	4	1	n/a	n/a	n/a	5
Volume (ac-ft)	1,947	630	281	2,424	170	208	984
Mean Depth (ft)	10	4.5	10.8	13.2	6.2	5.6	9.4
Max Depth (ft)	35	9	30	25.2	20.9	11.4	33.7
Length (ft)	6,022	3,401	1,468	5,866	2,159	2,178	3,517
Dev. Factor	3.7	2.4	1.4	n/a	n/a	n/a	3.5
Littoral (plant) zone							
Best: 0-10 ft (ac., %)	88, 54%	132, 100%	15, 62%	50, 27%	20, 73%	37, 100%	53, 50%
Some: 10-20 ft (ac., %)	41, 25%	0	3, 13%	113, 62%	7, 24%	0	50, 48%

	Turkeyfoot-Rex-Mud	Turkeyfoot	Rex	Mud	Nimisila
Area (ac)	504	366	53	85	769
Perimeter (mi)	16.1	n/a	n/a	n/a	15.5
Volume (ac-ft)	7,027	5,322	566	1,139	8,607
Mean Depth (ft)	14	14.6	10.7	13.4	11.2
Max Depth (ft)	61.2	61.2	42	25.8	31.8
Length (ft)	8,079	4,698	2,773	3,684	9,827
Dev. Factor	5.1	n/a	n/a	n/a	4.0
Littoral (plant) zone					
Best: 0-10 ft (ac., %)	273, 54%	199, 54%	28, 52%	46, 54%	349, 48%
Some: 10-20 ft (ac., %)	121, 24%	84, 23%	22, 41%	15, 18%	267, 37%

Comparing Figure 4.4 with Map 4.1 shows:

- Extensive shallows in Nimisila Reservoir, Turkeyfoot Lake, and West Reservoir
- North Reservoir is entirely less than 10 feet
- The shallows in Long Lake and East Reservoir are concentrated at one end of each lake.
- The deeper areas in Long Lake, Nimisila Reservoir, West Reservoir, and Turkeyfoot Lake are visible on the graph.

Figure 4.4 Area by Depth Portage Lakes

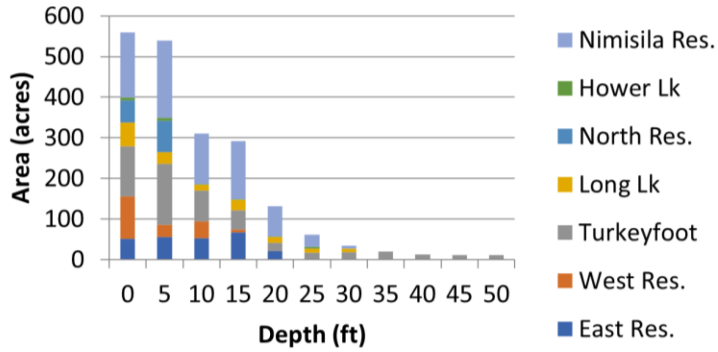
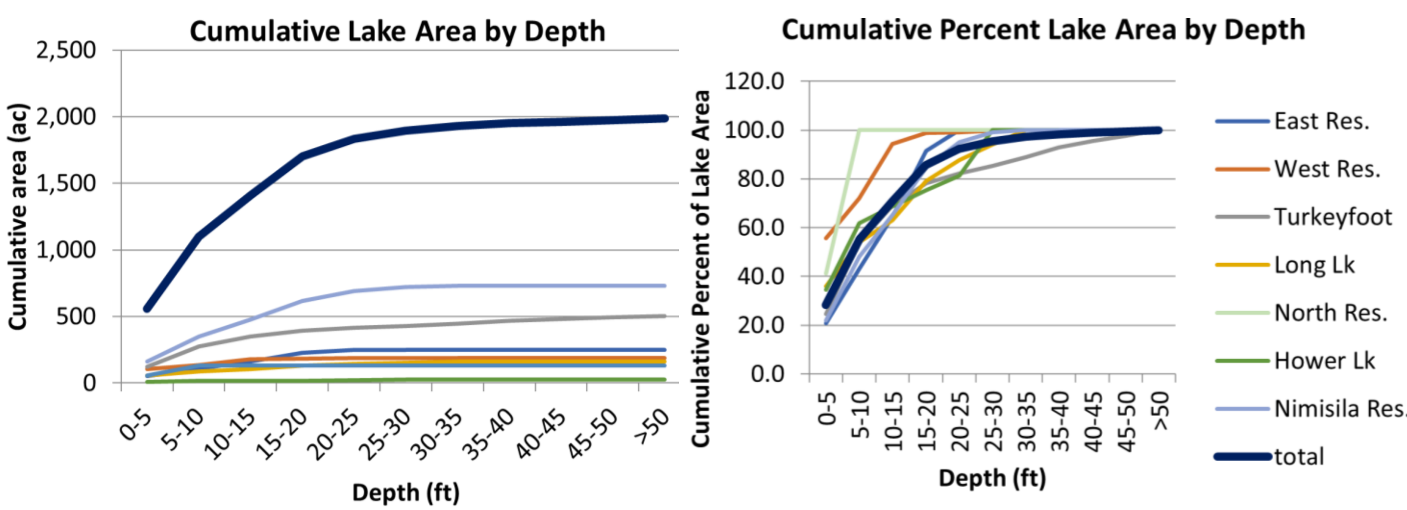


Figure 4.5 shows that 1,700 acres, 86 percent of the lakes area, is in the littoral zone. This shallow nearshore area is where the aquatic plants grow, where most people live, swim, boat, and interact with the lakes, affecting the lakes and encountering aquatic plants. Because it is at the edge of the lake, it is affected by and affects human activity – and expectations - to the greatest degree. (See Figure 4.6)

Figure 4.5 Cumulative Lake Area and Percent by Depth



Residence Time

The residence (or replenishment) time is how long water that come stays in a water body. Residence time can vary from days for a very small pond or lake to hundreds of years (e.g., Great Lakes). Residence time also represents how long nutrients entering the lakes may remain available if not used.

Residence time for the lakes was estimated by dividing lake volume in acre-feet (one acre area, one foot deep) by flow in or out (acre-feet per year), estimated with StreamStats.[5] This does not include flow management. Table 4.2 shows the residence time for the Main Chain and North Reservoir/Hower Lake is close to a year much less for Long Lake, which receives water from the other lakes and the Tuscarawas River. Additional input from Nimisila Reservoir during 18 inches of drawdown in the Main Chain affects residence time by a couple of days.

Table 4.2 Estimated Residence Time

Lake(s)	Volume (ac-feet)	Flow In/Out (ac-feet/yr)	Residence Time (yr)
Main Chain	10,227	11,730	.96
North/Hower	910	1,014	.87
Long Lake	1,947	48,255	0.04

Figure 4.6 Life at the Edge: Portage Lakes Littoral Zone

The littoral zone is:

- Where the rooted plants grow – converting nutrients, gases, and light, into oxygen and organic material (biomass); providing habitat, food, spawning areas, hunting areas for various creatures.
- The zone closest to the shoreline, where houses, roads, runoff, septic systems, land animals, boat activity, and chemical applications (or spills) affect the water.
- Where people just want to enjoy the water, where most use the water, and where they encounter the aquatic plants.
- Where nutrients enter from land by numerous pathways, adding what is already in the lakes.
- Where the natural lake environment is altered or preserved.
- Shallow, thus easily disturbed by waves, motors, and activity.





Lake Length and Wave Base

Wave base is how deep wave-generated turbulence extends, often much deeper than the wave height. It affects depth of mixing the depth that turbulence may re-suspend sediment.

Wave base is half the wave length (trough to crest), and it is a factor of wind speed and fetch (distance the wind blows across open water). Table 4.3 shows wave base depth estimated for fetch distances similar to the longest dimensions of the Portage Lakes.[6] The wind velocities typify an average summer breeze, a windy day in fall or spring, and a storm.[7]

Table 4.3 Estimated Wave Base Depth (ft) by Wind Velocity, Fetch

	Wind Velocity (mph)		
Fetch (ft)	6	14	24
2,000	1.7	4.2	7.3
4,000	2.3	5.7	10.1
6,000	2.7	6.9	12.2
8,000	3.0	7.9	14.0
10,000	3.3	8.7	15.5

Modified from: Florida Lakewatch, 2001.

These estimates convey a *general* idea how turbulence may affect the lakes, but do not account for:

- Direction of prevailing wind, which is southwest for much of the year; or
- Aquatic plants, or other obstructions, which dampen wave energy and stabilize sediments.

During a gentle summer breeze, turbulence may only extend a few inches to a couple of feet down, affecting only the margins of the lakes. During breezy days of autumn or spring, approximately half of the lakes area may be affected, depending on the fetch of each lake. During stormy weather, approximately two-thirds of the lakes area would be affected.

In the hundreds of pictures taken and reviewed for this study, at different dates, seasons, and locations, the surface of the water typically appears mirror-smooth or ruffled by small waves.

One of the reasons that the Portage Lakes are such a good location for boating is their relatively small size, many protected coves, and limited fetch. Being inland, they do not experience the stronger winds of Lake Erie.

The average wind speed for summer 2020 was 7 miles per hour. (Weather Underground, 2020)

Waves at the State Park beach after with 5-8 mph northeast wind blowing directly on-shore. Fetch - 2,000 feet; wave height - approximately 3 to 4 inches; wavelength, measured crest to crest – approximately 1 to 2 feet; wave base, one-half of wavelength - approximately 6 inches to 1 foot.

Portage Lakes Wave Base and Sediment Disturbance

In a Masters degree study of the Portage Lakes, Mitchell (2015) estimated the wave base of Rex, Mud, and Turkeyfoot Lakes as 2 m (~ 6 feet). Sediment samples from the lake bottom reflect the disturbed shallow lake bottom versus the accumulating, quiet, deep bottom below the wave base Figure 4.7 graphs the sediment characteristics by depth and the calculated wave base:[8]

- Shallow-water sediment dominated by sand and gravel with low organics, high density
- Deep-water sediment was dominated by mud and organic material, lower density
- Sediment samples were not collected in shallow water with plants.

Figure 4.7 Wave Base and Sediment in Rex, Mud, and Turkeyfoot Lakes

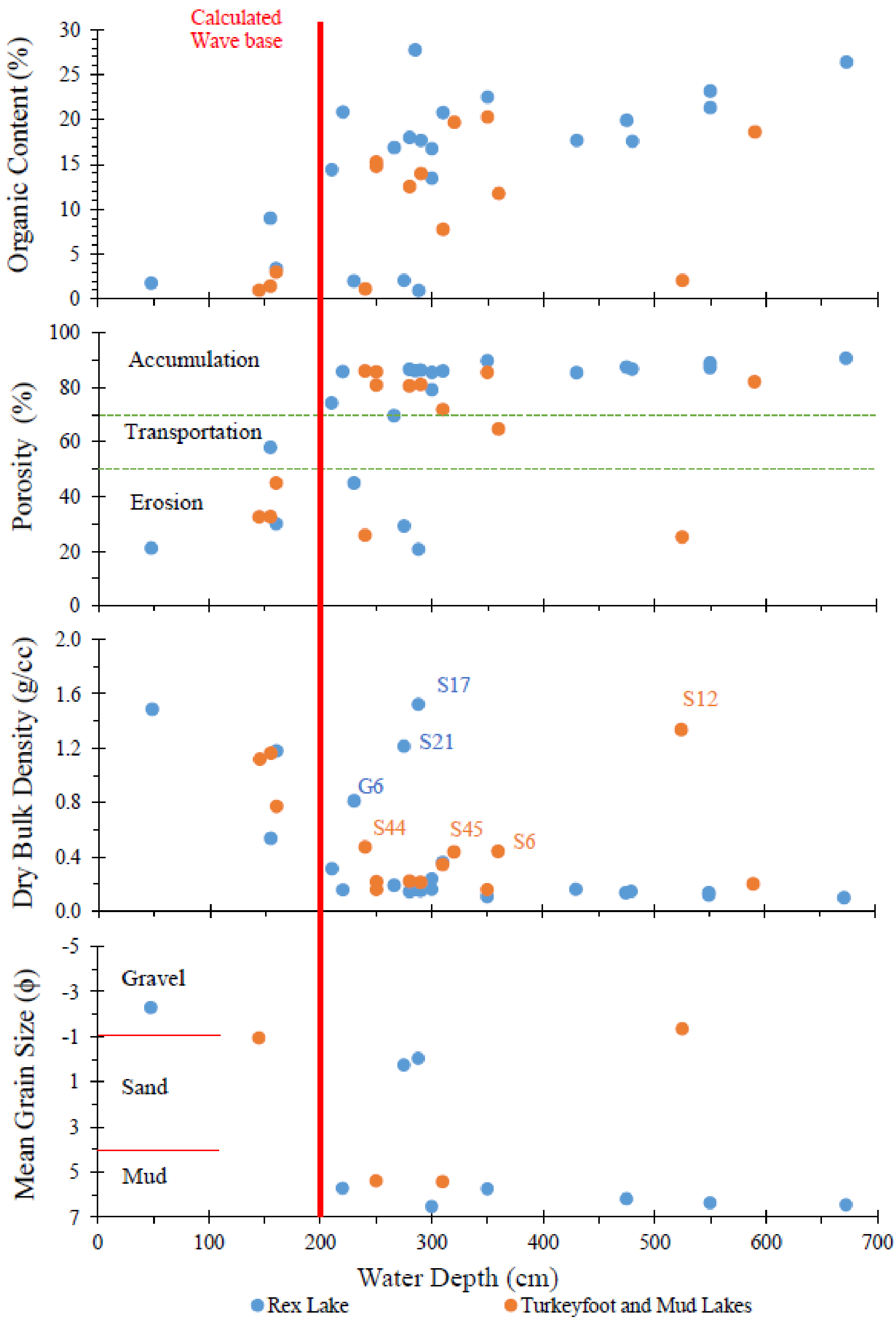


Figure 60. Surface sediment property variation versus water depth. The fields of erosion, transportation, and accumulation are inferred from sediment porosity values after Hakanson (1982). The red vertical line marks the calculated wave base, see text for explanation. *(Source: S. Mitchell, 2015.)*

Shoreline Development Factor

The shoreline development factor reflects how much the shoreline influences the lake. It compares the lake area to a perfect circle (development factor of 1). Higher numbers indicate more complex shapes, greater perimeter, and more shoreline influence. Hower Lake is closest to a circle, and Turkeyfoot Lake and East Reservoir have more complex shapes and are more susceptible to shoreline influence.

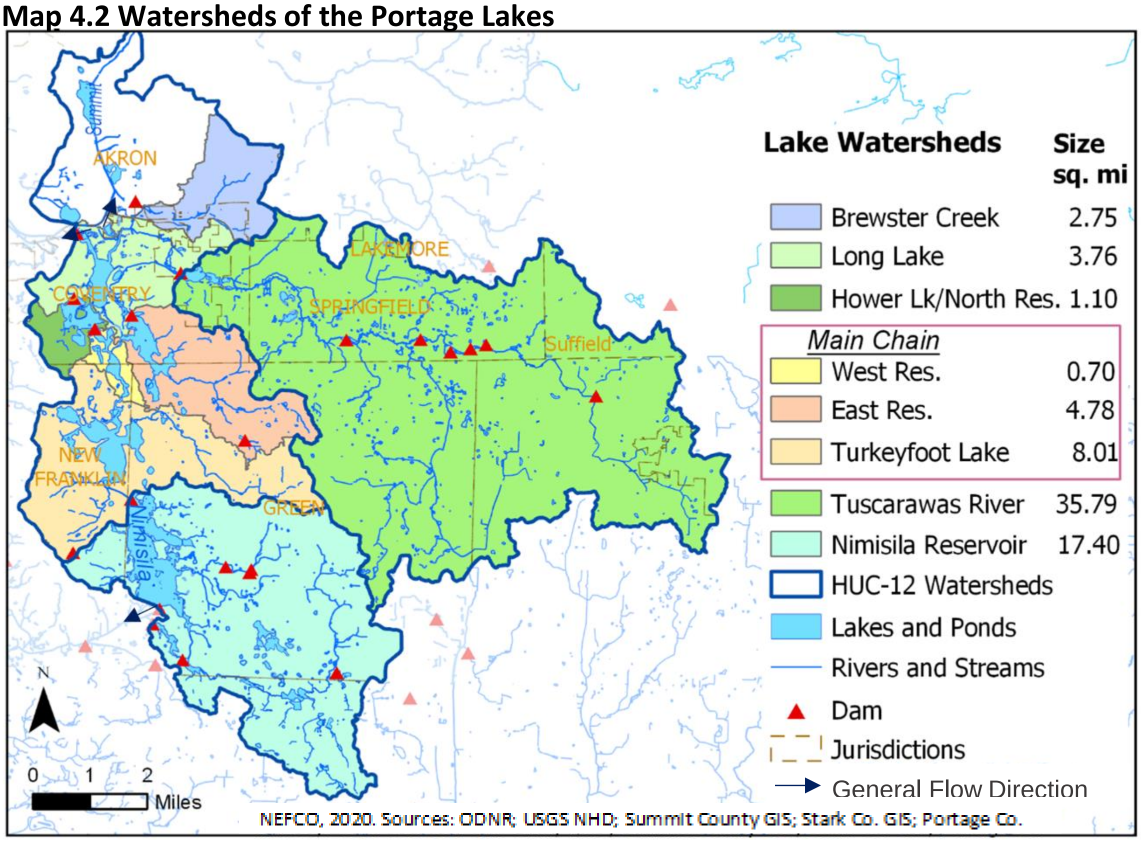
Individual Lake Watersheds

Watershed size reflects the influence on the watershed on lakes. The watersheds feeding each area of the Portage Lakes are shown in Map 4.2.[9] The Nimisila Reservoir drains south to the Tuscarawas River; the other Portage Lakes drain north to the canal or Tuscarawas River. Subwatersheds feeding each of the lakes in the Portage Lakes HUC 12 watershed were modeled using elevation data in ArcGIS Map.

- The three interconnected Main Chain lakes have a combined watershed of 13.5 square miles, and Turkeyfoot Lake, the most upstream lake, has a watershed of 8 square miles.
- Hower Lake and North Reservoir have very small watersheds. Hower Lake is likely an original kettle lake, small, deep isolated, with a small watershed, and is likely fed by groundwater. These two lakes are interconnected and receive some water from the upstream Main Chain.
- As noted previously, Long Lake receives water from the upstream lakes as well as the Tuscarawas River and Brewster Creek, totaling 42.3 square miles.
- Nimisila Reservoir, with a 17.4-mile watershed, is occasionally used to refill the other lakes.

Most of the lakes are interconnected and are influenced by watersheds upstream. If water quality concerns are identified, assessing watershed characteristics may help identify contributing factors.

Map 4.2 Watersheds of the Portage Lakes



Portage Lakes Limnological Data – Temperature, Oxygen, and Depth

ODNR Division of Wildlife periodically samples fish populations in the Portage Lakes and collects limnological data at the same time. Table 4.4 shows temperature and dissolved oxygen for example sites (shown on Map. 4.3)[10] The highlighted cells indicate data of interest:

- Blue shows the depth where the temperature changes by 0.5°C or more – this change was often associated with a sudden decrease in oxygen.
- Yellow indicates low oxygen values, from 2-5 ppm.
- Orange indicates oxygen-depletion, under 2 ppm.

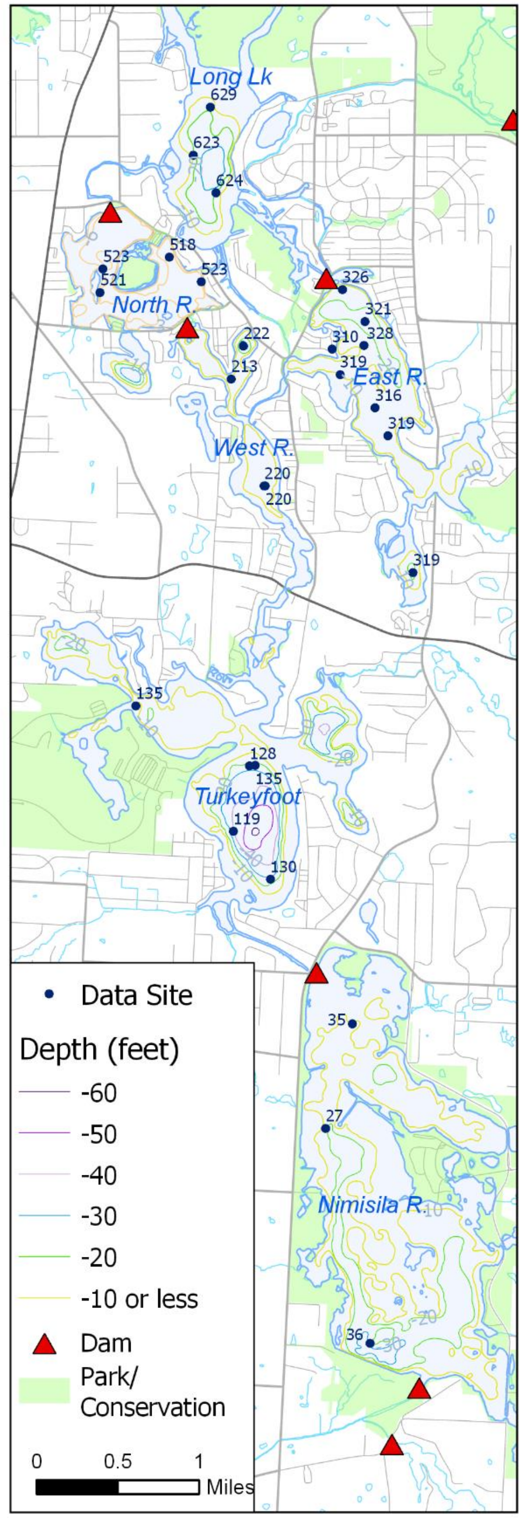
The example graphs shown previously in Figure 4.3 depict typical limnological profile changes over seasons.

The average temperature and depth values for several hundred sites over 18 years of ODNR data were compiled by lake and season (Appendix E) and are summarized in Table 4.5. Even though the data has been averaged, the total record shows similar characteristics to the example limnological profiles.

As shown on Table 4.4 and summarized in Table 4.5:

- In spring, the water column warms from the surface and often is well oxygenated through much of the depth.
- The summer warming extends through the top several meters of the lakes. There is a temperature and oxygen change from 3 to 6 meters overall.
- The thermocline is a barrier to mixing. The lower depths become depleted in oxygen, especially in summer and in the basins. Phosphorus is released in anoxic water.
- During the fall, the water column is mixed to much greater depths. The temperature and oxygen levels become much more uniform in the individual examples.
- In some cases, fall average temperatures increase toward the bottom, possibly reflecting cooling from the surface down to the warmer bottom water.
- Anoxic water occupies the lower levels of the lakes. The deep basins may remain stratified and low in oxygen much of the year, with the thermocline dropping lower in cooler weather. Fish may be able to migrate to higher depths, where oxygen is present.

Map 4.3
Example Limnological Data Locations



NEFCO, 2020. Sources: ODNR GIS; USGS NHD; Summit County GIS; Stark Co. GIS; Portage Co.

Table 4.4 Examples of Portage Lakes Limnological Profile Data

Spring			Summer			Fall		
Long Lake			***Long Lake***			***Long Lake***		
5/13/2013	Sample ID 623		7/29/2013	Sample ID 624		10/18/2016	Sample ID 629	
Depth (m)	**Temp °C**	**DO mg/l**	**Depth (m)**	**Temp °C**	**DO mg/l**	**Depth (m)**	**Temp °C**	**DO mg/l**
0	15.9	8.25	0	22.8	7.64	0	17.7	8.58
1	15.8	7.9	1	22.6	7.58	1	17.7	8.45
2	15.6	7.61	2	22.5	7.18	2	17.7	8.41
3	15.4	7.61	3	21.7	3.51	3	17.7	8.22
4	15.2	6.57	4	21.1	0.54	4	17.6	8.18
5	12.7	1.1	5	20	0.79	5	17.6	7.97
						6	17.5	7.54
						7	15.3	0.11
						8	12.9	0.08
						9	12.4	0.06
North Reservoir			***North Reservoir***			***North Reservoir***		
5/3/2016	Sample ID 521		7/17/2012	Sample ID 518		10/19/2017	Sample ID 523	
Depth (m)	**Temp °C**	**DO mg/l**	**Depth (m)**	**Temp °C**	**DO mg/l**	**Depth (m)**	**Temp °C**	**DO mg/l**
0	16.6	7.94	0	27.6	9.43	0	16.8	8.58
1	16.6	7.85	1	27.6	9.06	1	16.8	8.48
2	15.7	7.73	2	26.6	2.18	2	16.8	8.11
3	15	7.04	Note: several areas have low DO within 1 m of surface			3	16.4	7.35
West Reservoir			***West Reservoir***			***West Reservoir***		
5/13/2014	Sample ID 220		7/26/2010	Sample ID 213		10/18/2017	Sample ID 222	
Depth (m)	**Temp °C**	**DO mg/l**	**Depth (m)**	**Temp °C**	**DO mg/l**	**Depth (m)**	**Temp °C**	**DO mg/l**
0	21.7	11.03	0	29.1	4.87	0	18.7	5.88
1	21.3	10.78	1	28.5	5.56	1	18.7	5.68
2	20.1	10.76	2	28.1	4.5	2	18.7	5.44
3	17.3	6.3	3	28	4.74	3	18.7	5.43
4	14.7	2.12	4	27.7	2.05	4	18.7	5.33
			5	24.6	0.18	5	18.6	5.55
						6	18.6	4.97
						7	18.4	5.55
						8	17.9	3.92
						9	13.4	0.13
						10	11.1	0.04

Data Source: C. Wagner, ODNR, 2020.

Temp. drop 0.5°C or greater
DO from 2-5 mg/l
DO < = 2mg/l

Note: Each sample location is different, even within same lake

Table 4.4 Examples of Portage Lakes Limnological Profile Data - (cont'd)

Spring			Summer			Fall		
East Reservoir			*East Reservoir*			*East Reservoir*		
5/29/2013	Sample ID 319		7/29/2013	Sample ID 321		11/8/2018	Sample ID 328	
Depth (m)	**Temp °C**	**DO mg/l**	**Depth (m)**	**Temp °C**	**DO mg/l**	**Depth (m)**	**Temp °C**	**DO mg/l**
0	18.9	7.88	0	24.6	5.88	0	10.6	7.41
1	18.9	7.66	1	24.5	5.75	1	10.6	7.4
2	18.7	7.69	2	24.4	5.84	2	10.6	7.38
3	18.6	7.34	3	24.4	5.51	3	10.6	7.38
4	18.4	7.14	4	24.4	5.47	4	10.5	7.35
5	18	6.06	5	24.3	5.14			
			6	22.3	0.13			
			7	18.5	0.05			
Turkeyfoot Lake			*Turkeyfoot Lake*			*Turkeyfoot Lake*		
5/2/2012	Sample ID 128		7/29/2013	Sample ID 130		10/20/2015	sample ID 135	
Depth (m)	**Temp °C**	**DO mg/l**	**Depth (m)**	**Temp °C**	**DO mg/l**	**Depth (m)**	**Temp °C**	**DO mg/l**
0	18.3	10.12	0	23.6	7.42	0	13.5	7.06
1	18.1	10.38	1	23.7	6.99	1	13.5	6.74
2	17.8	10.35	2	23.7	6.56	2	13.5	6.57
3	13	8.74	3	23.5	6.29	3	13.5	6.76
4	12.3	8.53	4	23.2	4.68	4	13.5	6.45
5	11.7	7.27	5	21.3	0.93	5	13.5	6.86
			6	16.9	0.23	6	13.4	6.78
			7	13.8	0.2	7	13.3	6.06
Nimisila Reservoir			*Nimisila Reservoir*			*Nimisila Reservoir*		
5/28/2013	Sample ID 31		7/22/2014	sample ID 35		9/26/2012	sample ID 27	
Depth (m)	**Temp °C**	**DO mg/l**	**Depth (m)**	**Temp °C**	**DO mg/l**	**Depth (m)**	**Temp °C**	**DO mg/l**
0	18.3	9.29	0	26.9	9.89	0	17.7	8.2
1	18.2	9.17	1	26.3	9.46	1	17.7	8.14
2	17.5	8.86	2	25.4	8.88	2	17.7	7.75
3	17.4	8.53	3	24.5	5.62	3	17.6	7.31
4	17.3	8.44	4	24.2	3.72			
5	17.1	7.53						

Legend (cell shading):
- Temp. drop 0.5°C or greater
- DO from 2-5 mg/l
- DO < = 2mg/l

Note: Each sample location is different, even within same lake

Data Source: C. Wagner, ODNR, 2020.

Table 4.4 Examples of Portage Lakes Limnological Profilie Data (cont'd)

Spring			Summer			Fall		
Other sites of interest								
Turkeyfoot Lake Basin			***Nimisila Near Dam***			***Cottage Grove Lake***		
5/20/2008	Sample ID	119	7/22/2014	Sample ID	36	10/21/2015	Sample ID	325
Depth (m)	**Temp °C**	**DO mg/l**	**Depth (m)**	**Temp °C**	**DO mg/l**	**Depth (m)**	**Temp °C**	**DO mg/l**
0	15.4	7.83	0	26.9	8.72	0	13	7.92
1	15.5	7.41	1	25.6	9.36	1	12.9	7.88
2	15.5	7.93	2	24.9	8.55	2	12.7	7.82
3	15.5	7.71	3	24.4	8.24			
4	15.4	7.06	4	24	5.12			
5	15.2	6.26	5	23.8	3.39			
6	13.5	1.51	6	23.5	0.5			
7	9.1	0.32	7	20.5	0.27			
8	7.6	1.21	8	16.3	0.25			
9	6.8	1.43						
10	6.5	1.31						
11	6.4	0.4						
12	6.3	0.04						
13	6.3	0.02						
Miller Lake								
5/7/2009	Sample ID	316						
Depth (m)	**Temp °C**	**DO mg/l**						
0	17.7	7.79						
1	17.7	7.93						
2	17.6	7.79						
3	16.9	7.33						
4	16.7	7.67						
5	15.7	7.36						

Temp. drop 0.5°C or greater

DO from 2-5 mg/l

DO < = 2mg/l

Note: Each sample location is different, even within same lake

Data Source: C. Wagner, ODNR, 2020.

Table 4.5 Summary of Portage Lakes Temperature and DO Data

Characteristic	Spring	Summer	Fall
Temperature	5.20 to 18.65°C, declines with depth	13.8 to 29.1°C, declines with depth	10.6 to 18.6 °C Examples and averages vary, some uniform, some increase at depth as lake cools from the surface.
Oxygen	0 to 10.86 mg/l	0.18 to 9.36 mg/l	0.04 to 8.78 mg/l
Thermocline (temperature-oxygen change)	Average depth 3-4 m most lakes; 6 m Nimisila Res. Examples vary more	Average depth 2-4 m	No obvious change in individual examples. Averages show great variability in temperature change through water column.
Depth where Low/Depleted Oxygen Begins	4 to 8 meters Oxygen depletion apparent only in Long Lake, West Res., and Turkeyfoot Lake - Average depth 5 to 8 m; individual examples 4- 8 m	3 to 4 meters, shallower in some individual examples. Oxygen depletion in all lakes, starting at 4 to 6 m in averages and examples.	5-7 meters Oxygen depletion only in basins of Long Lake, West Reservoir, and Nimisila Reservoir, starting at 7 - 10 m

Discussion – Lake Form and Productivity

The Portage Lakes are all stratified during the summer. Many of the examples are low or depleted in oxygen during the summer and in the basins. Oxygen depletion is important in the release of phosphorus from the sediments, which spurs growth of aquatic plants, algae, and cyanobacteria ("blue-green algae"). This is part of the "internal loading" of phosphorus, discussed later in the chapter.

This study summarizes several years of data from many points. In understanding the contribution of phosphorus to lake productivity, it will be important to map out the individual limnological profiles of temperature and oxygen by depth, as well as develop a consistent sampling and monitoring program:

- Mixing of cold deep water with surface water may be limited, trapping phosphorus.
- In shallow lakes, phosphorus released in the bottom waters may be more readily mixed with surface waters, fueling growth, especially when the thermocline is not well developed. It will be instructive to compare oxygen profiles with temperature and depth in each lake, to better understand phosphorus release and mixing.
- The seasonal timing of oxygen depletion affects nutrient release and thus productivity (growth).
- Small, shallow, connected "urban" lakes (managed waters, large developed watershed) are susceptible to eutrophication. Both watershed and in-lake management are essential.[11]

The form and size of the lakes and their watersheds contribute to the "external loading" of phosphorus– the effect of the landscape and watershed on the lakes. As the watershed size and amount of shoreline increases, the influence of watershed and shoreline increase. The "downstream" lakes receive water from the others, as well as the entire watershed. Long Lake, the furthest downstream, is affected by all the lakes as well as the entire upper Tuscarawas watershed. The residence time indicates that phosphorus entering the lakes remains in the Main Chain and North Reservoir for approximately one year, but would be flushed out of Long Lake within weeks, assuming even mixing and flushing.

About Lakes - Lake Productivity and Trophic State

Lake productivity is the amount of biomass, or living matter, that a lake can support. It depends on photosynthesis and is often measured by the amounts of substances related to photosynthesis:

- Phosphorus – the primary, *critical* nutrient in freshwater systems for photosynthesizers (e.g., rooted plants and algae, photosynthesizing plankton like algae, diatoms, bacteria). Increased phosphorus is directly linked to an increase in photosynthesizers.
- Turbidity – cloudiness of the water, often growth of phytoplankton like floating algae. Turbidity is often measured by using a Secchi disk to measure water transparency. High transparency means low turbidity and vice-versa. High levels of turbidity can shade out aquatic plants.
- Chlorophyll –necessary for photosynthesis.

Secchi Disk: Measuring Water Clarity/Turbidity and Productivity

The depth that light penetrates, heating up the water and driving plant growth, is affected by water clarity or turbidity (cloudiness). Turbid water has a lot of suspended particles – fine sediment and micro-organisms (algae, plankton), reducing light penetration. Algal productivity increases turbidity. Turbidity can also increase where fine sediment enters from streams or is stirred up by waves or activity.

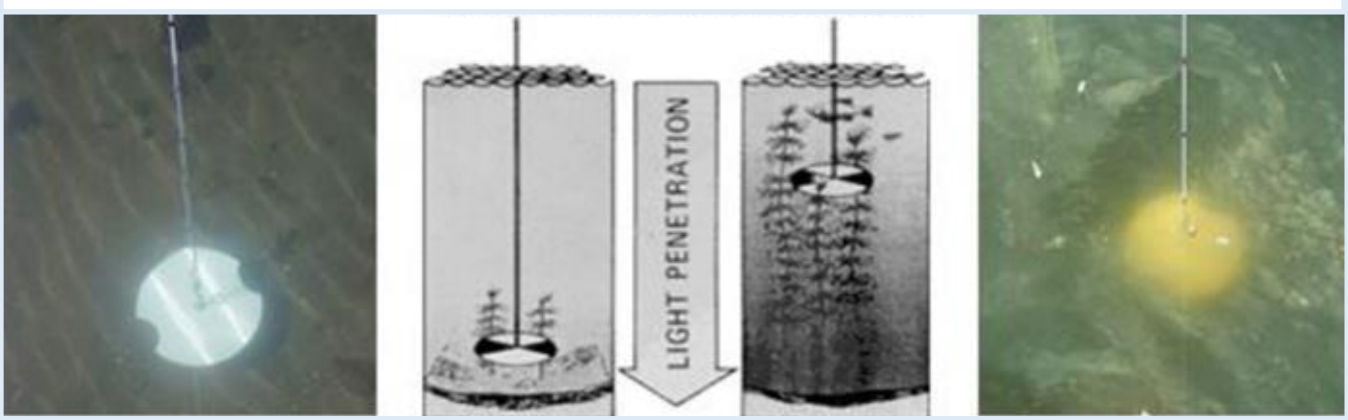
Lake monitors use Secchi discs to determine light penetration/turbidity and monitor seasonal and long-term changes at different locations, recording depth where the highly visible Secchi disc is no longer seen.

The depth that the disc is visible is related to how far light can penetrate – it is assumed that twice the Secchi transparency depth is the approximate depth that 1 percent of light can penetrate, the limit of plant growth.

The white areas allow volunteers to determine color, and thus the likely reason for turbidity (algae, sediment, or natural organic dyes like tannins).

Equations relate visibility of Secchi discs to trophic state indices, which are used with other factors to characterize lake productivity.

Measuring Turbidity with a Secchi Disc



Secchi disk in clear lake versus turbid lake. Modified from: Minnesota Water Pollution Control Agency (2016).

Trophic State - Oligotrophic? Mesotrophic? Eutrophic?

Productivity is affected by factors in the lake and watershed and affects characteristics of the lake. Lakes are classified by *trophic state* based on their productivity. The classifications are descriptive, but they can point to trends, potential risks, and management measures. Trophic status can change over time as conditions change.

Productivity reflects availability of nutrients. Table 4.6 highlights characteristics of trophic states identified by the Carlson Trophic State Index, one of many indices of productivity/trophic state.[12]

- *Oligotrophic* – the clearest lakes and ocean areas have lower levels of nutrients and little biomass. These are often deep and cold, limiting the amount of nutrients available from the deep water. There are many species of algae. Fish tend to be few but large, requiring cold, highly oxygenated water. Lake Superior and recent lakes in granite or sand are examples.

The clear water of oligotrophic Yellowstone Lake (left) contrasts with turbid water of highly productive Lake Erie (right), known for its walleye fisheries.

- *Mesotrophic* – intermediate level of productivity – more plant life supports more fish, often very productive sport fisheries like walleye. These lakes or areas are often shallower, with a higher proportion of the lake volume supporting plants and algae, and warming during the summer. Some of the shores of Lake Michigan are considered mesotrophic. Lake Erie has been identified as either mesotrophic or eutrophic at different times.
- *Eutrophic* – high level of nutrients and productivity. Like mesotrophic lakes, these tend to be warmer and shallower. They are characterized by higher turbidity and dense plant growth. Some support highly productive fisheries with warm-water sport fish like northern pike or bass. Because of the high level of algal productivity, warmer waters, and smaller proportion below the thermocline, there is increased chance of oxygen depletion in the deep water in summer.
- *Hypereutrophic* – water body extremely enriched in nutrients. In extreme cases, nuisance plant growth gives way to algae and harmful cyanobacteria, which out-compete plants for nutrients and light. The water is very cloudy (turbid) and may have extensive algal blooms and algae scums. The few fish species are tolerant of warm water and lower oxygen. There may be fish kills in summer. The bottom-dwelling "rough" fish and anoxic water release more nutrients from the sediment.

Trophic state reflects environmental conditions and possibly stage of development of a lake. The deep, cold, clear lakes differ in form, setting, and inputs from shallower, warmer, more productive lakes. Turbidity, nutrients, plants, algae, algal blooms, productivity are often an important part of how lakes work. However, a hypereutrophic lake is often unhealthy for plants and humans, and other animals:

- Excessive or nuisance algal blooms shade out rooted aquatic plants
- Oxygen depletion at depth during the summer, releasing phosphorus that spurs more growth
- The risk of toxic cyanobacteria, especially as nutrient input continues
- Fish kills during the summer due to low oxygen

Table 4.6 A list of possible changes that might be expected in a north temperate lake as the amount of algae changes along the trophic state gradient

TSI	Chl (µg/l)	SD (m)	TP (µg/l)	Attributes	Fisheries
<30	<0.95	>8	<6	**Oligotrophy:** Clear water, oxygen throughout the year in the hypolimnion	Salmonid fisheries dominate
30-40	0.95-2.6	8-4	6-12	Hypolimnia of shallow lakes may become anoxic	Salmonid fisheries in deep lakes only
40-50	2.6-7.3	4-2	12-24	**Mesotrophy:** Water moderately clear, increasing probability of hypolimnetic anoxia during summer	Hypolimnetic anoxia results in loss of salmonids. Walleye may predominate.
50-60	7.3-20	2-1	24-48	**Eutrophy:** Anoxic hypolimnia, macrophyte problems possible	Warm-water fishes only. Bass may dominate.
60-70	20-56	0.5-1	48-96	Blue-green algae dominate. Algal scums and macrophyte problems.	Nuisance macrophytes. Algal scums and low transparency may discourage swimming and boating.
70-80	56-155	0.25-0.5	96-192	**Hypereutrophy:** (light-limited productivity) Dense algae and macrophytes	
>80	>155	<0.25	192-384	Algal scums, few macrophytes	Rough fish dominate; summer fish kills possible.

TSI – Carlson Trophic State Index – one index of trophic state that focuses on algae production
Chl – Chlorophyll, usually measured as chlorophyll A
SD – Secchi Disk transparency
TP – Total Phosphorus
Source: Modified after North American Lake Management Society 2020.

Eutrophication

Eutrophication is the process of increasing the level of nutrients and productivity (biomass) in water bodies. Sediment and nutrients continuously wash in from the watershed and build up in a lake over time, spurring growth.

- Nutrients that wash in from the watershed outside the lakes are considered *external loading*.
- As areas of the lakes become shallower and enriched in nutrients, they support more plant matter and greater volumes of fish.
- Decay of dead plants and animals releases nutrients, which are stored in sediment, building up the level of nutrients in the system. Nutrients are recycled over and over as *internal loading*.
- Over time, the lakes continue to become shallower and support denser growth of plants, which decompose and continue to build up nutrients.
- Eventually some lakes may fill in so much that they become wetlands – marshes and swamps.

Eutrophication may occur naturally over centuries to millennia.

Eutrophication is greatly accelerated by human activities and alteration, which increase external loading from the watershed, as well as the internal loading that comes from recycling the increased amount of nutrients in the water. This cultural eutrophication takes *years to decades*:

- Clearing, farming, and converting natural landscapes to development introduces more sediment and nutrients into lakes, filling them in and spurring productivity.
- Pavement and turf increase how much rain runs off the landscape, which carries more sediment and nutrients into the lakes.
- Wastewater treatment plants, poorly-functioning septic systems, and phosphorus in fertilizers and other chemicals contribute additional nutrients into surface waters. ‘
- Urban lakes are more susceptible to eutrophication than pristine lakes.

Aquatic Plants, Green Algae, and Harmful Algal Blooms

Left - Filamentous green algae (dark green) attaches to aquatic plants (leafy, lighter green) and solid objects. Right - With excessive growth, mats may detach and float to the surface. (Portage Lakes Examples)

Lakes are full of photosynthesizers, which all require nutrients and light. Warm, nutrient-rich water may encourage excessive, nuisance growth of some types, is often an indicator of eutrophic conditions.

Plants – multi-cell organisms with specialized parts, can be floating, like the rooted duckweed or coontail, or sessile – rooted to the bottom.

Algae – single-cell, floating (plankton) or multi-cell unspecialized organisms. They generate oxygen, and are important to the food chain. Like plants, excessive growth can become a nuisance. An example is *Cladophora*, branching strands of green algae that attach to objects. In eutrophic waters, it can form mats that disconnect and then float to the surface. When it collects and decays, it releases nutrients. Decaying mats smell foul and may harbor bacteria.

Cyanobacteria, also known as blue-green algae or “Harmful algae” – Not true algae, they are related to bacteria and photosynthesize. Some use nitrogen directly from the air (“fix” nitrogen). Some are harmful to people and animals, releasing toxins that affect skin, digestive system, nerves, or liver. Cyanobacteria are present at all levels of nutrients, but at high levels of phosphorus, they may become predominant.[13]

Blooms of algae and cyanobacteria occur when nutrients are released in the water and conditions support growth. Hot weather, stormwater runoff, and phosphorus release from sediment in anoxic water all contribute to blooms. See Figure 4.8 for examples of plants, algae, and Harmful Algae Blooms.

- Algae blooms are *not* toxic. They make the water turbid.
- Cyanobacteria grow well in calm, slow-moving, warm, nutrient-rich water. “Harmful Algae Blooms” (HABs) often appear as strangely colored scum or blebs in the water. They can be on the surface, concentrated at lower levels, mixed through the water column, or they may migrate vertically. These may be toxic to people and animals and should be reported and avoided.

- The State of Ohio has developed response procedures among Department of Health, Ohio EPA, and ODNR.
- Ohio EPA posts weekly lists during warm months of larger lakes with cyanobacteria visible on satellite imagery.
- In the Portage Lakes, ODNR is responsible for monitoring, sampling, and posting notices about HABs.
- More frequent, intense storms associated with climate change increase algal blooms.
- Levels of response can range from warnings not to ingest the water and to clean after going in the water to the extreme measures of closing the lake to recreational use.

  Two good reference websites:
  - Ohio EPA https://epa.ohio.gov/hab-algae#147744472-basics
  - Ohio Dept. of Health https://odh.ohio.gov/wps/portal/gov/odh/know-our-programs/harmful-algal-blooms/Harmful-Algal-Blooms-in-Ohio/

Figure 4.8 Are they Harmful? Examples of Algae, Plants, Duckweed, and Harmful Algal Blooms.[14]

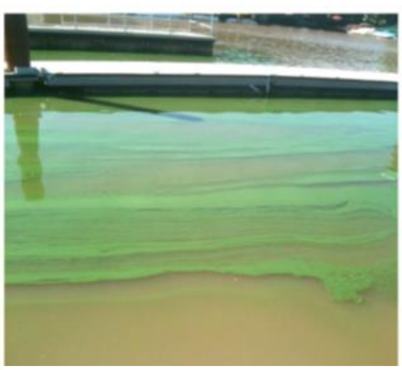
Plants and algae may be mistaken for HABs. These are *not* harmful, but excessive growth may become a nuisance, and it indicates high levels of nutrients, possibly eutrophic conditions.

a and b Filamentous green algae mats with plants (water lilies, spatterdock), Portage Lakes.

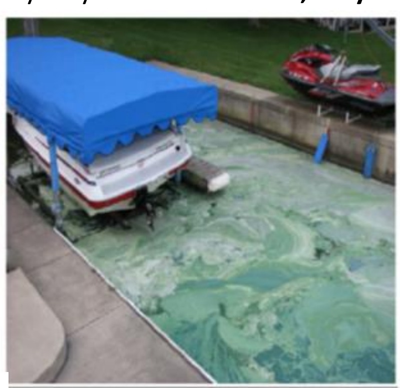
c Filamentous green Algae (Cladophora)

e ,f Duckweed –floating rooted plant. Duckweed is tiny rooted plants.. Example e from Portage Lakes.

Harmful algal blooms appear many ways. **When in doubt, Stay Out, and report your sighting.**



g - Huron River, 2009



h – Grand Lakes St. Marys, 2010

I – Microcystin blebs, mixed in the water column, Ohio River, 2008

Source: *https://odh.ohio.gov/wps/portal/gov/odh/know-our-programs/harmful-algal-blooms/media/habs-photos* *c, d, f, g, h, I*

Flipping the Switch from Plants to Algae/HABs

Limnologists and lake managers have found that highly eutrophic lakes can switch from a plant-dominated ("clear") state to an algae-dominated ("turbid") state, which has increased turbidity, HABs, and a loss of rooted plants. Perturbations in lake systems, e.g., removal of plants, may trigger the shift. The new algae- dominant equilibrium is very stable, difficult to reverse, and reinforced by feedback loops.[15]

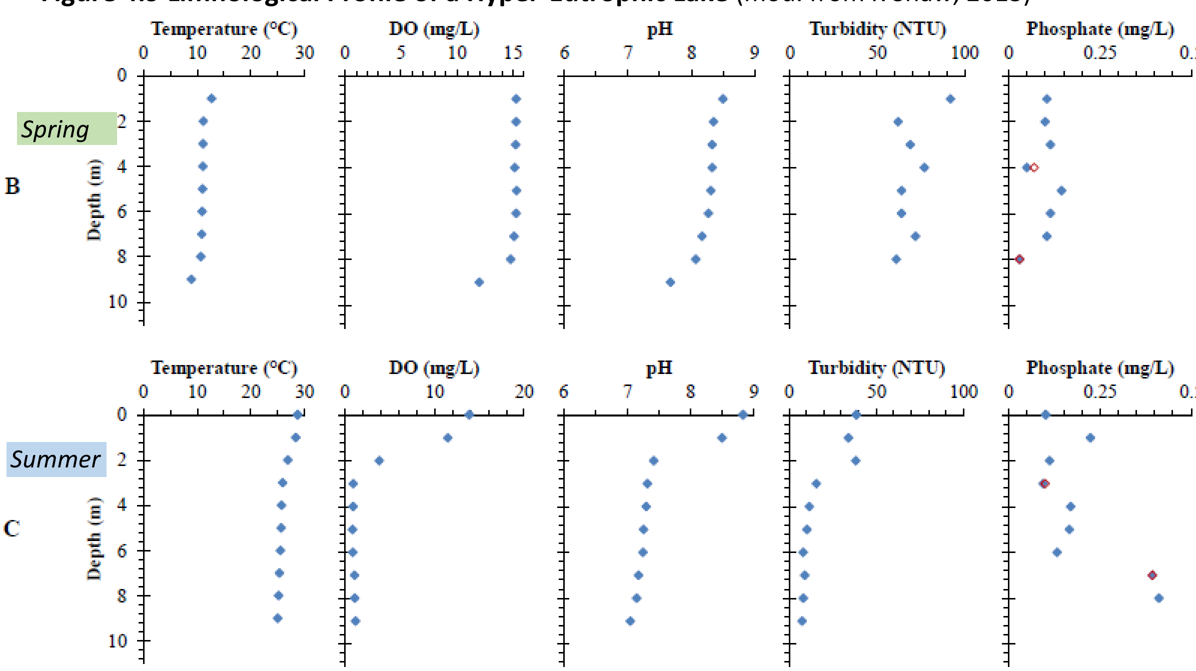
- Rooted plants and phytoplankton (algae) compete for nutrients and light. At certain high levels of nutrients, the algal growth shades out the rooted plants and out-competes them for nutrients. With no plants, sediment is stirred up, increasing turbidity.
- Particles in turbid water absorb and give off heat, raising water temperature and favoring algae.
- Decomposition of the algae results in anoxia at depth, fish kills, and more phosphorus release.
- At excessive levels of nutrients, the cyanobacteria that cause HABs become predominant. Some lakes become closed to recreational use, and are toxic to people, pets, and wildlife.

There are on-going efforts in lakes and rivers in Ohio to remediate lakes with HABs due to excessive nutrients, using various techniques to destratify lakes and remove phosphorus. While there has been some success, fixing nature when it is broken is very expensive, does not always work as planned, and may have unintended consequences if not carried out in the precise manner needed.

Case Example: Characteristics of a Hyper-Eutrophic Lake

Figure 4.9 shows data from a hypereutrophic lake in Summit County after the lake equilibrium had shifted to turbid, algae-dominated conditions. The spring data shows the water warming, phosphate and high levels of DO throughout the water column, and high turbidity, possibly due to spring algal blooms. Summer conditions show excessively warm water, DO absent below two meters, and high levels of phosphate being released in the anoxic deep waters. The lake has since been remediated, and the return of rooted plants is seen as a great success.[16]

Figure 4.9 Limnological Profile of a Hyper-Eutrophic Lake (mod. from K Shaw, 2013)



Portage Lakes Secchi Disk Data and Turbidity

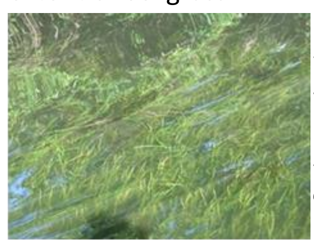
Secchi disk transparency data is one of the components used to measure and track productivity and trophic state. Volunteers and ODNR Wildlife staff have developed substantial records, which provide an important starting point for assessing lake productivity:

- Secchi disk transparency is a simple field measurement that does not require sampling or lab analysis. Lake managers and volunteers can develop long-term, seasonal records.
- It measures one of the key indicators of lake conditions, including productivity.
- It reflects a very visible aspect of lake condition – the clarity or turbidity of the water.

Figure 4.10 shows seasonal and long-term Secchi disk data (in inches) for three lakes, along with the Carlson Trophic State Index (TSI) for turbidity.[17] Map 4.4 shows the ODNR Secchi disk data, contrasting summer with other seasons, throughout the lakes. Lower transparency means higher turbidity.

- Turbidity is high (transparency low) in the summer, typical of lakes with summer algae growth.
- In some of the summer data, the Carlson TSI values correlate with moderate to higher eutrophy.
- North Reservoir and Long Lake generally are more turbid. Long Lake receives water (and nutrients) from the other Portage Lakes and the Tuscarawas River watershed.
- Nimisila has lower turbidity. The landscape around Nimisila is less developed, and there are extensive aquatic plant beds. The nutrients available and suspended algae may be less.
- Figure 4.10 shows that transparency has generally increased over time, indicating less turbidity. Lakers have noticed the increased clarity and greater extent of eel grass.





Left: Clear water of Nimisila Reservoir. Center: Turbid North Reservoir. Right – eel grass beds.

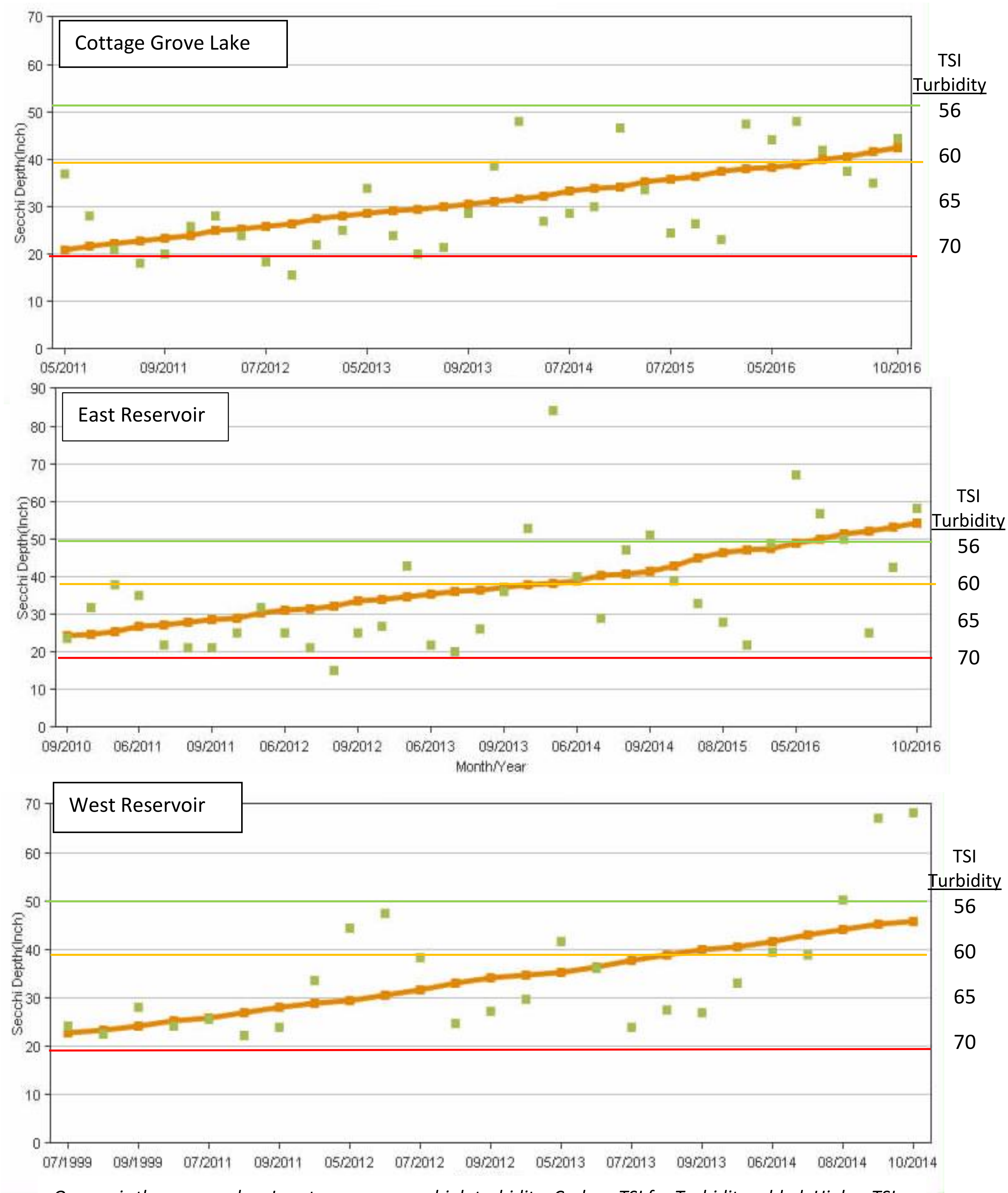
Additional factors can affect turbidity, including plant tannins, propeller disturbance, sediment entering from stream, silty versus sandy bottom, and the presence or absence of aquatic plants.

➢ *Note:* Secchi disk data is a valuable measurement. Seasonal monitoring should continue and expand to other areas, but it is only one of several factors used to measure lake productivity.

Water Clarity, Phosphorus, and Invasive Mussels

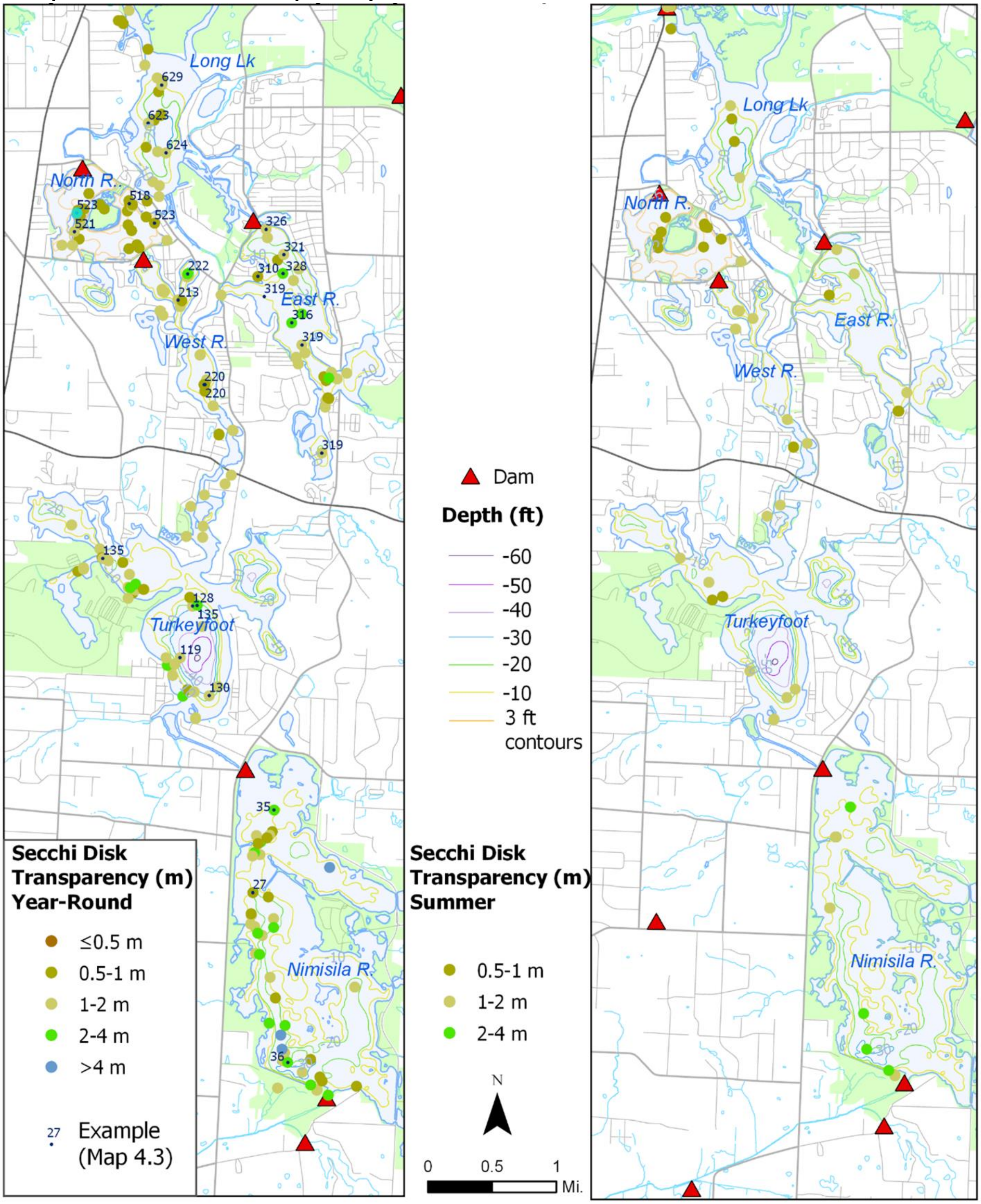
Invasive Zebra (and/or Quagga) mussels have been found in the Portage Lakes for over a decade. These animals filter vast quantities of water, removing algae and plankton, which is the base of the food chain. The water clarity increases, favoring plants versus algae. Boaters and anglers report increased stands of aquatic plants in deeper water. Increased water clarity does not necessarily mean an improvement in water quality, as the food chain is disrupted, and phosphorus is shifted from open water toward the littoral zone as the mussels filter great volumes of water and excrete the waste. The shift in nutrients may encourage more plant or algae growth in the shallow zones, and increased clarity may encourage plant growth in deeper water. The interactions are still being studied by researchers. The best tool is consistent monitoring of many characteristics, to better understand how the whole system works.

