Otter Lake Watershed Implementation Plan

Funded by Illinois Environmental Protection Agency (IEPA)

Final Report

4/18/2018

Prepared & Submitted By Northwater Consulting

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Acronyms

AFT - American Farmland Trust
AQI - Aesthetic Quality Index
ACEP - Agricultural Conservation Easement Program
BMP – Best Management Practice
CRP – Conservation Reserve Program
CREP – Conservation Reserve and Enhancement Program
CSP – Conservation Stewardship Program
CWS - Community Water Supply
CWLP – City Water, Light & Power
CCA - Certified Crop Advisors
C-BMP – Illinois Council on Best Management Practices
EMC - Event Mean Concentration
HUC - Hydrologic Unit Code
IDNR – Illinois Department of Natural Resources
IDPH - Illinois Department of Public Health
INPC – Illinois Nature Preserves Commission
IEPA – Illinois Environmental Protection Agency
ISGS - Illinois State Geologic Survey
ISWS – Illinois State Water Survey
ISA – Illinois Stewardship Alliance
NPDES - National Pollutant Discharge Elimination System
NVSS - Non-Volatile Suspended Solids
NCWS - Non-Community Water Supply
NWI – National Wetlands Inventory
NRCS – Natural Resource Conservation Service
NGRREC - National Great Rivers Research and Education Center
NTCHS - National Technical Committee for Hydric Soils
NPS – Nonpoint source
OLWC – Otter Lake Water Commission
RCPP - Regional Conservation Partnership Program
SWCD – Soil and Water Conservation District
STEPL - Spreadsheet Tool for Estimating Pollution Loading
TDS – Total Dissolved Solids
TP – Total Phosphorus
TSS – Total Suspended Solids
TSI - Trophic State Index
TSP - Technical Service Providers
TMDL – Total Maximum Daily Load
VSS - Volatile Suspended Solids
USFWS – U.S. Fish and Wildlife Service
USEPA – United States Environmental Protection Agency
USDA – United States Department of Agriculture
USGS - U.S. Geological Survey
USLE - Universal Soil Loss Equation
WIP - Watershed Implementation Plan
WWTP – Waste Water Treatment Plant

Executive Summary

The Otter Lake Watershed

The Watershed Implementation Plan (WIP) includes Otter Lake and its 12,897-acre watershed. The WIP provides a road map to achieve regulatory-based water quality objectives. It also characterizes and addresses other non-regulatory watershed problems identified through analysis and stakeholder input.

Characteristics of Otter Lake and its watershed are summarized below:

- Otter Lake is a 765-acre public water supply reservoir located in Macoupin County and serves eight towns and two water districts in three counties. The water supply also serves 400 retail connections.
- Average daily water output of the water supply is 1.8 million gallons.
- Otter Lake was created via the construction of a dam on the West Fork of Otter Creek in October of 1968. The capacity of the reservoir was 5.5 billion gallons (16,900 acre-feet).
- Otter Lake currently has regulatory water quality impairments for total phosphorus and mercury.
- Four established water quality monitoring stations are located within the lake, and data is available from 2010-2016.
  - The water regularly exceeds the Illinois 0.05 mg/L phosphorus standard (73% of the time).
  - The average phosphorus concentration is 0.18 mg/L. Since 2010, the maximum concentrations have decreased and average concentrations have decreased slightly.
  - Nitrogen concentrations are typically low, and average concentrations have decreased since 2010.
  - Total suspended solid concentrations exceed 15 mg/L, 45 % of the time.
- The West Fork Otter Creek is the lake's primary tributary and is 5.9 miles long before reaching the lake.
- There are 147 permanent residences, plus seasonal campgrounds owned and operated by the Otter Lake Water Commission (OLWC) within the watershed; the highest density of both residences and the camp ground is around the lake.
- There are 42 private water supply wells in the watershed with an average depth of 39 feet.
- The watershed is generally flat with elevations ranging from 559 to 703 feet above sea level. The average slope of the land is 1.8%.
- Average annual precipitation is 41 inches, based on the period of 2001 – 2015.
- Fifteen landuse categories cover the watershed:
  - 69%, or 8,948 acres of crop land.
  - 12%, or 1,533 acres of forest.
  - 7%, or 855 acres of grassland.
- Thirty unique soil types blanket the watershed:
  - Soils are primarily loess (wind-blown deposits) parent material.
  - Ipava silt loam is the dominant soil type (30%).

  - 13%, or 1,696 acres of highly erodible ground; 2.4% of all cropped soils are highly erodible.
  - 23%, or 3,358 acres of wetland or hydric soils.
  - Majority of soils (63%) have high rainfall runoff potential.
  - 81% of all soils are classified as limited for septic system suitability.
- 92% of all crop fields in the watershed practice conventional and reduced tillage.
- OLWC has led substantial efforts throughout the watershed to reduce sediment and nutrients entering the lake.
- 58% of all crop ground in the watershed is believed to be drained by tiles.
- A previously completed stream and lake survey concluded that the majority of the Otter Lake shoreline and watershed streams are well buffered with expansive riparian areas.
- Streambank erosion is responsible for 2% of the phosphorus load to the lake (408 lbs/yr) and 4% of the sediment load to the lake (558 tons/yr).
  - Most of the sediment and phosphorus is from the West Fork of Otter Creek and not tributary drainages. The majority of streambank erosion is considered low to moderate.
- Lake shoreline erosion is responsible for 14% of the phosphorus load to the lake (2,805 lbs/yr) and 32% of its sediment load (4,395 tons/yr).
  - 15% of lake shorelines is responsible for a majority of this phosphorus and sediment loading.
- There are an estimated 147 septic systems in the watershed and it is possible that up to 22 are failing.
  - Phosphorus loading from failing septic systems may contribute 1% of the total phosphorus load to the lake.
- Gully erosion is most severe in steep forested draws and on crop ground in the headwaters. There are approximately 9.5 miles of eroding gullies in the watershed.
  - Gully erosion is responsible for 1% of the phosphorus load to the lake (270 lbs/yr) and 5% of its sediment load (713 tons/yr).
  - 63% of the gullies are responsible for a majority of gully erosion.
- Sheet and rill erosion from crop ground is responsible the majority of soil loss from crop ground.
  - 58% of the entire sediment load from crop ground is originating from only 18% of the fields in the watershed.
- Total nutrient and sediment loading to Otter Lake (including internal nutrient release) is: 151,591 lbs/yr of nitrogen, 20,352 lbs/yr of phosphorus, and 13,801 tons/yr of sediment.
  - According to a 2005 Total Maximum Daily Load (TMDL) study, 6,554 lbs/yr of phosphorus is thought to release from lake sediment.
  - Internal release of nitrogen is estimated to be 47,166 lbs/yr.
  - Row crops are responsible for the highest percentage of the total watershed sediment and nutrient load: 59% of nitrogen, 46% of phosphorus, and 58% of sediment.
- Conventional and reduced tillage systems are responsible for 94% of the entire nitrogen load from crop ground, 93% of the phosphorus load, and 94% of the sediment load.
  - Conventional or reduced tillage on highly erodible soils contribute the highest rates of sediment and nutrient loading.

- Previous TMDL modeling indicates that Otter Lake needs to see an annual phosphorus reduction of 66% to meet the state's 0.05 mg/L standard.
  - A 66-96% reduction in phosphorus can be achieved with all recommended practices; in-lake strategies, such as aeration and alum treatment, are needed to achieve this.
  - A 45% reduction in nitrogen has been established and all recommended practices in this plan can increase this to 51-81%.
  - A 66% reduction in sediment has been established and all recommended practices can achieve a greater reduction.
- The most effective practices for addressing phosphorus and sediment are: widespread adoption of conservation tillage practices, lake shoreline stabilization, grass field borders, grassed waterways, a series of in-lake-low flow dams, in-lake alum treatment and aeration, small farm ponds, and nutrient management.
  - Shifting away from conventional or reduced tillage to no-till or strip-till will reduce 21% of the entire watershed phosphorus load, 38% of the sediment load and 5.5% of the nitrogen load.
  - Large scale in-lake management measures, such as alum treatment and aeration, can reduce 28% of the total nitrogen load and 29% of the total phosphorus load.
  - Extensive shoreline stabilization can reduce up to 11% of the total phosphorus load and 25% of the total sediment load.
- Installing up to four new in-lake/low flow dam structures and conducting maintenance on the existing dam will achieve substantial total reductions and will help to extend the life of any other in-lake measures; cost is a major consideration.
- An estimated expenditure greater than $8.5 million is likely necessary to achieve reductions necessary to meet regulatory standards.

Results of the Watershed Study

Table 1 - Otter Lake & Watershed Problem Ranking

	Assessment Item	Summary	Ranking
Watershed	Landuse & Watershed Characteristics	Currently, cropland has the greatest water quality influence in the watershed. The watershed contains a relatively high percentage of forest and grassland.	**Medium**
	Nutrient & Sediment Loading	Nutrient and sediment loading from upland runoff is high. Crop ground in the watershed is responsible for the greatest percentage of the watershed's phosphorus and nitrogen load. Sediment loading from upland runoff is also highest from crop ground. Addressing agricultural practices will be most effective in reducing sediment and nutrient loads to the Lake.	**High**
	Landuse Change	The watershed is sparsely populated and there is little evidence that development will increase and lead to major changes in landuse.	**Low**
	Streambank Erosion	Streambank erosion is responsible for small portion of the watershed sediment and phosphorus load. Although it is a natural process, bank erosion is severe at certain locations within the watershed's forested stream corridors. Due to access constraints and costs associated with stabilization, addressing other sources of sediment and nutrients should be prioritized.	**Low**

	Assessment Item	Summary	Ranking
	Gully Erosion	Past work in the watershed has addressed a large percentage of the gully erosion immediately adjacent to the lake. Gully erosion occurring in the upper reaches of the watershed on crop ground contributes some of the highest sediment and nutrient loads to the lake. Excessive gully erosion in steep forested areas adjacent to a receiving waterbody is also a concern. Structures that stabilize these gullies should be a priority.	**Medium**
	Tillage & HEL Soils	Conventional and reduced tillage systems on crop ground in the watershed are common on 92% of all fields. Nutrient and sediment loading from these fields is responsible for the vast majority of the crop land loading. A shift away from conventional or reduced tillage may have the single greatest impact on improving water quality.	**High**
	Septic Systems	There are an estimated 147 homes with septic systems in the watershed. It is possible that up to 22 of these may be failing and contributing to phosphorus loading in the lake. A septic system inspection and maintenance program is recommended to verify if septic systems are an issue.	**Low**
In Lake	Landuse & Lake Characteristics	The majority of the land directly adjacent to the lake is well buffered and in forest or grass. The small amount of residential and camp ground area near the lake does not appear to be significantly impacting water quality.	**Low**
	Lake Sediment & Lake Sediment Nutrient Release	It is estimated that 6,554 lbs/yr of phosphorus and 47,166 lbs/yr of nitrogen is mobilized from lake sediment annually. Total sediment loading to the lake is over 13,000 tons/yr. Phosphorus released from lake sediment is responsible for 32% of the entire load; nitrogen is responsible for 31%. In-lake management measures will be required to meet the phosphorus water quality standard; it is not realistically possible to reduce watershed phosphorus loads sufficiently to meet the standard. A moderate to long-term objective should be to mitigate nutrient release from lake sediment through aeration and alum treatment. Maintenance of the existing in-lake sediment basin should occur to reduce sediment and nutrient export into the main body of the lake.	**High**
	Lake Shoreline	Lake shoreline erosion is responsible for 14% of the total phosphorus load and 32% of the total sediment load. Given the high delivery rates associated with shoreline erosion, stabilization of critical areas should be a priority.	**High**
	Chemical Water Quality	The state water quality data collected and analyzed since 2010 indicates a slight trend toward lower phosphorus and a steady decline in sediment concentrations. Nitrogen concentrations are low overall with a slight decreasing trend since 2010. As tiling becomes more prevalent in the watershed, nitrogen load could increase.	**Medium**

Key Recommendations

Primary lake and watershed recommendations include:

1. Stabilize the most severely eroding shoreline segments.
2. Conduct maintenance dredging behind the existing in-lake dam.
3. Implement agricultural Best Management Practices (BMPs) that include: no-till/strip-till, field borders, grassed waterways, ponds in steep forested draws, and nutrient management. Other agricultural BMPs could include wetland restoration, grade control structures, cover crops, and pasture/livestock management systems. Locations adjacent to stream corridors or the lake and on steeper sloping ground should receive first priority.
4. Conduct education and outreach to encourage voluntary adoption of practices.
5. Initiate a formal water quality monitoring program aimed at evaluating tributary inputs; continue current in-lake monitoring.
6. Develop a watershed management and implementation tracking system to monitor practice adoption, load reductions achieved, and progress made towards meeting water quality targets.
7. Following treatment in the watershed to reduce inputs to the lake, install up to four new in-lake/low-flow dams.
8. Design a long-term strategy for in-lake management to reduce the internal release of phosphorus and nitrogen. Lake dredging is not a viable solution.

Northern Portion of Otter Lake

1.0 Introduction

The Otter Lake WIP serves to characterize Otter Lake and its watershed and define an achievable implementation strategy to address sediment and problems related to the lake.

Located in north central Macoupin County, the Otter Lake watershed is 12,897 acres in surface area and includes the 765-acre public water supply reservoir. The reservoir serves as the water supply for eight communities, two water districts, and 19,000 people across three counties.

With approximately 400 retail connections in addition to the towns and water districts served, average daily output is 1.8 million gallons. Water quality samples dating back to 1979 have shown elevated phosphorus concentrations, as well as other nutrients. Phosphorus concentrations regularly exceed the 0.05 mg/L total phosphorus standard for Illinois, however, data has indicated recent improvements due various watershed management activities.

1.1 Watershed Implementation Plan

The sections of this WIP are intended to be cohesive to achieve regulatory requirements, while also expanded to address watershed and lake concerns that do not have regulatory drivers. The intent of this plan is to deliver a road map to guide strategic implementation activities that will address water quality impairments and reservoir capacity issues that are resulting from nutrient and sediment loading to the lake.

The WIP provides a road map to achieve water quality objectives for sediment and nutrients. It characterizes and addresses other watershed problems identified through analysis and stakeholder input. The WIP outlines regulatory and non-regulatory impairments, causes and sources, identifies critical areas, and recommends specific BMPs and other management measures. It adheres to the nine minimum elements of a watershed plan as defined by the United States Environmental Protection Agency (USEPA).

The primary components of the WIP are summarized below:

- Inventory and characterize the lake and associated watershed
- Identify and prioritize lake and watershed issues and concerns
- Quantify lake and watershed impairments (regulatory and non-regulatory)
- Establish nutrient and sediment reduction targets
- Identify critical areas and priority projects
- Directive for outreach, education and implementation to achieve targets
- Strategy for monitoring and measuring success

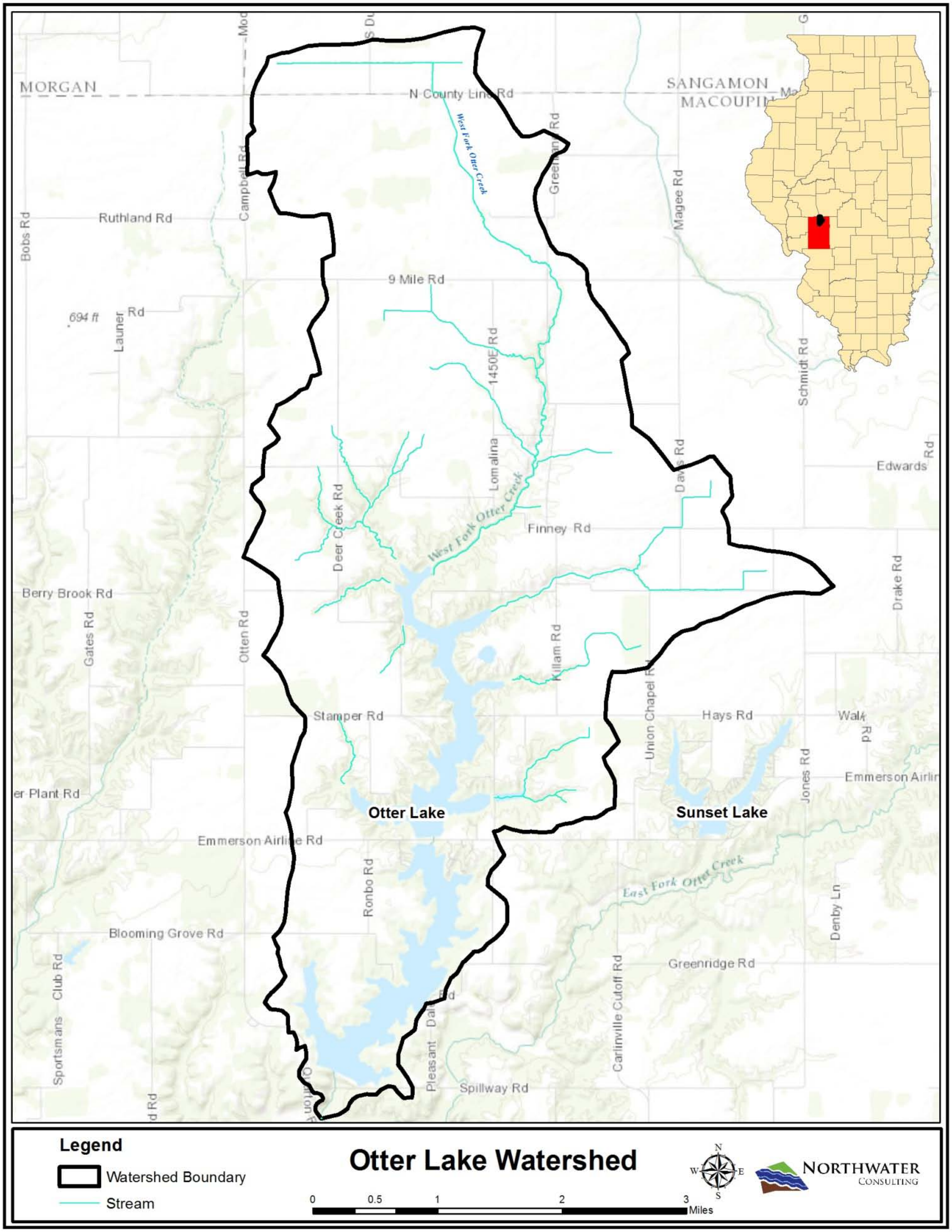


Figure 1 – Otter Lake Watershed

1.2 Water Quality Standards, Guidelines, & Lake Impairments

Water quality standards are laws or regulations that states authorize to enhance water quality and protect public health and welfare. Water quality standards consist of: a designated beneficial use or uses of a water body, the water quality criteria necessary to protect uses and an antidegradation policy. Examples of designated uses are primary contact (swimming), protection of aquatic life, and public and food processing water supply. Water quality criteria describe the quality of water that will support a designated use. Water quality criteria can be expressed as numeric limits or as a narrative statement. Antidegradation policies are adopted so that water quality improvements are conserved, maintained, and protected (CDM Smith, 2014). The water quality general use standard that applies to Otter Lake is **0.05 mg/L** for phosphorus (Title 35, Subchapter B, Part 302.205). The fish consumption guideline that applies is greater than or equal to 0.06 mg/kg in fish tissue of any species, in at least one of the two most recent years of samples collected in 1985 or later. The fish consumption mercury guideline is based on a Health Protection Value of 0.1 µg Hg/kg/day. The goal of the fish consumption guideline is to keep dietary mercury ingestion on average below 0.1 µg/Hg/kg body weight per day. For a 70 kg person, this equals 7 µg Hg/day.

