Planning for Protection in the Balsam Lake Watershed
Final Report for County Lake Grant LPL-1791-21

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Purpose of the Project

The Polk County Land and Water Resource Management Plan 2020-2029 identifies the Balsam Lake Watershed as the highest priority watershed for protection and restoration in Polk County. As a result, the Polk County Land and Water Resources Department applied for a Wisconsin Department of Natural Resources County Lake Grant in 2020 to compile existing water quality data and collect data where none exists to establish baseline conditions in the watershed. The grant was received, and data collection began in 2021 and continued through 2023. In 2022 the Polk County Land and Water Resources Department applied for a Large-Scale Targeted Runoff Management Grant to provide protection to surface and groundwater resources from nonpoint source pollution in the Balsam Lake Watershed. The grant was received in 2023.

This report will summarize challenges in the Balsam Lake Watershed, summarize baseline data for the lakes and streams in the Balsam Lake Watershed, and identify protection and restoration priorities in the watershed.

Challenges in the Balsam Lake Watershed

Polk County's population has been increasing since the 1960's, partly as a result to the proximity to the Minneapolis/St. Paul metropolitan area. The highest population growth from 1970 to 2000 occurred in the Town of Osceola, Town of Balsam Lake, and Village of Balsam Lake. Additionally, over this time frame, the towns with the highest growth tended to be located in areas with attractive lakeshore development areas. [1]

The owners of many lakefront properties in Polk County reside full time outside of the area. In 2000, seasonal units, or those intended for weekend or occasional use throughout the year, accounted for 20% of the County's housing stock. The Towns of Georgetown, Balsam Lake, and Milltown accounted for the areas with the largest number of seasonal units. [2]

During the COVID pandemic many lake groups noted increased recreational pressure on area lakes. With remote work a possibility for many, this trend may continue.

The transition of property ownership should be considered when assessing opportunities and challenges for improving and protecting water quality in the Balsam Lake Watershed.

[1] Polk County Comprehensive Plan 2009-2029
[2] Polk County Conditions and Trends Report 2009

Data Collection

In-lake data for this grant was collected during the 2021 and 2022 growing season summer index period (July 15th – September 15th) for lakes that lacked recent water quality data (Antler, Half Moon, Rice). Dissolved oxygen, temperature, conductivity, specific conductance, and pH were recorded at meter increments monthly with a YSI ProDSS multiparameter digital water quality meter. Secchi depth was recorded, and surface samples were collected once monthly with a 2-meter composite sampler and analyzed at the Wisconsin State Laboratory of Hygiene for total phosphorus and chlorophyll *a*.

Full spring and fall point intercept aquatic plant surveys were conducted on Antler Lake using the Jessen and Lound Rake Method. All other lakes in the Balsam Lake Watershed had recent aquatic plant surveys.

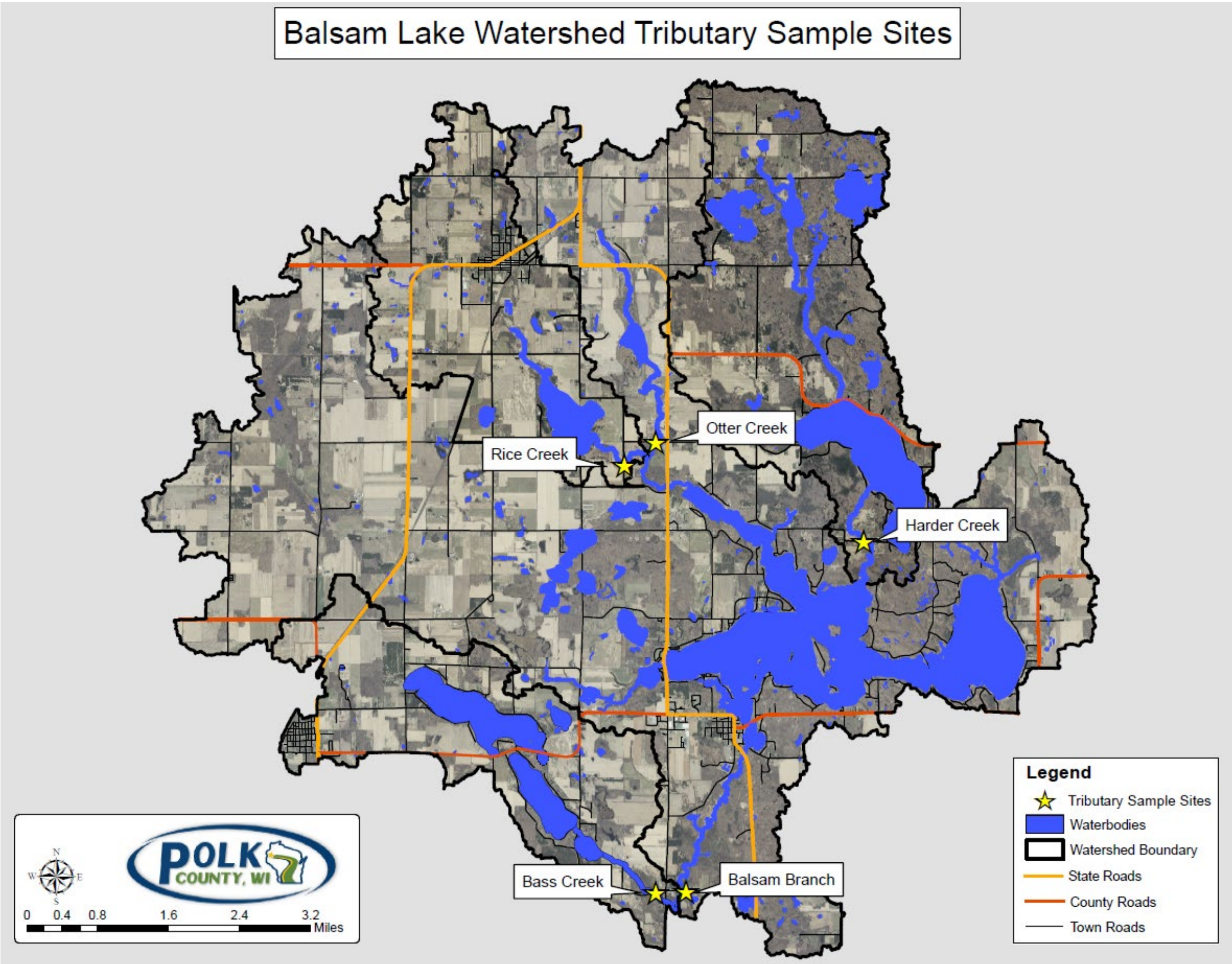
Shoreline inventories were completed using the Lake Shoreland and Shallows Habitat Monitoring Field Protocol developed by the Wisconsin Department of Natural Resources on lakes without recent shoreline data (Antler, Balsam, Half Moon, Rice). For each parcel on each lake, percent canopy, human structures, runoff concerns, and bank zone factors were documented in the first 35 feet of the shoreline landward from the water's edge. Additionally, human structures and aquatic plants were documented in the littoral zone for each parcel. A coarse woody habitat inventory was completed as part of each shoreline inventory. The surveys completed on Long and Loveless Lake were conducted at and earlier data and used different methodologies.

Using the Water Action Volunteers (WAV) protocol, a biotic index was completed on each tributary in the spring and fall of 2022 and 2023 and a habitat assessment was completed in 2023.

Baseline data was collected on the five tributaries in the Balsam Lake Watershed in 2022 and 2023. Data for temperature, dissolved oxygen, and transparency were collected each time the stream was visited. Additionally, flow data was collected at each tributary with a Marsh McBirney Flo-Mate TM velocity flowmeter. At 6-inch or 12-inch intervals (depending on stream width) across each tributary, water depth (feet) and velocity (ft/s) were measured. Grab samples were collected when there was flow on each tributary and analyzed at the State Lab of Hygiene for total phosphorus and total suspended solids.

HOBO data loggers were installed at each tributary on March 16th, 2022, and removed on October 2nd, 2023. Each hour loggers collected data for temperature, water pressure, and atmospheric pressure. The difference between water pressure and atmospheric pressure was paired with a depth of logger reading to determine an hourly water level. Next, a relationship between water level and field measured flow readings was calculated. This allowed for an hourly flow to be estimated for dates where field measured flow readings were not collected. Hourly flow readings were used to determine an average daily flow. Data for total phosphorus and average daily flow were input into a model called FLUX to estimate an annual phosphorus load for each tributary.

The HOBO logger readings become inaccurate in the winter when ice begins to form around the stilling well that houses the logger and when the stream freezes over. The timeframe where readings became inaccurate due to ice formation were determined for each tributary and removed from the hydrograph. These conditions existed on Balsam Branch, Harder Creek, and Otter Creek. When inputting the data into flux, the model substituted the daily flow for the missing grab sample flows when ice formation was present. Flux determines an annual total phosphorus load using seven methods. An average total phosphorus load for the seven methods for each tributary was determined.



Introduction to the Balsam Lake Watershed

The Balsam Lake Watershed (HUC 070300050801) is 39,004 acres and located entirely within Polk County, Wisconsin. The watershed is primarily forest (28%) and row crop (26%), followed by open water (10%), wetland (9%), rural residential (9%), and mixed agriculture (8%). PRESTO-Lite estimates the average annual nonpoint source phosphorus load as 2,930 pounds. The watershed includes the Towns of Balsam Lake, Milltown, Eureka, Georgetown, Apple River, St. Croix Falls, and Luck and the Villages of Balsam Lake, Milltown, and Centuria.

Sixty percent of the land in the Balsam Lake Watershed is in a Water Quality Management Area which is defined as an area 1,000 feet from a lake or 300 feet from a stream. The watershed encompasses 17 lakes (4 class one lakes and 13 class three lakes) and 5 streams including:

Lakes
Antler
Balsam
Camp Douglas
East
Elkins
Half Moon
Kenny
Laurel
Little Bass
Little Pine (Spur)
Long
Lost
Loveless
Lykens
Otter
Rice
Twenty-Ninth

Streams
Balsam Branch
Bass Creek
Harder Creek
Otter Creek
Rice Creek

Six of the lakes in the Balsam Lake Watershed can be accessed by public ramp access. These lakes include Antler, Balsam, Half Moon, Long, Loveless, and Rice.

Otter Creek Flows through Otter Lake and truncates with Rice Creek as it outlets Rice Lake. Rice Creek is one of two main inlets to Balsam Lake. The second inlet to Balsam Lake is Harder Creek which flows through Half Moon Lake. The outlet of Balsam Lake is the Balsam Branch. Bass Creek flows from Loveless Lake and through Little Bass Lake before joining the Balsam Branch. Bass Creek inlets into the Balsam Branch downstream of Balsam Lake. The point where these two tributaries truncate marks the outflow of the Balsam Lake Watershed, which eventually flows to Wapogasset Lake.

The Balsam Lake Watershed contains no Exceptional or Outstanding Resource Waters and three impaired waters (Long, Loveless, East Balsam). To address nutrient impairments, the Long Lake Protection and Rehabilitation District first applied alum in Long Lake in 2018 and the Balsam Lake Protection and Rehabilitation District first applied alum in East Balsam in 2020.

Lakes in the Balsam Lake Watershed

Lake Summaries

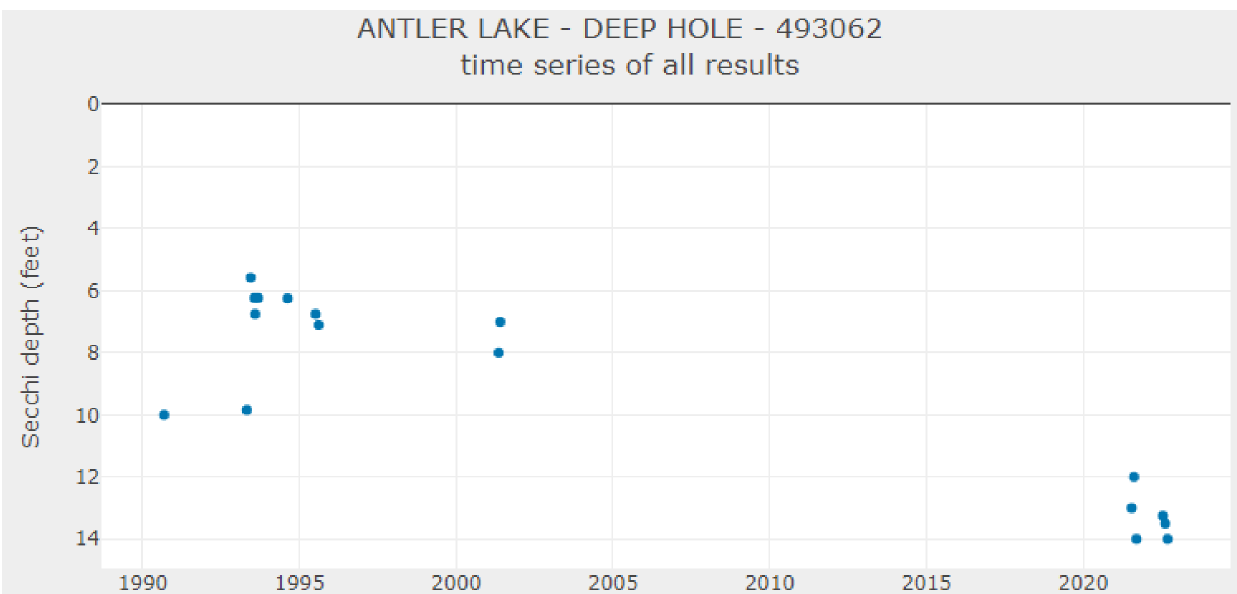
Antler Lake

Antler Lake is a 94-acre seepage lake with a maximum depth of 22 feet. A single boat landing located on the north side of the lake provides public access. Chinese mystery snails and curly leaf pondweed are present in the lake. Three ASNRI Sensitive Areas that merit special protection of aquatic habitat are identified on the lake. The watershed for Antler Lake is 689 acres and dominated by forest (76%). The Healthy Watersheds Assessment evaluated the Antler Lake Watershed as 69 for Health and 88 for Vulnerability. WiLMS determined the annual nonpoint total phosphorus load as 75 pounds per year.

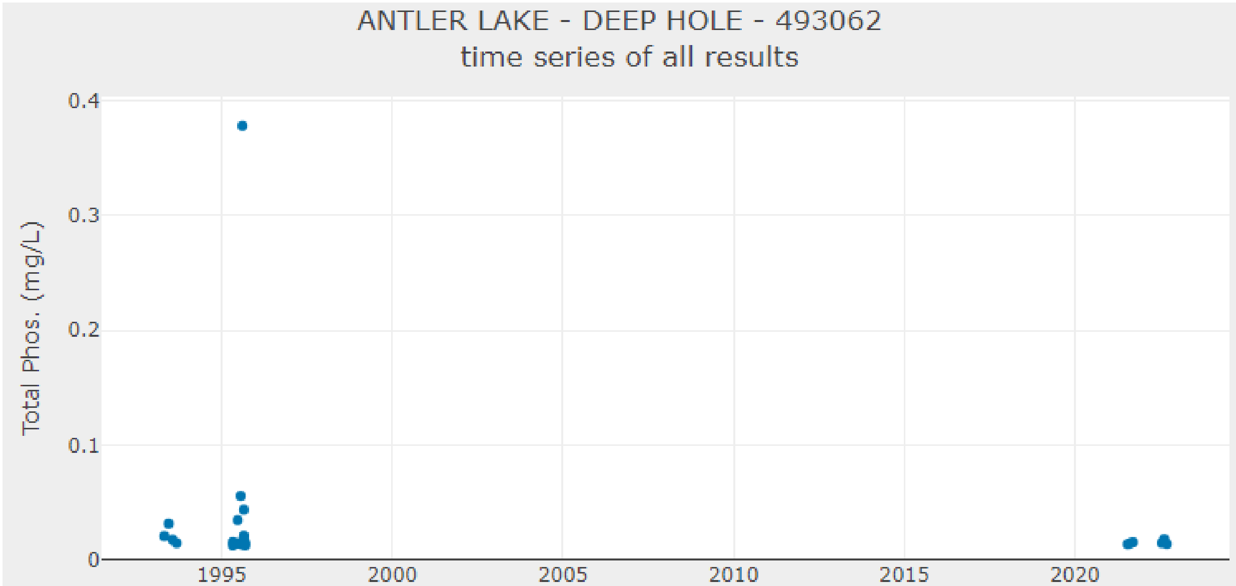
Trophic State Index data for 2021 and 2022 indicate that Antler Lake is mesotrophic. There is not currently enough data to allow for trend analysis for secchi depth, total phosphorus, and chlorophyll *a*.

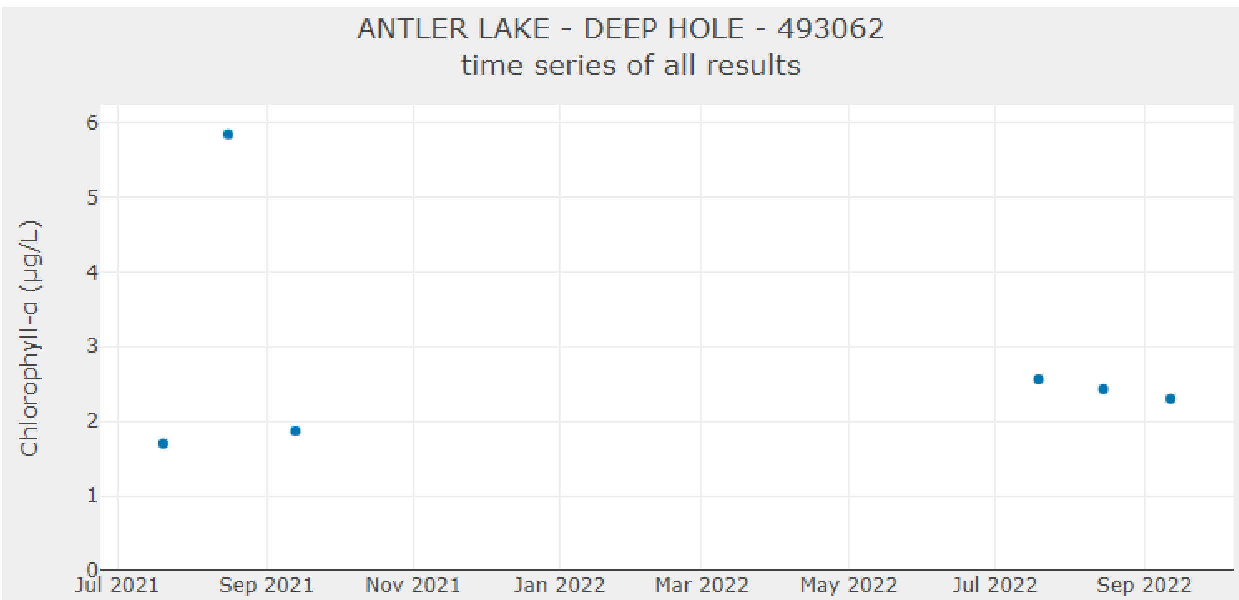
Antler Lake stratifies and was anoxic in the bottom 2 meters in 2022. Average surface conductivity in 2021 was 45 µg/L and 46 µg/L in 2022.

Secchi depth values on Antler Lake ranged from a low of 12 feet to a high of 14 feet over the course of this study. Summer index period average secchi depth was 13 feet in 2021 and 13.6 feet in 2022.



Total phosphorus and chlorophyll *a* were analyzed at the surface (top 2 meters) of Antler Lake. Summer index period average surface total phosphorus was 14.9 µg/L in 2021 and 15.9 µg/L in 2022. Summer index period average chlorophyll *a* on Antler Lake was 3.14 µg/L in 2021 and 2.43 µg/L in 2022.





A 2021 shoreline inventory determined that the average tree canopy cover per parcel on Antler Lake is 89%. Eighty-three percent of the ground cover in the riparian zone on Antler Lake is shrub/herbaceous and 13% is lawn. In total there are 3 firepits, 7 buildings, and 48 boats in the riparian buffer zone. Runoff concerns in the riparian buffer zone include 2 parcels with channelized water flow/gully and 12 parcels with bare soil. Five parcels have a combined total of 250 feet of riprap, one parcel has an artificial beach, and two parcels have bank erosion greater than a 1-foot face. There are 251 pieces of wood in the water or 79 per mile of shoreline.

Spring and fall aquatic plant point intercept survey were completed on Antler Lake in 2021. The spring survey indicated that 96% of the lake was vegetated in the spring and

97% was vegetated in the fall. Including visuals, there were 34 species identified in the lake in the spring and 30 species identified in the fall. The Simpson Diversity Index was 0.74 in the spring and 0.73 in the fall. The Floristic Quality Index was 38.4 in the spring survey and 35.7 in the fall survey. These values are well above the value for the North Central Hardwood Forest region (20.9) indicating that the plant community in Antler Lake is healthy and less tolerant to changing water quality and habitat modification. Three species were present on Antler Lake with a conservatism value of ten: spiny hornwort, dwarf water-milfoil, and algal-leaved pondweed. An additional six species with a conservatism value of nine, four species with a conservatism value of eight, and six species with a conservatism value of seven were present on Antler Lake.