Figure 4.10 Secchi Disk Transparency - Cottage Grove Lake, East and West Reservoirs



Orange is the mean value. Low transparency = high turbidity. Carlson TSI for Turbidity added. Higher TSI indicates more turbidity. Data Source: Citizens Lake Awareness and Monitoring data from Ohio Lake Management Society webpage http://www.eyesonthewater.org/olms/ (2018)

Map 4.4 Secchi Disk Transparency Data, Year-Round and Summer



NEFCO, 2020. Sources: ODNR Div. of Wildlife; ODNR GIS; USGS NHD; Summit County GIS; WRLC, AMATS

Portage Lakes Trophic State Indicators and Productivity

Periodically the ODNR staff take samples for chemical and physical limnological analyses, including phosphorus and chlorophyll A, which are used together to measure productivity. These samples are not taken yearly but provide important data related to the lakes' trophic state. Figure 4.11 and Table 4.9 show the Carlson trophic state indices (TSI) and data for Secchi disk transparency/turbidity, phosphorus, and chlorophyll. (Productivity increases toward the top of the graph.) The turbidity data reflect only the Secchi Disk measurements taken at the same time as the full sampling suite. (Other Secchi disk data, obtained with depth and DO measurements and shown in Map 4.4, have not been compared to the state criteria.) Table 4.7 also shows how the parameters compare to the Ohio inland lakes criteria.

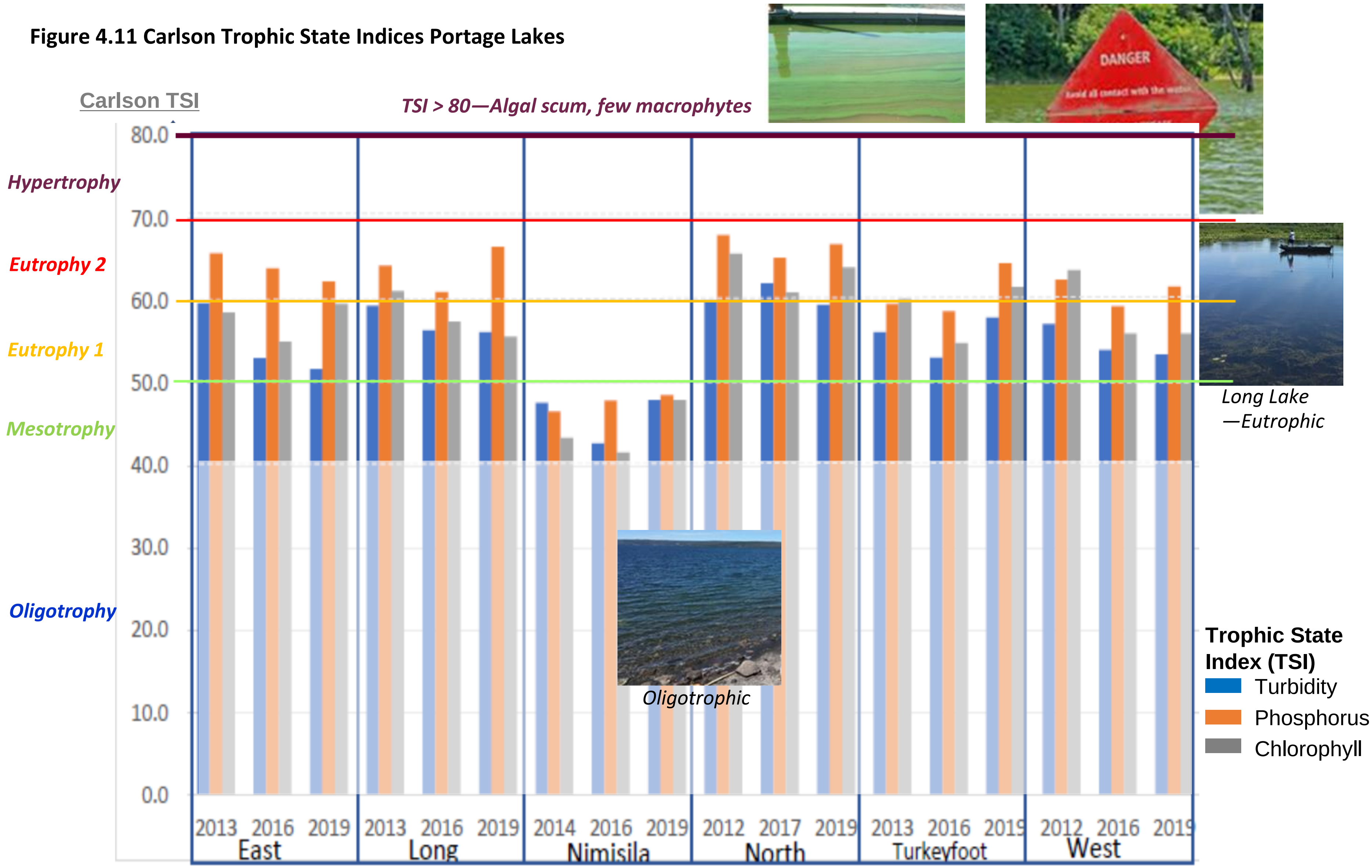
Figure 4.11 and Table 4.7 show that, except for Nimisila Reservoir, which is mesotrophic:[18]

- All the lakes except are in the eutrophic ranges, for all parameters.
- The phosphorus index is generally high. The phosphorus levels generally exceed Ohio criteria.
- The chlorophyll index is high, with chlorophyll often exceeding Ohio lakes criteria.
- North Reservoir appears to be the most eutrophic, and all indicators exceed state criteria.

The trophic state determined for the lakes is consistent with observations.

- Substantial amount of aquatic vegetation and algae, which use phosphorus for growth
- Bass fisheries
- Several of the aquatic plant species that are abundant in the lake are typically found in eutrophic waters, e.g., Eurasian watermilfoil, coontail, and curly-leafed pondweed.
- Urban lakes, like the Portage Lakes, are especially vulnerable to nutrient enrichment and eutrophication.

Figure 4.11 Carlson Trophic State Indices Portage Lakes



Hypertrophy *Dense algae, plants*
Eutrophy 2 *Nuisance plants, algae*
Eutrophy 1 *Possible plant/algae problems, bass*
Mesotrophy *Possible summer anoxia, walleye*
Oligotrophy *Low nutrients, low productivity, cold water fish*

Sources: NEFCO, 2020; ODNR Div. of Wildlife, 2020; NALMS, 2020 (mod.); image Ohio Dept. of Health, 2013.

Table 4.7 Carlson Trophic State Indices (TSI) and Soluble Reactive Phosphorus (SRP) - Portage Lakes
Table 4.7 Carlson Trophic State Indices (TSI) and Soluble Reactive Phosphorus (SRP) - Portage Lakes

			Secchi Disk Transparency*			Total Phosphorus (TP)**			Chlorophyll A (ChlA)**			
Lake	Year	Date	Secchi Depth (m)	Lake Criterion (m)	TSI Secchi	TP ug/L	Lake Criterion µg/L	TSI TP	ChlA ug/L	Lake Criterion µg/L	TSI Chl A	SRP** ug/L
East	2013	07/29/2013	1.02	1.19	59.71	71.9	34.0	65.8	17.4	14.0	58.6	3.5
	2016	07/19/2016	1.62	1.19	53.05	63.4	34.0	64.0	12.1	14.0	55.1	1.8
	2019	07/18/2019	1.77	1.19	51.77	56.7	34.0	62.4	19.5	14.0	59.7	2.5
Long	2013	07/29/2013	1.04	1.19	59.43	64.8	34.0	64.3	22.8	14.0	61.2	1.8
	2016	07/21/2016	1.28	1.19	56.44	52	34.0	61.1	15.6	14.0	57.5	3.4
	2019	07/18/2019	1.30	1.19	56.22	75.9	34.0	66.6	12.9	14.0	55.7	4.0
Nimisila	2014	07/22/2014	2.36	1.19	47.63	19.0	34.0	46.6	3.7	14.0	43.4	4.0
	2016	07/19/2016	3.32	1.19	42.71	20.8	34.0	47.9	3.1	14.0	41.6	2.0
	2019	07/18/2019	2.30	1.19	48.00	21.8	34.0	48.6	5.9	14.0	48.0	3.0
North	2012	07/17/2012	1.00	1.19	60.00	83.9	34.0	68.0	36.1	14.0	65.8	1.0
	2017	07/19/2016	0.86	1.19	62.17	69.2	34.0	65.2	22.4	14.0	61.1	4.0
	2019	07/18/2019	1.03	1.19	59.57	77.6	34.0	66.9	30.6	14.0	64.1	2.0
Turkeyfoot	2013	07/29/2013	1.30	1.19	56.22	47.0	34.0	59.7	20.7	14.0	60.3	4.4
	2016	07/19/2016	1.61	1.19	53.14	44.2	34.0	58.8	11.9	14.0	54.9	2.2
	2019	07/18/2019	1.15	1.19	57.99	66.2	34.0	64.6	24.0	14.0	61.7	2.0
West	2012	07/17/2012	1.21	1.19	57.25	57.6	34.0	62.6	29.5	14.0	63.8	10.2
	2016	07/19/2016	1.51	1.19	54.06	46.1	34.0	59.4	13.5	14.0	56.1	5.3
	2019	07/18/2019	1.57	1.19	53.50	54.5	34.0	61.8	13.4	14.0	56.1	4.2

*Secchi disk transparency is high when turbidity/productivity is low. Measurements *equal to or higher* than the criterion meet the Ohio lakes criterion.
** High values of phosphorus and chlorophyll A indicate high productivity. Measurements *equal to or lower* than the criterion meet the Ohio lakes criterion.

Values in green meet or are better than the Ohio inland lakes criterion. Values in red do not meet the Ohio inland lakes criterion.

Data Sources: C. Wagner 2020; Ohio EPA, 2010.

It is difficult to discern trends on Figure 4.11 and Table 4.7, as the data were not collected yearly. Table 4.8 compares data for turbidity, phosphorus, and chlorophyll from the 1990s with the recent data.[19] Ohio criteria for inland lakes are also shown for comparison. Except for Nimisila Reservoir, Secchi transparency/turbidity and chlorophyll levels have generally improved, but phosphorus shows more mixed results. Many of the parameters meet state criteria partially or not at all.

Table 4.8 Trophic Indicators Over Time - 1990s and Post-2010

Lake	Secchi Depth (m)			Total Phosphorus µg/l			Chlorophyll A (µg/l)*		
	1990s	2010-2018	Lake Criterion	1990s	2010-2018	Lake Criterion	1990s	2010-2018	Lake Criterion
Long	0.69-0.92	1.04-1.30	1.19	42-117	52-76	34	31.5-58.2	12.9-22.8	14.0
North	0.38-0.81	0.86-1.03	1.19	41-70	69-83	34	22.7	22.4-36.1	14.0
West	0.65-1.01	1.21-1.57	1.19	37-130**	46-54	34	72.5-73.2	13.4-29.5	14.0
East	0.84-7.90	1.02-1.77	1.19	20-190	57-72	34	54.8-63.6	12.1-19.5	14.0
Turkeyfoot	0.92-1.02	1.15-1.61	1.19	60-70	44-66	34	23.2-35.3	11.9-24.0	14.0
Mud	1.07-1.08			42-60		34	17.3-19.2		
Rex	0.98-1.12			50-90		34	21.7-35.0		
Nimisila	0.71-1.15	2.30-3.30	1.19	31-140	19-22	34	14.6-18.2	5.9	14.0

Data Sources: Ohio EPA 2010; ODNR Div. of Wildlife, 2020.

Note: *High* Secchi Disc readings indicate greater transparency; *low* readings mean more turbidity. Secchi disk data should *equal or exceed* the lake criterion. Other categories should be *less than or equal* to the criteria.

*1990s – August-Sep; 2010-2018 – July **Two values 100 µg/l or greater

(green)	Recent data improved	XX (green)	Recent data meets criterion
(yellow)	Some recent data improved	XX (orange)	Some recent data meets criterion
(orange)	Recent data worse	XX (red)	Recent data does not meet criterion

As shown on Table 4.10:

- Conditions have improved in Nimisila Reservoir, and the recent readings meet state criteria.
- Secchi Disc transparency/turbidity has improved since the 1990s in the other lakes, but only meets the Ohio criterion in some of the readings.
- Phosphorus has improved somewhat, with reduction of the highest readings but increase of lower readings. Except for Nimisila Reservoir, none of the readings meet the Ohio criterion.
- Chlorophyll has improved considerably in most lakes but does not meet the Ohio lakes criterion.
- Phosphorus and chlorophyll have not improved in North Reservoir as they have in other lakes. Secchi depth measurements in North Reservoir do not meet the lake criterion.

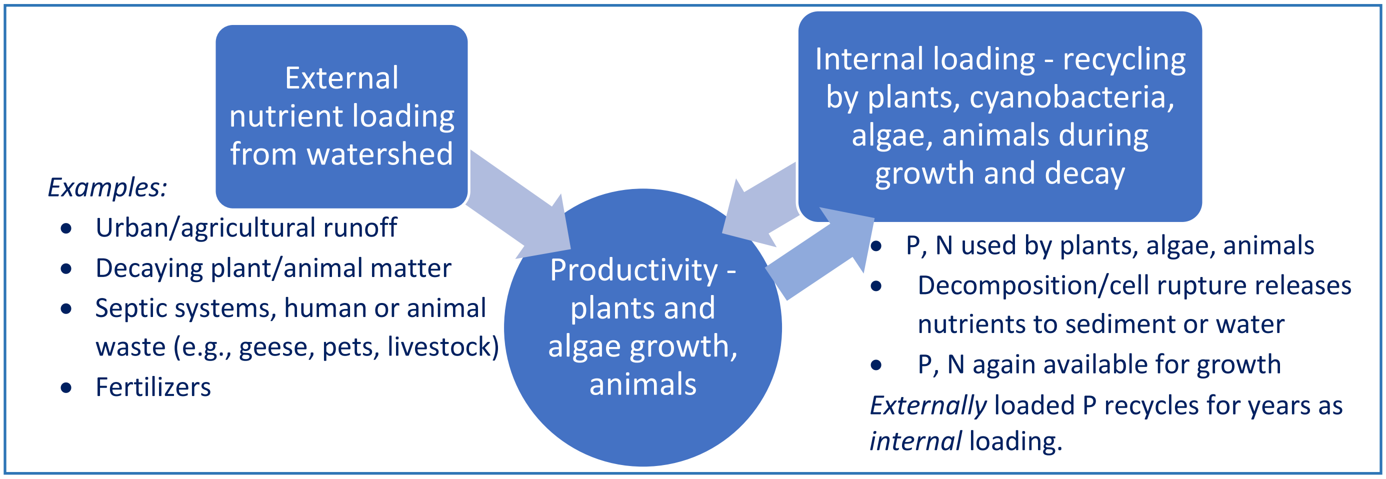
As an urban, eutrophic chain of lakes, the Portage lakes are especially susceptible to eutrophication. In 2020, two to three dozen Ohio lakes were listed on the state weekly cyanobacteria monitoring reports, including several reservoirs and state and local parks.[20] Some of the lakes are listed repeatedly, for many weeks, year after year. Turkeyfoot and Long Lake are occasionally on the list, usually with limited occurrence. Changing climate conditions, including more frequent and intense storms and hotter summers, will increase the likelihood of HABs. It is important to reduce the characteristics in the Portage Lakes that could trigger a shift to the "turbid" algae dominated state.

Portage Lakes Productivity and Nutrient Loads

Nutrients drive productivity in the Portage Lakes, which are all eutrophic except for Nimisila Reservoir. (Recent studies suggest that ***both*** phosphorus (P) and nitrogen (N) affect cyanobacteria blooms and toxicity.[21]) Both ***external*** and ***interna***l loading affect nutrient levels in the lakes: (See Figure. 4.12):[22]

- ***External loading,*** nutrients entering from the watershed. Development, fertilizer, small lots with septic systems, and geese have contributed large loads of for many years, and still do.
- ***Internal loading***, recycling of nutrients many times. Nutrients in lakes do not just go away, in fact the opposite happens. They enter the lakes as *external* loading from the watershed or shoreline and are used in living matter. Decomposition (or rupture of cyanobacteria cells) releases nutrients to the sediment or water, which are then available for more growth over and over again. *External* loading from the watershed thus lasts for years as recycled *internal* loading from within the lakes.

Figure 4.12 External and Internal Phosphorus Loading



How are nutrients internally recycled? Like many living systems, it is complex, with many interacting parts.

- Phosphorus occurs in dissolved/soluble or particulate forms.
- Photosynthesizers use dissolved phosphorus for growth.
- Decomposition of organisms (photosynthesizers, animals) or waste releases dissolved phosphorus to the water, which is immediately available for short-term bursts of growth (a few days).
- Particulate phosphorus may be bound to sediment but can be released in anoxic conditions over time.

Many factors affect when and how much phosphorus is available within lakes for growth including:

- How photosynthesizers obtain phosphorus (roots and/or directly from water)
- What kind of photosynthesizers are dominant –large plants/algae or phytoplankton
- Plant characteristics – when is the growth period, how much phosphorus is stored, and when is it released during senescence or fragmentation of aquatic plants and algae?
- Grazing on phytoplankton by zooplankton, which are then consumed by larger animals
- Filter-feeding by zebra mussels relocates phosphorus to near-shore sediment
- Water chemistry at the sediment surface and within it, including pH, oxygen, iron, aluminum, calcium. Pore water of sediment can be anoxic. Disturbance of sediment can release phosphorus.
- Lake mixing – shallow lakes are more easily mixed than deep basins.
- Recent research suggests cyanobacteria recycle nitrogen rapidly as individual cells rupture.

Figure 4.13 shows examples of where external and internal loading may be occurring in the lakes. The large volume of plants reflects the high levels of nutrients available in the lakes.

Figure 4.13 External and Internal Phosophorus Loading in the Portage Lakes

External *loading - nutrients enter the lakes from many sources on land. The abundant aquatic plants and algae in the eutrophic lakes use and recycle nutrients from the water and sediment. Decomposition of organic matter like dead plants, plant fragments, leaves, animals, or animal waste releases nutrients back into the water or sediment, resulting in* ***internal*** *loading that can continue for years after the external loading stops.*

Rooted Plants or Harmful Algal Blooms

Aquatic plants are part of the internal loading cycle, storing nutrients in life, releasing them during decay.

- It is important to note that internal loading is not due to plants but supports them. ***Without aquatic plants, the nutrients in the lakes would still be used – potentially by organisms that cause HABs.***

In hypereutrophic lakes, *excessive turbidity* and *loss of rooted plants* have marked the shift from plant-dominated to an algae-dominated system, with its much higher risk of HABs. The North American Lake Management Society notes that generally, lakes *either* have excessive rooted aquatic plants *or* HABs, because the plants and algae compete for light.

Fortunately, even though most of the Portage Lakes are eutrophic, the littoral zone is still dominated by rooted plants…for now. In spite of occasional HABs, the lake ecosystem is not dominated by algae/cyanobacteria, as in severely hypereutrophic lakes.

Aquatic plants in the lakes may, in fact, help defend against HABs-dominated lakes: Nutrients incorporated in plants are unavailable for HAB growth while plants are growing.

Safeguarding the Lakes: Reduce External and Internal Nutrient Loading

The eutrophic conditions, the dense aquatic plant growth in the Portage Lakes, are the product of decades of external nutrient loading from the surrounding land and internal loading, the recycling that extends the life of the external loading for years. With high nutrient levels from recycling and continued inputs, the lakes are at risk of shifting from plant- to algae-dominated turbid conditions.

The Portage Lakes community can – and needs to – take steps to minimize or reduce further eutrophication, and protect the lakes:

- ***Reduce external nutrient loading***
- ***Reduce internal loading***
- ***Seasonal monitoring of limnological conditions and biological communities to understand the role of nutrients in the lakes.***

Reducing External Nutrient Loading - involves watershed and property management practices:

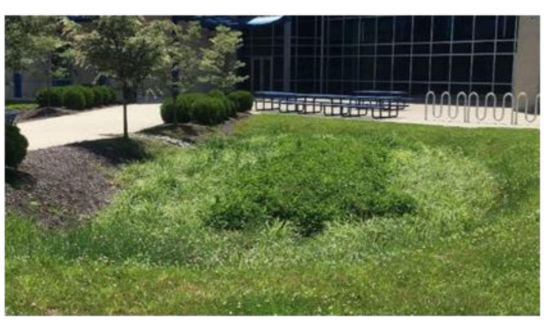
- Stormwater management to reduce or treat runoff or increase infiltration, such as rain gardens, stormwater treatment, reducing impervious surfaces, and using cover crops;
- Reduce septic system inputs, e.g., by extending sewers or septic system maintenance, siting, or replacement with non-discharging technology;
- Reducing animal waste, especially from geese along the shoreline; and
- Protecting/restoring important habitats (stream channels, deep-rooted vegetation, floodplains, wetlands, vegetated buffers) by the lakes and in the watershed.

Lessons from Grand Lakes St. Marys

These findings were highlighted in studies of HAB-dominated lakes in Ohio.

- Shutting down a lake due to long-term HAB problems is devastating to the local economy and property values.
- Fixing a lake after it shifts is *very* expensive and may not turn out as planned.
- Park managers may not have the technical background to manage lake ecosystems.
- Loss of aquatic plants was the warning sign that managers missed in Grand Lakes St. Marys.
- The first plants to become re-established may have a short growing season, allowing summer algal blooms. Stable, long-term recovery requires a diverse aquatic plant community, ensuring plant growth all season.
- It is necessary to "turn off the tap" of external nutrient loading, ***as well as*** address internal loading. Focusing on just one is not enough.
- It is very important to get to know the lakes and the watershed. Watch for changes.
- Climate change increases the risk of HABs.

S. Fletcher, n.d.; H. Paerl et al., 2021; S. Newell et al. 2021.


Watershed measures often used to reduce phosphorus loading range from use of deep-rooted native plants, trees, and shrubs to engineered measures like bioretention or restoration of stream channels and floodplains.

Watershed management is a large task, because of the number and variety of impacts in a developed watershed. However, there is a well-established knowledge base, programs, funding, and groups to carry it out. Many organizations in the Portage Lakes area are engaged in watershed management.

Studies of HABs-dominated and restored lakes have shown that

To address HABs and eutrophication,
both internal and external nutrient loading must be reduced.
Efforts that target just one source are not successful over time.

Reducing Internal Loading. Because there are so many factors affecting internal loading, there is not a single, universal solution. Depending on the lake characteristics, restoration efforts in lakes have included, among other things:

- Changing the chemistry of the water at the bottom or in the sediment, e.g., with alum;
- De-stratifying (aerating) the lake to change its structure;
- Harvesting and disposing of aquatic vegetation, which removes phosphorus from the lake but also leaves less vegetation to use up phosphorus;
- Dredging or capping sediment; or
- Changing the structure of the grazing, predatory, and bottom-feeding animal communities.

Harvesting (for navigation) can reduce internal P loading if the cuttings are removed right afterward.

It is essential to quantify internal versus external nutrient loading, including the contribution of phosphorus from sediment. The measures noted above are significant efforts that can be costly, may disrupt the lake ecosystem, and may not work as planned.[23] Choosing an approach requires full understanding of lake conditions and consideration of costs, requirements, resources, limitations, effectiveness, and impacts to the lake ecosystem of the different methods. The analyses are beyond the scope of this document and require more information about lake chemistry, processes, and plant community characteristics than is currently available.

- Managing internal loading requires focus, coordination, monitoring, and resources, which are not available now, in contrast with watershed management, which has an organizational framework, broad participation, coordination, technical background, and various sources of funding. Currently, there is no organized focus on reducing internal loading; any efforts are occurring as part of other efforts.
- The PLAC coordinates with other agencies as possible but is a volunteer organization.
- The ODNR Parks and Watercraft staff actively involved in lake management is responsible for flood and flow management, dams, and managing the park and lake facilities. These offices do not have adequate staffing, use of equipment, data, the mandate, or management options to monitor trophic conditions, coordinate efforts, and reduce internal phosphorus loading. There

is a limnologist on staff, and some expertise is available from ODNR in Columbus, but the focus is on concerns other than the health of the lake itself.

- The focus of the Wingfoot and Portage Lakes parks is on maintenance and improvements to support the visitor experience, recreation and nature education, and managing the buoys, docks, and access points in the lakes.
- The three ODNR Canal Lands staff responsible for maintaining the lake elevations, flood control, and flow into the Lake Erie basin are tasked with clearing vegetation for navigation on the Portage Lakes and elsewhere as their time is demanded. Disposing or composting harvested plant material on land is not feasible with the current level of staffing, resources, and disposal options.
- Note: ODNR will be dredging in the lakes for several years and may also be issuing contracts to reduce aquatic plants. Coordination is important to protect habitat, provide for navigation, and reduce nutrients. Dredge disposal sites could be evaluated as sites for disposing of harvested plants.

- The necessary data about limnological conditions and plant communities is minimal. Monitoring and inventories are needed to characterize the conditions, plant communities, and changes.

Aquatic plant management is part of managing internal loading and allowing for uses, regardless of other approaches used.

- Aquatic plants should be managed in a way that addresses needs of lake residents and visitors while protecting the lake ecosystem.
- Aquatic plants play an important role in the uptake and release of nutrients, which varies by species.
- It is important to use professional expertise and data to guide decisions about the most appropriate approach that balances the need for access with habitat and reducing nutrients.

Understanding what plant communities are present provides the basis for management decisions. For instance, curly-leafed pondweed, an early-season invasive plant common in eutrophic waters, takes up substantial amounts of phosphorus but then dies off early, creating anoxic areas on the bottom and releasing phosphorus that spurs new growth.[24] An approach may include insuring a more diverse plant population to spread growth and phosphorus uptake through the growing season.

Because of the potential for phosphorus uptake during the growing season, managing aquatic plants can play a part in reducing internal loading, if data about plant communities, staffing, equipment, and on-land disposal/ composting sites are available. Currently they are not. Such “phytoremediation” needs to proceed with caution, so as not to throw the lakes system out of balance into a turbid state.

Seasonal monitoring of limnological conditions and water chemistry through the water column; inventory and monitoring of aquatic plants and animals - is essential for:

- Understanding the chemical and physical lake conditions, plant and animal communities, and phosphorus loading mechanisms,

- Detecting changes, and
- Developing, implementing, and monitoring in-lake measures to address eutrophication.
- Monitoring flow between lakes would provide insight on residence time.

Ohio EPA has begun an Inland Lakes monitoring program. The Portage Lakes are not on the list, but Ohio EPA can provide some technical support and equipment for a monitoring effort.
ODNR Division of Wildlife staff periodically collects limnological data related to lake productivity, and there has been some volunteer monitoring. The limnological data available currently provides a basic understanding of certain characteristics, but additional data is needed during each growing season for each lake, for parameters related to productivity and nutrient loading, including:

- Temperature
- Dissolved oxygen (DO)
- Turbidity/clarity
- Chlorophyll A
- Phosphorus
- Nitrogen compounds
- pH
- Conductivity

  - Note: Phosphorus loading likely occurs from sediment throughout shallow urban lakes like the Portage Lakes, and it easily mixes. The sediments may have gradients of phosphorus or oxygen because of the dams and streams. It is important to take chemistry profiles at several locations within the lakes, including shallow areas, and in different settings (e.g., near developed shorelines, near streams, or near dams) not just in the deepest parts.

- An aquatic plant survey and monitoring are necessary to determine the extent, type, seasonality, and other characteristics of the aquatic plants, and to identify trends and changes.

Public Forum Questions

At the 2019 public forum, the following questions were asked about turbidity and water quality.

- Why does Hower Lake have such low turbidity when North Reservoir has much higher, even though they are so close? *-There is no Secchi data for Hower Lake; however, it is a deeper kettle lake with a small watershed and probably more limited inflow from the Main Chain. Sediment is less likely to get disturbed. Hower Lake may also have lower nutrient input and less algae.*

- Does the water get dirtier as you go from Turkeyfoot to the reservoirs?
  -There is limited water quality data for the lakes. Certain indicators from Turkeyfoot are comparable to some of the other lakes. North Reservoir is more eutrophic than the other lakes, and Nimisila Reservoir is less so. Some of the factors include watershed size and characteristics, and lake depth/volume. Long Lake receives water from other lakes and the Tuscarawas; North Reservoir is shallow in a developed watershed; Hower Lake is somewhat isolated and deep; Turkeyfoot Lake has a less developed watershed and is upstream of the others.

Key Considerations

Summary of the Portage Lakes Limnological Conditions

- 86 percent of the lakes area is in the littoral zone – the shallow, productive area with rooted plants and intense human activity, where human activities are affected by aquatic plants, and habitat areas are subject to disturbance from land- and water-based activities.
- The Portage Lakes include shallow reservoirs, and other, deeper lakes. The lakes are all stratified in the summer, limiting mixing of oxygen-rich surface waters and deeper nutrient-rich, oxygen poor waters. The lakes mix in fall and spring, but the deepest waters may not mix.
- The lakes are considered shallow urban lakes, managed, with the large development factor (perimeter) and watersheds, increasing potential for land-based impact and eutrophication.
- Turbidity, which often reflects algae growth, increases in the summer months.
- The lakes are highly productive. They are classified as eutrophic using the Carlson Trophic State Index, based on turbidity, phosphorus, chlorophyll, except for Nimisila Reservoir, which is mesotrophic. This classification is consistent with the volume of plants and nuisance algae.
- North Reservoir is the most eutrophic and has shown less improvement since the 1990s than other lakes. None of parameters measured in North Reservoir meet the state inland lakes criteria. In 2020, North Reservoir had extensive, nuisance growth (likely Eurasian watermilfoil).
- In the other lakes, some of the turbidity and chlorophyll measurements meet the state criteria, but phosphorus does not and generally has the highest trophic state index.
- Comparing recent data with records from the 1990s, turbidity has improved in all lakes, chlorophyll has improved in all lakes except North Reservoir. Some phosphorus levels have improved, some are higher.
- Phosphorus is the critical nutrient for photosynthesis, driving plant and algae growth. Recent studies indicate that both phosphorus (P) and nitrogen (N) affect HAB growth and toxicity. P and N enter as ***external*** loading from the watershed. They are recycled with growth and decay. P recycles for years as ***internal*** loading within the lakes from decay of organic matter – including aquatic plants. P is also released from sediment in anoxic water. Internal P loading occurs in the deep anoxic water and may occur throughout the lakes at the sediment-water boundary. The volume of plants indicates a great store of nutrients in the lakes and sediment, typical of urban, eutrophic lakes.
- In shallow lakes, phosphorus release in anoxic water at or within the sediment may mix throughout the lakes and continue to generate plant or algae growth during the growing season.
- Die-off of early season aquatic plants like the abundant, invasive, curly-leafed pondweed releases phosphorus and spurs new growth. Chemical application may have similar effects.

Lake Management Considerations

- Nutrient-rich lakes may switch from a plant-dominated (“clear”) to algae-dominated (“turbid”) state, with frequent HABS. Perturbations to lakes ecosystems (e.g., removing large amounts of plants) may trigger such shifts. The presence of rooted plants in the Portage Lakes is a positive sign that the lakes ecosystem is still healthy. However, eutrophic lakes with continued high phosphorus levels, as in the Portage Lakes, could become algae-dominated. This undesirable, harmful condition is difficult and expensive to reverse. Climate change impacts favor HABs.

- ***Protecting the future of the lakes requires reducing the external nutrient loading from the watershed and the internal loading within the lakes, involving land-based and in-lake actions.***
- Watershed management, which reduces *external* loading, is a well-developed discipline, with resources available to carry it out, and watershed partners already involved in the task. There is still a substantial need for documentation, external funding for projects, establishing priorities, project management and coordination by partners and, ideally, a coordinator.
- ***Protecting the lakes from further eutrophication will require a greater investment in time, staffing, equipment, monitoring, funding, and coordination than currently exists.*** Reducing internal loading is a complex, developing discipline, that involves water and sediment chemistry, aquatic plants, other biological components, as well as lake users. There is inadequate staffing or resources to carry it out, coordinate efforts, provide technical expertise and guidance, or even obtain data to characterize the lakes**.** Currently a small staff, along with a few volunteers, conduct some monitoring, manage the park, manage the water, clear vegetation for navigation, plan for projects, coordinate, work with residents, businesses, and visitors, and conduct outreach and events. Lake management is not their primary focus - in many cases, the staff and volunteers do what they can to address lake management concerns around their other responsibilities, with limited funding and resources.
- ***Protecting the Portage Lakes requires developing and implementing monitoring program(s)*** for limnology data, entering streams, and aquatic plants. ODNR Division of Wildlife staff and volunteers have collected limnological data occasionally, which provides a snapshot of lake conditions. Consistent, seasonal limnological data for each lake is needed, at different locations throughout the lakes to determine phosphorus loading, patterns, and changes. Monitoring streams will help determine input (e.g., phosphorus or bacteria), and an aquatic plant inventory with occasional monitoring is essential for characterizing the aquatic plant community, manage the aquatic plants and internal loading, and detect changes.
- The ODNR Wingfoot and Portage Lakes have the benefit of a boat, a naturalist, and at least for 2021, a naturalist intern, who could *assist* with monitoring. However, monitoring needs to be consistently done, with dedicated staff, time, and equipment from a partner agency/agencies.
- ODNR is beginning dredging and may contract for control of aquatic vegetation in limited areas with heavy traffic and intense use. This may help in certain areas and should be done in coordination with lake advisers.
- ***Managing plants and internal loading is likely to require a multi-pronged approach.*** Managing aquatic plants may be one tool that can achieve two goals – improving conditions for lake users and residents, as well as reducing internal loading. Any solution should be carefully considered, as manipulating ecosystems may have unintended consequences.

    - Control of nuisance vegetation and dredging should be done in such a way as to reduce nutrient loading and harmful effects to the ecosystem as much as possible. Use of chemicals and mowing without harvesting generates decaying vegetation, which releases phosphorus and fuels growth, dredging stirs up fine sediment, which carries nutrients and increases turbidity, even excessive harvesting may alter the plant-phosphorus balance.
    - Harvesting and on-land disposing/composting of plants would remove phosphorus from the lakes but should be evaluated in terms of resources needed and impacts to the plant-phosphorus balance, as well as other impacts (e.g., removing animals living within

the stands of vegetation). This is a substantial effort, requiring adequate staffing, funding, disposal/composting sites, background information on phosphorus uptake and impacts, and transportation. It should not be done exclusively, as excessive harvesting could disrupt the ecology and phosphorus-plant balance.

- A more diverse, native plant community would allow plant growth to better span the growing season and could reduce nuisance tangles of certain invasive species.
- Other techniques, such as alum or manipulating biological communities may be appropriate in places but should be carefully evaluated. Aeration can be useful in small isolated deep lakes but is unlikely to be beneficial in the linked shallow lake system of the Portage Lakes.

Recommendations:

Goal: Reduce external (watershed) and internal (in-lake) nutrient loading to decrease the risk of further eutrophication. This requires an in-depth understanding of lake conditions and the biological communities in the lakes, feasible approaches, benefits, impacts, and the resources to implement them.

Safeguarding the lakes, protecting them from further eutrophication, while addressing residents' concerns, requires increased emphasis, a stronger framework for lake management, including:

- Lakes management partnership and a decision-making process to provide for consistent direction, technical expertise, community engagement, a forum for discussion and outreach, coordination of efforts, and sharing resources.
- Coordinator(s) who work with the partners to identify and implement priorities, integrate efforts, provide technical background, seek funding, share resources, build partnership opportunities. Managing the lakes involves both a ***land-based approach*** to watershed/shoreline management and reducing external loading, as well as ***a water-based approach*** to coordinate monitoring, data management, aquatic plant/phosphorus loading management, and other in-lake activities. Ideally a single coordinator could address both areas.
- A structure that provides for funding source(s), coordination of responsibilities, a shared understanding and expectations among the Portage Lakes communities of what areas will be managed regularly, opportunities for community input and involvement in lake management, how decisions will be made. Lake management programs in other states operate this way.
- Consistent, seasonal monitoring of lake and stream conditions, an aquatic plant inventory and monitoring, and phosphorus budget to characterize the lakes, identify changes, and determine appropriate measures. Lake management staff need to keep abreast of current research, share information, and use the information to direct lake management efforts.
- Adequate staff, resources to carry out specific lake management measures in partnership with other agencies, partners, and volunteers.
- Increased awareness in the lakes community about the lakes system, needs, responsibilities, and opportunities.

Some of these efforts are underway already. Others that can be started soon include:

- Public outreach programs/workshops/tours/displays/website focusing on topics like lake ecology, plants, minimizing impacs, property management, lakescaping, geese. Potential audiences can include property owners, residents, boaters, anglers, community officials, and other visitors. Various partners can contribute. PLAC and SWCD already do similar work.

- Build a partnership that meets periodically to choose priorities, coordinate, review technical materials, and address concerns of the lakes community.
- Hire a coordinator for the watershed and/or lakes
- Bolster, build on existing monitoring efforts, develop preliminary guidelines, and identify resources and partners for monitoring lake and stream conditions
- Research lake management programs, funding, and in-lake phosphorus management options
- Along with wastewater management agencies, identify remedies for discharging septic systems.
- Continue to develop a coordinated aquatic plant management for docks and navigation areas, to manage plants to protect the habitat, water quality, and functions they provide, reduce internal loading of phosphorus, and accommodate the uses of the lakes, addressed further in Chapter 5.
- Continue discussions among Department of Health, wastewater treatment Management Agencies concerning the best wastewater treatment practices and feasibility for the area.

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[1] General limnological background from various sources, e.g.:
Kimball's Biology Pages, Freshwater Ecosystems. https://www.biology-pages.info/F/Freshwater.html;
Robert M. Thorson, 2009. Beyond Walden: The Hidden History of America's Kettle Lakes and Ponds. Walker and Co., New York, NY. Pp. 149-168.
J. Voshell, 2007. A Guide to Common Freshwater Invertebrates of North America. McDonald and Woodward Publishing, Blacksburg, VA. Pp. 17-37.
Walker, J.L., T. Younos, and C.E. Zipper, 2007. Nutrients in Lakes and Reservoirs – A Literature Review for Use in Nutrient Criteria Development. Virginia Tech Water Resources Center. VWRRC Special Report SR34-2007. Blacksburg, VA. https://vtechworks.lib.vt.edu/bitstream/handle/10919/49481/VWRRC_sr200734.pdf?sequence= Retrieved June, 2020.
Water on the Web, 2004. Understanding Lake Ecology. This is a closed site, but it has good background information. https://www.waterontheweb.org/under/lakeecology/index.html. Accessed May, 2020.

[2] Hans Paerl, et al., 2021. Where Do We Go from Here? Mitigating Harmful Cyanobacterial Blooms in a World Facing Human Nutrient Over-enrichment and Climate Change. Sylvia Newell et al., 2021. Nitrogen as a Driver of HABs and Toxins: The Missing Modeling Link? Both talks presented at Understanding Algal Blooms, State of the Science Virtual Conference, Sept. 8, 2021. Ohio Sea Grant/Ohio State University. Archived at: https://ohioseagrant.osu.edu/news/calendar/2021/09/08/rz151/state-of-the-science?utm_source=Ohio+Sea+Grant+and+Stone+Lab&utm_campaign=f238ceca56-EMAIL_CAMPAIGN_2019_05_22_01_28_COPY_01&utm_medium=email&utm_term=0_84c2c6f5d9-f238ceca56-424285100; May be viewed at: https://www.youtube.com/watch?v=Exc9zfVYjRY

[3] Data Source: C. Wagner, 2020. ODNR Division of Wildlife, District 3.

[4] Map Sources: ODNR. Bathymetry data and depth points for Portage Lakes and Nimisila Reservoir. https://ohiodnr.gov/wps/portal/gov/odnr/business-and-industry/services-to-business-industry/data-records/metadata-downloads Retrieved Feb., 2017. Bathymetry data currently available at: https://ohiodnr.gov/wps/portal/gov/odnr/business-and-industry/services-to-business-industry/gis-mapping-services/gis-mapping-services

[5] USGS StreamStats https://streamstats.usgs.gov/ss/ . Accessed March, 2021.

[6] Modified from Florida Lakewatch, 2001. A Beginner's Guide to Lake Management: Lake Morphometry, 2nd ed. Information Circular 104. University of Florida Dept. of Fisheries and Aquatic Sciences. Gainesville, FL. Accessed 6/22/2020 from https://edis.ifas.ufl.edu/pdffiles/FA/FA08100.pdf.

[7] Table Modified from Florida Lakewatch, 2001. Ibid. Akron wind information from Weather Underground, 2020. Akron, OH Weather Conditions. https://www.wunderground.com/weather/us/oh/akron, accessed Feb., 2021; Weather Spark, 2020. Average Weather in Akron, OH. https://weatherspark.com/y/18132/Average-Weather-in-Akron-Ohio-United-States-Year-Round accessed Aug., 2020.

[8] Stephanie Mitchell, 2015. Sediment Dispersal Processes and Anthropogenic Impacts at Rex Lake, Summit County, Ohio. Masters Thesis. University of Akron, Akron, OH.

[9] Map source: NHD, 2016; ArcGIS watershed mapping using USGS 2018 data; ODNR dams; Summit, Stark, Portage Co. GIS

[10] Data Source: C. Wagner, 2020. Op. Cit. Map sources: Summit Co. GIS ODNR Dams and Bathymetry data; NHD.

[11] Various writers have noted the susceptibility of shallow, connected, "urban" lakes to eutrophication, including:

Naselli-Flores, 2008. Urban Lakes Ecosystems at Risk, Worthy of the Best Care. In Sengupta, M. and Dalwani, R. (Editors). 2008. Proceedings of TAAL2007, the 12th World Lake Conference.1333-1337. https://www.researchgate.net/publication/228465620_Urban_Lakes_Ecosystems_at_Risk_Worthy_of_the_Best_Care Accessed Feb. 2021.

Dale Robertson and Matthew Diebel, 2020. Importance of Accurately Quantifying Internal Loading in Developing Phosphorus Reduction Strategies for a Chain of Shallow Lakes. Lake and Reservoir Management. 3(4):391-411. Taylor and Francis Online. Published online July 2020. DOI: 10.1080/10402381.2020.1783727 https://www.tandfonline.com/doi/full/10.1080/10402381.2020.1783727 Retrieved Feb., 2021.

Tom Schueler and Jon Simpson, 2001. Why Urban Lakes are Different. Wat. Prot. Techniques 3(4): 747-750. https://owl.cwp.org/mdocs-posts/schuelert-_why_urban_lakes_are_different/ Retrieved June, 2020.

[12] Table modified from North American Lake Management Society (NALMS) 2020. Trophic State Equations. . https://www.nalms.org/secchidipin/monitoring-methods/trophic-state-equations/ (excerpted from Carlson, R.E. and J. Simpson. 1996.A Coordinator's Guide to Volunteer Lake Monitoring Methods (North American Lake Management Society. 96 pp.)

[13] S. B. Watson, E. MacCauley, and J. Downing, 1997. Patterns in Phytoplankton Taxonomic Composition Across Temperate Lakes of Differing Nutrient Status. Limnol. Oceanogr. 42(3):487-495. American Limnological Society. https://aslopubs.onlinelibrary.wiley.com/doi/10.4319/lo.1997.42.3.0487 retrieved April, 2020.

[14]Ohio Dept. of Health, 2018. Know Our Programs, Harmful Algal Blooms. HABS photos. *https://odh.ohio.gov/wps/portal/gov/odh/know-our-programs/harmful-algal-blooms/media/habs-photos*

[15] Many writers describe the shift in ecological equilibrium between clear and turbid states. For example:

EcoShape, 2021. Clear and Turbid Lakes. https://www.ecoshape.org/en/knowledge-articles/sediment-and-ecology-in-delta-lakes/1-clear-and-turbid-lakes/ retrieved Feb., 2021.

Marten Scheffer and Egbert H. Van Nes, 2007. Shallow Lakes Theory Revisited: Various Alternative Regimes Driven by Climate, Nutrients, Depth, and Lake Size. Hydrobiologia 584:455-466. Springer Link: https://link.springer.com/article/10.1007/s10750-007-0616-7 Retrieved Feb., 2021.

Istvan Tatrai et al., 2008. Abrupt Shift from Clear to Turbid State in a Shallow, Eutrophic, Biomanipulated Lake. Hydrobiologia 620(1): 149-161. https://www.researchgate.net/publication/226817493_Abrupt_shift_from_clear_to_turbid_state_in_a_shallow_eutrophic_biomanipulated_lake Retrieved Feb., 2021.

[16] Kelly Shaw, 2013.Assessing Two Centuries of Anthropogenic Impacts, Silver Lake, Summit County, Ohio. Masters Thesis, University of Akron. Akron, OH; M. Hilovsky 2017. Presentation to NEFCO's ERTAC.

[17] Secchi disk data 3 lakes Data Source: Citizens Lake Awareness and Monitoring data from Ohio Lake Management Society webpage http://www.eyesonthewater.org/olms/ (2018)

[18] NALMS 2020, Op. Cit. Data sources: C. Wagner, 2020, Op. cit. Ohio Dept. of Health 2013 images; Ohio EPA 2010; Ohio EPA, 2010. https://epa.ohio.gov/Portals/35/rules/nutrient_criteria_document_2010.pdf

[19] Ohio EPA 2010, ibid.

[20] During the growing season, Ohio EPA obtains monitors satellite data for cyanobacteria in many lakes and sends out weekly reports. (The pixel size of the images is 30m x 30m, so lakes must be large enough to show pixels without interference from the shore.)

Webinars address several examples of hypereutrophic, "turbid state" lakes in Ohio, for example: Fletcher, S. n.d. Short and Long Term Strategies to Reduce Harmful Algal Blooms in Ohio Lakes.Webinar on Ohio Watershed Network, Ohio State University Extension. https://ohiowatersheds.osu.edu/resources/best-practices/short-and-long-term-strategies-address-harmful-algal-blooms-ohio-lakes Accessed April, 2020.

Articles in the Cleveland Plain Dealer also noted that inland lakes were experiencing algal blooms. For example: Brian Albrecht, 2020. Several Inland Lakes Battling Same Algal Blooms as Lake Erie. Cleveland Plain Dealer. https://www.cleveland.com/news/2020/04/several-inland-lakes-in-ohio-battling-same-algal-blooms-as-in-lake-erie.html; Brian Albrecht, 2020b. Toxic Algae Also Threatens Ohio's Inland Lakes and Waterways. Cleveland Plain Dealer. https://www.cleveland.com/news/2020/04/several-inland-lakes-in-ohio-battling-same-algal-blooms-as-in-lake-erie.html.

[21] H. Paerl et al., 2021 and S. Newell, et al. 2021, op. cit.

[22] There are a number of articles on the importance of internal phosphorus loading in lakes and the role of sediment, including:

Stephen Carpenter, 2005. Eutrophication of Aquatic Systems: Bistability and Soil Phosphorus. PNAS 102(29):10002-10005. https://www.pnas.org/content/102/29/10002 Retrieved Feb., 2021.

S. Fletcher, n.d. Op. cit.

Sabine Hilt et al., 2017. Response of Submerged Macrophyte Communities to External and Internal Restoration Measures in North Temperate Shallow Lakes. Front. Plant Sci., 19 February 2018 https://doi.org/10.3389/fpls.2018.00194 Retrieved Feb., 2021.

M.C. Randall, et al. (2019) Sediment potentially controls in-lake phosphorus cycling and harmful cyanobacteria in shallow, eutrophic Utah Lake. PLoS ONE 14(2):e0212238.https://doi.org/ 10.1371/journal.pone.0212238

Robertson, D.M. and Diebel, M.W. 2020. Op. cit.

M. Sondergaard, J.P. Jensen, J.P., and E. Jeppesen, 2001. Retention and internal loading of phosphorus in shallow, eutrophic lakes. TheScientificWorld 1, 427–442. https://www.researchgate.net/publication/10708991_Retention_and_Internal_Loading_of_Phosphorus_in_Shallow_Eutrophic_Lakes retrieved June, 2020.

Sondergaad, M., Jensen, J.P., and Jeppesen, E. 2003. Role of Sediment and Internal Loading of Phosphorus in Shallow Lakes. Hydrobiologia 506–509: 135–14. http://www.colby.edu/chemistry/EastPond/BioManipPDF/Sondergaard%202003.pdf retrieved June, 2020.

Gabrielle Thiebaut, 2008 . Phosphorus and Aquatic Plants. In P.J. White and J.P. Hammond (eds). The Ecoy-Physiology of Plant-Phosphorus Interactions, ch. 3. Springer Science and Business Media. https://link.springer.com/chapter/10.1007/978-1-4020-8435-5_3 retrieved Feb., 2021

Walker, J.L., T. Younos, and C.Zipper, 2007. Op cit.p. 28.

[23] For example:

S. Fletcher, n.d., Op. cit.;

Jan J. Kuiper, et al. 2017. Mowing Submerged Macrophytes in Shallow Lakes with Alternative Stable States: Battling the Good Guys? Environmental Management (2017) 59:619–634 DOI 10.1007/s00267-016-0811-2 https://link.springer.com/article/10.1007/s00267-016-0811-2. Retrieved Feb., 2021.

M. Sondergaard, et al., 2007. Lake Restoration: Successes, Failures, and Long-Term Effects. Journal of Applied Ecology. 2007 44: 1095-1105. https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/j.1365-2664.2007.01363.x Retrieved Feb., 2021.

[24] Steven Heiskary and Ray D. Valley. 2012. Curly-Leaf Pondweed Trends and Interrelationships with Water Quality. Minnesota Department of Natural Resources Investigational Report 558. https://www.researchgate.net/publication/230846292_Curly-leaf_pondweed_trends_and_interrelationships_with_water_quality

Chapter 5 – Overview
Habitats, Wildlife, and Aquatic Plants

The vegetation of the lakes is a major part of the interlinked system that affects the health of the lakes – and the sustainability of lake uses, providing varied habitats and shade, processing nutrients, and stabilizing sediment. Aquatic vegetation is interwoven with the lake processes, using nutrients for growth and releasing them during decay, affecting growth of algae – and HABs. High levels of phosphorus in the eutrophic water and sediment drive the lush growth along the lake margins – and would grow algae/HABs if not for the plants. Invasive species, which favor eutrophic water and silt, create dense tangles. Sustaining multi-use lakes requires active management of the plants - and uses - as part of a complex system of nutrients, lake processes, plants, landscape, and people, providing for conservation and access. An aquatic plant management program integrates information about plants and the ecosystem, shared priorities, and feasibility of control measures. Increasing awareness and involvement of lakers and lake managers is essential, to build understanding of the complex system, develop shared priorities and carry out management measures. This level of management requires a greater level of coordination, resources, and focus among the lake community and managers. A partnership among communities, lakers, and agencies may help provide coordination, shared resources, and funding.

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5. Habitats, Wildlife, and Aquatic Plants

As noted in Chapter 4, plants play important roles in the health and habitats of the lakes:

- Primary producers
- Habitat for fish, insects and other macroinvertebrates, birds, amphibians, reptiles, mammals, providing shelter and areas for forage and spawning.
- Nutrient processing and recycling, taking up and storing nutrients from the watershed, water, and sediment during growth, returning nutrients to the sediment and water during decomposition.
- Stabilizing sediment.
- Dampening wave action
- Adding to scenic beauty.

Also as noted, the dense growth of aquatic plants, while important for water quality, can become a nuisance to the people using the lakes. A central question of this plan is

➢ How can aquatic plants be managed in such a way as to protect the health and habitats of the lakes while accommodating the uses by residents and visitors?

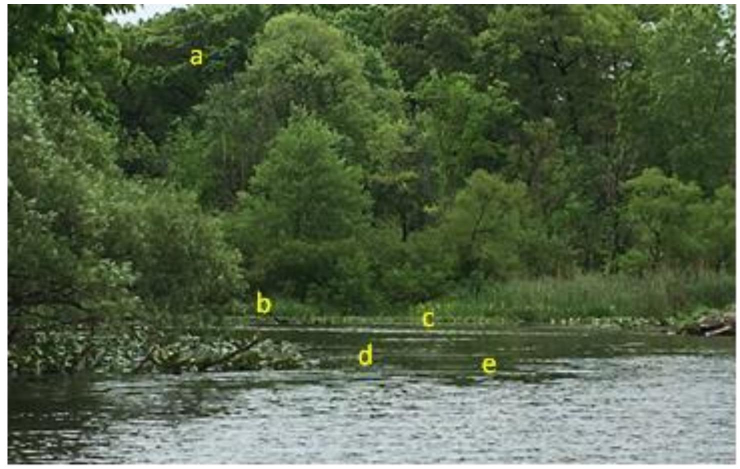
This chapter discusses the role and types of shoreline habitat; wildlife (briefly); aquatic plants and aquatic plant management considerations.

Shoreline Habitat - Background

The portion of the landscape with the greatest effect on water quality and habitat is along the water's edge, whether it is a stream or lake.

Natural Shorelines

Shoreline habitat is important for lake health. In undisturbed lakes, the habitat gradient extends from the upland woods through wetlands and shoreline, and into the littoral zone.



The natural habitat gradient to the lake by Wonder Lake Creek in Knapp Park, proceeding down from a) upland woods to b) wetlands, c) emergent, and d) floating leaved plants. Submerged plants (e) were present but are not visible in the picture

Natural shorelines provide benefits, including:[1]

- Complex habitat, supporting many species;
- Shade and cover for aquatic species;
- Allow animals to move between different types of habitat;
- Slow stormwater runoff;
- Soak up nutrients, filter out sediment; and
- Resilience to wave action, reducing erosion and sediment disturbance.

The Root of the Matter

The deep roots of the native plants do work:

- Slowing water flow from inland
- Allowing rainwater to infiltrate into the ground instead of flowing into the lake
- Taking up nutrients – especially important if nearby septic systems are releasing nutrients
- Reducing erosion – "nature's rebar"

The roots of plants are often proportional to the biomass above the soil. Lawns that are three inches tall are healthier than shorter lawns, because their roots go deeper. Lawns provide a small benefit in taking up nutrients or stormwater. Taller native plants and shrubs are much better, with much deeper roots often extending many feet into the ground, improving lake water quality.

Illustration: The roots of native upland plants, like coneflower, may grow many feet deep to reach water. Lakescaping or vegetated buffers may use upland plants farther from the water and wetland plants, like, blue flag, sedges, or pickerelweed near the water. The roots of wetland plants are not as deep as upland plants but still deeper than turf, intercepting water that would go to the lake.

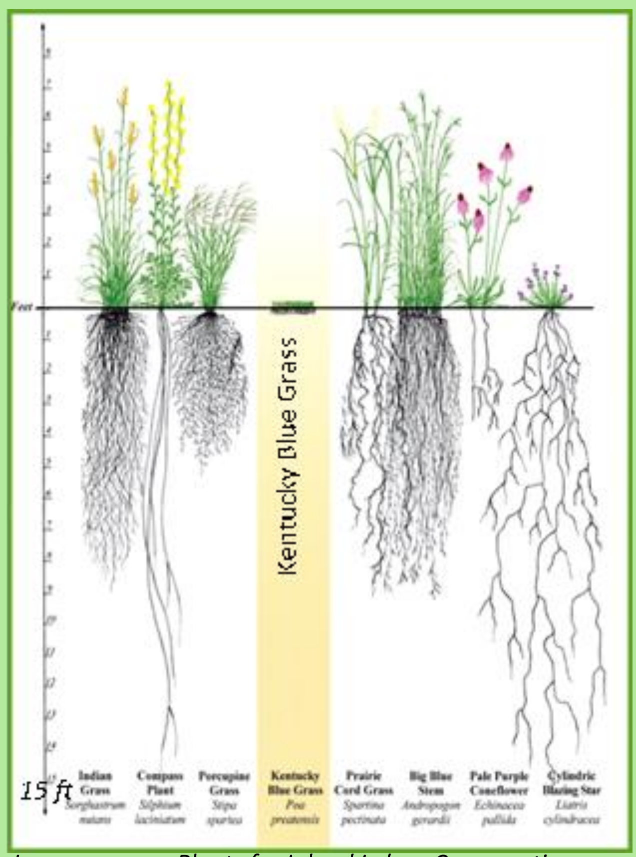


Image source: Plants for Inland Lakes, Conservation Research Institute adapted by Tip of the Mitt Watershed Council, Michigan Natural Shoreline Council.

Hardened Shorelines and Turf

In contrast to natural shorelines, hardened shorelines and turf:

- Allow storm water runoff to flow directly to the lake, carrying in all the contaminants it picks up
- Increases input of nutrients, chemicals from properties
- Reduces habitat, biodiversity, and movement of animals
- Disrupt the lake food web
- Reduces cooling of the water
- May increase erosion, as wave energy reflects back from the wall to the sediment. Turf roots are so shallow that they do little for erosion control.

Geese are attracted to large expanses of turf near the water:

- Geese forage on turf
- Geese avoid tall vegetation.
- Geese favor open sites near the water, where they have clear access to the water.

Naturalizing the Lake Shoreline – Natural Buffers/Lakescaping[2]

People living along the shoreline can improve water quality and habitat with natural buffers and lakescaping. Planting portions of the shoreline with tall native plants, shrubs, and trees instead of turf provides numerous benefits, including:

- Reducing maintenance and chemical use– watering, mowing, fertilizing, pesticide use
- Attracting pollinators and birds
- Reducing stormwater runoff into the lakes
- Improves water quality - especially where deep roots intercept nutrients from septic systems
- Improves erosion control – natural shorelines dampen waves, deep roots hold soil. Using plants to stabilize shorelines costs less than hardened materials.
- Taller vegetation discourages geese!

Shorelines can be restored and stabilized with vegetation.

Note: It is important to use plants native to the area and appropriate for the lakeshore setting, sun, soil, wind.

View of Lakescape One in summer. Stormwater retention area to the right.

Live cribwall, summer 2005.

Right: Michigan lakescaping demonstration projects. Above right example includes a shallow stormwater retention area, reducing runoff. Tall native plants intercept nutrients, provide habitat, reduce lawn maintenance, and discourage geese. Lower right example - a living cribwall is an engineered structure that reinforces the shoreline while still providing water quality benefits, habitat, cooling, and pathways for animals. Images: MI Inland Lake Shorelines, 2012.