One hundred and thirty-eight samples collected by the Illinois Environmental Protection Agency (IEPA) within Otter Lake since 2010 have exceeded the phosphorus standard; on average, phosphorus exceeds the standard 75% of the time. A total of eight fish tissue samples since 2005 exceeded the 0.06 mg/kg threshold; a sample collected in 2000 did not exceed the threshold. According to the 2016 Illinois Integrated Water Quality Report and List of Impaired Waters, Otter Lake is in full support the public water supply use and not supporting aesthetic quality or fish consumption.

The public water supply designated use is applied where there is the presence of an active public water supply intake and the assessment of this use is based on conditions in both treated and untreated water (IEPA, 2016). For freshwater lakes, the Aesthetic Quality Index (AQI) represents a point system used to assess the aesthetic quality designated use. The AQI represents the extent to which pleasure boating, canoeing, and aesthetic enjoyment are attained and is based primarily on physical and chemical water quality data. Three evaluation factors are used in establishing the number of AQI points; the higher AQI scores indicate increased impairment (IEPA, 2016):

1. Median Trophic State Index (TSI); data collected May-October and calculated from total phosphorus (at 1-ft depth), chlorophyll a, and Secchi disk transparency.
2. Macrophyte Coverage; average percentage of lake surface area covered by macrophytes during peak growing season
3. Nonvolatile Suspended Solids (NVSS) concentration; median lake surface NVSS concentration for samples collect at 1-ft depth (reported in mg/L)

Fish consumption use is associated with all water bodies in the state. The assessment of fish consumption use is based on (1) water body-specific fish-tissue data and (2) fish-consumption advisories issued by the Illinois Fish Contaminant Monitoring Program (IEPA, 2016).

Sediment, chemicals, and nutrients have negatively affected the lake, and it is listed on the 2016 Illinois 303(d) impaired waters list for phosphorus and mercury.

Table 2 - 2016 Otter Lake Impairments

Priority	10 digit HUC	Water Body Name	Assessment ID	Water Size (acres)	Designated Use	Cause
Medium	0713001202	Otter Lake	IL_RDF	765	Aesthetic Quality	Phosphorus (Total)
Medium	0713001202	Otter Lake	IL_RDF	765	Fish Consumption	Mercury

Although phosphorus is the primary lake impairment from a regulatory water quality standpoint, lake sedimentation and total suspended sediment (TSS) is of particular concern. Phosphorus loading in agricultural watersheds is often significantly associated with erosion, and agricultural soils often have elevated phosphorus concentrations. Many phosphate compounds are not very soluble in water, therefore, most of the phosphate in natural systems exists in solid form (Bushman, Lamb, Randall, Rehm and Schmitt, 2002). Nitrogen is also a water quality concern given the extent of agricultural land in the watershed, but it is not a regulatory impairment.

Otter Lake - aerator

Significant quantities of phosphorus can also exist in accumulated lake sediment. The release of phosphorus from sediment plays an important role in the overall nutrient dynamics of shallow lakes and, even where external phosphorus loading has been reduced, internal phosphorus may prevent improvements in lake water quality. Numerous studies have shown that high phosphorus loading leads to high phytoplankton biomass, turbid water and often undesired biological changes (Sondergaard, Jensen and Jeppesen, 2003). Furthermore, lake sedimentation and reductions in water capacity can be problematic during extreme drought conditions. Fortunately, an analysis by the Illinois State Water Survey (ISWS) indicates that Otter Lake will have sufficient water during a major drought based on the current usage.

The IEPA has established non-regulatory water quality guidelines for a number of parameters. Water quality guidelines are target values used by IEPA during assessments for parameters that do not have numerical water quality criteria. The previous guideline for listing TSS for aquatic life in lakes is a non-volatile fraction of suspended solids, or NVSS [TSS-volatile suspended solids (VSS)] greater than 12 mg/L. Although NVSS is only one of three evaluation criteria for determining the AQI, the maximum number of points (15) is achieved when NVSS concentrations are greater than or equal to 15 mg/L.

2.0 Lake & Watershed History

Otter Lake and its watershed are located west of Girard, approximately 20 miles southwest of Springfield, Illinois. Otter Lake has 765 acres of surface water and has a watershed area of 12,897 acres. The Otter Lake Water Commission (OLWC) owns and operates the lake and the land surrounding it. The lake is up to 50 feet depth, with an average depth of 19.7 feet (ISWS, 1999). The watershed surrounding the lake is 69% agricultural land which is 8,948 of the 12,897 acres.

In 1963, the legislature of Illinois enacted a law that allowed for the formation of commissions to organize and address water supply problems. In 1964, Auburn, Divernon, Girard, Pawnee, Thayer, and Virden came together to form the ADGPTV Water Commission; each appointing a water commissioner to represent their interests. At this time, water was supplied to these communities by City Water, Light, and Power (CWLP), located in Springfield. A major drought in the mid-1950s raised concern regarding water security and a reservoir project was initiated to dam the West Fork of Otter Creek. In June of 1968, permits were granted and construction started shortly thereafter. The project was funded by the United States Department of Agriculture (USDA), Farmer's Home Administration, at an expense of $3.7 million. The dam and its spillway were completed in October of 1968. The capacity of the finished lake was 5.5 billion gallons or 15,000 acre-feet (Lin Et. al., 1999).

Landuse characteristics in the watershed have made Otter Lake susceptible to sediment and nutrient inputs. There have been past occurrences of algae blooms that caused 1996 and 2002 regulatory impairments for both recreation and drinking water supply. In 2004, the IEPA listed Otter Lake as "Impaired," giving it a high priority ranking and, because of this, Otter Lake had a TMDL developed and approved in 2006. Hodges Creek was listed as impaired for dissolved oxygen and Otter Lake was listed as impaired for manganese. From 2006-2012, Otter Lake could not support Public and Food Processing Water Supplies and remained impaired for manganese, mercury, total phosphorus, and aquatic algae. Otter Lake was granted full use for the Public and Food Processing Water Supplies in 2014, and impairments were removed for both manganese and aquatic algae. Impairments still include mercury and total phosphorus as described in Section 2.2. A summary of historical lake impairments is presented in Table 2.

Table 3 - Otter Lake Historical Impairment Summary

Year Listed	Listed For	Use Support
1996	Manganese, Excessive Algae Growth	1. **Full Use Support**: Aquatic Life, Fish Consumption 2. **Partial Use Support**: Overall Use, Primary Contact, Secondary Contact, Public Water Supply
2002	Pesticides, Excessive Algae Growth	1. **Full Use Support**: Aquatic Life, Fish Consumption 2. **Partial Use Support**: Overall Use, Primary Contact, Secondary Contact, Public Water Supply
2004	Manganese, Excessive Algae Growth	1. **Full Use Support**: Aquatic Life, Fish Consumption 2. **Partial Use Support**: Overall Use, Primary Contact, Secondary Contact, Public Water Supply
2006	Manganese, Aquatic Algae	1. **Full Use Support**: Aquatic Life, Fish Consumption 2. **Not Supporting**: Public and Food Processing Water Supplies, Aesthetic Quality

Year Listed	Listed For	Use Support
		3. **Not Assessed**: Primary Contact, Secondary Contact
2008	Manganese, Mercury, Aquatic Algae	1. **Full Use Support**: Aquatic Life 2. **Not Supporting**: Fish Consumption, Public and Food Processing Water Supplies, Aesthetic Quality 3. **Not Assessed**: Primary Contact, Secondary Contact
2010	Manganese, Mercury, Aquatic Algae	1. **Full Use Support**: Aquatic Life 2. **Not Supporting**: Fish Consumption, Public and Food Processing Water Supplies, Aesthetic Quality 3. **Not Assessed**: Primary Contact, Secondary Contact
2012	Manganese, Mercury, Aquatic Algae, Total Phosphorus	1. **Full Use Support**: Aquatic Life 2. **Not Supporting**: Fish Consumption, Public and Food Processing Water Supplies, Aesthetic Quality 3. **Not Assessed**: Primary Contact, Secondary Contact
2014	Mercury, Total Phosphorus	1. **Full Use Support**: Aquatic Life, Public and Food Processing Water Supplies 2. **Not Supporting**: Fish Consumption, Aesthetic Quality 3. **Not Assessed**: Primary Contact, Secondary Contact

As detailed in subsequent sections, the OLWC has been very active over the years addressing both internal and external sources of sediment and nutrients. Multiple years of grant funding has led to the implementation of numerous BMPs on properties surrounding the lake. The OLWC has been successful in stabilizing shoreline throughout the lake and installed aerators near the water intake to promote mixing and mitigate algae growth. A large in-lake dam was constructed in 2002 at the north end of the lake and has been effective in containing sediment and nutrients delivered from the watershed.

2.1 Relationship to Other Plans & Studies

Over the last 20-years, there have been three applicable studies completed for Otter Lake:

- 1999 ISWS/Illinois Department of Natural Resources (IDNR) Phase I Diagnostic Study.
- 2004-2005 Illinois Department of Agriculture (IDOA) aerial stream survey of Otter and Hodges Creek.
- 2005 TMDL completed for the IEPA by Limno-Tech, Inc.

Each work product addressed different issues in the watershed. The 1999 study summarized previous studies from other lakes and looked specifically at the lake, whereas the 2004-2005 streambank report looked at tributaries draining to and from Otter Lake. The 2005 TMDL evaluated the Hodges Creek watershed, including Hodges Creek, Palmyra-Modesto Lake, Hettrick Lake, and Otter Lake. The 1999 study looked at many of the same issues described in this watershed plan but almost 20-years removed from the first study, changes have occurred in the watershed warranting that some elements be updated to reflect more current conditions.

1999 Diagnostic-Feasibility Study of Otter Lake

The study completed in 1999 sought to address and develop an integrated protection and management plan for both Otter Lake and its watershed to improve drinking water quality for residents and visitors that use the lake for recreation. The study concluded that people were being adversely affected because of deteriorating conditions in the lake; seven major problems were identified in the report:

1. Nutrient and sediment loading from runoff.
2. Eroding shoreline.
3. Northern zone of the lake experiencing elevated siltation.
4. Deterioration of coves around the lake from sedimentation, especially at the boat launch.
5. Water stratification during the summer leading to low dissolved oxygen levels deeper in the water column.
6. High atrazine levels.
7. Poor quality of raw water supply.

Water quality measurements for this study were taken from four stations on the lake to ascertain if changes occur uniformly or are specific to certain sections of the lake. The stations established for the study continue to be used for lake monitoring. One station is located at the southern portion of the lake by the spillway, one at the central part of the lake just south of Emmerson Airline road, one near the intake and boat launch, and one station at the northern end of the lake south of where the West Fork of Otter Creek enters the lake. Only three of the four stations were used by the researchers when comparing historical data.

Study Conclusions

Nitrogen: The study concluded that there was no significant difference in nitrogen between reporting stations. Two out of three stations' status were trending below the historical mean and the water was not listed as impaired for nitrogen. Of the estimated 95,000 lbs/yr nitrogen load, 82,100 lbs/yr was attributed to the watershed, and 13,400 lbs/yr was attributed to lakeshore erosion and precipitation. This translates into a rate of 7.3 lbs/ac/yr.

Phosphorus: Total phosphorus was evaluated at three stations. Two stations were found to have remained the same or showed improved phosphorus levels compared to historical data. The upper end of the lake showed phosphorus levels higher than historical data; this section of the lake was listed as impaired. Of the estimated 20,560 lbs/yr of phosphorus that enters the lake, 17,980 lbs/yr was attributed to runoff from the watershed, and 2,580 lbs/yr was attributed to lakeshore erosion and precipitation. This translates into a watershed loading rate of 1.6 lbs/ac/yr.

Sediment: The study referenced a 1998 lake sedimentation survey that noted that Otter Lake was losing 36.5 ac-ft of volume every year due to sediment accumulation. Estimates provided in the 1999 report describe an annual sediment budget or yield of 8,911 tons/yr, or 0.7 tons/ac/yr; 7,257 tons/yr was attributed to the watershed and 1,654 tons/yr to lakeshore erosion. This can be compared to a net erosion rate of 2.1 tons/ac/yr indicating that only a portion of the watershed erosion enters the lake. The southern basin of the lake received much lower amounts of sediment than the northern basin did and experienced some reduction of sediment released through the spillway. Wind and boat traffic contributed to shoreline erosion; 23% of the shoreline was considered moderately or severely eroded. Lake banks in 1999 had no erosion control measures installed. Sedimentation at the boat launch caused by the filter backwash from the water treatment plant resulted in changes to discharge from the treatment plant.

Dissolved Oxygen: During the summer months, dissolved oxygen becomes depleted in the deeper sections of the lake. If there are no natural or manmade currents, dissolved oxygen content will diminish, moving from the surface of the lake to the lake bottom. Low dissolved oxygen can cause adverse chemical changes to occur, such as phosphorus leaching out of the sediment. The lower layers of water replenish the dissolved oxygen content when the lake turns over in the spring and fall and regains contact with the surface. Any flow that disrupts the water layers can help draw down dissolved oxygen from higher layers. The general use criteria for dissolved oxygen is 5 mg/L. Dissolved oxygen was not a central focus of the 1999 study but it was addressed in the 2006 TMDL.

Atrazine: atrazine was applied to fields in the watershed at different rates since the early 1990s. In the fall of 1991, the IEPA recorded a sample that contained 6.8 ug/L of atrazine which is more than double the drinking water standard of 3.0 ug/L. Higher levels atrazine lead to higher treatment costs. Mitigation of atrazine before it enters the lake is not only less expensive but also helps to mitigate a water body from becoming impaired.

Report Recommendations

The 1999 study provided seven components to ensure water quality is maintained:

1. Dissolved oxygen levels should be maintained at a minimum of 5 mg/L year-round, especially during the summer months when the water in the lower reaches of the water column see reduced concentrations.
2. During the summer months, the Secchi disc transparency should not be less than 48 inches.
3. 0.05 mg/L or less of total phosphorus should be present when the lake undergoes the spring turnover.
4. The amount of suspended solids and turbidity introduced to the lake annually should not exceed 25 units.
5. Reduce watershed nutrient loading.
6. Mitigate soil erosion of the watershed.
7. Reduce the atrazine concentrations in the lake.

Specific actions or recommendations are as follows:

1. Conduct shoreline stabilization.
2. Sediment removal or dredging of legacy lake sediment, especially in shallow coves.
3. Relocate the raw water intake.
4. Install water de-stratifiers.
5. Install watershed management practices to control erosion, such as conservation tillage, terraces and filter strips.
6. Continue monitoring.

Lake bank erosion has been substantially reduced since this 1999 study was done. Many of the most severely eroding banks have been stabilized with riprap; today, 34%, or 10 miles of banks, are stable.

2005 IDOA Aerial Assessment Report for Hodges and Otter Creek

In 2005, the IDOA completed a report detailing a 2004 aerial assessment of Hodges and Otter Creek. The assessment video mapped the entire length of the West Fork of Otter Creek, followed by a ground truthing to verify video interpretations and gather additional data. Three stream cross-sections were evaluated on the West Fork of Otter Creek. The report noted 23 erosion sites, several log jams, and breakpoints on the West Fork of Otter Creek.

The report noted a cross-section near Otter Lake (cross-section 8) influenced by its backwater effects is limiting incision to slightly less than twice the bankfull depth. Cross-section 8 is depositional and the other two are degrading, although partially armored by heavy cobble. Above cross-section 8, the channel has already incised approximately 3 times its bankfull flow depth and will continue to cause the channel to widen. Report recommendations to address bank and bed instability include:

1. Install 2-foot tall rock riffle grade control structures above cross-section 8.
2. Install lateral bank treatment or Stone Toe Protection at the 23 identified erosion sites.

These above-stated recommendations are consistent with those outlined in Section 6 of this plan.

2006 Hodges Creek TMDL

A Total Maximum Daily Load (TMDL) is a calculation of the amount of a pollutant a water body is able to assimilate and meet water quality standards. A TMDL is typically completed when a waterbody is deemed to be impaired as a result of a pollutant with an associated water quality standard. The 2006 study focused on dissolved oxygen and manganese – impairments at the time in Otter Lake. This report looked at four different areas within the larger Hodges Creek watershed and indicated that during summer months, deeper water can become anoxic (oxygen deficient) allowing manganese to be released from legacy sediment on the lake bottom. The TMDL recommended oxygenating deeper water to prevent manganese from leaching into the water.

In Otter Lake, the TMDL was calculated only for manganese. The water quality standard for manganese in Illinois waters designated as a public water supply is 150 ug/l, and the general use standard is 1,000 ug/l. A sample taken in August of 1996 showed manganese levels below detection at the surface, 1,200 ug/L of manganese at 30 feet, and 2,800 ug/L at 44 feet. The primary source of manganese to the lake is from lake sediments during periods when there is no dissolved oxygen in bottom waters. The lack of dissolved oxygen is presumed to be due to the effects of nutrient enrichment, as there are no significant sources of oxygen-demanding materials to the lake. For this reason, release from lake sediments is considered a controllable source, and attainment of the total phosphorus standard is expected to result in oxygen concentrations that will reduce sediment manganese flux to natural background levels. The TMDL target for manganese, therefore, is set as a total phosphorus concentration of 0.05 mg/L (Limno-Tech, Inc, 2005).


Otter Lake Intake

The TMDL report noted manganese that has already entered the lake is found within the sediment layer on the lake bottom. During the summer months when dissolved oxygen is expended due to nutrient enrichment (there are no natural oxygen-demanding materials in Otter Lake), then nutrients, such as phosphorus and manganese, begin to leach out of the sediment into the water due to the anoxic conditions. Because phosphorus leaches out of the sediment under the same conditions as manganese, the TMDL looked at phosphorus levels to determine the leaching of manganese. It estimated that 6,554 lbs/yr of phosphorus is released from lake sediment on an annual basis.