The Antler Lake Protection and Rehabilitation District was established in 1989.

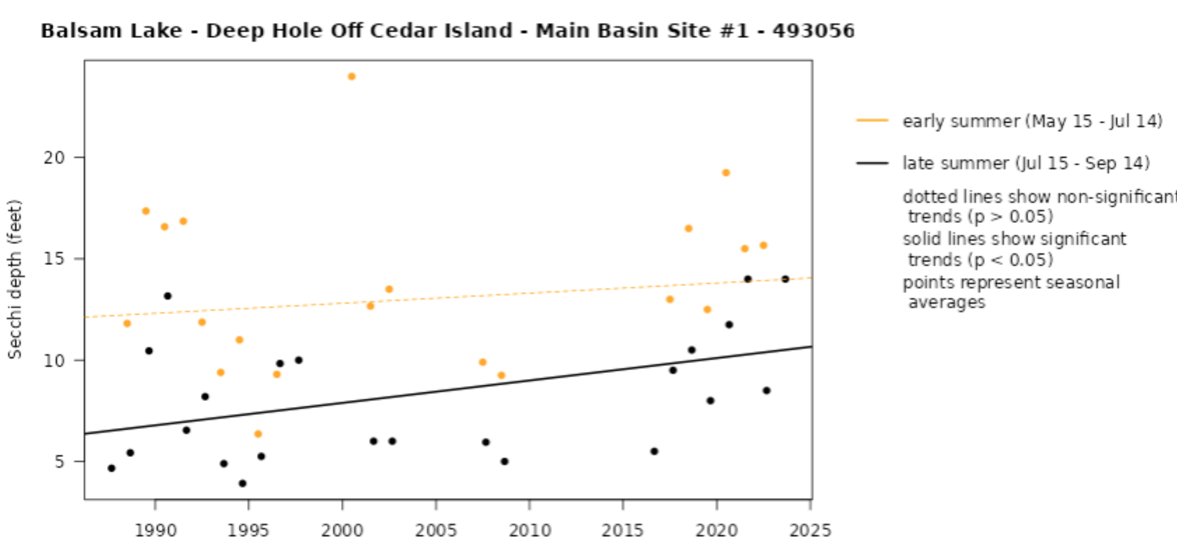
Balsam Lake

Balsam Lake is a 1,901-acre drainage lake with a maximum depth of 37 feet. Balsam Lake receives water from Otter Creek, Rice Creek, and Harder Creek. Water leaves Balsam Lake through the Balsam Branch. Seven boat landings on the lake provide public access and all have decontamination stations for aquatic invasive species. Chinese mystery snails, curly leaf pondweed, Japanese knotweed, purple loosestrife, yellow iris, and zebra mussels are present on the lake. Zebra mussels were first discovered in the lake in 2022. Thirty-five ASNRI Sensitive Areas that merit special protection of aquatic habitat are identified on the lake.

WiLMS determined the annual nonpoint total phosphorus load as 10,263 pounds per year. The watershed for Balsam Lake is 32,793 acres and dominated by pasture/grass (32%), forest (28%), and row crop (19%). The Healthy Watersheds Assessment evaluated the Balsam Lake Watershed as 57 for Health and 38 for Vulnerability.

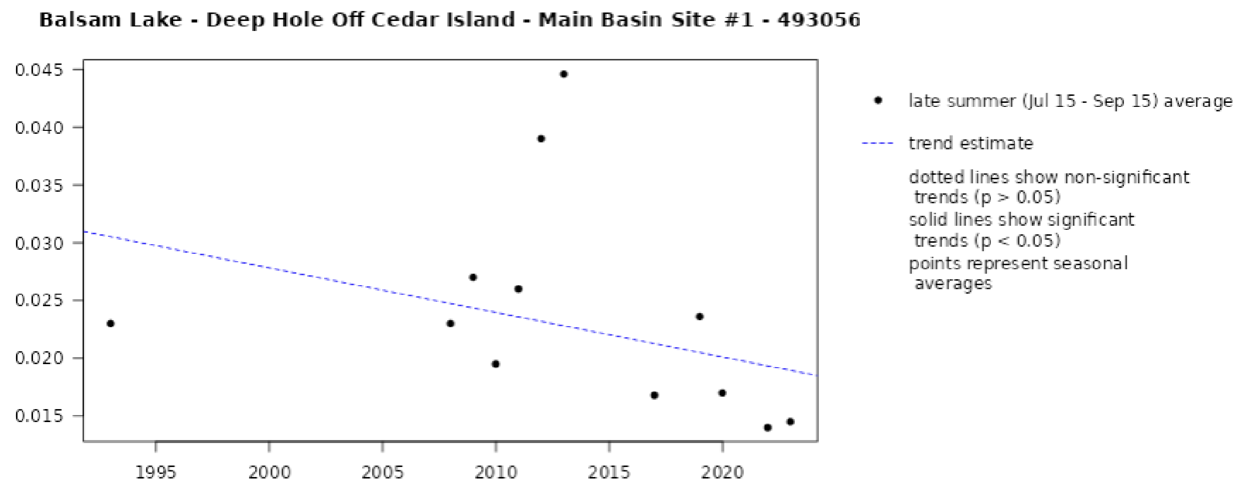
Balsam Lake has been monitored by volunteers since 1987. The average summer trophic state for the last five years based on secchi depth determined the lake is mesotrophic. Averages for the last ten years for secchi, total phosphorus, and chlorophyll *a* indicate that Balsam Lake has greater water clarity and lower nutrient and algal levels as compared to other shallow lowland lakes. Since 1987, early summer secchi has increased and late summer secchi has significantly increased ($p < 0.05$). Since 1993, late summer total phosphorus has decreased and since 2008 late summer total chlorophyll *a* has decreased.

Trends in Secchi depth



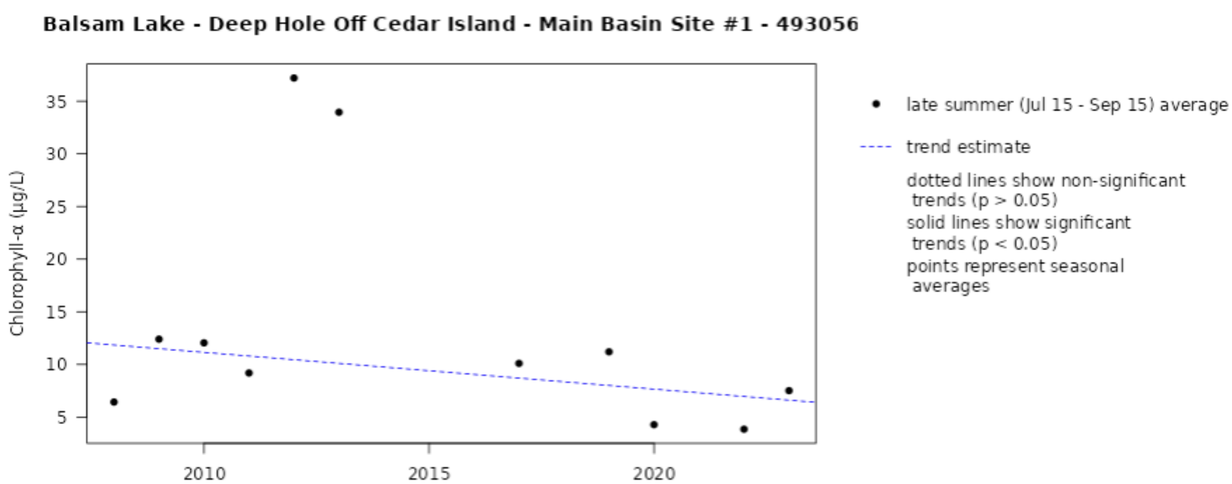
Legend notes: dotted lines show non-significant trends ($p > 0.05$), solid lines show significant trends ($p < 0.05$), and points represent seasonal averages

Trends in total phosphorus



Legend notes: dotted lines show non-significant trends (p > 0.05), solid lines show significant trends (p < 0.05), and points represent seasonal averages

Trends in chlorophyll-α



Legend notes: dotted lines show non-significant trends (p > 0.05), solid lines show significant trends (p < 0.05), and points represent seasonal averages

Data on Balsam Lake was not collected as part of this study but was instead collected through the Citizen Lake Monitoring Network. Three parameter Trophic State Index data exists for July 2022 and September 2023. Secchi depth was 10 feet in July 2022 and 14 feet in September 2023. Surface total phosphorus was 14 µg/L in July 2022 and 15 µg/L in September 2023. Surface chlorophyll *a* was 3.9 µg/L in July 2022 and 7.5 µg/L in September 2023.

In 2014, East Balsam was listed as an impaired water for excess algae growth, with chlorophyll *a* concentrations exceeding the threshold for recreational use (30% of sample days with chlorophyll *a* greater than 20 µg/L). Alum was first applied in East Balsam in 2020 to advance the goal of removing the waterbody from the Impaired Waters List.

A 2022 shoreline inventory determined that the average tree canopy cover per parcel on Balsam Lake is 69%. Fifty-seven percent of the ground cover in the riparian zone on Balsam Lake is shrub/herbaceous, 32% is lawn, and 8% is impervious. In total there are 152 firepits, 288 boats, and 323 buildings in the riparian buffer zone. Runoff concerns in the riparian buffer zone include 6 parcels with a point source, 24 parcels with channelized water flow/gully, 146 parcels with bare soil, and 23 parcels with sand/silt deposits. Forty-three percent of the shoreline on Balsam Lake is rip rap (71,098 feet). Other bank zone concerns include 764 feet of artificial beach, 230 feet of bank erosion greater than a 1-foot face, and 458 feet of bank erosion less than a 1-foot face. Nine boathouses are in the littoral zone on Balsam Lake. There were 896 pieces of wood in the water or 29 per mile of shoreline.

The most recent point intercept survey on Balsam Lake was completed in August 2020 by Endangered Resource Services, LLC. The survey indicated that 34% of the lake was vegetated. Including visuals, there were 48 species identified in the lake. The Simpson Diversity Index was 0.92. The Floristic Quality Index was 39.4. This value is well above the value for the North Central Hardwood Forest region (20.9) indicating that the plant community in Balsam Lake is healthy and less tolerant to changing water quality and habitat modification. Three species were present on Balsam Lake with a conservatism value of nine: wild calla, crested arrowhead, and creeping bladderwort. An additional ten species with a conservatism value of eight and five species with a conservatism value of seven were present on Balsam Lake.

The Balsam Lake Protection and Rehabilitation District was established in 1975. Three properties are owned by the District for conservation purposes.

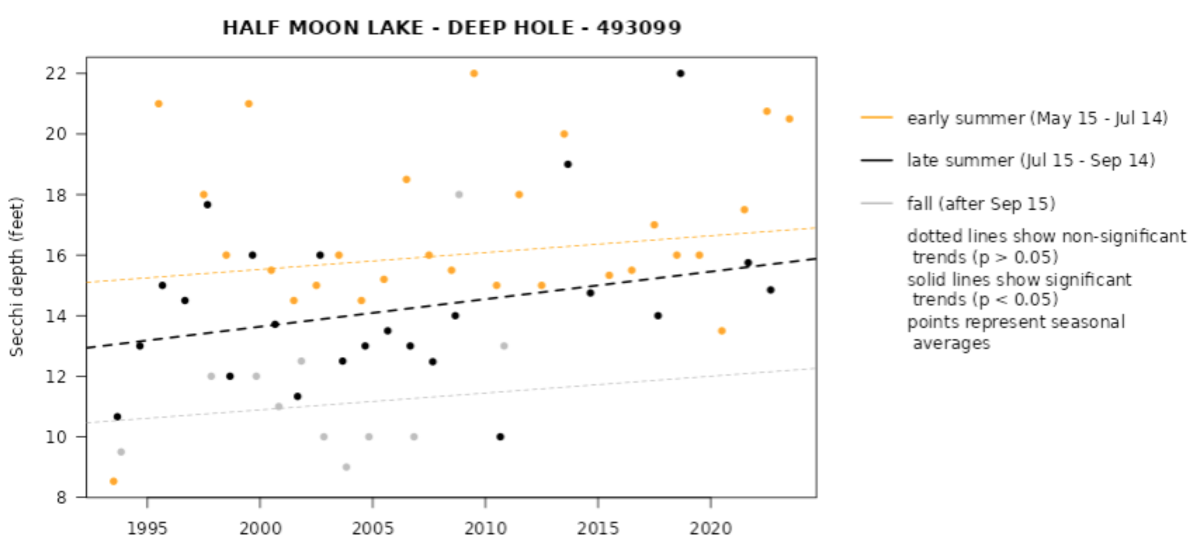
Half Moon

Half Moon Lake is a 550-acre drainage lake with a maximum depth of 60 feet. Harder Creek flows into Half Moon Lake on the north side of the lake and exits on the southwest side of the lake. Two boat landings on the lake provide public access. An aquatic invasive species decontamination station is present at the north ramp access (Voss Landing). Banded mystery snails, Chinese mystery snails, curly leaf pondweed, Eurasian water milfoil, and rusty crayfish are present on the lake. Eurasian water milfoil was discovered in the lake in October 2021. Six ASNRI Sensitive Areas that merit special protection of aquatic habitat are identified on the lake.

WiLMS determined the annual nonpoint total phosphorus load as 1,162 pounds per year. The watershed for Half Moon Lake is 6,541 acres and dominated by forest (51%) and pasture/grass (20%). The Healthy Watersheds Assessment evaluated the Half Moon Lake Watershed as 67 for Health and 23 for Vulnerability.

Half Moon Lake has been monitored by volunteers since 1993. Trophic State Index data for 2021 and 2022 indicate that Half Moon Lake is mesotrophic. Averages for the last ten years for secchi depth indicate that Half Moon Lake has greater water clarity when compared to other deep lowland lakes. Since 1993, secchi depth has increased, total phosphorus has remained relatively stable, early summer chlorophyll *a* has increased, and late summer chlorophyll *a* has decreased.

Trends in Secchi depth



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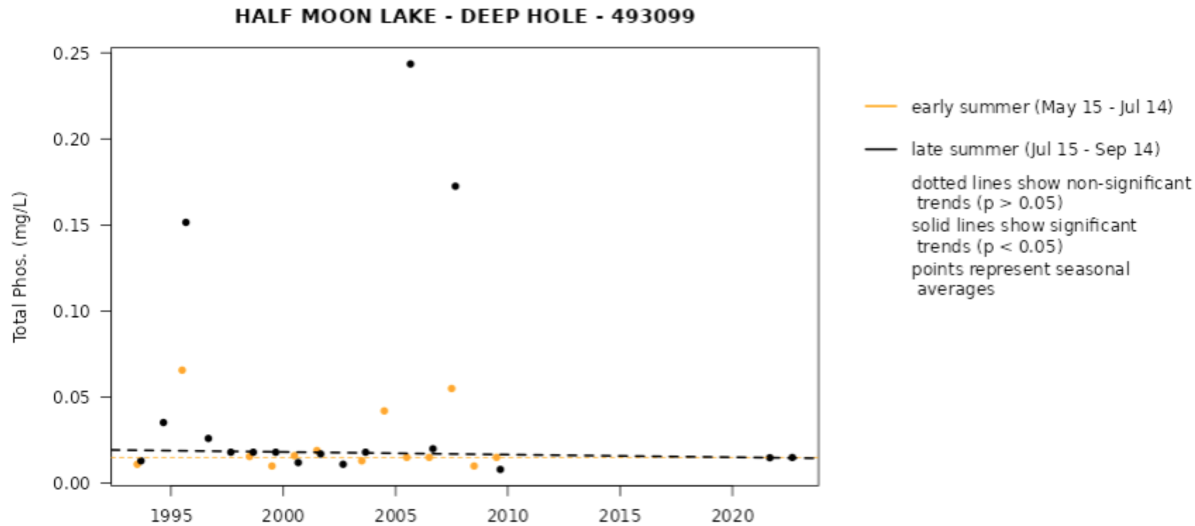
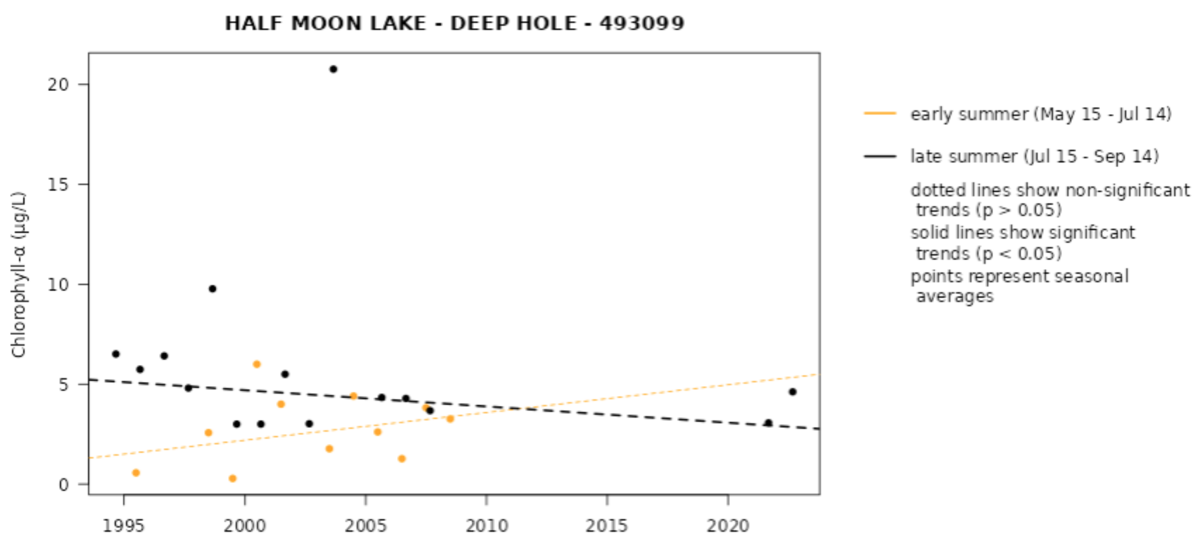
Trends in total phosphorus



Legend notes: dotted lines show non-significant trends ($p > 0.05$), solid lines show significant trends ($p < 0.05$), and points represent seasonal averages

Trends in chlorophyll-α



Legend notes: dotted lines show non-significant trends ($p > 0.05$), solid lines show significant trends ($p < 0.05$), and points represent seasonal averages

Half Moon Lake stratified and was anoxic in the bottom 9 meters in 2021 and 2022. Average surface conductivity in 2021 was 167 µg/L in 2021 and 173 µg/L in 2022.

Secchi depth values on Half Moon Lake ranged from a low of 12.5 feet to a high of 18 feet over the course of this study. Summer index period average secchi depth was 16 feet in 2021 and 14.6 feet in 2022.

Total phosphorus and chlorophyll *a* were analyzed at the surface (top 2 meters) of Half Moon Lake. Summer index period average surface total phosphorus was 14.8 µg/L in 2021 and 14.9 µg/L in 2022. Summer index period average chlorophyll *a* on Half Moon Lake was 3.07 µg/L in 2021 and 4.62 µg/L in 2022.

A 2021 shoreline inventory determined that the average tree canopy cover per parcel on Half Moon Lake is 66%. Fifty-three percent of the ground cover in the riparian zone on Half Moon Lake is shrub/herbaceous, 35% is lawn, and 8% is impervious. In total there are 31 firepits, 86 buildings, and 105 boats in the riparian buffer zone. Runoff concerns in the riparian buffer zone include 3 parcels with a point source, 4 parcels with channelized water flow/gully, 49 parcels with bare soil, and 1 parcel with sand/silt deposits. Fourteen percent of the shoreline on Half Moon Lake is rip rap (4,593 feet). Other bank zone concerns include 41 feet of artificial beach, 135 feet of bank erosion greater than a 1-foot face, and 185 feet of bank erosion less than a 1-foot face. One boathouse is in the littoral zone on Half Moon Lake. There were 98 pieces of wood in the water or 16 per mile of shoreline.

The most recent point intercept survey on Half Moon Lake was completed in July 2022 by Endangered Resource Services, LLC. The survey indicated that 28% of the lake was vegetated. Including visuals, there were 48 species identified in the lake. The Simpson Diversity Index was 0.95. The Floristic Quality Index was 43. This value is well above the value for the North Central Hardwood Forest region (20.9) indicating that the plant community in Half Moon Lake is healthy and less tolerant to changing water quality and habitat modification.

The Half Moon Lake Protection and Rehabilitation District was established in 1975. The Half Moon Lake Conservancy was established in 2003 and owns a 35-acre parcel along Harder Creek.