Portage Lakes Shoreline and Habitats

Natural Lakeshores and Natural Heritage Sites

Much of the shoreline is natural in the parks. The complex habitat supports many types of animals – birds, fish, amphibians, reptiles, insects, and other invertebrates. The vegetation cools the water and provides cover, food, pathways for movement between habitat types, shoreline stabilization, and water quality benefits.

Top right, Latham Bay in Portage Lakes State Park, Turkeyfoot Lake; above left, Mud Lake near Cottage Grove Cr. Above center and right, Nimisila Reservoir, east side.

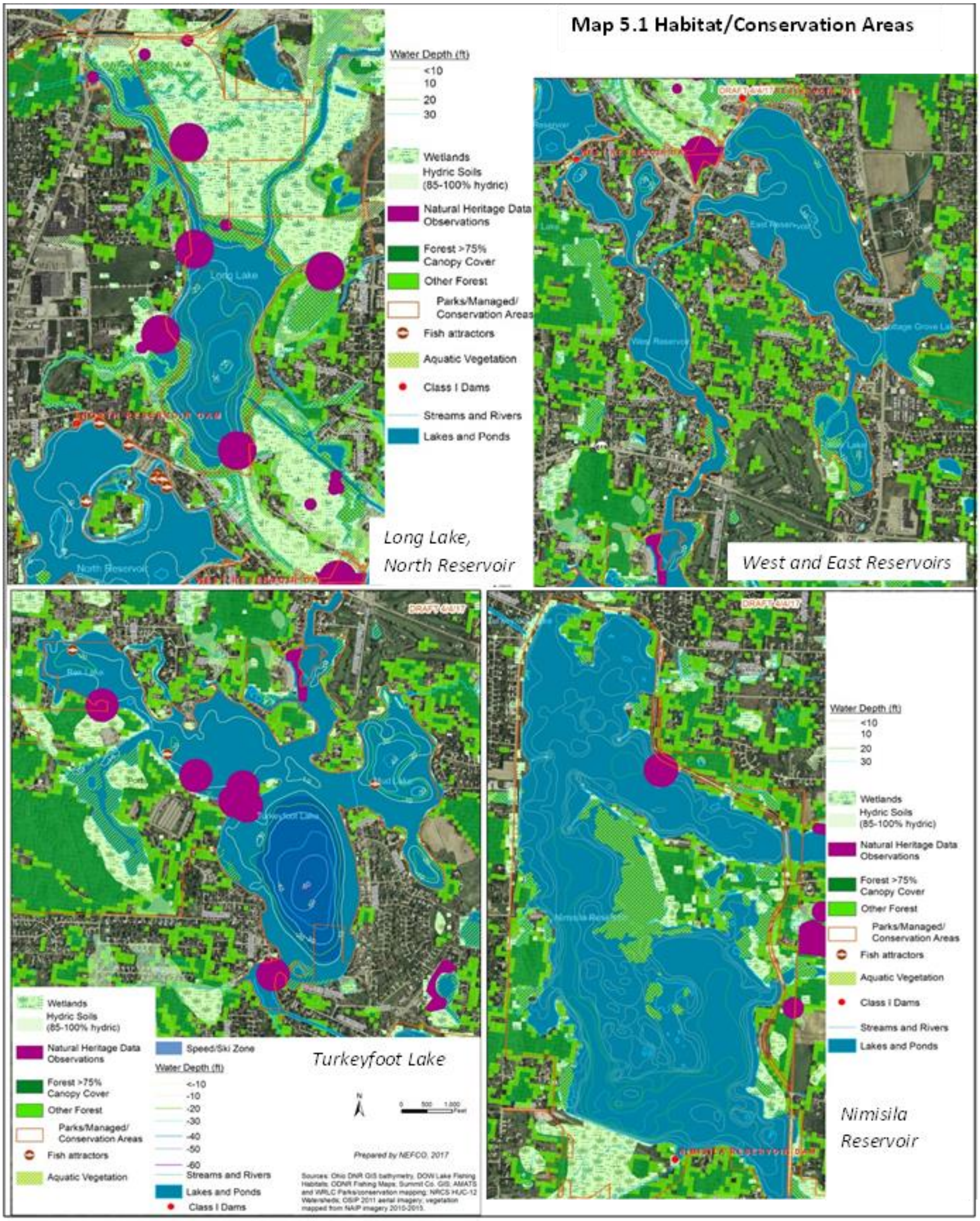
Map 5.1 shows important habitat features, including tree canopy percent coverage, wetlands, and Natural Heritage species observations.[3] Wetlands are shown as pale green, tree canopy as more intense green, developed areas as grey or other dark colors.

Long Lake, Turkeyfoot Lake, and Nimisila Reservoir have wetlands and 50 natural heritage database sites (Table 5.1), most of which are vascular plants . Much of the natural environment around these lakes, shown here, is protected as parks and conservation lands.

Table 5.1 Natural Heritage Database Sites Portage Lakes

	Terrestrial Community	Vascular Plant	Vertebrate
Long Lake	1	20	5
Turkeyfoot		7	2
Nimisila Res		14	2

Extensive wetlands at Long Lake are owned or managed by the State of Ohio (DNR), Summit Metro Parks or Cleveland Museum of Natural History. Above –Long Lake seen across wetlands at southeast; right – Long Lake wetland from Cove Road boat ramp.


Map 5.1 Habitat/Conservation Areas
Water Depth (ft)
<10
10
20
30
Wetlands
Hydric Soils (85-100% hydric)
Natural Heritage Data Observations
Forest >75% Canopy Cover
Other Forest
Parks/Managed/ Conservation Areas
Fish attractors
Aquatic Vegetation
Class I Dams
Streams and Rivers
Lakes and Ponds
Long Lake
Long Lake, North Reservoir
North Reservoir
West and East Reservoirs
East Reservoir
West Reservoir
DRAFT 4/4/17
Turkeyfoot Lake
Speed/Ski Zone
<-10
-10
-20
-30
-40
-50
-60
Prepared by NEFCO, 2017
Sources: Ohio DNR GIS bathymetry, DOW Lake Fishing Habitats; ODNR Fishing Maps; Summit Co. GIS; AMATS and WRLC Parks/conservation mapping; NRCS HUC-12 Watersheds; OSIP 2011 aerial imagery; vegetation mapped from NAIP imagery 2010-2015.
Nimisila Reservoir

Developed Shoreline

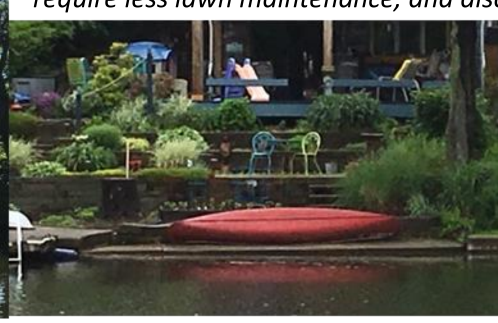
Map 5.1 shows that much of the shoreline outside the parks is developed, hardened, and landscaped with turf. Some property owners have retained trees, which provide shade for them and fish, and may shade out aquatic plants. Shrubs provide stormwater benefits, require less mowing watering, and lawn chemicals, and may provide habitat for birds or pollinators.


Above, uses integrated with a natural shoreline. Left, fishing dock at State Park Boat Launch is tucked in the vegetation. Right, natural shoreline along the golf course provides habitat and intercepts nutrient-laden runoff.



Above, some high visibility public lands (e.g., State Park boat launch, left, State Mill Rd. fishing access, center) would be good lakescaping demonstration sites, as at Confluence Park (right)

Various developed shorelines. Trees, shrubs, and tall grasses provide shade for people and wildlife, increase habitat, improve water quality, require less lawn maintenance, and discourage geese.




Where Trees and Shrubs Do Not Belong

Some lakeshores are not appropriate places for trees and shrubs or natural shorelines. The Iron Channel (right) is a maintained channel between East and West Reservoirs.

Tree roots damage earthen berms (Nimisila Reservoir, lower left), and the newly reconstructed dams, with concrete cores, do not support plant life well (lower right).

Fisheries[4]

Sport Fish

The Portage Lakes are known for bass fisheries, supporting a half-dozen fishing tournaments and club events per week during the open water season, with catches of 15-pound limits a frequent occurrence.[5]

The ODNR Division of Wildlife monitors fish populations through its Inland Management System and stocks channel catfish in all the lakes and walleye in Turkeyfoot Lake.[6] (ODNR formerly stocked walleye in Nimisila Reservoir, but stopped, due to low adult recruitment.)

Primary sportfish species in the Portage Lakes include:

- Largemouth Bass
- Bluegill Sunfish
- Redear Sunfish
- Pumpkinseed Sunfish
- Green Sunfish
- Black Crappie
- White Crappie
- Yellow Perch
- Channel Catfish

Non-Sport Fish

- Gizzard Shad is the primary forage (prey) fish species throughout the Portage Lakes. They are a good indicator of overall productivity and may be monitored in the future.
- Other species such as common carp, white sucker, yellow bullhead, warmouth sunfish are in the Portage Lakes but are not notable sportfish species.
- Grass pickerel and possibly chain pickerel, found in low abundance, are not targeted sportfish.
- Other species: of note White Perch have become established throughout the Portage Lakes and densely in North Reservoir. This is an undesired, invasive species, which eats eggs of other fish, competes for food and hybridizes with other fish, and can disrupt the fish community.[7]

Aquatic Vegetation and Fish

Aquatic vegetation supports fish and other wildlife in many ways, including: providing oxygen, substrate for micro-organisms and eggs, habitat for macro-invertebrates, food for herbivores, food sources for carnivores, cover for small prey like juvenile fish, and habitat for foraging fish and other animals. A diverse aquatic community provides the greatest benefit.

Invasive plants, such as Eurasian watermilfoil, often dominate the native plants and create dense tangled monocultures that shade out native plants. Such dense growth may affect fisheries by reducing predation of larger fish on smaller ones, reducing food available for larger fish and resulting in an over-population of smaller fish with inadequate food. In the Portage Lakes, dense stands of aquatic plants like Eurasian watermilfoil does not seem to have affected the sunfish or bass population size structure (with average to above average sizes of sunfish and growth rates). In smaller ponds, such dense growth may favor small fish over large predators, resulting in small sunfish size. However, the Portage Lakes system is likely large enough that the size structure of fish populations is not affected.

Canada Geese

The Portage Lakes provide an ideal situation for geese: open water on which to land surrounded by open greenery (turf) for food. Geese are unwelcome residents for several reasons:

- Goose droppings are unsightly and a source of nutrients and bacteria to the water.
- They can damage lawns, remaining and feeding in one location during nesting and while raising goslings. This also increases erosion.
- They can be aggressive with people.
- They interfere with traffic on the roads.

Geese are protected under the Migratory Bird Act of 1918. According to the Ohio State Extension, it is illegal to pursue, hunt, wound, kill, or capture migratory birds, nests, or eggs, outside of hunting season or without a permit. Ohio has a special permit for hunting geese. (Check with ODNR Division of Wildlife.) However, hunting is not usually an option in densely settled areas.[8]

There are several strategies for reducing goose problems. The most effective approaches rely on several strategies and persistence. OSU Extension recommendations include:

- *Don't feed the geese.* Human food is not healthy for them. Feeding them encourages them to visit and nest near homes, increasing the potential for encounters with aggressive geese.
- *Barrier fencing. S*tringing taut wire or string along the water prevents access to lawns. Two lines, six and 18 inches from the ground, makes it difficult for the geese to step over or duck under the lines.
- *Use taller plants and shrubs in lakescaping*. Tall plants at the edge of the water interrupts the field of view to the water and discourages geese. The taller plants, especially native plants, provide water

quality benefits, attract pollinators, and require less maintenance once established. Lakescaping can be preserves water views and access. A buffer of 24 inches tall and ten feet wide is recommended. Shrubs that overhang the water also provide shade for fish.

- *Repellants*. OSU Extension notes two types of repellants registered with the US EPA as of 2010. These make grass unpalatable or give geese stomach discomfort (methyl anthranilate, MA, and anthraquinone AQ, respectively). The repellants remain after rain and do not degrade to harmful chemicals, but they diminish with mowing. The entire grass area must be treated, or the geese will move to untreated grass. They are expensive and best used with other strategies. Make sure they are registered with the US EPA.
- *Harassment.* People can legally harass geese. Harassment is effective against geese that are not nesting, tending young, or molting in June-July. This requires persistence and quick response:
    - Chase away the geese quickly before they nest, from February through April.
    - Harass flocks of young geese that are not nesting
    - Herd families off the property, then put up a barrier or repellant.
    - Geese that have eggs or young will not likely move from the property.
    - After chasing the geese off, use a barrier or repellant to prevent them from returning.
    - Dogs are effective at harassing geese. They have more energy and interest in harassing geese than people do. Sunset (roosting time) is a good time for chasing geese.
    - Noisemakers can startle geese when they first arrive, but they may become accustomed to the noisemakers over time. Noisemakers have little effect on nesting geese.
- *Balloons, Mylar Tape, Flags, Scarecrows.* Brightly colored objects that flap in the wind may discourage geese initially, especially highly visible objects with large prominent "eye spots."
- *Predator Decoys.* These may work if they are highly visible and are moved around frequently (e.g. weekly). Coyote decoys can be effective, as they are natural predators of geese and eggs.
- *Remove Domestic Waterfowl.* Domestic waterfowl, which attract geese may be removed.
- *Special Permits.* Goose eggs may be addled (shaken) under permit. Geese will sit on the inert eggs without realizing they will not hatch.

Other Animal Species of Note

Invasive zebra or quagga mussels have been found in the lakes for over a decade. Water transparency has been increasing, possibly due to filtering by the mussels.

Cormorants, once a threatened population due to DDT, are considered a nuisance because of their acidic waste and the damage they cause to vegetation. ODNR is considering measures to reduce their population.[9]

Image Source: ODNR Division of Wildlife.

Purple martins – Residents and parks have installed purple martin boxes. There is a Purple Martin festival each year, and volunteers conduct tours for hundreds of schoolchildren each year to view and learn about the birds.

Aquatic Plants in the Portage Lakes

The aquatic plants of the Portage Lakes are a crucial part of maintaining water quality, lake health, habitat, and fisheries and provide numerous benefits. Rooted aquatic plants have become more widespread recently, according to observations by boaters and ODNR Division of Wildlife staff. The dense growth can be a nuisance to people living on and using the lakes. Accommodating the uses of the lakes while protecting the ecosystem health, maintaining flood control and flow will require management of the aquatic plants.

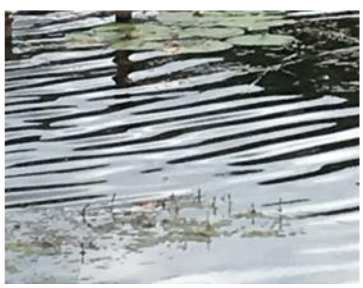
Managing aquatic plants requires knowledge of the types and locations:

- It is necessary to understand their role in the phosphorus budget. In order to be effective, management practices need to be specifically tailored to the species' growth patterns, seasons, reproduction methods, and benefits.
- Changes to aquatic plant communities must be tracked along with limnology, to determine the effect of any management measures or other changes to the system.

Eugene Braig, OSU, describing aquatic plants on a lakes visit.

During this study, NEFCO staff were able to view sites along the shoreline of most lakes by boat or from access points, over several visits. Where possible, staff determined species or species groups (e.g., pondweeds.) Over 1,200 geotagged photographs were mapped. The result gives a general sense of the type and extent of aquatic plants, but it is not an inventory:

- Certain seasonal growth was missed
- Observations were what was visible from the boat or shore.
- Plant species were identified in only some cases. Often, determining species would require more expertise, equipment, or direct access to the plants than available.



Left - "spring weeds." Curly-leafed pondweed grows densely in spring, choking passageways, and then dies back. Two spring boat trips allowed viewing of portions of the spring growth. Right – What kind of plant is it? Often several types grow together, and distinguishing them can be difficult from a distance. However, the summer flower spikes of Eurasian watermilfoil are visible above the water surface.

The extent of aquatic plants was estimated from visual observations and approximate mapping using the geotagged photos. In contrast, aquatic plant inventories sample along transects to determine species type, density, diversity, extent, and gradients.

In this study, certain plant types were grouped together due to difficulty in identifying individual species (e.g., floating-leafed pondweeds, thin-leafed pondweeds, and some similar Naiads.) In some areas, it was only possible to identify presence of aquatic plants, rather than type.

Aquatic Plants – Observations

Map 5.2 and Table 5.2 present the extent and types of aquatic plants observed mostly during the 2017 trips, as well as other visits. (See Appendix F for more maps and images of aquatic plants observed.) For the purposes of discussion, "macrophytes" or "aquatic plants" refers to rooted and floating plants, as well as filamentous algae (often *Cladophora*) and certain macroscopic algae species like chara.

The Portage Lakes produce extensive aquatic macrophyte growth. Cursory observations note aquatic plants in approximately 1,000 acres. The lakes have approximately 1,700 acres of shallow littoral/plant zone of less than 20 feet deep, 1,000 acres in 0-10 feet depth.



Left – Extensive beds of aquatic plants in northern Long Lake, likely Eurasian watermilfoil. Center – Eurasian watermilfoil (flower spikes visible) at docks. Right – eel grass

- Lake boaters and ODNR Division of Wildlife have noted an increase in aquatic plant beds, which are now growing in deeper water. Residents have noted more growth of "eelgrass," which washes up on shore. Deeper growth of aquatic plants may result from zebra or quagga mussels increasing water clari ty or other shifts in the ecosystem.

- There are large stands of native plants, e.g., eelgrass and thin-leafed pondweeds. In many areas, native plants are mixed in with invasive species. Examples include Nimisila Reservoir, the channel between West Reservoir and Turkeyfoot Lake, and portions of Long Lake.

Eel grass, spatterdock, Eurasian watermilfoil.

Invasive or Native?

The plant observations distinguish between invasive and native plants. Invasive plants are non-native species that establish their own reproducing population and can spread rapidly, causing harm and overtaking native species. [1] These species cause harm by out-competing the diverse high-quality habitats of native species and creating dense mats that choke passageways and infest docks. They do provide some habitat value, and they use phosphorus while growing. However, they increase phosphorus available in the summer when they fragment or die off. Stagnant water created by dense stands may harbor mosquitoes or parasites that cause swimmer's itch.

These species share characteristics that make them successful in the lakes and a nuisance to lake users:

- They grow tall quickly, creating dense mats that shade out native species and impede travel.
- They tolerate disturbed settings and silt bottoms better than native plants.
- They tolerate low light, deeper, turbid water.
- They grow well in eutrophic waters.

Both native and invasive plants can be considered a nuisance. Invasive plants tend to create dense masses. Some native plants, such as water lily, can grow very densely in shallow water.

Map 5.2 Observed Aquatic Plants - Summary

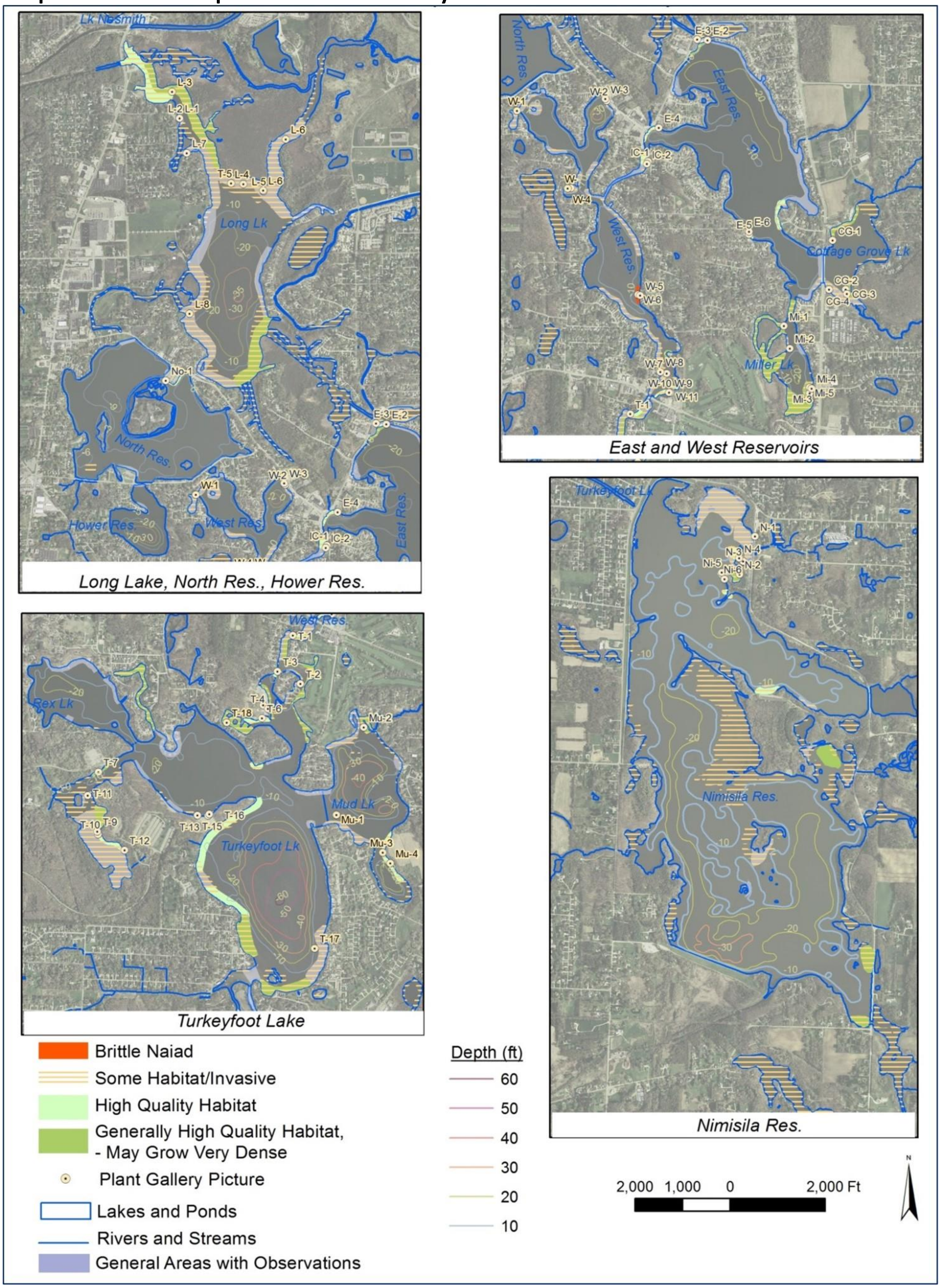


Table 5.2 Species Observed (See Appendix F for more detailed maps and Plant Photo Gallery)

Plant/Alga	**Comments**	**Plant Gallery Photos***
	Invasive/Harmful	
Eurasian watermilfoil	Found extensively along margins, by docks, in coves, Nimisila Res. Reproduces by fragments. Can grow to 30 feet tall.	L 3-8 E 4,5 CG 1-3 Mi3 W 1-4 W8 W10 T1,3,12 Mu1 Ni 1,4
Curly Leaf Pondweed	Found in several locations. Blooms early, dies off, reproduces by fragments. Can grow to 15 feet tall, boaters report some areas nearly impassable in spring.	W9 CG3
Brittle Naiad	Only observed at one location. Reproduces by fragments.	W6
Lyngbya	Small amounts found in Turkeyfoot Lake, pontoon boat pilot has found some. This filamentous cyanobacteria can be toxic, harbors e.coli, and may colonize areas where plants have been eradicated.[10]	No photo
Hydrilla	Highly invasive. NOT OBSERVED. Need to watch for it.	
	Native Plants	
Water Lily/ Spatterdock	Extensive beds near golf course, W. Res., Nimisila, Long Lake wetlands. Some near dock areas and wetland/woods habitat.	L1-3 CG4 Mi 2,3 W11 T2-6 T11 Mu2 Ni2
Filamentous Green Algae	Colonizes other plants. Often found with Eurasian watermilfoil. Found in coves, near margin. *Cladophora* may be a nuisance.	L3-6 E1,2,5,6 Mi1,3 T12
Coontail	Not rooted. Found near State Park boat launch ramp, Miller Lk.	Mi5 T8,13
Eelgrass	Extensive stands near state park, s. Turkeyfoot Lake, Cat Swamp. Smaller amounts found in various areas, sometimes mixed with invasives or other species. Anecdotal reports that beds are spreading to deeper water.	E2,3,6 IC2 T3,16
Var. Thin-leafed pondweeds	Found in various locations in Turkeyfoot, Nimisila Res.	No-1 E4 W5 W10 T9,10 Ni6
Floating-leafed pondweeds	Large areas in Nimisila Res.	Ni3, 4, 6
Muskgrass (chara)	Complex branching alga. One stand observed in Mud Lake	Mu4
Duckweed	Tiny floating rooted plant. Observed in still water, and at edges.	L6
Mosquito fern	*Azolla sp.* Floating fern with nitrogen-fixing cyanobacteria. Lives in nutrient-rich water, grows rapidly into mats. Long Lake marsh.	L6
American elodea	Nimisila Res. Similar to highly invasive Hydrilla but with fewer leaflets per whorl.	
	Various plants – species unknown	
Mapped from aerial images	Along margins and coves	
Visible on surface	Cat Swamp, Miller Lake, Long Lake, Turkeyfoot Lake, East Reservoir, West Reservoir, North Reservoir	Mi1,2 IC1 W7 T1,2,5,11,12,17,18 Mu3
	Emergents – not a focus of the study but some were observed	
Yellow iris	invasive	
Cattails	Most likely narrow-leaved, invasive	
Common Reed	Invasive, by wetland areas	
Var. arrowhead	Native	
Var. rushes, sedges	Native plants –Near woods, marshes, state park	

Plant Gallery photos arranged and labeled by lake: L = Long No = North Res. E = East Res. CG = Cottage Grove Lk Mi= Miller Lk W- = West Res. IC = Iron Channel E&W Res. T= Turkeyfoot Lk Mu = Mud Lk Ni = Nimisila Res.

**Refer to Appendix F Plant Gallery for photos.*

Nimisila Reservoir Left – floating-leafed and thin-leafed pondweeds, right, dense growth in a cove.

- Aquatic plants in Nimisila Reservoir range from large areas of native pondweeds, to dense beds of water lilies, spatterdock, and Eurasian watermilfoil.
- ODNR staff have noted little growth in East and West Reservoirs recently.
- Filamentous green algae is widespread. This is not the cyanobacteria "blue-green" algae. It is not harmful in itself. It anchors to plants and objects. Thick mats of C*ladophora* algae can detach and rise to the surface, buoyed up by oxygen bubbles. They can be a nuisance, may smell bad and harbor bacteria during decay. Nuisance growth of C*ladophora* is an indicator of a nutrient-rich lake.

"Green" in Miller Lake. Green patches on the surface are often filamentous green algae mats (possibly Cladophora) with rooted aquatic plants, including spatterdock or water lilies in shallow water; pondweeds, eel grass, and Eurasian watermilfoil in deeper water. These areas still provide benefits but may need to be actively managed for access/aesthetics.

- Areas with thick growth of macrophytes include:
  - Miller Lake,
  - Portions of Cottage Grove Lake,
  - the cove near the state park boat launch,
  - coves in Nimisila Reservoir,
  - the northern and southern margins of Long Lake and channels into/out of the lake,
  - The channel between West Reservoir and Turkeyfoot Lake.
  - Boaters report such dense "spring weeds" that certain channels are nearly impassible.
  - In August, 2020, North Reservoir and southern Long Lake were covered in dense growth.
- Some of the especially dense plant growth seems to occur in areas where nutrient loads may be higher – e.g., where tributaries enter coves (Cottage Grove, Nimisila), and near the golf course.
- The golf course is surrounded by dense stands of water lily/spatterdock, but these seem to be well contained by the deeper water beyond the golf course area. Some of these densely vegetated areas may impede navigation, but they are mostly outside the main channels and are valuable for habitat and nutrient uptake.

Invasive Plants in Portage Lakes

Four species of invasive aquatic plants/cyanobacteria were *observed* in the Portage Lakes, and others may be present – an aquatic plant inventory would help identify them:

Eurasian watermilfoil can grow to 30 feet tall. It reproduces by fragments, autofragmenting twice per summer after flowering in June and July. It provides some benefit for habitat and phosphorus uptake, but it is not as efficient as native plants in phosphorus uptake and spreads phosphorus by autofragmenting. It is widespread in the Portage Lakes, growing deeper than other species.



Eurasian watermilfoil. Left, fragment; right, with flower spikes

Curly leaf pondweed. It grows to 15 feet tall. It acts as a winter annual, sprouting in fall from dormant turions (buds along the stem dropped in the spring), living under the ice during the winter. It grows and flowers rapidly early in the season before other aquatic plants, then dies off. It is the widespread “spring weeds” in the lakes, choking off passageways. As it dies back in the spring, it releases phosphorus, which can increase productivity.


Curly-leafed pondweed

Brittle Naiad stems reach nine feet tall. It is similar to other naiads. It reproduces by fragments with seeds attached. It is highly aggressive. It is difficult to manage, because it is so brittle. The Brittle Naiad was observed at only one site, a fishing access on West Reservoir. It may be elsewhere, but if the population is confined, it can be eradicated.


Brittle Naiad

Lyngbya wollei – this species of cyanobacteria was recently renamed to *Microceiras wollei* but retains the common name, Lyngbya. It forms dense blackish mats in sediment, where rooted plants have been eradicated. In large amounts it can smother important benthic organisms, form dense mats that float to the surface, and may generate a toxin that causes a rash, eye, or respiratory irritation on contact, and intestinal problems if contaminated meat is consumed. It grows with high nutrients. It is a nuisance in western Lake Erie. A small amount was found during boat trips to observe aquatic plants, and there are anecdotal reports of sightings.


Lyngbya (Microceiras) in Lake Erie. Source: Ohio Sea Grant, 2010.

Are there Other Invasive Plants in the Lakes?
Quite possibly. Boaters and anglers may transport invasive plants on boats, gear or by water in the boats. These plants may arrive through affected rivers, by birds, or in dumped aquarium water.

Watch out for: *Hydrilla* has recently become an invasive species of great concern in Ohio. Found in the Ohio River and several small lakes around Cleveland, it is an extremely aggressive invasive plant that creates dense, choking mats, growing up to an inch per day. It reproduces by tubers and turions, which spread on plant fragments. Lakers should watch for it.


Hydrilla in Cleveland MetroParks Lakes Image source: John Navarro.

Aquatic Plant Management Practices

There are various types of practices to manage aquatic macrophytes at the scale of individual properties or larger areas, like channels. In a complex system like the Portage Lakes, it is likely that managers will use a combination of different approaches to manage plants (and phosphorus), depending on the circumstances, need, cost, etc.

Inventory and Monitor Before, During, and After

Aquatic plants are a living component of the lake ecosystem, habitat, and nutrient-processing. An aquatic plant inventory, which systematically documents plant types and density, is essential to developing and carrying out appropriate plant control measures:[11]

- Determine the type, amount, and extent of macrophytes being managed,
- Identify areas of native versus invasive species,
- Understand and incorporate the use, availability, and disposition of phosphorus in planning,
- Identify appropriate areas for management practices,
- Identify and implement appropriate management practices, and
- Monitor for changes in the aquatic plants of interest, phosphorus, and overall lake health.

In states with lake management/APM programs, aquatic inventories are conducted every few years. Other tools can be used before a full inventory is conducted, or to supplement information or monitor:

Citizen Science/Community Observations – Community observation/citizen scientists can provide information before or after an aquatic plant survey is completed. This also increases participation.

Citizen Science – there are several programs that train volunteers to collect data on aquatic plants or invasive species. For example, the New York CSLAP protocol describes a sampling program with some plant identification that can be done alongside lake scientists by citizen scientists in a localized or widespread area.[12]

Community Observation - Certain lakers, e.g., boaters, ODNR staff, boat tour operators, anglers, hikers frequently travel or visit the same areas on the lakes and many observe conditions as they travel. Lakeshore residents, visitors, and businesses have an up-close view (and often intense interest) in vegetation. Establishing a plant observer's corps would allow those frequently on or by the lakes to submit observations about plant density, easily identifiable invasive species, other characteristics, and changes. It could include training on some easy, visual species identification. This would provide additional information to supplement existing observations and may help indicate changes over time or priority areas. In New York state, targeted community observation efforts are recommended to help determine the extent of aquatic vegetation for aquatic plant management programs.[13]

Lake managers can begin with certain practices to manage aquatic plants on a limited scale to address localized concerns before a full inventory is conducted. Citizen observations are used in some states to provide basic information on extent of invasives and other plants.[14] However, an inventory is essential early in the process to develop an effective management program that protects the health of the lakes.

This is a Job for Professionals

Do-it-yourself approaches can cause more harm than good unless done with specific direction from professional lake managers:

- A permit is required to use chemicals. The wrong chemical or the wrong application may not address the problem, can harm aquatic species, and could introduce dangerous toxins into the water where people boat and swim, or harm the person using the chemical. It is illegal to discharge chemicals into the water without a permit.
- Mechanical measures as simple as pulling out or harvesting aquatic plants could cause them to spread, if the reproductive part (floating fragment, root, or seed capsule) is left in the water or in the sediment.
- Certain measures can affect the broad ecosystem, such as alum, dredging, widespread chemical use, biological controls, or draw-downs. These should be directed and carried out by professional lake managers, with an understanding of the consequences on various aspects of the ecosystem.

Some of the aquatic plant control requires consideration of lake conditions.

- Aquatic plants have different seasonal patterns of growth, die-off, and reproduction.
- Sediment type and water level management may encourage growth of certain species.
- Aquatic plants are phosphorus processors. Eradicating species or causing large die-offs may disrupt the phosphorus balance enough to cause problems with algal blooms.
- After using a management measure, the effects and impacts should be monitored.

Aquatic Plant Management Measures

Aquatic plant management tools that directly affect the environment may be categorized as chemical, mechanical, physical, or biological. (See Appendix G for a summary of many techniques from University of Wisconsin. The permitted activities may differ from Wisconsin, but many other considerations apply equally in Ohio.) Each technique has pros and cons, and must be used with careful consideration to cost, effectiveness, and duration and reversibility (if necessary) of effects, and ecosystem impacts:

- As with phosphorus management measures, some vegetation control measures are more appropriate in small, confined ponds than in the larger, connected Portage Lakes.
- Large-scale manipulation of aquatic plant communities and their physical, chemical, and biological environment can have significant effects on the nutrients and biological aspects of ecosystem. In some lakes, major "perturbations" shift the ecosystem to algae-dominated.[15]
- Use of these tools must consider and monitor for a range of potential consequences.

Aquatic plant management in the Portage Lakes will likely require use of various tools from the toolbox of available measures, depending on the circumstances.

Conservation ("No management")

Aquatic plants that are not creating a nuisance are helping keep the lakes healthy and free from HABs. There are many locations throughout the lakes where the plants do such an important job of providing habitat, stabilizing sediment, and using nutrients, that they should be left to do their work.

Chemical

- There are a number of chemicals that are used to treat for certain species.
- They may need to be applied multiple times per season.
- Chemical applications require permits and licensed applicators, because of their potential toxic effects on swimmers, wildlife, and beneficial plants.
- The effects of approved chemicals are generally well-understood and can be part of the planning/use, including posting warnings to swimmers.
- Chemical use is one way to promote growth of native species.
- Large die-offs of aquatic plants can release phosphorus during decay, which increases if the dead plant material creates anoxic areas on the sediment.
- Chemical use can be targeted to shallow areas near docks or beaches.

Mechanical means

Raking the "weeds"

One rather basic approach to washed-up aquatic plant fragments is to rake it out, as one would rake leaves, and compost the material. If the plant fragments are from invasive plants, such as Eurasian watermilfoil, it may reduce their spread. This also removes some of the nutrients from the lake.

Harvesting, similar to mowing a lawn, clips off the top several feet. It is useful for clearing passageways. Like any aquatic plant control, over-harvesting could affect the ecosystem. Considerations include:

- Useful in monocultures, e.g., Eurasian watermilfoil – it is not meant to target certain species.
- It cuts off the dense canopy, improving passage and fisheries.
- Harvesting is very time-consuming, as harvesters travel very slowly.
- Multiple cutting is needed per season
  Many harvesters cannot operate at less than two or three feet deep.
- Harvesters require a skilled operator.
- Removing the cut material composting it on land benefits the lake:
  - Cut material may float, creating a nuisance.
  - Decay releases phosphorus, spurring growth. Large amounts of dead plants may create anoxic conditions.
  - Plants that reproduce by fragmentation may spread, although in areas infested with plants like Eurasian watermilfoil, plants auto-fragment and are also cut by propellors.

  This is time- and labor-intensive and requires off-loading sites or barges and composting sites. The large pile of cut vegetation (possibly containing animals) is unattractive but quickly dries.

ODNR Harvester, Long Lake.

Removal of the Plants and Reproductive Parts

- This is labor intensive, as it involves manual removal.
- This requires a good understanding of the plants being targeted, so as to get all reproductive parts of the plants.
- Advantages are it can target individual species, and it can be used in confined or shallow areas.

Physical Measures

Physical measures change the conditions that the plants grow in. There have been some reports of positive results with aquatic plant management, but altering physical characteristics can have widespread, potentially damaging effects on the lake ecosystem and should be used with great caution.

Water drawdown – This is often used in reservoirs to provide for maintenance. Changing the water level favors certain plants over others. It is important that drawdowns be carried out with precautions.

- Drawdowns allow deeper plants to reach the light, but dry up the shallow areas.
- Drawdowns affect sediment composition and nutrient flow from the land.
- Drawdown that extends into the winter may damage desirable plants and favor invasive species.
- Plants that reproduce by seeds may be favored during extended drawdowns.
- Drawdowns of entire lakes may disrupt the system enough to encourage algae growth.

Flow alteration – changing the residence time may reduces the time that phosphorus is in the lake.

Barriers include mats, which are hand-installed.

- These are sometimes used in swimming areas.
- They are labor intensive to install and may require maintenance to stay in one place.

Dredging - is primarily used for removing sediment, rather than controlling aquatic plants. Locally deepening the lake floor below the photic zone may prevent plant growth but not algae. Dredging removes nutrient-rich sediments from algae-dominated lakes. Large-scale dredging would be extremely disruptive to a large vegetated lake complex like the Portage Lakes, disrupting lake morphology and valuable habitat. It should be limited to where it is essential for navigation.

Effects of dredging include increased turbidity and conditions that favor invasive species:

- Disturbing the substrate, removing stabilizing plant roots, and removing more coarse sandy material than suspended silt increases the fine particles in the water, increases turbidity, and may encourage growth of invasive plants like Eurasian watermilfoil or algae over native plants.
- Increased turbidity due to sediment may be harmful to fish and shades out the important rooted aquatic plants, in favor of algae

Alum – is primarily used to coat the sediment layer, bind phosphorus and prevent its release into the water. In addition to altering the nutrients available to plants, it may affect the plant species. One study notes that after alum treatment, the aquatic plant community re-grew as a diverse native assemblage. A tool with potential ecosystem impacts should be carefully evaluated before use.

Dyes – In confined ponds, dyes are sometimes used to reduce light penetration for algae and plants.

Biological Controls

Biological measures involve engineering the species mix to alter the community. Examples include:

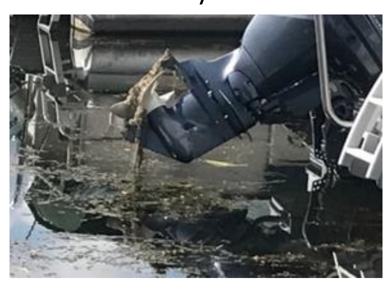
- Parasites, which attack the species of interest (e.g., controlling purple loosestrife with beetles.)
- Changing the nature of predator-prey communities to favor zooplankton that feed on algae
- Eradicating "rough fish," like carp, which disturb sediment, releasing phosphorus
- Introducing species that consume unwanted plants
- Killing off invasive species and replacing them with native species.

These measures may not be feasible, and some are not permitted due to potential impacts. Some may be more appropriate in confined ponds than in a system of connected lakes that feeds into two drainage basins. As with other disruptive measures, impacts need to be accounted for and monitored.

Control of Invasive Species

While it is possible to alter plant communities chemically, physically, or biologically, it may be very difficult in a connected set of lakes. Techniques include eradicating the invasive populations and planting native species, and altering the conditions that favor the invasive species (e.g., silty substrate, turbidity). Removal or chemical treatment of invasive species and altering lake conditions need to be done by professionals, with consideration to potential impacts and monitoring.

The best control is avoidance or detection and quick eradication. The lakes are affected by more than one species already. Practicing Clean-Drain-Dry techniques on boats and fishing gear can reduce further spread to or from other water bodies. Boater education is important:



- Inspect boat and gear for plant fragments
- Dry the gear.
- Don't dump the water in a storm drain or lake.
- Dispose unwanted bait in the trash.
- Some lakes have clean-drain-dry stations set up.

A plant inventory and monitoring for invasive species should be conducted. With early detection, invasive plants may be eradicated. If lakers find species that they believe are invasive, they can report it and provide a photograph and the location of where the plant was seen. [16]

Case Example: Casey Lake, MN[17]

The example of Casey Lake (next page) illustrates use of several tools to address water quality and aquatic plant concerns in a small, eutrophic headwaters lake.

Casey Lake, MN

Casey Lake is a 12-acre, eutrophic lake, 2-4 feet deep, in a developed watershed in the headwaters of the Phalen Chain of Lakes. It is adjacent to a major park in North St. Paul and is used for neighborhood recreation. In 2009 the lake had switched to a turbid, algae-dominated state, preventing recreational use due to HABs.

The watershed management district uses BMPs in the watershed. However, studies showed that the lake supported a large population of common carp, which stirred up sediment, releasing phosphorus. In 2012, the lake was drawn down, in accordance with a carp management plan, killing the carp. Sunfish and bass were introduced. The city installed an aeration system to allow the game fish to overwinter.

In 2013, the lake switched to a clear state with abundant vegetation that did not reach the surface, but it became choked with tall plants in 2014. The switch from turbid, algae-dominated to clear with vegetation is typical, the preferable choice between the two possible equilibrium states, but the dense vegetation impaired recreation.

Lake managers use harvesting instead of chemicals for plant management, to avoid creating anoxic conditions with die-off. Over two summers, their contractor removed 57 and 75 wetted tons of material for composting, (photos 2 and 3), removing 36 and 47 pounds of phosphorus, respectively. Composting the harvested material cost less per pound of phosphorus than stormwater treatment installations (an average of $230 per pound of phosphorus for composting harvested plants versus thousands of dollars per pound by using stormwater BMPs).

1) Above, vegetation before harvesting   *2) Above, harvester at work*
3) Below, lake cleared of vegetation   *4) Below right, 30-foot pile of harvested material was composted.*

The case example raises some considerations:

- This is an intensely managed, small headwaters lake.   While a balanced, healthy ecosystem is important, a major priority is the need for an attractive recreational water body. The partners have been using a variety of techniques to reduce external and internal phosphorus loading, including stormwater BMPs, drawdown and changing the fish populations, and harvesting.
- Because the lake is small and at the headwaters, total drawdown was a feasible method to control nuisance fish populations.
- Removing the fish switched the equilibrium from turbid, algae-dominated to clear, vegetation dominated, one of the two possible equilibrium states for eutrophic lakes. In spite of the dense vegetation, it is still preferable to algae-dominated. (Vegetation can be cleared. HABs cannot.)

- Harvesting vegetation and composting it removes phosphorus from the lake system. Leaving it in place would leave about 40 pounds of phosphorus in the lakes, enough to fuel tons of growth.
- A 12-acre lake generated over 50 tons of cut vegetation, creating a 30-foot tall pile.
- This effort involved several partners (watershed district, city, MN DNR, University of Minnesota) and a contracted harvester. The partners provided technical guidance, funding, labor, fish, and a composting site, and conducted studies and monitoring.
- It would be interesting to follow up on the subsequent changes to the lake. Has harvesting been continued? Did the carp return? Did the lake retain its new clear equilibrium, or did it revert to a turbid state? Were there downstream effects?

The "Cultural" (Human) Part of Aquatic Plant Management – Lakers, Communities, Caretakers

Involving the people who live with, use, and manage the lakes is just as necessary – and part of – choosing and applying the right tools to manage aquatic plants.[18] The actions, impacts, expectations, priorities, of the lakes community members and partners affect the lakes through:

- Use of the lakes and landscape
- Impacts
- Minimizing impacts and protecting the lakes
- Supporting and participating in measures to balance use and protection,
- Paraticipating in decision making about management
- Educating and encouraging others to help with the above
- Persuading others to enact changes at all levels.

Developing an aquatic management program to balance use and protection is likely to require lake users, their communities, and agencies to:

- Establish priorities,
- Make choices,
- Establish and support programs with funding, staff, resources, technical support, guidelines,
- Increase resources, information sharing, and coordination,
- Change how or where some activities should occur, and
- Change expectations about how and where plants are managed and how people use and take care of the lakes.

In other states, lake management and aquatic plant management is a well-developed practice that involves lake users and residents, lake associations, and government agencies.[19] As a collaborative effort, the participants have developed a shared understanding about the needs, tools, balance of priorities, acceptable practices, expectations, limitations, funding, and administration. Establishing a management program in the Portage Lakes could benefit from successful models elsewhere.

Current Aquatic Plant Management – Portage Lakes

Currently, there is not a coordinated approach to aquatic plant management. ODNR and property owners are addressing individual areas perceived as problems as they can.

Chemical Application

Individual property owners contract with Aqua Doc, the only licensed applicator, to chemically treat local areas, usually within 30 feet of the property. There are discounts for group contracts, which encourages treatment of larger areas. Typical treatment is three times per growing season.

There are anecdotal reports that some property owners apply bargain chemicals that they purchase off the internet. This is dangerous. The pesticides may contain unknown toxins that could affect wildlife and people. The chemicals and application also may not be appropriate for the targeted plants.

In 2021, ODNR was authorized to contract for chemical application over approximately 12 acres in heavy use and high visibility areas (e.g., beach, boat ramps, channels).

Harvesting

ODNR Canal Lands staff conducting harvesting periodically on the Portage Lakes to maintain flow in the Long Lakes Feeder to the Canal, and to provide clear passage for navigation. Harvesting is time-intensive. The harvester travels at 2-3 miles per hour, and can harvest up to four tons of wetted material per load. In 2020, 140 loads, primarily from Long Lake and North Reservoir. Due to limitations in staff, time, equipment, and sites on land, the cut vegetation is not removed. Even though harvesting is not their primary responsibility, the small Canal Lands staff, are also requested to harvest on Mosquito Lake. Composting the harvested material would benefit the lakes by removing phosphorus and reproductive fragments of invasive species, but would require sites, equipment, dedicated harvester operators, trucks, and drivers.

Dredging

In 2021, ODNR is beginning a dredging program to remove sediment from channels in limited areas throughout the lakes. Dredging will temporarily stir up nutrients, but will also remove nutrient-rich sediment and affect plant communities by removing plants and locally deepening the water. The effort will take 5-7 years. Dredging will begin in Turkeyfoot Lake, which has a dedicated dredge material area across from the dog park in the State Park. A dredge material site must be established in each lake where dredging will occur. Some of these may be on private lands by arrangement.

Drawdown and Water Flow

ODNR draws down the lakes by 18 inches every two years for two months in autumn, exposing several feet of otherwise submerged land. Desiccation and freezing temperatures affect sediment, nutrient transfer, and may favor the return of certain species over others. ODNR's practice of limited drawdown minimizes many of the potential impacts. The effect of water management practices on various species of vegetation should be further explored.

Residence time affects eutrophication and phosphorus loading. Longer residence time means phosphorus stays in a lake longer, fueling growth. Water flow in the lakes is regulated at several locations. The feasibility of altering residence time in certain lakes could be evaluated.

Biological Controls

In response to the dense vegetation on North Reservoir, 300 triploid (sterile) grass carp were introduced. These feed voraciously on vegetation. Populations may live for decades. It will be important to monitor the lake condition over time. It is unclear whether these will have an effect downstream.

Shoreline/Land-Based Management

The ODNR is finalizing a dock and shoreline management plan that will address dock management and specifications, shoreline modifications, and aquatic plants.

The watershed management efforts focus primarily on reducing runoff, stream restoration, and addressing septic system concerns. Summit SWCD is establishing an Upper Tuscarawas watershed coordinator, will be monitoring streams, conducting outreach, including goose management and lakescaping. and monitoring streams.

"Cultural" Measures – Outreach, Involvement, Coordination

The "cultural" measures specifically focused on aquatic plant management are limited. Other related outreach and coordination efforts are scattered among many organizations but could provide a good basis and opportunities for education, outreach, involvement, and coordination focusing on aquatic plant management:

Source: Summit SWCD

- PLAC, Ohio EPA, ODNR Parks, Summit SWCD, Summit Metro Parks, regional agencies, communities, volunteers, businesses, and local organizations conduct many activities that increase awareness and stewardship. These partners can share resources and expertise.
- Coordination occurs through the PLAC and the management plan TAC, and informally, but there is no central decision-making entity or process, little staff, no dedicated technical support or guidance, and limited funds.

Putting Aquatic Plant Management Tools to Work in the Portage Lakes: Discussion

Aquatic macrophytes provide so much benefit that they should be retained, protected where feasible. However, there are locations where dense growth impedes travel and creates a nuisance for property owners and lake users.

Aquatic Plant Management Plans

In other states, aquatic plant management (APM) and lake management plans are regularly done as part of living with and protecting lakes.[20] Developing an APM plan would provide a cohesive, coordinated framework for applying tools, considering:

- Type and extent of plants,
- Goals and uses,
- Preferences of residents and visitors,
- Potential ecosystem impacts,
- Feasibility, and
- Capabilities and resources of the lake managers.

These technically-based documents have input and involvement from the lake community and agencies:

- Identifying priorities,
- Designating management zones and
- Identifying and carrying out appropriate management techniques.

Conducting an aquatic plant inventory is one of the necessary first steps.

The process of developing such plans helps to build a shared understanding and expectations among the community members and lake managers:

- Community members better understand the reasons and methods for aquatic plant management, their role in the process, the need for funding or actions.
- Lakers participate in setting priorities, help carry out the plan, knowing their needs will be met.
- Lake managers get a well-considered framework that provides guidance on decisions and impacts, and allows them to plan for projects, staffing funding, resources, and track changes.

This section is not an APM plan. There is not enough information about the types, extent, and roles of plants in the lake ecosystem to incorporate on in this plan. Nor has there been the necessary community and agency discussions to determine priorities throughout the lakes and determine willingness and ability among community members and agencies to run such a program (e.g., funding, staffing, management areas, coordination, decision making).

This section raises considerations of managing aquatic plants and offers suggestions for an approach. Lake managers will be managing plants before developing an APM plan. They can build these elements separately from or prior to developing an APM plan and use them to frame APM decisions; some already have. To protect the health of the lakes and meet the needs of lakers and communities, the APM effort needs to be comprehensive, sustainable and effective. There needs to be an institutional and community structure, funding, decision-making, technical background, coordination, and community involvement. An APM plan documents that structure, providing a guidebook for managers.

Aquatic Plant Management Decision-Making

Managing aquatic plants in a balanced way means deciding:

- Which areas to protect,
- Which areas to maintain access
- The appropriate tools to use, based on feasibility, cost, effectiveness, and ecosystem health.
- Who should pay for, coordinate, and carry them out.

In selecting a tool or tools, managers should consider:

- *Need/purpose* - Is there a need to actively manage vegetation? How much of a need? How much needs to be managed – enough for passage or clearing a broader area? Can conservation co-exist with passage and nuisance reduction?
- *What kind of plants are being managed?* Invasive/native? What do they indicate about lake conditions? What is their role in the ecosystem?
- *Feasibility, logistics* What is the feasibility for the size, configuration, location within the connected lakes? What resources, staffing, partners are needed/available? Are the logistics acceptable (e.g., dredging , temporary use restrictions)? What is the cost and funding?
- *What are the long-term impacts?* How do they affect the phosphorus budget, turbidity, lake ecosystem? Can the tool be phased in, used in a localized way, reversed or altered if needed?

This discussion should involve technical expertise, an understanding of the plant communities, and input from the lakers, communities, and agencies. It is important to monitor the effects during/after use.

The following examples illustrate considerations that would go into APM decisions in the Portage Lakes.

Case Examples: Portage Lakes

North Reservoir - In summer, 2021, North Reservoir became choked with aquatic vegetation. ODNR staff cut it but could not remove it due to limitations of staff and land disposal options.

Lake Characteristics:

- 141 acres, mean depth 4.5 feet; deepest 9 feet, larger and deeper than the Casey Lake example.
- Midway in the connected chain, which drains to the Tuscarawas River and the Lake Erie basin.
- The most eutrophic of the Portage Lakes. Future dense growth is likely.
- Residential shoreline with state park boat ramp and fishing accesses, and two parking lots.
- Water inflow is regulated by a gate on West Reservoir; outflow is over a spillway into Long Lake.

Consideration of Tools:

- Access to docks and fishing is likely not enough. The entire lake is covered, impairing recreation and aesthetics. Perhaps some vegetation can remain for habitat and phosphorus removal.
- Phosphorus management is very important in this shallow, eutrophic lake. Tools include plants, alum, dredging, altering residence time, changing plant species, shoreline/watershed practices.
- Widespread dredging, chemical use, or alum could be expensive and may affect the lake ecosystem. Chemical use and harvesting without composting may spur more growth as phosphorus is released during decay and from anoxic areas under the decaying plants.
- This lake is compact enough that If there were a site and equipment/staffing to remove the cut material, a combination of harvesting and composting might be feasible, in deep enough water. Transporting heavy, wet material requires many trips. Drying a large pile of plant material (possibly with fish in it) would likely take several days but would reduce trips on land.
- Any measure taken, especially on a large scale, needs to be monitored.

Long Lake

Long Lake has several management settings, with residential and conservation areas, and Long Lakes Feeder, in the northwest, which outlets to the Tuscarawas River and O&E Canal. Flow maintenance in the feeder is important for flood control at the dam and for diverting flow to the Lake Erie basin via the Canal. The feeder is by a wetland complex and becomes choked with vegetation. ODNR harvests vegetation in the Feeder but, due to staffing and infrastructure limitations, cannot remove it.

Left, vegetation by wetlands, where Tuscarawas enters (cleared zone); center, dense vegetation at southern end of Feeder, looking southeast toward the open lake; right, vegetation by residences.

<u>*Lake Characteristics*</u>

- 192 acres, mean depth 10 feet, deepest, 35 feet; extensive shallow areas and vegetation at the northern and southern ends.
- It is downstream of all the lakes, it also receives water from the Tuscarawas (northwest end).
- Shoreline - residential, fishing/boating accesses (northern and southern ends), wetlands/conservation lands, parks.
- Long Lake Feeder – Half-mile long by 300 feet wide, two parking lots provide boating and fishing access. ODNR launches and stores the harvester at a public access in the Feeder.

<u>*Consideration of Tools*</u>

ODNR maintains passageways at the ends by harvesting, leaves large areas undisturbed. This allows recreation, navigation, and flow, and reduces fragmentation of Eurasian watermilfoil by boaters.

It is difficult to offload cut vegetation onto the land, due to the expanse of the lake, the length of the Feeder, the amount of privately owned shoreline, density of vegetation, and speed of the harvester. Cut fragments of Eurasian watermilfoil drift and pile up. Composting material would remove phosphorus and floating vegetation, and would require staff, a barge, trucks and drivers, and composting sites.

At the residential docks, coordinating contracting for aquatic plant control at residential docks, while maintaining channels for navigation is probably ideal. This would limit disturbance, provide consistent management, while allowing navigation and assuring residents that the “weeds” will be taken care of. In addition, to the requirements of composting noted above, there would need to be an administrative structure for collecting fees and contracting with the aquatic plant control company. Outreach and signage at the boat access points would help alert boaters to conservation areas.

Conceptual Aquatic Plant Management Zones

Managing aquatic plants in the lakes is not a one-size-fits-all approach, especially on a multi-use chain of lakes. APM plans developed for lake management in other states designate management zones based on local priorities and the aquatic plant inventory. These allow uses to be accommodated while protecting the lakes, providing a common expectation of what will be managed and how.

The Portage Lakes Management Plan recommends designating such APM zones, with recommended practices, for the Portage Lakes. Some zones would be maintained for access and use, others would be set aside for protection with less aquatic plant control.

Developing a full APM plan requires an aquatic plant inventory to characterize the type of plants, their location, volume, and areas of conflict with use. This is an important element. However, even without this information, the Portage Lakes Management Plan offers conceptual recommendations for aquatic plant management zones, with input from the lakers and lake management partners, based on:

- Observations of Portage Lakes aquatic macrophytes,
- Importance for habitat and other benefits,
- Uses, need for access and clear zones, and
- Feasibility of likely tools.

Conceptual aquatic plant management zones have been identified in discussions with the plan's TAC, based on observations of aquatic plants and discussions about use/problem areas. (See Maps 5.3-5.6 after the zone descriptions). ODNR has begun using this to help direct harvesting. The zones will likely evolve with further discussion and public involvement, and as more information is available about plant communities, need for access, feasibility, effectiveness, and impacts.

Habitat Zone –Plants providing high quality habitat, areas used for fishing, and areas where plants have the most value for taking up phosphorus. Many of the areas with invasive plants should be maintained as is, if they are not impeding access, because of the water quality and habitat benefits they provide.

Residential/ Business Dock Zone – Licensed contractors could control plants in these zones as necessary/ desirable to maintain access and aesthetics for residences and businesses. Harvesting is not likely to be feasible in these areas, because of water depth and proximity to the shore and docks. Some of these areas also have native plants, requiring careful management. If dense growth farther from the docks impedes navigation or is a nuisance, channels could possibly be maintained to a band of open water near the shore, connecting to more open areas but still preserving some plants intact.

- Docks or nearshore areas could be appropriate for hand harvesting *if done correctly for the species,* removing all reproductive parts (fragments, roots, seed capsules) to avoid spread.
- Chemical treatments*, if done correctly by licensed applicators with state permits*, can be used to target certain species. Individual homeowners should not purchase and apply chemicals on their own: the chemicals can be toxic to humans and wildlife; they may target the wrong plants or apply the wrong amounts; and the chemicals may interact with each other between properties. Currently,

property owners contract with AquaDoc for aquatic plant control. A coordinated approach is more efficient, identifying and treating plants consistently across a wide area.

- Ideally, tall vegetation could be planted on the shoreline. In addition to other benefits, canopy shades the water and may deter aquatic growth.
- Currently, property owners hire contractors. Centralizing the process should be considered for consistency of treatment and expectations.

Marina Management Zone – These zones would need to be maintained for access. Some of these areas are in deeper water. As with residential management zone, chemicals may be the best way to target certain species close to the boat slips. In deeper water, it may be possible/advisable to use a harvester. Management should extend only as far as necessary to maintain access.