The average allowable phosphorus load to mitigate the release of manganese in lake sediment is 3.68 kg/day between the months of March and August. For the same period of time, the load cannot exceed 710 kg. If this phosphorus load reduction can be achieved, it would result in a 66% reduction.

According to the TMDL, soils in the watershed are naturally high in manganese; these soils are eroded and carried into the lake as rain water runs off the crop fields. Soil particles settle on the bottom of the lake where, in the summer months, deeper water becomes anoxic, allowing manganese to be released. During the summer months, drinking water is extracted lower in the water column resulting in a greater risk of impacts from manganese. The TMDL noted that the primary sources of phosphorus to the lake are agricultural sources, leaching of sediment during anoxic conditions, shoreline erosion, and private sewage systems that have fallen into disrepair. The TMDL recommended the following actions or practices to reduce phosphorus and manganese:

1. Sediment control basins.
2. Shoreline buffers.
3. Grassed waterways.
4. Nutrient management.
5. Animal waste control.
6. Conservation tillage.
7. Shoreline stabilization.
8. Erosion control for new developments.
9. Inspection and maintenance program for private sewage disposal systems.
10. Aeration or destratification of lake water.
11. Dredging
12. Phosphorus Inactivation.

3.0 Watershed Resource Inventory

The resource inventory summarizes watershed characteristics specific to Otter Lake. It includes information on hydrology, landuse, soils, habitat and water quality, demographics, and other relevant information specific to the watershed.

3.1 Location & Watershed

Otter Lake and its 12,897-acre watershed are located in north-central Macoupin County with a portion of its headwaters in the southwest corner of Sangamon County. The watershed is within the larger Hodges Creek watershed, which encompasses 148,961-acres (233 square miles). Otter Lake is fed by the West Fork of Otter Creek and other smaller, unnamed tributaries. Immediately downstream of the lake spillway, the West Fork of Otter Creek converges with the East Fork of Otter Creek to form Otter Creek. The West Fork of Otter Creek begins in Sangamon County and meanders 6.8 miles southward through agricultural and heavily forested riparian zones before entering Otter Lake. Smaller, ephemeral and perennial streams and forested drainages also drain to the West Fork and directly to Otter Lake.

For the purposes of this report, the IEPA has included all lands upstream of the Otter Lake spillway or outlet and a small (83-acre) section immediately downstream of the spillway contained in the 12-digit U.S. Geological Survey (USGS) Hydrologic Unit Code (HUC) basin 071300120201 (Figure 1). This 12-digit Otter Lake – Otter Creek basin is contained within the Macoupin Creek HUC 8 watershed (07130012); the HUC 10 watershed code is 0713001202.

Supplemental watershed delineation was performed to aid in watershed planning and modeling. The watershed was delineated into four sections for this purpose:

1. The area upstream or draining to the in-lake/low-flow dam at the north end of the lake – 6,944-acres or 54% of the watershed.
2. An east basin along 1400E Rd located north and east of the water treatment plant – 530-acres or 4% of the watershed.
3. A small 83-acre section of the HUC boundary immediately downstream of the spillway – 0.6% of the watershed.
4. The remaining portion of the watershed – 5,340-acres, or 41% of the watershed.

3.2 Lake Water Quality

As detailed in Section 1.1, Otter Lake is impaired for total phosphorus and has exceeded the standard of 0.05 mg/L on 138 occasions out of 184 since 2010 (75%). Although total phosphorus is the only impairment with a numeric water quality standard, other water quality issues exist. This section also summarizes water quality concerns related to nitrogen and TSS. Dissolved oxygen (DO), temperature, chlorophyll-α, Secchi depth and pH are also addressed as they are common lake water quality parameters. Furthermore, fish tissue mercury levels will be discussed within context of the fish consumption impairment.

Lake and watershed pollutant loads and recommendations described in this report will specifically address total phosphorus, total nitrogen and TSS.

The IEPA maintains four monitoring sites within Otter Lake (Figure 2). All data presented in this section was obtained from the IEPA for a period from 2010-2016; DO, depth, and temperature data were collected from the OLWC and the Volunteer Lake Management Program database for a period of 2009-2016; all other water quality data was obtained from the IEPA for a period of 2010-2016. Average annual results indicate a very slight trend of decreasing total phosphorus, ammonia, TSS, total nitrogen, and a slight increase in Secchi depth since 2013. Figures 3 through 8 display average concentrations of nitrogen, phosphorus, TSS, ammonia, Secchi depth, and chlorophyll-α between 2010 and 2016. Results represent averages from all sampling locations at all depths within the lake.

Although not included in the average values presented in this section, recent sampling performed by the OLWC does indicate elevated levels of nitrate in tributary streams between 2015 and 2016 of 9.7 mg/L compared to lower concentrations within the lake itself. Recent, but limited, sampling of the in-lake dam at the North end of the lake indicates average nitrate concentrations of 5.6 mg/L between 2015 and 2016; a 2017 sample taken from the area behind the in-lake structure showed a total phosphorus concentration of 0.25 mg/L; this result is higher than historical averages from within the lake. This limited sampling may indicate that agitation and re-mobilization of sediment and phosphorus is occurring upstream of the sediment dam. Higher turbidity water was also noted in samples taken from the overflow water at the in-lake dam. The higher turbidity overflow may indicate that in-lake sediment deposits being re-mobilized and transported downstream. See Section 8.2.3 for a more detailed evaluation of the in-lake structure.

Otter Lake

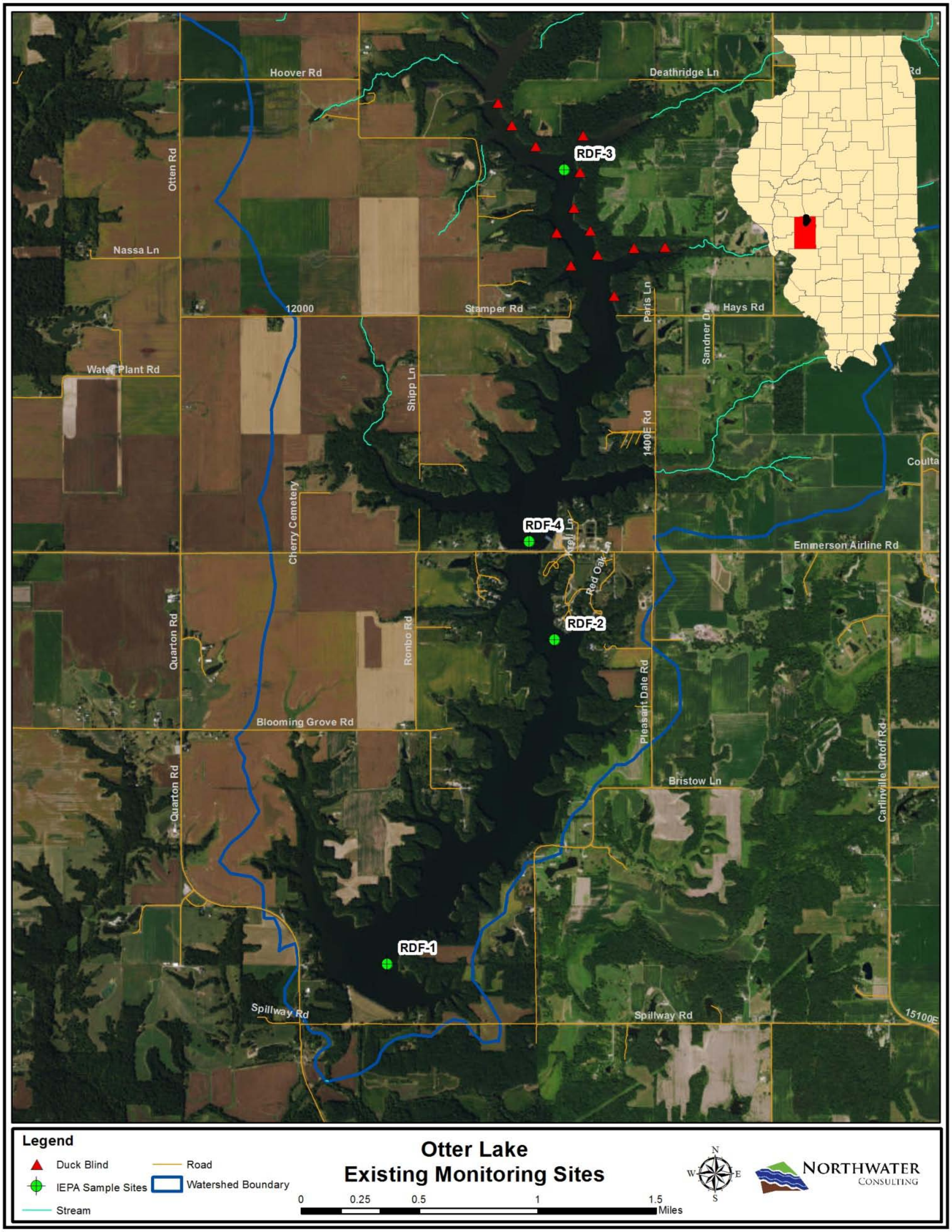


Figure 2 - Otter Lake Water Quality Monitoring Stations

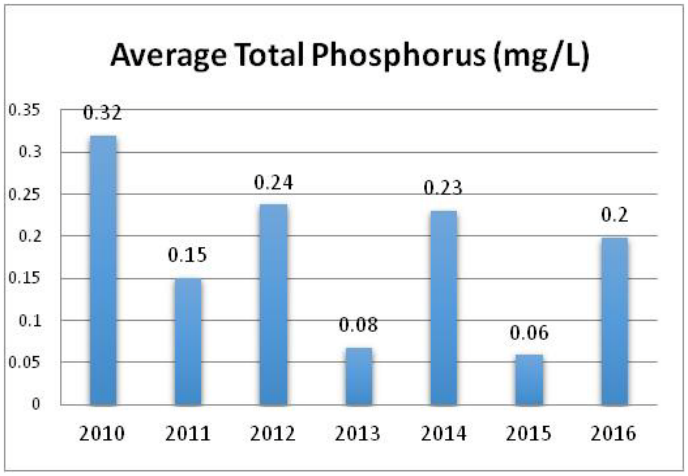


Figure 3 - Average Total Phosphorus 2010-2016

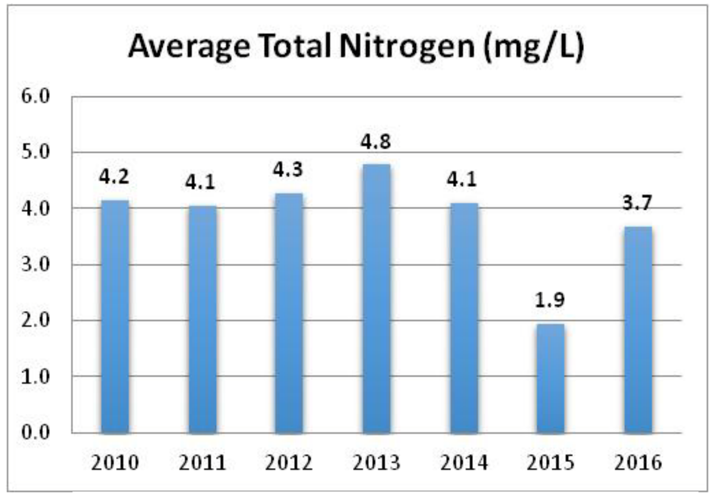


Figure 4 - Average Total Nitrogen 2010-2016

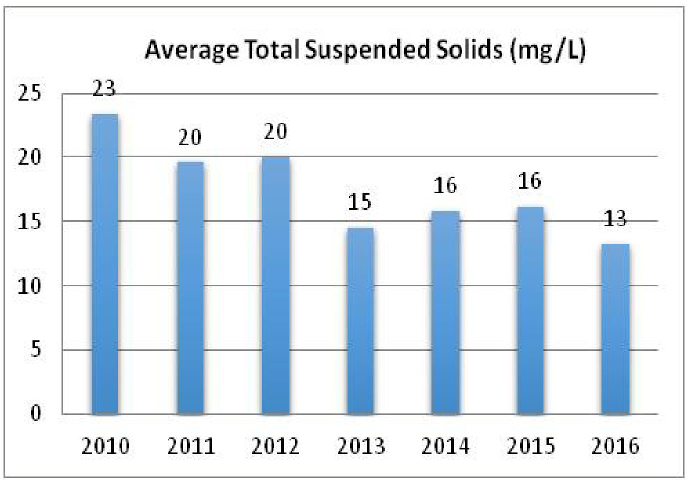


Figure 5 - Average Total Suspended Solids 2010-2016

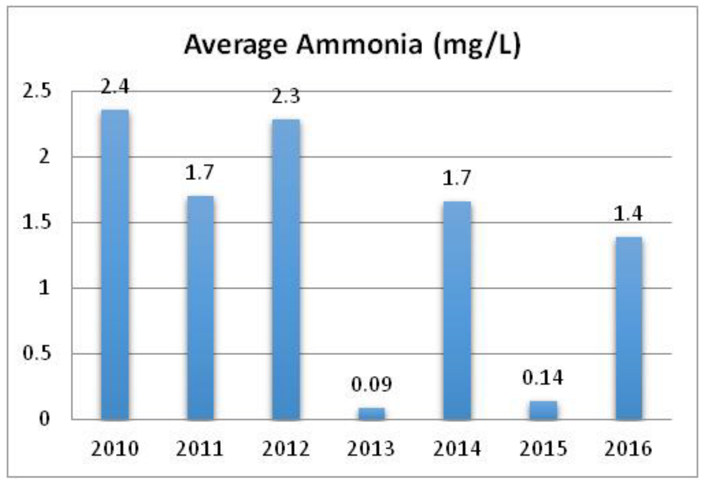


Figure 6 - Average Ammonia 2010-2016

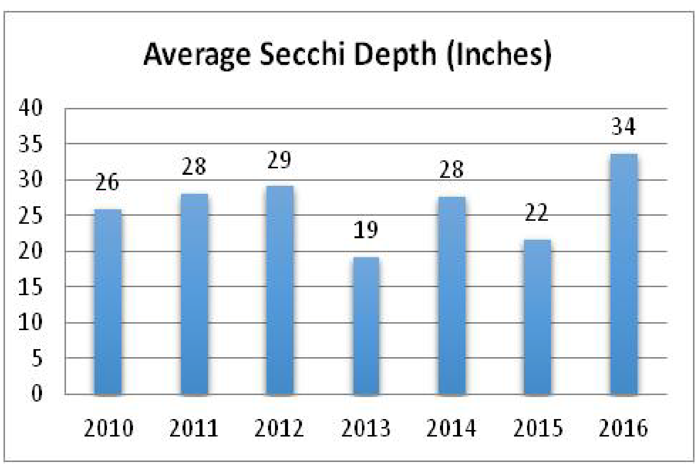


Figure 7 - Average Secchi Depth 2010-2016

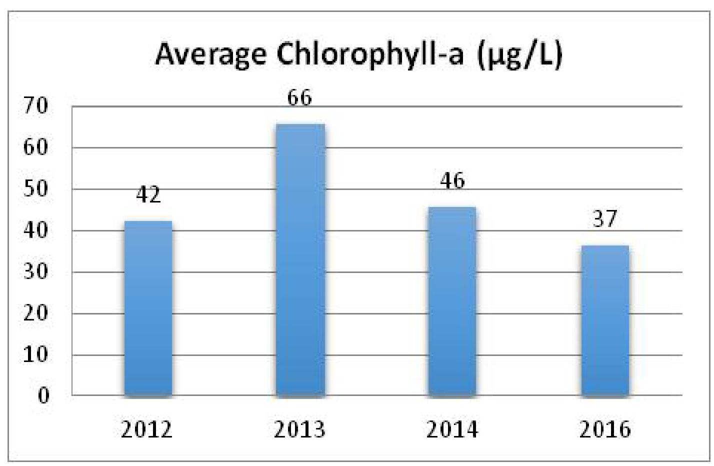


Figure 8 - Average Chlorophyll- α 2012-2016

3.2.1 Phosphorus

Phosphorus is a major cellular component of organisms. Phosphorus can be found in dissolved and sediment-bound forms. However, phosphorus is often locked up in living biota, primarily algae. In the watershed, phosphorus is found in fertilizers and in human and animal wastes. The availability of phosphorus determines the growth and production of algae and makes it the limiting nutrient in the system. The more nutrients such as phosphorus present in a body of water, the more algae that will grow and form a bloom which can be harmful to water quality and aquatic health. Dissolved phosphorus is important because it is readily usable by algae and other plants. The two common forms of phosphorus are:

- **Soluble reactive phosphorus (SRP)** – is dissolved phosphorus readily usable by algae. SRP is often found in very low concentrations in phosphorus-limited systems where the phosphorus is tied up in the algae and cycled very rapidly. Sources of dissolved phosphorus include fertilizers, animal wastes, and septic systems.
- **Total phosphorus (TP)** – includes dissolved and particulate forms of phosphorus. According to Illinois water quality standards, total phosphorus must not be greater than 0.05 mg/L in lakes greater than 20 acres in size.

Total annual phosphorus concentrations in Otter Lake routinely exceed the state water quality standard. Since 2010, the maximum concentrations have decreased, minimum values have remained consistent, and average concentration values have decreased slightly overall with fluctuations from year to year. The standard has been exceeded 73% of the time on average. The highest TP values recorded each year have occurred between the months of July and October.

Table 4 lists the results of TP data collected between 2010 and 2016, organized as annual averages from all sites and depths. It is important to note that reported data varied by year and by station; data was only reported for two out of the seven years at RDF-2; RDF-3 was missing data from 2013 and 2015. Site RDF-4 is the only station with a complete set of data from 2010 through 2016.

Table 4 - Total Phosphorus Results - 2010-2016

Year	Max Value (mg/L)	Min Value (mg/L)	Average Concentration (mg/L)	# Excedences	% Exceeded
2010	1.3	0.03	0.32	28	90
2011	1.3	0.03	0.15	43	65
2012	1.2	0.03	0.24	20	80
2013	0.1	0.04	0.07	5	63
2014	1.1	0.03	0.23	27	90
2015	0.1	0.04	0.06	5	63
2016	0.8	0.02	0.22	10	63
Average	**0.9**	**0.03**	**0.18**	**20**	**73**

Monthly average TP results between 2010 and 2016 are presented in Table 5; results represent averages from all sample sites and depths. Results indicate that the TP standard is exceeded at a slightly higher percentage between July and October. Results show that the month of July experienced the largest number of TP exceedences followed by September, October, and August; June experienced the fewest number of exceedences. Maximum values and average concentrations are also highest from July through October. Average TP concentrations appear to be the lowest in April.