Little Bass

Little Bass Lake is a 22-acre drainage lake with a maximum depth of 15 feet. Bass Creek flows into Little Bass Lake on the north side of the lake and exits on the southeast side of the lake. Little Bass Lake can be accessed (walk in only) through private land on the west side of the lake that is open to public access.

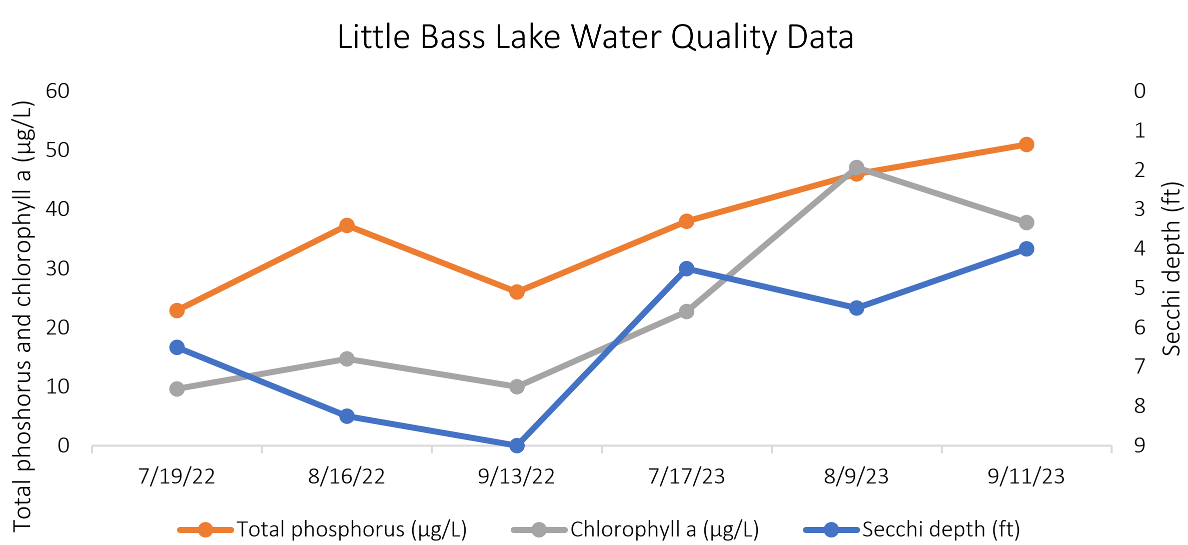
WiLMS determined the annual nonpoint total phosphorus load as 180 pounds per year. The watershed for Little Bass Lake is 707 acres and dominated by forest (39%), the lake surface (22%), and pasture/grass (21%). The Healthy Watersheds Assessment evaluated the Little Bass Lake Watershed as 61 for Health and 87 for Vulnerability.

The Polk County Land and Water Resources Department collected data on Little Bass Lake through a Directed Lakes project. Trophic State Index data for 2021 and 2022 indicate that Little Bass Lake is eutrophic. There is not currently enough data to indicate trend analysis for secchi depth, total phosphorus, and chlorophyll *a*.

Little Bass Lake remained oxygenated at the bottom in 2022 and 2023. Average surface conductivity was 216 µg/L in 2022 and 228 µg/L in 2023.

Secchi depth values on Little Bass Lake ranged from a low of 4 feet to a high of 9 feet over the course of the Directed Lakes Study. Summer index period average secchi depth was 7.9 feet in 2022 and 4.7 feet in 2023.

Total phosphorus and chlorophyll *a* were analyzed at the surface (top 2 meters) of Little Bass Lake. Summer index period average surface phosphorus was 28.7 µg/L in 2022 and 45 µg/L in 2023. Summer index period average chlorophyll *a* on Little Bass Lake was 11.4 ug/L in 2022 and 35.9 µg/L in 2023.



A 2022 shoreline inventory determined that the average tree canopy cover per parcel on Little Bass Lake is 75%. Ninety-seven percent of the ground cover in the riparian zone on Little Bass Lake is shrub/herbaceous and 2% is lawn. In total there are 6 boats in the riparian buffer zone. Runoff concerns in the riparian buffer zone include 1 parcel with bare soil. There were no documented bank zone concerns on Little Bass Lake. There were 22 pieces of wood in the water or an estimated 26 per mile of shoreline.

A point intercept survey on Little Bass Lake was completed in August 2022. The survey indicated that 87% of the lake was vegetated. Including visuals, there were 17 species identified in the lake. The Simpson Diversity Index was 0.78. The Floristic Quality Index was 17.9. This value is below the value for the North Central Hardwood Forest region (20.9). One species was present on Little Bass Lake with a conservatism value of seven: small pondweed.

Long Lake

Long Lake is a 273-acre seepage lake with a maximum depth of 17 feet. Two boat landings on the lake provide public access. The boat landing on the west side of the lake has an aquatic invasive species decontamination station. Chinese mystery snails and curly leaf pondweed are present on the lake. Two ASNRI Sensitive Areas that merit special protection of aquatic habitat have been identified on the lake.

WiLMS determined the annual nonpoint total phosphorus load as 880 pounds per year. The watershed for Long Lake is 2,530 acres and dominated by pasture/grass (38%), row crop (21%), and forest (16%). The Healthy Watersheds Assessment evaluated Long Lake as 27 for Health and 98 for Vulnerability.

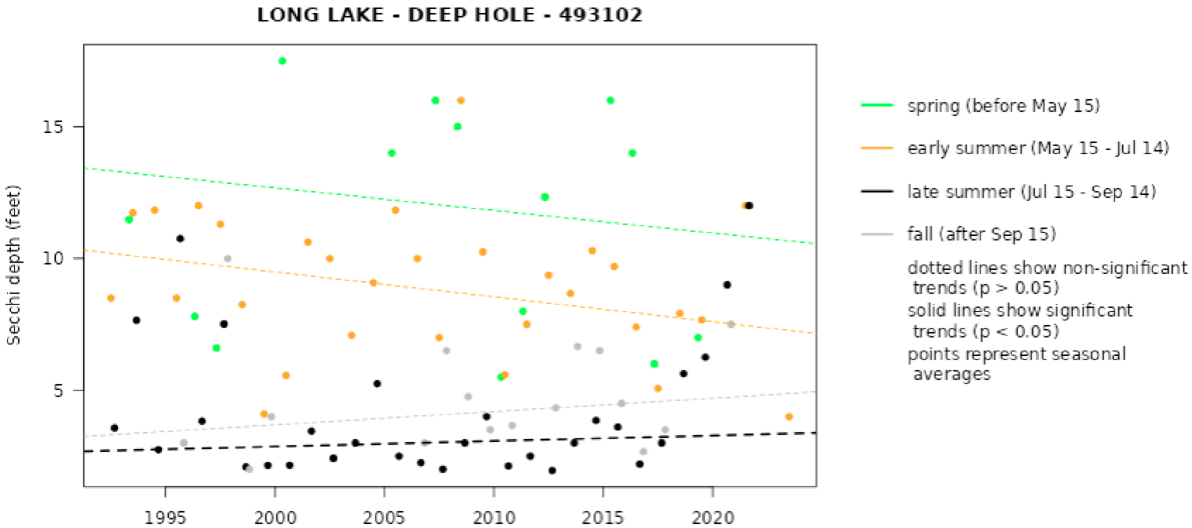
Long Lake has been monitored by volunteers since 1992. Long Lake was listed as an Impaired Water in 2014 for the pollutant total phosphorus. Values for Long Lake total phosphorus exceed the recreation standard (40 µg/L) and values for chlorophyll *a* exceed the recreation standard (30% of sample days with chlorophyll *a* greater than 20 ug/L). Alum was first applied in Long Lake in 2018 to advance the goal of removing the lake from the Impaired Waters List.

The average summer trophic state for the last five years based on chlorophyll *a* determined the lake is eutrophic. Averages for the last ten years for secchi, total phosphorus, and chlorophyll *a* indicate that Long Lake has comparable water clarity and higher nutrient and algal levels as compared to other shallow seepage lakes. Since 1992, spring and early summer secchi has decreased and late summer and fall secchi has increased. Since 1993, early and late summer total phosphorus has decreased (late summer $p < 0.05$) and since 2012 early and late summer total chlorophyll *a* has decreased (late summer $p < 0.05$).

Data on Long Lake was not collected as part of this study but was instead collected through the Citizen Lake Monitoring Network.

Total phosphorus and chlorophyll *a* data exists for July and August 2022 and August 2023. July and August 2022 average surface total phosphorus was 26.5 µg/L and August 2023 total phosphorus was 29 µg/L. July and August 2022 average chlorophyll *a* was 12.8 µg/L and August 2023 chlorophyll *a* was 10.9 µg/L.

Trends in Secchi depth



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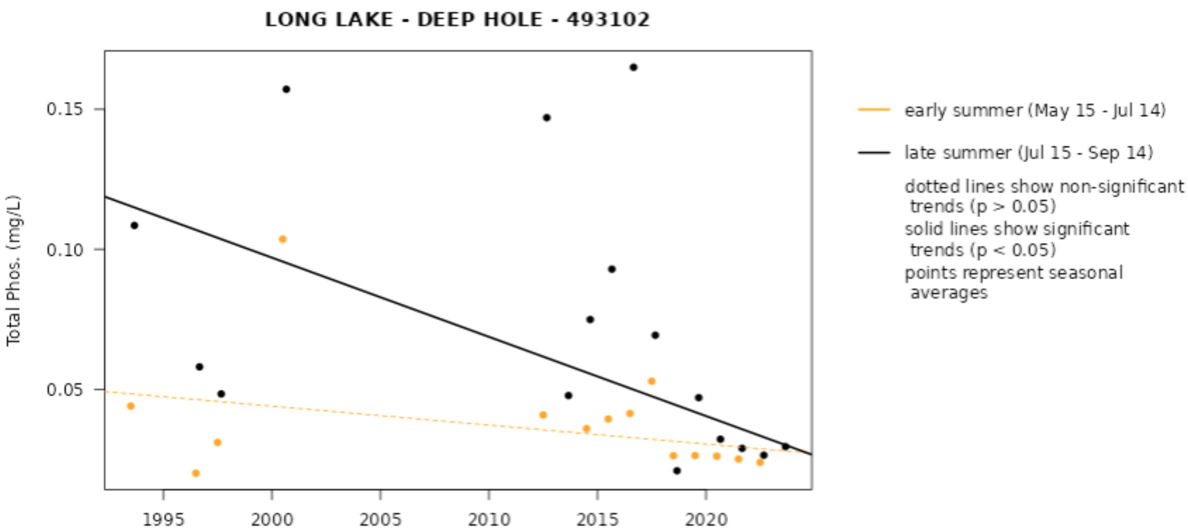
Trends in total phosphorus



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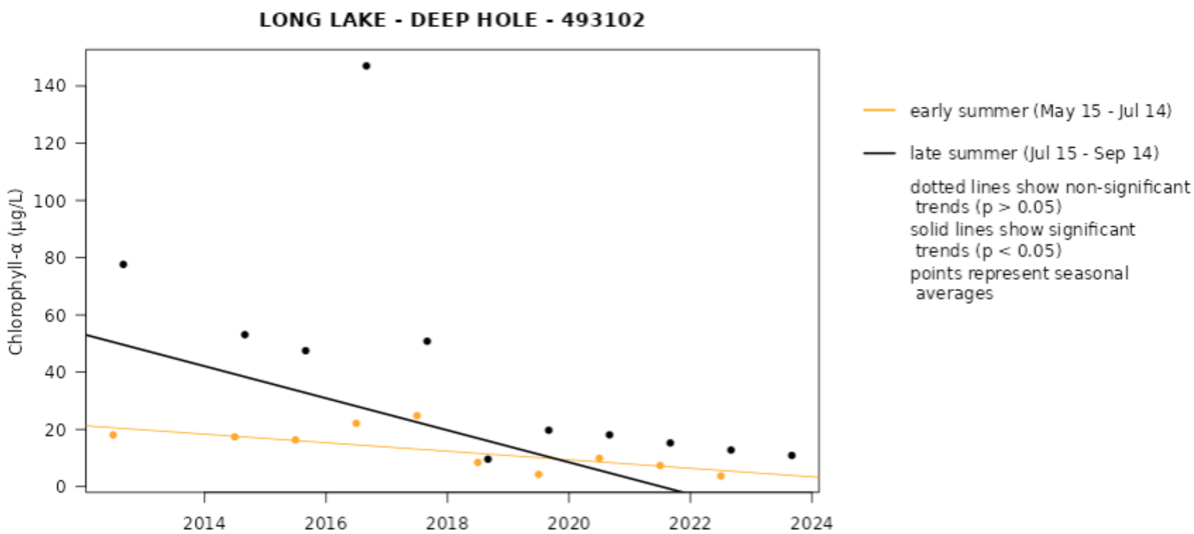
Trends in chlorophyll-α



Legend notes: dotted lines show non-significant trends ($p > 0.05$), solid lines show significant trends ($p < 0.05$), and points represent seasonal averages

A shoreline inventory was completed on Long Lake by volunteers in 2012. For each parcel on the lake land use was categorized for the shoreline and the shoreline buffer area. The presence of coarse woody habitat was also determined at each parcel. Forty-seven percent of the shoreline buffer was natural and 46% was lawn. The survey also showed that 2% of the shoreline buffer area was bare soil and 2% was hard surface. Two parcels, out of a total of one hundred sixty-five, had coarse woody habitat present.

The most recent point intercept survey on Long Lake was completed in July 2021 by Endangered Resource Services, LLC. The survey indicated that 41% of the lake was vegetated. Including visuals, there were 21 species identified in the lake. The Simpson Diversity Index was 0.86. The Floristic Quality Index was 22.4. This value is above the value for the North Central Hardwood Forest region (20.9) indicating that the plant community in Long Lake is healthy and less tolerant to changing water quality and habitat modification. One species was present on Long Lake with a conservatism value of nine: grass-leaved arrowhead. An additional three species with a conservatism value of seven were present on Long Lake.

The Long Lake Protection and Rehabilitation District was established in 1978. The Long Lake Association also exists.

Lost Lake

Lost Lake is an 11-acre seepage lake with a maximum depth of 6 feet. The lake does not have public access.

WiLMS determined the annual nonpoint total phosphorus load as 13 pounds per year. The watershed for Lost Lake is 131 acres and dominated by forest (89%). The Healthy Watersheds Assessment evaluated the Lost Lake Watershed as 73 for Health and 89 for Vulnerability.

The Polk County Land and Water Resources Department collected data on Lost Lake through an Undeveloped Lakes study during which access from a private landowner was obtained. This is the first-time data has been collected for Lost Lake. Lost Lake remained well oxygenated in 2023. Average surface conductivity was 13.4 µg/L in 2023. Summer index period average secchi depth was 6.1 feet in 2023. Total phosphorus and chlorophyll *a* were analyzed at the surface (top 2 meters) of Lost Lake. Summer index period average surface total phosphorus was 28.8 µg/L in 2023. Summer index period average chlorophyll *a* on Lost Lake was 28.3 µg/L in 2023. Lost Lake will also be sampled in 2024.

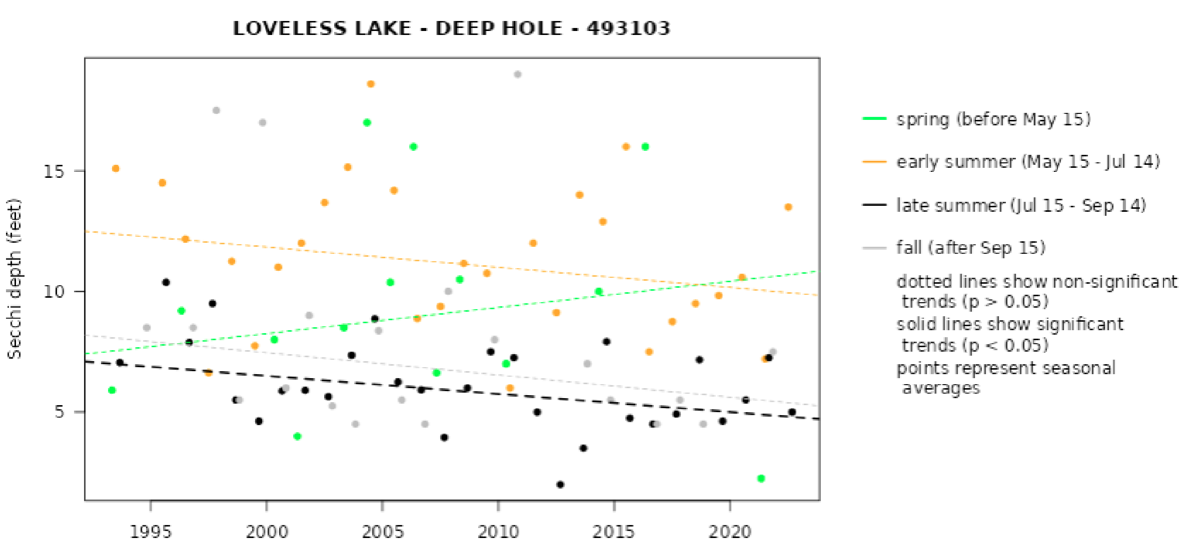
Loveless

Loveless Lake is a 132-acre drainage lake with a maximum depth of 20 feet. Bass Creek exits Loveless Lake on the southeast side of the lake. A single boat landing with a decontamination station provides public access. Chinese mystery snails and curly leaf pondweed are present on the lake. Three ASNRI Sensitive Areas that merit special protection of aquatic habitat are identified on the lake.

WiLMS determined the annual nonpoint total phosphorus load as 147 pounds per year. The watershed for Loveless Lake is 554 acres and dominated by forest (38%), the lake surface (24%), pasture/grass (19%), and row crop (13%). The Healthy Watersheds Assessment evaluated the Loveless Lake Watershed as 55 for Health and 23 for Vulnerability.

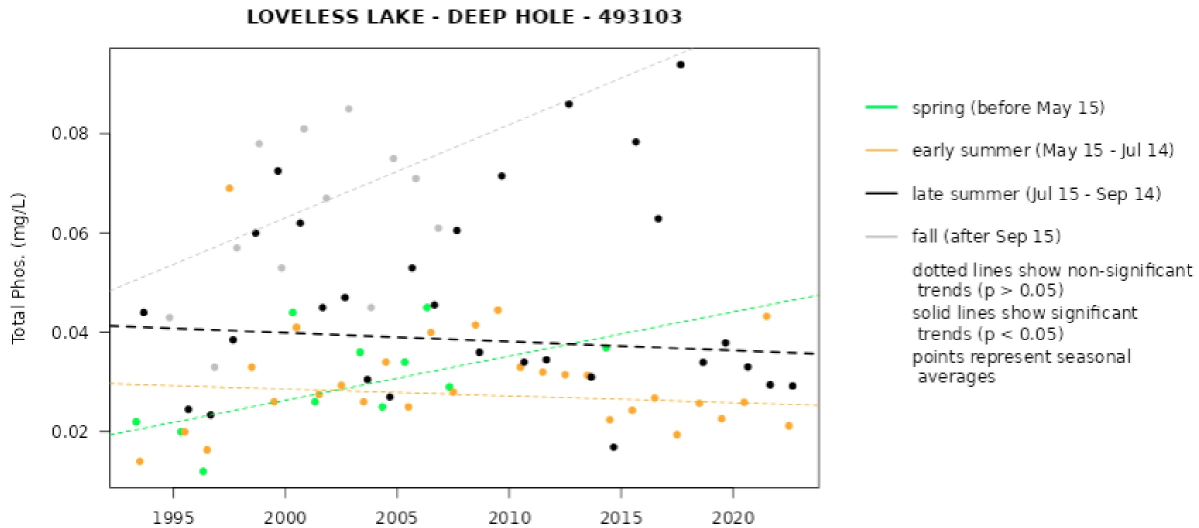
Loveless Lake has been monitored by volunteers since 1994. The average summer trophic state for the last five years based on chlorophyll *a* determined the lake is eutrophic. Averages for the last ten years for secchi, total phosphorus, and chlorophyll *a* indicate that Loveless Lake has comparable water clarity and higher nutrient and algal levels as compared to other shallow headwater lakes. Since 1992, spring secchi has increased and summer and fall secchi has decreased. Since 1993, summer total phosphorus has decreased and spring and fall total phosphorus has increased. Since 1994, summer and fall total chlorophyll *a* has increased.