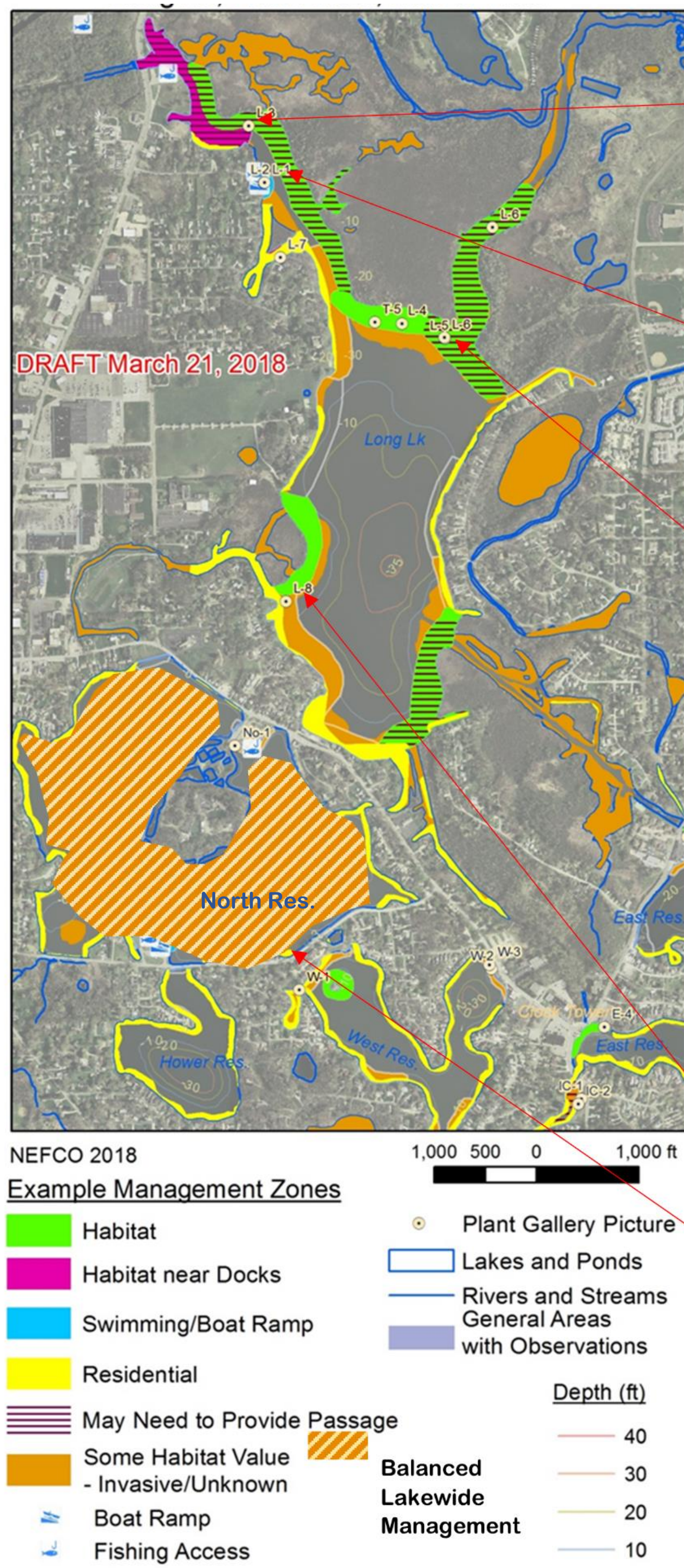
Passage Zone – Some areas with dense plant growth are important for access within the lakes. Invasive species like curly leaf pondweed and Eurasian watermilfoil, which impede access, may spread when boat propellers cut them. These areas could be appropriate for large-scale harvesting - with removal of cut material - to maintain access wide enough for residential passage, fishing, or general travel between the lakes. Passage may need to be provided offshore of docks in areas with dense growth.

Swimming Areas/Boat Launch Ramp Zone – The goal in these zones is to maintain clear lake access and remove vegetation that might entangle and discourage swimmers. Control methods could include appropriate, licensed, chemical use and possibly harvesting with removal farther from shore.

Cove Zone -These shallow areas often have dense plant growth. These areas should be protected to the extent feasible, especially if the plants are taking up nutrients from sources such as incoming streams, the golf course, or agricultural areas.

Lakewide Management –A holistic approach to APM is needed, in North Reservoir that reduces the nuisance and considers phosphorus loading and use by plants. The lake is semi-isolated within lakes. It may be suitable for lake-scale approaches, if perturbations to the phosphorus budget and ecosystem are controlled. An alternative approach would be to chemically treat residential areas and harvest and remove material from a wide, perhaps irregular buffer along the shoreline where residences and access points are. This would provide open water but retain some undisturbed areas. The harvester cannot operate in less than three feet of water, so certain areas of the lake may be inaccessible by harvester. Caution should be used in widespread use of chemicals or harvesting without removal. Cut plant fragments may float for a while, impairing travel and aesthetics, releasing phosphorus during decay, and creating anoxic zones on the lake floor. This would fuel more growth and exacerbate the problem.

Map 5.3 Example Aquatic Plant Management Zones Long Lake, North Reservoir, Hower Reservoir



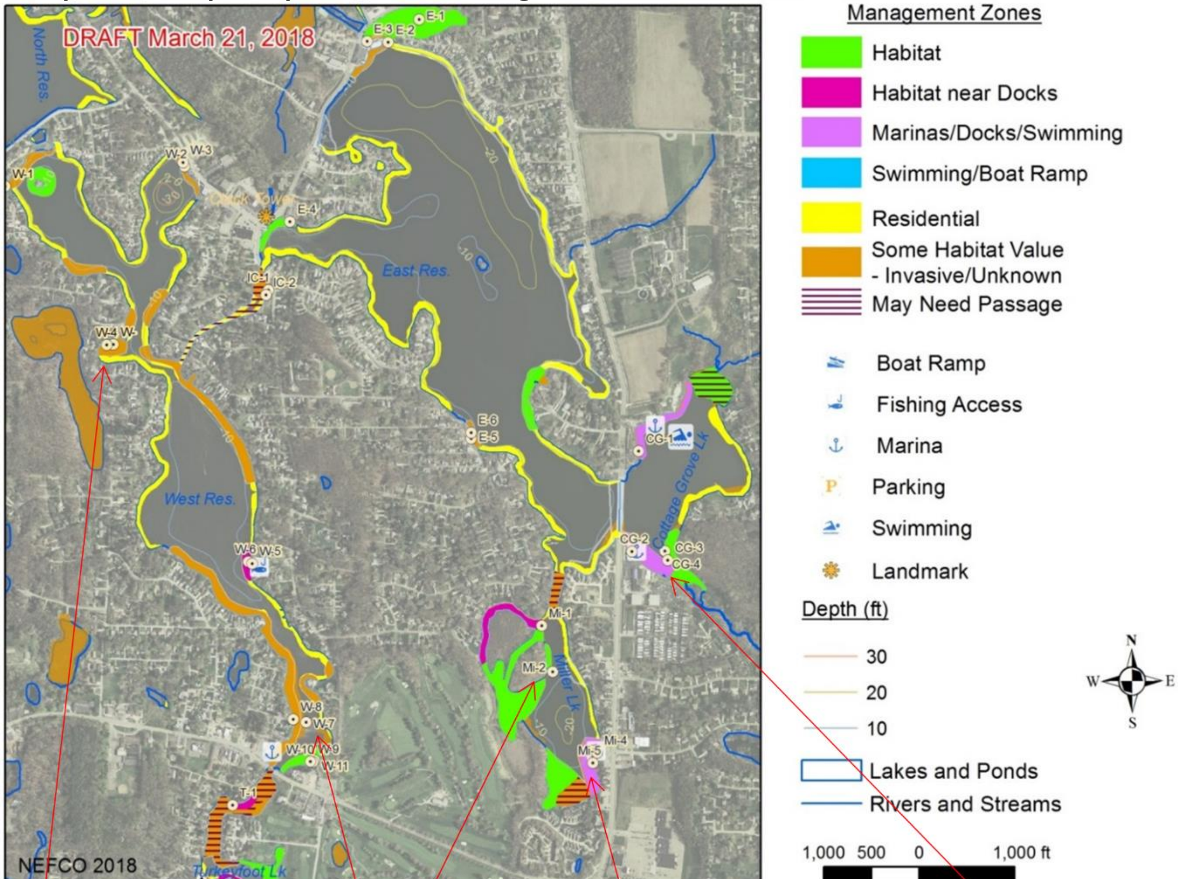
L1, L3 Spatterdock, etc. both sides of passage, Eurasian watermilfoil clogs the passage in summer

L5 Eurasian watermilfoil and other species by marsh. Note passage that has been cut.

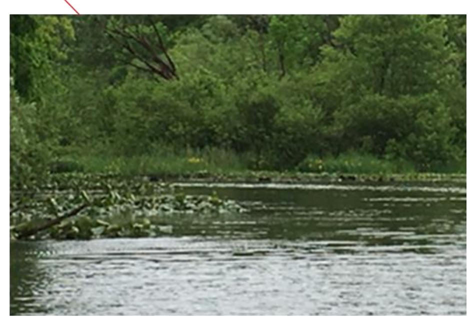
L8 E. watermilfoil from houses to foreground.

No 2 North Reservoir choked with vegetation, summer, 2020.

Map 5.4 Example Aquatic Plant Management Zones – East and West Reservoirs



Refer to Plant Gallery, for more photos.



Top row: Mi-4 spatterdock, etc. by golf course; Mi-5 dense growth Miller Lake looking SW (similar to dense growth by marinas in Cottage Grove Lake); CG-4 C.G. Lake cove

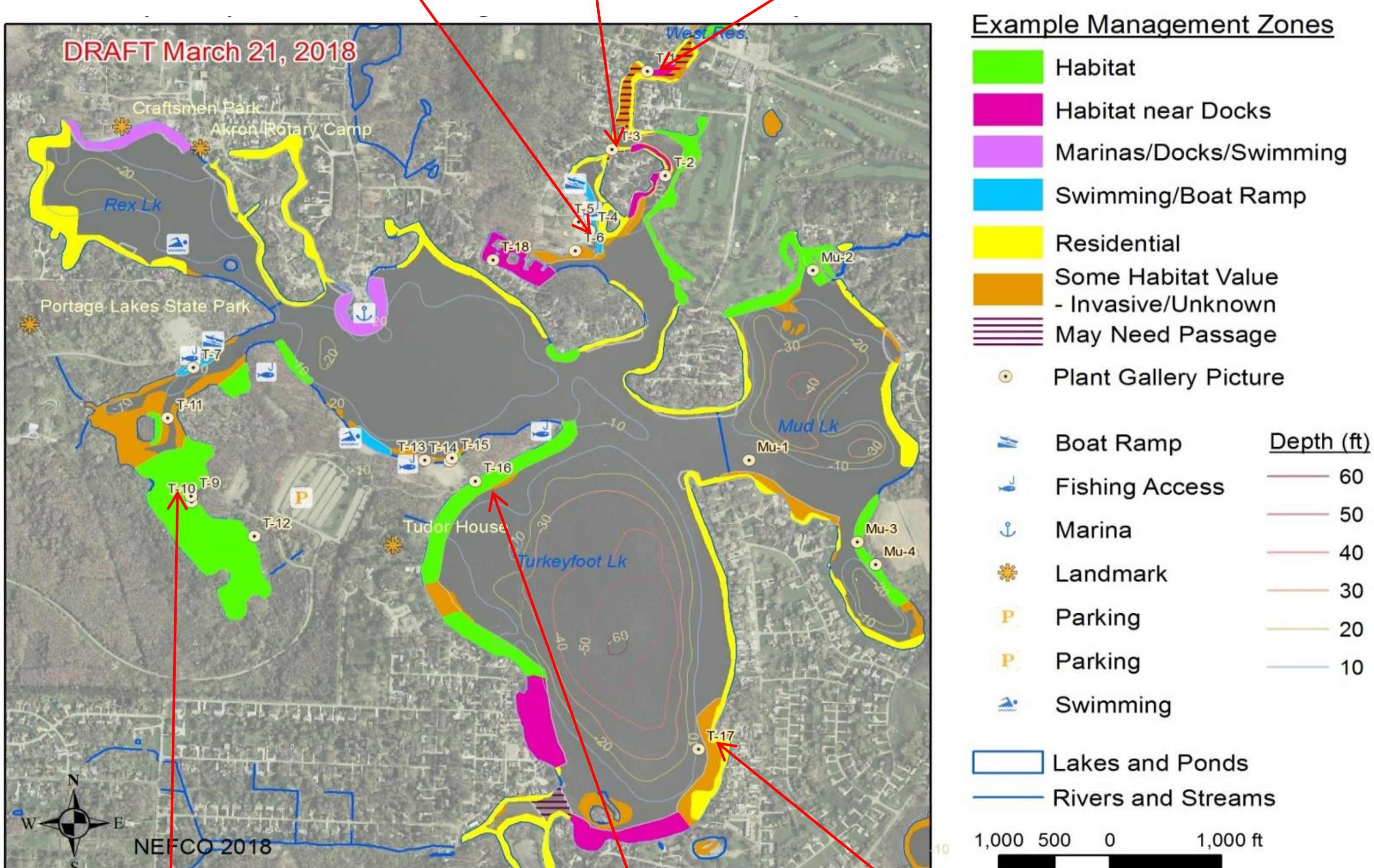
Bottom Row W-7 – spatterdock, other growth by houses, dock, with anglers; W-4 Eurasian watermilfoil by residence

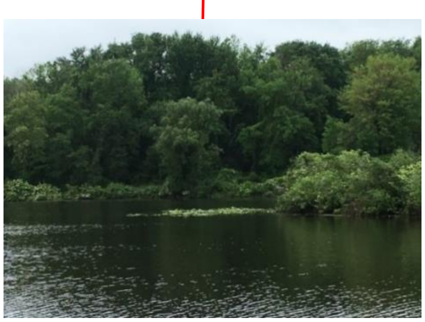
Map 5.5 Example Aquatic Plant Management Zones – Turkeyfoot Lake

T6 Spatterdock and water lilies by Old State Park boat launch

T3 Eelgrass, spatterdock, and E. water-milfoil near homes and channel

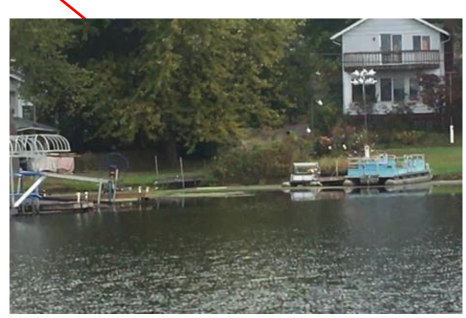
T1 Aquatic plants by home and dock along channel





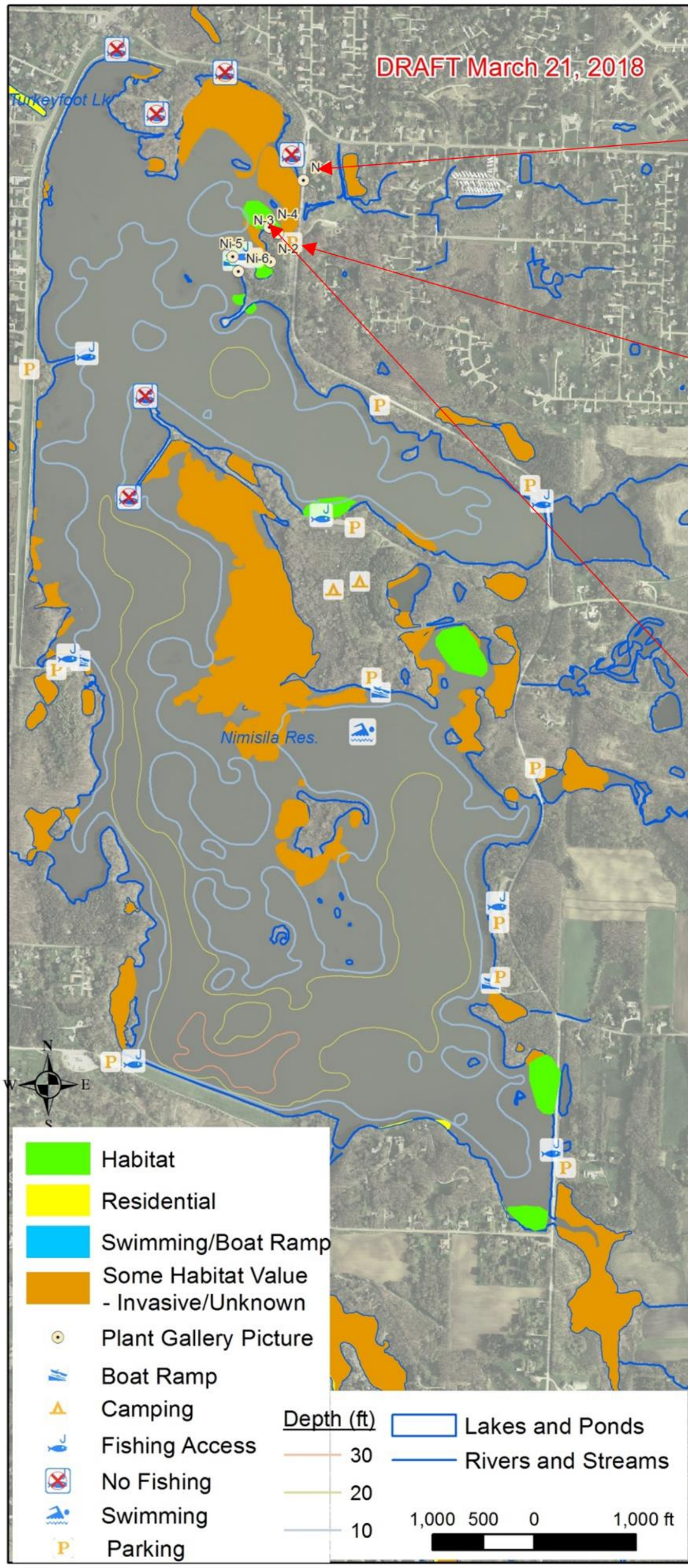
T10 Conservation area – Latham Bay

T16 Eel grass near Mosquito Point



T17 Aquatic plants by home and dock

Map 5.6 Example Aquatic Plant Management Zones - Nimisila Reservoir



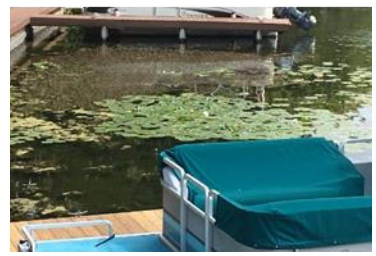
Vegetation observed in Nimisila includes extensive growth of Eurasian watermilfoil and filamentous green algae (Cladophora?) (N-1), dense growth in coves (N-2), and high quality habitat consisting of various native pondweeds and eelgrass (N-3).

-Nimisila is primarily used for recreation. All zones assumed to be managed as "habitat" zones.

What Residents Said about Aquatic Plants

Lakers at the public focus group and in other discussions shared observations and opinions about aquatic plants. Many of the questions asked by participants focuses on plants.

Many of these questions have been addressed elsewhere in this section. Some, like state-managed “weed” control, should be addressed through further discussion among the partners. The questions indicate a level of interest as well as a need for education about managing aquatic plants.



- What are the native plants in the area?
- There is a plant that looks like eel grass (which washes up on shore when cut by propellers) – what can be done to safely eradicate these weeds?
- Who can I get to remove seaweed by my dock without chemicals? Is AquaDoc an acceptable company for weed control? Are there less expensive alternatives?
- Why doesn’t the state pay for weed control?
- Why can’t the state charge a launch $5 fee to pay for lake maintenance?
- Certain areas get so choked with “spring weeds” that passage is almost impossible.

What suggestions do you have for thousands of feet of seawall and lakescaping?

Participants were asked if they thought aquatic plants are (multiple responses were allowed):

- A nuisance
- Important for habitat
- Important for water quality
- Affected by water quality, or
- All of the Above,

The most popular responses (about half) chose “Important for water quality,” or “All of the Above.”

When asked what should be done about the plants, the alternatives considered most important were:

- Harvest in certain areas
- Protect certain areas for habitat
- Protect water quality
- Increase education about aquatic plants, clean-drain-dry, best management practices
- Learning to live with plants was a less popular answer
- Almost no one favored do-it-yourself treatments.

Key Considerations

The plants and other photosynthesizers on land and in the water are a crucial part of the land and water habitats of the lake system, providing such important functions as:

- Oxygen
- Shade
- Shelter, nurseries
- Foraging
- Food
- Nutrient flow and cycling
- Stabilizing sediment and soil
- Water quality protection

However, dense aquatic vegetation can impair use and aesthetics in certain areas. Sustaining the lakes as a multi-use resource requires a commitment to actively managing the aquatic plants - and uses - to accommodate priorities of lakers while protecting the benefits that the vegetation provides. The observations and considerations discussed below should help shape the management efforts.

Habitats Observed in the Portage Lakes

Land habitats around the lakes include:

- Natural areas – woods, wetlands, floodplains, and stream channels protected as conservation areas, primarily around Long Lake, Turkeyfoot Lake, Nimisila Reservoir, and Wonder Lake Creek.
- Development – Developed parks, residential areas, businesses, and some farmland – is much of the landscape surrounding the lakes, especially East, West, and North Reservoirs. Tree canopy is sparser in developed landscapes – trees are interspersed with lawn and hard/altered surfaces.
- The shoreline, the important margin between land and water, has been altered and hardened in many places.

A cursory survey of aquatic vegetation during several boat trips and shoreline visits, and conversations with ODNR staff have indicated that:

- Dense aquatic growth occurs along many of the shallow areas, including coves and lake margins. Especially dense growth occurs in Nimisila Reservoir, Miller Lake, the northern and southern ends of Long Lake, and North Reservoir. The latter was choked with plants in summer, 2020.
- ODNR staff who work on the lakes, have noted less vegetation in East and West Reservoirs.
- There are areas of native aquatic plants, including eelgrass, pondweeds, and chara. Native plant communities tend be diverse and provide high-quality habitat for fisheries. Lakers are noticing greater extent of eel grass.
- Invasive species, which take over and create tangled monocultures, are found throughout the lakes, especially:
  - Curly-leafed pondweed (“spring weeds”), an early-season plant that chokes passages in the spring, dying off by mid-summer.
  - Eurasian watermilfoil, which grows taller than most other species, creating tangled masses. It reproduces by fragmentation, autofragmenting twice each summer.
  - In addition, Brittle naiad was observed in one location. If caught early, it could be eradicated, otherwise, it could become an infestation.
- Filamentous algae is widespread. It is not harmful by itself but can create nuisance mats.
- Small amounts of *Microceiras*, a mat-forming species of cyanobacteria, have been observed.

The observations reflect only what was visible and readily apparent during the boat trips and shoreline visits, which covered portions of the lakes during some of the growing season. Many species could not be determined, due to a lack of access, clear visibility, or expertise. An aquatic plant inventory is necessary to determine the extent and type of aquatic plants, as well as identify changes.

Aquatic Plants and the Lakes Ecosystem

The dense growth of aquatic vegetation is woven into the functioning of the lakes, the nutrient flow and use. The urban, altered, manipulated Portage Lakes are more susceptible to eutrophication from excessive nutrients. High levels of nutrients affect the growth of rooted and floating photosynthesizers and, thus, the water quality. Management measures should include these considerations:

- The dense vegetation is a direct result of high phosphorus levels from external (watershed) and internal loading (recycling during decay and from sediments).
- Rooted aquatic vegetation uses available phosphorus for growth and releases it during decay.
- Rooted aquatic vegetation competes with HABs for phosphorus. During growth, phosphorus used by macrophytes is not available for phytoplankton like algae and the cyanobacteria that cause HABs. When the plants are removed or decay, the phosphorus is available and can be used by algae and cyanobacteria for growth.
- Early die-off of certain species, widespread use of chemicals, or harvesting without removing cut material, releases phosphorus from decay during the growing season, spurring algae growth for a couple of weeks afterward. These die-off events can also create anoxic zones under the matted vegetation, releasing more phosphorus from the sediment, leading to more growth.
- Highly turbid water shades out plants and favors algae/HABs. Dense algae growth or disturbed sediment increase turbidity. Fine-grained sediment is more easily disturbed than sand. Plants help anchor sediment.
- Perturbations in eutrophic lakes that affect plant growth can trigger a switch from the “clear” state, dominated by rooted vegetation to a “turbid” state, dominated by floating algae and HABs. These conditions shade out rooted vegetation, cause health risks, affect property values, and are difficult and expensive to remedy. Changes that have caused perturbations in other lakes include removal of aquatic plants, drastic drawdowns, populations of “rough” fish like common carp that stir up sediment in the bottom.

An aquatic plant inventory and APM plan are important for managing aquatic plants in multi-use lakes.

Aquatic Invasive Plants

Aquatic invasive plants often cause the greatest nuisance – tangles of vegetation at the surface, where boats go, along docks, and choking fishing areas. Changing the conditions that favor them may help reduce their number. Several invasive species are already found throughout the lakes. It is important to reduce their initial and further spread in or to other water bodies.

- The invasive plants identified in the lakes favor disturbed sites, high nutrients, and turbid water. Dredging only where necessary, protecting native aquatic plants, and reducing nutrient input may help encourage growth of native species instead of invasive ones.
- Identifying and treating aquatic invasive plants also requires an inventory and monitoring for existing and new invasive species. If such species are detected quickly, they may be eradicated.

- In some cases, lake managers have eradicated invasive species and replace them with native species. This could be difficult in the connected Portage Lakes with high visitation. Impacts could be severe and should be evaluated.

The Need to Characterize the Plant Communities

The plant information presented in this chapter is from observations from several boat and shoreline trips. It is not comprehensive in extent or seasonality, and species identification is cursory. There is a need to characterize the plants in the lakes.

- Managing them requires knowing what kind of plants are in the lakes, their location, and extent.
- Because the aquatic plants are such an integral part of the nutrient cycling of the lakes and the habitats, management decisions must consider the effects on those roles, including:
  - Nutrient use
  - Seasonal characteristics
  - Potential to fragment
  - Sediment type/turbidity
  - Effect on other plants
  - Resistance to perturbations
  - Habitat value

  Ohio EPA's stream/river monitoring program includes biological, chemical and physical characteristics, because of the importance of biota to ecosystem health.

Aquatic plant inventory – systematically documents plant types and density.[21] In states with lake management/APM programs, aquatic inventories are conducted every few years.

Citizen Science/Community Observations – Community observation/citizen scientists can provide information before or after an aquatic plant survey is completed to supplement existing information. This also increases participation.

Citizen Science – there are several programs that train volunteers to collect data on aquatic plants or invasive species. This would likely result in structured observations at certain locations.

Community Observation – Many lakers, certain boaters and anglers, and agency staff regularly view certain areas and are often keenly aware of the aquatic plants. Community observations, either as a concerted effort or as individual observations, would be less time-consuming and less involved than an inventory or citizen science. The data collection would not be as rigorous, but it could be done throughout the growing season and throughout the lakes. Boaters or other visitors could submit comments and possibly photos on an on-line map maintained by one of the partners. Comments would remain private until reviewed. This could be linked with workshops, a lakes plant guide, boat tour or park activities, public forums like the PLAC website, and other outreach.

Aquatic Plant Management Tools

A variety of tools that can be used to control aquatic vegetation. Each has pros, cons, and effects on the ecosystem. An APM program will likely use various tools in response to different conditions. The methods should be evaluated based on feasibility (location, resources needed/available, cost, acceptability within the community); effectiveness; potential long-term effects – local and lakewide; and ability to modify or reverse the results. The lakes should be monitored following use of the tools.

In the Portage Lakes, the ODNR staff are using conceptual management zones as guidance for plant control and are using several tools to address focused concerns, as described below. However, technical support, equipment, and staff for some efforts are limited. A holistic APM program that integrates habitat, phosphorus cycling, plant types, lakers' concerns, feasibility, and available resources, would provide consistent guidance and allow lakers and lake managers to plan for, budget, and carry out aquatic plant management effectively. Some of the most commonly used tools include:

Conservation – One of the most important tools, where feasible, to protect the benefits provided by plants (e.g., habitat, phosphorus cycling, sediment stabilization, food, etc.)

- *ODNR is using the conceptual management zones to focus harvesting on high use areas, letting vegetation remain for habitat and nutrient uptake.*

Chemical – Toxins can be targeted to species, applied near docks. Applicators must have permit for use, because applying toxic chemicals to water can create health risks. Large-scale use may cause vegetation die-offs that release phosphorus or create anoxic zones.

- *In the Portage Lakes, residents contract individually with AquaDoc to treat docks. (Some may be applying their own chemicals.) ODNR will be hiring a plant control company to treat approximately 12 acres of high-use/high visibility areas in the lakes.*

Mechanical

- Manual removal – remove plants, including reproductive parts. This needs professional guidance and is labor intensive.
- Barriers – installed in high use areas, may need to be maintained.
- Harvesting – removes the top two feet of plants, preserving the rest. It is time-consuming and cannot be used in shallow water or too close to shore. Removal of cut material is recommended, because cut material may create nuisance mats or reproduce, and it releases phosphorus with decay. Removal requires dedicated staff, trucks, and a site but benefits the lake by potentially removing many pounds of phosphorus and fragments that could reproduce.
- *ODNR harvests for navigation and water flow. Due to limitations in staff, equipment, composting sites, and transportation, ODNR staff cannot remove the cut material. Most is harvested from Long Lake and North Reservoir.*

Physical – Altering conditions of lake chemistry, water level, or bottom, e.g., alum, dredging, drawdown. Some of these are used for other lake management purposes, e.g., water flow. Widespread use should be done with consideration to broad-scale ecological impacts.

- *ODNR conducts short-term drawdowns of 18 inches during fall every two years. This reduces impacts of large-scale drawdowns on plants during freezing conditions.*
- *ODNR will be conducting limited dredging for navigation for several years, starting in Turkeyfoot Lake. Each lake will require a dredge material recovery site.*
- *ODNR regulates how much water enters or leaves lakes with gates and drains. Residence time affects how long incoming phosphorus is available for growth.*

Biological – Replacing invasive plants with native plants; Introducing pests or species that change the structure of predators and herbivores. This can result in significant changes to the ecosystem and should be done with caution and monitored.

- *ODNR released 300 sterile grass carp into North Reservoir for plant control.*

Land-based – Watershed and shoreline measures to reduce phosphorus and sediment coming in, including: stormwater BMPs; addressing discharging septic systems; discouraging geese; lakescaping; restoring wetlands, floodplains, stream corridors; planting trees and native plants.

- *In the Portage Lakes watershed, Summit SWCD, and watershed communities use several of these and conduct activities and outreach. SWCD is establishing a watershed coordinator position for the Upper Tuscarawas. PLAC members have expressed interest in lakescaping and goose control. However, many lakers are likely unaware of these measures.*

Cultural – Aquatic plant management can only be accomplished with involvement and understanding by lake users and managers.

<u>*Needs of Lake Managers*</u>

- Technical information about plant control tools, impacts, and effects that considers the interconnected lakes system, nutrients, and aquatic plants.
- Institutional structure for an APM program with a focus on aquatic plant management and lake management, providing decision-making process, funding, staff, resources, guidelines, expertise, and expectations. This could be composed of elements from various organizations, but it needs to be coordinated and a long-term priority.
- *In the Portage Lakes, the roles of the park manager and most of his small staff focus primarily on the visitor experiences and park facilities. They also coordinate permits, contracts, and projects related to the lakes. The small Canal Lands staff focuses on flood control and maintaining flow; they also conduct harvesting to provide for navigation. There is little time to evaluate limnological aspects of plant control. The Management Plan TAC provides a forum for technical coordination and sharing of resources and should continue in some form. Summit SWCD is establishing a watershed coordinator position for the Upper Tuscarawas. These measures are a good start but should be coordinated and enhanced to increase awareness and participation among lakers and lake managers.*

<u>*Needs of Lakers*</u>

Outreach and involvement are key as this will be a new – but necessary – approach to lake management. A lake management program will follow guidelines developed to protect the lake ecosystem and lakers' concerns. Involvement of a well-informed community in developing and carrying out the management plan is especially important because of the large and diverse population of lakers, with varied interests.

The lakers are the people who use the lakes and will be directly affected by management practices. They need to understand the role of plants and phosphorus in a sustainable lake. They can contribute knowledge about problem areas and should participate in setting priorities, considering, and carrying out solutions. Lakers can also be important advocates for change.

Efforts should range from raising awareness to building stewardship and advocacy.

- *Raising awareness* - topics include: providing information, about the lakes' habitats and ecosystem, the benefits of aquatic plants, the reason for management zones, appropriate means of managing nuisance aquatic macrophytes, the role of nutrient management, lakers' opportunities to improve water quality, opportunities for stewardship and involvement, and recognizing and reducing the spread of aquatic invasive species.
- *Participation* –stewardship, developing and carrying out priorities, support for new approaches, and increasing advocacy for a dedicated, coordinated aquatic plant management effort.
- *In the Portage Lakes, there are a many disparate efforts and opportunities for increasing awareness, including activities and information offered by ODNR, Summit SWCD, PLAC, and local communities. There has been local interest in goose management, lakescaping, a public forum about HABs, and developing material for boat tours. The efforts need to be coordinated and targeted to specific lake/plant management topics.*

Management

Sustaining multiple uses on urban lakes is complex and challenging. It requires active management of conditions, aquatic plants, and uses. (In contrast, lakes with single uses are simpler to manage, as with public water supplies that severely restrict other uses to protect water quality). This is a new way to think about use and management of the lakes, but it is an approach used successfully in many parks, to allow both use and protection of a natural system. The connected chain of the Portage Lakes in a heavily settled area provides opportunities for supporting the multiple uses but also complicates management.

An APM program would integrate several elements, developed with technical input and community involvement to learn about and set priorities for APM. The public process helps build a shared understanding of the concerns, priorities, and actions. The elements below could be developed as part of an APM plan or individually and used together in coordination with the lake management partners.

Management Structure

Currently APM in the Portage Lakes involves individual decisions by lakers and lake managers. The decisions are often isolated responses to situations, with limited understanding or consideration of the lake system, and limited staff, guidance, or resources. Managing aquatic plants to support both lake ecology and multiple uses requires:

- Commitment to providing adequate staff, resources, and support.
- Technical support in understanding lakes and plant ecology
- Coordination of efforts, sharing information and resources and, through participation, developing a common understanding of priorities, tools, and effects
- Decision making process
- Funding source(s)
- Increased education and participation among lakers, communities, agencies, and lake managers is key is key to developing and carrying out an APM program.

A comprehensive APM program would allow lakers and lake managers to share expectations, improve decision-making and stewardship. Managers would be able to plan for expenses, staff, resources.

Other states have well-established lake or aquatic plant management programs that involve technical support, guidelines, permitting requirements, funding, or even lake-specific assistance (e.g., harvesting). These would provide good examples of practices that a Portage Lakes partnership could strive for. Ohio does not have such a program. Portage Lakes partners are taking on certain roles and responsibilities, but they will likely need additional support, coordination, a decision process, guidance, and outside funding. These are discussed further in Chapter 7.

APM Plans

APM plans are an important part of managing lakes, providing a framework for management decisions:

- Address areas of use, management, conservation, and invasive species.
- Based on aquatic plant inventories, an understanding of lake ecology, community priorities, management capabilities and resources, and potential impacts.
- Developed with the participation and involvement of lake users and managers to determine the priorities, tools, and management zones. The planning process could develop new management zones or refine preliminary ones.
- Because they specify plant types and amounts, they can be used to track changes and help reduce phosphorus.

Development of management plans requires adequate staffing, time, and technical support to complete the task, which is often done with external assistance.

Management Zones

Designating management zones and appropriate measures, in coordination with lakers, PLAC, agencies, and communities, is a way to accommodate different uses, allow management and conservation measures to be targeted. These can be developed separately or as part of an APM plan. They should involve a good understanding of the type and extent of plants, how that part of the lakes work, stakeholders' priorities, and capabilities and shared/available resources of the lake partners. The conceptual zones suggested in this report are based on limited reconnaissance and input, but could provide a starting point.

Coordinate contracts for APM at docks.

It is important to develop a vegetation control program at the docks to provide for consistent management, build common expectations among property owners that "weeds" will be addressed, and discourage property owners from applying their own chemicals to plants. Currently, the dock fees that residents pay go to the Ohio general fund, and residents manage nuisance vegetation on their own. There needs to be coordinated approach and a way to collect fees for the APM at docks. This will require establishing a fund for APM, staff commitment to focus on handling the contracts and fees, and communication with property owners.

Harvesting Program with Removal of Cut Vegetation

Harvesting with removal, as part of an APM program, could provide important benefits for managing the Portage Lakes (and others), improving conditions in the lakes and for lake users. ODNR Canal Lands staff conduct harvesting, in the Portage Lakes and others, in addition to their primary focus. Lacking staff, time, equipment, and resources, they cannot remove cut material.

Harvesting with removal is a substantial enough effort that it should be a focus rather than an additional task for a staff with other primary tasks. It may be possible to share tasks, responsibilities, resources with other partners. Establishing a program, e.g., within ODNR or another organization, would allow management of harvesting and composting that fulfills the guidelines of an APM program or plan.

- Harvesting with removal requires additional equipment on the lakes (e.g., barge) and on land (trucks), staff on land and on the harvester, and a site for off-loading, drying and composting. The pile of drying vegetation may be unattractive for several days at a time.
- The staff and equipment could be housed within ODNR, contracted out, or shared with other partners. Communities may be able to assist with transportation to compost facilities.
- It may be possible to use dredge material receiving areas to store and dewater harvested material, at least temporarily.
- The harvesting operations would need to be coordinated with the APM program and partners, not only to provide navigation but also to provide for water flow from the Feeder Canal. If there were a coordinated program, ODNR Canal Lands staff could integrate harvesting for water flow with the other harvesting priorities.
- Funding would be needed for a new program. US Coast Guard and ODNR have grant programs for improving navigation, which may be available for sites, equipment, or labor. In addition, projects that remove substantial amounts of phosphorus may be eligible for water quality improvement funding.
- Effects on the lake ecosystem should be monitored.
- An established program could more efficiently serve other lakes, improving the lakes for visitors and residents. The Canal Lands staff would be able to focus on flood and flow management.

Recommendations Summary

Sustainably managing aquatic plants and lake uses requires additional commitment on many levels, from individual lake owners through agencies, to be effective:

- A new focus, funding, coordination, decision-making, and some changes to the way the lakes are used and managed.
- Advocacy and creativity in obtaining/sharing resources, and coordination to integrate technical understanding with lakers' priorities and organization capabilities.

Until an APM plan is developed for the Portage Lakes, or as phased parts of its development, ODNR and other Portage Lakes partners can coordinate efforts and evaluate the need, feasibility, resources, impacts, and costs of APM measures. With input from the lakers, communities, and agencies, the partners can identify priorities, management zones and practices, and apply management techniques to some degree. The recommendations discussed in this chapter include:

- **Develop a management structure for APM**
  - Within an organization or as a partnership
  - Consistent, defined roles, purpose, and funding
  - allowing for technical input, coordination, sharing of resources and opportunities, decision-making, and funding.
- **Develop a more thorough understanding of the plant communities -** type, extent, seasonality, and changes in the aquatic plant communities, role within ecosystem, how users and plants affect each other. Tools could include:
  - An aquatic plant inventory
  - Developing a guide to lake plants
  - Citizen science plant surveys
  - Community observation program
- **Seek input and involvement from stakeholders** to identify problem areas and priorities, providing a context of lake ecology
  - PLAC and the Portage Lakes TAC/Partners
  - Public forums
  - Volunteer observation opportunities
- **Develop an APM plan or program**, with input and involvement from lake scientists, residents, users, partners, and communities. Many of the elements can be phased in, which would set up a comprehensive framework for understanding, decision-making, applying plant control measures, and allocating resources.
- **Identify Management Zones, specifying level of management, appropriate tools, cost, equipment, and guidelines** based on observed plants, priorities, involvement and discussion with lakers, community representatives, and agency staff. Preliminary zones, similar to those shown in the chapter, could be based on available observations and input and refined after an aquatic plant inventory is completed.
- **Coordinate contracts for APM at docks**, and establish a funding mechanism.
- **Develop a harvesting program with removal of cut material.** This requires coordination, staff, equipment, and on-land sites for storing/composting material. This effort would probably need outside resources. Grants and sharing resources with partners may help meet the needs.
- **Minimize the spread of invasive species.**
  - Encourage boaters, anglers, and visitors to use Clean Drain Dry practices. The PLAC webpage has information. There could be more posters and videos at marinas.
  - Consider establishing Clean Drain Dry stations. External funding may be available.
  - Monitor for invasive species.
  - Develop rapid response program for new or isolated invasive species.
  - Evaluate a demonstration project to replace invasive plants with native ones.
  - Minimize disturbed sites, protect native plants, dredge only where necessary.
- **Outreach and involvement** targeted to lake/aquatic plant management, with the purpose of raising awareness, stewardship, participation in decision making and plant management, and advocacy. There are a lot of individual efforts under way, and the PLAC, SWCD, and ODNR have programs but there needs to be a coordinated approach. Ideas that have been discussed among partners for early efforts focused on plants include:

- Information columns in local news media and on the PLAC website.
- Guidebook or information sheet about aquatic plant types in the lakes.
- Information sheet for boaters about lake management zones, display at boat ramps/marinas; informative menus for restaurants
- Workshops and demonstration projects on lakescaping and goose management
- Public workshops focusing on HABs and the dock/shoreline management plan (postponed due to COVID)
- Developing a lake management display and suite of information brochures for use at public gatherings.
- Trivia night at local restaurants.
- Homeowner's guide to the lakeshore
- Frequently asked questions, facts of the month on the PLAC website or in other community messaging.
- Signage describing BMPs or conservation areas
- Others as discussed in Chapter 7.

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[1] The shoreline habitat discussion draws from several inland lakeshore websites from different states. The species may differ, but the concepts are widely applicable. Examples include:

New York State Department of Environmental Conservation (NYSDEC), 2005. *A Primer on Aquatic Plant Management in New York State. Draft*. Division of Water. https://www.dec.ny.gov/docs/water_pdf/ch6apr05.pdf Retrieved October, 2017.

Dixie Sandborn, 2020. Understanding Lakeshore Ecosystems Part 3 – Natural Vegetation. Michigan State University Extension https://www.canr.msu.edu/news/understanding_lakeshore_ecosystems_part_3_natural_vegetation accessed June, 2020.

[2] Descriptions from various sources. It is important to use plants native to the area and appropriate for the lake edge, sun, soil, and wind conditions. Summit County Soil and Water Conservation District, Ohio State University Extension, and ODNR are good sources of local or Ohio information about lakescaping and native plants. Wetland and lakeshore plants are often listed as native plants for rain gardens

General discussions of lakescaping and planting guidebooks include:

Beth Clawson, 2017. Making your Native Plant Choices for Michigan Inland Lake Shorelines. MSU Extension. https://www.canr.msu.edu/news/making_your_native_plant_choices_for_michigan_inland_lake_shorelines Accessed 2/2021

Federation of Vermont Lakes and Ponds, 2015. *A Guide to Healthy Lakes Using Lakeshore Landscaping.* https://dec.vermont.gov/sites/dec/files/wsm/lakes/Lakewise/docs/lp_VTlakescape.pdf accessed Feb. 2021.

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[13] *The Primer for Aquatic Plant Management Plans in New York State* notes that a community plant observation program can provide a good basic foundation for APM when aquatic plant inventories are not available, although they do not identify all the species. (NYSDEC, 2005. *Op. cit.)* In the Portage Lakes citizen observations/citizen scientist monitoring could be a good start before developing an aquatic plant inventory, and a way to monitor in between inventories. The 2005 draft Primer recommends viewing the lakes from above, e.g., airplane or rooftops. In the Portage Lakes, on-the-water observations are an important tool, spotting vegetation below the surface in turbid water, or from a distance. Since 2005, the personal phone with gps and a camera has become widely available and is a powerful tool in mapping conditions at a certain date and location. The CSLAP Aquatic Plant Survey has a more rigorous sampling protocol and helps identify certain species.

[14] For example, NYSDEC, 2005, *Op. cit.;* Vermont Invasive Patrollers https://dec.vermont.gov/watershed/lakes-ponds/aquatic-invasives/monitoring/vips

[15] There are a number of case histories of unanticipated consequences of biomanipulation in lakes, including (cited in Ch. 4)

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[17] Bill Bartodziej, 2015. Aquatic Plant Harvesting and Phosphorus Reduction. Ramsey-Washington Metropolitan Watershed District, Little Canada, MN. *https://www.rwmwd.org/aquatic-plant-harvesting-and-phosphorus-reduction/, retrieved June, 2020.*

[18] One study specifically addresses the importance of public involvement in reversing an ecosystem shift: Romina Martin, Maja Schluter, and Thorsten Blenckner, 2020. PNAS The importance for transient social dynamics for restoring ecosystems beyond ecological tipping points. https://www.pnas.org/content/pnas/early/2020/01/17/1817154117.full.pdf Retrieved Feb., 2021.

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Wisconsin -Wisconsin Dept. of Natural Resources, Aquatic Plants, https://dnr.wisconsin.gov/topic/lakes/plants, Aquatic Plant Management in Wisconsin https://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/ecology/aquaticplants/default.aspx , https://dnr.wi.gov/lakes/plants/research/ ;

New York State Dept. of Environmental Conservation (NYSDEC) 2005. Op. Cit.

Minnesota https://www.dnr.state.mn.us/apm/index.html ;

Vermont Dept. of Environmental Conservation (VDEC) https://dec.vermont.gov/watershed/lakes-ponds/aquatic-invasives/control

[20] Examples include: Wisconsin Dept. of Natural Resources, Aquatic Plants, https://dnr.wisconsin.gov/topic/lakes/plants, *Aquatic Plant Management in Wisconsin* presents a good framework for developing an aquatic plant management plan: https://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/ecology/aquaticplants/default.aspx , https://dnr.wi.gov/lakes/plants/research/ ;

New York State Dept. of Environmental Conservation (NYSDEC) Aquatic Plant Management. Op cit.

[21] For example, Hauxwell, J. et al., 2010. Op. cit.

Chapter 6 – Overview
Water Quality and Watershed

Chapter Organization

The water quality of the Portage Lakes depends on what goes on in the watershed. Landscape features and activities can help protect or impair water quality and flood management. Natural features such as woods, wetlands, floodplains, and riparian vegetation protect water quality, reduce nutrient loading, increase resilience of stream channels, and reduce problem flooding and erosion. Developed landscapes are products of people living in the watershed, but they can increase runoff, stream damage, and contamination from activities. The external nutrient loading entering the lakes comes with runoff, as do floods, erosion, sedimentation, harmful chemicals, and pathogens. Any or all of these can harm the lakes and threaten their uses. Balancing the human use of the watershed with water quality protection and flood management requires protecting and restoring important landscape features and reducing runoff and contamination. This chapter presents an overview of many key watershed characteristics and suggests ways to reduce impacts from the developed landscape and sustain healthy lakes and streams.

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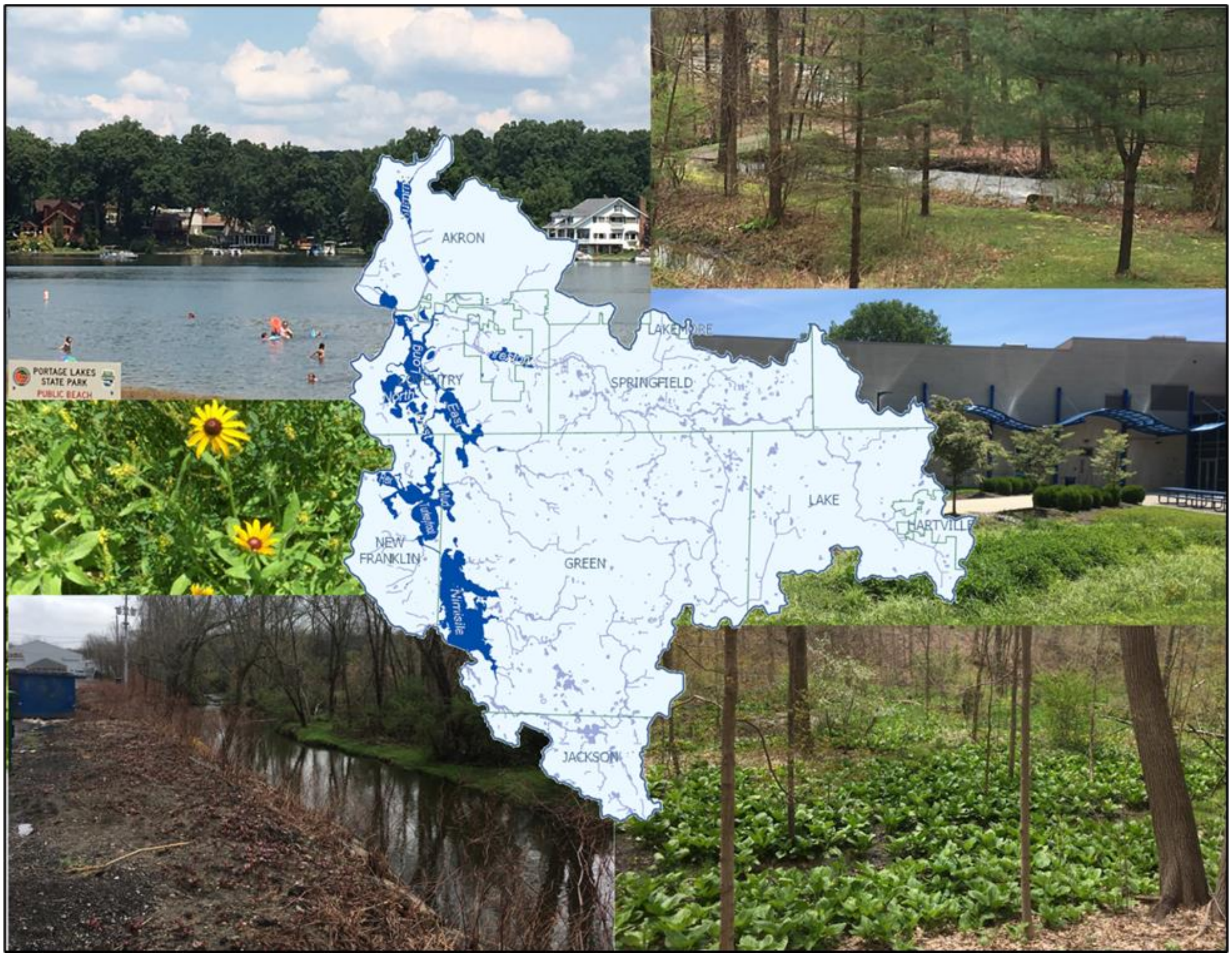


6. Portage Lakes Water Quality and Watershed

The water of the Portage Lakes flows in across the landscape of the watershed. The landscape and land uses affect the water quality in the streams the Portage Lakes. Certain landscapes, such as wooded stream corridors, floodplains, and wetlands, help protect water quality, absorbing or storing rainwater and taking up nutrients and other contaminants. In developed and agricultural land, stormwater runoff increases and carries with its nutrients, chemicals, bacteria, and sediment from the altered landscape.

In the Portage Lakes, contaminants of greatest concern include:

- Nutrients, especially phosphorus, which fuels eutrophication, aquatic plants, and HABs
- Harmful bacteria
- Sediment

High levels may harm the water quality or uses of the lakes.

This chapter

- Describes the link between watershed landscape and water quality,
- Addresses the water quality of the watershed in light of the watershed characteristics, and
- Identifies practices can help protect and improve water quality of the streams and lakes.

Portage Lakes Watershed Setting - Ecoregion

Ecoregions are ways to characterize the landscape, areas of similar ecosystems and natural resources. They are determined by identifying living and non-living landscape characteristics. The Portage Lakes area is in a glaciated landscape, and shows many features of moving and melting ice. It is a portion of the Erie/Ontario Drift and Lake Plain, known as the Summit Interlobate area.[1] This area formed between lobes of ice, and is characterized by gently rolling hills of glacial drift and fine-grained lake deposits. It has abundant lakes, wetlands, bogs, sluggish streams, glacial kames (sandy hills that formed near ice) and kettles (isolated lakes from stranded ice blocks). The substrate is often sandy outwash from glacial meltwater, and till, a mixture of materials, from silt to boulders, left by the ice. Well-drained uplands once supported mixed oak forests but are largely developed.

The Portage Lakes began as kettle lakes in this landscape. Some still retain those characteristics, small, steep-sided, deep lakes with small watersheds. The area has some substantial wetlands, low-gradient streams, and bogs.

This area around Singer Lake has the kettle lakes, bogs, and other wetlands (darker land) of the ecoregion, as well as the developed uplands.

The Ohio EPA and Water Quality

When the Clean Water Act[2] was established, rivers, lakes, and areas of the oceans were so full of oil and other toxic chemicals, bacteria, and nutrients that many waters were toxic, unusable, dead zones, some caught fire, and many of transmitted diseases.

The goal of the Clean Water Act is to restore the chemical, physical, and biological integrity of the nation's waters. The Ohio EPA carries out the requirements of the Clean Water Act. Their role includes:

- Designating "beneficial uses" for waters in categories of water supply, recreation, and habitat. All waters are designated as high quality uses unless prohibit such uses, e.g., industrial discharge precludes use as a public water supply, canals are assigned different aquatic uses than streams.
- Developing and enforcing water quality standards,
- Permitting discharges within acceptable limits and activities that do not degrade water quality
- Monitoring the chemical, physical, and biological integrity of water for attainment of standards
- Listing water bodies not attaining water quality standards (i.e., impaired)
- Identifying causes, sources, and remedies of impairment
- Providing funding for water quality improvements
- Research, technical support, and outreach

Watershed Features Affect Water Quality

The Ohio EPA monitors the chemical and physical conditions of the water itself, pathogens, and the biological communities. The condition of the habitat and animals that the water can support reflect the long-term overall health of a water course and its watershed. Water courses that support a diverse community of pollution-sensitive species tend to be well-functioning and healthy – for people as well as animals. Ones that only support a few pollution-tolerant species tend to be so impaired that they cause problems for people as well.

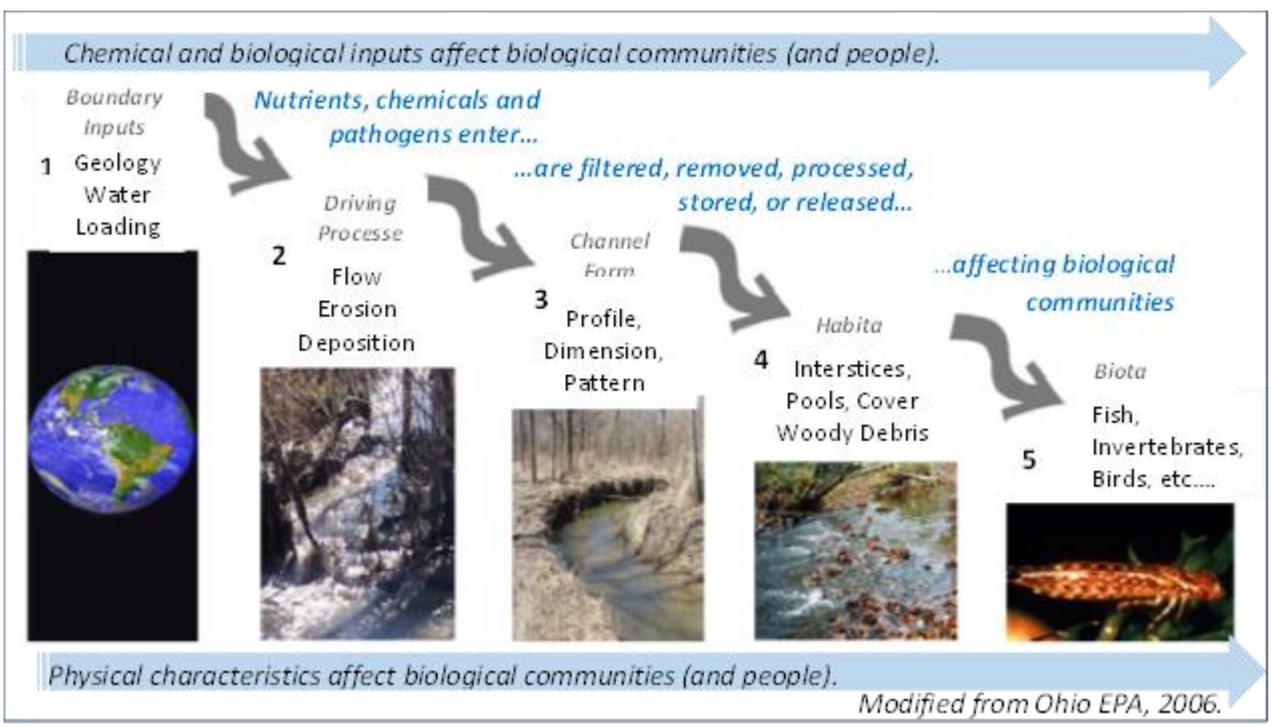
This chapter presents the known water quality indicators in the context of the contributing watershed. Figure 6.1 illustrates that:[3]

- Watershed characteristics affect the processes, inputs and forms, which influence
- Streams, contaminants, flooding, channel characteristics, habitat, and then,
- The biological organisms.

People affect and are affected by the system at all levels.

1. **Watershed conditions** affect loading of water, sediment, and contaminants into a stream
2. **The slope and load** affect flow, erosion, deposition,
3. **Flow, erosion and deposition** affect channel form, contaminants, and flood management
4. **Channel form** affects the habitat, oxygenation, channel stability (tendency to erode down or silt in), the connections to floodplain, and the sediment within the stream and channel
5. **The characteristics of the system**, from the watershed to the stream segment, affect the type of life that the stream will support.

Figure 6.1 Landscape Effects on Stream and Biota



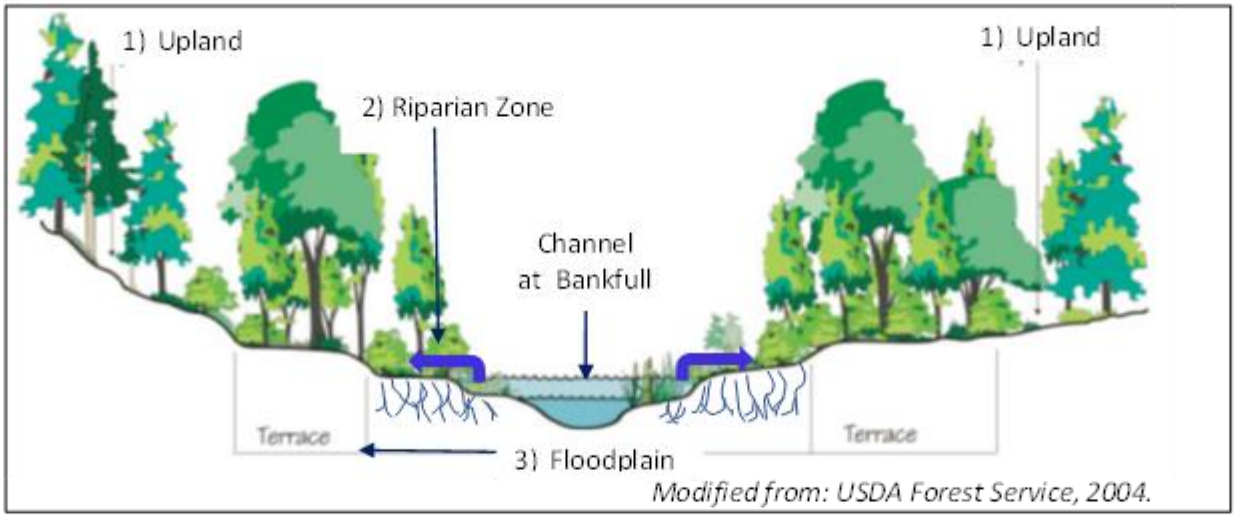
Ohio EPA monitors the biological communities at the receiving end, because they reflect the contributing factors from the watershed. Changes in the "upstream" end of system have effects all the way "downstream." When Ohio EPA identifies impaired waters, they look upstream to determine the causes and sources.

This chapter focuses on the watershed conditions that influence water quality.

Intact Natural Landscapes Help Streams, Lakes, and People

In an undisturbed landscape, the natural features perform important functions that contribute to a well-functioning stream (or lake) and diverse biological community. (Fig. 6.2)[4]

Figure 6.2 Riparian Ecosystem Cross Section



1. Upland woods and fields intercept and allow rain to infiltrate into the ground.
2. Wetlands, floodplains, and deep-rooted plants in the riparian (streamside) corridor slow and absorb storm water, take up nutrients, stabilize stream banks, and provide shade, cover, and important habitat. Riparian vegetation is water loving – the roots extend to where the groundwater flows into the stream, taking up nutrients or contaminants.
3. When a stream exceeds bankfull, it spills onto its floodplain, which acts like a safety valve, reducing stream flow and erosion during storms. Floodplains allow silt to settle out, keeping contaminants out of streams and lakes, and sustaining the floodplain habitat.