Table 5 - Total Phosphorus Results by Month - 2010-2016

Month	Max Value (mg/L)	Min Value (mg/L)	Average Concentration (mg/L)	# Exceedances	% Exceeded
April	0.21	0.03	0.08	8	67
May	0.51	0.03	0.13	20	74
June	0.75	0.02	0.15	26	66
July	1.2	0.03	0.28	29	81
August	1.3	0.03	0.3	25	76
September	1.1	0.04	0.5	4	80
October	**1.3**	**0.03**	**0.2**	**26**	**79**

Table 6 summarizes TP results by monitoring station; results represent average values by year and depth. The highest average values are found at Station RDF-4 near the water intake (5-year average of 0.24 mg/L). The lowest average results are found at Station RDF-2. In both 2013 and 2015, Station RDF-1 (near spillway) TP was below the standard for majority of samples taken. From 2010-2016, all samples taken at RDF-3 (North end of lake) and RDF-4 (near intake) exceeded the standard. It should be noted that no data exists for multiple years at Stations RDF-2 and RDF-3.

Table 6 - Total Phosphorus Results by Monitoring Station - 2010-2016

Year	RDF-1		RDF-2		RDF-3		RDF-4	
	Average Concen. (mg/L)	Number of Exceed. in Std./%	Average Concen. (mg/L)	Number of Exceed. in Std./%	Average Concen. (mg/L)	Number of Exceed. in Std./%	Average Concen. (mg/L)	Number of Exceed. in Std./%
2010	0.34	9/75%	ND	ND	0.14	6/100%	0.4	12/100%
2011	0.11	8/36%	0.04	1/20%	0.1	10/100%	0.2	25/83%
2012	0.18	5/50%	ND	ND	0.15	5/100%	0.3	10/100%
2013	0.05	1/25%	ND	ND	ND	ND	0.09	4/100%
2014	0.21	9/75%	ND	ND	0.15	6/100%	0.29	12/100%
2015	0.04	2/50%	ND	ND	ND	ND	0.07	3/75%
2016	0.17	2/50%	0.03	0/0%	0.1	2/100%	0.28	6/75%

Due to a lack of data between 2012 and 2016, it is difficult to identify any trends in dissolved phosphorus levels. The maximum recorded concentration and the highest average concentration over all sites occurred in 2010 and decreased in 2011 and 2012. Table 7 lists the results of dissolved phosphorus data collected between 2010 and 2011.

Table 7 - Dissolved Phosphorus - 2010-2012

Year	Max Value (mg/L)	Min Value (mg/L)	Average Concentration (mg/L)
2010	0.75	0.002	0.15
2011	0.63	0.003	0.04
Average	**0.69**	**0.003**	**0.1**

3.2.2 Total Nitrogen & Ammonia Nitrogen

The various forms of nitrogen are of particular importance with respect to lake health. Inorganic forms of nitrogen are readily available by algae for growth and other forms of nitrogen, in high concentrations, can be toxic to fish and other aquatic organisms. The four common forms of nitrogen are:

- **Nitrite (NO2)** – is an intermediate oxidation state of nitrogen, both in the oxidation of ammonia to nitrate and in the reduction of nitrate.
- **Nitrate (NO3)** – generally occurs in trace quantities in surface water but may attain high levels in some groundwater. Nitrate travels easily through soil carried by water into surface waterbodies and groundwater. The current standard of 10 mg/L for nitrate nitrogen in drinking water is specifically designated to protect human health.
- **Ammonia (NH4)** – is present naturally in surface waters. Bacteria produce ammonia as they decompose dead plant and animal matter. In Illinois, the total ammonia general use standard is 15 mg/L.
- **Organic nitrogen (TKN)** – is defined functionally as organically bound nitrogen in the tri-negative oxidation state. Organic nitrogen includes nitrogen found in plants and animal materials, which includes such natural materials as proteins and peptides, nucleic acids and urea. In the analytical procedures, Total Kjeldahl Nitrogen (TKN) determines both organic nitrogen and ammonia. Raw sewage will typically contain more than 20 mg/L.

Total nitrogen is the sum of TKN (ammonia, organic and reduced nitrogen) and nitrate-nitrite and for the purposes of this report; the nitrate nitrogen standard of 10 mg/L is applied for total nitrogen. Nitrogen sampling varied substantially; not all forms of nitrogen were collected during each sampling event or at each sampling station. For example, total nitrogen could not be generated using samples from site RDF-2 and RDF-3 only had complete samples for 2010, 2011, and 2014. Overall, nitrogen sampling was more complete in 2010 and 2011, compared to the period of 2012 through 2016.

The highest recorded concentration occurred in October of 2011. One sample exceeded the 10 mg/L standard in May of 2010 at Station RDF-4 (near spillway). Despite increases in the minimum values, average total nitrogen concentrations and maximum recorded concentrations have been declining since 2011. Table 8 lists the results of total nitrogen data collected between 2010 and 2016.

Table 8 - Total Nitrogen - 2010-2016

Year	Max Value (mg/L)	Min value (mg/L)	Average Concentration (mg/L)
2010	10	0.03	4.2
2011	7.1	0.02	4.1
2012	5.4	0.02	4.3
2013	6.4	0.02	4.8
2014	5.9	0.03	4.1
2015	1.8	0.04	1.9
2016	3.6	0.05	3.7
Average	**5.7**	**0.03**	**3.9**

As with total nitrogen, ammonia has remained consistently below the general use standard of 15 mg/L. The highest recorded value of 7.5 mg/L occurred in October of 2010 at Station RDF-1 (near spillway). Average concentrations have fluctuated since 2010 but remain relatively steady with the exception of 2013 and 2015. It is important to note that only 2 samples were collected in 2013 and 2015. Table 9 lists the results of ammonia data collected between 1999 and 2015. Recent sampling by the OLWC from late 2016 and through 2017 shows average ammonia concentrations of 0.24 mg/L from raw water at the intake and an average ammonia concentration from 3 samples of 0.03 mg/L at the in-lake dam. This would indicate substantially lower-than-average ammonia concentrations than observed in the lake from sampling conducted between 2010 and 2016.

Table 9 - Ammonia - 2010-2016

Year	Max Value (mg/L)	Minimum Value (mg/L)	Average Concentration (mg/L)
2010	7.5	0.06	2.4
2011	5.9	0.03	1.7
2012	5.1	0.04	2.3
2013[1]	0.2	0.02	0.09
2014	4.9	0.1	1.7
2015[1]	0.17	0.1	0.14
2016	3.2	0.05	1.4
Average	**3.9**	**0.06**	**1.4**

1 – Only 2 samples collected; 1 at RDF-1 and 1 at RDF-4

3.2.3 Total Suspended Solids

Total Suspended Solids (TSS) is a water quality measurement which refers to the portion of total solids retained by a filter; whereas total dissolved solids (TDS) refers to the portion that passes through the filter. TSS includes both organic forms and inorganic forms and can be divided into volatile suspended solids (VSS), which include organic materials such as algae and decomposing organic matter and nonvolatile suspended solids (NVSS), which includes non-organic "mineral" substances (IEPA, 2016). TSS measurements and modeling are frequently used to represent sediment loading; TSS data presented represents a period from 2010 through 2016.

All average annual TSS results exceed the 15 mg/L AQI maximum point score for suspended solids. In no year did all samples exceed 15 mg/L; on average, only 45% of samples exceed 15 mg/L. The highest levels are typically observed in the spring and are associated with storm events and runoff. The average annual TSS concentration for Otter Lake is 18 mg/L. There is a noticeable trend of decreasing TSS concentrations in the lake. Table 10 lists the results of TSS data collected between 2010 and 2016.

Table 10 -TSS - 2010-2016

Year	Max Value (mg/L)	Min Value (mg/L)	Average Concentration (mg/L)	# Exceedences	% Exceeded
2010	149	6	23	14	48%
2011	133	4	20	21	37%
2012	72	6	20	16	67%
2013	20	9	15	3	38%
2014	51	5	16	11	38%
2015	21	11	16	4	57%
2016	40	4	13	4	27%
Average	**69**	**6.4**	**18**	**10**	**45%**

3.2.4 Dissolved Oxygen & Temperature

Dissolved oxygen (DO) is the gaseous form of oxygen available in the water and is essential for respiration of aquatic organisms (e.g., fish and plants). Dissolved oxygen enters water by diffusion from the atmosphere. It also enters as a byproduct of photosynthesis by algae and other plants. During the day, DO levels increase as a byproduct of photosynthesis, but as plant respiration continues throughout the night, DO levels drop. DO is also consumed during bacterial decomposition of plant and animal matter. Low levels of DO in the water do not provide adequate oxygen for aquatic organisms. Excessively high levels of DO in the water could be an indicator of excessive algae growth. The Illinois's DO standard is no less than 5.0 mg/L; a standard intended to support natural ecological functions and resident aquatic communities.

Temperature affects overall water quality in a lake in several ways and is used to characterize the presence or absence of thermal stratification. Colder water holds more DO than warmer water. Higher temperatures can lead to increased photosynthesis and plant growth. Decomposition of greater quantities of organic matter causes increased biological oxygen demand.

Temperature and DO measurements were made by the IEPA and the OLWC at various depths (between 0 and 47 feet) from 2009 through 2016. Results presented in this section represent average results by varying depth ranges at each sampling station (Tables 11 through 14). Generally, the lowest DO values are recorded during the summer months at the greatest depths when temperatures are higher.

Average DO in Otter Lake remained consistently above the standard up to 15 ft in depth at RDF-1 (near intake), whereas at depths greater than 15 ft, DO remained below the standard. At Station RDF-2 (center of lake), DO is consistently below the standard at depths greater than 9 ft. DO at RDF-3 (North end of lake) is consistently above the standard; this site has a maximum depth of 7 ft. As with RDF-2, DO is consistently below the standard at Station RDF-4 (intake) at depths greater than 9 ft.

Table 11 - Otter Lake Average Temperature & DO by Depth; RDF-1

RDF-1	Depth (0-3 ft)		Depth (3-15 ft)		Depth (>15 ft)	
Year	Average Temp (°C)	Average DO (mg/L)	Average Temp (°C)	Average DO (mg/L)	Average Temp (°C)	Average DO (mg/L)
2009	24	11	18	7.8	13	2.9
2010	24	8.9	23	5.6	15	1.1
2011	22	9.9	22	6	15	0.6
2012	25	9.3	23	6.8	13	0.48
2013	24	12	22	6.7	12	0.54
2014	24	8.7	22	6.2	12	0.57
2015	24	10	22	5.8	12	0.45
2016	26	9.6	19	7.5	11	0.38
Average	**24**	**9.5**	**21**	**6.6**	**13**	**0.88**

Table 12 - Otter Lake Average Temperature & DO by Depth; RDF-2

RDF-2	Depth (0-9 ft)		Depth (9-19 ft)		Depth (>19 ft)	
Year	Average Temp (°C)	Average DO (mg/L)	Average Temp (°C)	Average DO (mg/L)	Average Temp (°C)	Average DO (mg/L)
2009	20	11	17	5	14	2.9
2010	24	8	21	2.9	17	1.5
2011	24	10	21	3.8	17	1.2
2012	24	9	21	4.8	16	1.2
2013	24	11	19	3.3	14	1
2014	23	9	20	3.9	14	1.2
2016	26	9	21	2.4	15	0.18
Average	**24**	**9**	**20**	**3.7**	**15**	**1.3**

Table 13 - Otter Lake Average Temperature & DO by Depth; RDF-3

RDF-3	Depth (0-7 ft)	
Year	Average Temp (°C)	Average DO (mg/L)
2009	20	11
2010	24	9
2011	25	11
2012	26	9
2013	25	10
2014	24	9
2016	24	10
Average	**26**	**9**

Table 14 - Otter Lake Average Temperature & DO by Depth; RDF-4

RDF-4	Depth (0-9 ft)		Depth (9-19 ft)	
Year	Average Temp (°C)	Average DO (mg/L)	Average Temp (°C)	Average DO (mg/L)
2009	19	7	15	2.4
2010	23	5	17	2.1
2011	22	5	18	0.57
2012	23	5	17	1.2
2013	22	5	15	0.45
2014	22	5	15	0.24
2016	22	5	16	0.67
Average	24	6	16	0.1

3.2.5 pH

The acidity or alkalinity of water is measured using the pH scale. Water contains both hydrogen ions (H+) and hydroxide ions (OH-) and the relative concentrations of these ions determine whether it is acidic, neutral, or alkaline. pH is defined as –log [H+]. A low pH signifies an acidic medium; acids are defined as proton donors (lethal effects of most acids begin to appear at a pH of 4.5). A high pH signifies an alkaline medium; alkalis are defined as proton acceptors (lethal effects of most alkalis begin to appear at a pH of 9.5). Neutral pH is 7. The actual pH of a water sample indicates the buffering capacity of that waterbody. Illinois designates a water quality standard which supports aquatic life for pH as values between 6.5 and 9.0.

Data provided by the IEPA for this study was reported as total alkalinity converted into pH. This conversion was done using the following formula: pHactual = 1.7177 log (M alk) + 4.1333. Station RDF-2 lacked data for 2013 through 2015, so only 2016 values are included in the analysis. Likewise, there was no data collected for Station RDF-3 in 2015.

Values averaged among all lake monitoring sites between 2010 and 2016 show small fluctuations but indicate consistent pH values over time. At no point since 2010 has Otter Lake experienced pH values outside of the 6.5-9.0 range. Higher or more alkaline pH values tend to be observed in the spring and early summer whereas lower or more acidic values are observed late summer and into the fall. Historical pH results are presented in Table 15.

Table 15 - Otter Lake Historical pH

Year	Maximum pH	Minimum pH	Average pH
2010	8	7	7.7
2011	8.2	7.3	7.7
2012	8.3	7.3	7.7
2013	8.1	7.2	7.7
2014	8	7.3	7.6
2015	7.6	7.2	7.4
2016	7.9	7.3	7.6
Average	**8.0**	**7.2**	**7.6**

3.2.6 Secchi Disk Transparency

Secchi disk transparency refers to the depth to which the black and white disk can be seen in the lake water. Water clarity, as determined by a Secchi disk, is affected by two primary factors: algae and suspended particulate matter. Particulates (soil or dead leaves) may be introduced into the water by either runoff or sediments already on the bottom of the lake. Measurements reveal how deep sunlight can reach into the water and low Secchi transparencies can indicate a lack of available sunlight for the growth of algae and rooted aquatic plants in the eutrophic zone. In Illinois, there are no standards for Secchi transparency, although the Illinois Department of Public Health (IDPH) suggests at least 48 inches of clarity for swimming safety.

Average results from all three sampling stations from 2010 through 2016 indicate fluctuating Secchi disk transparency with no apparent trends. The average value over the 7 years of sampling is 26 inches or 2.1 ft. In Otter Lake, low average Secchi disk transparency may be a limiting factor in the growth of algae and rooted aquatic plants. Data from 2013 represents a year when the Lake experienced the lowest average value of 19 inches of transparency. The greatest average depth of 34 inches was observed in 2016. Table 16 lists average, minimum, and maximum depth measurements.

Table 16 - Otter Lake Historical Secchi Disk Transparency

Year	Max Depth (inches)	Minimum Depth (inches)	Average Depth (inches)
2010	40	13	26
2011	56	12	28
2012	58	14	29
2013	35	9	19
2014	51	14	28
2015	29	11	22
2016	58	15	34
Average	**47**	**13**	**26**

3.2.7 Chlorophyll-*a*

Chlorophyll is the pigment in plants that allows them to create energy from light in a process called photosynthesis. Different forms of chlorophyll absorb a different wavelength of light and chlorophyll-*a* is found in all photosynthesizing plants. For this reason, the amount of suspended algae in a lake is commonly estimated using the chlorophyll-*a* concentration (IEPA, 2016). Algae produce oxygen during daylight hours but use up oxygen during the night and again when they die and decay. Decomposition of algae also causes the release of nutrients to the lake, which may allow more algae to grow. Their processes of photosynthesis and respiration cause changes in lake pH, and the presence of algae in the water column is the main factor affecting Secchi disk readings (State of Washington, 2016).

Illinois' general lake assessment criteria suggests that chlorophyll-*a* levels greater than 55 µg/L (micrograms per liter) could "highly impair recreational lake use," while concentrations of 7-20 µg/L could cause slight impairment (IEPA, 2016). Chlorophyll-*a* data is only available from 2012-2014 and 2016.

There are no apparent trends in average results from all four sampling stations (Table 17). Results do indicate that, on average, Otter Lake exceeded the 55 µg/L threshold in 2013 and 7-20 µg/L "slight impairment" threshold in all other years.

Table 17 – Chlorophyll-*a* - 2012-2014 & 2016

Year	Maximum Chlorophyll-*a* (µg/L)	Minimum Chlorophyll-*a* (µg/L)	Average (µg/L)	# of Exceedences in Criteria	% Exceeded
2012	96	3.1	42	5	33%
2013	132	9	66	4	50%
2014	107	12	46	10	34%
2016	109	12	37	3	19%
Average	**111**	**8.9**	**48**	**5.5**	**34%**

3.3 Watershed Jurisdictions & Demographics

The Otter Lake watershed is located in north-central Macoupin County, with a small portion of its headwaters in Sangamon County. No incorporated communities exist within the watershed.

3.3.1 Watershed Jurisdictions & Jurisdictional Responsibilities

The OLWC is the primary entity responsible for watershed protection and the management and improvement of Otter Lake. Including the lake, the OLWC owns 1,649 acres in the watershed. Excluding the lake, the OLWC owns approximately 775 acres of forested area and 100 acres of grassland adjacent to the lake (Figure 9).

State or federally owned lands are not known within the watershed and, therefore, the U.S. Fish and Wildlife Service (USFWS), IDNR, or Illinois Nature Preserves Commission (INPC) does not hold any jurisdictional responsibilities within the basin.

The IEPA Bureau of Water regulates wastewater and stormwater discharges to streams, rivers, and lakes through the National Pollutant Discharge Elimination System (NPDES). There is only 1 NPDES permit within the watershed, issued to the OLWC for lagoon filter backwash (NPDES ID ILG640095). The discharge is located at the water treatment plant with an average design flow is 0.045 mgd; the plant is permitted to discharge flow, pH, and TSS to the lake. It is considered a general NPDES permit for discharges from public water supply reservoirs and loading to the lake is negligible.

The Macoupin County Soil and Water Conservation District (SWCD), and the Natural Resources Conservation Service (NRCS), are both active in watershed protection activities through various conservation incentive programs, as well as technical assistance and education and outreach to the agricultural community.

3.3.2 Demographics

An analysis of 2015 aerial imagery for the watershed indicates that there are an estimated 147 permanent residences in the watershed; seasonal residences are located on the OLWC-owned camp grounds. Of the 147 residences, 146 are in Macoupin County and only one resides in Sangamon County. The greatest number of homes in the watershed are located near the Lake.