Trends in Secchi depth



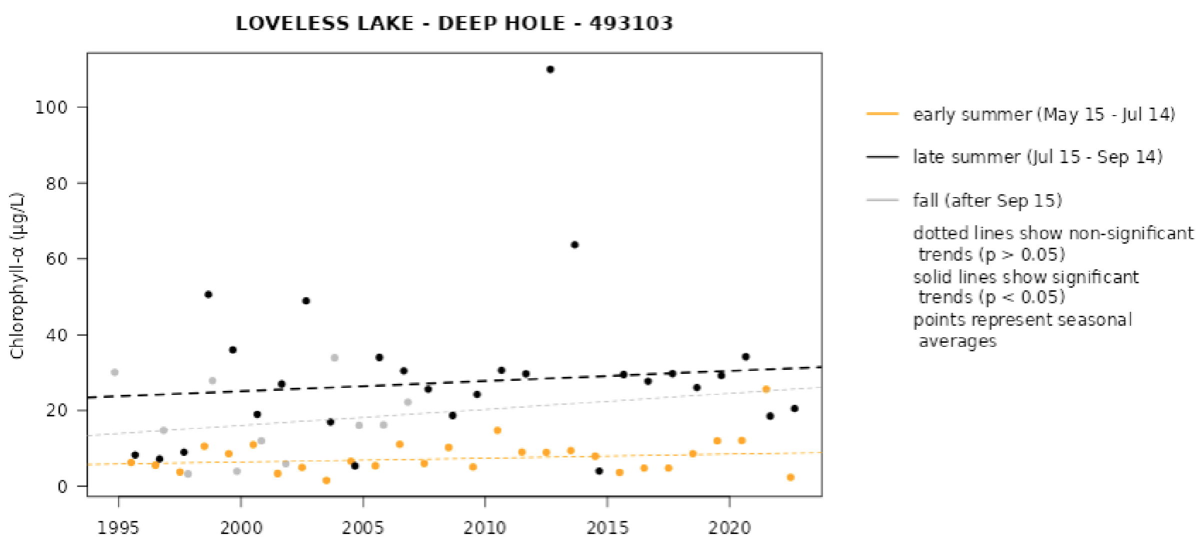
Legend notes: dotted lines show non-significant trends (p > 0.05), solid lines show significant trends (p < 0.05), and points represent seasonal averages

Trends in total phosphorus



Legend notes: dotted lines show non-significant trends (p > 0.05), solid lines show significant trends (p < 0.05), and points represent seasonal averages

Trends in chlorophyll-α



Legend notes: dotted lines show non-significant trends (p > 0.05), solid lines show significant trends (p < 0.05), and points represent seasonal averages

Data on Loveless Lake was not collected as part of this study but was instead collected through the Citizen Lake Monitoring Network. Three parameter Trophic State Index data exists for July and August 2021 and August 2022. July and August 2021 average secchi depth was 7.7 feet and August 2022 secchi depth was 5 feet.

July and August average surface total phosphorus was 29.5 µg/L in 2021 and 29 µg/L in 2022. July and August average chlorophyll *a* was 18.5 µg/L in 2021 and 20.5 µg/L in 2022.

Loveless Lake was listed as an Impaired Water in 2012. At that time, values for Loveless Lake total phosphorus exceeded the recreation standard (40 µg/L) and values for chlorophyll *a* exceed the recreation standard (30% of sample days with chlorophyll *a* greater than 20 ug/L).

A 2014 shoreline inventory was completed on Loveless Lake using the methodology developed by the University of Wisconsin Stevens Point Center for Watershed Science and Education. The survey indicated that 53% of the shoreline was organic leaf pack/needles, 25% was mowed vegetation, and 17% was short un-mowed vegetation. The shoreline inventory also characterized disturbances around Loveless Lake. There was a total of 5 decks, 1 personal boat landing, 2 artificial beaches, and 1 concrete slab. Additionally, there were 23 segments containing riprap and 8 segments containing seawalls. Two shoreline segments were dominated by bare dirt and 19 segments had bare dirt present, although it was not dominant. There were 27 areas along the shoreline of Loveless Lake that included coarse woody structure.

Spring and fall aquatic plant point intercept surveys were completed on Loveless Lake in 2022. The surveys indicated that 16% of the lake was vegetated in the spring and 13% was vegetated in the fall. Including visuals, there were 18 species identified in the lake in the spring and 13 species identified in the fall. The Simpson Diversity Index was 0.89 in the spring and 0.84 in the fall. The Floristic Quality Index was 24.3 in the spring survey and 21.9 in the fall survey. These values are above the values for the North Central Hardwood Forest region (20.9). Three species were present on Loveless Lake with a conservatism value of eight: fries' pondweed, stiff pondweed, and white-water crowfoot. An additional two species with a conservatism value of seven were present on Loveless Lake.

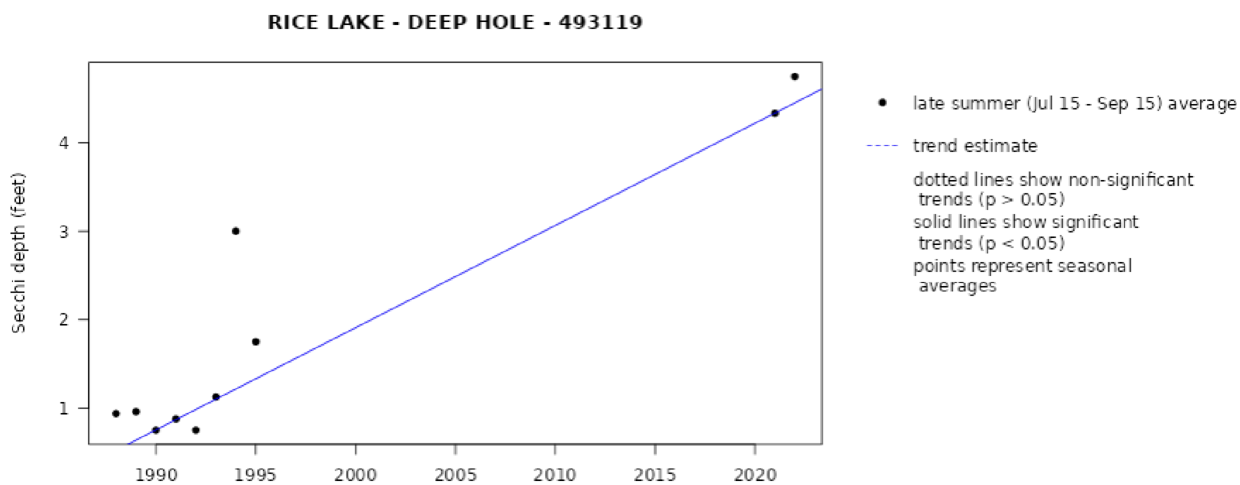
The Loveless Lake Association is currently in the process of transitioning to a lake district.

Rice Lake

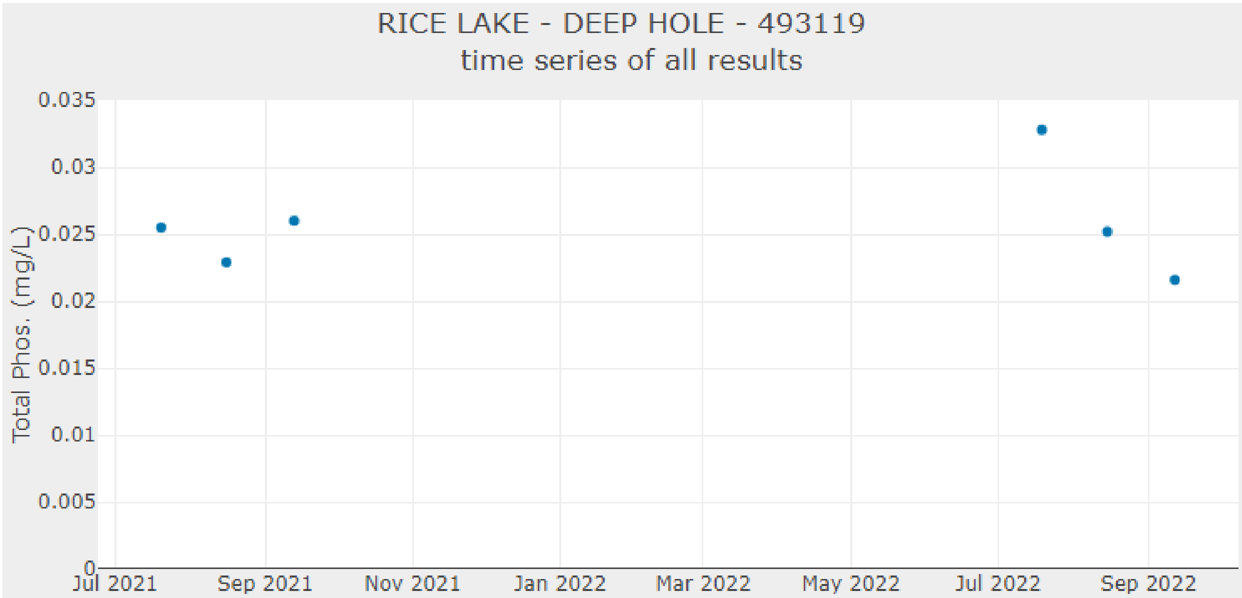
Rice Lake is a 128-acre drainage lake with a maximum depth of 10 feet. A single boat landing located on the south side of the lake provides public access. The lake is designated as an ASNRI Wild Rice Area. The watershed for Rice Lake is 4,992 acres and dominated by pasture/grass (43%), row crop (32%), and forest (10%). The Healthy Watersheds Assessment evaluated the Rice Lake Watershed as 29 for Health and 23 for Vulnerability. WiLMS determined the annual nonpoint total phosphorus load as 2,175 pounds per year.

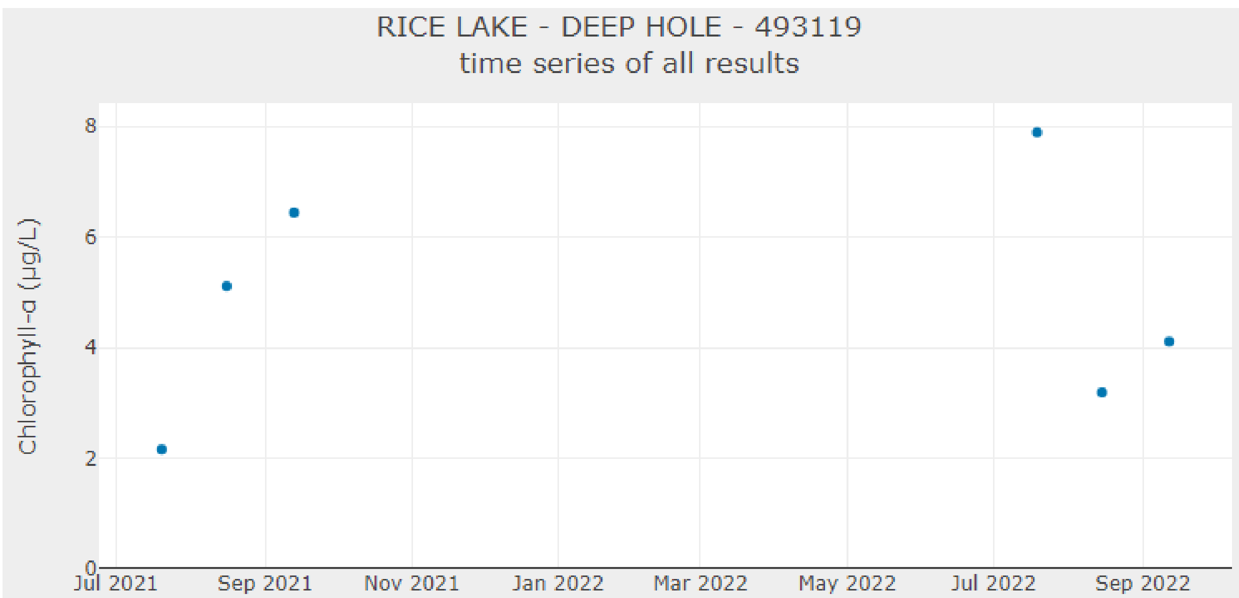
Rice Lake was monitored by volunteers from 1988 to 1995. Trophic State Index data for 2021 and 2022 indicate that Rice Lake is eutrophic. Since 1988, late summer secchi has increased ($p < 0.05$). There is not currently enough data to indicate trend analysis for total phosphorus and chlorophyll *a*.

Trends in Secchi depth



Legend notes: dotted lines show non-significant trends ($p > 0.05$), solid lines show significant trends ($p < 0.05$), and points represent seasonal averages





Rice Lake remained well oxygenated in 2021 and 2022. Average surface conductivity in 2021 was 224 µg/L in 2021 and 204 µg/L in 2022.

Secchi depth values on Rice Lake ranged from a low of 4 feet to a high of 5 feet over the course of this study. Summer index period average secchi depth was 4.3 feet in 2021 and 4.8 feet in 2022.

Total phosphorus and chlorophyll *a* were analyzed at the surface (top 2 meters) of Rice Lake. Summer index period average surface total phosphorus was 24.8 µg/L in 2021 and 26.5 µg/L in 2022. Summer index period average chlorophyll *a* on Rice Lake was 4.6 µg/L in 2021 and 5.1 µg/L in 2022.

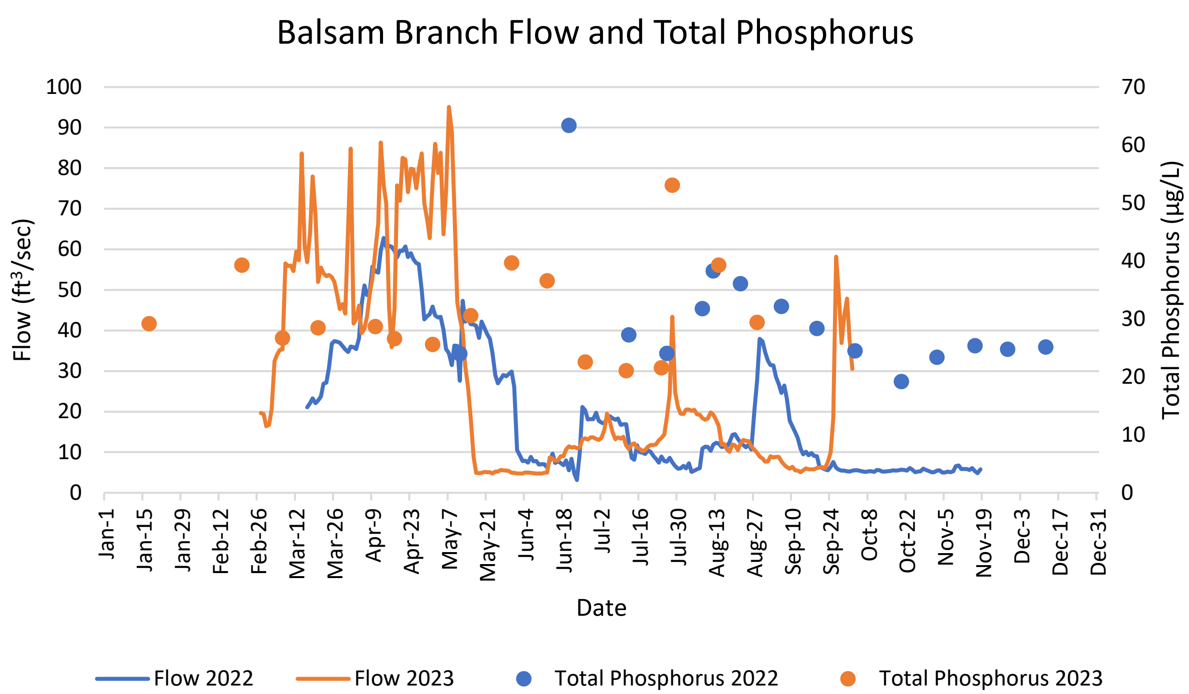
A 2021 shoreline inventory determined that the average tree canopy cover per parcel on Rice Lake is 89%. Ninety-nine percent of the ground cover in the riparian zone on Rice Lake is shrub/herbaceous and 1% is lawn. In total there is 1 firepit and 6 boats in the riparian buffer zone. Runoff concerns in the riparian buffer zone include 1 parcel with sand deposits and 3 parcels with bare soil. There were no documented bank zone concerns on Rice Lake. There were 11 pieces of wood in the water or 3 per mile of shoreline.

Spring and fall aquatic plant point intercept survey were completed on Rice Lake in 2014. The surveys indicated that 95% of the lake was vegetated in the spring and 97% was vegetated in the fall. Including visuals, there were 23 species identified in the lake in the spring and 26 species identified in the fall. The Simpson Diversity Index was 0.89 in the spring and 0.87 in the fall. The Floristic Quality Index was 26.8 in the spring survey and 25.6 in the fall survey. These values are above the value for the North Central Hardwood Forest region (20.9). One species was present on Rice Lake with a conservatism value of nine: large purple bladderwort. An additional two species with a conservatism value of eight and six species with a conservatism value of seven were present.

Stream Summaries

Balsam Branch

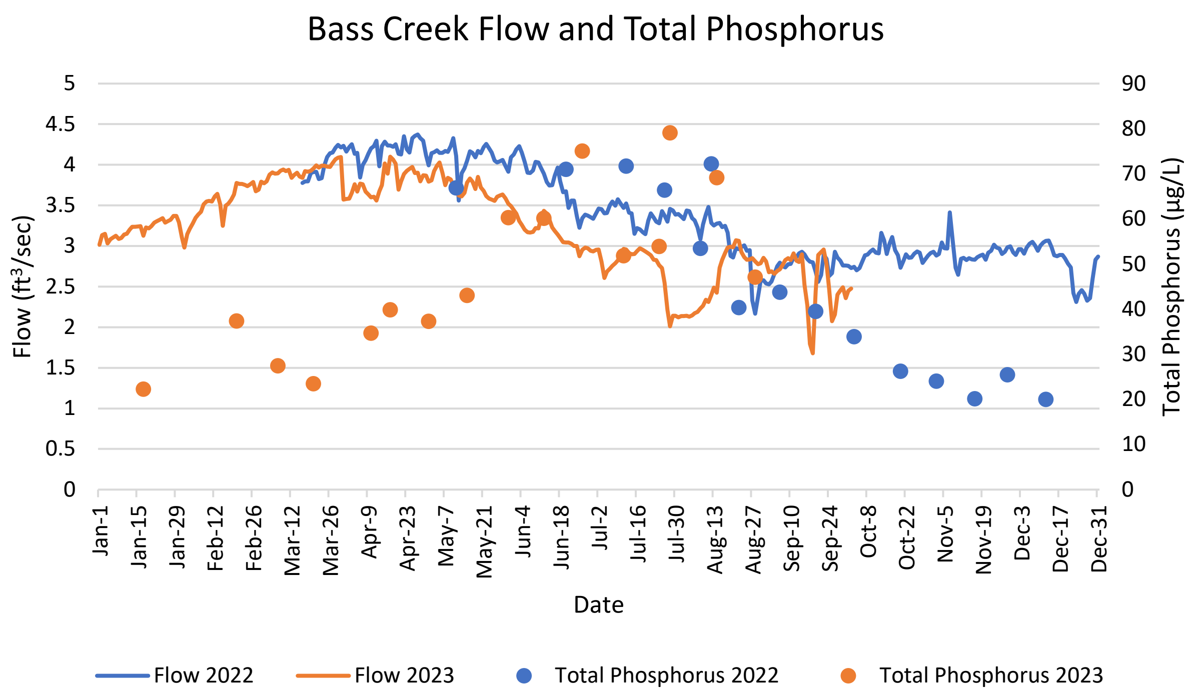
The Balsam Branch exits Balsam Lake and flows to Lake Wapogasset. The entire tributary is designated as either an ASNRI Wild Rice Stream or an ASNRI Wild Rice Area. The Balsam Branch was sampled at 150th Avenue. The two reinforced concrete pipe culverts were replaced in August 2022 with a larger single corrugated metal box culvert. Dissolved oxygen at the Balsam Branch ranged from 6.16 mg/L to 12.95 mg/L. Transparency was greater than 120 on 87% of the sampling days. Flow ranged from a low of 7.52 ft^3/sec to a high of 94.80 ft^3/sec on May 1st, 2022. Average total phosphorus over the course of the study was 30.5 µg/L and average total suspended solids were 4.34 mg/L. FLUX determined an annual total phosphorus load for the Balsam Branch of 1,402 pounds.



The Average Macroinvertebrate Score for the Balsam Branch was 2.6 which is considered good. The Total Qualitative Fish Habitat Score for the Balsam Branch was 70 which is considered good.