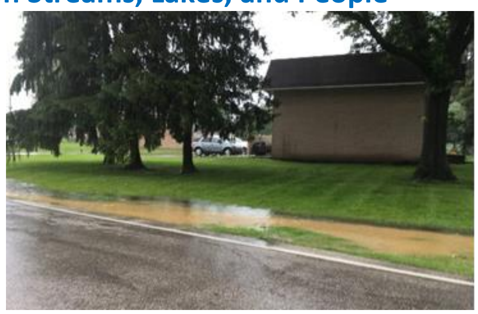
***Landscapes providing benefits**. Riparian vegetation, with its roots in the water, takes up nutrients and other contaminants and stabilizes streambanks. Floodplains and wetlands store floodwater, keeping it out of lakes and basements, take up nutrients, and allow sediment and associated contaminants to settle out, enriching the habitat.*

Even the form of the stream channel helps maintain equilibrium and good water quality.

The stream channel form has developed in equilibrium with the slope, amount of water, and sediment coming in. The low gradient stream to the right meanders and shift horizontally but will maintain its vertical position, neither eroding nor silting in.

Meanders help regulate flow, allowing silt to be cleared out of channels in low flow and accommodating higher flows. The riffles (rough water over stones) and pools provide varied, habitats supporting various species. The flow over riffles adds oxygen.

Impacts of Altered Landscapes on Streams, Lakes, and People



People moving into an area develop and farm the land. Altering the natural landscape, replacing trees, wetlands, and floodplains with agricultural land and the hardened landscape of roofs, pavement, and sod, increases flooding, erosion, and contaminants going into the streams and lakes:

- Altering and hardening natural features increases the water that runs off the land, carrying contaminants from the agricultural and built landscape, including animal waste, chemicals, nutrients, metals, oil, and other toxins. (Figure 6.3)
- Certain uses discharge contaminants, e.g., septic systems, wastewater treatment plants, industries.
- Filling in wetlands and floodplains, removing deep-rooted riparian vegetation removes the features that slow down and store excess water. More water and contaminants enter and course through the streams. Stream banks erode more easily without deep-rooted vegetation to stabilize it ("nature's re-bar").
- The excess water has no place to go without accessible floodplains. Stream channels become unstable, eroding deeper and wider, increasing erosion, siltation, input of nutrients, metals, and other contaminants within the sediment, and severe flooding once it escapes the channel.

A developed watershed, decades of "mowing to the edge," and altered stream slope resulted in this eroded, incised stream. The short, thin roots of turf offer little bank stability, flood reduction, or contaminant removal. With no accessible floodplain to store floods, the channel continues to erode, exacerbating a hazard, sediment and pollutant load, and habitat degradation.

Figure 6.3 Hardened Landscape and Runoff

1 Rain runs off hardened surfaces, unvegetated landscape, and turf.
2 and 3 Runoff carries with it sediment, oil, toxic metals, chemicals, animal waste, pathogens, nutrients.
4 Excess water erodes channels deeper and wider, increasing sediment and everything attached to the sediment, reducing floodplain access, increasing downstream flooding, disrupting habitat, causing hazards. This torrent started off in small ditches along three neighborhood blocks with half-acre lots.

5-8 Runoff enters rivers and streams via storm drains and direct flow. 6 - Runoff entering the Upper Tuscarawas River. 7 - Sediment plume where runoff enters a river (stones are still visible in the clear water). 8 - Coalescing brown plumes show that runoff, laden with sediment and other contaminants, has entered the river from multiple sources, including a storm drain outfall.

The landscape changes affect water quality, flooding, stream function, habitat, aquatic life, and people.

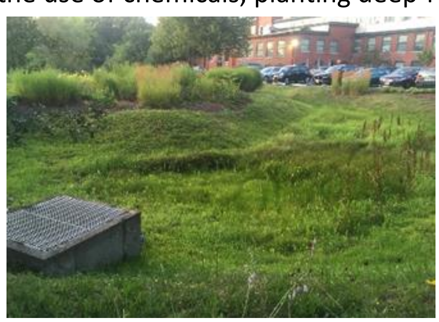
- Increased bacteria and toxins entering the water are harmful to wildlife and people.
- Increased nutrients promote excessive growth of aquatic plants, algae, and possibly HABs. which can harm people and aquatic animals.
- Sediment fills in habitat, overloads streams, and carries nutrients and other contaminants.
- Turbidity, related to sediment, decreases visibility for predators and raises water temperature.
- Destabilized stream channels from excessive runoff and channel alteration degrades habitat, reduces nutrient uptake, increases erosion and sedimentation, and increases flooding and erosion, which are harmful to water quality and habitat and pose hazards to people.



Reducing Impacts with Best Management Practices and Restoration

Because people live in communities within watersheds, watersheds can no longer be pristine natural settings. However, there are ways to reduce impacts to the watershed and waters, balancing water quality with people's use of the watershed:

- Protect the existing landscapes that provide the most benefit, such as floodplains, riparian vegetation, and floodplains,
- Restore lost functions, such as stormwater infiltration, nutrient uptake, or flood storage with Best Management Practices (BMPs), planting trees, shrubs, or native plants, or restoration.
- Reduce impacts by cleaning up after pets, discouraging geese, taking care of septic systems, controlling spills, limiting the use of chemicals, planting deep-rooted plants near the water.


***Restoring natural landscape functions**. Best management practices range in scale and complexity, from replacing turf with native plants, shrubs, or trees, to addressing stormwater at the scale of a development or stream reach. Left - Deep-rooted native plants help rainwater infiltrate into the ground reducing runoff and taking up nutrients. Center – Stormwater detention basins temporarily store runoff. Vegetation, especially tall vegetation with deep roots, helps filter out, adsorb, and take up nutrients and other contaminants. Right – Stream channel restoration restores floodplains and meanders, improving flood storage, habitat, and resiliency of streams. Native plants planted along the riparian area will protect the stream. Restoration projects are typically protected by easements. With a range of costs, such projects can be funded privately, included in development requirements, or grant-funded.*

Portage Lakes Watershed Designated Beneficial Uses, Aquatic Life Use Attainment

Table 6.1 lists the Beneficial Use Designations for the Portage Lakes watershed.[5] Ohio EPA monitors attainment for water supply, recreation, and aquatic life use criteria.

Table 6.1 Beneficial Use Designations Portage Lakes Watershed

Water Body	Water Supply	Recreation	Aquatic Life Use
Tuscarawas	Agricultural, Industrial	Primary Contact	Warmwater Habitat
Canal			Modified Warmwater
Nimisila Creek	Agricultural, Industrial	Primary Contact	Warmwater Habitat
Tributaries	Public Water Supply	Primary Contact	Warmwater Habitat
Lakes	Public Water Supply	Primary Contact	Exceptional Warmwater

The Aquatic Life Use (ALU) attainment is an important indicator of the health of water courses. In order for a water body to attain its ALU standards, it must meet the standards for three biological indices that reflect the type and diversity of fish and macroinvertebrate populations (Index of Biological Integrity, IBI; Modified Index of Well Being, MiWB, and Invertebrate Community Index, ICI). Ohio EPA also monitors the habitat quality (QHEI), due to a strong link between habitat quality and the biological community. Map 6.1 and Table 6.2 present the ALU attainment for the Portage Lakes watershed.[6]

Map 6.1 Aquatic Life Use Attainment, Portage Lakes Watershed

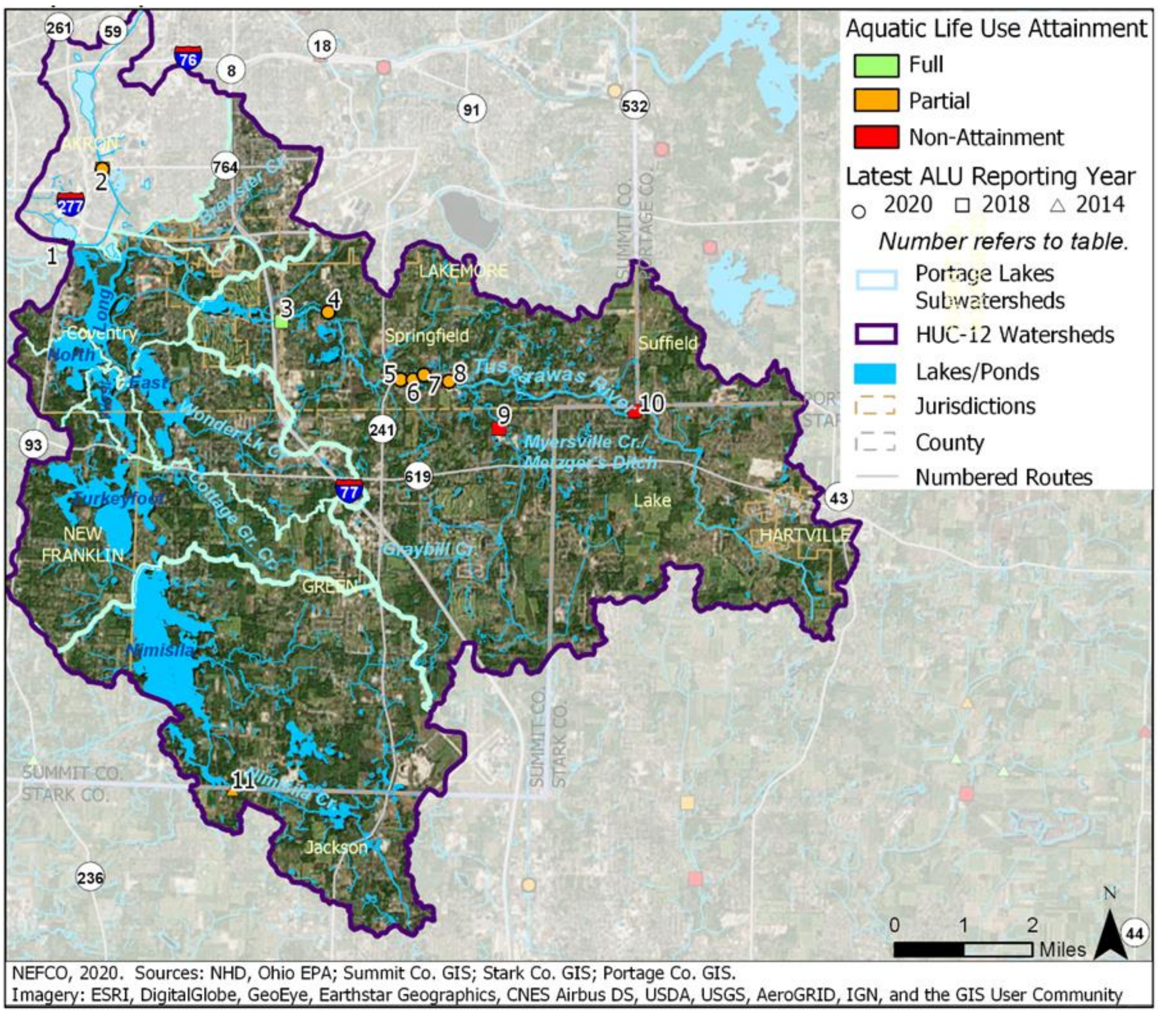


Table 6.2 Aquatic Life Use Attainment Portage Lakes Watershed

			Fish					Macroinvertebrates				
Site		Reporting Year(s)	Sample Year	IBI Score	IBI Narrative	MIwb Score	MIwb Narrative	Sample Year	ICI Score	ICI Narrative	QHEI Score	Attain.
Ohio Canal, AU ID 050400010105, River Code 17-500-029 Modified Channel, Modified Warmwater Habitat												
1	303368 DST Manchester Rd, Lk Nesmith, RM 4.4	2018, 2020	2016	32	Fair	8.5888	Good	2015	30	Marginally Good	37	Full
2	Wilbeth Rd., RM 6.2	2018, 2020	2016	40	Good	8.8406	Good	2015	16	Fair	39.3	Partial
Tuscarawas River, AU ID 050400010101, River Code 17-500-000 Unless Noted, Warmwater Habitat												
3	Arlington Rd. RM 119.3	2014, 2016, 2018	2003	38	Good	7.7	Mar. Good	2004	40	Good	58	Full
4	UPST Summit Co. WWTP RM 120.1	2018, 2020	2015	41	Good	7.2649	Fair	2015	46	Exceptional	81.8	Partial
		2014, 2016	2003	38	Good	7.5	Mar. Good	2004	42	Very Good	75	Full
5	303016 Massillon Rd., RM 122.05	2018, 2020	2015	37	Mar. Good	7.2533	Fair	2015	46	Exceptional	63.5	Partial
6	R06K17 DST Killian Latex, RM 122.4	2016, 2018, 2020	2005	34	Fair	7.037	Fair	2005	18	Low Fair	71	Partial
	RM 122.5	2014	2005	34	Mar. Good	7.1	Fair	2005	18	Fair	71	Partial
7	R06P25 Near Uniontown, Adj. Killian Latex, RM 122.65	2016, 2018, 2020	2005	34	Fair	5.9463	Fair	2005	28	Fair	62.5	Partial
	RM 122.7	2014	2005	34	Mar. Good	6	Fair	2005	28	Fair	62.5	Partial
8	R06P27 Pressler Rd., RM 123.1	2018, 2020	2015	43	Good	6.6068	Fair	2015		Good	69.8	Partial
		2016	2005	34	Fair	5.67	Poor	2005	32	Mar. Good	70.5	Non
		2014	2005	34	Mar. Good	5.7	Poor	2005	32	Mar. Good	70.5	Non
9	R06K20 Metzgers Ditch Upst. Meyersville Rd., RM 0.5	2014, 2016, 2018	2003	28	Fair			2004		Fair	60.5	Non
10	R06S28 Mogadore Rd. RM 126.7	2014, 2016, 2018	2003	18	Poor			2004		Fair	70.5	Non
11	R06G11 Mt. Pleasant RC 17-538-000 RM 7	2014	2004	30	Fair			2003		Mar. Good	79	Partial

IBI - Index of Biological Integrity
MIwb – Mod. Index of Well-Being
ICI – Invertebrate Community Index
QHEI – Qual. Habitat Eval. Index

WWH Criteria:

IBI Score	MIwb Score		ICI Score	QHEI Score	*Good*	*Excellent*
40	Wading	7.9	34	Headwaters	55-69	>=70
	Boat	8.7		Lg Streams	60-74	>=75

Ohio EPA has monitored the Upper Tuscarawas River since before 2000 and found the river to be impaired. Ohio EPA's 2009 Total Maximum Daily Load (TMDL) study identified causes and sources of impairment. The TMDL indicates:

- Tuscarawas - full attainment at River Miles (RM) 119.3 and 120.1, (sites 3 and 4). However, recent monitoring found Site 4 was in partial attainment, with MIwb falling below the criterion.
- Tuscarawas RM 120.1-126.7 - partial attainment due to flow alteration, organic enrichment, and nutrients, from channelization and suburbanization.
- RM 126.7 (site 10) - non-attainment due to habitat alteration, siltation, organic enrichment, and pathogens from suburbanization and channelization.
- Metzgers ditch - non-attainment, due to a natural "wetland stream"
- Nimisila Creek -partial attainment - organic enrichment - suburbanization, failing septic systems.

Even though Ohio EPA has not monitored other tributaries in the Portage Lakes watersheds, the same factors likely affect the lakes and tributaries in those watersheds.

Portage Lakes Land Cover and Imperviousness

Land Cover

Land cover is mapped from aerial imagery and helps predict water quality impacts of the landscape. The Portage Lakes watershed is primarily altered by development and agriculture. Runoff from these landscapes can degrade water quality. Best management practices can reduce impacts.

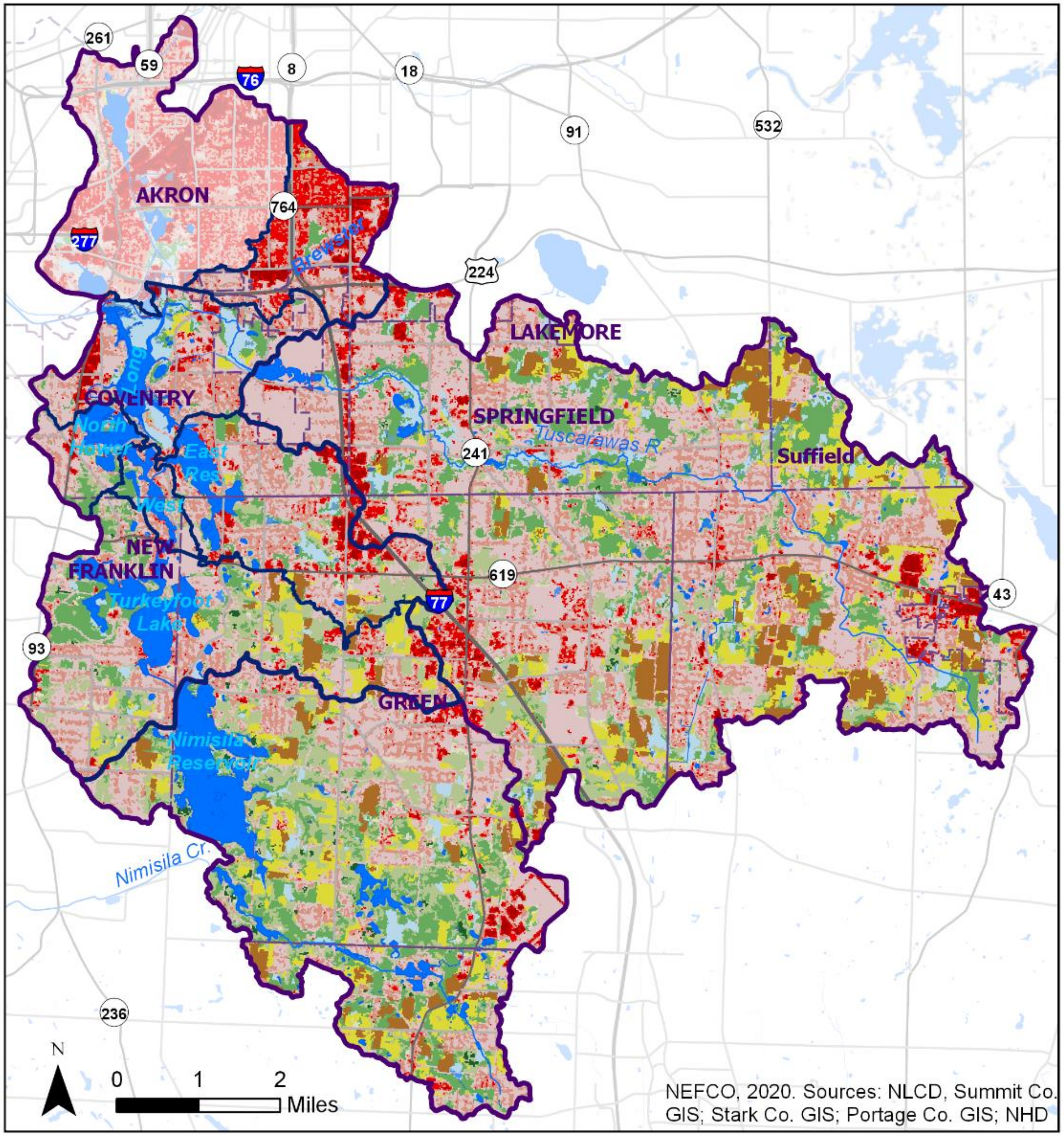
Suburbanization in the Portage Lakes watershed.

- As shown on Map 6.2 and Table 6.3, the watersheds draining to the Portage Lakes, except Nimisila, and Brewster Creek are 50 to 67 percent developed, primarily with low-density development and developed open space.[7]
- The highest-density development is concentrated along interstate highways, major roads, and in Akron and Hartville. The Brewster Creek watershed is intensely developed at 97 percent.
- Nimisila, Turkeyfoot, and the Tuscarawas watersheds have the most agricultural land.
- Nimisila is the least developed watershed, with the most woods.
- Woods and wetlands, 20-35 percent of most watersheds, help protect water quality. The woods and wetlands along the water courses are especially beneficial.
- Substantial in the Long Lake, Tuscarawas River, Nimisila Reservoir, and East Reservoir watersheds are important for conservation. Long Lake has the most wetlands.

Imperviousness

Imperviousness is the "hardness" of the landscape, how easily water runs off. Pavement and roofs are impervious, woods are not. Low-density development is in between. Developed open space, with its compacted ground, is largely impervious.

Map 6.2 Land Cover by Subwatershed



- HUC-12 Watersheds
- Subwatersheds
- Numbered Routes
- Other Major Roads
- Lakes/Ponds
- Jurisdictions

Note: Outline of Portage Lakes HUC-12 Watershed is shown. Area outside Portage Lakes drainage area is screened back.

NLCD Land Cover Classification Legend

- 11 Open Water
- 12 Perennial Ice/ Snow
- 21 Developed, Open Space
- 22 Developed, Low Intensity
- 23 Developed, Medium Intensity
- 24 Developed, High Intensity
- 31 Barren Land (Rock/Sand/Clay)
- 41 Deciduous Forest
- 42 Evergreen Forest
- 43 Mixed Forest
- 51 Dwarf Scrub*
- 52 Shrub/Scrub
- 71 Grassland/Herbaceous
- 72 Sedge/Herbaceous*
- 73 Lichens*
- 74 Moss*
- 81 Pasture/Hay
- 82 Cultivated Crops
- 90 Woody Wetlands
- 95 Emergent Herbaceous Wetlands

* Alaska only

Table 6.3 2017 Land Cover and Percent Impervious by Subwatershed

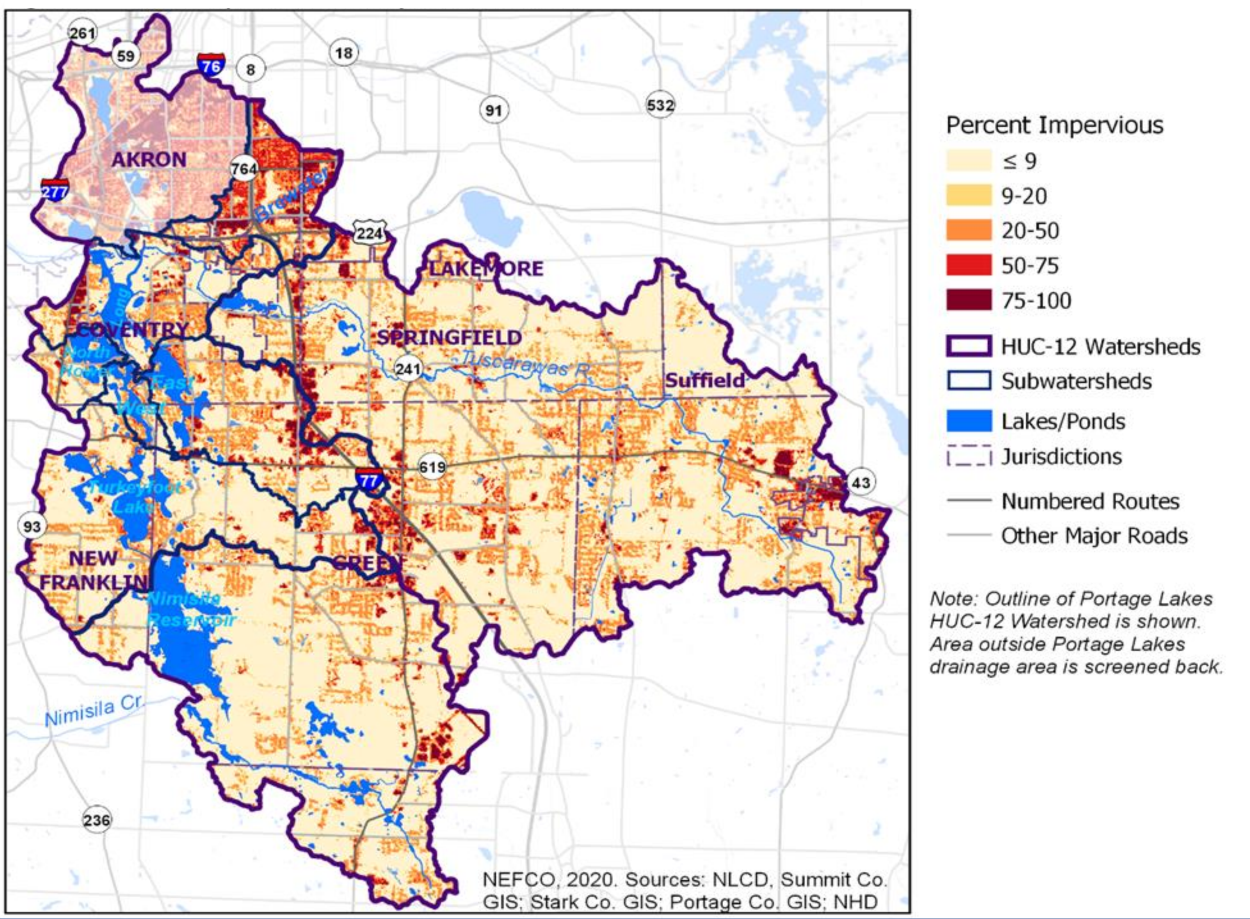
	Tuscarawas		Brewster Cr.		Long Lake		Hower-North		West		East		Turkeyfoot		Nimisila	
Land Cover	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pct.	Acres	Pct.
Open Water	146	0.6	0	0.0	202	8.4	161	22.8	103	22.8	230	7.5	480	9.4	922	8.3
Developed	13,534	59.2	1,772	97.4	1,510	62.9	387	55.0	256	56.6	2,048	66.7	2,569	50.2	4,275	38.3
Open Space	7,767	34.0	350	19.2	690	28.7	202	28.7	134	29.8	902	29.4	1,443	28.2	2,556	22.9
Low Intensity	4,268	18.7	560	30.8	554	23.1	145	20.6	94	20.7	746	24.3	915	17.9	1,383	12.4
Medium Intensity	1,077	4.7	636	35.0	181	7.5	30	4.2	23	5.1	275	9.0	169	3.3	244	2.2
High Intensity	421	1.8	227	12.5	85	3.5	10	1.5	4	1.0	125	4.1	42	0.8	92	0.8
Barren Land	2	0.0	2	0.1	0	0.0	1	0.1	1	0.2	1	0.0	0	0.0	1	0.0
Forest	4,476	19.6	35	1.9	198	8.2	149	21.1	86	19.1	542	17.6	1,420	27.7	3,801	34.0
Deciduous Forest	2,718	11.9	34	1.9	173	7.2	114	16.1	54	12.0	242	7.9	626	12.2	1,666	14.9
Evergreen Forest	33	0.1	0	0.0	0	0.0	0	0.0	0	0.0	4	0.1	20	0.4	111	1.0
Mixed Forest	1,724	7.5	1	0.1	24	1.0	35	5.0	32	7.1	296	9.6	774	15.1	2,024	18.1
Shrub/Scrub	23	0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	0.0	27	0.2
Herbaceous	181	0.8	3	0.2	10	0.4	5	0.8	5	1.1	31	1.0	67	1.3	144	1.3
Agricultural	3,709	16.2	6	0.3	51	2.1	2	0.3	1	0.2	147	4.8	510	10.0	1,686	15.1
Hay/Pasture	2,185	9.6	6	0.3	51	2.1	2	0.3	1	0.2	64	2.1	373	7.3	1,115	10.0
Cultivated Crops	1,524	6.7	0	0.0	0	0.0	0	0.0	0	0.0	83	2.7	137	2.7	571	5.1
Wetlands	802	3.5	0	0.0	430	17.9	0	0.0	0	0.0	72	2.3	69	1.4	312	2.8
Woody Wetlands	687	3.0	0	0.0	364	15.2	0	0.0	0	0.0	62	2.0	64	1.2	292	2.6
Emergent Wetlands	115	0.5	0	0.0	66	2.7	0	0.0	0	0.0	10	0.3	6	0.1	20	0.2
Impervious percent		13.1		45.7		17.8		13.0		13.0		19.7		10.8		7.7
Total acres	22,872		1,819		2,401		705		451		3,070		5,118		11,169	
Total square miles	35.7		2.8		3.8		1.1		0.7		4.8		8.0		17.5	

At watershed imperviousness of 10 to 15 percent, streams may degrade because of runoff intensity and volume. Well-vegetated riparian (streamside) corridors and wetlands can protect against the impacts of impervious watersheds. Best management practices, such as rain gardens, bioinfiltration measures, and permeable pavers, and planting trees, shrubs, and native plants can all improve infiltration of rain water, reducing runoff and impacts to water courses. Rain water collected in rain barrels can be used water gardens.

As shown on Map 6.3 and Table 6.3, imperviousness may lead to degraded streams in most watersheds:

- Most of the watersheds range from 13 to 20 percent impervious, making degradation likely.
- Turkeyfoot Lake watershed is over 10 percent impervious, and streams could start to degrade.
- Nimisila is under eight percent impervious. Depending on riparian vegetation and the effects of agriculture, many of the streams may still be relatively intact.
- Brewster Creek is highly impervious, reflecting its high degree of development.

Map 6.3 2016 Imperviousness by Watershed



Riparian Landscape and Water Quality

The riparian *corridor* is the low-lying landscape in direct contact with the stream, including flanking vegetation/land cover, wetlands, floodplains, and the stream channel itself. As the transition between upland and stream, it is one of the most important parts of the landscape for water quality and stream function. It affects flooding and erosion, nutrient processing, water quality, stream health and habitat. and includes flanking vegetation, wetlands, floodplains. The Ohio EPA habitat evaluations (QHEI for larger streams, HHEI for smaller streams) emphasize the importance of stream morphology, riparian corridor, and floodplain character in habitat and water quality.[8]

Riparian Buffer

The riparian *buffer* is the vegetation along the stream. The quality of the riparian (streamside) vegetation is related to both land use and water quality:

- A well-vegetated riparian stream corridor acts as a buffer between upland land uses and the stream, slowing stormwater, taking up nutrients and other contaminants, providing shade, habitat, and streambank stability. Well-vegetated riparian corridors can add resilience to streams in developing watersheds.
- In contrast, a developed or agricultural riparian corridor is a direct conduit for stormwater and contaminants, including nutrients and pathogens, to enter the stream, and cannot protect the stream against the warming sun or streambank erosion. Areas with degraded riparian corridors are at higher risk for water quality problems.

NEFCO characterized the quality of the riparian buffer along several tributaries, using aerial photographs, updating a study from 2000.[9] The assessment looked at width of wooded riparian buffer and type of land cover within a 100 m of each stream bank, in 600-foot segments. Points for each segment and stream bank were based on criteria similar to the QHEI and HHEI for riparian buffer/floodplain quality:

- Headwater streams (watersheds less than 20 square miles) require smaller buffers, and received maximum points for buffers greater than 10 meters.
- Mainstem Tuscarawas below Metzgers Ditch (watershed greater than 20 square miles) needed a wider buffer to receive full points.
- The “floodplain quality” category was applied to the width of the corridor. Woods, wetlands, and scrub-shrub received more points; agriculture and development received less, reflecting the potential impact of each land cover on the nearby stream.
- Scores were assigned to each side of the stream and averaged.

The riparian buffer of the Tuscarawas River near Arlington Road would be evaluated using the width for larger streams (vegetation beyond 10 m). The near side is a highly disturbed riparian buffer - low score. The far side is well-vegetated - high score.

The riparian buffer analysis is based on aerial imagery and cannot duplicate the field-based habitat evaluations. However, it may point out areas that are well-protected or at risk across the watershed.

Maps 6.4-6.6 and Table 6.4 present the results:[10]

- Map 6.4 shows the riparian buffer quality along with the Aquatic Life Use attainment data. The QHEI scores for the sites monitored by Ohio EPA were uniformly good to excellent. However, the impaired sites occurred on stream segments downstream of lower-quality riparian buffers. The TMDL notes that many of these sites were affected by suburbanization.
- Map 6.5 shows a close-up view of the results for Wonder Lake Creek and Cottage Grove Creek. In the red segments, there is little dense vegetation protecting the stream, and the nearby land cover is urban or agricultural. The green segments have large proportions of woods or wetlands protecting the streams. Appendix H contains large-scale maps of all the riparian analyses.
- Table 6.4 summarizes the riparian buffer quality results by stream. The Tuscarawas River and Nimisila Creek had the highest percent of high-quality segments. Cottage Grove Creek had the highest percent of low-quality segments.
- Map 6.6 shows that the riparian buffer quality largely reflects land cover. In developed and agricultural portions of the watershed, many of the segments are in the low or moderate categories. Many high-quality buffer segments occur in wooded areas. In some of the developed areas, the buffer may be present but not apparent at the regional scale of the watershed map. This comparison may help characterize streams that were not assessed, such as Brewster Creek.

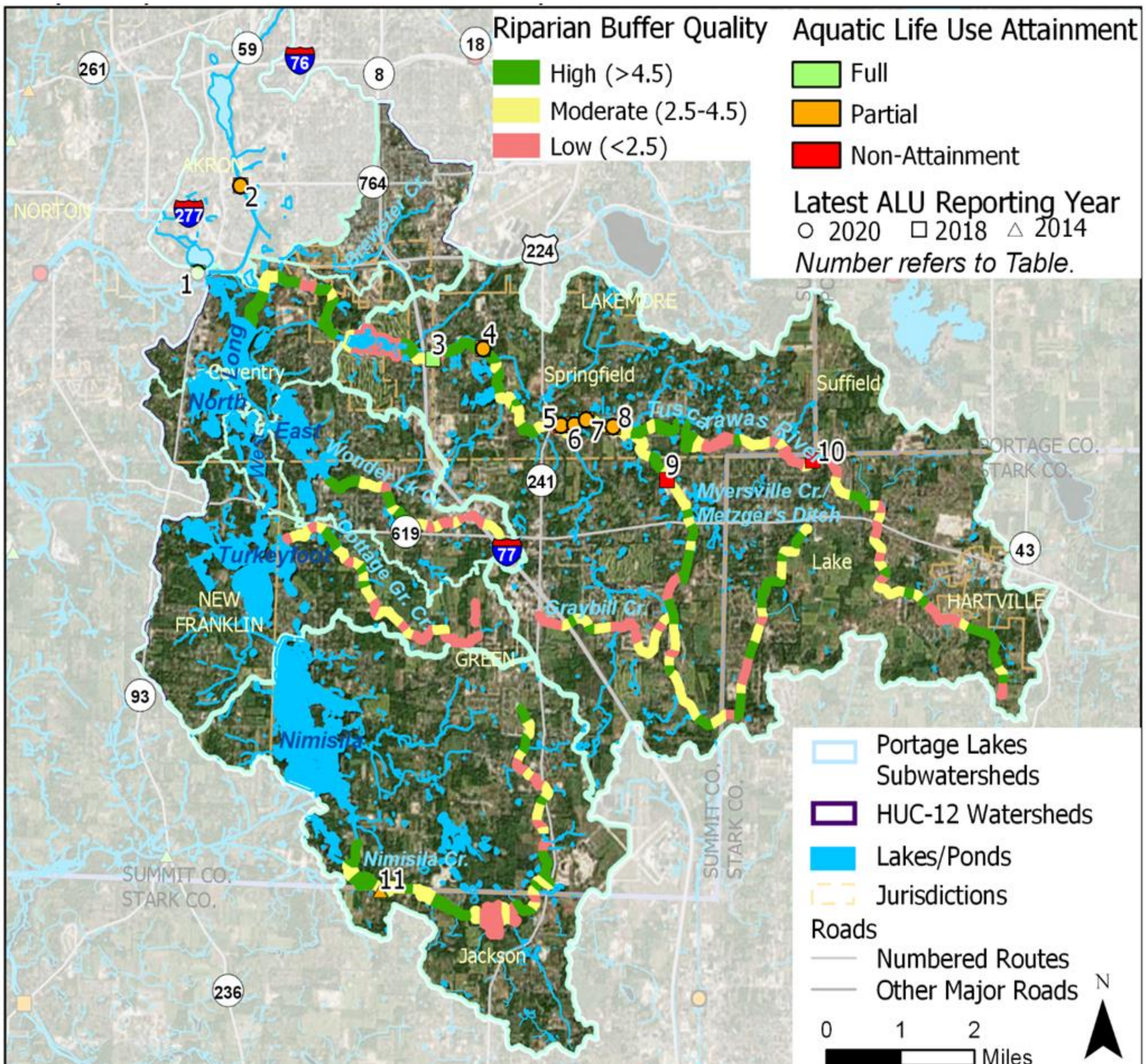
Restoring or planting altered riparian buffers improves stream conditions and helps improve water quality. The riparian buffer analysis can help target buffer areas to restore or replant.

Riparian buffers in the watershed. *Left, center – low quality riparian buffers (along the Tuscarawas River and Metzger ditch) are direct conduits for stormwater and contaminants, and lack protective vegetation and habitat. Right, well-vegetated riparian corridor protects streams, habitat, flood storage, and water quality.*

Table 6.4 Summary of Riparian Buffer Quality

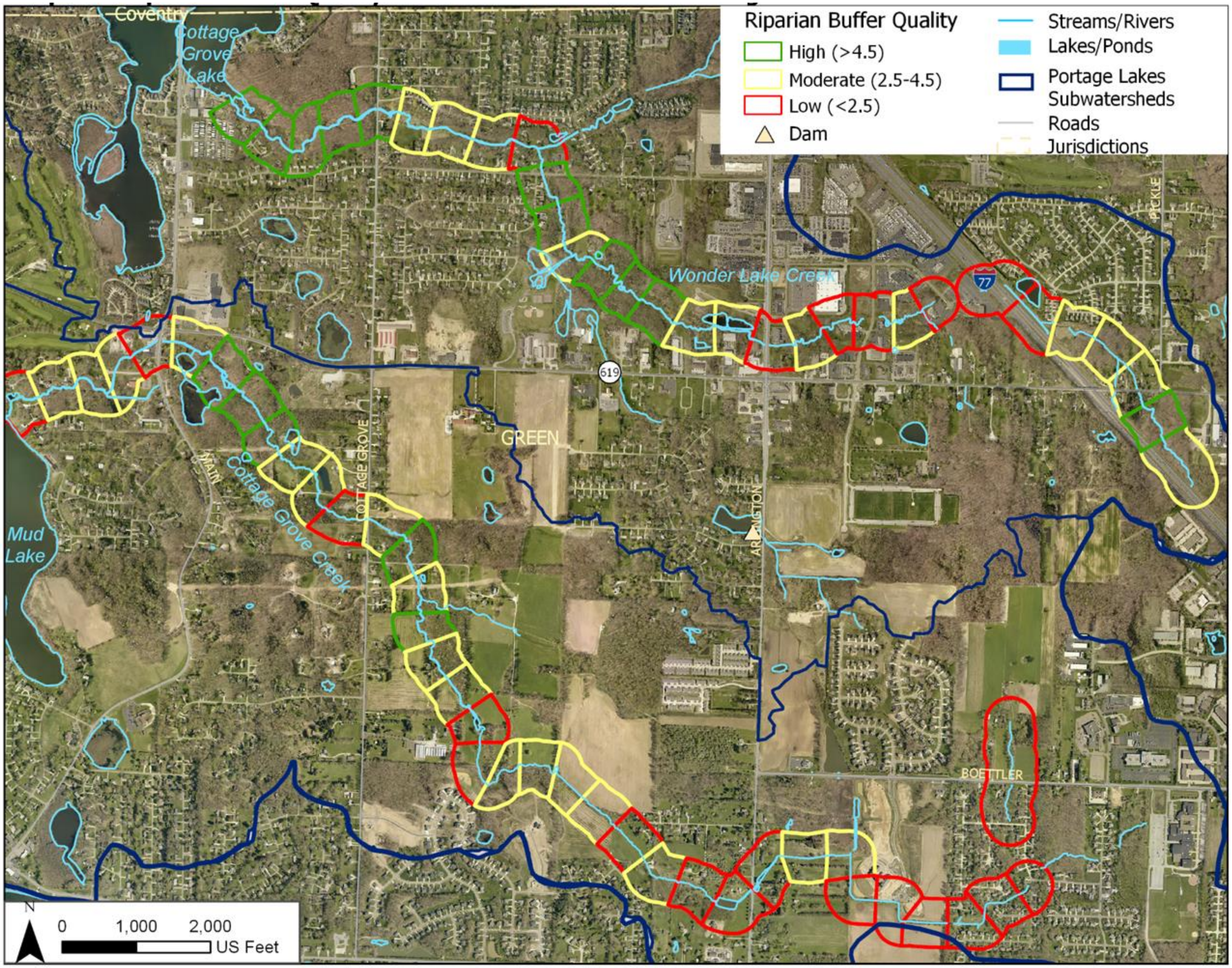
	High			Moderate			Low			Total	
Water Course	**Segments**	**Percent**	**Acres**	**Segments**	**Pct.**	**Acres**	**Segments**	**Pct.**	**Acres**	**Segments**	**Acres**
Tuscarawas R.	65	44	606	49	33	454	35	23	351	149	1,411
Metzger Ditch	31	33	278	44	47	395	18	19	171	93	844
Wonder Lk Cr.	11	37	93	12	40	108	7	23	64	30	265
Cottage Gr. Cr.	5	14	43	17	46	146	15	41	163	37	351
Nimisila Cr.	26	44	269	22	37	231	11	19	174	59	674

Map 6.4 Riparian Buffer Quality and Aquatic Life Use Attainment



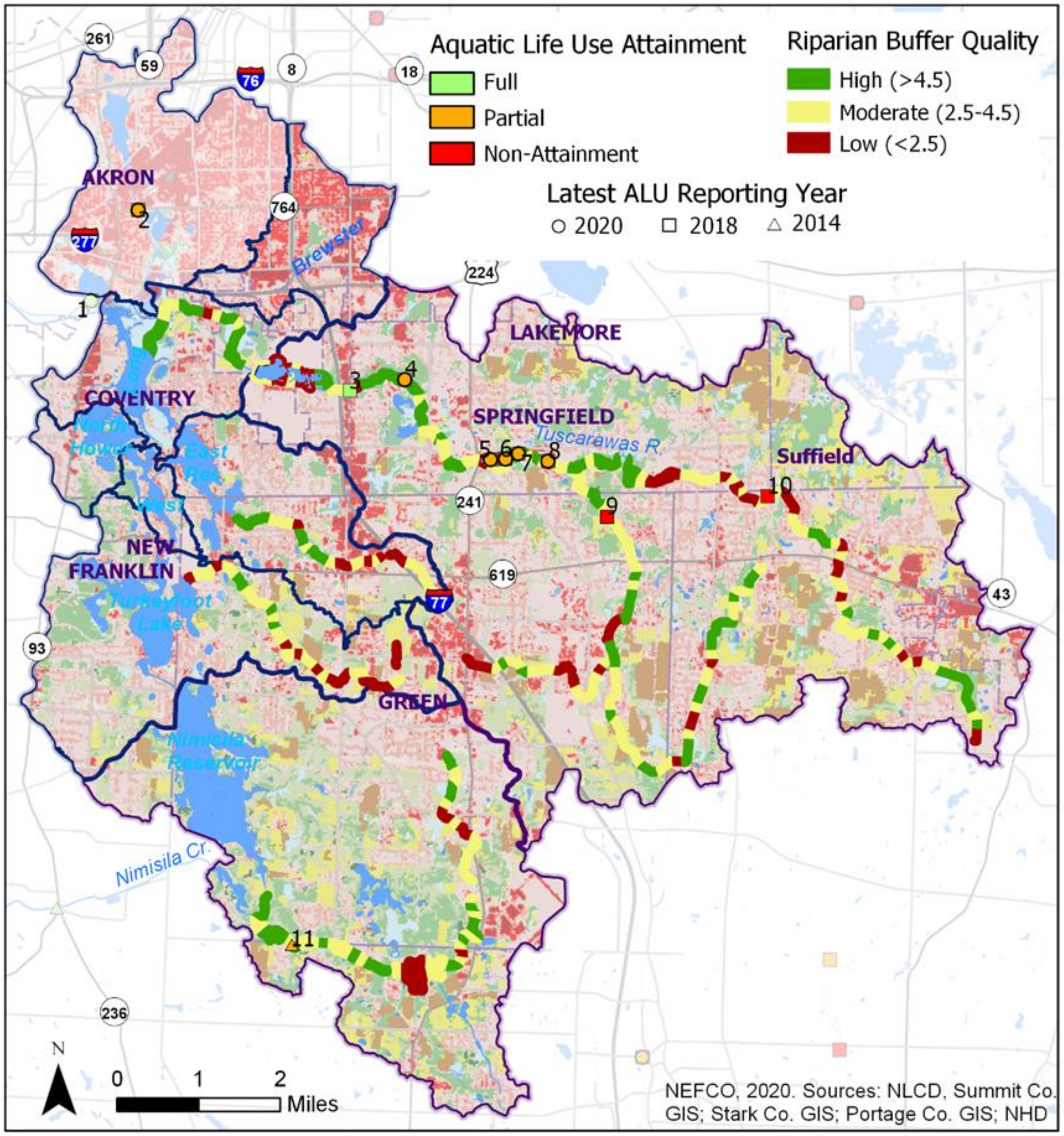
NEFCO, 2020. Sources: Ohio EPA; NHD, Summit Co. GIS; Stark Co. GIS; Portage Co. GIS. Imagery source: ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map 6.5 Riparian Buffer Quality – Wonder Lake Creek and Cottage Grove Creek



NEFCO, 2020. Sources: OSIP; ODNR; Summit County GIS; NHD

Map 6.6 Riparian Buffer Quality, Land Cover, and Aquatic Life Use Attainment



HUC-12 Watersheds
Subwatersheds
Numbered Routes
Other Major Roads
Lakes/Ponds
Jurisdictions

Note: Outline of Portage Lakes HUC-12 Watershed is shown. Area outside Portage Lakes drainage area is screened back.

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- 90 Woody Wetlands
- 95 Emergent Herbaceous Wetlands

* Alaska only

Wetlands

Wetlands, especially along streams and rivers, are one of the key landscape features protecting the health and functioning of streams, reducing impacts to the lakes. Map 6.7 shows potential wetland areas and flood zones, based on available mapping.

Wetlands help regulate flow, acting as sponges that absorb floodwater and release water during dry periods. They provide habitat for a diversity of animals and plants and are important in productivity of a system, providing a source of nutrients and organic matter, and taking up nutrients from stormwater.

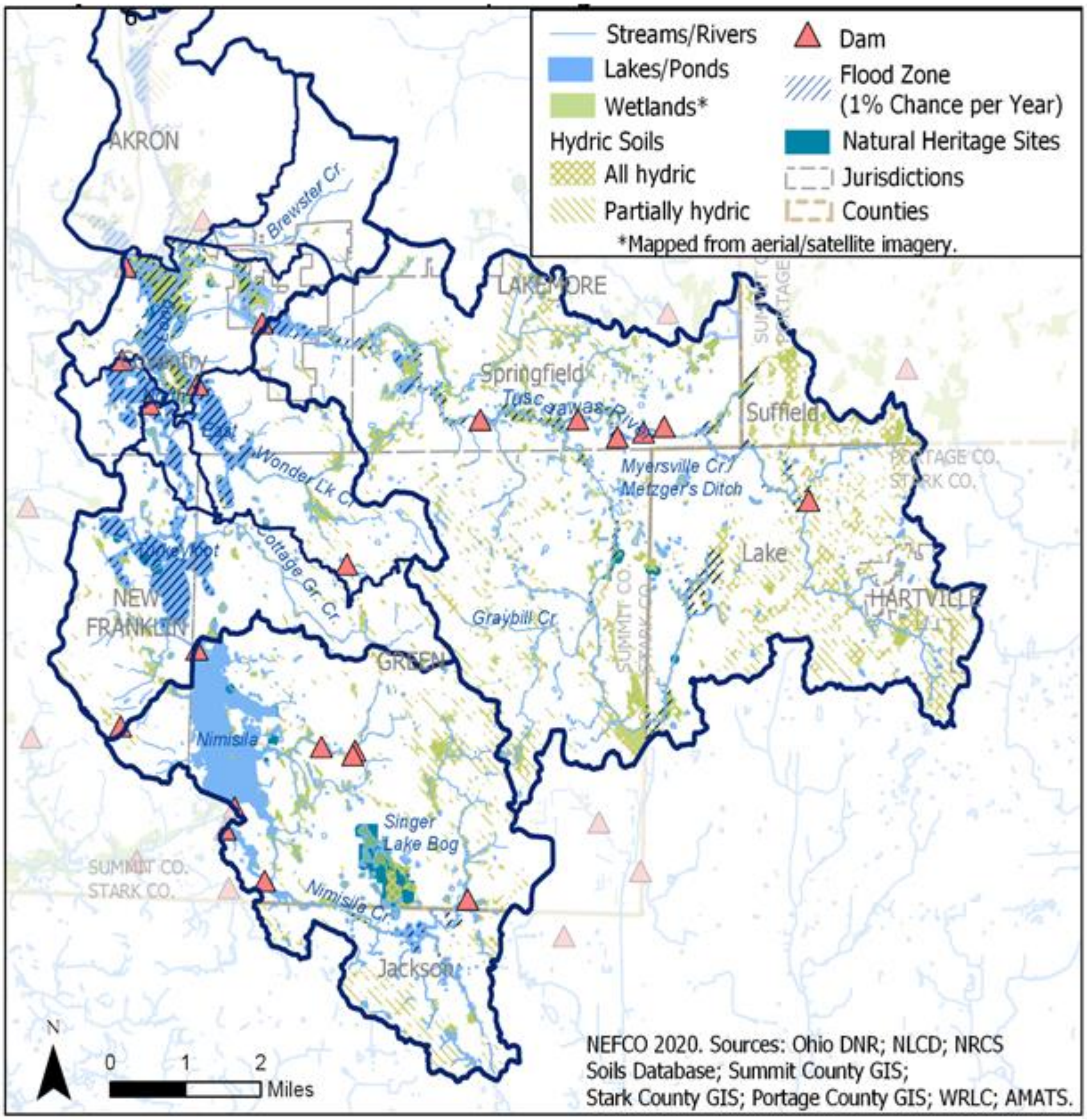
Wetlands are delineated through field work to identify soils and plants that are characteristic of saturated conditions. At the scale of this mapping, it is not possible to identify wetland boundaries or even small wetlands. However, it is possible to map *potential* wetlands especially the largest ones:

- *Hydric soils* are soils that are formed in saturated, ponding, or flooded conditions long enough during the growing season to develop anaerobic conditions (due to water between particles). Their presence is one of several indicators used to delineate wetlands. Mapped soil types can be used to identify potential wetland locations at a general level. The mapping is not precise enough to identify specific wetlands. Soils are mapped at a landscape scale rather than at a parcel scale, they may have inclusions with different characteristics, and may grade from one type to another. The mapping shows two categories – soils that are more than 86 percent hydric, and soils that have a lower percent of hydric inclusions.
- *Wetlands mapped from satellite imagery*
  The National Land Cover Database, used in Map 6.2 and others, classifies land cover at a scale of 30m pixels from satellite imagery. Map 6.7 includes several large wetland areas from Map 6.2.
- *Wetlands mapped from aerial photography.* In the early 2000s, Summit and Portage Counties had likely wetland areas identified from aerial photographs, combined with soil maps and limited ground-truthing. These represent areas with a high probability of being wetlands.

Map 6.7 shows wetland areas mapped from imagery or photography along many of the streams and the Tuscarawas River, including the large wetlands by Long Lake.[11] These helps protect the health of the streams, rivers, and lakes, and provide valuable habitat. Even small or less diverse wetlands provide important habitat, flood storage, and water quality benefits. The hydric soils, soils with hydric inclusions, and potential wetland areas are scattered throughout the watershed. Natural Heritage Database sites, Table 6.5, where species of concern have been identified, are concentrated in wetland areas and lakes. The mapping indicates potential resource areas and treats all potential wetland areas as equal. Field work is essential for determining the presence and quality of wetlands.

Wetland alteration is regulated by Ohio EPA and the Army Corps of Engineers. Summit County has included wetlands and wetland buffers as protected categories in its subdivision and zoning regulations, and many municipalities have adopted similar requirements.[12] Activities that may alter wetlands must minimize and mitigate impacts. The most stringent requirements apply to altering wetlands that have the most intact, diverse habitat. Wetlands can be affected by upland alteration, and mitigation for impacts may not be required on-site. The most effective protection is acquiring land or conservation easements surrounding the wetlands, which reduces the risks of alteration or impacts from off-site uses.

Map 6.7 Wetlands, Flood Zones, and Natural Heritage Areas, Portage Lakes Watershed



Left - The land surrounding the Tuscarawas River in Firestone Metro Park is mapped as likely wetland. Center – wetlands by Long Lake. Right – this wetland in a developed setting, affected by invasive Phragmites reeds, may have a less diverse/high quality habitat, but it still provides tremendous flood management and water quality benefits.

Table 6.5 Natural Heritage Database Sites in Portage Lakes Watershed

	Terrestrial Community	Vascular Plant	Vertebrate	Non-Vascular Plant	Invertebrate
Portage Lakes					
Long Lake Area	1	20	5		
Turkeyfoot		7	2		
Nimisila Res		14	2		
Watershed					
Firestone Park		7	4		
Singer Bog	2	73	1	1	4
Myersville Fen	1	15	1		1
Springfield Bog		6			
Sparrow Fen		2			
Total	4	144	15	1	5

Floodplains and Flood Hazard Zones

In highly altered Brewster Creek, a little extra room lets it spread out during high flow, reducing erosion, sediment transport, and downstream flooding. S. Main St.

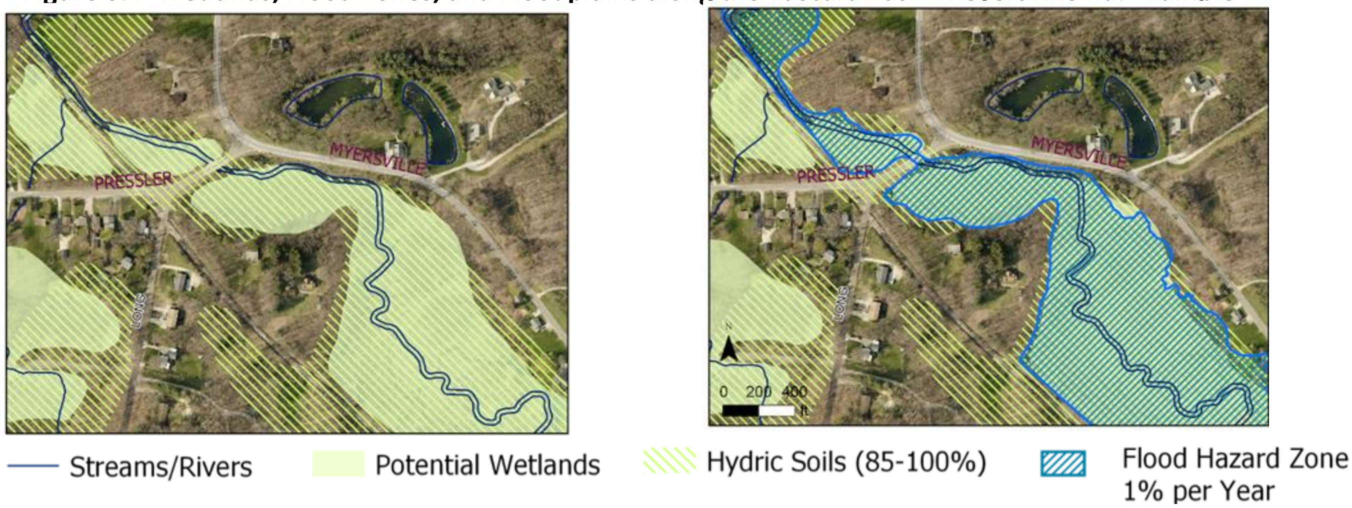
Floodplains are important for stream function, taking excess water. A *floodplain* is a natural, low-lying feature along a stream that allows water to spill out from the channel during high flow. Spreading water out slows it down and reduces its depth and erosive power – a quiet pool versus a raging torrent. Floodplains remove water, silt, and nutrients from the channel, and protect stream channel stability, water quality, and habitat. In altered stream systems, the stream may be entrenched and the floodplain inaccessible, due to erosion or filling in the floodplain for development. Altered channels often erode deeper, wider channels, increasing bank erosion and siltation. They lack access to a natural floodplain, but eventually high-water escapes from even deep channels, flooding nearby land.

The Federal Emergency Management Agency has mapped *flood hazard zones*, areas with a certain risk per year of flooding, to provide information about flood risk to property owners, banks, and insurance agencies. (See examples, Figures 6.4 and 6.5.) Areas with a one percent risk per year are often known as "100 year" flood zones. However, a one percent risk of flood *per year* is *26 percent chance* over the life of a 30-year mortgage that a property will be flooded in a severe event. *Flood hazard zones* may differ from natural *floodplains.* Flood hazard zones may extend beyond the functional, natural floodplain.

Map 6.7 shows flood hazard zones along many of the lakes, Tuscarawas River, and some large wetlands.[13] Floods in developed areas are hazardous to people and degrade streams and water quality, especially where toxic materials could enter the water. Flood hazard areas are mapped using models and topographic mapping. Delineation of requires field work to determine how far the stream can spill out onto the nearby land. Floodplains and flood hazard zones are best left undisturbed if possible.

In order to participate in the national flood insurance program, communities must develop building standards for flood hazard areas. The State of Ohio has developed minimum standards for building elevation and floodplain mitigation. Summit County's riparian setbacks apply to FEMA flood zones also.