Otter Lake - Campground

The 2010 census provides an average of 2.42 people per household in Macoupin County putting the number of permanent residents living in the watershed at roughly 356. Census data reports a 2010 population of 47,756 in Macoupin County and a 2015 population of 46,045 (a 3.6% decline). Using these population estimates, it is believed that permanent watershed residents make up approximately 0.7% of the total Macoupin County population. The median household income for 2015 was estimated at $51,206.00 and persons over the age of 65 made up 17.1% of the county population. Macoupin County is 863 square miles with a population density 55.4 people per square mile.

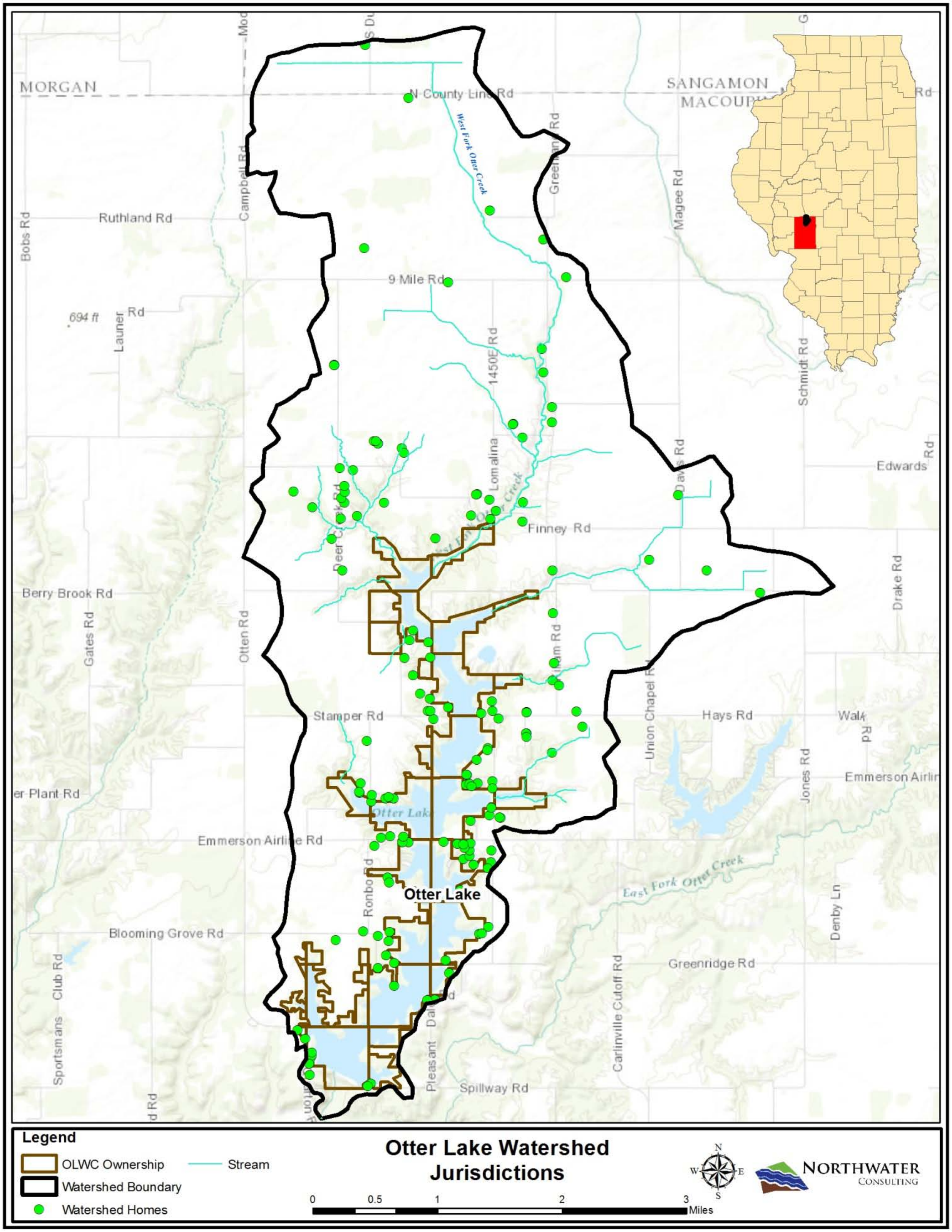


Figure 9 - Otter Lake Watershed Jurisdictions

3.4 Geology, Hydrogeology & Topography

3.4.1 Geology

The Otter Lake watershed is located in the northwest portion of the Springfield Till Plain region of Illinois in Macoupin County. The surficial materials and hydrology of the watershed have been fundamentally shaped by glacial processes of deposition and erosion. The watershed is primarily covered with loess, a fine-grained windblown glacial deposit which is highly erodible on steeper slopes. Beneath this veneer of loess is typically a sandy or loamy glacial till with variable thickness and composition. The spatial extents and statistics of each surficial deposit type are illustrated in Figure 10 and Table 18.

Surficial geology was adapted from Illinois State Geologic Survey (ISGS) 1995 Stack-Unit mapping of the top 50 ft of earth materials. Drift thickness varies from less than 20 feet to over 100 ft and is generally thickest in the western portion of the watershed. Underlying the unconsolidated deposits is the Pennsylvanian-aged Patoka and Shelburn formation, which is locally primarily shale. Bedrock is mapped to be at depths of at least 20 ft and up to 100 ft in the entire watershed, with the shallowest occurrences in the eastern portion of the watershed. The widespread veneer of highly erodible and fine-grained glacial loess is a major potential source of sediment in the watershed.

Table 18 – Waverly Lake Watershed Surficial Geology

<table>
<tr><th>Surficial Geology</th><th>Bedrock Geology (if present)</th><th>Description[1]</th><th>Area (acres)</th><th>Percent of Watershed</th></tr>
<tr><td>Alluvium</td><td rowspan="2">Shale</td><td>Cahokia Alluvium less than 6 m thick and continuous throughout area, underlain by loamy and sandy diamictons of Glasford Formation greater than 6 m thick with Pennsylvanian bedrock consisting of mainly shales often present at or around 15 meters below surface</td><td>1,105</td><td>9%</td></tr>
<tr><td>Loess</td><td>Peoria and Roxana Loess less than 6 m thick and continuous throughout area, underlain by loamy and sandy diamictons of Glasford Formation with Pennsylvanian bedrock consisting mainly of shales present between 6 and 15 meters below surface</td><td>4,899</td><td>38%</td></tr>
<tr><td colspan="2">Loess and sandy till</td><td>Peoria and Roxana Loess less than 6 m thick and continuous throughout area, underlain by loamy and sandy diamictons of Glasford Formation greater than 6 m thick and continuous throughout area. Bedrock greater than 15 m below surface</td><td>2,495</td><td>19%</td></tr>
<tr><td colspan="2">Loess and sandy till with gravel</td><td>Peoria and Roxana Loess less than 6 m thick and continuous throughout area, underlain by loamy and sandy diamictons of Glasford Formation greater than 6 m thick with local layers of sand and gravel throughout area. Bedrock greater than 15 m below surface</td><td>4,399</td><td>34%</td></tr>
<tr><td colspan="5">[1] Adapted from Illinois State Geological Survey Stack-Unit Mapping of Geologic Materials in Illinois to a Depth of 15 Meters</td></tr>
</table>

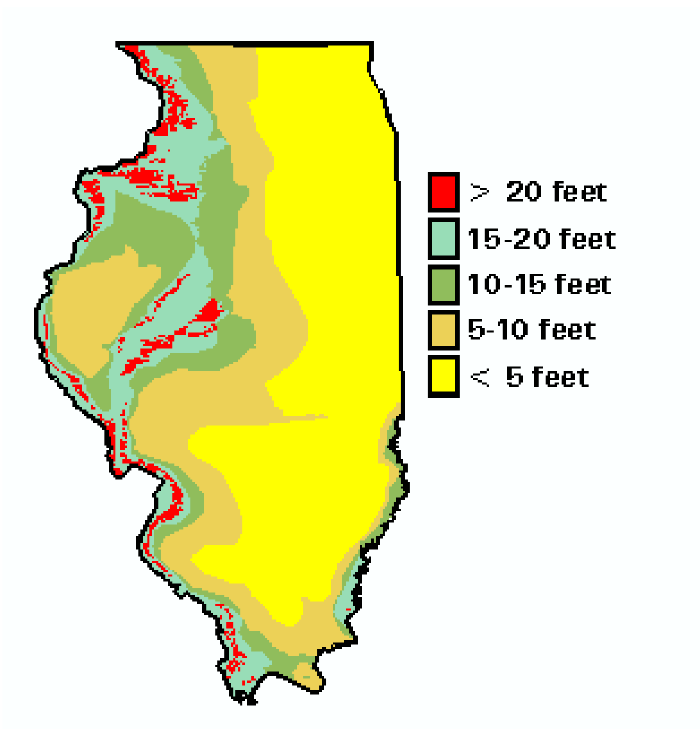
3.4.2 Hydrogeology

There are estimated to be at least 42 private water wells within the watershed based on ISGS Wells and Borings database. There are no Community Water Supply (CWS) or Non-Community Water Supply (NCWS) wells found in the state database. Based on the data available for private wells, the average depth is 39 feet; an inferred average depth to water bearing units of 17 feet was calculated based on the 36 wells which denoted depth to top of screened interval. Only one of the wells was greater than 100 ft deep. No well yields were available from ISGS databases. Summary statistics for private wells are presented in Table 19 and the locations of wells are shown in Figure 10.

The recorded wells are primarily located near drainages and Otter Lake; no pattern was discernible relative to thickness of drift and well density. Based on the 37 wells which reported the aquifer formation type, it is likely that none are in the bedrock units. ISGS mapping for major sand and gravel aquifers and major bedrock aquifers show no regional sand and gravel or bedrock aquifers present in the watershed above 500 ft.

Table 19 - Otter Lake Summary Statistics for Private Wells

	Average	Minimum	Maximum	Count
Total Depth (ft)	39	3	116	42
Top of Aquifer (ft)	17	1	53	36
Bottom of Aquifer (ft)	26	3	61	36



Loess Thickness - Illinois

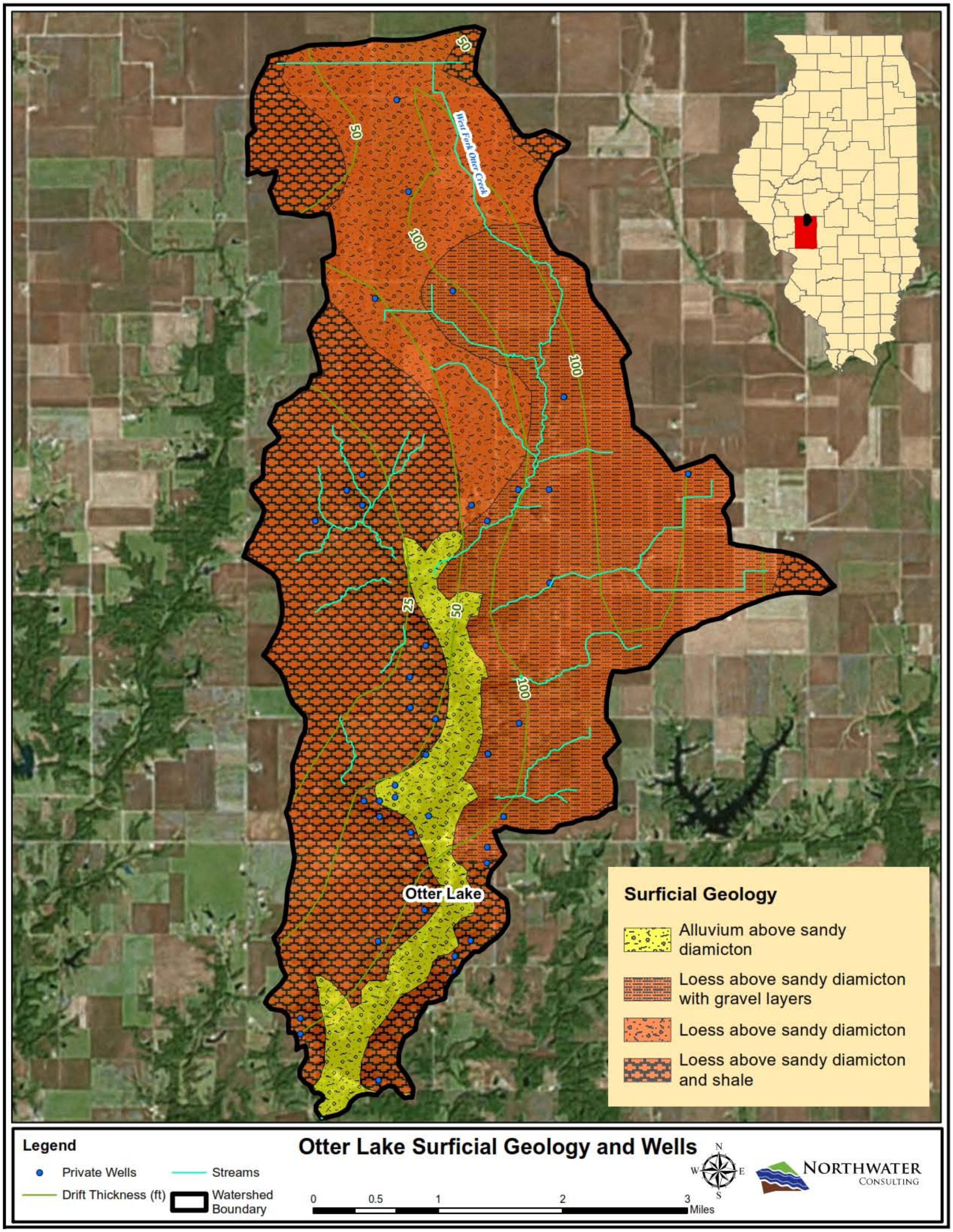


Figure 10 - Otter Lake Watershed Geology & Wells

3.4.3 Watershed Topography & Relief

The Otter Lake watershed is generally flat with steeper slopes throughout; the elevation ranges from 559 to 703 ft above sea level (Figure 11). The watershed is flatter in the headwaters or upland areas transitioning to steeper slopes adjacent to stream corridors and major waterbodies. The watershed has an average slope of 1.8% (1°) and a maximum percent slope of 32% (18°), as shown in Figure 12.