Bass Creek

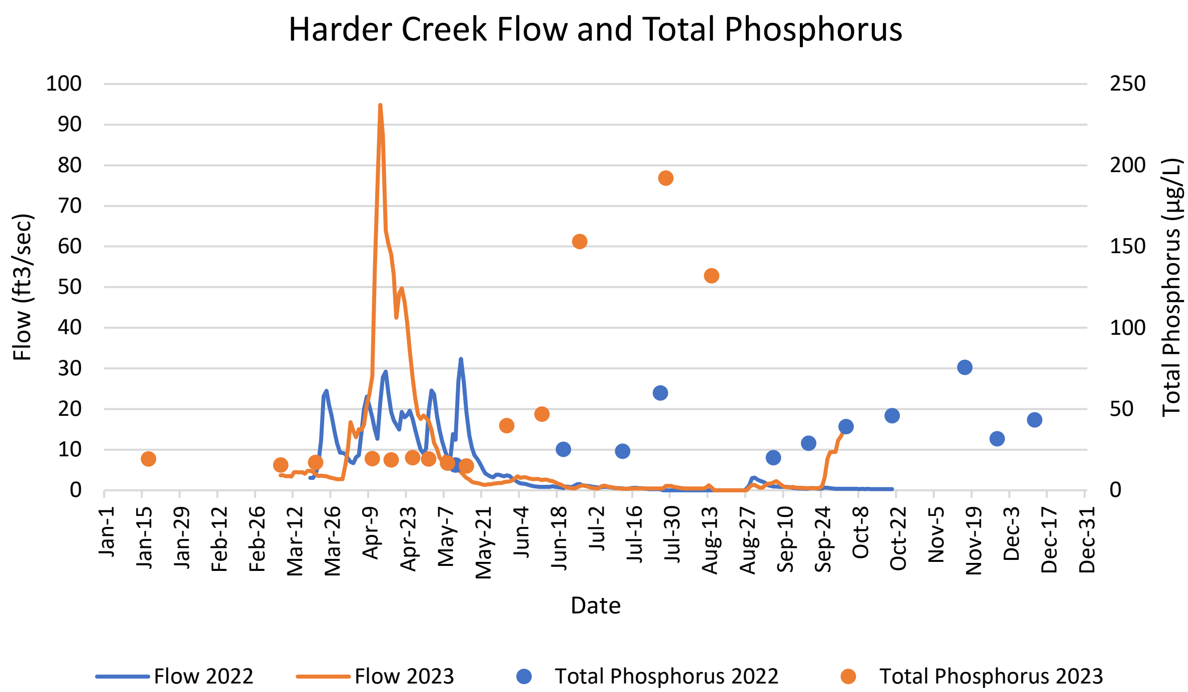
Bass Creek exits Loveless Lake and flows through Little Bass Lake. Bass Creek was sampled at 150th Avenue. Dissolved oxygen at Bass Creek ranged from 2.18 mg/L to 12.29 mg/L. Transparency was greater than 120 on 100% of the sampling days. Flow ranged from a low of 2.18 ft^3/sec to a high of 5.88 ft^3/sec on March 16th, 2022. Average total phosphorus over the course of the study was 46.4 µg/L and average total suspended solids were 3.6 mg/L. FLUX determined an annual total phosphorus load for Bass Creek of 299 pounds.



The Average Macroinvertebrate Score for Bass Creek was 2.3 which is considered fair. The Total Qualitative Fish Habitat Score for Bass Creek was 45 which is considered fair.

Harder Creek

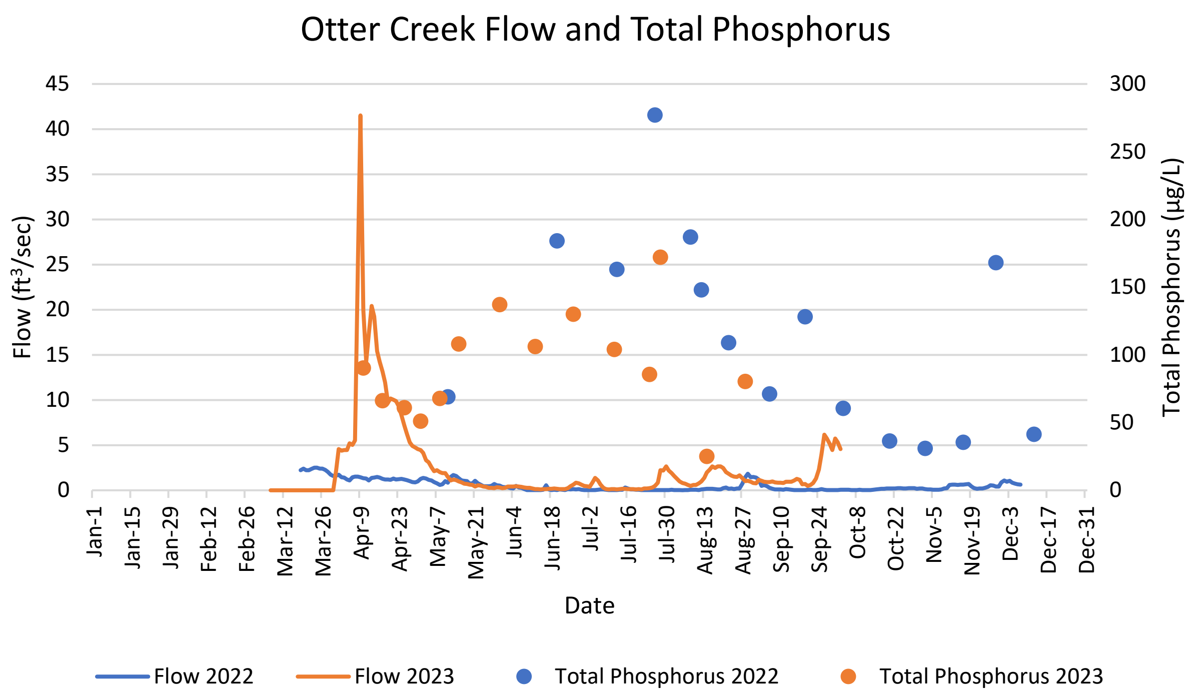
Harder Creek flows through Half Moon Lake before entering Balsam Lake. Harder Creek was sampled at 190th Avenue. Dissolved oxygen at Harder Creek ranged from 2.24 mg/L to 13.73 mg/L. Transparency was greater than 120 on 83% of the sampling days. Flow ranged from a low of 0 ft^3/sec (when the stream bed dried up) to a high of 48.85 on April 17th, 2023. Harder Creek was dry when the site was visited on August 8th, August 22nd, and November 2nd, 2022, and on July 11th and July 24th, 2023. There were also periods of no flow with standing water. Average total phosphorus over the course of the study was 45.3 µg/L and average total suspended solids was 0.615 mg/L. FLUX determined an annual total phosphorus load for Harder Creek of 291 pounds.



The Average Macroinvertebrate Score for Harder Creek was 2.1 which is considered fair. The Total Qualitative Fish Habitat Score for Harder Creek was 45 which is considered fair.

Otter Creek

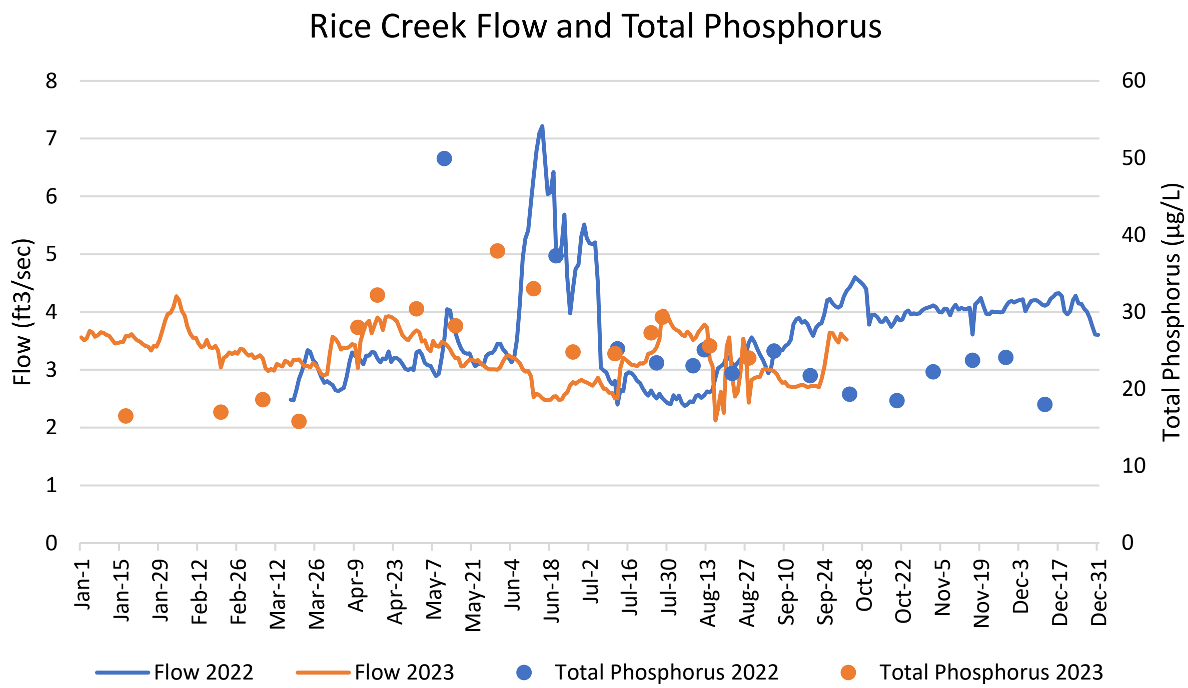
Otter Creek flows through Otter Lake before joining Rice Creek and entering Balsam Lake. Otter Creek was sampled at 200th Avenue. Dissolved oxygen at Otter Creek ranged from 5.68 mg/L to 12.89 mg/L. Transparency was greater than 120 on 79% of the sampling days. Flow ranged from a low of 0 ft^3/sec to a high of 14.11 ft^3/sec on April 17th, 2023. Otter Creek was dry when the site was visited on March 7th and March 20th, 2023. Average total phosphorus over the course of the study was 103 µg/L and average total suspended solids was 6.2 mg/L. FLUX determined an annual total phosphorus load for Otter Creek of 225 pounds. The state standard for impairment for total phosphorus for streams is 75 µg/L. Otter Creek exceeded the standard in 2022 and 2023.



The Average Macroinvertebrate Score for Otter Creek was 2.3 which is considered fair. The Total Qualitative Fish Habitat Score for Otter Creek was 48 which is considered fair.

Rice Creek

Rice Creek flows through Rice Lake before entering Balsam Lake. Rice Creek was sampled at 155th Street. Dissolved oxygen at Rice Creek ranged from 1.7 mg/L to 14.87 mg/L. Transparency was greater than 120 on 84% of the sampling days. Flow ranged from a low of 1.97 ft^3/sec to a high of 19.35 ft^3/sec on June 20th, 2022. Average total phosphorus over the course of the study was 25.5 µg/L and average total suspended solids was 2.12 mg/L. FLUX determined an annual total phosphorus load for Rice Creek of 173 pounds.

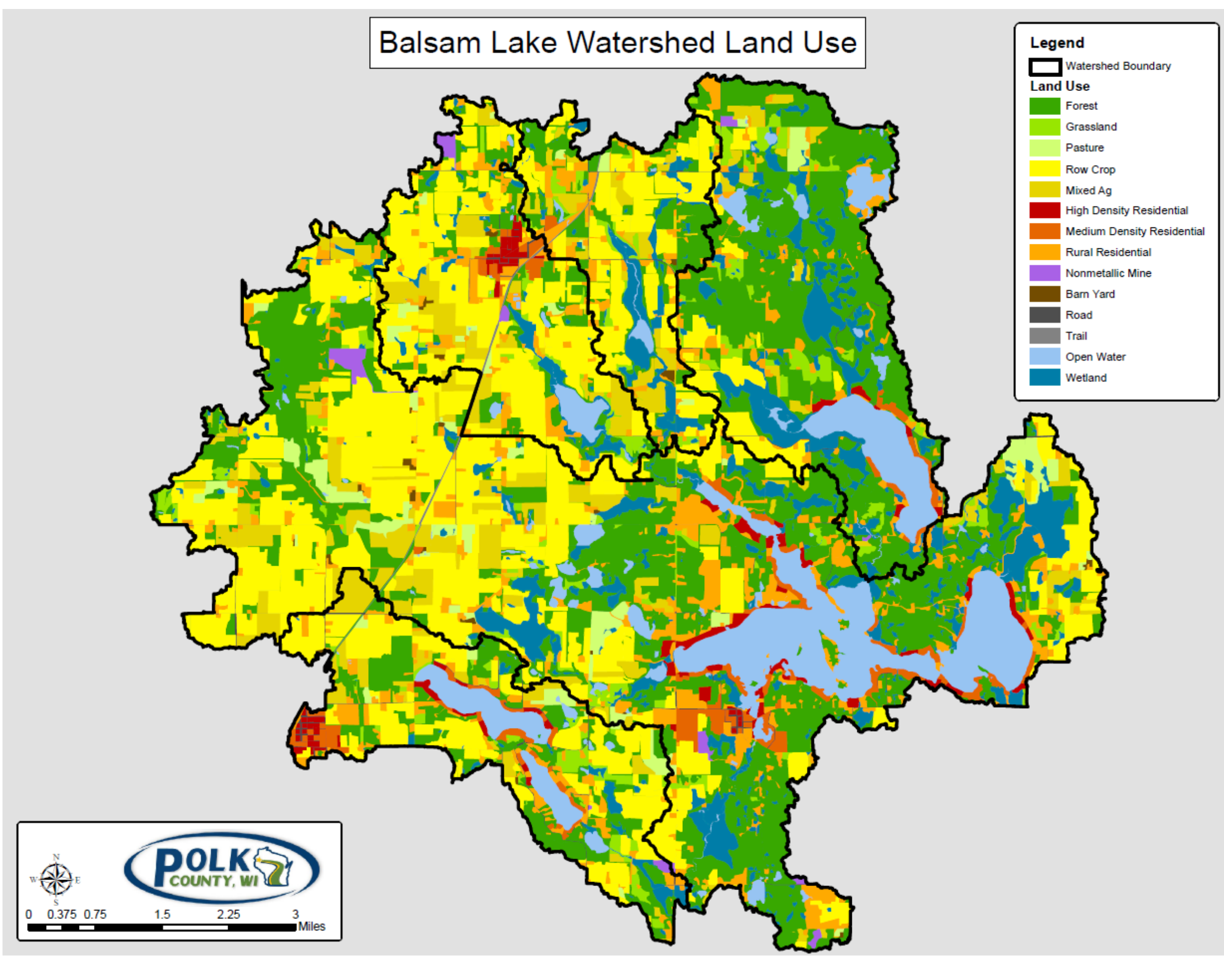


The Average Macroinvertebrate Score for Rice Creek was 2.4 which is considered fair. The Total Qualitative Fish Habitat Score for Rice Creek was 35 which is considered fair.

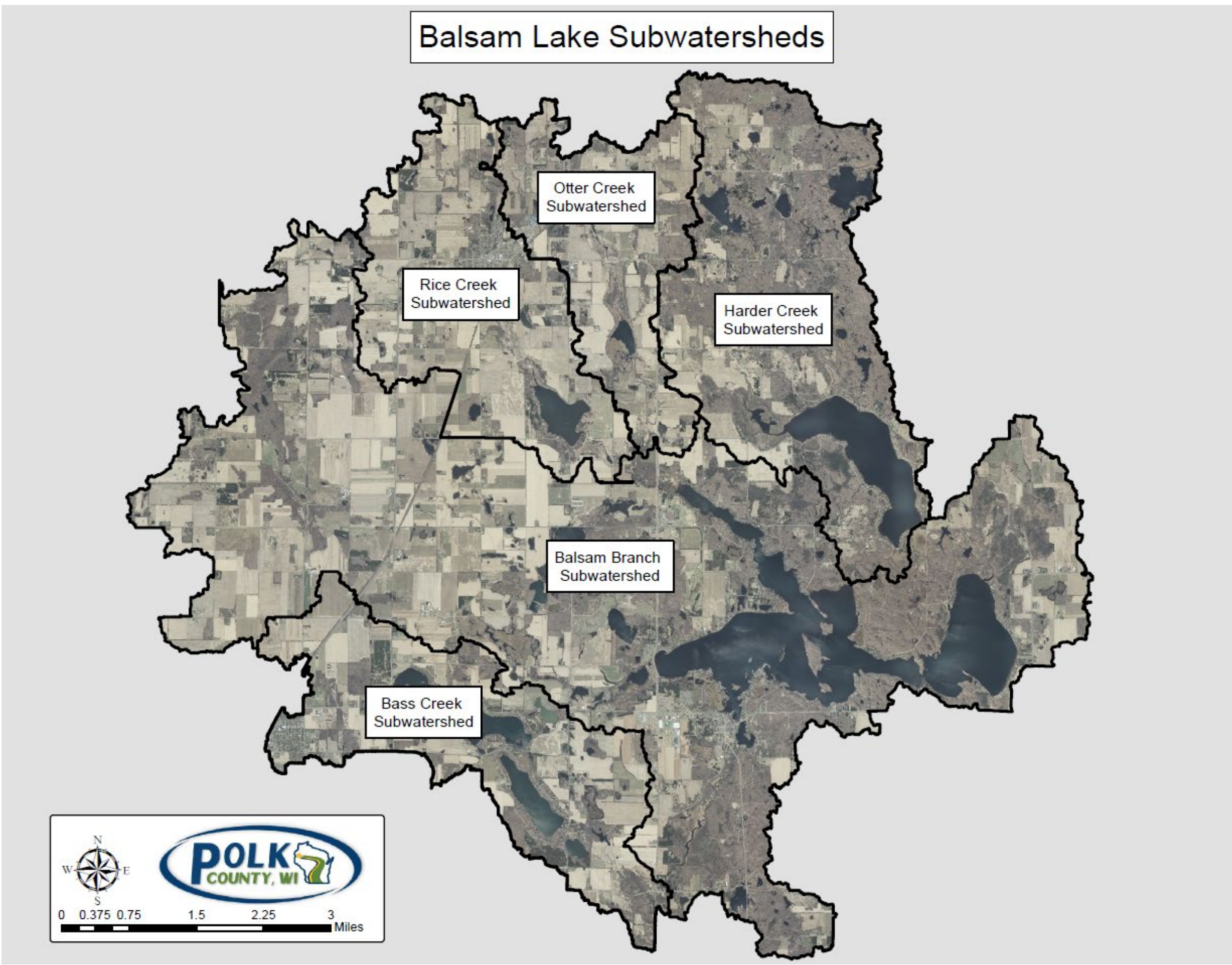
Balsam Lake Watershed Land Use

The area of land that drains to a lake is called a watershed. The ArcMap spatial Analyst Toolbox and LiDAR elevation data was used to delineate the Balsam Lake Watershed. Field verification was used to identify culvert locations within the watershed to allow for accurate watershed delineation. The Balsam Lake Watershed is 39,004 acres in size. The watershed is primarily forest (28%) and row crop (26%), followed by open water (10%), wetland (9%), rural residential (9%), and mixed agriculture (8%).

Land Use	Acres	Acres (%)
Forest	10,743	28%
Row Crop	10,324	26%
Open Water	3,899	10%
Rural Residential	3,525	9%
Wetland	3,453	9%
Mixed Ag	2,985	8%
Grassland	1,182	3%
Pasture	845	2%
Medium Density Residential	723	2%
Road	529	1%
High Density Residential	483	1%
Nonmetallic Mine	185	0%
Barn Yard	74	0%
Trail	53	0%
Total	**39,004**	**100%**



The Balsam Lake Watershed was divided into five subwatersheds: the Balsam Branch Subwatershed, the Bass Creek Subwatershed, the Harder Creek Subwatershed, the Otter Creek Subwatershed, and the Rice Creek Subwatershed. The Harder Creek, Otter Creek, and Rice Creek Subwatersheds all flow to Balsam Lake and the Balsam Branch Subwatershed. Subwatershed boundaries can be visualized by looking at flow paths or areas where water channelizes into a small stream. Small flow paths can remain nearly invisible to the naked eye or can combine as a larger flow path which is visible as a stream. Subwatershed boundaries are delineated based on changes in stream order. Flow paths can also be used to identify areas of overland flow where best management practices should be prioritized.