Figure 6.4 Wetlands, Flood Zones, and Floodplains along the Tuscarawas – Meyersville Rd. Example



Streams, wetlands, and flood zones tend to coincide. Above left: potential wetlands identified using aerial photography overlain by hydric soils mapping. Wetlands are delineated in the field, using a combination of hydrology, vegetation, and soils. Mapping at this scale can only indicate ***potential*** *wetlands – soil mapping is generalized, and does not show all the inclusions or gradations. If the landscape has been altered, it may no longer be wet. Above right: FEMA flood hazard zones overlain on the potential wetlands/hydric soil mapping. Below, the cross-section indicates that the tributary is within a broad, low-lying floodplain. The photograph was taken from the road crossing looking southeast. On this rainy day, the Tuscarawas flowed onto its floodplain, leaving water, silt, etc.*

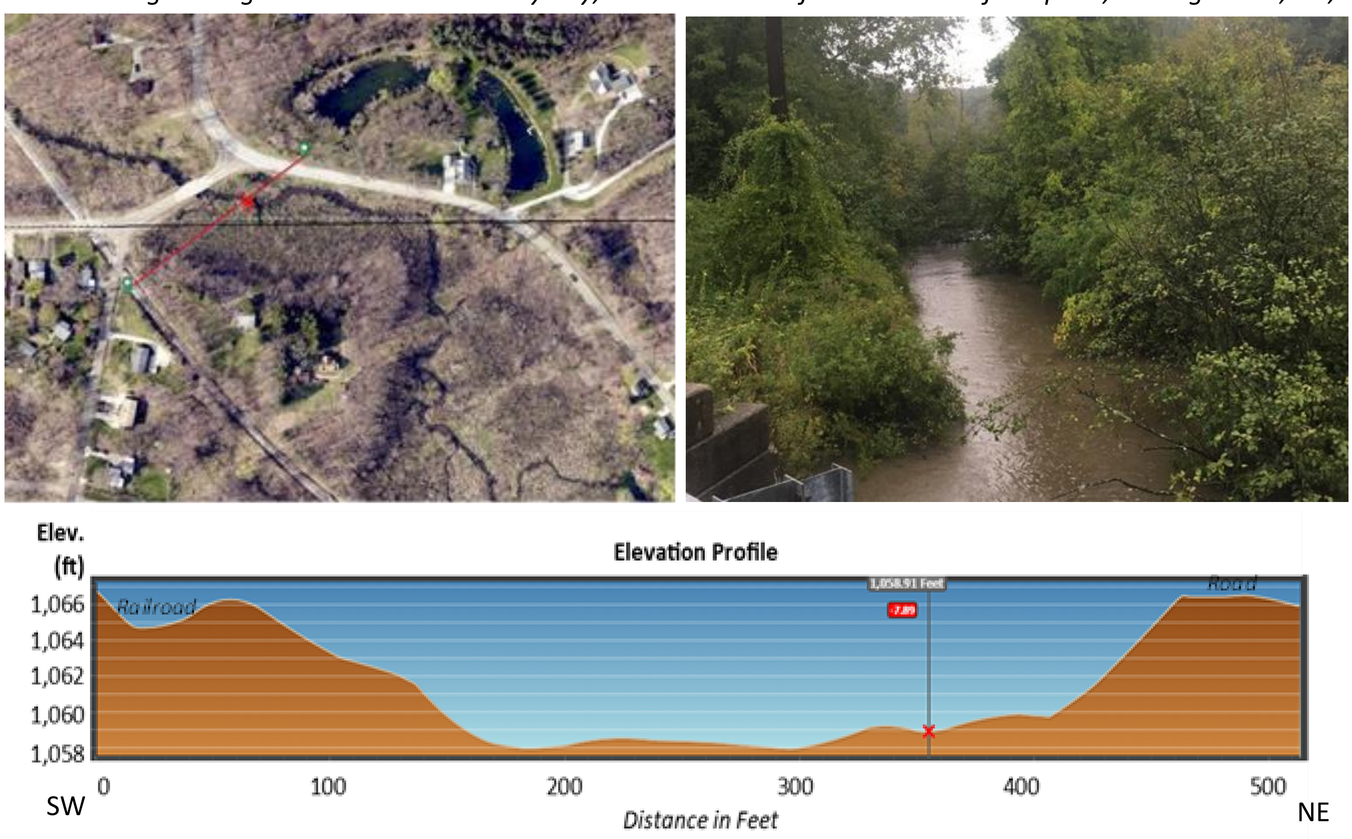
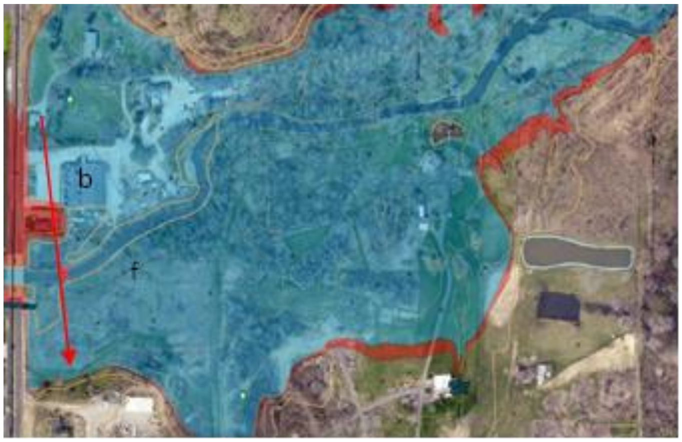
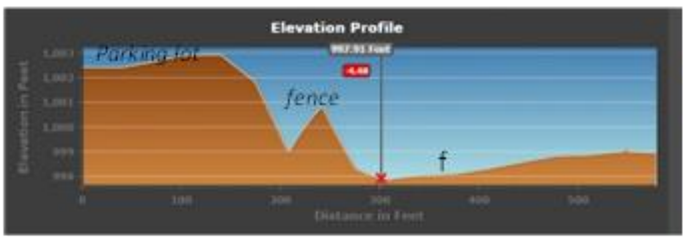


Figure 6.5
Altered Floodplain and Flood Zone



Altered Tuscarawas floodplain Arlington Rd. – The southern portion of the site is low-lying natural floodplain and is mapped as likely wetland. On the northern side, the building (b) is on filled land five feet above the natural floodplain. The 1% per year flood hazard zone extends up beyond the natural floodplain (f), past several buildings. When natural floodplain is filled, the water still goes somewhere, often up, putting buildings and people at risk. Buildings are permitted in the FEMA flood hazard zone if they follow the local requirements for the National Flood Insurance Program. The designated flood hazard zone can change over the years, with improved modeling, as more development upstream increases flooding downstream, and as people fill in the floodplain. This is likely an older use, pre-dating environmental rules.



Channel Morphology

The form of stream channels reflects the slope and inputs from the landscape and is important in regulating flow, oxygenation, sediment, nutrient uptake, flood storage, and habitat. Sinuous, low-gradient streams with accessible floodplains, provide stable, varied habitat, move sediment through at low and high flow, and are resilient to flooding.

Wonder Lake Creek in Knapp Park shows many features of a healthy stream system. The sinuous form creates narrow areas of fast flow (thalweg, A), which clears out sediment during low flow. The wide, shallow channel accommodates high flow, which can also access the adjacent floodplain. The sinuosity slows down high flow. The substrate is stony, not silted in. It and the tree roots provide excellent habitat. The shallow riffles oxygenate the water and add to habitat. Cut banks due to the thalweg are on the outside of the curves and are paired with point bars (B), sediment deposited inside the curves in high flow. The smooth water in the background (C) may be a pool, increasing habitat diversity. Vegetation (greening up for spring) intercepts runoff, takes up nutrients, and stabilizes the banks.

In channelized and altered streams, many of the functions have been lost, affecting flood storage, nutrient and sediment transport, and habitat. Streams may adjust by eroding or silting in. Straightened channels are too wide for concentrated flow during low water. The channels fill with fine silt, which covers over habitat. Increased sediment from erosion is carried out during high flow, fills in the lakes, and carries with it nutrients and other contaminants. Storm flow, no longer contained within wetlands and floodplains, rises as floods onto higher ground.



Above left, center - Brewster Creek flows through a highly impervious, watershed, generating heavy "flashy" flows. The banks and stream form have been altered, reinforced, straightened, and there is minimal functional floodplain. The habitat is degraded, banks erode, the creek is full of sediment, and high flows may cause urban flooding.

Above right and right – Metzger Ditch at Raber Rd. Ditches are carved to convey water quickly. Without meanders and accessible floodplain, they have no mechanism to slow down or release storm flow. Metzger/Myersville ditch, has been largely straightened, has minimal buffer, and flows through a densely developed area, which increases runoff. Stormwater races through the ditch in high flow, in an erosive torrent, through three culverts. The sediment deposits and the sediment plume in the channel demonstrate the high sediment load, which fills in stream habitat and receiving waters and carries nutrients, pathogens, and other contaminants.

Observations from mapping, field visits, and aerial imagery indicate the following, which should be verified by field visits:

- Substantial portions of the Tuscarawas River in Summit County are sinuous, within floodplains and likely wetlands. In Stark County, more of the river has been straightened.
- Many of the streams mapped as having lower quality riparian buffers have also been straightened, degrading habitat, resiliency, flood storage, and water quality downstream.
- Brewster Creek was not part of the riparian buffer analysis, but field visits and aerial photographs, indicate that portions of the riparian corridor and stream channel are degraded.
- Local boaters have noted that Mud Lake seems to be silting in. Aerial photographs, (Map 6.5 and Appendix I), indicate that in many areas, the riparian buffer of Cottage Grove Creek has been altered, and the creek straightened, which tends to degrade stream function and water quality. On-going development nearby also may be increasing runoff and sediment load into the stream.

Dams

Dams are major alterations to stream channels, interrupting flow, often creating anoxic, silted-in areas along streams that disrupt habitat and nutrient uptake, and release nutrients in anoxic dam pools. The Portage Lakes dams are still in use, but many of the other old dams in the region are not. They may no longer provide economic benefit, may be in disrepair, and degrade water quality. Dam removal is a common practice to improve water quality, habitat, and safety. Map 6.7 shows dams in the watershed – it is worth evaluating their benefit versus the costs and risks of maintaining them. Dam removals and accompanying stream restoration can often be funded through water quality improvement funds.

Old dams in the Portage Lakes watershed. *As old dams are no longer used and fall into disrepair, it is worth evaluating whether to repair or lower/remove them. The latter improves the stream channel and water quality. Above, the water level behind Tritts Mill dam was lowered (temporarily) to reduce strain on the old dam. Image source Summit County Environmental Viewer. Left, Wonder Lake dam was lowered. The creek in the former dam pool area may be further restored.*

Wastewater Management in the Portage Lakes Watershed

Home Sewage Treatment Systems (HSTS)

Septic systems use filtration, biological, and chemical processes within the soil to treat wastewater and are generally effective if designed, installed, and maintained to meet the site conditions and use. When they do not function well, they may become "nuisance" systems, discharging incompletely treat wastewater and introducing additional nutrients and harmful organisms to receiving waters.

The following conditions pose a greater risk of "nuisance" wastewater systems:

- Small lots, which may not provide adequate space to treat household waste or which may not have enough space to accommodate setback requirements.
- Older systems – septic systems typically last about 20 years, and more recent designs are better suited for the wide range of soil conditions found in the watershed, and older systems were installed before more stringent regulations went into effect.
- Soil limitations – earlier soils data indicated that the soils of the Portage Lakes area had almost universally "severe" limitations for trench leach fields. Advances in septic system design have provided options to address certain soil limitations. The effectiveness of septic systems is still constrained by depth to limiting conditions such as high-water table or bedrock.
- Septic system maintenance – in order to function well, septic systems need to be inspected, maintained, and the accumulated solids need to be cleaned out periodically. Summit County has point-of-sale inspection and maintenance requirements, which help to reduce the occurrence of nuisance septic system discharges.

Maps 6.8 and 6.9 show the wastewater management characteristics in the watershed and the Portage Lakes vicinity, including parcel locations, small lots, areas served by sanitary sewers, and soil limitations for soil absorption wastewater treatment systems (septic systems) in areas without sewer service.[14] Map 6.9 identifies small lots with houses more than 20 years old, higher risk for nuisance systems. Note: It is likely that some parcels within sewered areas still rely on septic systems. Maps 6.8 and 6.9 show:

- There are several clusters of small lots in the Tuscarawas River Headwaters east of the Portage Lakes, many of which are served by sanitary sewer service.
- The greatest concentration of small lots, south of Akron and Lakemore, is around the Portage Lakes. While some of these are in areas served by sewers, there are clusters of small, unsewered lots with older homes around all the lakes, some of which are near swim areas.

In unsewered areas where soil-absorption systems will not work, it is possible to install a "wastewater treatment system of last resort," an NPDES-permitted individual wastewater treatment system, which is essentially a miniature discharging sewage treatment plant sized for a single lot, with increased maintenance requirements.

Wastewater Management Planning

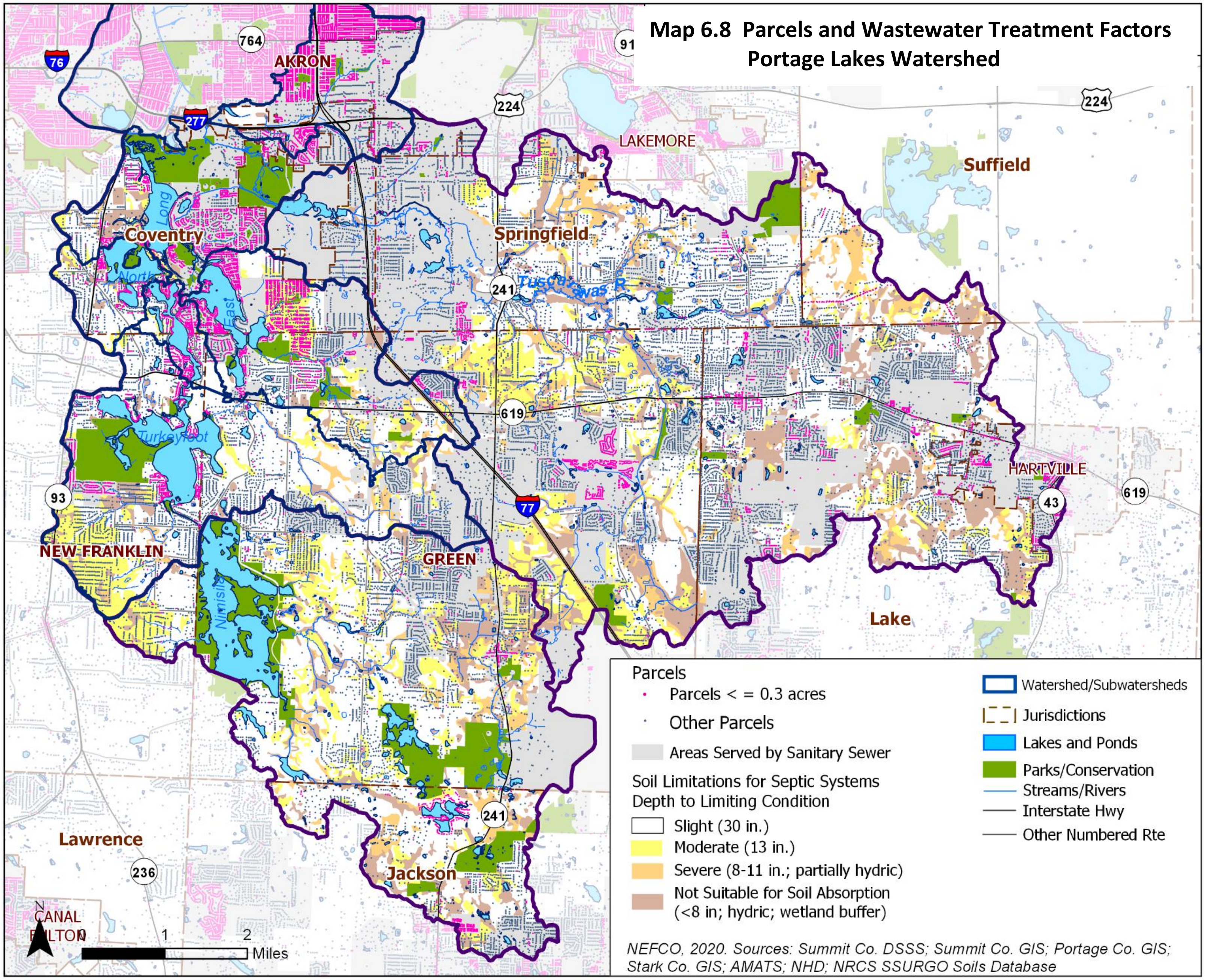
NEFCO has been designated by the Ohio governor to perform areawide water quality management planning for Portage, Stark, Summit and Wayne Counties under Section 208 of the Clean Water Act. NEFCO develops a "208 Water Quality Management Plan," which addresses a range of water quality issues on regional scale. The wastewater management chapter of the 208 plan is developed by local wastewater treatment providers (Management Agencies, MAs) in coordination with NEFCO and local governments. It specifies wastewater management "prescriptions" within Facilities Planning Areas (FPAs), Map 6.10. The prescriptions specify where sewers or on-site wastewater treatment measures can be approved by Ohio EPA or local health districts. Prescriptions can be modified with community input.

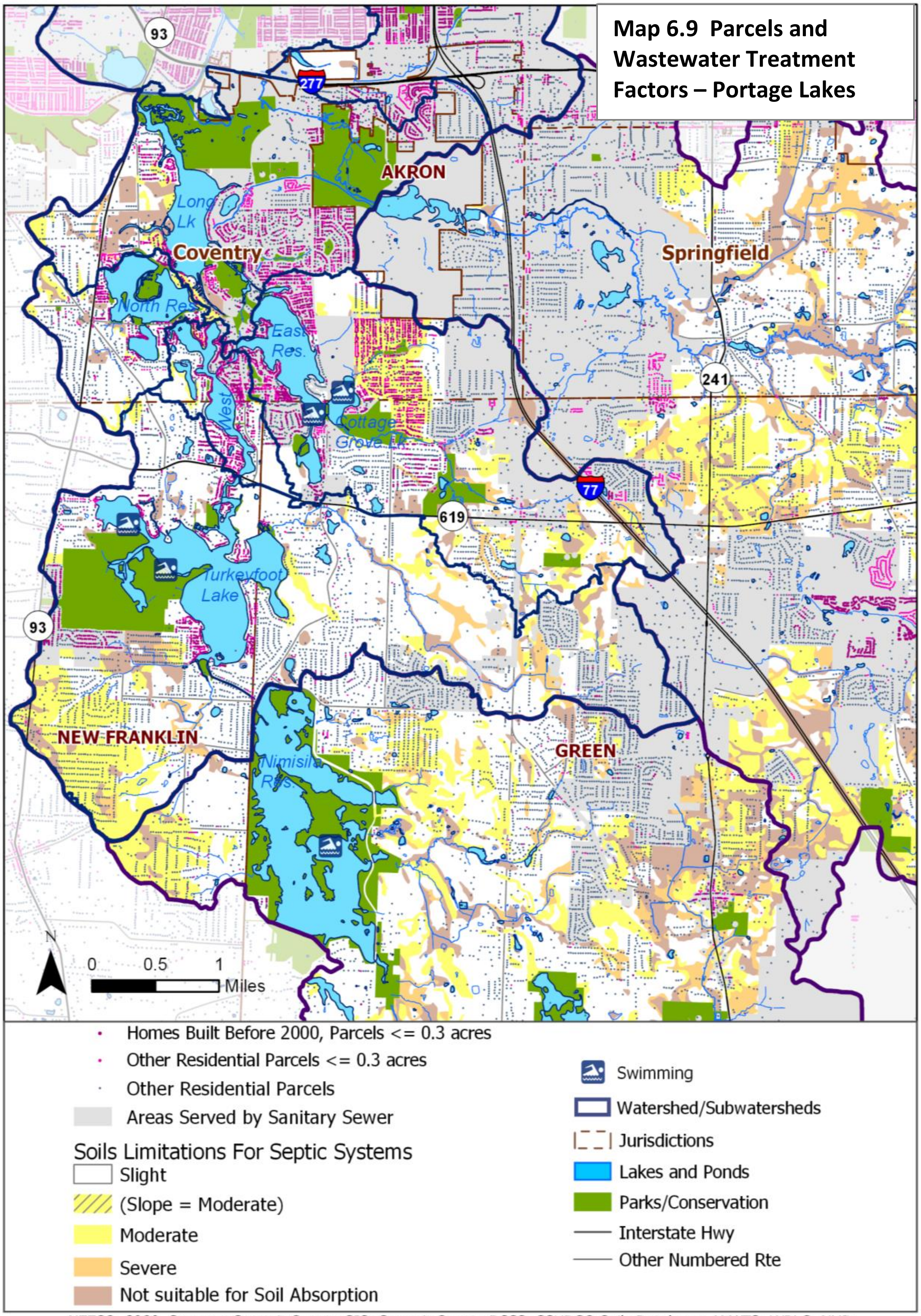
As shown on Map 6.10, the Portage Lakes watershed is primarily within the Springfield-91 and Franklin-Green Facilities Planning Areas (FPAs), which are served by Summit County Department of Sanitary Sewer Services. Other watershed FPAs include Akron, Canton-Nimishillen Basin, Barberton-Wolf Creek, Hartville, Portage County Water Resources, Fish Creek, and Massillon.

Comparing Maps 6.9 and 6.10, there are several areas around the Portage Lakes with small lots and older homes that are not served by sanitary sewer. These present greater risks of nuisance septic systems. Due to the small lot sizes, they may need to use the NPDES wastewater systems, which discharge phosphorus into the water. Summit County DSSS is working with communities to determine the need and feasibility for sanitary sewer service in the Portage Lakes vicinity.

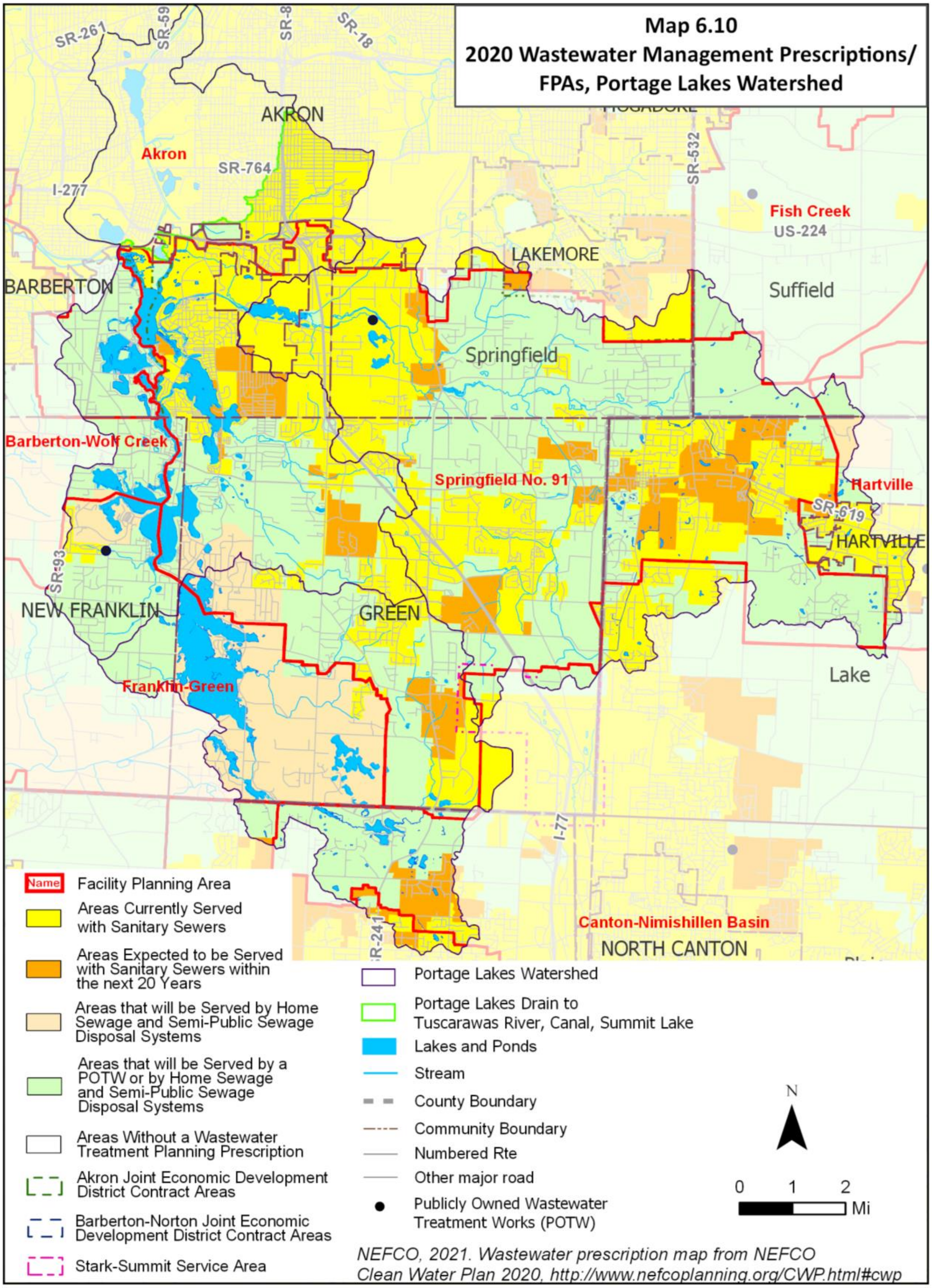
The FPA boundaries and wastewater management prescriptions shown are occasionally modified through an amendment or update process, in coordination with the MAs, communities, and NEFCO. NEFCO's website has the Clean Water Plan, with current wastewater prescriptions FPA boundaries, and MA contact information in the Clean Water Plan Appendix 3, http://www.nefcoplanning.org/CWP.html. Appendix I in this document has further discussion about wastewater management planning.

Communities are urged to work with the MAs and local Health Districts/Departments to support wastewater management options that reduce harmful bacteria and phosphorus entering the lakes.


Map 6.8 Parcels and Wastewater Treatment Factors
Portage Lakes Watershed
AKRON
Coventry
Springfield
LAKEMORE
Suffield
NEW FRANKLIN
GREEN
HARTVILLE
Lake
Lawrence
Jackson
CANAL FULTON
Tuscarawas R.
Turkeyfoot
Nimisila
Long
North
East
76
764
91
277
224
241
619
93
77
43
236
0 1 2 Miles
Parcels
Parcels < = 0.3 acres
Other Parcels
Areas Served by Sanitary Sewer
Soil Limitations for Septic Systems
Depth to Limiting Condition
Slight (30 in.)
Moderate (13 in.)
Severe (8-11 in.; partially hydric)
Not Suitable for Soil Absorption (<8 in; hydric; wetland buffer)
Watershed/Subwatersheds
Jurisdictions
Lakes and Ponds
Parks/Conservation
Streams/Rivers
Interstate Hwy
Other Numbered Rte
NEFCO, 2020. Sources: Summit Co. DSSS; Summit Co. GIS; Portage Co. GIS; Stark Co. GIS; AMATS; NHD; NRCS SSURGO Soils Database



NEFCO, 2020. Sources: Summit County GIS; Summit County DSSS; SSURGO Soils Database; AMATS; WRLC; NHD


Map 6.10
2020 Wastewater Management Prescriptions/
FPAs, Portage Lakes Watershed
SR-261
SR-59
SR-8
SR-18
AKRON
Akron
SR-764
I-277
SR-532
Fish Creek
US-224
LAKEMORE
BARBERTON
Suffield
Springfield
Barberton-Wolf Creek
Springfield No. 91
Hartville
SR-619
HARTVILLE
SR-93
NEW FRANKLIN
GREEN
Lake
Franklin-Green
I-77
SR-241
Canton-Nimishillen Basin
NORTH CANTON
Name
Facility Planning Area
Areas Currently Served with Sanitary Sewers
Areas Expected to be Served with Sanitary Sewers within the next 20 Years
Areas that will be Served by Home Sewage and Semi-Public Sewage Disposal Systems
Areas that will be Served by a POTW or by Home Sewage and Semi-Public Sewage Disposal Systems
Areas Without a Wastewater Treatment Planning Prescription
Akron Joint Economic Development District Contract Areas
Barberton-Norton Joint Economic Development District Contract Areas
Stark-Summit Service Area
Portage Lakes Watershed
Portage Lakes Drain to Tuscarawas River, Canal, Summit Lake
Lakes and Ponds
Stream
County Boundary
Community Boundary
Numbered Rte
Other major road
Publicly Owned Wastewater Treatment Works (POTW)
N
0 1 2 Mi
NEFCO, 2021. Wastewater prescription map from NEFCO Clean Water Plan 2020, http://www.nefcoplanning.org/CWP.html#cwp

Bacterial Monitoring

According to the 2020 Ohio EPA Integrated Report:[15]

Image Source: Ohio Dept. of Health 2020. Beach Guard.

- Ohio DNR conducts periodic monitoring at the swimming beach, posting advisory signs when bacteria reach 235 colony forming units (cfus)/100 ml and conducting additional testing. Between 2015 and 2019, the Integrated Report notes that Ohio DNR took 8 to 10 samples each summer, totaling 43 samples.
- During the five years, a total of five samples were high enough to post advisory signs, from zero to two samples each year. The intensely rainy spring-summer of 2019 resulted in advisory postings only once.
- The beach monitoring data does not fulfill the Ohio Qualified Data Collector requirements and is presented for informational purposes.

The 2009 TMDL notes that:[16]

- The Tuscarawas River from the Long Lake outlet upstream to Mile 126.7 (Site 10 on Map 6.2, Stark County border) is in full attainment of recreational use; at Mile 126.7 (Site 10), it is in non-attainment due to pathogens.
- Nimisila Creek was in full attainment for recreational use but affected by failing septic systems.

Reducing Inputs from Septic Systems

Many of the septic systems in the Portage Lakes are on small lots (< 0.3 acres) with limited soils. Summit County has requirements for inspection and maintenance of septic systems. It is likely that some will fail over the next 10-20 years, and it is also likely that some will be replaced, either with soil absorption systems or with NPDES direct discharge treatment systems.

Nuisance septic systems may introduce e. coli and other pathogens to the lakes. The Portage Lakes beach has been closed in the past due to high e. coli counts. Swim areas other than the beach are not currently monitored – those near unsewered areas may have higher bacteria counts.

Failing and direct-discharge systems may introduce phosphorus into the lakes, at an estimated rate of 4.6 pounds per household per year, the equivalent of a 50-pound bag of 10-10-10 fertilizer, which would support hundreds of pounds of aquatic plants per year per household. The phosphorus load from thousands of older systems on small lots would support hundreds of tons per year. With phosphorus loading also a concern for HABs, it is important to minimize this source.

Property owners can adopt practices that ensure septic systems function well, reducing the risk of nuisance septic systems. See Appendix I for a full discussion.

Recommended Best Management Practices (BMPs) for HSTS Owners to Prevent Premature System Failure and Negative Impacts on the Water Quality of the Portage Lakes *(Full discussion in Appendix I)*

- Make sure you always have a valid HSTS operation permit from the local health district
- Maintain continuous a service contract with a registered HSTS service provider—since registrations must be renewed annually, check with your local health district or its website every year to verify that your service provider is registered and bonded
- Do not put solid waste items in an HSTS; put them in a trash can, including food waste (use garbage disposals sparingly), paper towels and related rags, cloth, disposable diapers and other personal care items, hair, cat litter, cigarette butts, matchsticks.
- Microorganisms in the system break down the waste. Protect them. Do not put fats, grease, toxins, household chemicals, beer or winemaking waste, antibacterial soap, commercial septic tank additives, or prescriptions an HSTS.
- Have your septic tank(s) pumped when your registered service provider says its needed

Actions to Take to Reduce the Negative Impacts from Wastewater on the Lakes

- Contact your local health district when you observe an HSTS nuisance, which can be reported anonymously and may be able to be reported on its website
- Disseminate the HSTS BMPs listed above to lakeside property owners
- Learn about and seek ways to reduce nutrient loads from off-lot discharging NPDES HSTSs

Pollutant Loads from Land Use

Pollutant loading from land use has been studied for decades. The STEP-L (Spreadsheet Tool for Evaluating Pollution Load) is a relatively simple way to estimate the pollution load based on land cover and land management practices in a watershed.

Table 6.6 is an example of how land use affects pollutant loading and how BMPs can reduce loading.[17] It assumes: a relatively small 400-acre watershed, with equal areas (100 acres) of developed land, pasture, crops, and forest; one feed lot; a mixture of developed land; 100 septic systems; direct discharge of wastewater from 100 people; a shallow gully 100 feet long, and a shallow degraded streambank of 1,000 feet long.

The example shows that urban land, agricultural land, and septic systems contribute substantial loads of contaminants per year to streams and lakes. Applying Best Management Practices (BMPs) to each category can reduce the load. BMPs vary in efficiency, with greatest percent reduction in sediment.

Table 6.6
STEP-L Model for Example Watershed Total load by land use

Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)*	Sediment (tons/yr)
Urban	441.5	68.0	1,678.1	10.2
Cropland	850.7	279.0	1,723.8	199.0
Pastureland	429.6	72.3	1,234.4	40.4
Forest	20.2	9.0	45.6	3.0
Septic	976.0	207.1	5,279.9	0.0
Gully	10.5	4.0	20.9	5.7
Streambank	11.6	4.5	23.2	6.3
Total	2,740.0	643.9	10,005.9	264.7
BMP Reduction	-872.6	-265.3	-1,649.7	-217.3

** Biological Oxygen Demand – organic matter that uses oxygen during decomposition.*

STEP-L was used to estimate pollutant loading in the Portage Lakes watersheds, based on Portage Lakes watershed land cover data, estimated septic systems (Table 6.7), and modest use of BMPs applied to 20-50 acres per watershed.

Tables 6.8 and 6.9 show the results of the STEP-L model for the Portage Lakes watershed. These are estimates based on assumptions about the watershed.

Table 6.7 Estimated Septic Systems by Watershed

Brewster	0
Long	646
Tuscarawas	6,985
Hower-North	727
West	580
East	1,753
Turkeyfoot	2,885
Nimisila	2,148

Table 6.8
STEP-L Model for Portage Lakes Watersheds Total Pollutant Loading by Watershed with BMP

Watershed	N Load (lb/year)	P Load (lb/year)	BOD (lb/year)	Sed. Load (tons/year)
Brewster	4,895	769	19,520	114
Long	8,334	2,229	31,955	114
Tuscarawas	50,934	9,505	167,210	2,340
Long Lake total	*64,193*	*12,503*	*218,685*	*2,568*
Hower-North	1,245	304	4,802	22
West	5,867	1,083	20,923	246
East	1,572	503	6,357	12
Turkeyfoot	9,858	2,087	33,724	403
Main Chain/HN total	*18,542*	*3,976*	*65,806*	*684*
Nimisila	*18,232*	*3,582*	*59,058*	*1,041*

Table 6.9 STEP-L Pollutant Loading by Land Cover Main Chain/Hower-North and Long Lake

Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
Long Lake, Brewster Creek, and Tuscarawas River				
Urban	40,099	5,934	143,210	934
Cropland	6,928	1,959	14,329	1,197
Pastureland	7,861	958	24,234	374
Forest	691	323	1,405	62
Septic	8,643	3,329	35,507	0
Long Lake Total	*64,193*	*12,503*	*218,685*	*2,567*
Main Chain plus Hower-North				
Urban	11,351	1,669	40,561	264
Cropland	1,274	405	2,713	270
Pastureland	1,556	226	4,971	106
Forest	372	170	860	44
Septic	3,989	1,506	16,702	0
Main Chain/H-N Total	*18,542*	*3,976*	*65,806*	*684*
Nimisila Cr.				
Urban	9,338	1,372	32,289	219
Cropland	2,935	860	6,081	549
Pastureland	3,745	497	12,254	215
Forest	586	272	1,372	59
Septic	1,628	582	7,062	0
Nimisila Total	*18,232*	*3,582*	*59,058*	*1,041*

Tables 6.8 and 6.9 use present a rough idea of the external loading coming from each watershed and land cover type, affecting stream and lake habitat, biota, and water quality.

- The water entering Long Lake from its watershed, Brewster Creek, and the Tuscarawas River is about three times the load from the Main Chain and Hower-North.
- Urban land is the largest source of pollutants, followed by septic systems and agriculture.
- The influence of agriculture is higher in the Tuscarawas and Nimisila watersheds.

The phosphorus entering the lakes as external loading generates hundreds of pounds of plant matter per pound of phosphorus as it is recycled. Ohio EPA has set targets for streams of 0.08 to 0.1 mg/l of phosphorus.[18] Reducing the external loading from the watershed is necessary for addressing nuisance plants and the risk of HABs. Practices include reducing runoff, reducing contaminants entering the water, and protecting/restoring important landscapes.

Watershed Priorities

Priorities in all the watersheds include reducing phosphorus, protecting and restoring important landscape features, and encouraging the use of BMPs to reduce sediment, pathogens, nutrients, and other contaminants. Considering each lake and its watershed may help identify specific priority areas.

Lake/Watershed	Concern	Observations
Brewster Cr.	Degraded stream channel	Highest percent imperviousness, urban land cover, altered channel and floodplain.
Long	Dense aquatic vegetation	Receives water from Brewster Cr., the Tuscarawas River, and the Main Chain. Small, unsewered lots along the Feeder.
Tuscarawas	Largest watershed, highest loads	Some altered channels; several areas protected by parks, wetlands.
North-Hower	Dense aquatic vegetation Most eutrophic	Small, unsewered lots, receives some water from West Reservoir but may not be well-flushed.
East	Dense aquatic vegetation in the north	
Cottage Grove	Dense aquatic vegetation Swim areas	Neighborhood with small unsewered lots. Wonder Lake Creek altered as it passes through Arlington commercial area and other densely developed area. Older stormwater management measures may have focused on volume.
Miller	Dense aquatic vegetation	Some small lots with septic systems. Abuts golf course. Miller Lake may not be well flushed out.
West		Small lots with septic systems.
Turkeyfoot	Swim areas, areas of dense vegetation at margins	Neighborhoods with small lots and septic systems. Large phosphorus load for Turkeyfoot/Rex/Mud .
Rex	Swimming area	Small lots with septic systems. May not flush well.
Mud	Silting in	Development and stream alteration along Cottage Grove Cr., which is developing rapidly.
Nimisila	Dense aquatic vegetation, high P loads, mesotrophic.	Lowest percent imperviousness, high percent forest, high percent agriculture.

- Almost all lakes have small lots with septic systems in the watershed.
- The area around East Reservoir is largely served by sewers. Nutrients from other sources include development and the golf course near West Reservoir, Turkeyfoot Lake, and Miller Lake.
- Small semi-isolated coves may not flush out as well.
- In the shallowest lakes, phosphorus in the sediment may be stirred up more easily.
- Streambank and stream channel alteration are factors in Brewster Creek, and may be factors in Cottage Grove Creek (Mud Lake) and Wonder Lake Creek (Cottage Grove Lake).
- Brewster Creek is also affected by the dense development of its watershed.
- Long Lake and North Reservoir, especially, may be affected by upstream loading.
- The mapping and pollutant loading analyses is based on remotely obtained data, proxies, approximations, and assumptions. It is important to determine landscape conditions in the field, identify resources, and monitor water quality to characterize water entering the lakes and identify opportunities for protection or restoration.

Reducing Impacts from Land Use - Best Management Practices and Conservation

Much of this chapter has focused on impacts of the altered watershed on water quality, flooding, stream functions, and habitat. Because the watersheds are the communities where people live, work, shop, go to school, raise or grow food, and recreate, it is not possible or desirable to return to pristine watersheds. There are many types of Best Management Practices (BMPs) that can reduce the impacts, which can be applied on a small, individual scale or to dozens of parcels, tens of acres, thousands of feet of stream corridor. As the impacts are incremental, the improvements can also be made incrementally, by many individuals helping protect their watershed, streams and lakes.

Below are some examples. Some of these can be done by individuals or scaled up. The longer-term, large scale efforts generally should be done on properties under long-term control of institutions, communities, parks, other public entities, or conservancies. Some of these efforts may require external funding, land acquisition, or other resources, and may take years to realize, e.g., tree planting or corridor acquisition - planning for and beginning a long-term effort is a good way to start.

Protect important landscapes

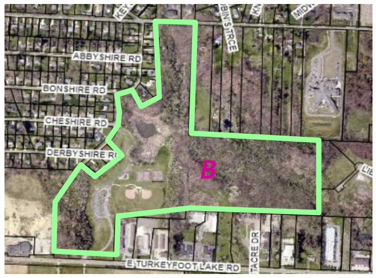
Intact wetlands, riparian corridors, stream corridors, floodplains provide important benefits for stormwater and flood management, habitat, and water quality. Map 6.11 shows important landscapes within the watersheds and conservation lands.[19] These are best left undisturbed, because they provide important benefits and are often not suitable for structures or HSTS.

Some tools to protect landscapes are described below, with examples from the watershed:

Ownership/Easements/Deed Restrictions

- Owning land or conservation easements around sensitive resources, especially with deed restrictions, is the one of the most effective ways to control what happens to that portion of the resource over the long term. Public or non-profit ownership is often required for externally funded restoration projects.

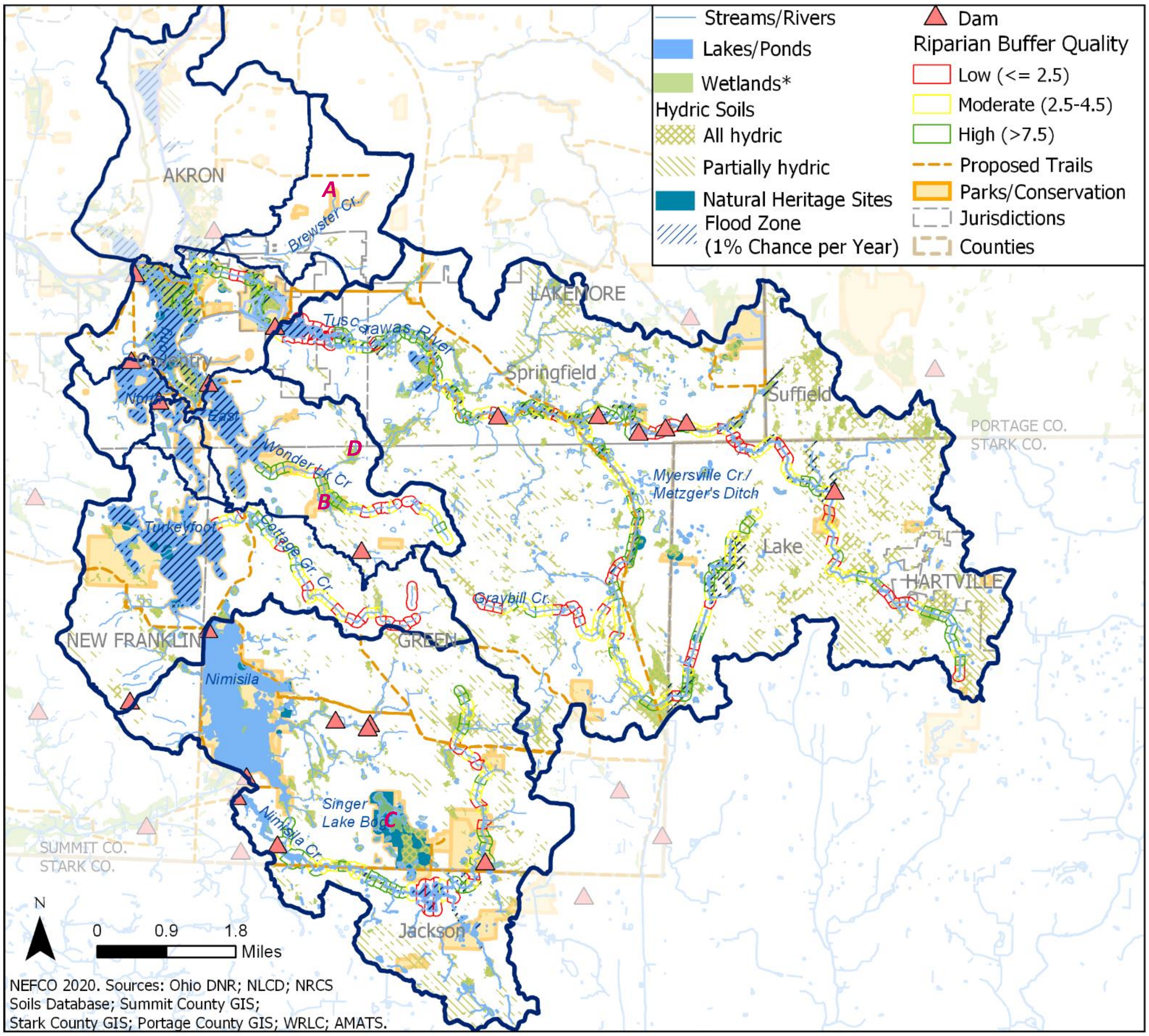
Wilbeth-Arlington Park protects Brewster Creek headwaters. (A)



Above - ownership by community and Cleveland Natural History Museum protects a portion of the Wonder Lake Creek (B) as a park and Singer Lake Bog (C) as conservation land.

Land development can protect land as buffers or open space within a development. (D) Above, some are deeded setbacks, the area just open.

Map 6.11 Important Natural Resources for Conservation or Restoration



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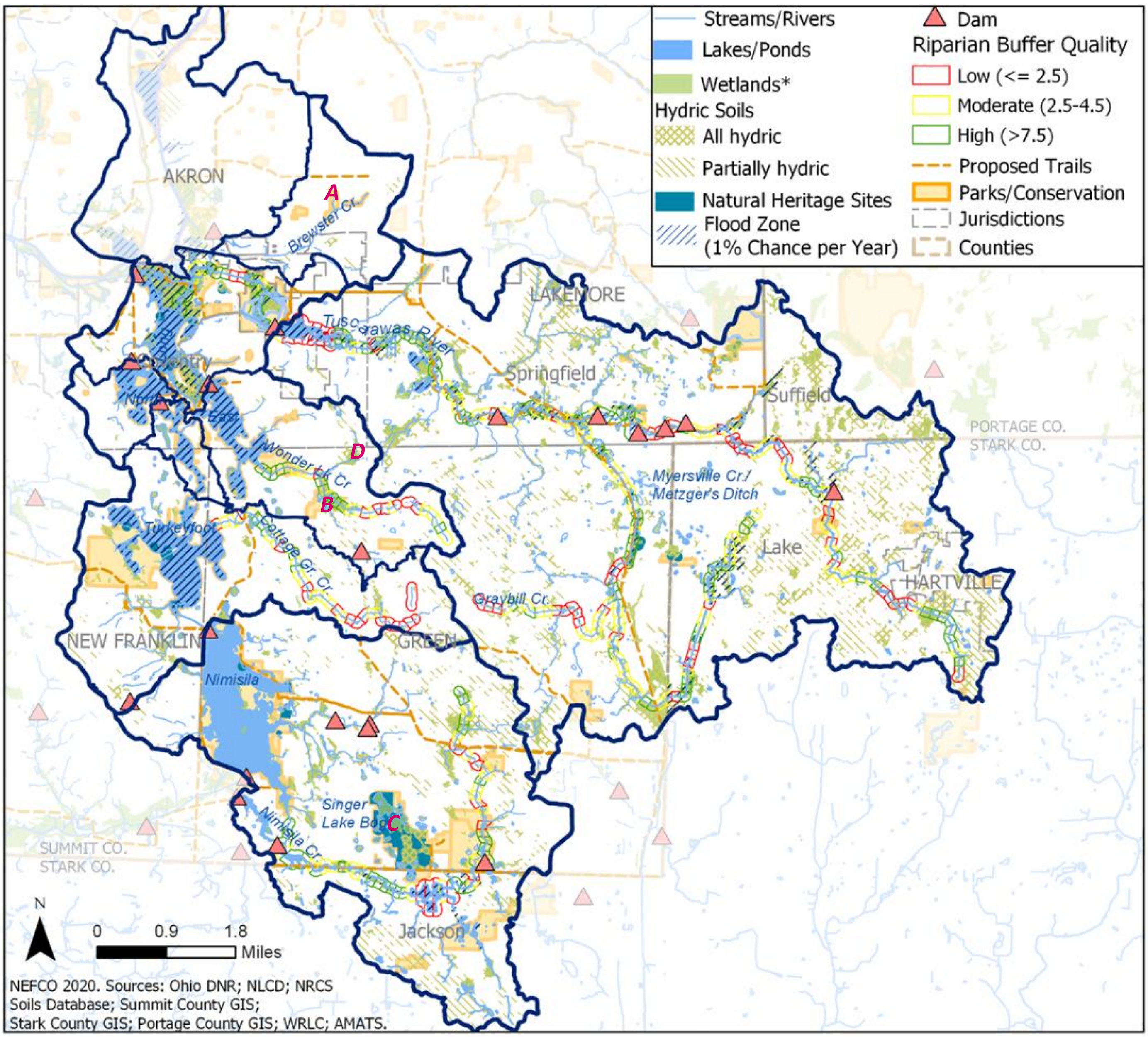

- Stream corridors provide valuable protection and can be used for passive recreation such as trails. The Metro Parks of Summit, Stark, and Portage Counties and other organizations like the Nature Conservancy and Cleveland Natural History Museum have focused efforts on acquiring certain stream corridors for conservation and passive recreation.
- Conservation easements pay landowners to cede the rights to further develop the land. The property owners retain the property but cannot develop the land further. In addition to being paid for the easement, landowners may get a tax benefit, since the land cannot be developed. Various organizations (e.g., SWCDs) hold the easements separately from the owner.
- Land can be acquired as opportunities arise, and then restoration work can be done if necessary.

Setbacks and Buffers Vegetated buffers are one of the most effective – and relatively straightforward – tools for protecting streams. Setbacks are requirements to leave undisturbed or vegetated buffers and are part of many environmental regulations. Buffers are best sized for the size of the stream/watershed. In Summit County's Riparian setback regulations, headwater streams draining less than 32 acres have a 30-foot setback, while water courses with larger watersheds have larger ones, up to 300 feet for drainage areas greater than 300 square miles. Additional setbacks apply to wetlands, FEMA flood zones, and steep slopes.[20] In many cases, however, stream banks are covered with turf, rather than deep-rooted vegetation.

- Summit County and many of the municipalities have adopted riparian setbacks that require development (and disturbance) be set back from streams.
- Land use development laws can require open space buffers/setbacks. Many of these are the minimum required by the laws, so the laws should specify percent of open space and percent undisturbed. In some cases, development codes can provide for larger setbacks if density is increased elsewhere (on-site or on a different parcel, through transfer of development rights.)
- Leaving an undisturbed buffer protects streambanks from erosion and filters runoff.

Fencing agricultural fields (A) is an effective way to keep livestock off most of the bank and protects the streambank from erosion.

BMPs – Reducing Stormwater Runoff and Contaminants

Rain on pavement generates a lot of runoff, laden with sediment, nutrients, pathogens, and chemicals. A wide variety of practices is available for reducing and treating stormwater runoff at different scales – for individual use or large-scale projects. Their purpose is to reduce the amount of stormwater leaving a site or entering the water, and to reduce the amount of contaminants in the water. It is best to infiltrate or use the water on-site, if possible, to reduce overloading of streams and the erosion, sedimentation, bank instability, and contaminant loads that goes with stormwater.

Construction sites within Municipal Separate Storm Sewer Service areas (MS4s) are required to develop stormwater management plans, both during and after construction. These use many of the tools described above. SWCDs implement stormwater programs. Ohio DNR has fact sheets on BMPs.[21]

Rain gardens are depressions designed to capture and infiltrate stormwater. Water-tolerant plants use the water and nutrients and bind other contaminants with their roots. Rain garden instructions are widely available. Individual property owners can make their own with a good site, a bit of planning and labor, soil amendments if necessary, and plants. SWCDs are a good place to start.

Bioinfiltration devices are similar to rain gardens but more highly engineered. They infiltrate and treat stormwater. Many are put in or next to parking lots to capture and treat stormwater. They are often connected to storm drain systems in case of high flow.

Detention basins/retention basins Stormwater regulations require developments to reduce the peak flow leaving the property, which has resulted in a lot of dry detention basins. These temporarily store water, and release them within a few hours. They provide minimal water quality benefits due to the short detention time, and may contribute to bank erosion, since high (not peak) flow continues for a longer period of time than pre-development conditions. Retention ponds or basins store the water on-site and may include wetland vegetation. These are more efficient at removing nutrients and binding other contaminants. These occasionally need to be cleared out. They are regulated as wetlands.

Covering Soil - Runoff can be reduced by covering soil. Individual property owners can use straw to reduce erosion from disturbed soils. Cover crops on agricultural fields protect the soil from erosion, and their roots infiltrate stormwater and use nutrients.

Containing contaminants – Silt fences are used on construction sites to contain disturbed sediment. Coir tubes or mats also can be used. Larger development sites often have sediment basins.

Reducing runoff from sites – Use cisterns/rain barrels to catch roof runoff. Reduce commercial parking requirements and replace spaces with bioinfiltration measures. Both of these reduce runoff and require adjustments to regulations.

Other Best Practices focus on reducing the materials that can enter the water, including Fixing septic systems, cleaning up after pets, using fertilizer according to instructions, discouraging geese.

Restore altered landscapes – these are often large-scale projects

Formerly incised stream, with restored channel and floodplain. Photo source: R. McCleary, 2014.

- Restore floodplains, and stream channel morphology – this improves flood resilience, sediment removal, nutrient uptake, habitat, cooling, oxygen levels, water quality, etc. These are often large-scale projects but are often eligible for outside funding, which can be done in pieces, e.g., land donation, labor, various water quality improvement funding. "Daylighting" culverted streams gives them room to spread out and allows vegetation to grow, which slows and filters water.
- Restoration projects with external funding generally need to be done on land protected by a conservation easement and/or owned by public or certain non-profit organizations.
- Wetland restoration often focuses on habitat. (Wetlands can also be used for stormwater treatment, but the two may not overlap due to the effects of stormwater.)
- Plant riparian corridors, host tree-plantings, replace turf with native plants, shrubs, trees. These are good opportunities for volunteers. Riparian corridors identified on Figure 6.11 as low or moderate quality are good targets.
- In many cases, old dams no longer used for their purpose are in disrepair, unsafe. Dam removal is often considered a water quality improvement, eligible for water quality funding. These are often done with stream restoration, together or as phased projects.
- Channel or floodplain restoration projects are most effective when connected to others or in the headwaters. Small, isolated projects mid-stream in a highly altered corridor are less likely to withstand flooding from upstream. Stream restoration projects are often phased in segments.
- In some cases, developers need to mitigate for unavoidable large-scale wetland alteration. Identifying target areas for restoration and acquiring the land in advance allows future restoration opportunities to move more smoothly and quickly, providing a better potential for moving the project forward.
- There are some organizations that have established wetland restoration/mitigation banks, allowing developers to alter wetlands and pay for restoration in another area. These need to have competitive pricing per acre of restoration. They tend to be large undertakings.

Left - Volunteers planting a former dam pool. Right – View of the bank they planted several years later.

Reduce imperviousness, increase rainwater infiltration, reduce runoff

- Plant deep-rooted plants, shrubs, trees, especially along the water's edge.
- Rain gardens, bio-infiltration, rain barrels/cisterns help reduce runoff and increase infiltration. Some people use rain barrels/rain chains in connection with disconnected downspouts.
- The State Park has a lot of high visibility sites for stormwater Best Management Practices such as rain gardens and lakescaping.
- Establish cover crops and buffers in agricultural lands.


Reduce contaminants that can enter the water.

Many of these are individual stewardship practices

- Compost plant matter, keep it out of streams.
- Clean up after your pet, clean up litter.
- Discourage geese (plant tall native plants by the water, try other techniques)
- Be careful cleaning equipment, so the water doesn't go into drains or ditches
- Don't dump chemicals into road drains or ditches.
- Test your soil for nutrients, apply only the necessary amount per instructions.
- Cover exposed soil.
- Don't wash your car where the water will run into the ditch or drain.
- Don't dump toxic chemicals into your septic system.
- Maintain your septic system with periodic pumping, etc., according to "O&M guidelines."

Best practices related to Best Practices

- Look for opportunities to increase awareness and participation.
  - Seek high visibility public sites for demonstration projects and restoration.
  - Be sure to include signage!
  - Plantings can look attractive or weedy. Attractive enhances the setting and message.
  - Involve volunteers, e.g., plantings, monitoring, signage, art projects, tour guides.


Signs help a lot.

- Mowing to the edge of streams is harmful. Streamside vegetation does a lot to protect streams – and property.
- Look for projects that can address multiple interests for multiple potential partners, e.g., flood control, nutrient reduction, wastewater management agencies, recreation, the arts, urban beautification, transportation, environmental education, LEED-certification, Audubon golf course certification, garden clubs, watershed districts, civic/religious organizations, schools, eco-related businesses, foundations.
    - Partner assistance can often serve as local match for external funding, e.g., land, labor, financial, design, materials, etc. It also broadens the discussion about project design.
    - Stream corridors make great transportation corridors for hiking trails, provided the stream buffer becomes or remains well-vegetated.
    - Look for opportunities to connect new passive recreation/ conservation/restoration projects to existing ones.
    - Water quality protection or stormwater management funding can often be used for projects that accomplish multiple goals.
    - Wastewater management agencies may be able to help with funding or labor.
    - Design for water quality, as well as flood control.
    - Sites by schools are high visibility and can serve as an eco-lab.
    - Shared interests will likely increase the number of people who view the improvement.
    - Partners may be able to share resources, offer staff time or land.
    - Recreation funds can pay for a canoe pull out, hiking trail, or parking area.
    - Mini-parks along a stream can incorporate community art projects, a place to rest and enjoy a bit of greenery, and signage celebrating the local history and environment.

- Acquiring conservation easements or properties in environmentally sensitive areas protects resources and provides opportunities for future projects. For example, FEMA funds may be used to acquire properties in frequently flooded areas, which can be a first step toward restoration. Publicly funded projects generally need to be protected by conservation easements or occur on publicly owned land.
- Replace turf with taller, deeper-rooted vegetation. When planting or re-planting areas, use native species appropriate to the setting as much as possible. Get professional advice. SWCDs, OSU extension, and plant suppliers are good places to start. If planting trees, get an arborist's advice on proper installation. Protect them from deer.
- Remember to account for maintenance, if necessary.

- SWCDs implement stormwater management requirements for development in urbanized areas. Summit County land development regulations address water resource protection.
- Document the need, conditions, and planned project, before and after. Many funding sources prefer "shovel-ready" projects. A Non-Point Source Implementation Strategy plan (NPSIS) is required for projects before applying for "Section 319" grants from Ohio EPA, which are often used to fund large-scale water quality improvement projects.

- Make sure local regulations encourage rather than hinder stormwater best management practices like disconnecting downspouts.

Key Considerations

The lakes and streams of the Portage Lakes watershed are affected by the watershed landscape. Development and alteration affect stream function, floodplains, riparian zones, and water quality.

There is a considerable amount of loading of stormwater, nutrients, pathogens, sediment, and other contaminants from the land uses, septic systems, and altered stream channels. Nutrient loading from the watershed begins as external loading but then is recycled within the lakes as internal loading, which can last for years. It is important to reduce both sources of nutrients. BMPs, conservation, restoration, and plantings will help reduce flooding and input of nutrients and other contaminants.

- The lakes are in the upper Tuscarawas River watershed. The Tuscarawas flows into northern Long Lake. The Tuscarawas River and Nimisila Creek are the only water courses that have been monitored in the watershed, and they have minimal to no effect on the Main Chain lakes. Water quality monitoring indicates that attainment of Aquatic Life Use standards ranges from non-attainment to a few sites in full attainment. The two water courses have been affected by flow alteration, habitat alteration, siltation, organic enrichment, pathogens and nutrients, from channelization, suburbanization, and failing septic systems. Nimisila Creek and the Tuscarawas River represent approximately three-fourths of the modeled pollutant loading, but their effect on the Main Chain lakes is minimal to none. The tributaries primarily affecting the Main Chain have not been monitored, but because of landscape similarities, it is likely they exhibit similar impacts from these sources. They need to be monitored to determine what is entering the lakes.
- Lake conditions should be evaluated in light of the watershed characteristics, land cover, and the presence of small lots with septic systems. Intact stream channels, floodplains, vegetated riparian buffers, and wetlands help protect water quality, reduce flooding problems, and improve stream resilience to high flows. The riparian buffer analysis, resource mapping, and review of aerial photographs indicates that some of the stream and river segments appear to be intact, flowing through vegetated buffers, wetlands, and low-lying floodplains. Some of these are within parks and conservation areas. Many areas have been disturbed, which harms stream function and water quality, increasing loading of nutrients, sediment, bacteria, and other contaminants to the lakes.
- The numerous small unsewered lots makes nutrient loading and pathogen input from septic systems extremely likely. Several swim areas are located near unsewered neighborhoods, which should be monitored for bacteria. Some of these neighborhoods are near lakes with especially dense vegetation, possibly contributing nutrients to the eutrophic conditions. Discussions among representatives of wastewater management agencies, communities, and health districts that were started during development of this plan should continue concerning the need and feasibility of various wastewater treatment measures. The focus should be on reducing phosphorus loading and pathogens in a way that is acceptable to the MAs and communities.
- The imperviousness (hard surfaces) of the watersheds affects runoff and stream quality. The watersheds generally range between 10 and 20 percent, which is high enough to cause stream

degradation. Nimisila Reservoir is 7.7 percent impervious, and Brewster Creek is 45 percent impervious. Vegetated riparian buffers can reduce stream damage.