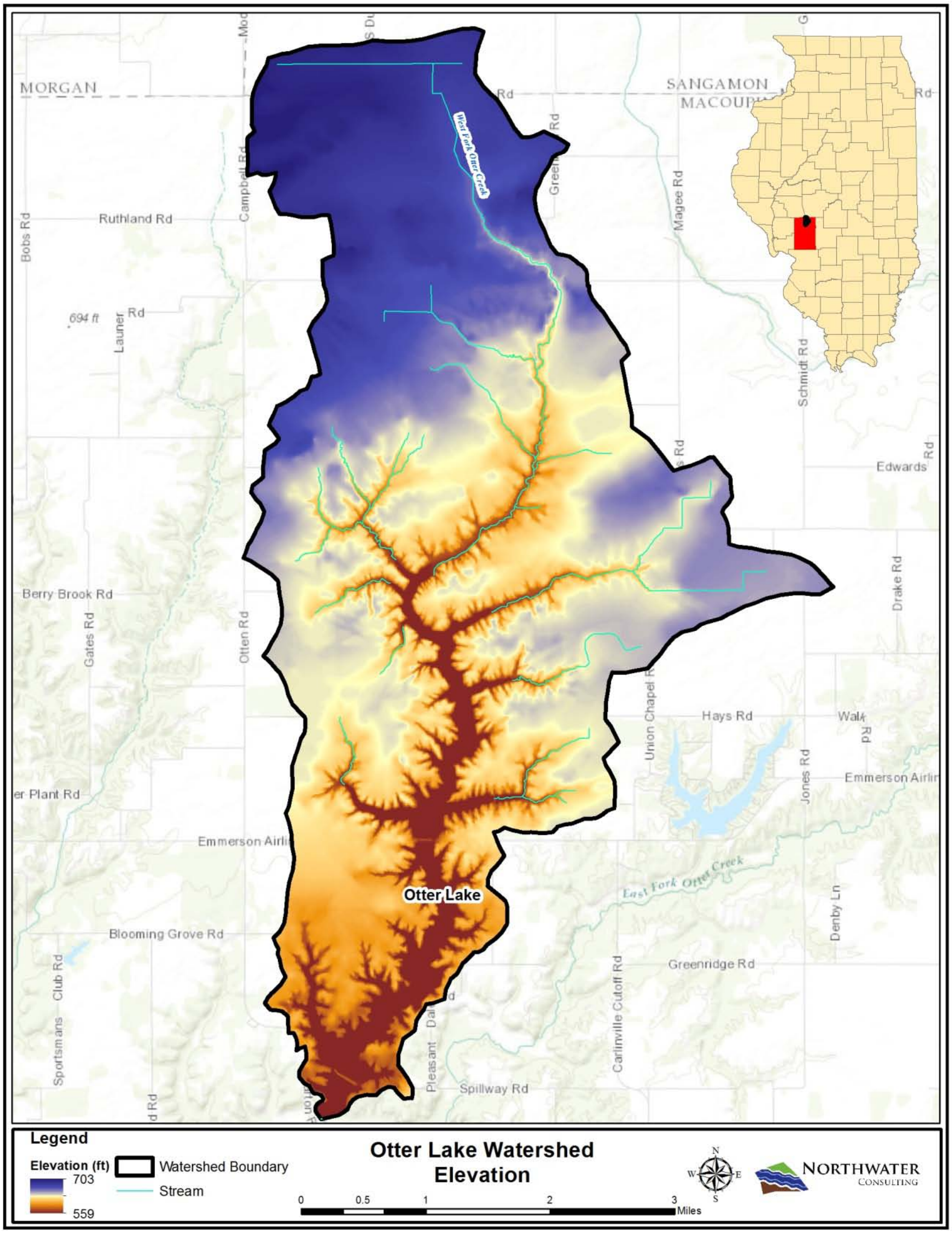


Figure 11 - Otter Lake Watershed Elevation above Sea Level

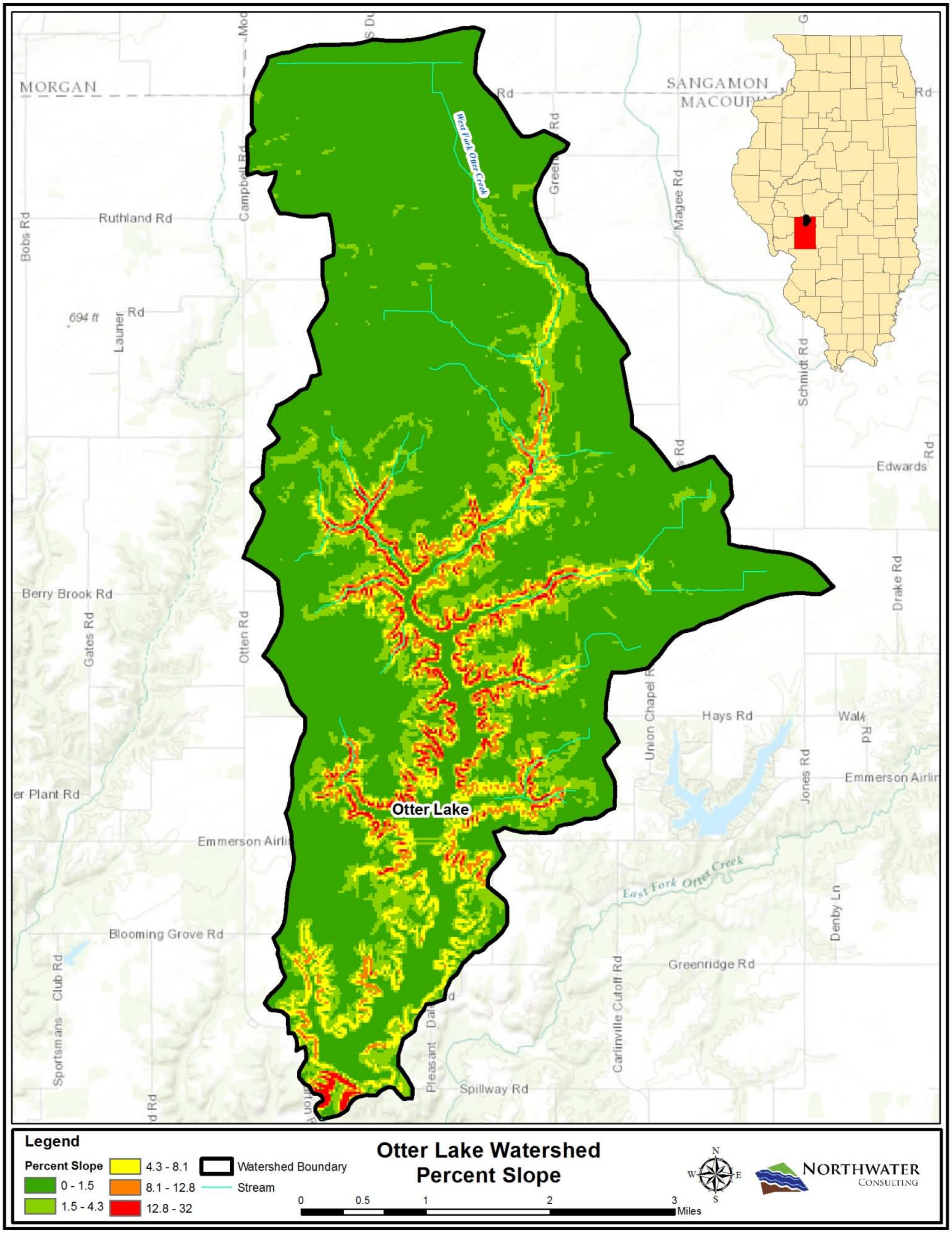


Figure 12 – Otter Lake Watershed Slope

3.5 Climate

The Midwestern Regional Climate Center houses data from a variety of weather stations throughout Illinois. No active weather station exists at Otter Lake. Climate data presented in this section is aggregated from 11 weather stations within Macoupin County, primarily Virden and Carlinville. To ensure consistency with climate parameters used to model sediment and nutrient loading, a 15-year period from 2001 through 2016 was used. Dues to the lack of available temperature data during 2015 and 2016, temperate values represent a 13-year period from 2001 through 2014.

The 15-year average annual precipitation is 41 inches. The spring and summer months see much higher rainfall totals than the fall and winter months do. The highest average monthly rainfall occurs in May and June (4.8 inches). The month of January experiences the lowest average precipitation or 1.6 inches. April through July is the wettest part of the year with average precipitation ranging from 3.9 inches to 4.8 inches.

Average annual temperature is 64° F. June through July experience monthly average temperatures greater than 80° F; the lowest average temperatures are in January (36° F). The highest average maximum temperature is 96° F in August and the average minimum temperature is in January (-0.3° F). In general, the minimum and maximum temperatures follow the same monthly trends as average temperature values.

Table 20 - Otter Lake Area Climate Normals (2001 - 2015)

Month	Max. Temp. (F)	Min. Temp. (F)	Mean Temp (F)	Mean Precip. (in)
Jan	59	-0.3	36	1.6
Feb	61	4.0	39	2.0
March	73	16	53	2.5
April	85	29	66	4.6
May	89	40	74	4.8
June	93	52	84	4.8
July	95	55	87	3.9
Aug.	96	53	86	3.0
Sept.	94	40	79	4.0
Oct.	85	30	66	3.7
Nov.	74	21	54	2.8
Dec.	61	6.0	39	3.2
Average	**80**	**29**	**64**	**41 (total)**

3.6 Landuse


OLWC Owned Timber Area

In order to better characterize watershed landuse and nonpoint source pollutants contributing to lake impairments, a custom GIS landuse layer was created for the watershed (Figure 13). This layer was developed from 2015 aerial imagery and verified through field surveys. Table 21 summarizes landuse categories and coverage, and Figure 13 illustrates the distribution throughout the watershed. The predominant land use in the watershed is row crop agriculture. Cropland makes up 69% (8,948 acres) of the watershed area. Crops are primarily a corn-soy bean rotation. Forest and grassland combined cover 19% of the watershed.

Table 21 – Otter Lake Watershed Landuse

Landuse	Acres	Percent of Watershed
Row Crops	8,948	69%
Forest	1,533	12%
Grassland	855	7%
Open Water Pond/Reservoir	816	6%
Urban Open Space	352	3%
Pasture[1]	145	1%
Roads	89	1%
Rural Residential	51	0.4%
Wetland	32	0.2%
Farm Building	23	0.2%
Open Water Stream	22	0.2%
Camp Ground	17	0.1%
Utilities	10	0.1%
Feed Area	3	0.02%
Cemetery	0.9	0.01%
Total	**12,897**	**100%**

[1] – Exact livestock numbers are unknown; total number estimated to be 150 -200

NORTHWATER CONSULTING

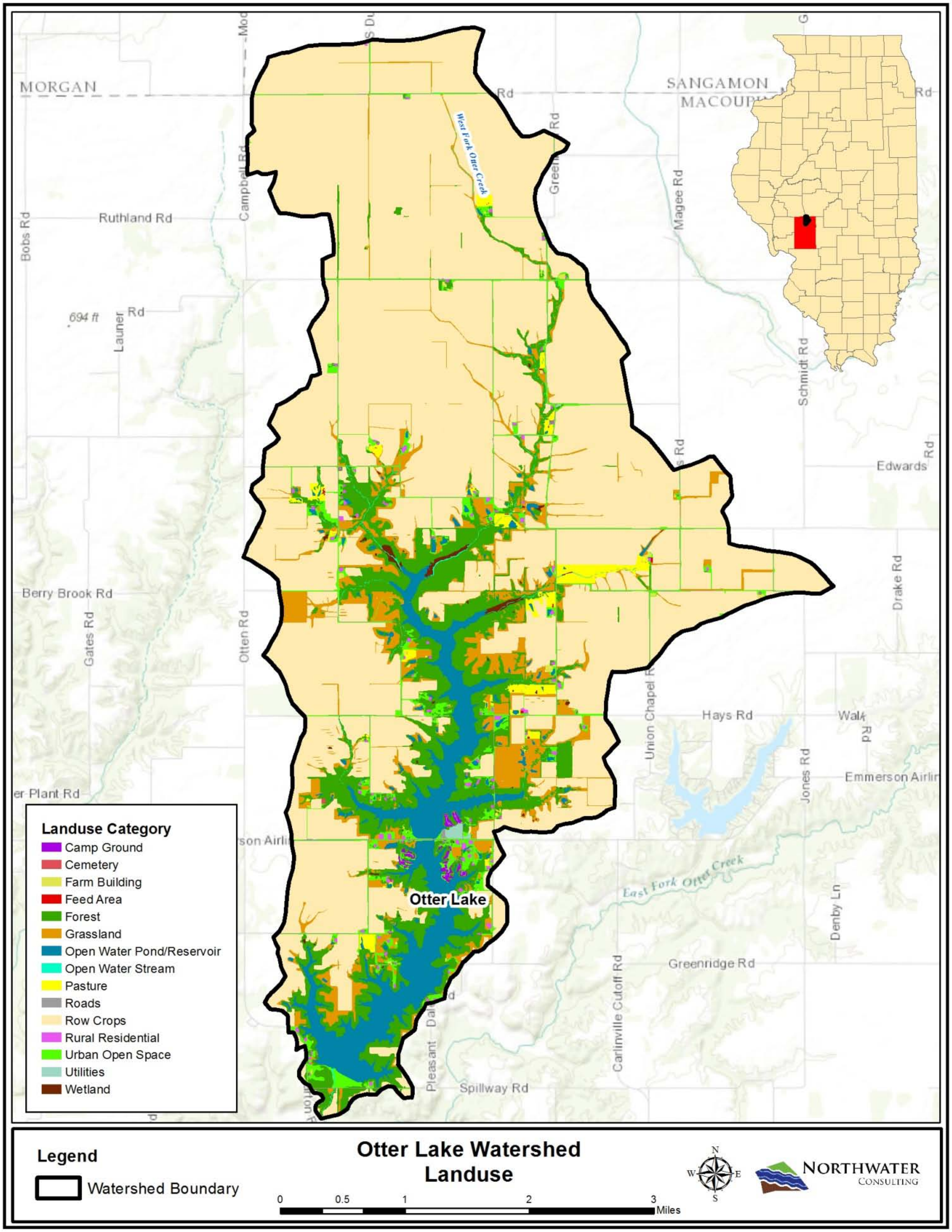


Figure 13 - Otter Lake Watershed Landuse

3.7 Soils

Based on spatial and tabular soils data available online from the USDA National Cooperative Soil Survey, thirty unique soil types exist within the watershed (Table 22 and Figure 14); the remaining category found within the soils database is water. Of the 12,897 acres in the Otter Lake watershed, Ipava silt loam is the most dominant soil type by acreage, with 3,813 acres covering 30% of the watershed. Virden silty clay loam is the second most abundant soil type with 3,035 acres covering 24% of the watershed. Hickory silt loam is the third most abundant type of soil at 6.9% (895 acres) of the watershed. Ipava soils consist of somewhat poorly drained, slowly permeable soils on upland ridges and on side slopes along shallow drainageways. These soils are formed in loess; slopes range from 0 to 5 %. Virden silty clay loams are very deep and poorly drained; they are moderately permeable and are formed in loess on level till plain summits. Hickory silt loams are deep and well-drained on dissected till plains. Since the soil is formed in till, it can have up to a 20-inch layer of loess capping the top (USDA, 2011).

Table 22 - Otter Lake Watershed Soils

Soil Type	Total Acres	% of Watershed
Ipava silt loam, 0 to 2 percent slopes	3,813	30%
Virden silty clay loam, 0 to 2 percent slopes	3,035	24%
Hickory silt loam, 18 to 35 percent slopes	895	6.9%
Keomah silt loam, 0 to 2 percent slopes	794	6.2%
Water	780	6.0%
Rozetta silt loam, 2 to 5 percent slopes	730	5.7%
Rozetta silt loam, 0 to 2 percent slopes	634	4.9%
Buckhart silt loam, 2 to 5 percent slopes	476	3.7%
Elco silt loam, 5 to 10 percent slopes, eroded	251	1.9%
Hickory silt loam, 10 to 18 percent slopes, eroded	192	1.5%
Assumption silt loam, 2 to 5 percent slopes	164	1.3%
Rushville silt loam, 0 to 2 percent slopes	143	1.1%
Bunkum-Atlas silt loams, 5 to 10 percent slopes, eroded	134	1.0%
Velma silt loam, 10 to 18 percent slopes	97	0.76%
Clarksdale silt loam, 0 to 2 percent slopes	95	0.74%
Assumption silt loam, 2 to 5 percent slopes, eroded	94	0.73%
Lawson silt loam, 0 to 2 percent slopes, frequently flooded	90	0.70%
Fishhook silt loam, 2 to 5 percent slopes, eroded	80	0.62%
Elco silt loam, 2 to 5 percent slopes, eroded	69	0.53%
Assumption silt loam, 5 to 10 percent slopes, eroded	64	0.49%
Keller silt loam, 2 to 5 percent slopes	63	0.49%
Bunkum-Atlas silt loams, 10 to 18 percent slopes, eroded	44	0.34%
Edinburg silty clay loam, 0 to 2 percent slopes	40	0.31%
Hickory silt loam, 18 to 35 percent slopes, eroded	36	0.28%
Coffeen silt loam, 0 to 2 percent slopes, frequently flooded	26	0.20%
Coatsburg silt loam, 5 to 10 percent slopes, eroded	19	0.15%
Elco silt loam, 10 to 18 percent slopes, eroded	19	0.15%
Fishhook silt loam, 5 to 10 percent slopes, eroded	8.6	0.07%
Orthents, loamy, hilly	6.2	0.05%
Cowden silt loam, 0 to 2 percent slopes	3.7	0.03%
Spaulding silty clay loam, 0 to 2 percent slopes	1.7	0.01%
Total	**12,897**	**100%**

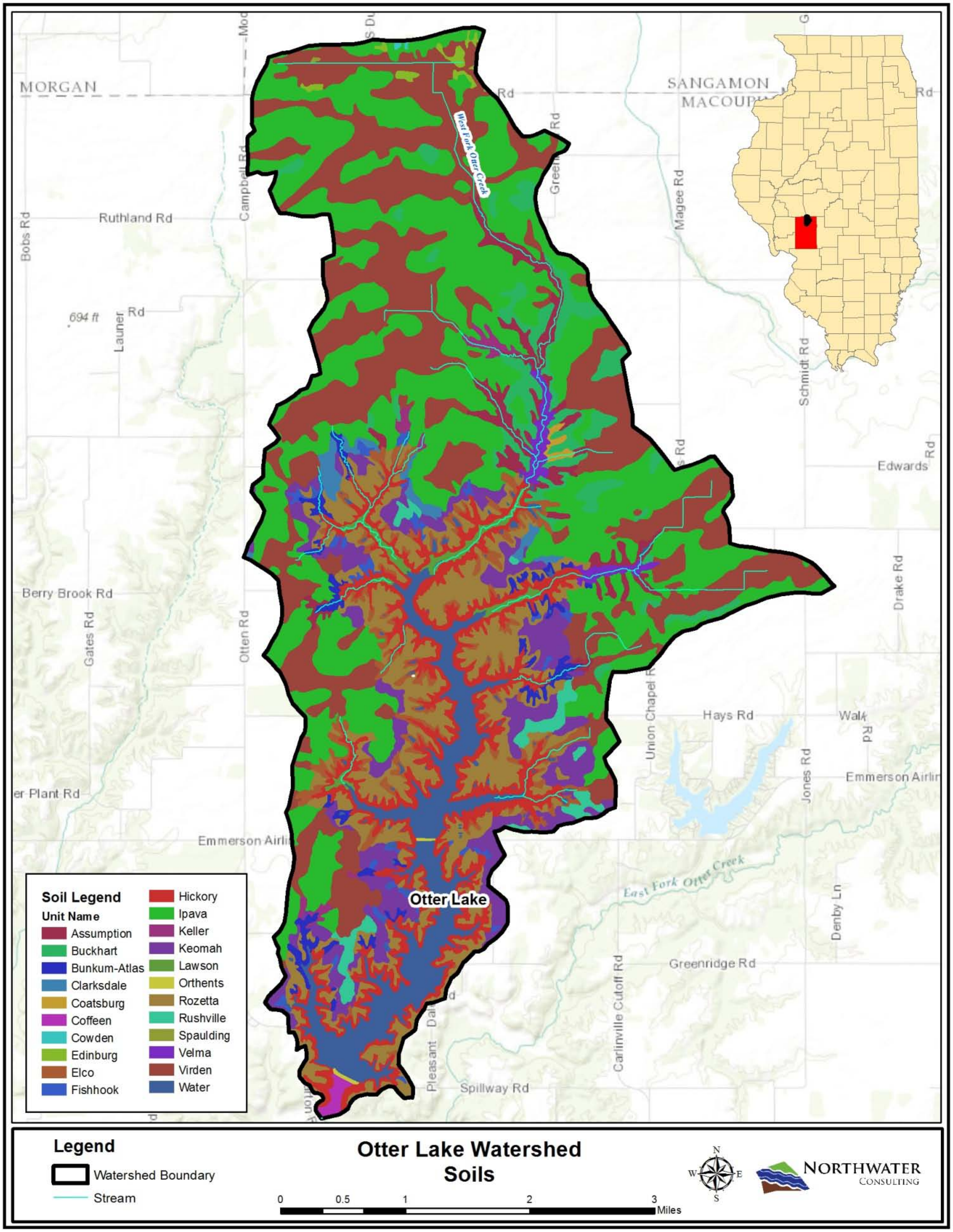


Figure 14 - Otter Lake Watershed Soils

3.7.1 Highly Erodible Soils

HEL Timber Soils

As defined by the NRCS, a highly erodible soil, or soil map unit, has a maximum potential for erosion that equals, or exceeds, eight times the tolerable erosion rate. The maximum erosion potential is calculated without consideration to crop management or conservation practices, which can markedly lower the actual erosion rate on a given field.

The Otter Lake watershed contains 1,696 acres of highly erodible soils representing 13% of the total watershed area (Table 23 and Figure 15). The location and extent of highly erodible soils were identified using the USDA-NRCS SSURGO database and the Morgan County frozen soils list. These soils are generally located immediately adjacent to streams and in steep forested or grassed areas. A small percentage of these soils are being cropped as described below.

3.7.2 Cropped Highly Erodible Soils

According to the NRCS, Highly Erodible Land (HEL) is cropland, hayland or pasture that can erode at excessive rates, containing soils that have an erodibility index of eight or higher. If a producer has a field identified as highly erodible land and wishes to participate in a voluntary NRCS cost-share program, that producer is required to maintain a conservation system of practices that maintains erosion rates at a substantial reduction of soil loss. Fields that are determined not to be highly erodible land are not required to maintain a conservation system to reduce erosion.