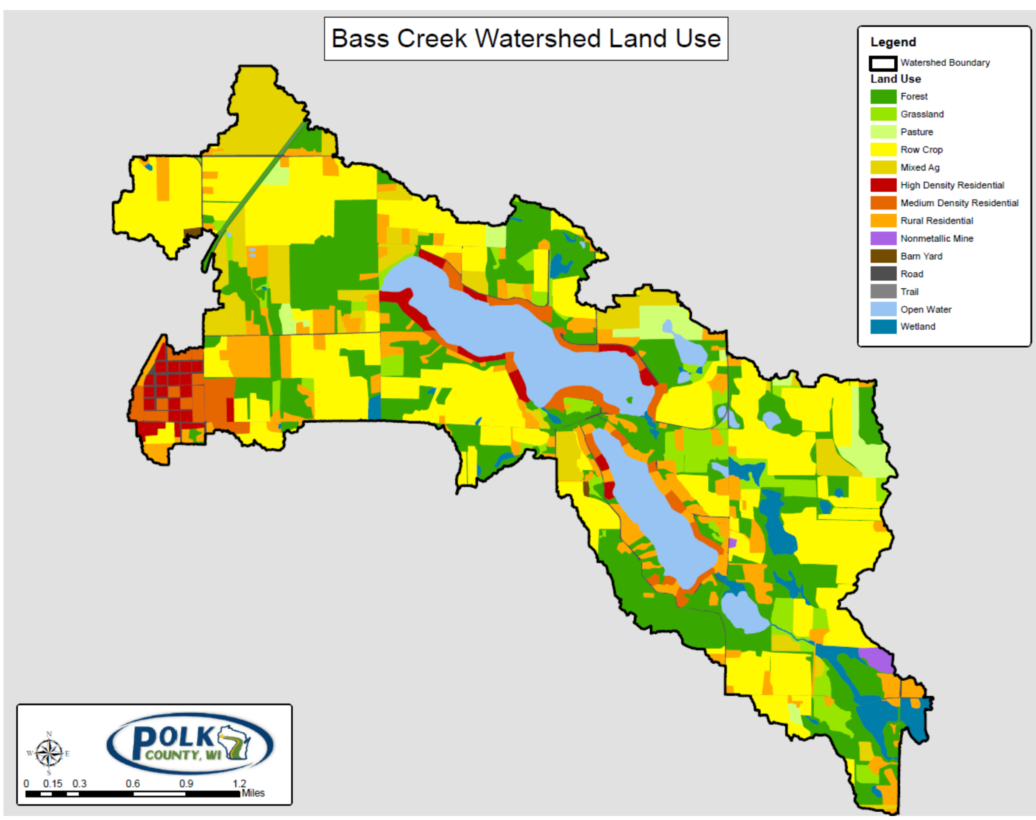
Bass Creek Subwatershed

The Bass Creek Subwatershed is 4,541 acres in size and is primarily row crop (30%) and forest (23%) followed by open water (11%) and rural residential (10%).

Land Use	Acres	Acres (%)
Row Crop	1,358	30%
Forest	1,036	23%
Open Water	482	11%
Rural Residential	464	10%
Mixed Agriculture	356	8%
Grassland	203	4%
Medium Density Residential	156	3%
Wetland	155	3%
Pasture	115	3%
High Density Residential	102	2%
Road	90	2%
Nonmetallic Mine	14	0%
Barn Yard	5	0%
Trail	4	0%
Total	**4,541**	**100%**

The Bass Creek Subwatershed includes Long Lake, Loveless Lake, and Little Bass Lake which are all eutrophic. A portion of the Village of Centuria also falls inside the watershed.

Average total phosphorus for Bass Creek was 46.4 µg/L and the system contributes 299 pounds of phosphorus to the Balsam Branch. On a pound per acre basis, the Bass Creek Subwatershed is the second highest loading subwatershed in the Balsam Lake Watershed (0.066 pounds per acre). Long and Loveless Lakes are highly developed with areas of high density residential. These areas should be prioritized for best management practice implementation. Additionally, with a high percentage of row crop, opportunities exist for agricultural best management practices in this subwatershed.



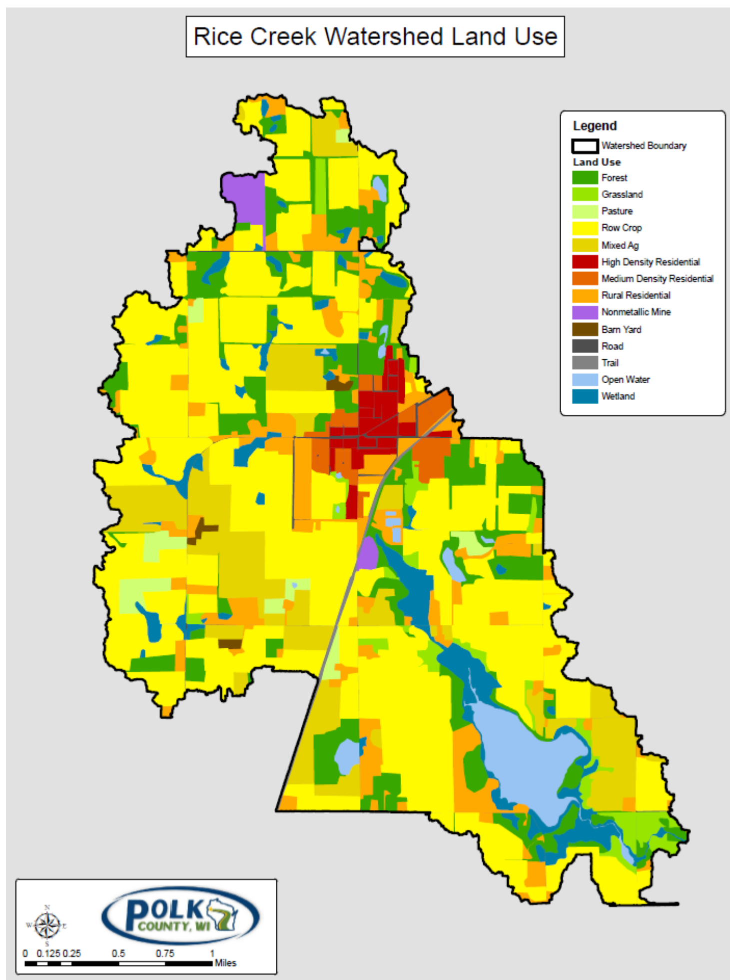
Rice Creek Subwatershed

The Rice Creek Subwatershed is 4,463 acres in size and is primarily row crop (45%) followed by forest (13%), mixed agriculture (11%), and rural residential (10%).

Land Use	Acres	Acres (%)
Row Crop	1,998	45%
Forest	567	13%
Mixed Agriculture	510	11%
Rural Residential	444	10%
Wetland	242	5%
Open Water	180	4%
Grassland	122	3%
Medium Density Residential	83	2%
High Density Residential	82	2%
Road	80	2%
Pasture	75	2%
Nonmetallic Mine	45	1%
Trail	21	0%
Barn Yard	14	0%
Total	**4,463**	**100%**

The Rice Creek Subwatershed includes Rice Lake which is eutrophic and portions of the Village of Milltown.

Rice Creek average total phosphorus was 25.5 µg/L which was the lowest of all the tributary sample sites. On an annual basis the Rice Lake Subwatershed contributes 173 pounds of phosphorus. The Rice Creek Subwatershed has the second lowest phosphorus load on a pound per acre basis (0.039 pounds per acre). Although there is a high percentage of development and agriculture in this subwatershed, this subwatershed would be the lowest priority for project implementation in the Balsam Lake Watershed.



Otter Creek Subwatershed

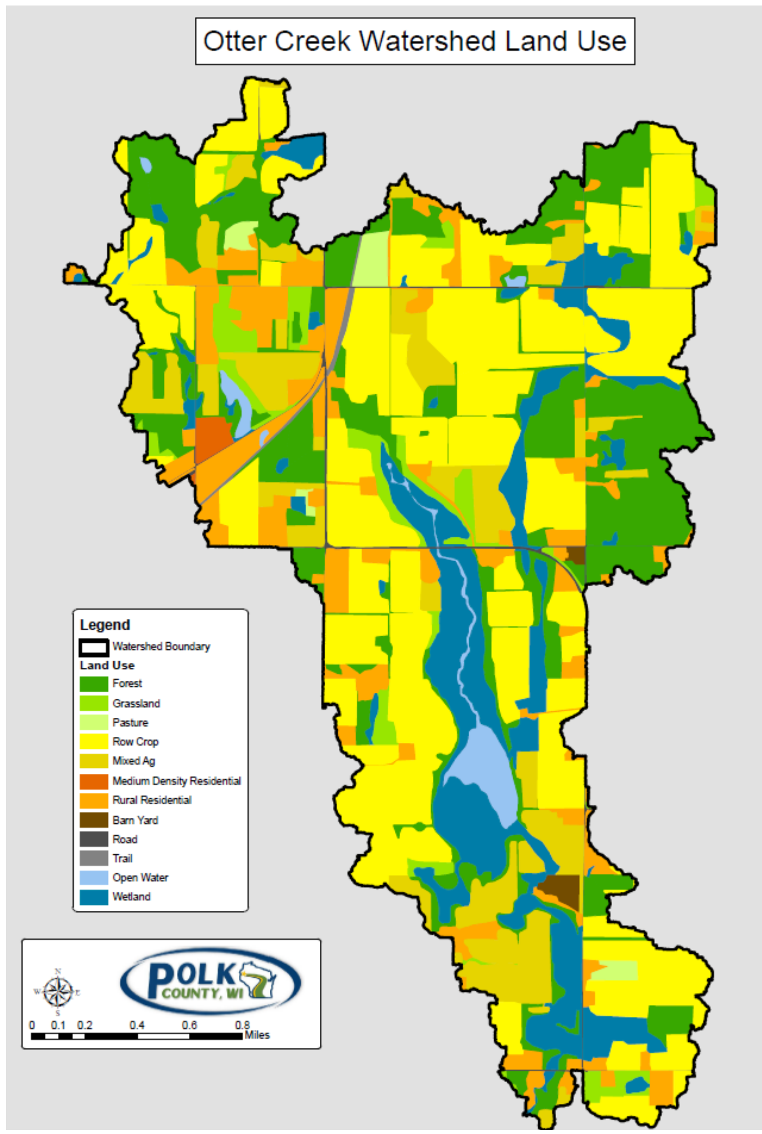
The Otter Creek Subwatershed is 3,175 acres in size and is primarily row crop (36%) followed by forest (21%), wetland (12%), rural residential (11%), and mixed agriculture (11%).

Land Use	Acres	Acres (%)
Row Crop	1,156	36%
Forest	663	21%
Wetland	392	12%
Rural Residential	347	11%
Mixed Agriculture	335	11%
Grassland	115	4%
Open Water	56	2%
Road	47	1%
Pasture	31	1%
Medium Density Residential	12	0%
Barn Yard	12	0%
Trail	9	0%
Total	**3,175**	**100%**

The Otter Creek Subwatershed includes Otter Lake.

Otter Creek has the highest average total phosphorus concentration (103 µg/L) and is considered impaired since this value exceeds the standard for streams which is set at 75 µg/L. Additionally, the Otter Creek Subwatershed has the highest phosphorus loading on a pound per acre basis (0.071 pounds per acre).

With a large percentage of agriculture land use, opportunities exist for agricultural best management practices. When considering the entire Balsam Lake Watershed, the Otter Creek Subwatershed should be prioritized for project implementation.



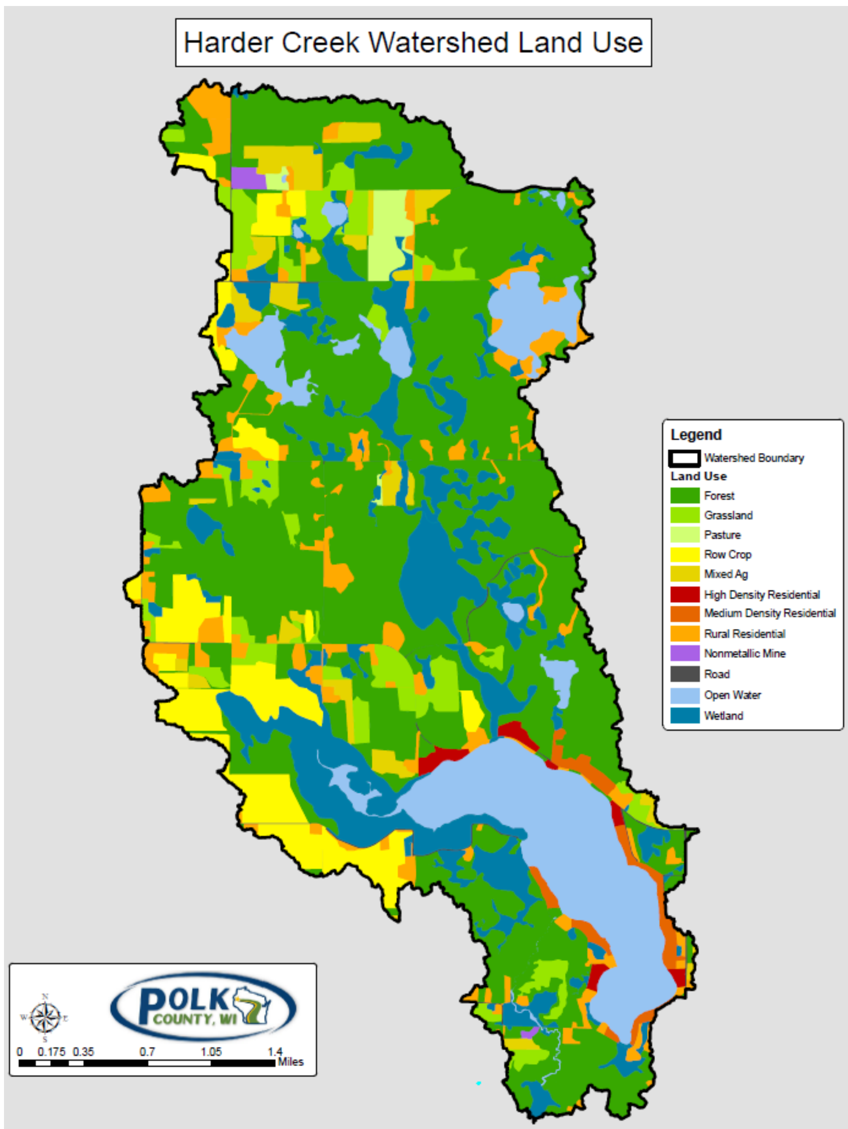
Harder Creek Subwatershed

The Harder Creek Subwatershed is 6,543 acres in size and is primarily forest (46%) followed by wetland (15%) and open water (13%).

The Harder Creek Subwatershed includes Antler Lake and Half Moon Lake, both of which are mesotrophic.

Harder Creek has an average total phosphorus concentration of 45.3 µg/L and an annual phosphorus load of 291 pounds per acre. The Harder Creek Subwatershed has the third highest phosphorus loading on a pound per acre basis (0.044 pounds per acre). Numerous areas of high density residential exist on Half Moon Lake which should be prioritized for restoration.

Land Use	Acres	Acres (%)
Forest	2,997	46%
Wetland	972	15%
Open Water	837	13%
Row Crop	455	7%
Rural Residential	453	7%
Grassland	365	6%
Mixed Agriculture	215	3%
Medium Density Residential	68	1%
Pasture	65	1%
Road	63	1%
High Density Residential	38	1%
Nonmetallic Mine	16	0%
Total	**6,543**	**100%**



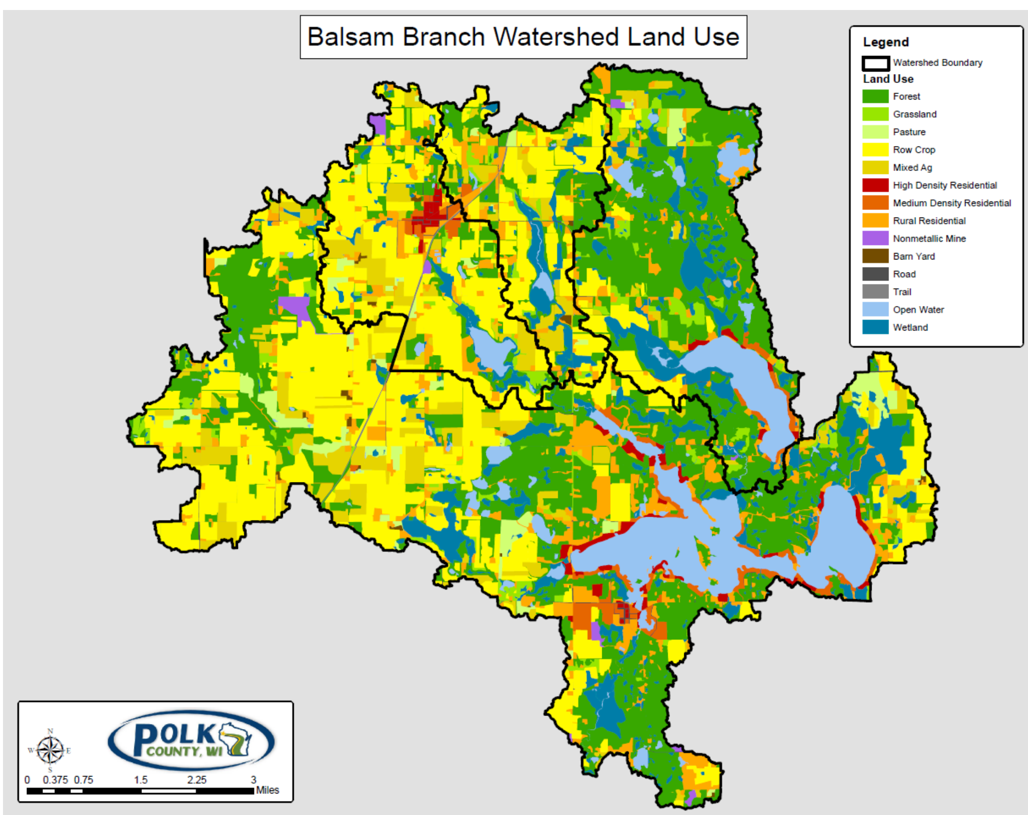
Balsam Branch Subwatershed

Land Use	Acres	Acres (%)
Forest	9,707	28%
Row Crop	8,966	26%
Open Water	3,417	10%
Wetland	3,298	10%
Rural Residential	3,061	9%
Mixed Agriculture	2,629	8%
Grassland	979	3%
Pasture	730	2%
Medium Density Residential	567	2%
Road	439	1%
High Density Residential	381	1%
Nonmetallic Mine	170	0%
Barn Yard	68	0%
Trail	49	0%
Total	**34,463**	**100%**

The Balsam Branch Subwatershed is 34,463 acres in size and is primarily forest (28%) and row crop (26%), followed by open water (10%), and wetland (10%).

The Balsam Branch Subwatershed includes Rice Lake which is eutrophic and Antler, Balsam, and Half Moon Lakes which are mesotrophic. East Balsam Lake is listed as an Impaired Water and is also included in the Balsam Branch Subwatershed.

The Balsam Branch Subwatershed includes the Rice Creek, Otter Creek, and Harder Creek Subwatersheds as well as the area of land that drains directly to Balsam Lake. By removing the contributing areas from the Rice Creek, Otter Creek, and Harder Creek Subwatersheds it was determined that the annual phosphorus load for the remaining land area was the lowest in the Balsam Lake Watershed (0.035 pounds per acre). With a large amount of high-density residential areas around Balsam Lake, these areas should be prioritized for restoration.



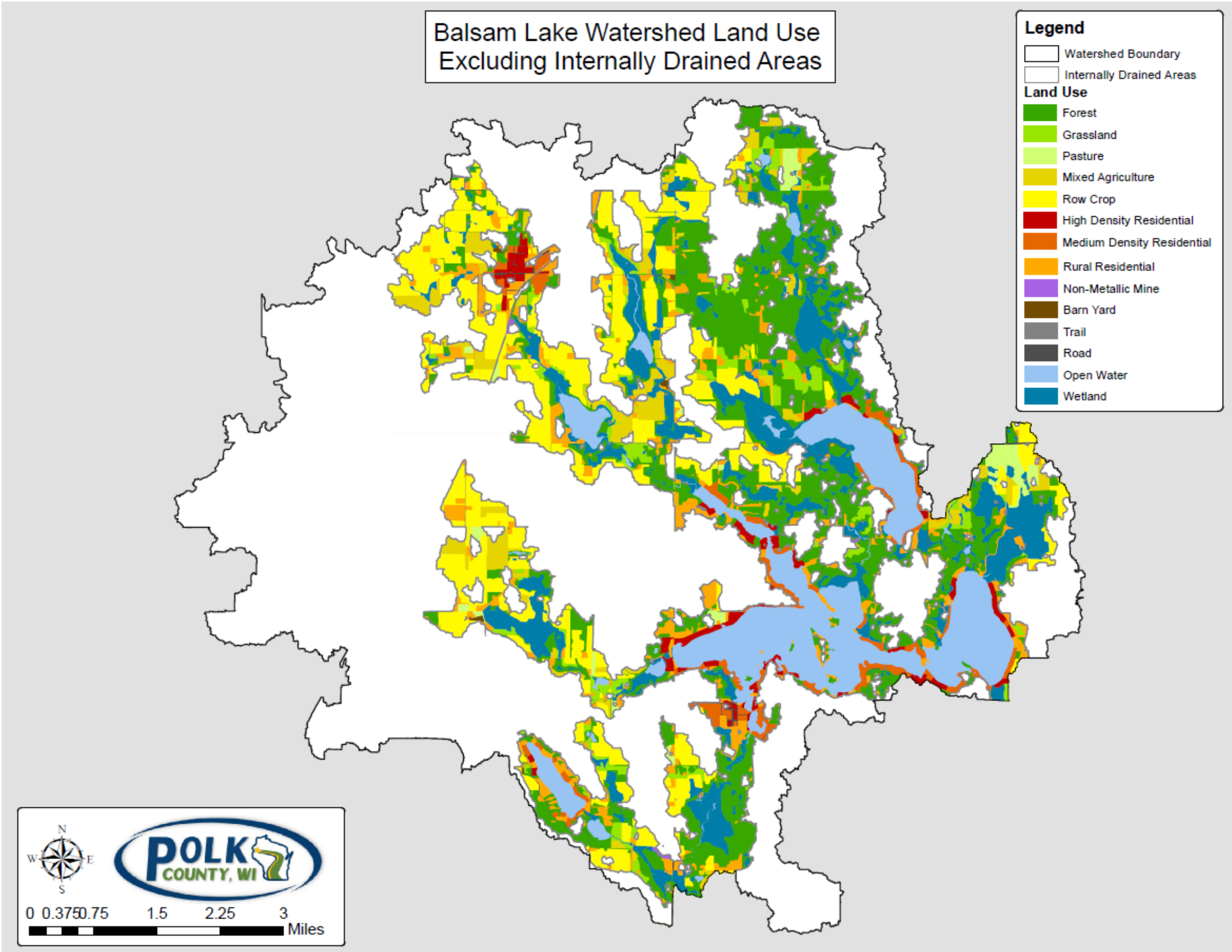
Internally Drained Areas

The Balsam Lake Watershed is a unique landscape because a part of the landscape is internally drained. Internally drained areas are depressions on the landscape that accumulate water during rainfall events and spring snowmelt. The depressions are deep enough that water is not able to exit the depression. Therefore, water that accumulates in internally drained areas infiltrates into the ground rather than contributing to overland runoff/flow to a lake or river. Internally drained areas are delineated based on storm intensity. For this project, a 10-year storm with a duration of 24 hours was used to delineate internally drained areas. This is equivalent to 4.2 inches of rain falling within a 24-hour period. This storm intensity is the commonly used standard for which conservation practices are designed to withstand.