- An analysis of potential pollutant loading indicates that urbanized landscapes are a major source of nutrient loading into the lakes, followed by septic systems and agricultural land. Reducing the external loading coming from the watershed is an important part of protecting lake health.
- There are many practices available to reduce the impacts and protect and improve water quality in the streams, river, and lakes. Protecting and restoring riparian buffers, stream corridor landscapes is an important part of watershed protection. Conservation, protection, and BMPs can and should be widely used by individuals, organizations, and communities. These can be individual activities, like planting deep-rooted vegetation or reducing materials that can enter water, to large-scale stormwater management BMPs and restoration efforts. Small efforts and demonstration projects can be tried and scaled up.
- Public sites, like the State Park, are well-suited for demonstration projects and restoration of stream-side and lakeshore vegetation and other important habitats. Some large private landowners, e.g., churches, golf course, may be open to increasing the use of BMPs.
- An innovative approach to reducing nutrients from the watershed is to harvest and compost aquatic plants. This requires additional staffing and location(s) to off-load harvested materials.
- Where possible, communities and organizations should continue to protect and restore important landscape features, such as wetlands, riparian corridors, floodplains, and streams. The mapping in the chapter of important natural features and the riparian buffer quality could help identify target sites for acquisition or restoration. The Summit County Environmental Viewer is a good online tool for viewing environmental data on an aerial photo base. It also has topography and an elevation profile tool.
- Watershed streams should be monitored, to determine substances are entering the lakes.
- Altering wetlands, streams, and floodplains is regulated by federal, state, and county laws, many of which require undisturbed buffers around resources. Summit County has adopted riparian setbacks. In many cases, parcels either pre-date the regulations or are not covered by them, and streambanks lack vegetated buffers. Landowners should be encouraged to plant deep-rooted plants along streams.
- There are many land use regulations that can encourage practices that protect water quality, such as buffer guidelines and ordinances concerning roof drains. These regulations should be reviewed to encourage "green" practices that reduce runoff and increase vegetated buffers.
- The City of Green has developed NPS-IS documents for certain streams in the Portage Lakes watersheds. These documents, which are required for certain external funding, can be amended to address additional streams in each watershed.
- Many of these efforts rely on and can encourage public stewardship and partnerships. Events like creek clean-ups and planting events (trees or other native species) would build public involvement and understanding, and would improve conditions in the streams feeding the lakes.

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Chapter 7 – Overview

Sustaining the Portage Lakes as a multi-use resource requires actively managing the lakes, aquatic plants, and interaction with lakers' activities. Important elements include: reducing nutrients, sediment, eutrophication, other contaminants; increased understanding of lakes, plants, processes, and interaction with human activities to guide decisions and reduce impacts; working with lakers to determine priority plant management areas and approaches; monitoring change; and increasing awareness and stewardship. The management plan TAC, which has met for five years as advisers to the lake management effort, will likely continue working as a partnership, assisting the lakes management efforts with a wide variety of expertise, interests, and shared resources. However, the complex task of lakes management requires long-term, consistent, staffed and funded coordination. This chapter includes goals and recommendations for tasks, priorities, and roles.

Recommendations and Management

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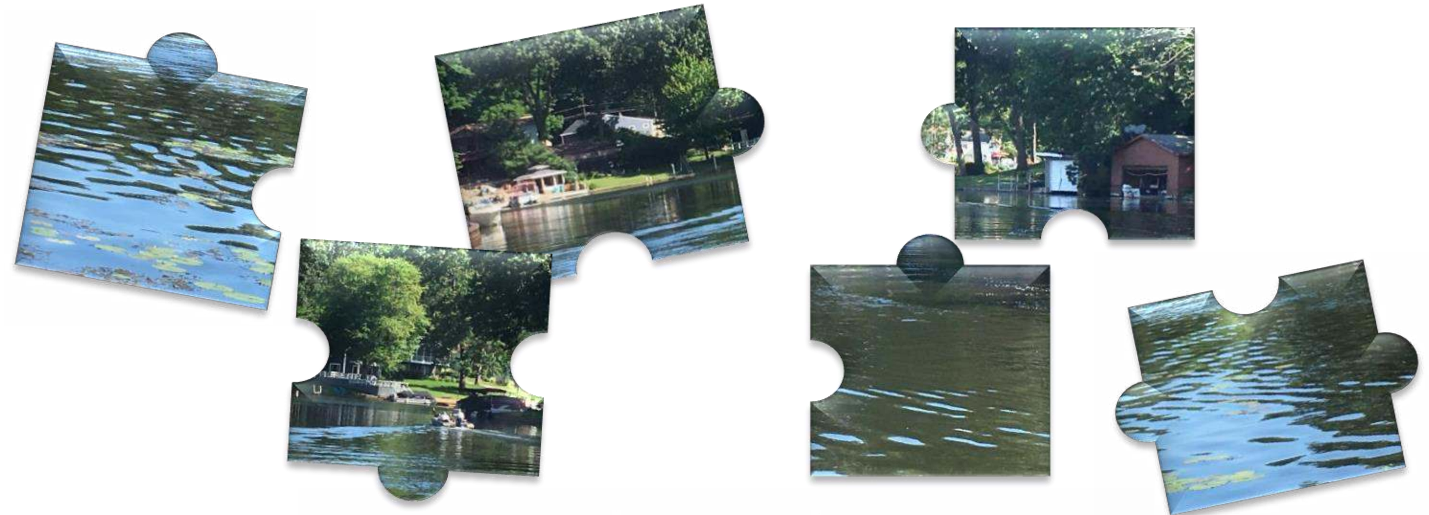


7. Recommendations and Management

The Portage Lakes are a natural resource within a park, attracting thousands of residents and visitors to live, recreate, and do business on and along its waters. They are the center of a community of lakers, and businesses, providing, a community gathering place, business opportunities, an economic engine, and the front street connecting neighbors and businesses. The lakes are considered urban, as they are in a developed watershed and have been modified for flood and flow control, but their appeal is their natural beauty, fishing, swimming, and natural habitats. They are driven by natural processes.

Good water quality and habitat are essential for the long-term health of the lakes, the organisms within them, and the thousands of people who use them, and the communities that rely on them. Recently there have been some water quality improvements:

- Extension of sewers to some areas with septic systems,
- Improved outboard motors reduce oil and gas contamination of the lakes,
- Turbidity and chlorophyll levels have generally improved since the 1990s, with substantial decreases in chlorophyll, and
- There has been some improvement in phosphorus levels.

However, the lakes are eutrophic. High levels of phosphorus drive dense growth of aquatic vegetation that gets in the way of activities. Active management of the lakes is necessary to balance the uses and water quality and improve conditions in the lakes.

When Urban Lakes are Not Managed as a System

Without managing the lakes system, the balance in the Portage Lakes has shifted and will continue to do so toward eutrophication and HABs. The only way to improve conditions is to manage the problem – and lakes – as an inter-connected system. Using the wrong approach may not work or could make conditions worse.

Needed: A New Approach


Photo Source: J. Garretson, 2021.

Currently, individuals and organizations try to manage lake conditions or plants on their own, within the narrow focus of their experience or organizational scope. They may consult with each other, but there is no individual or organization with the staff, scope, funding, technical background, time, or resources to provide the lakes-wide perspective. There is minimal monitoring. The lakes are inter-connected systems, changes to one part affect the rest of the system. Because the aquatic plants are part of the lakes system, reflecting and affecting lake conditions, aquatic plant management must be done within the context of the lakes.

A piecemeal approach to plant and lake management may be ineffective at best and may cause more harm, in spurring more eutrophication, growth, transport of invasives, or HABs. Managing the lakes system must integrate the pieces.

This plan proposes a new approach for the Portage Lakes in order to sustain the lakes and their uses, systematic management of the lakes system and plants within it. Lake and aquatic plant management programs would affect activities in the lakes, on the shoreline, and in the watershed, and would involve:

- ***Commitment*** by lakers, organizations, and communities to balance human use and the natural lakes system, improving conditions, minimizing impacts, and considering the lakes system;
- ***Increased support*** for lakes management programs from the lakes community, organizations;
- ***Organization(s), individual(s), or consultant(s) whose scope is the broad lakes perspective***, with adequate funding, technical background, procedures, guidelines, monitoring, and resources;
- ***Coordination and collaboration*** to share information, concerns, ideas, resources, perspectives;
- Inventory and monitoring of lake conditions, aquatic plants, and invasive species – baseline and changing conditions, especially after treatment measures are used;
- ***Well-defined process*** for developing and carrying out management plans, including monitoring conditions, identification of problem areas and priorities, selection of appropriate measures, and monitoring, which involves the lakes community;
- ***Identification of priorities*** for use, conservation, management, minimizing impacts, improving conditions on land and in the lakes;
- ***Guidelines*** for the use of best practices and programs to encourage their use; and
- ***Involvement of the lakes community*** in identifying problems, establishing priorities, developing feasible measures, minimizing impacts, supporting programs, building a common understanding of the lakes, stewardship. Involvement should include property owners, boaters, visitors, PLAC, local governments, agencies, lake scientists, and others interested in the lakes.

This is a big shift from the current individual, piecemeal approach. It requires increased awareness of how the lake system and activities affect each other, dedication to improve conditions by lakers and organizations, additional support, technical information, and collaboration. Similar programs are successfully used elsewhere to sustain activities and health of multi-use lakes. Such programs provide the additional benefits of predictability and accountability – residents, agencies, communities understand what will be managed and how, what the process and timeframe are, what their roles are, and what is needed to accomplish the tasks.

This chapter presents detailed discussions and recommendations related to this new approach, including lakes management and aquatic plant management programs and activities that individuals and organizations can take to improve lake conditions. Central to this chapter and plan is the need for coordinated, systematic, well-supported management to balance uses and lake health and habitats.

Overall Considerations

Sustaining a connected chain of urban lakes as a multi-use resource is a challenge, requiring careful management.

- Lakes have complex interactions among components, from the microscopic to watershed-wide.
- Urban lakes, like the Portage Lakes, are very susceptible to eutrophication.
- As connected lakes, isolating problems, causes, management measures, and effects is difficult.
- Sustaining uses and ecosystem health requires a balanced approach, understanding and minimizing impacts, and evaluation (and re-evaluation).
- The large number of visitors each year increases potential impacts. There is a great need to need to inform people about living with a lakes system and involve them in stewardship and management.

Added to the complexities of managing connected urban lakes, are :

- Lack of knowledge about how these lakes work, and
- Lack of an administrative structure – and shared expectations - focused on managing the lakes.

The management plan identifies five goals and numerous recommendations. The considerations described below are central elements that run through the plan.

Eutrophication

Decades of development and small unsewered lots have contributed external loading of nutrients, which recycle for years as internal loading. The lakes are eutrophic, with high phosphorus levels, nuisance plant and algae growth, and occasional harmful algal blooms. As phosphorus levels continue to build up from the watershed and internal recycling, the risk increases of an ecosystem dominated by algae and HABs rather than rooted plants.

Interaction of Natural and Human Activities

The Lakes are a natural system that supports intense use. This raises the potential for impacts of the natural system and human activities on each other and conflicting priorities.

- Nearly 80 percent of the lakes' area is in the shallow littoral zone, where rooted aquatic plants grow, and where people live, boat, swim, and fish. The aquatic plants are essential to the ecology of the lakes, providing habitat, food, cover, sediment stabilization, and using the available nutrients that might otherwise spur excessive algae growth and HABs. Residents, businesses, and visitors often perceive the plant growth as a nuisance that should be removed.

However, the dense vegetation, which gets in the way of some uses, protects the lake from shifting to a dangerous, "turbid," algae-dominated state with frequent HABs.
- Some lakeshore property owners use their own chemicals to control the aquatic growth. These add unknown toxins to water that people swim in and that is habitat for animals.
- Other lakeshore contamination sources may include discharging or nuisance HSTS, trash, geese, boat and property maintenance practices and chemicals.
- Thousands of people using the lakes can have thousands of small impacts, if lakers are not stewards as well.
- Watershed uses affect the lakes. Altered landscapes introduce sediment, nutrients, bacteria, and toxins, while intact or restored landscapes reduce inputs to the lakes.

Need for Technical Expertise

Managing lakes, especially a chain of urban, multi-use lakes, requires technical expertise, to characterize the lakes and aquatic plants, identify problems and causes, choose appropriate management measures, monitor changes, and reduce unwanted impacts in these complex, interconnected systems.

- Reducing eutrophication and managing aquatic plants requires an understanding of how lake characteristics, plants, and nutrients interact. The effects of management measures should be monitored to determine if they work. There has been limited monitoring of limnological conditions, incoming nutrients and sediment, and aquatic plants.
- The expertise of ODNR staff managing the park facilities, fisheries, and flood/flow control in the lakes is focused on their particular area of management. Managing multi-use lakes requires that a broad understanding of lake processes be applied to decisions and minimizing impacts.

Need to Manage the Lakes as a System

Sustaining the lakes and their uses requires actively managing the lakes, aquatic plants, and human activities to improve conditions, protect water quality, and accommodate uses. This requires a long-term commitment, adequate funding, staff, equipment, coordination, and resources.

There are many individuals and organizations involved in discrete elements of the lake management.

- The small ODNR Portage Lakes staff focus on the visitor experience, park facilities, docks, boat ramps. They are supervising limited dredging and plant control.
- The small ODNR Canal Lands staff that focuses on flood and flow management also harvests plants in the Portage Lakes and Mosquito Lake.
- Property owners manage the aquatic plants at their docks.
- The lakers – residents, visitors, boaters – experience the lakes directly.
- SWCD and communities – watershed focus, stormwater, erosion control.
- PLAC focuses on public information and communication about the lakes and hosts events.
- Other agencies and organizations focus on their element or individual situations.

There is no mechanism to manage and understand the lakes as a natural and human system - characterize the lakes, lake processes, concerns, management measures, and impacts. Managers and lakers address individual situations as best they can, without comprehensive guidance and, in some cases, adequate resources. A piecemeal approach, responding to immediate problems, is unlikely to achieve the goal of sustaining the lakes as a multi-use resource. There needs to be a holistic, consistent, coordinated approach, that considers ecological and community impacts, which is focused on achieving broad goals, adequately funded and staffed.

Funding

The recommendations in this chapter involve a greater level of commitment and effort devoted to management of the lakes than is possible under the current staff and budget. Carrying out the recommendations will require additional funding, staff, and resources. There are several approaches that can be used to help supplement existing budget and staff, including:

- There may be some opportunities to share resources among partners. For example, in some creek clean-ups, local parks or communities help coordinate or provide trash pick-up and disposal services; in some projects, wastewater management agencies have assisted with sampling or lab work. The Portage Lakes TAC/partners have provided valuable technical background and support as part of their work as advisers/partners.
- Providing land for demonstration projects can allow them to proceed.
- Contractors instead of staff could complete certain tasks.
  - Certain tasks that require specialized expertise e.g., aquatic plant inventory.
  - Certain regularly occurring services, such as plant control at docks or harvesting with removal of cut material, could be provided by skilled/licensed contractors.
- Certain projects can be funded through grants, individually or as part of other projects being managed by someone else. Partners or staff would need to write grant proposals and lay the groundwork (find sites, arrange for development of plans, manage contracts, provide/seek match or other contributions). There are many funding opportunities including water quality, environmental education, recreation, community beautification, funding for public arts projects, Muskingum Watershed Conservancy District, stormwater fees. The Portage Parks manager regularly uses U.S. Coast Guard and ODNR boat registration/navigation funds for work related to docks and navigation.
- The potential for fees for coordinated aquatic plant control should be investigated.
- Certain tasks can be accomplished with volunteer helps (often supervised), if the tasks are tailored to the volunteer's level of interest, time commitment, and background. PLAC volunteers have organized events, participated in clean-ups, conducted Secchi disk monitoring, coordinated playground development. These efforts range considerably in the commitment and supervision needed. Many have been successful; some have involved more time commitment than volunteers could manage.
- Partnering with local universities can provide interesting opportunities for monitoring, outreach, and other collaboration. Students and faculty often seek research or field work opportunities. This is not a free replacement for staff time or contractors – students prefer paid internships, materials and supplies need to be purchased or replaced, students should be well-supervised by faculty or employers, so they produce high-quality results. However, partnering with local universities can provide long-term

collaboration and expertise that might not otherwise be available. There has been only minimal university involvement in the Portage Lakes so far.

The examples above would all need to be included as budget items – repeating or as a single year's item – and there would still need to be staff (full-time or part-time) dedicated to consistent and continuous lakes management, coordination, and carrying out certain tasks.

Increasing Awareness, Involvement, and Stewardship

Thousands of visitors and residents come to the lakes and their surrounding community. It is important to raise their awareness of the lakes system, potential impacts, and management measures.

- The lakers – residents, businesses, and visitors – interact frequently with the lakes and can have a large impact on the lakes. Many organizations and communities conduct activities affecting the lakes. It is important to raise awareness and stewardship of the lakes system among residents, visitors, businesses, communities, and organizations, to improve decision-making, reduce negative impacts, improve conditions in the lakes, and protect them for future use.
- As the users of the lakes, the lakers are an important part of managing them and should participate in identifying lake conditions, concerns, priority areas, and management measures.
- Volunteers can provide valuable assistance for certain efforts. Involving volunteers raises awareness and stewardship.

Shared Interests and Opportunities for Collaboration

Collaboration increases the resources, expertise, and potential for involvement. For example:

- Properties for restoration or demonstration projects may be available on public lands. In some cases, properties can be acquired for one purpose – e.g., recreation trail or flood hazards – and be used for restoration as well.
- Opportunities for volunteer work and citizen science may appeal to a wide range of interests. Some companies or organizations seek tree-planting projects or clean-ups.
- Water quality projects related to streams or plantings can overlap with community arts or writing projects or other seemingly unrelated interests. E.g., sculptures, murals, poetry, or artwork that celebrate the importance of rivers or lakes, an urban oasis of greenery and artwork, native plants for pollinators, or public-school artwork displayed at the Cleveland airport that celebrated the Cuyahoga River.
- Flood control, wastewater management, and water quality projects often overlap and can bring in multiple funding sources.
- Groups interested in gardening and wildflowers may be interested in rain gardens.
- Audubon Cooperative Sanctuary for Golf certifies golf course that incorporate environmental planning and habitat protection.
- Lakes boat tours, restaurants, and area schools could incorporate tour information, activities, or trivia events that focus on the lakes.

Where to Start? First Things First and Low Hanging Fruit

Establishing a lakes management program is a long-term effort, with many elements. Certain efforts are a high priority to get started on first. Taking the first steps on longer-term projects is a good start. Targeting these and other efforts that produce early successes, "low-hanging fruit" helps build momentum and energy while getting some good work done.

Important early steps include:

- Establish partnership, decision-making structure
- Monitoring – limnology, streams
- Aquatic plant inventory (needs funding and commitment)
- Community input to identify areas with aquatic plants – submission of geotagged photos, interactive online map, public workshops
- Community discussions about where aquatic plant management is a priority.
- Stormwater management or lakescaping demonstration projects at the State Park, with signs.
- Identify landscapes for protection/restoration

Early tasks could include starting longer-term efforts, such as:

- Characterize phosphorus cycling in lakes
- Protect/restore landscape features
- Develop a coordinated aquatic plant management program
- Identify wastewater treatment measures, support feasibility of sewer extensions
- Establish funding sources
- Investigate ways to establish aquatic plant harvest with removal
- Stormwater BMPs
- Mini-parks with community art celebrating the lakes

Outreach examples that would be good to start include:

- Lakescaping demonstrations, goose management, brochures/posters/pop-up displays at public events or for newspaper or webpage
- Plant guide to portage lakes
- Boat tour information/boat tours
- Clean-ups
- Signs at existing BMPS or conservation areas
- Develop on-line tour information about lakes
- Outreach at local businesses
- Public forums, school science fairs, etc.

Central Elements of the Plan

The following recommendations are central to all the goals of the plan and are important for sustaining the lakes and uses:

- *Long-term coordinated direction and management, including:*
  - *Decision-making process,*
  - *Adequate funding, staff and resources*
- *Manage external (watershed) factors and internal (in-lakes) factors to reduce nutrient loading, sediment disturbance, and other contamination.*
- *Manage aquatic plants to accommodate uses while protecting the water quality and habitat benefits provided by rooted aquatic plants.*
- *Adequate technical expertise and skills. Certain tasks need to be performed by specialists, (e.g., manage flow/floods, aquatic plant inventory).*
- *Inventory, sampling, monitoring of limnology, e. coli, aquatic plants, streams, watershed landscapes.*
- *Characterize and develop guidelines for reducing factors of eutrophication, minimizing impacts, on the habitat, fisheries, and ecosystem*
  - *Lake processes;*
  - *Phosphorus cycling and ecosystem; and*
  - *Effects, feasibility, and impacts of lake management measures.*
- *Increasing awareness, participation, and stewardship to better understand and protect the lakes.*

Goals - Overview

During the course of the study, the stakeholders developed five topical goals and an overall goal. This chapter presents the goals, objectives, and recommendations, in a framework of who is likely to be involved and the resources needed.

Overall Goal:
Manage the Portage Lakes as a sustainable multi-use resource, in a way that protects the natural lakes system in balance with the needs and interests of lake/watershed users, communities, and organizations.

Five goals have been identified, which are linked. Recommendations for each should be carried out in conjunction and coordination with the others.

1. *Water Quality – Lakes and Shoreline. Protect and improve the water quality of the Portage Lakes by reducing factors of eutrophication and other contaminants within the lakes and along the shoreline.*
2. *Manage Aquatic plants in a way that accommodates property owners and visitors while protecting habitat and water quality.*
3. *Water Quality – Watershed. Protect and improve the water quality of the Portage Lakes by reducing factors of eutrophication and other contaminants within the lakes and along the shoreline.*

4. *Long-term Management. Establish a long-term multi-disciplinary management program to provide technical expertise, coordinate efforts, and ensure there are adequate resources to sustain the multi-use, connected, urbanized Portage Lakes resource.*
5. *Understanding/Stewardship. Increase understanding and stewardship by lake/watershed residents, visitors, businesses, and communities.*

- Goals 1 and 3 focus on improving water quality by reducing eutrophication and other contaminants. Improving conditions in the lakes requires addressing sources internal to the lakes as well as external, watershed-based sources. These goals involve different approaches and targets but share the same desired end result.
  - Goal 1 focuses on the lakes themselves, and will likely involve reducing release of phosphorus *within* the lakes, focusing on management of plants, sediment, and other lake characteristics.
  - Goal 3 focuses on preventing nutrients, sediment, and other contaminants from reaching the lakes *from the watershed*, using BMPs and restoration of important landscape features. The targets and approaches should be modified if necessary, as a better understanding of stream and lake conditions is developed.
- Goal 2, which addresses a balanced approach to aquatic plant management, relates closely to in-lakes factors of eutrophication – nutrient cycling/availability, sediment stabilization, and competition with algae.
- Goals 4 and 5 focus on establishing long-term management and increasing awareness and stewardship.

Each goal is discussed in the following individual sections. Tables 7.1-7.5, included with the discussions of each goal, present objectives, actions, recommended priority and time frame, and potential partners.

Goal 1 – Water Quality – Lakes and Shoreline

Protect and improve the water quality of the Portage Lakes by reducing factors of eutrophication and other contaminants within the lakes and along the shoreline.

Eutrophication

High nutrient levels drive dense plant growth and potentially HABs. Phosphorus builds up and is recycled in the lakes for years.

- Phosphorus and nitrogen that enter the lakes from the watershed are used – and temporarily stored - by stationary or floating photosynthesizers. During decomposition, nutrients are released into the water or stored in sediment.
- Rooted plants can take phosphorus from the water or sediment, depending on the species. Floating photosynthesizers use dissolved phosphorus and nitrogen from the water.
- Phosphorus that is stored as particles in sediment dissolves in anoxic conditions, which occur within sediment pores or at the sediment surface. It is then released and is available for growth.

As nutrient levels continue to build up, and the climate becomes warmer and wetter, there is a greater risk that the ecosystem will switch to turbid, algae-dominated state, with frequent HABs and a loss of aquatic plants.

With limited monitoring, it is difficult to specify the best approach to reduce internal loading. The Ohio EPA has developed inland lakes criteria for phosphorus, turbidity, and chlorophyll A, three linked indicators/factors of eutrophication. These values should be the target for management but could be revised with a better understanding of the Portage Lakes characteristics and nutrient dynamics.

The available data show that the lakes partially meet the inland lakes criteria. Nimisila Reservoir meets all three criteria, North Reservoir meets none, and the other lakes meet them to varying degrees. In most lakes (except North Reservoir), chlorophyll levels have been reduced almost to the state criterion, and phosphorus levels have decreased somewhat since the 1990s. ***Note:*** Recent research indicates that nitrogen is also a key nutrient in HAB severity and toxicity. Lakes management efforts will need to monitor for several parameters and include keeping abreast of recent research and sharing information.

Management considerations related to the inland lakes criteria include:

- *Phosphorus Inland lakes criterion 34 µg/l; the limited data shows that the lakes (except Nimisila) range from 44 to 83 µg/l.* Phosphorus levels are an indicator of eutrophication, as well as the driving force. It is essential to characterize the phosphorus levels in different areas of the lakes to determine the conditions that increase available phosphorus – e.g., plant die-offs, sediment disturbance, location in the lakes, stagnant waters. This involves monitoring streams for input and limnological conditions in various areas of the lakes – anoxic conditions can exist within sediment pore water and thin layers at the sediment surface. Determining patterns of phosphorus levels would contribute to developing a phosphorus budget and would help lake managers understand the sources in the lakes and develop management measures to reduce or minimize phosphorus release.

- *Turbidity - Inland lakes criterion Secchi disk reading 1.19 m or higher. Lakes (except Nimisila) range from 0.86 m to 1.77 m.*
  Turbidity is affected by algal growth, which is driven by phosphorus. Turbidity is also affected by suspended fine sediment. Sediment disturbance can release phosphorus. By altering light penetration and water temperature, turbidity can affect fisheries, and excessive turbidity encourages algae and cyanobacteria over rooted plants. Turbidity appears to have decreased generally over the last few years, possibly due in part to zebra or quagga mussels. Increased rooted vegetation may be reducing algae and suspended sediment. Lakes that are typically high in turbidity should be monitored for chlorophyll (from algae) and suspended sediment, to determine which factor is making the lakes cloudy. Lake management practices should reduce suspended sediment, e.g., minimize unnecessary dredging, protect rooted vegetation, and reduce boat traffic in silty areas, especially at sediment sources like streams, reduce sedimentation from the watershed.

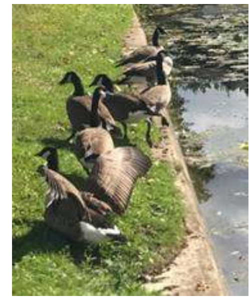
- *Chlorophyll A - Inland lakes criterion 14 µg/l, lakes (except Nimisila) range from 11.9 to 36.1 µg/l.*
  Chlorophyll A reflects algal growth, a result of available phosphorus. Reducing this indicator requires reducing available phosphorus and protecting and improving conditions for rooted plants. Not only do rooted plants compete with algae, they also stabilize sediment, further minimizing release of phosphorus from the sediment.

It is difficult to make more specific recommendations due to the lack of monitoring data and understanding of how the lakes systems work. A consistent, seasonal monitoring program lakewide and in the incoming streams, is an essential first step and can help track changes. Some assumptions and general recommendations can be made currently to improve lakes management. Greater understanding will allow concrete guidelines for management practices to be developed.

Recommendations – Reduce/Minimize Factors of Eutrophication:

- Seasonal monitoring of limnology throughout the lakes to characterize the lakes and changes;
- Seasonal, dry-weather and storm-flow monitoring of streams to characterize inputs to the lakes;
- Develop an understanding of nutrient cycling in the lakes (or phosphorus/nitrogen budget);
- Characterize effects of lake management/APM measures, develop guidelines for management practices to minimize phosphorus release and other negative effects;
- Protect rooted aquatic plants, to use available nutrients and stabilize sediment;
- Minimize large die-offs, e.g., widespread chemical use, early-season invasive species;
- Develop a harvest and removal program;
- Investigate other measures to reduce phosphorus, e.g., change flow or drawdown, increase aquatic plant diversity;
- Limit dredging to areas necessary for passage and water flow and minimize impacts to the ecosystem, to protect plant communities and sediment disturbance; and
- Reduce sediment and phosphorus input from the watershed.
- There should be a focused effort on understanding and managing eutrophication and dense growth in certain areas, including North Reservoir, which is the most eutrophic, Miller and Cottage Grove Lakes, and portions of Long Lake.

Other Contaminants



Reducing shoreline contaminants by increasing stewardship is a good topic for outreach – demonstration projects, workshops, lakeshore property owners' guide, etc. Sources include:

- Geese and other animal waste – Geese favor turf near open water.
  - There are several approaches to discourage or exclude them from lakeshore properties.
  - Lakescaping with taller vegetation reduces runoff into the lakes and discourages geese, which prefer sites with clear views to the water.
- Chemicals obtained/applied without permits for aquatic plant control – Any chemical use on the water must be done with a permit. Applying chemicals acquired over the internet or at a hardware store may not work on the plants as intended and may have toxic effects on wildlife or people in the water nearby.
  - Outreach to lakeshore property owners is important.
  - Developing a coordinated approach to management of aquatic vegetation at docks may discourage property owners from applying chemicals.
- Chemicals related to boat maintenance – chemicals used to clean docks and boats can include toxins and phosphorus. When working near the water, seek alternatives for these chemicals:
  - Ammonia
  - Antibacterials and disinfectants
  - Butyl glycol, ethylene glycol, monobutyl
  - Chlorine bleach
  - Petroleum solvents ("surfactants")
  - Phosphates
  - Pthalates

  Property owners and boaters should seek phosphate-free and biodegradable products instead.

  The U EPA Safer Choice website lists environmentally safer replacements for common chemicals. https://www.epa.gov/saferchoice/products
  Ohio State University Sea Grant has resources for boaters and marina operators to encourage good stewardship. https://ohioseagrant.osu.edu/clean#news. The Clean Marinas program offers technical assistance, resources, additional marketing, and recognition for marinas that become certified Clean Marinas and help sustain their lakes. https://ohioseagrant.osu.edu/clean

The following sources occur throughout the watershed but have great impact because shoreline properties are directly on the lakes.

- *Vegetation waste disposed in the lakes* – compost yard waste from properties on or near the water if possible, as decaying vegetation releases phosphorus into the water.
- *Discharging or nuisance HSTS* – Increase phosphorus loading and bacteria. This should be a focus of of the watershed efforts to reduce septic system/HSTS discharges into the lakes.
  - Work with wastewater MAs, communities, and Summit County Dept. of Health to determine appropriate areas for sewer extension; support sewer service extensions; determine appropriate measures to reduce discharging septic systems.
  - Swim areas near concentrations small lots and HSTS should be monitored for bacteria.

- *Erosion/runoff* – Since lakeshore properties drain directly into the lakes, there is little opportunity off-site to reduce their impact. Lakescaping, rain gardens, capturing runoff, covering exposed soil are good techniques to reduce input of contaminants into the lakes
- *Home/yard maintenance chemicals.* As elsewhere in the watershed, proper use of lawn chemicals, proper disposal of oil, washing cars on grass rather than on the driveway help reduce contaminants entering the lakes.

Recommendations to reduce contamination from the shoreline include:

- Demonstration projects and property owner workshops can help encourage people to use some of the techniques noted above. Public lands are good sites for demonstration projects, especially at high-visibility areas with signage – e.g., State Park shoreline, parking lot. Using supervised volunteers increases participation.
- Many of the topics noted above are good subjects for outreach materials such as topic-specific brochures and workshops, property-owner's guide to living on the lakes, etc.
- Coordinating aquatic plant management at docks, combined with outreach, would reduce the perceived need for individual treatment and decrease use of inappropriate plant management.
- Work with wastewater management agencies and the department of health to identify and support programs to reduce discharging or nuisance HSTS, identify appropriate areas for sewer extension and support those efforts.

- Monitor streams and swim areas for harmful bacteria.
- Encourage marinas to achieve Clean Marina Certification
- Encourage boaters to practice good stewardship. Measures can include brochures at high-use sites, good stewardship programs, lakeshore property owners' guidebook. Ohio Sea Grant has many outreach materials and workshops. https://ohioseagrant.osu.edu/clean#news
- Clean-ups to increase awareness and stewardship.

Table 7.1 **Objectives and Actions** **Goal 1 – Water Quality – Lakes/Shoreline** *Note: These reflect ideas from various discussions. Lake partners must decide priority, details, feasibility.*	Objectives: A. *Use improved understanding of lake conditions to guide lake management decisions.* B. *Reduce phosphorus release/availability* C. *Minimize sediment disturbance* D. *Minimize bacteria risk and nutrients from septic systems.* E. *Discourage geese* F. *Increase use of Best Management Practices and appropriate property and boat maintenance at lakeshore properties to reduce input of contaminants and trash* G. *Increase awareness of the lake ecology and the value of plants*			
	Objectives	**Priority, Time Frame (years)**	**What is Needed/Comments**	**Potential Partners/Resources**
Monitoring				
Limnological sampling to characterize trophic state, and lakes conditions and processes	A	High, 1-2 years, ongoing as needed to monitor lake conditions and trophic state	Sampling protocol, Funding for lab work, dedicated sampling staff for seasonal sampling, data storage. Sampling locations/frequency may change as lakes conditions are characterized.	Partner with wastewater agencies, SWCD, OEPA, ODNR, NEFCO Could involve internship program, e.g., with university, agencies
Characterize nutrient sources within lakes	A, B	High, 2-3	Monitoring, tech support	Tech. support partners, consultant
Monitor chemistry, sediment, and bacteria in streams, during dry weather and during/after storms; compare with models	A, B, C,	High 1-2, periodically afterward	See goal 3	
Monitor swim areas	A, D	High 1, ongoing	Boat, sampling, analysis, staff	SWCD, wastewater MAs
Citizen science e.g., boat tours, schools	G	Low-Medium 2, ongoing	Equipment, leaders, water access	Boat tour operators, State Park, schools
Reduce Internal Phosphorus Loading				
Develop guidelines to minimize phosphorus and sediment release in lake/plant management	A, B, C	High, 1-4	Monitoring results. Some general recommendations can be developed early on based on known characteristics of lakes/measures	Partners/consultant
Special focus areas, e.g., North Res., Miller Lk, Cottage Gr. Lake	A, B,	High 1-4	Certain areas may need more intensive focus. Also in Goal 2.	Partners/consultant, lakers
Designate plant management zones that include conservation	A, B	High	See Goal 2	

<table>
<tr><td>Table 7.1 (cont'd)
Objectives and Actions
Goal 1 – Water Quality – Lakes/Shoreline

Note: These reflect ideas from various discussions. Lake partners must decide priority, details, feasibility.</td><td colspan="4">Objectives:
A. Use improved understanding of lake conditions to guide lake management decisions.
B. Reduce phosphorus release/availability
C. Minimize sediment disturbance
D. Minimize bacteria risk and nutrients from septic systems.
E. Discourage geese
F. Increase use of Best Management Practices and appropriate property and boat maintenance at lakeshore properties to reduce input of contaminants and trash
G. Increase awareness of the value of plants and lake ecology</td></tr>
<tr><td></td><td>Objectives</td><td>Priority, Time Frame (years)</td><td>What is Needed/Comments</td><td>Potential Partners/Resources</td></tr>
<tr><td>Develop harvest and removal program where feasible</td><td>A, B</td><td>High</td><td>See Goal 2</td><td></td></tr>
<tr><td>Work with partners to identify HSTS solutions</td><td>A, B, D</td><td>High</td><td>See Goal 3</td><td></td></tr>
<tr><td colspan="5">BMP Demonstration Projects</td></tr>
<tr><td>Lakescaping demonstration projects</td><td>B, F</td><td>Medium, 2, ongoing</td><td>Public site (e.g., State Park), labor, staff, materials</td><td>SWCD, volunteers</td></tr>
<tr><td colspan="5">Outreach/workshops</td></tr>
<tr><td>Geese management</td><td>B, E, F, G</td><td>Medium, 1 ongoing</td><td>Materials, staff</td><td>SWCD</td></tr>
<tr><td>Lakescaping, rain gardens, native plants</td><td>B, E, F, G</td><td>Medium, 1 ongoing</td><td>Plants, labor</td><td>SWCD</td></tr>
<tr><td>Tree, shrub planting by volunteers</td><td>B, E, F, G</td><td>Medium, 2, ongoing</td><td>Site – e.g., State Park, plants, materials, expert leaders to direct planting. Certain seasons best.</td><td>SWCD, communities, PLAC, ODNR</td></tr>
<tr><td>HSTS maintenance</td><td>B, D, F, G</td><td></td><td>Outreach materials</td><td></td></tr>
<tr><td>Lakeshore property owners' guidebook</td><td>B, C, D, E, F, G</td><td>High, 2-3</td><td>Funding; editing; tech support Coordinate with ODNR shoreline management plan</td><td>OEEF grant, could be published in sections/online partners, PLAC, SWCD</td></tr>
<tr><td>FAQs, webpages, brochures about lakeside property maintenance</td><td>A, B, C, D, E, F, G</td><td>High</td><td>Outreach materials
Coordinate with ODNR shoreline management plan</td><td>Partners, PLAC, SWCD</td></tr>
<tr><td>Encourage Clean Marinas/ Clean Boater practices</td><td>F, G</td><td>Medium, ongoing</td><td>Outreach materials</td><td>Ohio Sea Grant resources, businesses, ODNR, PLAC</td></tr>
<tr><td>Clean-ups – boat/land</td><td>F, G</td><td>Medium, ongoing</td><td>Gloves, implements, bags, trash disposal, volunteer support, leaders</td><td>Trash bandit and other volunteers, PLAC, communities,</td></tr>
</table>

Goal 2 – Aquatic Plant Management (APM)

Manage aquatic vegetation in a way that accommodates uses and priorities of lakers, communities, visitors, and managers, while protecting water quality and aquatic habitat, and minimizing the spread of aquatic invasive species.

The aquatic plants in the Portage Lakes are essential are to the health of the lakes, water quality, wildlife, and people using the lakes. The aquatic plants compete with HABs for nutrients, stabilize sediment, and provide valuable habitat for fish and other wildlife. However, the excessive aquatic plant growth can be a nuisance for boaters, anglers, residents and businesses. There are some management efforts under way, but they need to be coordinated, have adequate staff, technical support, resources, and funding.

- The ODNR Portage Lakes Parks manager is contracting limited chemical control for passage in high-traffic areas and limited dredging in high-traffic areas
- Individual property owners manage aquatic vegetation at their docks, resulting in inconsistent approaches and the potential for use of inappropriate or toxic chemicals on their own.
- ODNR Canal Lands staff conduct harvesting, without removal, in addition to their duties of flood and flow management, and are requested to harvest in Mosquito Lake as well.
- APM should consider effects on phosphorus cycling, sediment disturbance, and habitat, as well as access and nuisance reduction.
- APM should address the priorities of residents, businesses, and other lakers while protecting the ecological services that the plants provide.
- Currently, APM decisions are made in response to individual situations, rather than as part of a comprehensive management program.

APM Program/Plan

Developing an APM program is an important part of managing the lakes sustainably, addressing lakers' needs while protecting habitat and water quality. A management program should:

- Be a long-term commitment, with adequate funding, staff, and necessary resources;
- Develop and maintain a shared understanding of the importance of aquatic plants, needs and priorities of users, feasibility, impacts, and the decision-making process;
- Designate management zones and measures that protect habitat and minimize/reduce eutrophication factors, the risk of HABs, other contaminants.
- Coordinate decisions and guidelines among lake scientists, lake managers, lakers, communities, and organizations to address water quality goals and potential impacts, as well as users' needs.

An APM plan document could be developed by a consultant efficiently and quickly, but the lakes partners could develop many aspects of a program or plan phases over time.

Establish a management structure - Currently, the Portage Lakes Parks Manager and small staff of Canal Lands are carrying out some APM measures, in addition to their primary responsibilities. An APM program will involve additional tasks, including coordination, obtaining and managing funds, managing contracts, harvesting with removal, and managing projects/programs. There should be adequate funding, staff, and resources to handle this new effort. The program could evolve over time.

- Some of the tasks could be performed by outside contractors.
- Lakes partners or individual organizations may be able to assist with labor, equipment, dewatering sites, technical support, coordination, or outreach.
- Additional responsibilities require additional dedicated staff, at least part-time, rather than adding it to the responsibilities of current staff.
- Funding sources may include funds for navigation, fees for plant control, external water quality improvement grants for nutrient removal, line items in organization budgets, fundraising.

Identify types and extent of plants

An aquatic plant inventory is essential, to characterize the types, amounts, locations, and seasonal characteristics of aquatic plants. This information will help determine appropriate management measures and impacts.

Subsequent monitoring is important to determine changes:

- Over time and following treatment.
- Identify new invasive species, so they may be controlled

Community observations – before and after an inventory, community observations can help identify what is there and how it changes over time. An aquatic plant inventory can provide a detailed snapshot of plants, but the people who live with the lakes are familiar with areas of dense growth, locations, changes. Involving the community in an inventory helps raise awareness of the plants and their importance, the need for setting priorities, and potential for balancing use with management zones. Fact sheets, a web page, an aquatic plants book, and training workshops could help lakers identify certain general types of plants and certain obvious ones. A curated, interactive webpage could be set up where people submit geotagged, dated, photos and brief comments.

Identify management priorities and zones, similar to the conceptual map in chapter 5, identifying areas for access, conservation, private dock maintenance, etc. ODNR staff are using preliminary mapping of management zones as guidance to focus harvesting efforts on certain areas while allowing others to remain undisturbed as habitat. These conceptual maps could be refined after conducting a plant inventory and evaluating priorities and potential measures.

Vegetation is closely linked phosphorus cycling and fisheries. Management zones and practices should:

- Preserve vegetation where possible,
- Minimize extensive die-offs,
- Minimize sediment disturbance,
- Address and minimize negative effects of dredged areas,
- Reduce reproduction of invasive plants by fragmentation, and
- Encourage native species over invasive ones, if possible.

Vegetation in passageways should be controlled or harvested to provide access, and others, which are providing habitat or taking up nutrients, should be left alone, e.g., outside of high-traffic areas, high-quality habitat, along wetlands, in areas with fine sediment, at the outlet of streams, along the golf course, or other nutrient/sediment sources. The plant management strategy should identify appropriate control measures and minimize negative impacts. Cut plant material should be removed and disposed of/composted on land to the extent practicable as much as possible, to remove fragments and nutrients from the lakes.

Large areas with dense vegetation, e.g., North Reservoir, Miller Lake, Long Lake Feeder, or Cottage Grove Lake may, require focused analysis. Monitoring of North Reservoir indicates it is the most eutrophic of the lakes. Note: With the release of grass carp into North Reservoir in 2020, conditions may be changing in that lake. It is important to monitor conditions over time.

Identification of priorities, management zones, and techniques should involve discussions with lakers, who will be affected by the management measures. There should be a clear understanding among lake managers, partners, and lakers of the planning process and how lakes management will be affected. Management zone maps can help increase awareness of the importance of aquatic plants and the balance of protection with accommodating uses.

Management techniques – There are several techniques that should be evaluated for different areas, based on the priorities, impacts, scale of application, costs, feasibility, and the logistics of carrying them out. It is important to consider the effects on the lake ecosystem and phosphorus budget when evaluating the technique and the scale of applying it. An aquatic plant management program will likely involve a multi-prong approach. Some specific considerations include:

- *Conservation* is the preferable technique where feasible, to protect habitat and water quality, temporarily storing phosphorus and stabilizing sediment.
- *Aquatic plant management at docks* should be coordinated, done professionally under permit, and should have a funding stream to pay for the service. Currently, individuals are responsible for their own maintenance, people may try their own remedies to address “weeds.” Developing a management program for the docks will provide a shared expectation that the weeds will be managed. This should be accompanied by outreach about the management program – what will be done, what is recommended, and what is not acceptable. Centralizing the process would allow a controlled approach to managing aquatic plants, treating dock areas systematically.
- *Chemical use* is necessary in some areas. APM should minimize extensive die-offs and avoid denuding large areas. Areas treated with chemicals should be posted with cautionary signs.
- *Dredging* should be limited to areas where it is necessary for navigation and water flow, and impacts minimized.
- *Harvesting with removal of cut material* is an important technique for the lakes, allowing managers to provide passage while retaining some of the plants for phosphorus uptake and habitat. Currently, Canal Lands staff conduct harvesting both in the Portage Lakes and at Mosquito Lake, funded with watercraft fees. Due to limited staff, time, equipment, and on-land sites, they cannot remove cut material, which can create problems with nutrient release, floating mats of vegetation, and spread of invasive plants.

Harvesting should be combined with removal of the cut material, ideally for composting. This is a large undertaking, requiring dedicated funding, skilled harvester staff, equipment, trucks, and land-based sites, but it would address nuisance aquatic plants while removing phosphorus. Partners may be able to assist with some labor or sites, existing organizations could provide dedicated staff to focus on harvesting, or the service could be contracted out. Dredge material areas may be available to store vegetation (and included animals) while it dries out. A harvesting program requires developing a new focus, additional staff, and equipment but provides a consistent approach, and helps sustain uses and water quality. It is important to determine how and where this could work in the lakes.

- *Increasing Native Plants* - It may be possible to replace tangles of invasive species with native aquatic plants, which offer better habitat, more diversity, fewer die-offs of monocultures, potentially more resilience or better phosphorus management. With connected eutrophic lakes, it may be difficult to successfully manipulate the ecosystem to this extent.
- *Reducing invasive plants* – encourage clean-drain-dry practices to reduce spread elsewhere, discourage dumping of cut material back in the water. Minimize sediment disturbance and other factors that favor invasive plants.
- *Large areas with dense growth* and intense use may require a combination of approaches to preserve some plants while allowing passage. North Reservoir and Miller Lake could be focus areas for large-scale, multi-pronged approaches.
- *Guidelines for plant management* should be developed for plant management staff/consultants. This could be part of an APM plan or a separate document developed by the partners.
- *Monitoring* is very important to determine how effective methods are and their impacts.

Recommendations:

- Inventory aquatic plants periodically as recommended in other APM programs, e.g., 5-10 years.
- Develop program for community observations program, e.g., curated interactive web map.
- Monitor aquatic plants to detect changes – community/partners, consultant, internship.
- Work with lakers, partners, community members to determine APM priority areas. Charrette-style workshops involve participants in identifying priorities and solutions.
- Designate management zones and approaches, considering community priorities, logistics, and impacts to phosphorus, sediment disturbance, habitat, invasive species, and ecosystem.
- Areas with high levels of eutrophication, intense use, and/or dense aquatic vegetation, may require special focus, e.g., North Reservoir, Miller Lake, Cottage Grove Lake, Long Lake Feeder.
- Develop guidelines for aquatic plant management zones, measures.
- Establish and carry out a coordinated plant control program at docks, including a funding source and outreach to lakeshore property/dock owners.
- Develop a program for harvesting and removing cut material where feasible.
- Investigate the potential for replacing invasive with native species
- Encourage use of Clean-Drain-Dry practices.
- Outreach focusing on aquatic plants, management zones, and invasive species, including maps, brochures, Portage Lakes aquatic plants guidebook.

Table 7.2 **Objectives and Actions Managing Aquatic Plants** *Note: These reflect ideas brought up in various discussions. Lake partners must decide priority/ feasibility.*	Objectives: A. *Improve management strategies based on increased knowledge of aquatic plants in the Portage Lakes* B. *Develop and use management zones and measures that reflect the priorities of lakers, partners, and communities, while protecting water quality and habitat and reducing eutrophication.* C. *Reduce the spread of invasive species* D. *Establish an aquatic plant management program with adequate staffing and funding.* E. *Increase awareness among residents, visitors, boaters, and businesses of the ecological importance of aquatic plants and appropriate means of control.*			
	Objectives	**Priority, Time Frame (years)**	**What is Needed/Comments**	**Potential Partners/Resources**
Monitoring				
Inventory aquatic plants	A	High, 1-3; repeat every few years	Funding, contractor	
Monitor plants	A	High		
- Develop community monitoring program	A,B	High 1-3 years, ongoing	Training, interested lakers, brochures/guide to plants, curated interactive map	NEFCO, SWCD, PLAC, ODNR
- Citizen science	A	Medium 3-5 years, ongoing	Training, dedicated volunteers, equipment, boats, coordination	SWCD, PLAC. Some training efforts may be funded through grants.
- intern	A	Part of ongoing internship?	Funding, supervision for internship	Ohio EPA, ODNR, PLAC, universities, SWCD
Monitor for invasive species	A, C	Periodically		
- volunteers			Training, guidebooks, protocol, equipment, volunteers who can devote time, coordination	External funding, SWCD
- professional			Funding, contractor	
- intern			Funding, supervision Need consistent monitoring.	Regional universities, ODNR

Table 7.2 *(cont'd)* **Managing Aquatic Plants** *Note: These reflect ideas brought up in various discussions. Lake partners must decide priority/ feasibility.*	Objectives: A. *Improve management strategies based on increased knowledge of aquatic plants in the Portage Lakes* B. *Develop and use management zones and measures that reflect the priorities of lakers, partners, and communities, while protecting water quality and habitat and reducing eutrophication.* C. *Reduce the spread of invasive species* D. *Establish an aquatic plant management program with adequate staffing and funding.* E. *Increase awareness among residents, visitors, boaters, and businesses of the ecological importance of aquatic plants and appropriate means of control.*			
	Objectives	**Priority, Time Frame (years)**	**What is Needed/Comments**	**Potential Partners/Resources**
Manage Plants				
Public workshop(s)/ charettes to identify APM priorities, zones	A, B, D, E	High, 1-2		ODNR, SWCD, PLAC, NEFCO, communities
Develop and use management zones to specify treatment intensity and type - harvesting/ chemical control (e.g., habitat; residential; navigation)	A, B	High, 1-3 (can be developed in phases)		ODNR, NEFCO, lake scientists, PLAC
Determine feasibility/Establish site/method for composting harvested aquatic plants	B, C	High 1-3 years	Off-loading & dewatering/ sites, possibly barge, trucks, drivers, harvester operators/ contractor	Communities, ODNR, OEPA, SWCD Grant funding for properties, some operations– boat fees, water qual. funds
Establish APM program with adequate staff & funding	A, B, D	High 1-3	Staff, funding	ODNR/PLAC
Coordinate APM at docks	A, B, D, E	High 1-3, ongoing	Funding source (e.g., fee), outreach, managing contracts	ODNR, PLAC, SWCD, partners, contractor; fee for plant control
Develop an APM plan to guide APM measures, based on the inventory and priorities	A, B, C, D, E	Medium/high 2-4 – could replace several separate tasks	Funding, contractor	Contractor, partners, PLAC
Special focus: North Res., Long Lake Feeder; Miller Lake; Cottage Grove Lake	A, B, D	High 1-4	Inventories, contractor	Partners, communities, PLAC

Table 7.2 *(cont'd)* **Managing Aquatic Plants** *Note: These reflect ideas brought up in various discussions. Lake partners must decide priority/ feasibility.*	Objectives: A. *Improve management strategies based on increased knowledge of aquatic plants in the Portage Lakes* B. *Develop and use management zones and measures that reflect the priorities of lakers, partners, and communities, while protecting water quality and habitat and reducing eutrophication.* C. *Reduce the spread of invasive species* D. *Establish an aquatic plant management program with adequate staffing and funding.* E. *Increase awareness among residents, visitors, boaters, and businesses of the ecological importance of aquatic plants and appropriate means of control.*			
	Objectives	**Priority, Time Frame (years)**	**What is Needed/Comments**	**Potential Partners/Resources**
Conduct demo APM projects to test out different approaches	A, B, C	Medium 2-4	Funding, contractor	Contractor, partners
Invasive Species				
Evaluate the feasibility of replacing invasive species with native species	A, B, C	3-5	Funding, contractor	SWCD (fundraising), ODNR, lake scientists
Establish clean-drain-dry stations at marinas, boat ramps	C, E		Funding, control of drainage, site	ODNR, marinas, external funding
Outreach	E			
Develop a Guide to Aquatic Plants of the Portage Lakes	A, E	High, 1-3	Funding, contractor	
Develop, make available maps/ web materials/ brochures of management zones	B, E	High, 1-3	Staff/contractor time, Reproduction costs	SWCD, ODNR, NEFCO, PLAC, communities
Awareness campaigns – aquatic plant management/invasives, Clean-Drain-Dry, lakes ecology	A, B, C, D, E	High 1-3, ongoing		PLAC, ODNR, SWCD
- Dock owners/ homeowners				
- Marinas, bait shops				
- Boat ramps				
- Homeowners Associations				
- Articles, brochures,				
Ecology of the lakes forums	B, E			PLAC, ODNR Parks, F&W, MetroParks

Goal 3 – Reduce Inputs from Watershed

Improve stream function and reduce loading of sediment, pathogens, stormwater, nutrients from the watershed.

Reducing external loading involves preventing phosphorus and fine sediment from entering the lakes by using BMPs and restoring landscape elements to remove contaminants. Stream health is determined using a combination of biological indicators and stream characteristics. For lake health, it is important that stream conditions continue to be evaluated based on what they are contributing to the lakes and how the lakes respond. Reductions can be modeled based on the type of BMP or restoration measure applied, and monitoring streams should show improvements.

There is likely considerable loading coming from the watershed – land use, septic systems, and altered streams/riparian corridors. Most of the lakes are affected by one HUC-12 watershed, and the sub-watersheds within it. Long Lake is the only one affected by the Tuscarawas River, and Nimisila Reservoir, affected by its own watershed, contributes minimally to the other lakes. The characteristics of each lake should be evaluated based on the watershed and other lakes contributing to it.

- Ohio EPA has monitored the Tuscarawas, but there is little data on pollution sources within the watershed. Data is needed on bacteria contamination from septic systems in swim areas, and the constituents in streams (e.g., nutrients, sediment, bacteria, TSS). The latter is important to help understand the input of nutrients, sediment, bacteria, and other contaminants to the lakes.
- Much of the tributary riparian buffers are altered, and the streams privately owned.
- Some stream sections appear to be degraded.
- The watershed is largely developed, with imperviousness at or approaching the levels where stream degradation is likely.
- Thousands of older homes on small, unsewered lots are likely to discharge nutrients and pathogens. The "system of last resort" discharges phosphorus to the lakes. Summit DSSS is evaluating the feasibility of extending sewer service into certain areas. Wastewater management agencies, communities, and the Department of Health should continue ongoing discussions about appropriate wastewater management techniques to reduce nutrient loading.
- Swim areas, especially near areas with older homes and small lots, should be tested for bacteria.
- Boaters report that Mud Lake is silting in. Cottage Grove Creek is in a developing area, with an altered riparian buffer. Brewster Creek, flowing through a highly impervious area, has degraded channel and floodplain. Dense vegetation Cottage Grove Lake, and Miller Lake may result from inputs from the watershed. These may be good targets for evaluation, BMPs, or restoration.

Considerations Related to Best Management Practices

Function - to reduce or mitigate the effects of land use and septic systems on the natural environment:

- Increase infiltration
- Reduce or contain runoff, contaminants, or other loading
- Treat runoff

- Protect important landscapes (e.g., deep-rooted vegetation, vegetated riparian corridors, wetlands, floodplains, stream morphology)
- Restore important landscapes - Restoration of riparian buffer, stream channel, floodplain, or wetlands can reduce flooding, erosion, sedimentation, and nutrient loading. Vegetated riparian buffers can help minimize impacts from impervious landscapes.

The scale of BMPs is also important:

- Small-scale is manageable by individuals, may be scaled up to community or institutional scales
- Starting small on relatively easy projects can lead to bigger ones.
- State Park and other public sites are ideal starting points
- Larger scale may be more effective but more involved and costly

Importance of Headwaters

Many BMPs applied to the landscape are most effective when used first in the headwaters and extended along as much of the stream corridor as possible. Headwaters have less land contributing to them, and impacts are more easily addressed. Trying to fix a stream bank or floodplain further down may not be as effective, as the available land is limited, and the contribution from upstream is higher.

Location, Long-term Ownership, Stewardship, and Signage

In order for BMPs to have a long-term effect, they should be on land controlled by a single party for the long term. Individual property owners can have a great effect by planting deep-rooted native plants and installing rain gardens, but when the property changes hands, the BMP may be removed. Publicly-funded BMPs not on public lands often require an easement on the property be held by a public or non-profit conservancy organization.

BMPs in high-traffic areas are a great way to demonstrate their effectiveness and, perhaps, inspire others. It is important to have attractive signage by the BMPs, or people will not realize what they are and how the property owner is helping the watershed.

Certain land use controls protect/improve water quality by

- Protecting wetlands, buffers, stream corridors through setbacks or conservation development open space requirements
- Encouraging use of BMPs (e.g., directing roof drains to rain barrels, use of bioinfiltration)
- Reducing parking requirements in commercial/institutional developments

Partnerships - Seek partners with related interests.

- Certain agencies or organizations can offer technical support, e.g., Summit Soil and Water Conservation District, Ohio EPA, NEFCO, wastewater management agencies.
- Some wastewater management agencies have experience (and interest) in working on watershed-based water quality improvements, e.g., Summit County Department of Sanitary Sewer Services and the City of Akron.
- Community and Metro Parks and conservancies are often interested in demonstrating stewardship projects, conducting outreach, or acquiring land in high visibility, environmentally sensitive areas. The MetroParks for the three watershed counties (Summit, Stark, and Portage)

all have focused land acquisitions along stream corridors and wetlands, protecting these important landscapes, providing opportunities for passive recreation the ability to perform restoration as funding becomes available. The Cleveland Museum of Natural History owns several especially valuable wetlands in the Portage Lakes watershed. The Portage Lakes watershed is within the Muskingum Watershed Conservancy District, which provides funding for certain conservation or restoration projects.

- Organizations like Audubon, US Green Building Council, and Ohio Clean Marinas offer certifications, recognition, and in some cases, technical support for developments and private uses that incorporate "green" practices and stormwater management. Marinas, golf courses, or other businesses thus can get recognition and marketing for helping sustain the lakes.
- Interest in pollinators overlaps with stormwater management through beneficial native plants.
- Partners can include volunteer labor, e.g., tree planting, which can be very effective outreach.
- There is a great deal of overlap between certain water quality improvement projects and flood management. One may provide funding for the other. For instance, properties experiencing repeated flooding problems are sometimes acquired with Federal Emergency Management funds. Once the property is held by a public agency, e.g., a community, it can be used for water quality BMPs with additional funding. A project to provide flood storage by restoring a floodplain and stream channel has substantial water quality benefits. Water quality projects, such as stream restorations, reduce flooding.
- Recreation funding can be used for certain aspects of acquiring or improving properties.

Summary of Recommendations

- Monitor streams for inputs to the lakes.
- Monitor swim areas for bacteria near neighborhoods with small lots and septic systems.
- Demonstration projects at high visibility public sites, e.g., lakescaping, rain garden at State Park.
- Protect intact natural features that help water quality, e.g., wetlands, floodplains, buffers.
- Restore altered stream channels, floodplains, wetlands, riparian buffers.
- Review land use controls to make sure they encourage practices that reduce stormwater runoff.
- Convene discussions with Dept. of Health and wastewater management agencies to determine appropriate measures for areas with small lots and septic systems.
- Conduct outreach to build awareness and stewardship. Examples include signs at BMPs; homeowners' guides to living on the shore; workshops about lakescaping and goose control; encourage golf courses, marinas, and businesses to become certified as "green" businesses.
- Host plantings of trees or native plants with volunteers.
- Outreach with homeowners, lakers about best management practices and HSTS maintenance.
- Work with farmers to encourage the use of cover crops and other agricultural BMPs.