Table 23 - HEL & Cropped HEL Soils

Watershed Area (Acres)	Acres HEL Soils	Acres Cropland	Acres Cropped HEL	% of Watershed as HEL	% of Watershed as Cropped HEL	% Cropped Soils HEL
12,897	1,696	8,948	211	13%	1.6%	2.4%

Of the 8,948 acres of crop ground in the watershed, 2.4%, or 211 acres (1.6% of the entire watershed), are considered HEL and could be targeted for erosion control measures, if necessary. Cropped HEL soils and tillage practices are further discussed in Section 5.

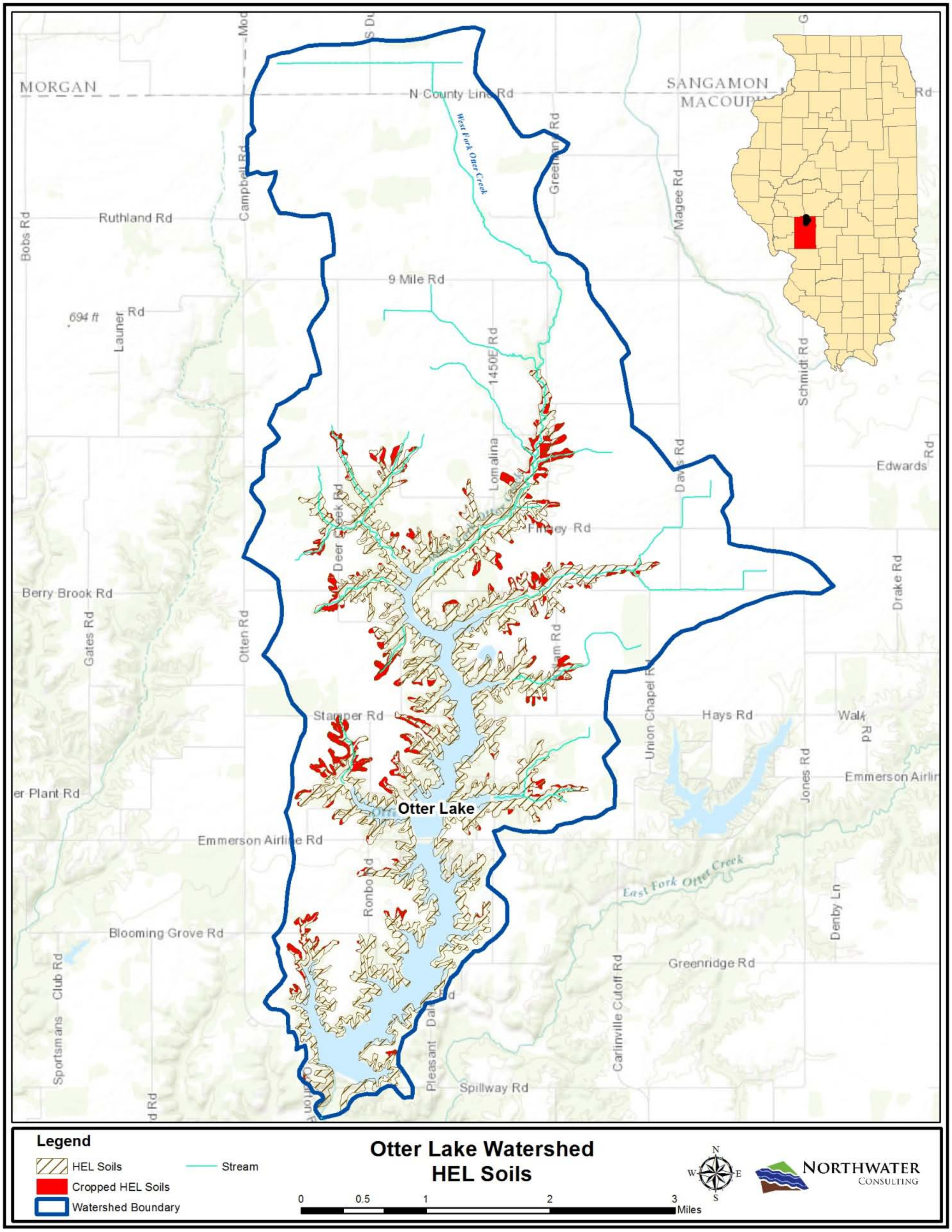


Figure 15 - Otter Lake Watershed HEL & Cropped HEL Soils

3.7.3 Hydric Soils

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part. These soils, under natural conditions, are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation (NRCS, 2014).

Hydric soils are scattered throughout the watershed and are an indicator of former wetlands and potential areas for wetland development. These soils are typically wet and will flood if proper drainage, overland or through field tiles, is not available. In the Otter Lake watershed, there are eight unique types of hydric soils found that cover 23% of the watershed, or 3,358 acres. Virden silty clay loam dominates the hydric soil makeup in the watershed containing 3,036 acres, or (90%). Rushville silt loam (141 acres or 4.3% of all hydric soils) and Edinburg silty clay loam (40 acres, or 1.2% of the watershed) are the second and third most prevalent in the watershed (Table 24).

Virden silty clay loams dominate the hydric soils in the watershed and are spread throughout. Rushville silt loams with a hydric designation are found in smaller areas immediately surrounding the lake. Edinburg silty clay loam with a hydric designation is only found at the very northern edge of the watershed; most of these soils are planted in row crops or as grassland in undisturbed areas.

Figure 16 depicts the location of hydric soils within the watershed. As an indicator of the potential for wetland development, understanding where hydric soils are located can inform wetland restoration and creation activities.

Table 24 - Otter Lake Hydric Soils

Hydric Soil Type	Total Acres	% Hydric Soils	% Watershed
Virden silty clay loam	3,036	90%	24%
Rushville silt loam	141	4.2%	1.1%
Lawson silt loam	90	2.7%	0.7%
Edinburg silty clay loam	40	1.2%	0.3%
Coffeen silt loam	26	0.77%	0.2%
Coatsburg silt loam	19	0.57%	0.1%
Cowden silt loam	4	0.12%	0.03%
Spaulding silty clay loam	1.7	0.05%	0.01%
Total	**3,358**		

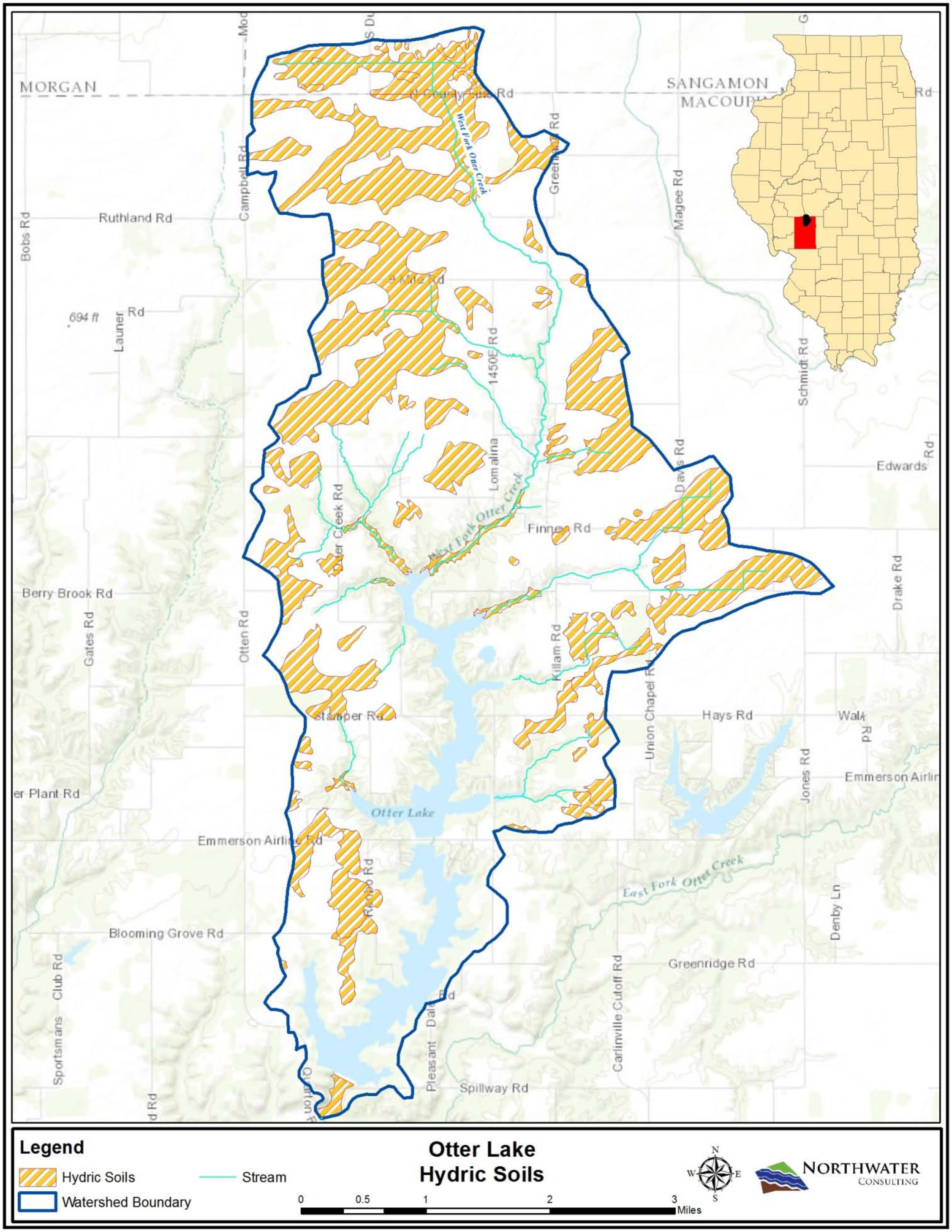


Figure 16 - Otter Lake Watershed Hydric Soils

3.7.4 Hydrologic Soil Groupings

The NRCS has classified soils into four hydrologic soil groups based on the infiltration capacity and runoff potential of the soil. The soil groups are identified as A, B, C, and D. Group A has the greatest infiltration capacity and least runoff potential, while group D has the least infiltration capacity and greatest runoff potential. In its simplest form, a hydrologic soil group is determined by the water transmitting soil layer with the lowest saturated hydraulic conductivity and depth to any layer that is more or less water impermeable or depth to a water table, if present (USDA, 2007). For those soils with two groups, certain wet soils are tabulated as D based solely on the presence of a water table within 24 inches of the surface, even though the saturated hydraulic conductivity may be favorable for water transmission. If these soils can be adequately drained, then they are assigned to dual hydrologic soil groups (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and the water table depth when drained. The first letter applies to the drained condition and the second to the undrained condition (USDA, 2007).

Hydrologic soils grouping information presented in this section represents the most up-to-date spatial and tabular data available (10/9/15) for download through the USDA National Cooperative Soil Survey and may differ from what is available or being used by local NRCS staff and watershed partners.

Table 25 provides a breakdown of hydrologic groupings and Figure 17 illustrates the distribution of hydrologic soil groups within the watershed.

Table 25 - Otter Lake Watershed Hydrologic Soils Groupings

Hydrologic Group	Acres	% of Watershed
B	2,585	20%
B/D	118	1%
C	1,142	9%
C/D	8,111	63%
D	162	1%
Unclassified (water)	780	6%
Total	12,898	100%

The watershed is dominated by the C/D group soils which make up 63% of the soils found in the watershed. Soil group C/D has poor ground infiltration capacity and a high amount of stormwater becomes runoff. The second largest hydrologic group in the watershed is B at 20%, providing the area it covers with decent ground infiltration capacity and limited stormwater runoff. Groups C, C/D, and D, which have poor water infiltration and high runoff, account for 9,415 acres (73%) of the watershed. Tile drainage is discussed in Section 3.10.

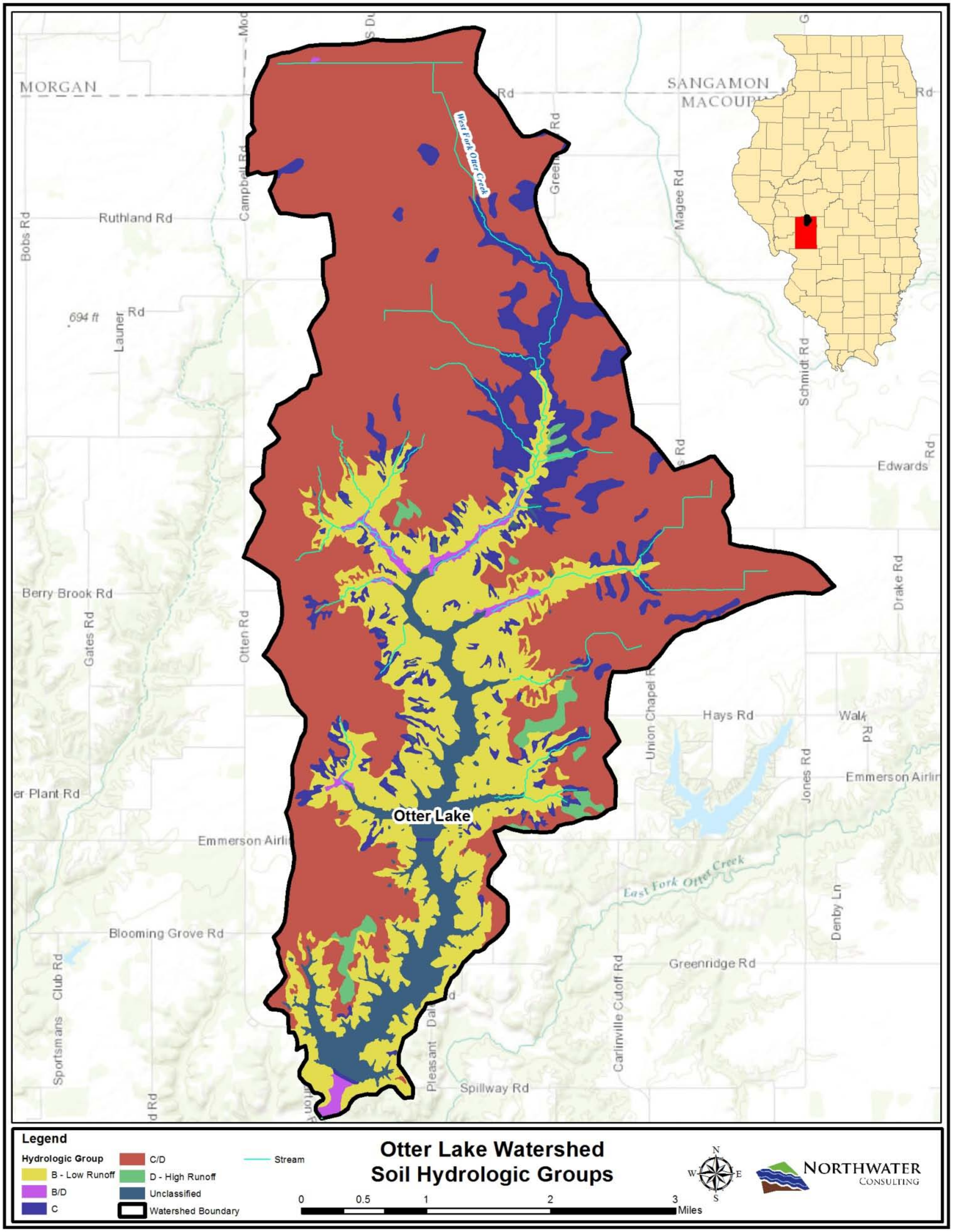


Figure 17 - Otter Lake Watershed Hydrologic Soils Groupings

3.7.5 Septic System Suitability

Not all soil types support septic systems and improperly constructed systems can lead to failure and allow leaching of wastewater into groundwater and surrounding waterways. An analysis of the USDA national soils dataset indicates that 81%, or 10,464 acres (Table 26) of the watershed, has soils classified as "very limited" with respect to septic suitability; 13% that are somewhat limited, and 6% are unrated. This does not necessarily indicate that all of the soils are unsuitable for septic systems but special consideration is required when establishing systems within most of the watershed. Figure 18 illustrates the extent of limiting soils for septic fields along with the location of homes within the watershed. Out of 147 homes in the watershed, a total of 68 residences (46%) are located on soils classified as very limited for septic systems.

Table 26 - Otter Lake Septic Soil Suitability

Septic Suitability	Acres	% of Watershed
Very Limited	10,464	81%
Somewhat Limited	1,653	13%
Not Rated	780	6%

Otter Lake

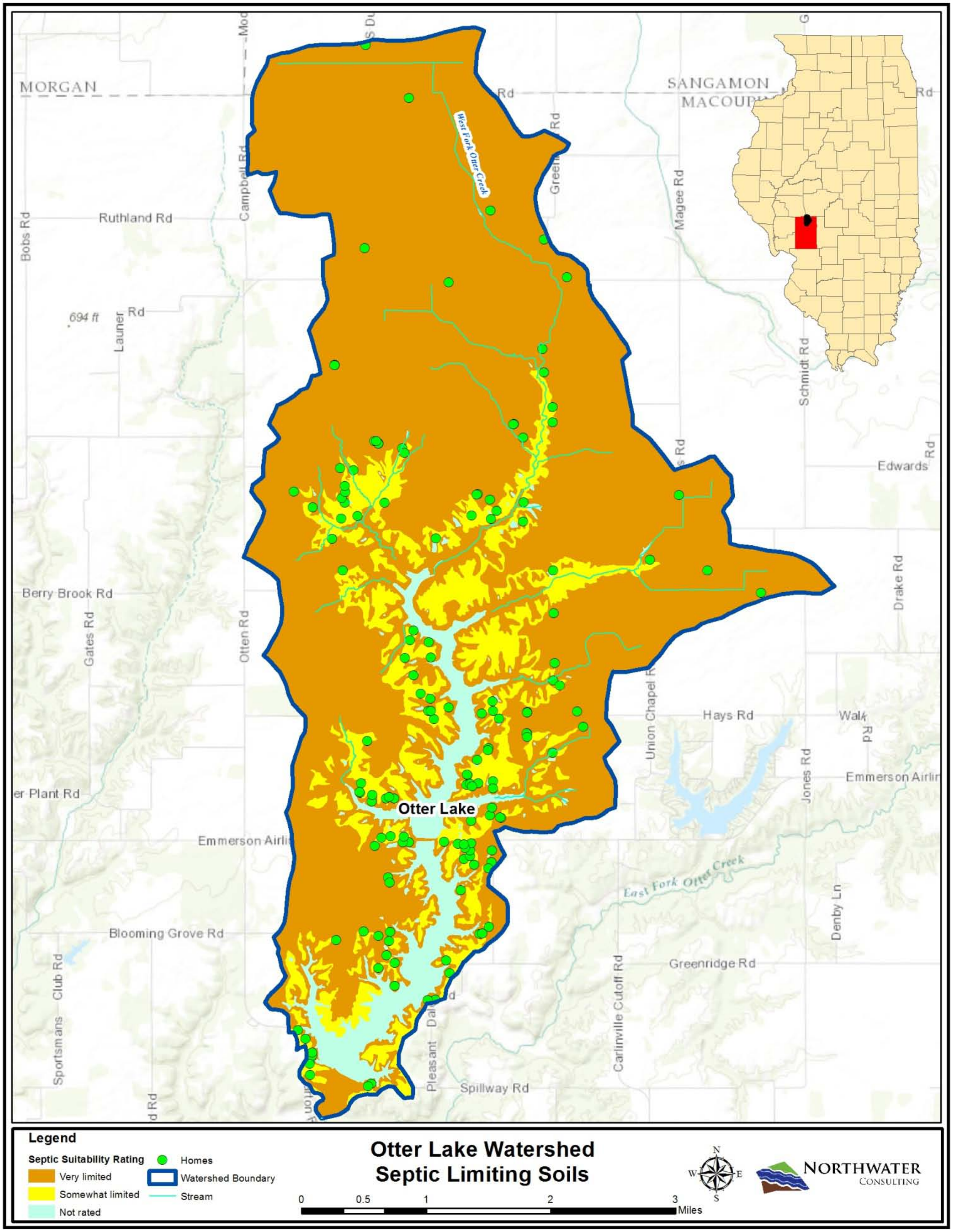


Figure 18 - Otter Lake Watershed Septic Limiting Soils

3.8 Tillage

According to the 2015 Macoupin County tillage transect survey, approximately 61.8% of the corn and 21.2% of the soybean croplands are tilled using conventional tillage methods that leave little or no residue on the surface. An additional 17.8% of the corn cropland and 15.8% of the soybean cropland are tilled by reduced tillage methods, which can reduce soil loss in comparison to conventional methods by 30%.