In total, 17,823 acres (46%) of the Balsam Lake Watershed is internally drained. If 4.2 inches (or less) of rain falls within a 24-hour timeframe these acres of the Balsam Lake Watershed will not contribute runoff to lakes or rivers. One way to prioritize project installation is to focus more effort on the land within the watershed that contributes runoff to lakes and rivers during lower intensity events. It is important not to entirely discount internally drained areas because under higher storm intensity events or snow melt events runoff from these areas would contribute runoff to lakes and rivers in the Balsam Lake Watershed.

Excluding the internally drained areas, the Balsam Lake Watershed is primarily forest (25%), followed by row crop (19%), open water (17%), and wetland (15%). The following map displays the land use for the areas that contribute runoff from the Balsam Lake Watershed and excludes the areas that are internally drained based off a 10 year 24-hour storm.

Land Use	Acres	Acres %
Forest	4,438	25%
Row Crop	3,328	19%
Open Water	3,059	17%
Wetland	2,698	15%
Rural Residential	1,451	8%
Mixed Agriculture	900	5%
Grassland	650	4%
Medium Density Residential	430	2%
High density Residential	337	2%
Pasture	249	1%
Road	230	1%
Trail	21	0%
Barn Yard	19	0%
Non-Metallic Mine	14	0%
Total	**17,823**	**100%**


Balsam Lake Watershed Land Use
Excluding Internally Drained Areas
Legend
Watershed Boundary
Internally Drained Areas
Land Use
Forest
Grassland
Pasture
Mixed Agriculture
Row Crop
High Density Residential
Medium Density Residential
Rural Residential
Non-Metallic Mine
Barn Yard
Trail
Road
Open Water
Wetland
POLK COUNTY, WI
0 0.375 0.75 1.5 2.25 3
Miles

Identification of Protection and Restoration Priorities

The results of the shoreline inventory were used to develop maps for each lake to identify shoreline lengths to prioritize for both protection and restoration. Shoreline lengths with minimal disturbance were mapped as areas of protection and shoreline lengths with runoff concerns in the riparian buffer zone (bare soil, channelized flow/gully, and sand/silt deposits) were mapped as areas of restoration.

The historic shoreline inventories completed on Long and Loveless Lakes were done with different methodologies and data was collected for each parcel. For Loveless Lake, parcels with a dominant vegetation and ground cover of organic-leaf pack/needles and short un-mowed vegetation should be prioritized for protection. Parcels with barren/bare dirt (erosion) and parcels with gullies should be prioritized for restoration. On Long Lake, parcels with at least 75% natural shoreline should be prioritized for protection. Parcels with bare soil and at least 50% lawn should be prioritized for restoration. Data for Long Lake was collected in 2012. Since this time, land use practices have likely changed meaning priorities should be field verified.

Priorities and maps will be shared with Lake Districts and Associations to direct limited resources towards meaningful protection and restoration initiatives.

Areas of forest, grassland, and wetland were delineated for the Balsam Lake Watershed. These areas are providing benefits for water quality and should be prioritized for permanent land protection.

Areas of wetland and forest within 1,000 feet of a lake and within 300 feet of a stream were mapped as areas to prioritize for protection. Row crop within these areas was also mapped as priorities for best management practice installation.

Flow paths can be analyzed to further refine priorities for restoration and protection. For example, a high priority area for protection would be an area of natural vegetation (forest or grassland) where a flow path is present and near surface water. In contrast, a high priority area for restoration would be an area of row crop, bare soil, or high density residential where a flow path is present and near a surface water. The Agricultural Conservation Planning Framework toolbox, described in the following section, can be used to further prioritize areas of agricultural land use for restoration. Additionally, continuing conservation practices currently in use, such as cover crops and no-till, should be prioritized as a reoccurring conservation practice that offers protection for water quality.

Maps for priorities are included in the appendix files.

Agricultural Conservation Planning Framework Restoration Priorities

The Agriculture Conservation Planning Framework (ACPF) is a toolbox in ArcMap used to identify and prioritize conservation practices on the landscape at a watershed scale. ACPF uses high resolution LiDAR elevation data (3D model of the earth's surface) and a user supplied culvert inventory to determine surface water runoff flow paths on the landscape. Once the flow paths are created, the program prescribes conservation practices on the landscape based on slope, soils, field boundaries, and relevance to flow paths. The implementation of conservation practices would have a positive impact on water quality in the Balsam Lake Watershed. ACPF is agriculture based, so the prescribed practices are designed for and located within agricultural fields.

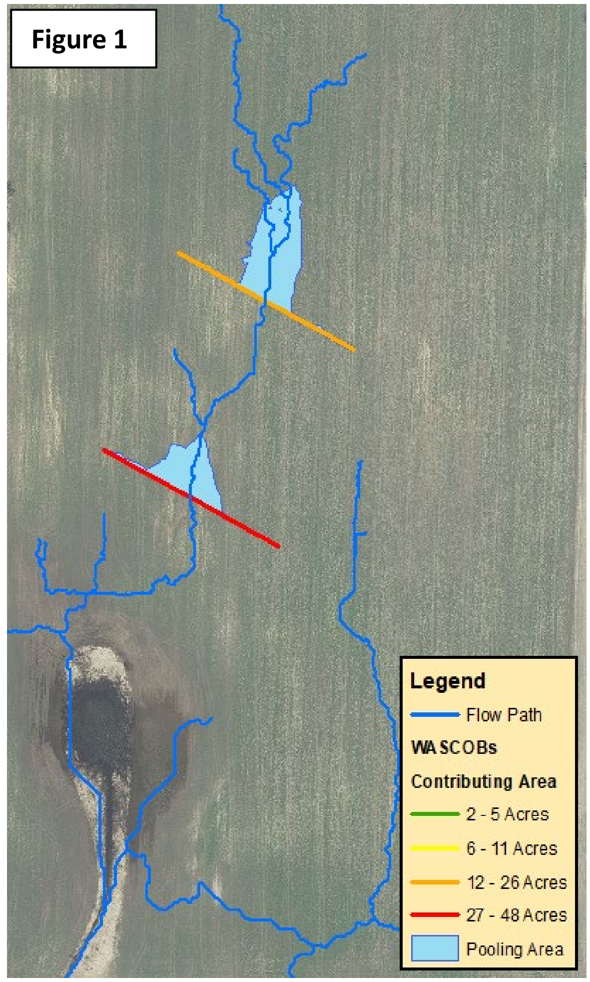
ACPF was used to identify and prioritize agricultural conservation practices within the Balsam Lake Watershed. The program recommended a variety of conservation practices for implementation including water and sediment control basins, contour buffer strips, grass waterways, and sediment ponds. The following summary of each practice will include how each conservation practice works, in-field examples, and the number of potential practices identified within the Balsam Lake Watershed. ACPF prioritizes practices with adjustable criteria. The practices displayed will be color coordinated based on priority, with green being lowest concern, yellow being moderate concern, orange being moderately high concern, and red being high concern. Distance to stream and field runoff risk were used to rank the priority level of conservation practices.

The outputs of ACPF allow for the prioritization of conservation practices that reduce runoff, erosion, and nutrient/sediment loading to surface waters. It is important to consider all the outputs of ACPF because the implementation of agricultural best management practices requires landowner participation and can directly impact the yields and economics for an agricultural system. Implementation of best management practices may not be possible in the highest priority areas, so it is important not to overlook lower ranked areas which will still result in a positive water quality impact.

The ACPF geospatial data outputs will be kept with the Polk County Land and Water Resources Department. Data will be made available to the board members of lake organizations and landowners interested in watershed improvement in the Balsam Lake Watershed to assist with conservation practice implementation planning. Field verification will be required to verify the location and type of conservation practice best suited for each site.

Water and Sediment Control Basin

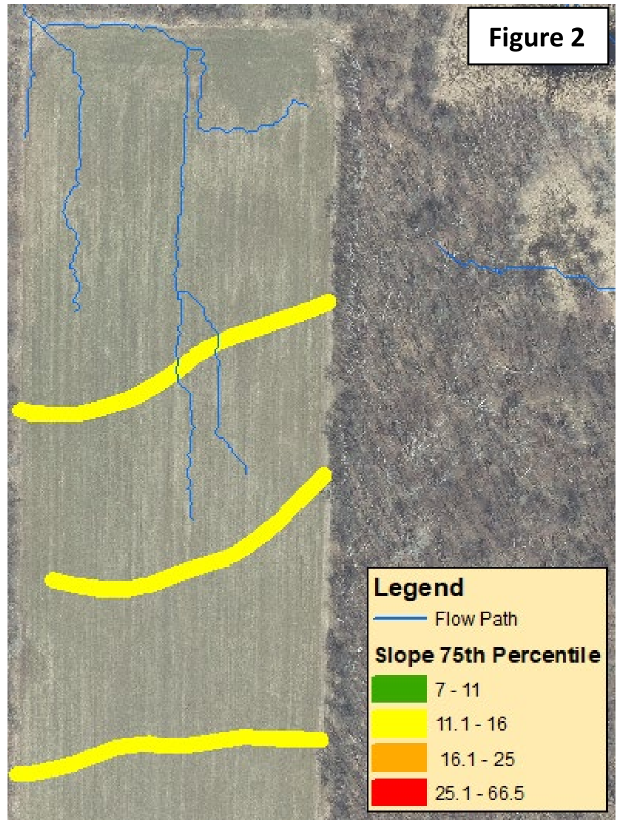
A water and sediment control basin (WASCOB) is a 5 foot or higher embankment (red/orange lines in figure 1) built perpendicular to a flow path (blue line in figure 1) in an agricultural field or an area receiving runoff from an agricultural field. During a rainfall event, WASCOBs collect water in a pooling area (light blue area in figure 1). The water is then slowly discharged though a pipe to a stabilized outlet. The WASCOB reduces the volume and velocity of water within the flow path thus reducing erosion. WASCOBs can slow down peak discharge (runoff) and reduce phosphorus loading, sediment erosion, and gully formation.



The embankment height can be changed to increase the size of the WASCOB. A larger embankment will allow for more water to be stored during a precipitation event, which will control runoff from a greater area of the watershed. In the Balsam Lake Watershed, there is an output for a 1.5-meter (4.9 ft) embankment as well as a 4 meter (13.1 ft) embankment.

In the Balsam Lake Watershed 190 potential locations for WASCOBs were identified in agricultural fields. ACPF ranks the WASCOBs by the contributing area of land that drains to each WASCOB, measured in acres. The prescribed WASCOBs in figure 1 are in the moderately high (26 acres), and high categories (29 acres). As contributing area increases, multiple in-field WASCOBs may need to be installed to intercept the flow path of surface water runoff to ensure erosion is not occurring above or below a WASCOB. The contributing area is not the only factor in prioritizing WASCOBs. Soil conditions, topography, and proximity to a tributary also need to be considered. All sites should be field verified to confirm priority level and identify if the site is suitable for a WASCOB.

Contour Buffer Strips

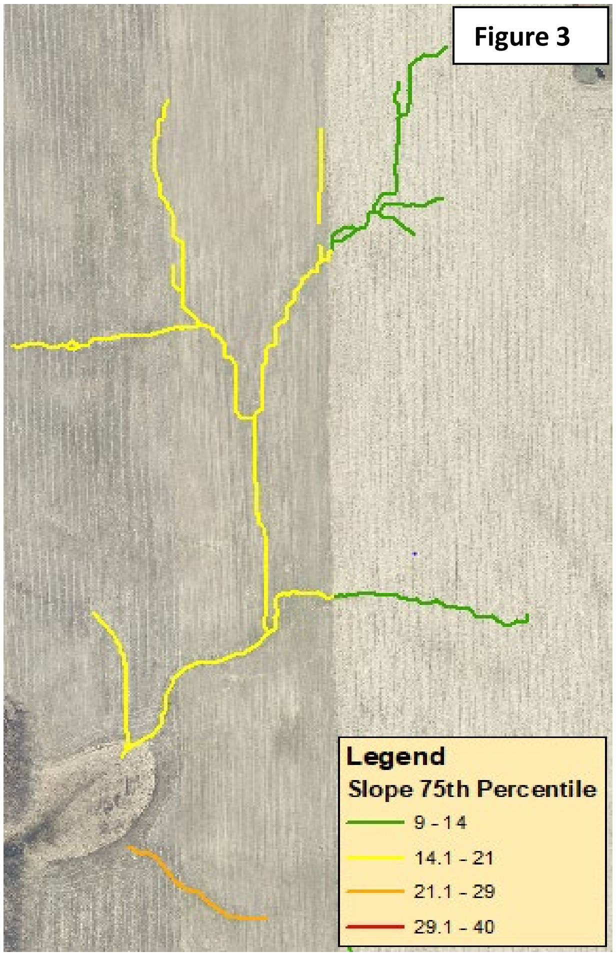


Contour buffer strips are strips of perennial vegetation planted parallel to the contour line that intercept the flow of surface runoff (yellow lines in figure 2). Contour buffer strips are often alternated throughout a field to allow for farming practices to continue between the buffer strips. This practice uses permanent vegetation to reduce the overall flow length on a slope which reduces the speed of runoff. This practice reduces erosion and overall runoff volume, which improves water quality and prevents the formation of gullies.

A total of 714 contour buffer strips were identified in the Balsam Lake Watershed. These practices were categorized based off runoff risk potential and slope. Runoff risk is the risk of direct runoff contributing to stream channels within the watershed. The values for slope steepness of each field are represented for the 75th percentile. In other words, 25% of the field has slopes greater than this value. In figure 2, ACPF prescribed multiple buffer strips in one field. These multiple strips of vegetation, if implemented, will significantly reduce the surface runoff within the field.

Grass Waterways

Grass waterways are installed within an agricultural field in areas where concentrated flow paths occur. Grass waterways are planted and maintained with permanent vegetation (perennial grasses). The grass roots and plant density stabilize the soil within the concentrated flow path. Installing grass waterways in areas where concentrated water flows through a field ensures that water is moving within a vegetated flow path (rather than over bare soil) which reduces the velocity of water and the risk of erosion by preventing the formation of gullies in the field. However, grass waterways do not trap or store water and sediment; rather, they are reducing sediment loss where erosion and runoff has a high probability of occurring on the landscape.



ACPF identified 117 locations within the Balsam Lake Watershed where grass waterways could potentially be implemented. The tool breaks apart flow paths as they reach field boundaries or change in ranking designation, so the 117 is a slight overestimate. ACPF prioritizes grass waterways through the runoff risk potential (direct runoff contributing to stream channels), slope rank (slope steepness) and slope (25% of the field has slopes greater than this value). Figure 3 contains networks of grass waterways within the same field that contain multiple rankings based off the slope 75th percentile. The implementation of grass waterways will reduce soil erosion within fields, resulting in a reduction in nutrients entering surface waters.

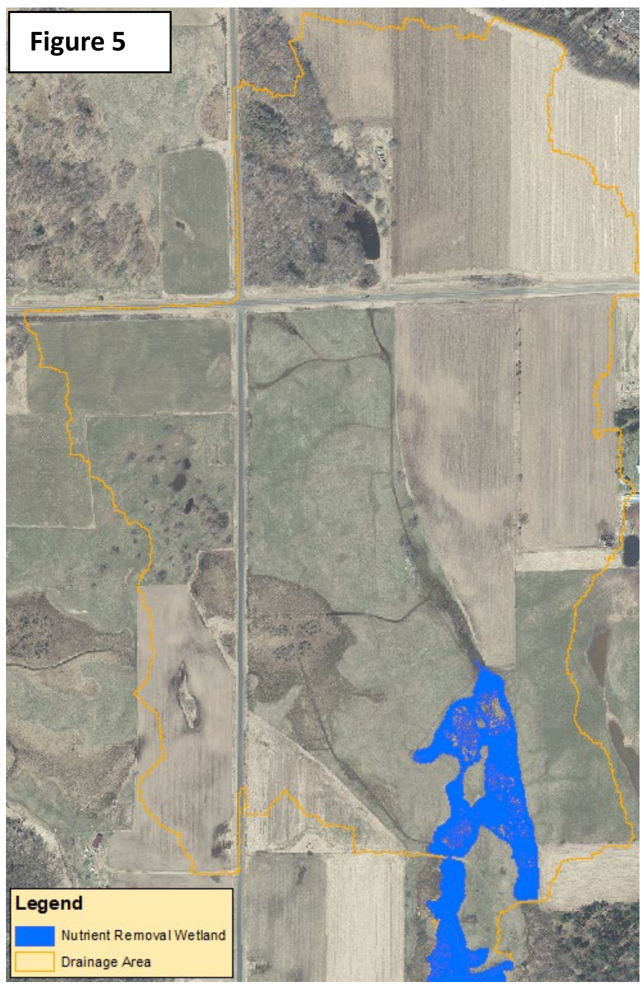
Sediment Ponds

Sediment ponds are depressions that are created in areas of higher slopes where other practices are not suitable. They are designed to catch runoff, reduce erosion, and allow for sediment and nutrients to settle out before entering surface waters. The outlet of the pond is reinforced to ensure no erosion occurs when the pond reaches maximum capacity and outlets to surface water. Sediment ponds are designed to catch runoff from five to one hundred acres of contributing area (drainage area).

There were 166 areas in the Balsam Lake Watershed that ACPF identified as suitable for a sediment pond. In figure 4 the blue area is the pond, and the orange line is the drainage area for the pond. If overland flow occurs during a rainfall event, any rainwater that falls within the orange area will drain to the pond. When ponds are prescribed by ACPF, the pond follows the contours of the land in its current state. When the pond is constructed, the landscape will be reshaped so that the project benefits water quality while minimizing the impact to the production of the field and minimizing the loss of tillable ground. The example in figure 4 is a desirable location because much of the drainage area includes agricultural land. However, to reduce the amount of farmable ground lost to the pond itself, shifting the holding area closer to the edge of the field or combining the two ponds may be ideal for this location. Implementing a sediment pond in this location would keep nutrients and sediment from entering surface water and reduce the overall impact from the agricultural practices occurring in this field.

Nutrient Removal Wetlands

Nutrient removal wetlands are much like sediment ponds. However, nutrient removal wetlands typically don't have standing water (other than after large rain events or spring snow melt); whereas sediment ponds contain water most of the year. In figure 5, the blue area is the wetland, and the orange line is the drainage area for the wetland. In this example, a large amount of the drainage area includes agricultural lands. Wetlands are also full of native plants which use nutrients and increase wildlife and habitat. Nutrient removal wetlands are designed to have a significant impact on reducing the amount of phosphorous and nitrogen entering surface waters as well as increase ground water recharge. ACPF identified 10 areas where nutrient removal wetlands could potentially be implemented.



Field Runoff Risk

This tool is used to identify areas of concern by ranking agricultural fields based on their runoff potential and the risk of direct runoff contributing to stream channels within the watershed. This tool takes into consideration slope, soil type, and land use classification (row crop or pasture) in the ranking process. This portion of ACPF can be paired with the results from other models, such as EVAAL, to pinpoint fields in the watershed of most concern that would benefit from implementation of conservation practices.