Table 7.3 **Objectives and Actions -** **Reduce Inputs from Watershed** *Note: These reflect ideas brought up in various discussions. Lake partners need to agree on priority/ feasibility.*	**Objectives:** A. Monitor pollutant loading – streams, septic B. Reduce nutrient and sediment loading through BMPs C. Reduce nutrient and pathogen loading from septic systems D. Improve habitat, stream function, water quality by restoring important landscapes – riparian corridors, stream channels, floodplains E. Protect intact landscapes with easements/purchase F. Increase awareness and personal stewardship through outreach, engagement			
	Objectives	**Priority, Time Frame (years)**	**What is Needed/Comments**	**Potential Partners/Resources**
Monitoring				
Monitor water quality in streams – nutrients, chlorophyll A, TSS, bacteria, etc.	A	High 1-3, ongoing	Staff, testing equipment, protocol, maybe lab analyses	SWCD, wastewater management agencies, OEPA
Monitor swim areas for bacteria	A	High 1-3 ongoing	Boat, sampler, lab analysis of cold sample	Wastewater management agencies, volunteers, communities, interns
BMPs and Restoration				
BMP demonstration projects – rain gardens, riparian plantings, bioinfil-tration, e.g., at State Park/public sites	B, F	High, 1-3, ongoing	Funding, design, materials, possibly NPS-IS documents. Include signage.	SWCD, grant funding, volunteers, public sites, e.g., parks
Identify target areas for restoration/protection	B, D, E	High, 2-4	Mapping, field work to assess areas. Restoration areas may include old dams, Cottage Gr. Creek, Brewster Cr., Wonder Lake Creek.	Communities, conservancies, SWCD. Riparian buffer maps, Summit County environmental viewer, other county GIS.
Watershed BMPs to remove nutrients, treat stormwater	B	High 1-5, ongoing	NPS-IS documents, Funding, properties	Communities, SWCD, wastewater management agencies, funding through Section 319, MWCD, stormwater. Partner with conservancies, parks Green is developing NPS-IS documents.
Develop NPS-IS documents for Brewster Cr. or other streams, coordinate with Akron/ communities	C	High, 1-3	Funding, identification of projects/critical areas	Akron, communities, SWCD

Table 7.3 *(cont'd)* **Reduce Inputs from Watershed** *Note: These reflect ideas brought up in various discussions. Lake partners need to agree on priority/ feasibility.*	**Objectives:** A. Monitor pollutant loading – streams, septic B. Reduce nutrient and sediment loading through BMPs C. Reduce nutrient and pathogen loading from septic systems D. Improve habitat, stream function, water quality by restoring important landscapes – riparian corridors, stream channels, floodplains E. Protect intact landscapes with easements/purchase F. Increase personal stewardship through outreach, engagement			
	Objectives	**Priority, Time Frame (years)**	**What is Needed/Comments**	**Potential Partners/Resources**
Protect intact important landscapes with purchase/easement	E	High, ongoing	Funding, easement/land purchase	Conservation grants, FEMA, MWCD, communities, conservancies, parks
Restore altered stream channels, floodplains, wetlands, buffers.	D	2-5, ongoing	Funding; supplies;, design; NPS-IS documents; public ownership of land; contractor; local match	Communities, conservancies, SWCD, ODNR, PLAC, Water quality/stormwater grants, FEMA, donations: land, materials, labor; volunteers.
Review land use regulations to make sure they encourage reducing impervious surfaces, protection of vegetation, wetlands, streams	B, D	Medium, 2-5	Access to regulations, understanding of regulations, time for review	Communities, volunteers with training
Wastewater Management				
Coordinate wastewater management discussions with DSSS, DOH to identify appropriate HSTS measures	C	High, 1-3		
Coordinate discussions with Summit DSSS, DOH and communities about which areas should be sewered.	C	High, 1-3		
Outreach				
Install signage at BMPs, native plants	F	High, ongoing	Design, produce, install	Communities
Community planting events, cleanups	B, D, F	Medium, ongoing		
Volunteer monitoring	A, F	High, 1-3, ongoing		
Septic system maintenance outreach	C, F	High, ongoing		

Table 7.3 *(cont'd)* **Reduce Inputs from Watershed** *Note: These reflect ideas brought up in various discussions. Lake partners need to agree on priority/ feasibility.*	**Objectives:** A. Monitor pollutant loading – streams, septic B. Reduce nutrient and sediment loading through BMPs C. Reduce nutrient and pathogen loading from septic systems D. Improve habitat, stream function, water quality by restoring important landscapes – riparian corridors, stream channels, floodplains E. Protect intact landscapes with easements/purchase F. Increase personal stewardship through outreach, engagement			
	Objectives	**Priority, Time Frame (years)**	**What is Needed/Comments**	**Potential Partners/Resources**
Workshops – BMPs, lakescaping, plantings, rain gardens, easements	B, D, E, F	High	Materials, sites	SWCD, PLAC, ODNR
Outreach to homeowners assoc. about BMPs, rain gardens, etc.	B, D, F	Medium-high, 2-4		PLAC, homeowners Assoc., SWCD
Outreach to marinas, golf course encouraging industry green practices (Ohio Clean Marinas, Audubon)	B, D, F	Medium-High 2-4		PLAC, SWCD
Work with farmers to encourage the use of cover crops, etc.	B, F	High		SWCD

Goal 4 Management Structure

Develop a long-term management structure to provide direction, coordination, and support for lake management efforts.

Management Considerations

Managing a chain of urban lakes to be sustainable multi-use resources, accommodating uses, minimizing impacts, and protecting the water quality and habitat is a complex task. The process will span many years and combine technical knowledge about the lakes system with an understanding of the uses and priorities of the lakers and potential impacts. Lakes management should be a focused, long-term effort, with adequate staff, funding, and resources, rather than a task added on to existing responsibilities.

The Portage Lakes management program should include:

- Coordinated direction and management with a long-term commitment
- Decision-making process
- Understanding and sharing of technical background
- Integration of management focus areas: lakes-based, watershed, park, uses and needs/impacts
- Certain tasks need to be done by specialists (e.g., manage flow/floods, aquatic plant inventory)
- Inventory, characterize, and monitor limnology, bacteria, plants, streams, watershed landscapes
- Develop guidance for lake management measures to allow use while minimizing impacts
- Development and implementation of an aquatic plant management program
- Involvement of lakers, communities, and managers in identifying characteristics and priorities
- Staff responsible for the program
- Funding from various sources and a mechanism to manage the funding
- Raise awareness and participation among lakers, communities, and lake managers

Portage Lakes Partners and Participants

The Portage Lakes benefit from group of partners, lake managers, and lakers, who are dedicated to taking care of the lakes. Currently, many organizations and individuals are involved in individual efforts related to lake management. for a long-term, multi-disciplinary management effort, there needs to be a single, focused approach that brings the separate efforts together.

Most of these organizations described below have participated in the Portage Lakes TAC or in related discussions, and are likely to continue to work together in partnership to manage the lakes. This will allow input from and coordination with a broad set of backgrounds, interests, and capabilities. Early efforts should include identifying the partnership roles and decision-making process.

ODNR Parks and Watercraft

Portage Lakes Park The focus of the small staff at Wingfoot and Portage Lake Parks is primarily on the visitor experience, including:

- Maintaining and upgrading park facilities and coordinating contracts;
- Water-related facilities - beach, buoys, park docks;
- Shoreline activities, including permitting private docks.

- Monitoring the swim beach for bacteria and, as necessary, HABs.
- Naturalist activities at the park and elsewhere
- Currently issuing contracts for limited aquatic plant control in high travel areas
- Coordinating limited dredging in the lakes.
- The budget is zero-based and does not carry over.
- Navigation-related efforts are paid with ODNR boat registration and US Coast Guard funds

O&E Canal Lands – The small staff is primarily responsible for maintaining water level, flood control, and maintaining flow to the Lake Erie basin. They are also harvest aquatic plants in the Portage Lakes and Mosquito Lake, but they lack adequate staff, resources, and time to remove cut material from the lakes.

Division of Wildlife, Dam Safety - These divisions of ODNR have specialized responsibilities:

- Division of Wildlife stock and monitor fish and some limnological characteristics in the lakes.
- The Dam Safety division is responsible for dam inspection and repair of state-owned dams.

PLAC, a 501(c) (3) nonprofit organization consists of lakers and representatives from the three lakes communities. PLAC is the primary public point of contact for the lakes and meets monthly. PLAC also:

- Coordinate with ODNR and other organizations
- Conduct outreach and maintain an informative website,
- coordinate fundraising and other activities on the lakes.
- PLAC members have coordinated projects, such as playgrounds in the State Park.

Ohio EPA enforces water quality requirements, including discharges to the water and wetland alteration, and provide technical and financial support for monitoring, restoration and outreach.

SWCDs focus on stormwater management, erosion control, and natural resource protection.

- Implement stormwater management requirements for MS4 communities
- Their extensive range of outreach and technical support includes:
  - Erosion control
  - Urban and Agricultural Stormwater BMPs
  - Riparian buffers, native plants, water quality
- Summit SWCD is creating an Upper Tuscarawas watershed coordinator position. Tasks already identified include:
  - Stream and limnological monitoring,
  - Outreach related to goose control, cover crops, and lakescaping
- SWCDs and watershed coordinators frequently pursue grants for water quality projects

NEFCO - coordinates regional wastewater management planning through the 208-water quality plan, maintaining wastewater treatment prescription mapping, designations, and amendments. NEFCO is actively involved in watershed management and assists communities and partners in the four-county region with related technical support.

Wastewater Management - Health Districts/Health Departments issue permits for HSTS and monitor swim areas outside the state parks. Wastewater Management Agencies are responsible for sewer service. Some partner with other organizations for restoration activities or assistance with lab analyses.

Parks - Metro Parks and other parks acquire and manage land for conservation and recreation.

- Summit Metro Parks manages Nimisila Reservoir, and Confluence, and Firestone Metro Parks.
- Parks often acquire land by streams and lakes for conservation, or passive recreation, e.g., trails.
- Parks staff conduct outreach and engagement activities and grant-writing.

Communities - Many community efforts relate to lake management, including:

- Land use controls,
- Stormwater management,
- Land acquisition,
- "Green" initiatives
- Water quality/restoration projects
- Participation in/ financial support of regional efforts,
- Grant-writing and
- Outreach.

Volunteers - Volunteers are involved in efforts including fundraising, Secchi disk monitoring, outreach, and coordinating projects. They bring a wide range of interests and capabilities. Volunteer efforts should be tailored to the skills and background needed, interest, and level of commitment.

Lakers – Residents, visitors, boaters, anglers, businesses directly interact with the lakes. They experience aquatic plants and will be carrying out many of the lake management recommendations. Property owners manage aquatic plants by their docks on their own. Many contracts with AquaDoc, but some use their own chemicals, without permits, which may be hazardous to swimmers and wildlife.

Managing the Portage Lakes – Putting the Pieces Together

The Portage Lakes TAC/partners can contribute to many aspects of lakes management, but sustaining the lakes requires a long-term focus on lakes management and staff, resources, and responsibilities dedicated to that purpose which includes:

- Adequate funding, resources, equipment, staff
- Decision making based on balancing use with protection of the lakes system
- Technical expertise
- Participation of lakers
- Shared understanding of lakes processes and priorities
- Coordination among interests and expertise

Figure 7.1 shows many of the organizations currently and potentially involved in lakes-related activities and their roles. The colored boxes on the outside list some current roles and activities that partners are involved in on the lakes or have capabilities to perform. The white box in the center lists some important tasks and roles required for a Portage Lakes management program, and likely participants. The notations of "staff" could be responsibilities of a full or part-time lakes management staff position.

Partner involvement has provided a great contribution to developing the plan, shown in the colored boxes. As shown in the white box, partners will continue to be valuable for technical expertise, technical support, and sharing of resources, tasks, opportunities, and ideas. ODNR, PLAC, and SWCD play central roles in lakes management and will continue doing so.

Sustaining the lakes will involve increased commitment, staff, and resources. Some tasks can be done by consultants or with partner participation/contributions, but lake management requires consistent coordination, direction, and effort, which cannot be supported with current levels of staff and budget.

Figure 7.1 Portage Lakes Management Roles and Participants – Current and Potential

Tech Support/Background
- SWCD
- Ohio EPA
- NEFCO
- Wastewater Mgmt.
- Dept of Health
- Lake Scientists
- Volunteers
- Contractors

Technical/Specialized
- ODNR Portage Lakes Pk
- ODNR Canal Lands
- ODNR Dams/Fish & Wildlife
- OEPA
- NEFCO
- Wastewater/Health
- Communities
- Lake Scientists
- Contractors

Monitor
- ODNR Portage Lakes Park
- ODNR Fish & Wildlife
- SWCD
- OEPA
- NEFCO
- Metro Parks (monitor parks)
- Volunteers/Lakers
- Wastewater Management
- Health
- Contractors

Aquatic Plant Management
- ODNR – coordinate
- Contractor
- Property Owners/Aqua Doc

Coordinate
- *ODNR Portage Lakes Park*
- *PLAC*
- *SWCD*
- *NEFCO*
- *Communities*
- *Volunteers/Lakers*

Portage Lakes Management Roles & Participants – Future/Potential

*Decision-making……………………………..**staff??** Partners??*
*Coordinate……………………………………Partners and **?? staff??***
*Tech support……………………………….Partners, contractors, **staff??***
*Technical/Specialized……………………Partners, contractors, **staff??***
*Monitor limnology, streams…………SWCD and ?? partners?? **Staff??***
*Phosphorus analysis, guidelines......Partners, contractor, **Staff??***
Aquatic plant inventory………………..Contractor
*APM – planning, implementation….Partners, lakers, contractor? **Staff?***
*APM – implementation…………………Partners, lakers, contractor? **Staff?***
*Harvest & remove……………………….Contractor, partners?? **Staff?***
*Coord. Plant Control at Docks, fee...Partners?? **Staff?***
Budget item………………………………….
*Obtain funds (grant-writing)…………SWCD, partners, **staff??***
*Manage funds……………………………..Partners? **Staff?***
*Outreach……………………………………..Partners, **staff??***
*BMPs…………………………………………..Partners, lakers, contractor**, Staff?***

Outreach
- *ODNR Parks*
- *ODNR Division of Wildlife*
- *SWCD*
- *NEFCO*
- *Communities*
- *Metro Parks*
- *Volunteers/Lakers*
- *Health District*
- *Wastewater Management*

Manage Park/Lakes Property
- ODNR Portage Lakes Park
- ODNR Canal lands
- ODNR dams
- ODNR Division of Wildlife
- Communities
- Metro Parks
- Property owners

Manage Funds
- ODNR Parks & Watercraft
- ODNR Fish & Wildlife, dams
- PLAC
- SWCD
- NEFCO
- Communities, Metro Parks
- Health Dept., Wastewater Management

Obtain Funds/Fundraising
- ODNR Parks & Watercraft
- PLAC
- SWCD
- OEPA
- NEFCO
- Communities
- Metro Parks
- Volunteers/lakers

BMPs/Restoration
- Communities, parks
- SWCD
- ODNR
- Property owners
- Businesses, Marinas
- Wastewater Mgmt.
- Volunteers
- Other organizations

A Portage Lakes management program will bring together various elements and participants.

- *Decision-making mechanism* for consistent long-term direction, e.g., partnership vote or staff.
- *"Staff"* –Dedicated to lakes management (full- or part-time) to work on tasks, coordinate, and provide consistent, dedicated, long-term focus on lakes management efforts, could be supplemented by contractors, partners or shared resources, or possibly volunteers.
- *Tech support, technical/specialized* – Sharing technical background on lakes ecology is crucial for management. Some tasks must be completed by technical specialists – partners or consultants.
- *Summit SWCD Watershed Coordinator/Monitoring* - Summit SWCD is expanding its lakes-management roles with a watershed coordinator position, which will likely involve coordination, grant-writing, and outreach. SWCD will monitor stream/lake conditions but may also need help.
- *Aquatic plant inventory* should be done early in the management process by a consultant.
- *APM planning* – Priority areas and recommendations could be developed by the partners, lakers, and staff, or with a consultant. Participation of stakeholders (lakers) is important.
- *APM implementation* will be conducted by field staff, either contractor(s) or dedicated lakes management staff. *Harvest and removal* of cut material is more involved than chemical use but provides greater benefit. It may require additional staff, equipment, land, resources.
- *Coordinating plant control at docks* will likely involve managing contracts and fee collection.
- *Consistent funding needed* – External funding and fees (e.g., for plant control at docks) can supplement budget items. However, supporting a staff position and other expenses will require long-term budget commitments, indicated by the blank "budget item."
- *Obtaining and managing funds.* There are various sources of funding that can be used for specific efforts, supplementing budget items, including grants for specific projects or efforts, shared resources, fees, e.g., for plant control/stormwater, fundraising. As part of a management structure, an entity or entities need to manage the funds, with approval from staff or partners.
- *BMPs and Restoration* - As noted in Goal 3, BMPs and restoration can occur at various scales, from plantings on individual lakeshore or riparian properties to engineered bio-infiltration or other large-scale stormwater management measures. There are many potential participants, and these are important areas for outreach, identifying opportunities, and funding. Some restoration projects offer volunteer opportunities and resource sharing. Signs raise awareness.
- *Outreach.* As noted in Goal 5, there is a great need and many opportunities to raise awareness, involvement, and stewardship. Outreach combining various disciplines reaches more people.
- *Shared interests.* Identifying overlapping interests, even if seemingly unrelated, can increase the potential for sharing resources and outreach, and broaden potential involvement.

Table 7.4 **Management Structure** *Note: These reflect ideas brought up in various discussions. Lake partners need to agree on priority/ feasibility.*	**Objectives:** *A. Manage aquatic vegetation to balance navigation, aesthetics, habitat, water quality, waterways maintenance* *B. Coordinate larger scale/long-term efforts, interagency work, outreach, and volunteers* *C. Improve management strategies based on increased knowledge of aquatic plants, water quality, limnological conditions in the Portage Lakes* D. *Obtain funding*			
	Objectives	**Priority, Time Frame (yr.)**	**What is Needed/Comments**	**Potential Partners/Resources**
Establish a partnership that meets periodically; shares resources and efforts; and provides technical support, long-term guidance, and an overall perspective of lakes activities.	A, B, C,	High; 1	Partnership, decision-making structure, funding management. One suggestion was to have PLAC convene partner meetings periodically	PLAC, Ohio EPA, Summit Metro Parks, ODNR, community representatives, etc.
Hire staff, e.g., to coordinate lakes management, e.g., lakes/ watershed coordinator	A, B, C, D	High, 1-2	Funding for position or host agency	SWCD, PLAC
Develop management structure, including staff, decision-making, funding	B, C, D	High, 1-2		
Coordinate management program, monitoring described in Goals 1-4.	A, B, C, D,	High, ongoing		
Coordinate aquatic plant control near docks	A	High, 1-3, ongoing	Coordinate contracts Outreach	PLAC, ODNR, SWCD, partners, contractor(s); plant control fee

Goal 5 Increasing Awareness and Stewardship

Increase understanding of lake ecology and the value of plants, and stewardship by lake/watershed residents, visitors, businesses

Throughout development of this plan, discussions have highlighted the need for outreach, education, and increased awareness about the lakes system and potential impacts. There are tens to hundreds of thousands of lakers, community members, and visitors, and dozens of communities, agencies/departments, and organizations that interact with the lakes. However, few people understand how the lakes work and how people and the lakes affect each other.

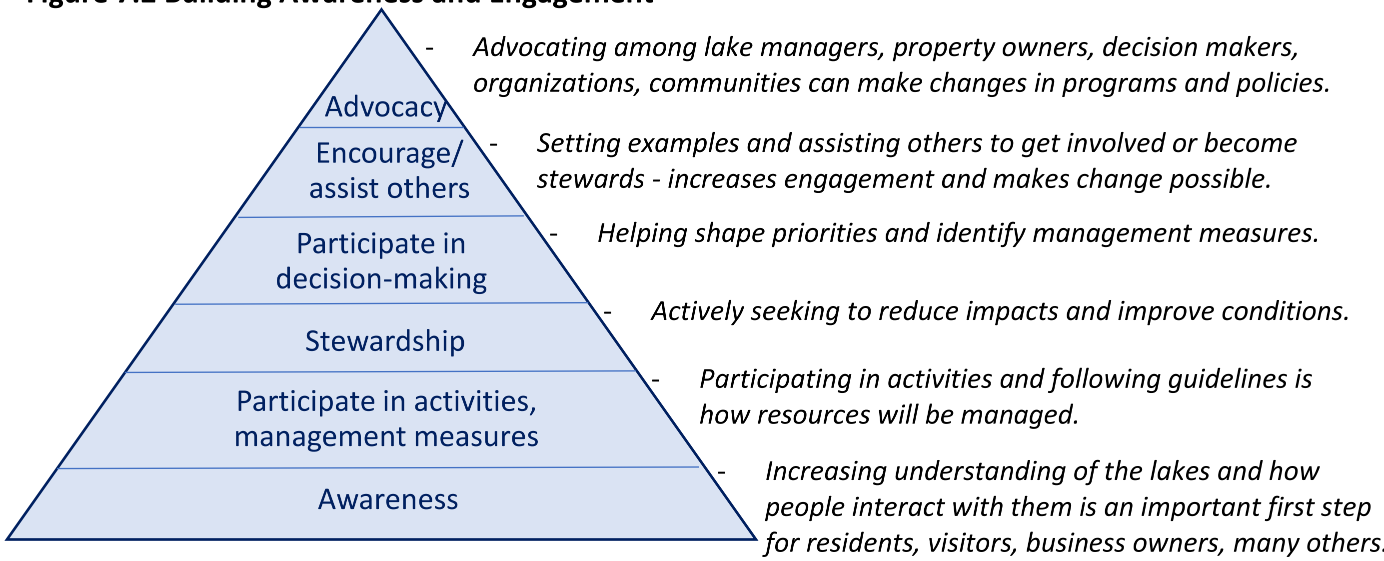
- Property owners and renters are direct contact with the lakes every day. Practices like best management practices (BMPs), lakescaping, maintaining septic systems, discouraging geese, controlling runoff, and minimizing the use of harmful chemicals, can help take care of properties and the water at the same time.
- Hundreds of thousands of boaters and other visitors can have a large cumulative impact. Promoting an awareness of the fragile environment and how to minimize impacts can help increase appreciation and protection of the lakes.
- Lakers live, work, and recreate near or on the lakes and are familiar with the aquatic plants. Lakers can contribute to surveys of aquatic plants just through their observations and, ideally, geotagged photos.
- The lakers are the people who will be directly affected by APM or other lakes management decisions, and who will be carrying out many of the recommendations. Lakers should be not only educated about aquatic plants and lake ecology, but should be involved in setting APM priorities, identifying management zones and measures.

Increasing Awareness and Involvement

An important part of living with and visiting a natural system is understanding and minimizing potential impacts, protecting the integrity of the resource. Building awareness is an important first step but does not create change. Managing lakes involves many levels of engagement, including: learning about the lakes, choosing areas to protect or maintain for use, committing to carrying out a management program, stewardship to minimize impacts, and advocating for change, as shown in Figure 7.2. Outreach initiatives need to focus on building involvement, engagement in taking of the lakes at various levels.

Figure 7.2 shows how different types of outreach involve different levels of awareness and engagement, although the individual levels may differ slightly. Raising awareness reaches the most people directly, and the efforts higher up in the pyramid result in change. Increasing involvement at any level improves active management of the lakes. Ideally, many lakers would be involved in carrying out programs, setting priorities, stewardship. The lists below offer some suggestions for increasing awareness and engagement.

Figure 7.2 Building Awareness and Engagement



Building Awareness

- Signage at BMPs, conservation areas
- Homeowners' guides to living on the lake
- Tours (boat/paddling tours, BMP, purple martin)
- Posters/brochures at boat launch ramps, marinas
- Lakes ecology book
- Trivia nights
- Workshops and forums (e.g., lakescaping)

Participation, stewardship

- Community surveys of aquatic plants
- Lakescaping/goose management demonstrations (especially with volunteers)
- Maintain septic systems
- Follow guidelines for conservation areas, management practices
- Lake events
- Clean-ups
- Planting trees, native plants along streams
- Photo competitions
- Composting
- Rain gardens, rain barrels
- Science Fair

Decision-making

- Forums – charrette-style for identifying problem areas, priorities, management measures
- Discussions with communities/MAs about wastewater treatment

Encourage/Assist Others, Leading by Example

- Become part of tour of BMPs/lakescaping
- Speak/reach out to civic groups/homeowners' associations
- Host or organize a clean-up/event
- Gather volunteers for native plant installations at State Park
- Adopt-a-spot for plantings, cleaning litter, monitor aquatic plants
- Share information about lakes, watershed, BMPs, native plants, with residents, visitors, others
- Establish a lakes arts project with schools, library, parks, communities

Advocacy

- Campaigns for lake management fees for aquatic plant control
- Contact decision-makers about need for APM program, harvesting with removal, etc.
- Work with communities, organizations to establish a lakes-centered program or visitors center
- Advocate for clean marinas projects

Working with Volunteers

The Portage Lakes experience demonstrates the range of experience with volunteers. PLAC is a volunteer group. Its members have a wide range of expertise, and some are very interested and involved. PLAC has coordinated major events such as fundraising events, XX. PLAC volunteers have initiated projects with ODNR, such as playgrounds. Volunteers lead school tours for hundreds of students at the purple martin sites. Some PLAC members take Secchi disk readings on a regular basis. PLAC volunteers have organized lake-related events at local restaurants.

On the other hand, volunteers may not have the background, sustained interest or focus needed for reliable data source data collection. A recent Secchi disk training workshop did not result in consistent data collection or participation. Volunteer efforts may wane after the volunteers leave the area or become too busy.

The use of volunteers is extremely valuable, not just for the labor and varied expertise they bring to a task, but also for the important task of raising awareness and participation. Tasks for volunteers should be assigned based on the level of commitment the volunteers are willing and able to provide, the amount of technical background and supervision needed. Plantings and assisting with rain gardens should be done with skilled supervision to make sure the plants are installed correctly. Make sure there is a commitment by staff or volunteers to do necessary follow-up work e.g., weeding, watering plants.

Working with Partners and Existing Framework

Build Collaboration, Pool Resources, Shared Interests and Opportunities

Raising awareness among so many people, including a transient audience, is a large task. Fortunately, many elements are in place, the effort can be done one step at a time, and there are great opportunities for partnerships. Building a collaborative network will allow organizations to coordinate efforts and needs, share resources, and reach larger audiences. Partnerships can help by:

- Listing events and volunteer opportunities, sharing and posting information, media, speakers;
- Maintaining and sharing mailing lists and databases;
- Coordinating events; and
- Sharing materials, supplies, equipment, expertise, speakers.
- Volunteers can help provide local match and involvement for grants, reduce project labor costs; and provide expertise, capabilities, or contacts that organizations may not have.
- Various organizations can take the lead on projects of mutual interest, with mutual assistance.

Partners should develop and maintain a contact list of interested groups and individuals, including interests, materials, expertise, capabilities, and needs for collaboration. Potential partnership opportunities include:

- *PLAC* already provides a forum for education and outreach and notification of events. PLAC also has an eager group of volunteers with a wide range of skills and interests, including litter pick-up, boating, monitoring, publicity, writing, photography, conservation, wildlife, the science of the lakes and water quality. PLAC members have expressed an interest in helping, provided there is an understanding of what they are trying to achieve and why.

- *Summit Soil and Water Conservation District (SWCD)* has a strong public education component in support of their work with property owners and communities on stormwater and drainage management, best management practices, erosion control, water quality, habitats, lakescaping, native species. SWCD can provide technical expertise, speakers, workshops (rain gardens, rain barrels, stream habitat and macroinvertebrates, etc.), rain garden supplies, and stacks of helpful, interesting literature that partners can pass out. SWCD also loans out interactive demonstration equipment and pre-made displays. As a long-time partner in the Portage Lakes process, they have offered assistance with databases and educational materials. A related group, Northeast Ohio Public Involvement Public Education (NEOPIPE), a regional stormwater education collaboration among SWCDs, has developed downloadable graphics.
- Ohio EPA offers technical support, monitoring, literature, funding for certain projects, and a long-time connection with the Portage Lakes management partnership.
- The lands of the State Park, Metro Parks, other parks, schools, and public/institutional lands are well-suited for demonstration projects, events and workshops, and informational signage.
- Communities, organizations, and agencies involved in stormwater management, wastewater management, and stream restoration may have opportunities and need for public engagement.
- The lakes communities and schools already have ongoing conservation/sustainability efforts.
- Enlisting businesses and civic groups (e.g., Lions Club, churches, Craftsmen Park) can provide mutual benefit, additional outreach/involvement opportunities, and additional resources.

Start Small, Build on What is Already Going On

Portage Lakes outreach efforts can start with smaller tasks and build on existing opportunities, e.g., setting up a table, display, kiosks, or activities at other events or locations. Later, partners can explore more ambitious efforts, such as a nature center or a Portage Lakes festival.

- Go where the people are – Setting up a display table/activity at events can raise the profile of the lakes and lake management. Build a collection of display materials and establish a group of event volunteers to have an ongoing presence at existing events throughout the area. Examples of existing meeting or information sites include: PLAC meetings, PLAC website, libraries, newspaper columns, fishing reports, agency websites, businesses (restaurants, marinas), libraries, boat launch sites, tours (boat tours or purple martin tours), reaching out to homeowners' associations, civic groups, campers, etc.
- Use public sites and other high-visibility areas for demonstration projects like BMPs, lakescaping, and landscaping with native plants, green infrastructure. Other installations could include lakes-related public art or benches. Informational signs are important.
- Install informational signs at existing BMPs to raise awareness (and give credit where it is due). For example, the Coventry High School uses innovative stormwater treatment measures, which provide water quality benefit, but could better help raise awareness if they had signs.

- Highlight existing BMPs through actual or on-line tours or photo galleries

Seek Projects with Multiple, Mutual Benefits

- Volunteer monitoring programs provide important data and engage people directly in the lakes.
- Tree-plantings, lakescaping, planting native plants, rain barrel and rain garden workshops help protect water quality and are rewarding ways to actively involve community members.
- On-line outreach, e.g., virtual boat tours, can raise awareness widely and also draw attention to the lakes as a recreational resource.
- Recognition of businesses and organizations using good stewardship can be good publicity for them. "Passport" programs offering a discount at local businesses for good practices serves as advertising for the businesses.

Funding Possibilities

- PLAC does some fundraising each year, and could choose to fund certain activities or could use funds or volunteer labor to provide local partnership match for larger grants.
- Funding is available for environmental education through the Ohio Environmental Education Fund, which seeks grant proposals twice per year for small projects (up to $5,000) or larger efforts ($50,000). *Note: OEEF funding on hold during 2020 due to budget reductions.*
- Some grants for larger projects that might be undertaken by other agencies, such as stream restoration or stormwater management, might require public involvement/outreach or local match, which can often be volunteer time. These may provide opportunities to get some good outreach projects done, signage, events, tree-planting, displays, etc.
- Local businesses may be willing to sponsor or donate to projects that improve their ties to the lakes, e.g., placemats, videos, eco-tourism maps, reusable bags, clean-ups, events, displays.

Topics and Ideas

Priority Topics and Audiences

Discussions with focus groups, PLAC members, partners, and others identified important topics for raising awareness and engagement, generally focusing on lake ecology, potential impacts, and minimizing impacts. These important topics are examples of the "why" of outreach, including:

- Lake ecology and water quality
- Property owner/renter FAQs, and appropriate property management (e.g., compost waste, reduce runoff, nutrients, bacteria and other inputs to the lakes, role of ODNR)
- Increase use of BMPs, native vegetation, lakescaping, tree plantings, restoring important landscapes (watershed, lakeshore)
- Navigating the agencies (for property owners, renters)
- Aquatic plants -general ecology, importance, learning to live with them, management program
- Helping set priorities for APM
- Property owner/renter - safe control of aquatic plants, use of chemicals
- Wastewater: Septic system problems and maintenance, tying into sewer service
- Reduce geese

- Reduce trash around the lakes and entering the lakes
- Invasive plants

Target audiences:

- Lakes homeowners/property owners, renters
- Boaters, anglers
- Visitors
- Businesses
- Watershed residents, businesses, communities

Ideas for Outreach, Education, Engagement

Table 7.5 lists many ideas that have arisen in discussions during development of this plan, along with comments about resources needed and potential partners. The approaches vary widely in message, targeted group, media, need for resources. Most can be adapted to on-line presentation, which would take advantage of existing websites (PLAC or others) and increase exposure of the lakes as a resource and destination. Partners should choose a message and audience to focus on and medium or approach that seems appealing, collaborating with others to share resources and audiences. When new materials are developed (e.g., handouts, activities, video tours) they should be made available to others and other media (e.g., putting fact sheets and videos on-line). These are representative ideas, there is plenty of room for other ideas help raise awareness of the lakes system, impacts, and best practices.

Note: Table 7.5 does not reference a watershed coordinator, but If one were hired to focus on the Portage Lakes, even part-time, some of their responsibilities would likely be coordinating priority initiatives, grant-writing, outreach. Summit SWCD has funding from ODNR for a watershed coordinator for areas within Summit County, who is currently focusing on supporting NPS-IS efforts in multiple watersheds, conducting QHEI assessments. There is not currently a watershed coordinator specifically for the Portage Lakes.

Virtual/Remote Presence and Activities

This plan is being written during a period of COVID-19 quarantine, remote meetings and events, at-home activities. The activities suggested can and should be adapted to new ways of conducting events, including maintaining social distance and relying on internet-based and other remotely accessible communication and events. The new stronger reliance on on-line activities can and should be applied to many of the actions listed in Table 7.6 and other opportunities, depending on the creativity of the organizers. Creating online materials and events is also a good way to advertise the lakes as a recreational and natural resource and prepare visitors for the special opportunities and expectations of spending time at the lakes.

Table 7.5 **Objectives and Ideas Outreach/Education/ Engagement** *Note: These reflect ideas from various discussions. Lake partners must decide priority/ feasibility.*	Objectives: 1 Increase understanding of the lakes, how to minimize impacts, live with lakes 2 Increase engagement (active participation) and/or ecotourism 3 increase use of BMPs, property management, septic system management 4 Monitor lake or plants 5 Reduce spread of invasive species 6 Manage aquatic plants effectively and safely for water quality, swimmers, wildlife 7 Water quality, litter removal, watershed management, discourage geese		V/R - Virtual/remote event/series or resource possible
	Objectives; target audience	**What is Needed/Comments**	**Potential Partners/ Resources**
Prepare for Additional Outreach			
Build and maintain a network of volunteers, speakers, and partner organizations	1, 2, 3, 4, 5, 6, 7 residents, visitors, businesses, schools, agencies	Centralized, coordinated contact lists of interests, capabilities, availability, willingness to volunteer, resources, expertise, needs for volunteers, materials, speakers, funding, etc.	PLAC, Summit SWCD, wastewater treatment operators, communities, parks
Build a collection of display materials, equipment	1, 2, 3, 4, 5, 6, 7 residents, visitors, schools	Volunteers, handouts, brochures, displays (photos, maps), display board, Table, banner? Canopy? There are many handouts available from SWCD, other partners, online materials. SWCD has equipment like enviroscape to lend.	PLAC Summit SWCD, ODNR, communities, local businesses, NEFCO (maps and materials developed for Portage Lakes or watershed outreach.)
Printed, Viewable, or On-line Materials			
Virtual tours, activities, reference materials, see below specific activities.	1, 2, 3, 6, 7 Target: residents, visitors, interested viewers, students, businesses, etc.	Coordinated labor to develop and film tours of lakes, BMPs, activities, etc. Labor and/or commercial production for video.	PLAC, Summit SWCD, boaters, volunteers, students, OEEF - V/R
Lake residents'/property owners' handbook	Obj. 1, 2, 3, 7; Target: property owners, renters. Includes navigating agencies, docks, ODNR lake management, septic systems, chemicals, lakescaping, aquatic plants, native plants, property maintenance, reducing geese and inputs to lakes	Coordinated labor to compile or outside contractor, printing costs Could be put on-line	PLAC, Ohio EPA, Summit SWCD Resources: PLAC, OEEF - V/R

Table 7.5 *(cont'd)* **Outreach/Education/ Engagement Ideas**	Objectives: 1 Increase understanding of the lakes, how to minimize impacts, live with lakes 2 Increase engagement (active participation) and/or ecotourism 3 increase use of BMPs, property management, septic system management 4 Monitor lake or plants 5 Reduce spread of invasive species 6 Manage aquatic plants effectively and safely for water quality, swimmers, wildlife 7 Water quality, litter removal, watershed management, discourage geese		V/R - Virtual/remote event/series or resource possible
	Objectives; target audience	**What is Needed/Comments**	**Potential Partners/Resources**
Printed, Viewable, or On-line Materials, *cont'd*			
Aquatic plant identification book and lakes ecology	Obj. 1, 2, 5, 6, 7; Target: everyone	Outside contractor with expertise Good photos	PLAC, Ohio EPA, OEEF V/R
Eco-tourism informative maps – could include plant management zones	Obj. 1, 2, 4 Target: visitors, everyone	Coordinated labor to compile; graphics and printing costs, or outside contractor Could be put on-line, could use QR codes	PLAC, marinas, boat clubs, stores, Craftsmen Park, libraries V/R
Web/Facebook/newspaper articles/FAQs/photo galleries/ Kids' activities	Obj: 1, 2, 3, 4, 5, 6, 7 Any topic related to lake ecology, aquatic plants, living with the lakes, problem-solving, Best Management Practices, septic systems, etc. Increase engagement, ecotourism, understanding of lake ecosystem, how to minimize impacts; Target: residents, visitors, everyone	Articles by knowledgeable partners Dedication and medium to create an ongoing series (e.g., PLAC web page, local newspaper, agency newsletters)	Ohio EPA, Summit SWCD, ODNR, volunteers, other agencies, schools V/R
Lakes tour guide –materials (stops, text) highlighting lakes ecology for tour boats or boaters	Obj. 1, 2 Target: residents and visitors	Coordinated, dedicated labor, with some technical expertise to compile, or outside contractor. Could be put on-line	PLAC, residents, volunteers, tour boat operators V/R
PL video (marinas, boat tours)	Obj. 1 Target: visitors, boaters	Professional production, could be put on-line	V/R

Table 7.5 *(cont'd)* **Outreach/Education/ Engagement Ideas** *Note: These reflect ideas brought up in various discussions. Lake partners must decide priority/ feasibility.*	Objectives: 1 Increase understanding of the lakes, how to minimize impacts, live with lakes 2 Increase engagement (active participation) and/or ecotourism 3 increase use of BMPs, property management, septic system management 4 Monitor lake or plants 5 Reduce spread of invasive species 6 Manage aquatic plants effectively and safely for water quality, swimmers, wildlife 7 Water quality, litter removal, watershed management, discourage geese		V/R - Virtual/remote event/series or resource possible
	Objectives; target audience	**What is Needed/Comments**	**Potential Partners/Resources**
Lake based placemats with facts, activities, highlights, could have QR code	Obj. 1, 2, 7 Visitors, restaurant patrons	Coordinated labor to compile lake facts/stories/photos and design the placemats; funding to print. Could be online.	PLAC, volunteers, restaurants. V/R – could be available as .pdfs
Handbooks/brochures for boaters and visitors at marinas, or ODNR kiosks – aquatic plant zones, lake ecology, stewardship.	Obj. 1, 2, 5, 6, 7 Target: visitors, everyone primarily boaters and anglers	Coordinated labor to compile, or outside contractor, local photos Could be on-line Could have QR code.	PLAC, ODNR, Marinas, Ohio EPA, OEEF V/R
Engagement/outreach/Events On-site, Virtual/Remote/On-line			
Community survey aquatic plants	Obj. 1, 2, 4, 5, 6 Target residents, frequent visitors, businesses.	Request for geotagged photos, observations of aquatic plants. Could use interactive map for input.	PLAC, residents, boaters, marinas, other visitors, NEFCO, on-line map
Lakes re-usable bags	Obj. 1 Target visitors, residents. Can be used as to thank volunteers.	Coordinated labor to compile, design. Printing costs.	PLAC, local businesses
Neighborhood ambassadors/ speaker series, BMP/ lakescaping/rain garden/rain barrel/native plant workshops	Obj. 1, 3, 6, 7 Target: residents	Dedicated and coordinated volunteers with outreach materials, contact info for questions Materials, facilitator, assembly, site for BMP workshops. Could be on-line via internet.	Homeowners Associations, PLAC, SWCD; V/R
Lakes-based events e.g., at restaurants, library, lakes, etc.	Obj. 1, 2, 3, 5, 6 visitors and residents	Venue, knowledgeable volunteers to curate trivia questions, lead discussions, activities, outside or agency speakers, photographers, etc. Could be virtual with internet access.	SWCD, Ohio EPA, other speakers, local restaurants, library, schools. V/R

Table 7.5 *(cont'd)* **Outreach/Education/ Engagement Ideas** *Note: These reflect ideas brought up in various discussions. Lake partners must decide priority/ feasibility.*	Objectives: 1 Increase understanding of the lakes, how to minimize impacts, live with lakes 2 Increase engagement (active participation) and/or ecotourism 3 increase use of BMPs, property management, septic system management 4 Monitor lake or plants 5 Reduce spread of invasive species 6 Manage aquatic plants effectively and safely for water quality, swimmers, wildlife 7 Water quality, litter removal, watershed management, discourage geese		V/R - Virtual/remote event/series or resource possible
	Objectives; target audience	**What is Needed/Comments**	**Potential Partners/Resources**
Engagement/outreach/Events On-site, Virtual/Remote/On-line (cont'd)			
Public art projects, photo contests, and displays involving the community (children, HS students, adults) ranging from art displays to permanent art.	Obj. 1, 2, 7. These could be installed at/in local businesses, adding to eco-tourism and awareness. Target – residents and visitors of all ages, schools.	Coordinator and venue(s)for art display. Possibly external funding if it is permanent art. E.g., Some watershed groups fund installations along a stream course. These become part of eco-tourism trails. Could be on-line event or become part of on-line tour. (e.g., students submit drawings)	Local schools, library, PLAC, parks, businesses, Summit Metro Parks, ODNR, Summit SWCD, OEEF, sponsors, paid "bricks." Some foundations fund public art installations. V/R
Engage with schools, summer camps, Craftsmen camp– monitoring, tours, eco-projects, visits, WET curricula, teacher education workshops, nature info/activities.	Obj. 1, 2, ?4, 7. Target – children of the lakes (residents and visitors), teachers, camp visitors	Volunteers with programs or activities coordination with groups, possibly boats or parking for volunteers or participants. Materials/supplies. Could be online with internet access and materials available.	Volunteers, Summit SWCD, Summit Metro Parks, PLAC, ODNR, Craftsmen Camp - V/R
Lake-based science fairs – could be displayed publicly, e.g., library or science fair night at school.	Obj. 1, 2, 7. Target – students, parents, visitors. Could be community/watershed wide.	Coordination with schools and other venues, science fair judges, etc. Could have virtual showing.	PLAC, schools, ODNR, libraries, local businesses - V/R
Nature-cam	Obj. 1, 2, 4 Target: residents, visitors, students, boaters, distant viewers, fishermen, marinas, etc.	Outdoor web-cam, maintenance, platform to upload images. V/R	Parks, Cleveland Museum of Natural History, schools - V/R
Periodic lakes discussion groups (e.g., at local restaurants)	Obj. 1, 2, 3, 6,7 Target: residents, businesses, visitors.	Venue, coordination. Events could be in-person or remote, with internet meetings.	PLAC, businesses, SWCD, Ohio EPA etc. V/R

Table 7.5 *(cont'd)* **Outreach/Education/ Engagement Ideas** *Note: These reflect ideas brought up in various discussions. Lake partners must decide priority/ feasibility.*	Objectives: 1 Increase understanding of the lakes, how to minimize impacts, live with lakes 2 Increase engagement (active participation) and/or ecotourism 3 increase use of BMPs, property management, septic system management 4 Monitor lake or plants 5 Reduce spread of invasive species 6 Manage aquatic plants effectively and safely for water quality, swimmers, wildlife 7 Water quality, litter removal, watershed management, discourage geese		V/R – Virtual/remote event/series or resource possible
	Objectives; target audience	**What is Needed/Comments**	**Potential Partners/Resources**
Engagement/outreach/Events On-site, Virtual/Remote/On-line			
Coordinating with Ohio DNR District 3 office and Summit Metro Parks to offer and list educational events	Obj. 1, 2, ?4. Target: visitors, residents, children	Speakers/events, venue, coordination. List can be online. Events could be in person or remote, if recorded or broadcast on internet.	PLAC, ODNR, Summit Metro Parks, Summit SWCD, schools, local communities, etc. V/R
Lake Stewards Program, Gallery - online	Obj. 1, 2, 3 Target: residents, visitors, business patrons.	On-line platform, coordination – criteria, recognize individuals/groups for stewardship.	PLAC, Summit SWCD, local communities, businesses V/R
Stewardship passport/discount program	Obj. 1,2,7 Target: residents, visitors, businesses, civic groups. Passport stamps, discounts for stewardship. Promotes businesses.	Coordination, discounts with businesses, identify activities to get "passport" stamps. Could be watershed-wide. Program criteria and passport form could be on-line.	PLAC, local businesses, parks, communities, Summit SWCD - V/R
Green Business certificate/logo Work with watershed businesses to encourage patrons to dispose of trash properly.	Obj. 1, 2, 3, 7 Target: businesses. Audubon, Ohio Clean Marinas, LEED certify golf courses, marinas, etc. using eco-friendly practices.	Coordination with businesses, development of recognition program. Can create good publicity for businesses. Criteria and award recipients could be on-line, in Lake Stewards' Gallery.	PLAC, Summit SWCD, businesses, other resources. Lakes Stewards gallery could be online. V/R
Tours and awards - of Best Management Practices, rain gardens, lakescaping, stream restoration– virtual or on-site	1, 2, 3, 7 Target: residents, businesses, communities	Identify examples, coordinate with owners. On-site tour requires transportation and facilitator(s) – each person drive or use bus; on-line or video/ power-point, requires photos and information on each stop; or field trip guide, with permission, directions to each site. Can be on-line.	Summit SWCD, communities, regional stormwater programs, other interested groups. V/R

Table 7.5 *(cont'd)* **Outreach/Education/ Engagement Ideas** *Note: These reflect ideas brought up in various discussions. Lake partners must decide priority/ feasibility.*	Objectives: 1 Increase understanding of the lakes, how to minimize impacts, live with lakes 2 Increase engagement (active participation) and/or ecotourism 3 increase use of BMPs, property management, septic system management 4 Monitor lake or plants 5 Reduce spread of invasive species 6 Manage aquatic plants effectively and safely for water quality, swimmers, wildlife 7 Water quality, litter removal, watershed management, discourage geese		V/R – Virtual/remote event/series or resource possible
	Objectives; target audience	**What is Needed/Comments**	**Potential Partners/Resources**
Engagement/outreach/Events On-site, Virtual/Remote/On-line (cont'd)			
Volunteer Monitoring – lake chemistry, secchi disk, stream sediment, stream habitat, etc.	Obj. 1,2,4, 7 Target: residents, students, boaters, long-term volunteers	Coordination, equipment, training, dedicated volunteers who will go out regularly, data forms/storage (SWCD). Funding for or donated analyses. (If lab analysis needed, coordinate with lab/Ohio EPA/ wastewater treatment plants for lab work to monitor water quality.)	Summit SWCD, PLAC, schools, volunteers, ODNR, Ohio EPA, CLAMS, wastewater treatment plants.
Volunteer Monitoring – invasive plants	Obj. 1, 2, 4, 5, 6 Target: residents, boaters, long-time volunteers	Coordination, training, guidebooks, equipment, data plots, collection, database. Similar programs have been done elsewhere. Could be part of a demonstration project for testing different treatment of invasive plants.	Ohio EPA, contractors, funding Training – V/R
Occasional free boat tours to raise awareness of lakes within communities/watershed.	Obj. 1, 2, 4,7. Target: decision-makers, visitors and residents	Donations/funding for the cost of the tour. Could be paired with tour materials, speaker, etc. Video of tour could be put on-line.	Tour boat operator, volunteers, local businesses. Reach out to watershed/ lakes communities.
Boat/paddle group eco-trips – explore, monitor, litter cleanup	Obj. 1, 2, 4,7 Target: visitors and residents	Trip coordination. Could be part of eco-tourism. If monitoring, need equipment and trained leader, data collection. Could be on-line tour, with video cams and website.	PLAC, volunteers, parks, communities, scout groups, school groups. V/R

Table 7.5 *(cont'd)* **Outreach/Education/ Engagement Ideas** *Note: These reflect ideas brought up in various discussions. Lake partners must decide priority/ feasibility.*	Objectives: 1 Increase understanding of the lakes, how to minimize impacts, live with lakes 2 Increase engagement (active participation) and/or ecotourism 3 increase use of BMPs, property management, septic system management 4 Monitor lake or plants 5 Reduce spread of invasive species 6 Manage aquatic plants effectively and safely for water quality, swimmers, wildlife 7 Water quality, litter removal, watershed management, discourage geese		V/R – Virtual/remote event/series or resource possible
	Objectives; target audience	**What is Needed/Comments**	**Potential Partners/Resources**
Engagement/outreach/Events On-site, Virtual/Remote/On-line *(cont'd)*			
Adopt-a-spot on the water, similar to adopt a spot on the highways	2, 3, 7 Target: residents, boaters	Program to encourage groups to periodically clean up or beautify areas around the lakes. Beautification should be done with SWCD input – using native plants, protecting habitat.	ODNR, Parks, communities, PLAC
Litter pick-ups, trash bandit crew. Work with watershed businesses to encourage disposing of trash properly.	2,3,7 Target: residents, visitors, businesses	Coordination, trash pick-up materials, safety guidelines. Individual cleanups program - encourage visitors and residents to pick up a bagful. Could be tied to passport program.	PLAC, volunteers, ODNR, parks, communities, interest groups, scouts, high school, etc.
Tree-planting, lakescaping, beautification planting days with native plants, rain garden or rain barrel – Installation and site-specific or demonstration workshops	Obj 1, 2, 3, 7 Target: lake/ watershed residents, visitors, agencies, parks, concerned citizens. Can link with community/watershed water quality/restoration efforts.	Site needing vegetation, trees/plants, materials, expertise, instructions in planting/making rain garden, labor to maintain, signage. Rain gardens/ rain barrels are great installations at high traffic public sites (similar to high school and Metro Park). Best educational value with signage.	PLAC, communities, SWCD, parks, ODNR, schools, organiz-ations doing restoration, public private funding, agencies, businesses. I-tree to assess canopy. V/R workshop.
Signage program for BMPs	Obj. 1, 2, 3, 7 Target: residents, communities, businesses, parks	Design and funding for signs, installation.	SWCD, communities, OEEF. Counties/park districts/ communities could produce signs. Volunteers could install.
Tags for trees (value of trees)	Obj. 1, 2, 3, 6, 7	Sites, identify trees for signage, determine $ value of benefits, installation. Watershed-community wide. Tree tag templates at: https://www.unri.org/news/treetags042019/	Parks, communities, SWCD, PLAC, schools, scout groups. I-tree software; business owners, USDA Urban Natural Forests Institute

Table 7.5 *(cont'd)* **Outreach/Education/ Engagement Ideas** *Note: These reflect ideas from various discussions. Lake partners must decide priority/ feasibility.*	Objectives: 1 Increase understanding of the lakes, how to minimize impacts, live with lakes 2 Increase engagement (active participation) and/or ecotourism 3 increase use of BMPs, property management, septic system management 4 Monitor lake or plants 5 Reduce spread of invasive species 6 Manage aquatic plants effectively and safely for water quality, swimmers, wildlife 7 Water quality, litter removal, watershed management, discourage geese		V/R – Virtual/remote event/series or resource possible
	Objectives; target audience	**What is Needed/Comments**	**Potential Partners/Resources**
Displays/Signage			
Watershed/lakes wayfinding signs, Natural Habitat signs, park installations	Obj. 1, 2, 6, 7	Design, funding for signs, installation. Can be installed throughout watershed – "you are here", water goes downhill, context, part of trails and parks. Could be part of lake or regional eco-tours with qr codes. Could be paired with public art.	SWCD, ODNR, parks, OEEF, communities. Park districts/ counties/ communities could produce signs. Volunteer groups could install.
Nature kiosks/popup displays at high visitation areas, events (e.g., library, marinas, Metro Parks, State Park, boat ramps)	Obj. 1, 2, 3, 5, 6, 7	Need: kiosks/displays, information, brochures, maps. Setting up at events requires volunteers, portable displays, through SWCD. Permanent kiosks would require materials, installation.	ODNR, parks, communities, Summit SWCD, sponsors.
Facilities			
Clean-drain-dry stations at boat launches	Obj. 1, 5 Target: boaters	Sites, power-wash or waterless stations, funding for establishing station, operation, maintenance, waste/water disposal. Purpose: to prevent spread of invasive species to other lakes.	Marinas, ODNR
Nature Center/Visitor Center	Obj. 1, 2, 6, 7 Target – visitors, schoolchildren, residents, business patrons.	Long-term capital project, initial steps could be smaller, pop-up facilities. Needed – site, design, facilities, parking, access. Could be lakes welcome and nature center. Could be initially part of existing facility, e.g., ODNR, library room. Could have info, displays, reading materials, photos, community activities, public art.	Community, parks, civic groups. Fundraising, donations, sponsors. Summit SWCD and other information sources.

Key Considerations

Sustaining the Portage Lakes as a multi-use resource is a challenge, requiring careful management.

- The urban eutrophic lakes support dense plant growth and intense use by lakers and visitors. The plants are important to lake health, habitat, water quality, but impede uses.
- Reducing phosphorus, sediment disturbance, and other contaminants from both the watershed and lakes/lakeshore are important for improving water quality. Isolating problems, causes, management measures, and effects is difficult in connected lakes.
- It is essential to characterize and monitor internal and external loading, nutrient cycling, and interactions of lake processes and people.
- Aquatic plant management/lakes management should be managed in a coordinated way that protect water quality and habitat while accommodating uses.
- It is important to involve lakers in determining APM priorities and measures, as they are most affected by lake conditions and management.
- Sustaining a balance between use and ecosystem health requires careful management, consideration of impacts, and evaluation (and re-evaluation).
- The large number of visitors each year increases potential impacts and need to raise awareness of the lakes system and foster stewardship.
- Managing the lakes will require coordination, consistent direction, technical expertise, involvement of lakers, and more resources than are currently available. The partners, representing varied interests, can coordinate and share expertise, insights, and resources to assist with lakes management. However, sustaining the lakes over time will require dedicated funding and staff, and long-term decision mechanism, as well.

Summary of Goals and Recommendations

The overall goal is to manage the Portage Lakes as a sustainable multi-use resource, in a way that protects the natural lakes system in balance with the needs and interests of lake/watershed users, community, and organizations. Five topical goals have been identified, which are linked. Recommendations for each should be carried out in conjunction and coordination with the others.

1. **Water Quality** – **Lakes and Shoreline**. Protect and improve the water quality of the Portage Lakes by reducing factors of eutrophication and other contaminants within the lakes and along the shoreline.
2. **Manage Aquatic Plants** in a way that accommodates property owners and visitors while protecting habitat and water quality.
3. **Water Quality – Watershed**. Improve stream function and reduce loading of sediment, pathogens, stormwater, nutrients from the watershed.
4. **Long-term Management**. Establish a long-term multi-disciplinary management program to provide technical expertise, coordinate efforts, and ensure there are adequate resources to sustain the multi-use, connected, urbanized Portage Lakes resource.
5. **Understanding/Stewardship**. Increase understanding and stewardship by lake/watershed residents, visitors, businesses, and communities.

As shown in Table 7.6, the recommendations include characterizing the lakes, plants, and streams; developing guidelines for APM and lake management; creating a management structure; establishing an APM program; and raising awareness/stewardship.

Table 7.6 Summary of Recommendations

Goal	Recommendation	Time Frame (yr.)
Use Improved Knowledge of Lakes to Guide Decisions		
1	Seasonally monitor limnology throughout lakes	1, ongoing
1, 3	Monitor incoming streams for phosphorus, sediment, bacteria	1, ongoing
1, 3	Characterize phosphorus sources in the lakes	2-3
2, 4, 5	Community survey/monitoring of aquatic plants – interactive website with map	1, ongoing
1, 2	Aquatic Plant Inventory	1-3
1,2	Monitor aquatic plants to detect change	periodically
1, 2	Monitor bacteria in streams, at swim areas during summer, after storms if possible	1-2, ongoing
Reduce Nutrients/Sediment, Other Contaminants in Lakes and from Shoreline		
1	Develop phosphorus, sediment reduction guidelines for lake/plant management	1-4
1, 2, 4	Protect rooted aquatic plants where feasible as part of lake management activities	ongoing
1, 2	Develop a harvest and removal program for aquatic plants where feasible	2-4
1, 2, 3, 5	Encourage participation in programs, e.g., Audubon golf course, Clean Marinas, Clean Boater, and LEED certification to reduce contaminants through BMPS/design	1-5, ongoing
1, 5	Workshops/demonstration projects to discourage geese	1-2, ongoing
1, 2, 3, 5	Lakescaping demonstration projects, workshops	1-2, ongoing
Manage Aquatic Plants to accommodate users' needs while protecting water quality and habitat		
1, 2, 4, 5	Hold charrette style public workshops to identify priorities for APM and conservation	1-2
1, 2, 4	Develop comparison of lakes management/APM - benefits, costs, impacts, logistics	1-2
1, 2,4, 5	Develop and carry out coordinated APM program for docks, outreach	1-2, ongoing
1,3	Investigate ways to reduce invasive species, increase native species	3-5
1, 2	Special focus: North Reservoir, Miller Lk, Cottage Grove Lk, Long Lake Feeder	1-4, ongoing
Reduce Contaminants from the Watershed		
1, 3	Work with wastewater management agencies, communities, and Departments of Health to identify appropriate solutions for discharging HSTS, including sewer service	1-2, periodically afterward
1, 3, 5	Demonstration project(s) at park/public site – BMPs, native plants, lakescaping, etc.	2-4, ongoing
1, 3, 4	Identify areas for restoration or protection (stream channels, wetlands, buffers)	2-4
3	Develop NPS-IS documents for areas not already addressed (e.g., Brewster)	2-4
1, 3	Stormwater/stream projects to reduce sediment, phosphorus	1-2, ongoing
1, 3, 4, 5	Review land use measures to make sure they encourage BMPs	2-4
1, 3, 5	Outreach HSTS maintenance	1-2, ongoing
3, 5	Outreach to farmers – cover crops, easements, buffers, etc.	
1, 2, 3, 5	Outreach to become "green" certified e.g., Clean Marinas, Audubon Sanctuary, LEED	2-4
Management – Goals 1, 2, 3, 4, 5		
	Establish partnership to coordinate and share technical information, direction	1
	Establish full- or part-time staff position for lakes management	1-2
	Establish management structure with funding, decision-making mechanism	1-2
Outreach		
1, 3, 5	Signage at BMPs	2-4
1, 2, 3, 5	Articles, brochures about living with the lakes, BMPs, HSTS maintenance	1, ongoing
1, 2, 3, 5	Volunteer opportunities - Clean-ups, planting trees, rain gardens, monitor, etc.	1-2, ongoing
1,2, 5	Guidebook to Portage Lakes Plants and Ecology	1-2
1, 2, 3, 5	Displays, brochures for kiosks, events – aquatic plants, lake ecology, stewardship, etc.	Ongoing
1, 2, 3, 5	BMP outreach – property owners, agricultural	Ongoing
1, 2, 3, 5	Lakes-centered events, kiosks, tours, tour information, other as noted in Goal 5	1-4, ongoing

Goals: 1 – Water quality lakes/shore 2 – Plants 3 – Watershed 4 – Manage 5 - Outreach

Priorities for Getting Started

Tasks to start working on soon include foundational work and items that could generate early success, including:

- Establish a partnership to provide coordination, guidance, share resources
- Establish a management structure with staff, funding, resources, decision-making
- Inventory and monitoring of limnology, streams, aquatic plants
- Work with lakers to identify APM needs, priorities, APM zones and management measures – could include community surveys/submissions of geotagged photos and observations
- Characterize phosphorus sources in the lakes
- Develop coordinated APM at docks, including a fee structure
- Develop guidelines for lake/aquatic plant management measures that allow use of the lakes and minimize phosphorus release and sediment disturbance and protect habitat and ecosystem
- Start the process for developing a harvest and removal program
- Outreach, including goose management, lakescaping, lake ecosystem, aquatic plants, clean-ups