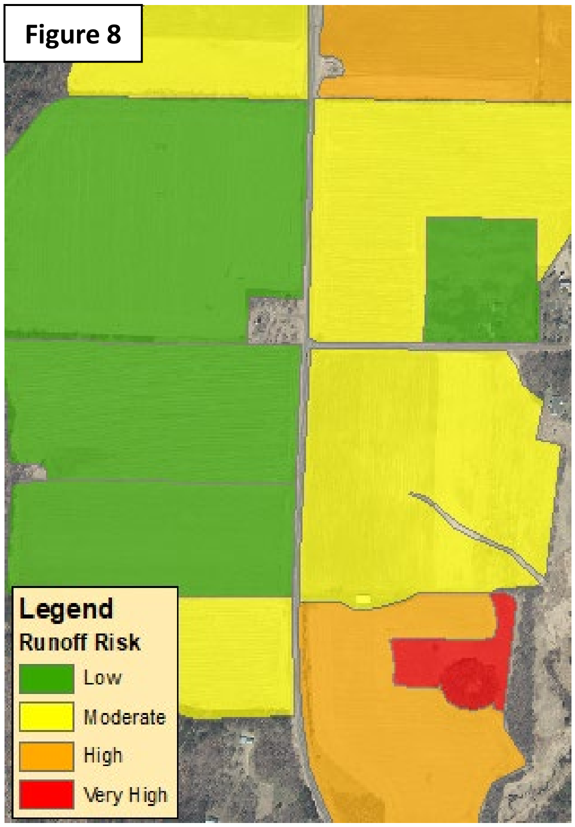
Figure 6

Figure 7

Fields classified as having high runoff risk potential would be excellent candidates for the implementation of no-till or cover crops. No-till planting is a conservation practice where crops are grown without the use of tillage. Soil tillage is a common agricultural practice used to loosen soil, incorporate crop residue and plant nutrients (fertilizer and manure), and prepare a suitable seed bed for planting the crop. However, tillage increases the potential of soil erosion and nutrient runoff. Tillage breaks the soil structure, inhibits the process of soil aggregation, and reduces surface crop residue. Soil is left exposed and more susceptible to the erosive forces of wind and water. An example of no-till can be seen in figure 6.

Planting cover crops (as seen in figure 7) is another conservation practice that can reduce agriculture's impact on water quality. Cover crops are plants that are grown outside of the main production crop specifically for their benefits to the soil or main crop. The primary benefit of cover crops is the reduction of erosion. Cover crops reduce erosion because the vegetation and roots protect the soil from early spring and late fall rains when the primary crop is not growing. Cover crops can increase infiltration, capture unused nutrients, build soil structure, promote soil bacteria and fungi growth, break

Figure 8



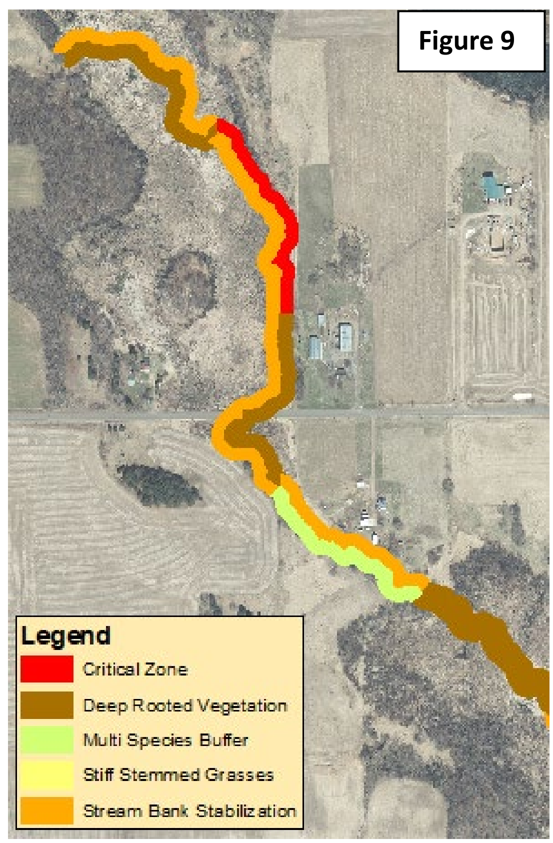
compaction layers, suppress weeds, and provide many other benefits to the soil and environment.

Based on runoff risk at a field scale, 15 fields in the Balsam Lake Watershed were considered very high risk (red), 50 were considered high risk (orange), 79 were considered moderate risk (yellow), and 390 were considered low risk (green). In figure 8 each defined field is given a runoff risk. Multiple fields in figure 8 are ranked as high, which is partly due to the fields being located directly next to a tributary.

Riparian Attribute Polygons

The riparian attribute polygons tool splits the main tributaries in the Balsam Lake Watershed into 250-meter stream corridor segments and creates a 15-meter buffer area on each side of the stream as displayed in figure 9. Three factors are determined for each 250x15-meter stream segment: preferred buffer type, desired buffer width, and runoff risk.

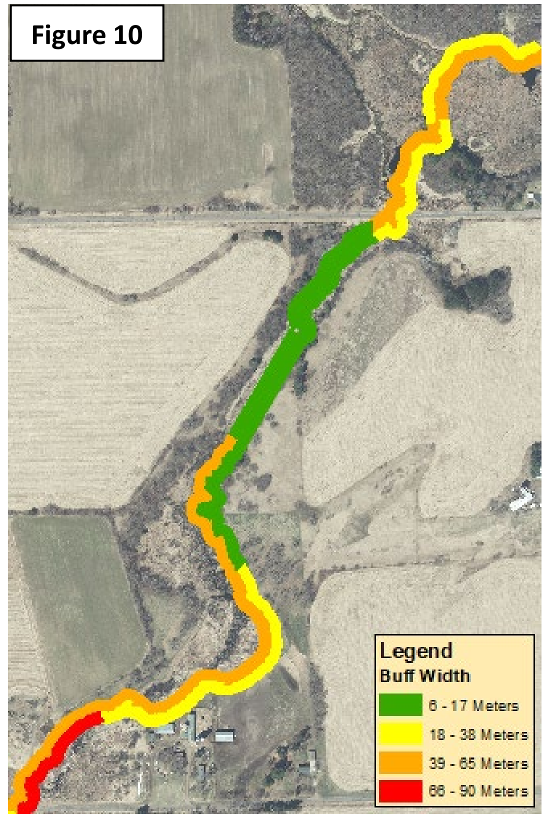
Figure 9



The preferred buffer type is determined using slope, land use, and soils. The three main buffer types include deep rooted vegetation, multiple species vegetation, and stiff stemmed grasses. In areas where the three buffer types are inadequate, the tool classifies areas as either critical zones or those requiring additional bank stabilization.

The Balsam Lake Watershed has a diverse network of streams varying in depth, width, flow, substrate, and shoreline condition. There was only one area in the watershed that was identified as a critical zone, with the remainder of the shoreline split between stream bank stabilization (59%), deep rooted vegetation

(20%), stiff stemmed grasses (12%), and multispecies buffer (8%). In areas where deep-rooted vegetation, multispecies buffer, and stiff steamed grasses are prescribed by ACPF, the program believes there is an opportunity for the buffer to intercept surface runoff and/or shallow ground water. When none of these opportunities are possible the critical zone and stream bank stabilization designation is given. Site visits will still need to be conducted to address site suitability and identify the best practice or buffer for the specific site.

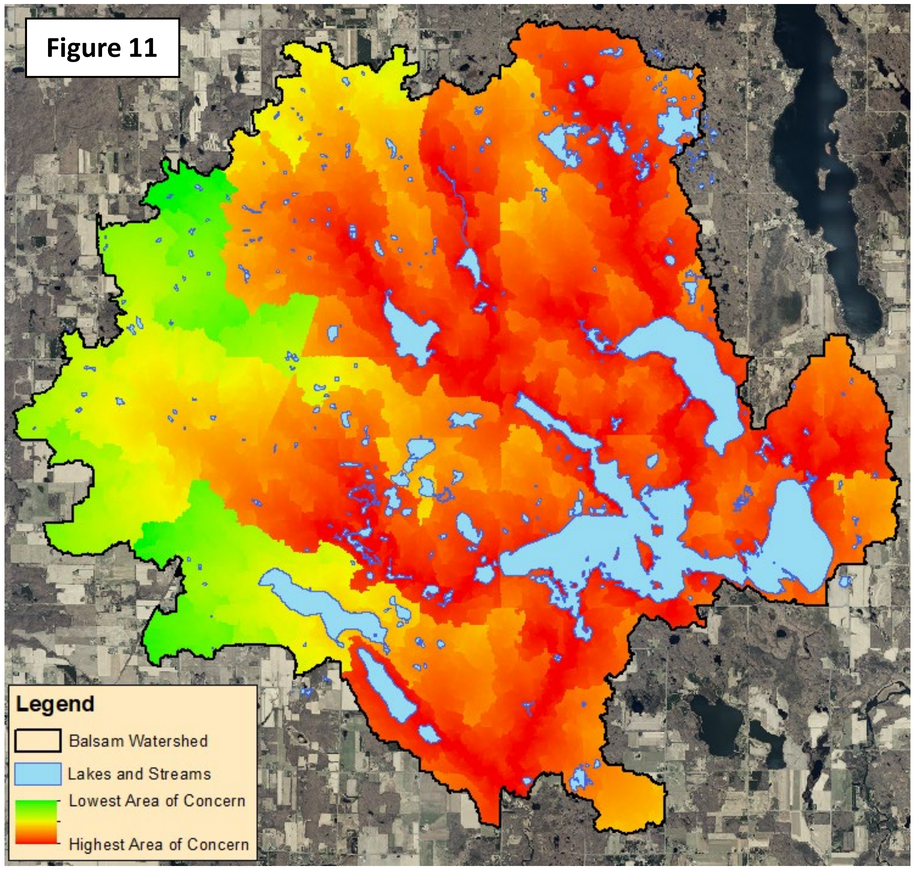


An additional output from the riparian attribute polygons tool is the prescription of a desired buffer width in meters along the main stream segment. ACPF takes into consideration the amount of low-lying land surrounding the stream segment as well as the amount of potential surface water runoff that enters the 200-meter stream segment and determines the natural capacity for a riparian zone to provide water quality benefits through a riparian buffer.

For each individual stream segment, ACPF provides a designated riparian buffer width in meters. In the Balsam Lake Watershed, the range of buffer width was between 6 and 90 meters with the average being 20 meters. In total, 81 riparian catchments have a recommended buffer width of over 50 meters, however; many of the areas that would benefit from a substantial buffer are surrounded by woods and wetlands. Areas around the stream bank that are already surrounded by natural areas are beneficial to overall water quality. Ideally, these areas would stay undeveloped.

In an agricultural setting, a 90-meter buffer may be an unrealistic option for a producer, considering these acres would no longer be used for crop production which would have a financial impact on the producer. The areas with the greatest buffer width may be the areas to focus on for implementation, working with the producer to identify a width that benefits water quality and is a manageable size for the producer. Additionally, practices such as cover crops and no-till could be added in these areas.

Distance to Stream



The distance to stream output uses flow direction, stream reach, and slope to determine relative risk of sediment delivery from the Balsam Lake Watershed via tributaries. The tool ranks the land in the watershed according to the distance from the main streams in meters. In figure 11 the darkest red areas represent the main flow path (or tributaries) exiting the Balsam Lake Watershed. The distance to stream is displayed on a scale from red to green, with red areas being closest to the main tributaries in the Balsam Lake Watershed and green areas being furthest from the main tributaries in the Balsam Lake Watershed.

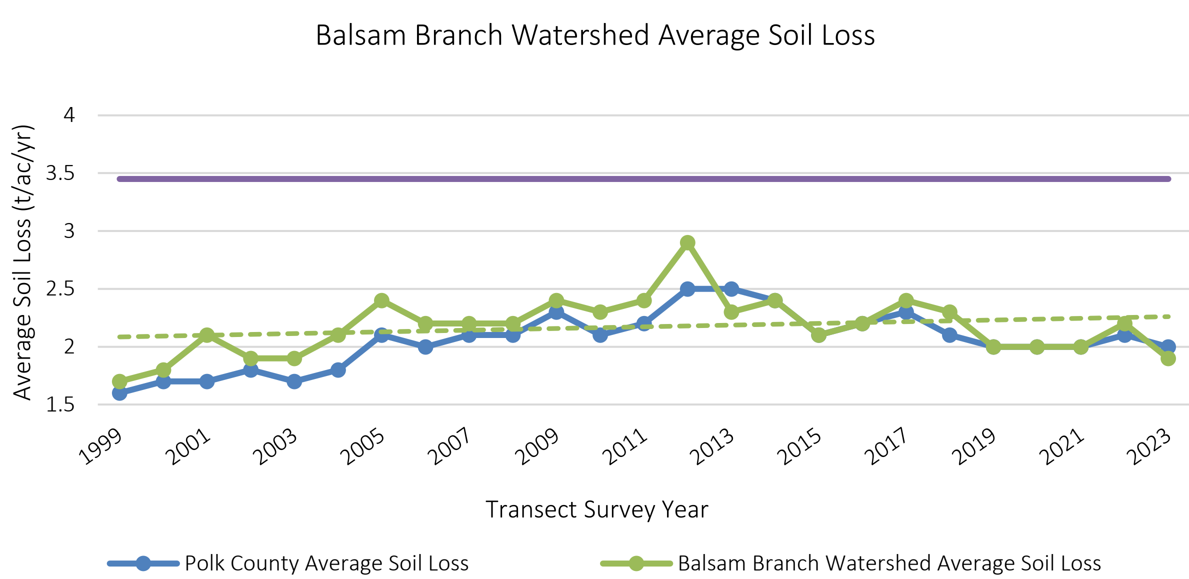
The Balsam Lake Watershed is unique in the fact that it has a complex drainage network making nearly all the watershed an area of high concern for project implementation. However, this is also beneficial for watershed management because it gives ample opportunity for the implementation of conservation practices that will have a significant benefit to surface waters. The distance to stream map (figure 11) can be used to prioritize where to implement conservation practices, with areas in red being the most critical for implementation due to the proximity to the drainage network. Even though the green areas are the farthest from the stream and likely have the lowest impact, they should not be overlooked. The areas in green overlap with the internally drained areas which do still contribute runoff during snowmelt and larger than 10 year 24-hour storms. Implementation in the green areas could still be very important and beneficial in watershed management.

Polk County Transect Survey Summary

Since 1999, the Land and Water Resources Department has been conducting a cropland transect survey of approximately 835 fields in Polk County. The survey was developed by Purdue University and is designed to collect conservation tillage and crop residue information to estimate county-wide soil loss by watershed. Each field is visited in the spring after crop emergence and the current crop, tillage system, residue cover, and the existence of erosion is documented. All soils have an estimated amount of soil they can lose annually and still maintain productivity. The value is called "T" or tolerable soil loss, and it is measured in tons/acre/year.

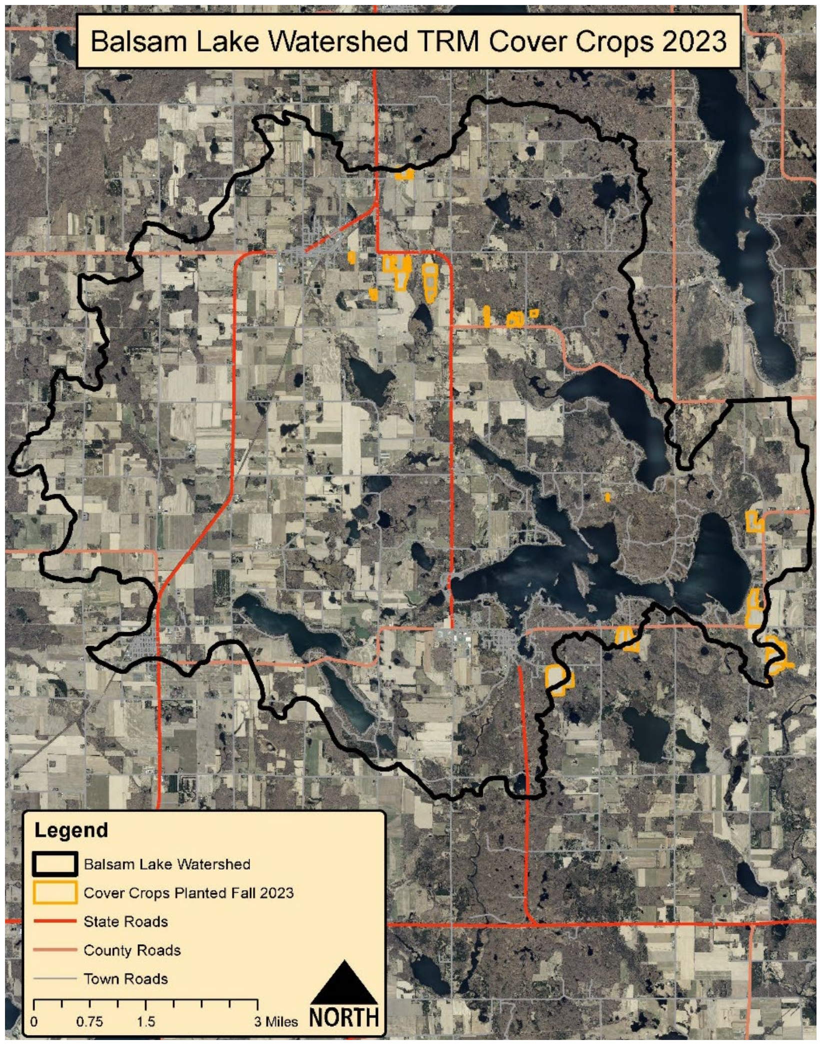
The average T value for Polk County soils is 3.29 tons per acre per year and the average T value for the Balsam Lake Watershed is 3.45 tons per acre per year. The transect survey helps estimate soil erosion levels in individual watersheds countywide and allows for a comparison to the county wide average value for T. This inventory is helpful in assessing which watersheds may be a priority to focus soil health and water quality programming.

The average soil loss for the Balsam Lake Watershed from 1999-2023 was 2.17 tons per acre per year which is below the average tolerable (T) soil loss for the watershed (3.45 tons per acre per year). While this is positive, the trendline for the 25 years of transect survey data indicates a slight increase in soil loss over the length of the survey. With this trend it will be important to continue focusing on cropland best management practices to minimize the loss of soil and degradation of water quality from soil erosion and agricultural nutrients. Practices like nutrient management, cover cropping, crop rotation, and reduced tillage can help protect against further erosion of soils in the watershed.



Targeted Runoff Management Grant Summary

The Polk County Land and Water Resources Department (LWRD) received a Wisconsin Department of Natural Resources Targeted Runoff Management (TRM) Grant for the Balsam Lake Watershed. The Balsam Lake Watershed TRM Grant is designed to aid farmers and agricultural landowners in the implementation of best management practices on their properties. The grant is three years long spanning from 2023 to 2025. With the use of best management practices, the Polk County LWRD will improve the overall water quality within the Balsam Lake Watershed.



During the first year of this grant being active, Polk County LWRD staff worked with three landowners to implement best management practices on their agricultural properties. With those three landowners, the Polk County LWRD was able to cost share 330 acres of cover crops and one manure storage facility closure within the watershed. Cover crops protect the soil after the crop has been harvested. They provide a root structure for the soil which makes it harder for the soil to erode along with any nutrients that are within that soil. The cover crops will slow down the movement of any rainfall or snow melt giving it time to infiltrate down through the soil. Once the farmers are ready to plant their fields in the spring, the cover crops will be terminated. Those cover crops will break down and release carbon and nutrients back into the soil for the following years crops to utilize making cover crops valuable for both soil health and water quality. Unused or failing manure storage facilities have the potential to discharge nutrients to surface and groundwater. These structures are also a threat to human health and safety. Properly closing these structures ensures that any environmental contamination is prevented.

Looking ahead to 2024, LWRD staff have identified several practices and projects that could be implemented within the watershed. Specifically, the Otter Creek watershed has been identified as an area where best management practices would be greatly beneficial to the landscape. Water quality testing through the County Lake Grant has shown high levels of phosphorus in Otter Creek which eventually flows into Balsam Lake. Row crop is the greatest percent land use in the Otter Creek Subwatershed which makes it ideal to target for agricultural best management practices through the TRM grant. Within this watershed there are already two practices scheduled for the 2024 year, one of them being a creek crossing and the other being a gully repair. Along with those projects, there is also the expectation of cost sharing more acres of cover crops within this area.

Summary

The results of this project are intended to be used by the Polk County Land and Water Resources Department, lake organizations, agricultural producers, and partner groups to implement protection and restoration priorities in the Balsam Lake Watershed. The outputs of this project identify priorities for protection and restoration on a Watershed, Subwatershed, and individual waterbody scale. Priorities are also identified for individual shoreline parcels and field boundaries. As a result, this project offers an opportunity for all that reside in the Balsam Lake Watershed to ensure that their land management choices provide water quality benefits for future generations.