The remaining 20.3% of corn cropland and 63% of soybeans are planted using mulch-tillage methods, or without any tillage (no-till). Mulch-till methods leave 30% residue of the previous year's crop on the land and can reduce soil loss by 75%. These two conservation tillage systems can significantly reduce soil loss in the watershed.

Northwater performed a detailed field-based assessment of watershed tillage practices in the spring of 2017 in order to better characterize the current conditions. Tillage specific to the Otter Lake watershed falls into six categories: Conventional, Reduced, Spring-Till, Strip-Till, No-Till, and Hay/Wheat (Table 27 and Figure 19). Conventional and reduced tillage combined account for 87% (7,786 acres) of all cropped acreage; no-till occurs on 3% and strip-till on 5% of crop ground in the watershed. A total of 16 acres of cover crops were observed on no-till ground in the watershed.

Table 27 - Otter Lake Watershed Tillage

Conventional Tillage		Reduced Till		Spring Till		No Till		Strip Till		Hay/Wheat	
Acres	% Cropped Soils	Acres	% Cropped Soils	Acres	% Cropped Soils	Acres	% Cropped Soils	Acres	% Cropped Soils	Acres	% Cropped Soils
3,844	43%	3,942	44%	477	5%	231	3%	444	5%	11	0.1%

Conventional Tillage

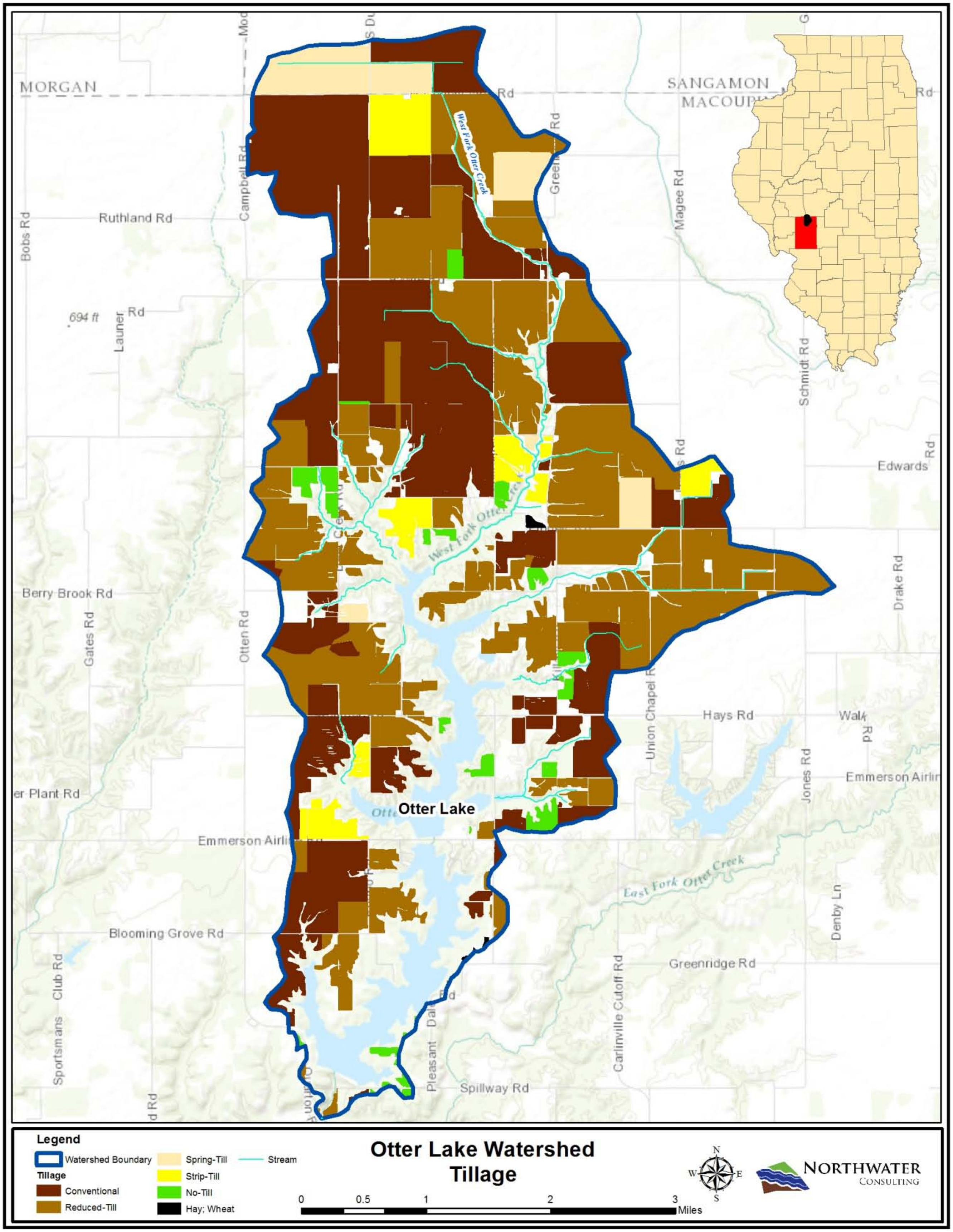


Figure 19 - Otter Lake Watershed Tillage

3.9 Existing Conservation Practices

Existing management practices within the watershed are extensive and vary by individual property. Numerous producers have taken advantage of federal or state cost-share programs, participated in previous grants sponsored by the OLWC, or have implemented conservation practices on their own, independent of any state or federal program. Based on an in-depth knowledge of the watershed and previous work completed on private ground, there are approximately 313 acres of land in the watershed enrolled in the Conservation Reserve Program (CRP); no land within the watershed is enrolled in the Conservation Reserve and Enhancement Program (CREP). Additionally, in 2010, the OLWC participated in a forest restoration initiative; this project resulted in the treatment of invasive species (Bush Honeysuckle) on 175 acres of OLWC-owned timber ground.

Numerous structural BMPs, such as grassed waterways, filter strips, water and sediment control basins (WASCB), terraces or ponds, constructed wetlands, have been applied in the watershed. Excluding in-lake/low flow and low head dam structures, existing conservation practices treat approximately 10,000 acres within the watershed, or 80% of the entire watershed (Table 28 and Figure 20). Of the forest restoration, ponds, WASCBs, basins, grade control structures, and riffles noted in Table 28, 93 were completed and funded using grant funds, applied for, and awarded to the OLWC. See Section 3.9.1 for a summary of these grants.

It is important to note that each practice varies in its ability to effectively remove pollutants, however, these practices appear to be providing benefits to lake water quality. With relatively large reductions still required to meet water quality targets, areas of high loading still exist and should be addressed. This is especially true where sediment and nutrient loading is the greatest or where pollutants may bypass existing BMPs, such as nitrogen in tile water bypassing a filter strip.

Table 28 – Otter Lake Watershed Existing Watershed BMPs

Best Management Practice	Number	Acres	Estimated Area (acres) Treated
Pond	118	84	2,163
WASCB/Basin/Grade Control/Riffle	98	N/A	381
Grassed Waterway[1]	115	168	5,056
Field Border/Filter Strip/Prairie	387	641	2,040
Constructed Wetland	3	1.2	155
In-Lake/Low Flow Dam/Low Head Dam[2]	3	N/A	8,452
Forest Restoration	1	175	175
Total	**721**	**1,069**	**18,422**[3]

1 - A grassed waterway is designed to reduce erosion in a concentrated flow area, such as in a gully or in ephemeral gullies, and reduce sediment and nutrients delivered to receiving waters. Vegetation also reduces runoff and filters some of the sediment and nutrients delivered to the waterway; however, filtration is a secondary function of a grassed waterway. 2 – Two in-lake/low flow dams are located on OLWC property, one constructed at the north end of the lake and the other at a road crossing and impoundment east of the lake over a small tributary. The low-head dam is located east of the lake on a small tributary on private property, within a pasture operation.
3 – Treated area includes overlapping BMPs.

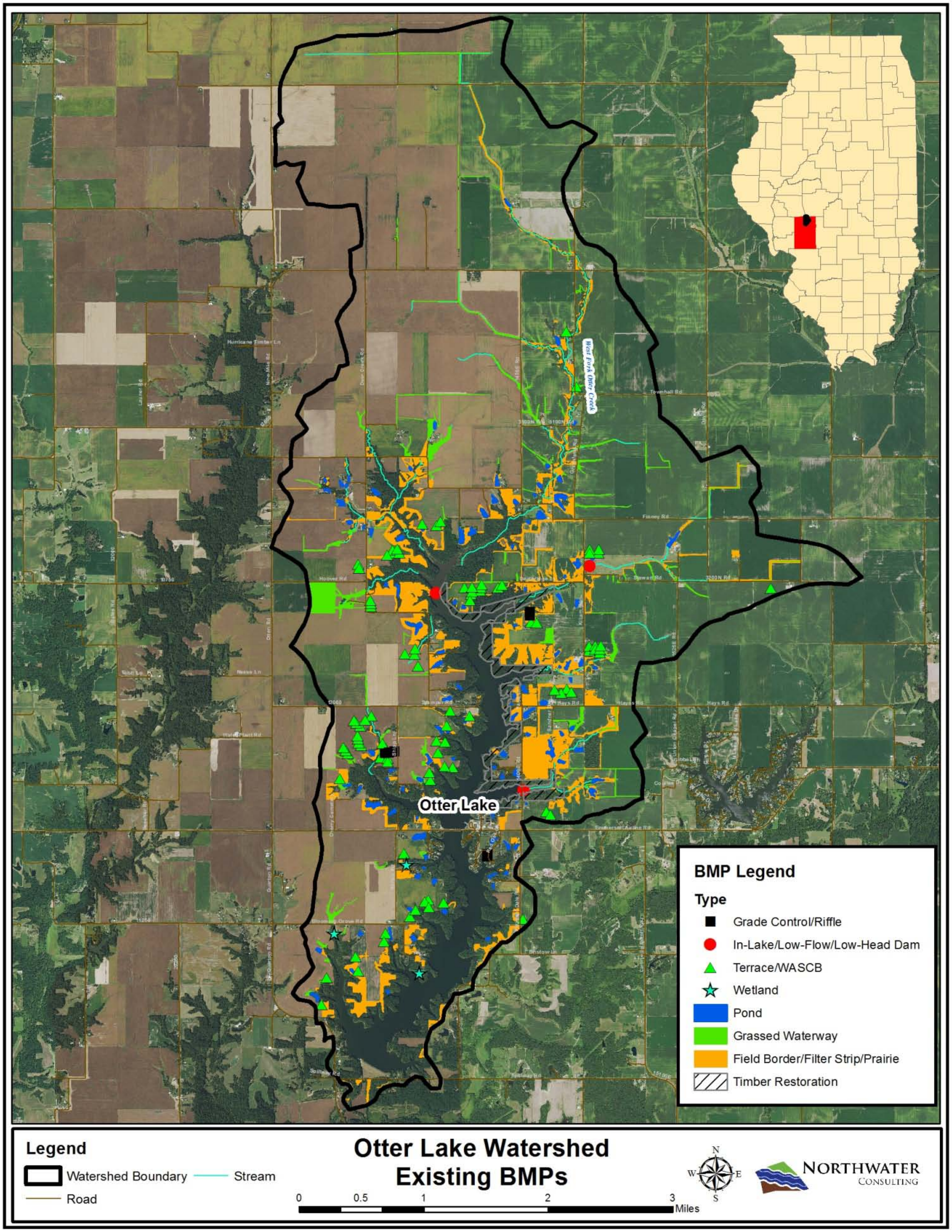


Figure 20 – Otter Lake Watershed Existing Conservation Practices

3.9.1 BMP Implementation Grant Summary

Pond completed in 2015

This section summarizes the results of three previous grants awarded to the OLWC to improve water quality in Otter Lake. Since 2010, the OLWC has been successful at obtaining grant funds through the IEPA's Section 319 program to install a series of BMPs aimed at reducing sediment and nutrient loads to the lake. The first grant awarded in 2010 and completed in 2012 included a series of targeted upland BMPs combined with lake shoreline stabilization. The second grant, funded in 2013 and completed in 2015, included a similar suite of BMPs combined with shoreline stabilization. A recent grant, funded in 2016, is being used for the completion of this watershed plan combined with upland BMP construction and shoreline stabilization. These projects have been successful at reducing sediment and nutrient loading as summarized in Table 29.

Table 29 - Otter Lake BMP Grant Implementation Summary

Grant Year	BMP Summary	Nitrogen Reduction (lbs/yr)	Phosphorus Reduction (lbs/yr)	Sediment Reduction (lbs/yr)
2012	1. 38 WASCB 2. Maintenance of 2 existing WASCBs 3. 6 ponds 4. 2 riffle systems 5. 1 sediment basin	7,246	2,532	2,035
2012	8,950 feet of shoreline stabilization	13,079	6,540	6,540
2015	1. 7 WASCB 2. 10 ponds 3. 2 riffle systems 4. 2 Wetlands	2,833	1,456	500
2015	2,819 feet of shoreline stabilization	751	451	375
2016	1. 1 WASCB 2. 5 ponds 3. 50 acres cover crops	2,016	509	400
2016	2,819 feet of shoreline stabilization	1,073	536	536
	Total[1]	**26,998**	**12,024**	**10,386**

1 – Load Reductions for 2012 and 2015 upland BMPs calculated based on edge-of-field loads; delivered loads to Otter Lake are likely lower

3.10 Hydrology & Drainage System

There are no USGS stream-flow gages in the watershed and, therefore, no historical data on stream flow is available. The West Fork of Otter Creek is the primary named stream draining to Otter Lake and all other tributary drainages are unnamed. Due to limitations with the accuracy of the National Hydrography Dataset (NHD), a custom-generated GIS layer was generated to better represent the actual wetted extent of perennial streams in the Watershed. Based on this layer, the wetted extent of all open water, perennial streams is 70,555 feet, or 13.4 miles. The West Fork of Otter Creek is the only named perennial stream in the watershed at 31,199 feet, or 5.9 miles in length. All unnamed perennial tributaries combined total 39,356 feet or 7.5 miles. All remaining tributaries, forested gullies or subsurface drainageways in the watershed can be considered intermittent or ephemeral and account for an additional 56,348 feet, or 10.6 miles, according to the NHD.

An analysis of the West Fork of Otter Creek at its confluence with Otter Lake using the USGS StreamStats system indicates that estimated peak flows range from 672 cubic feet per second (ft^3/s) for a 2-year recurrence interval to 4,280 ft^3/s for a 500-year recurrence interval. Five-year peak flows are estimated to be 1,240 ft^3/s and 10-year peak flows are 1,660 ft^3/s. These estimates are based on an 8.12 square-mile drainage area and a stream slope of 13.1 feet per mile.

Including Otter Lake, open water ponds and reservoirs are scattered throughout the watershed totaling 816 acres, or 6% of the watershed. These open water areas range in size from 732 acres to 0.05 acres with the majority concentrated around the Lake. Otter Lake is the largest body of water at 732 acres; the area above the in-lake/low-flow dam at the north end of the lake is approximately 21 acres. The watershed drainage system is depicted in Figure 22.

As noted in a previous section, supplemental watershed delineation was performed to aid in nutrient and sediment load modeling. The watershed was delineated into four sections for this purpose; these basins are also depicted in Figure 22.

3.10.1 Drought Vulnerability

The following section summarizes a 1989 drought vulnerability study produced by the Illinois State Water Survey (ISWS). Water is pumped from Otter Lake to the treatment plant at up to 2,200 gallons per minute (gpm). An emergency connection with Chatham is available. Connected satellite communities and water districts include: Auburn, Divernon, Girard, Pawnee, Thayer, Virden, Nilwood, South Palmyra Water District, and Henderson Water District.

The ISWS has determined that a 50-year drought yield is sufficient at present level of water use. Classified as a marginal system**,** although there is greater than a 90% probability that the current system would have sufficient water during a drought similar to the drought of record, the pending threat of potential shortages during the drought would likely force the community to take extraordinary measures (enacting severe water use restrictions or developing alternative supply sources) to avoid shortages.

If a situation similar to the 1952-1956 drought of record were to recur today, it is estimated with 50% confidence that the current system would be able to support a demand of 3.78 million gallons per day (mgd) (the mid- or best yield estimate). It is estimated with 90% confidence that the current system would be able to support a demand of 2.96 mgd. Although the system would be able to fulfill the community's current demand of 1.77 mgd with 90% confidence, the drought vulnerability of the system is classified as marginal because the system would not be able to produce more than 1.64 mgd with 90% confidence without using a portable intake in the southern basin of Otter Lake.

Since 1989, a water plant upgrade from 2.7 mgd to 3.5 mgd was completed. Emergency access to Taylorville's supply via Chatham is being considered; the connection is with Chatham through the South Sangamon Water Commission. During the 2005 drought, an algae bloom generated many complaints about the water's taste and odor, requiring solar-powered circulators and heavy doses of powder-activated carbon for treatment. The OLWC sells, on average, 1.36 mgd per year. The most water sold since 1993 was in 2012, a total of 541 million gallons or 1.48 mgd (Figure 21).

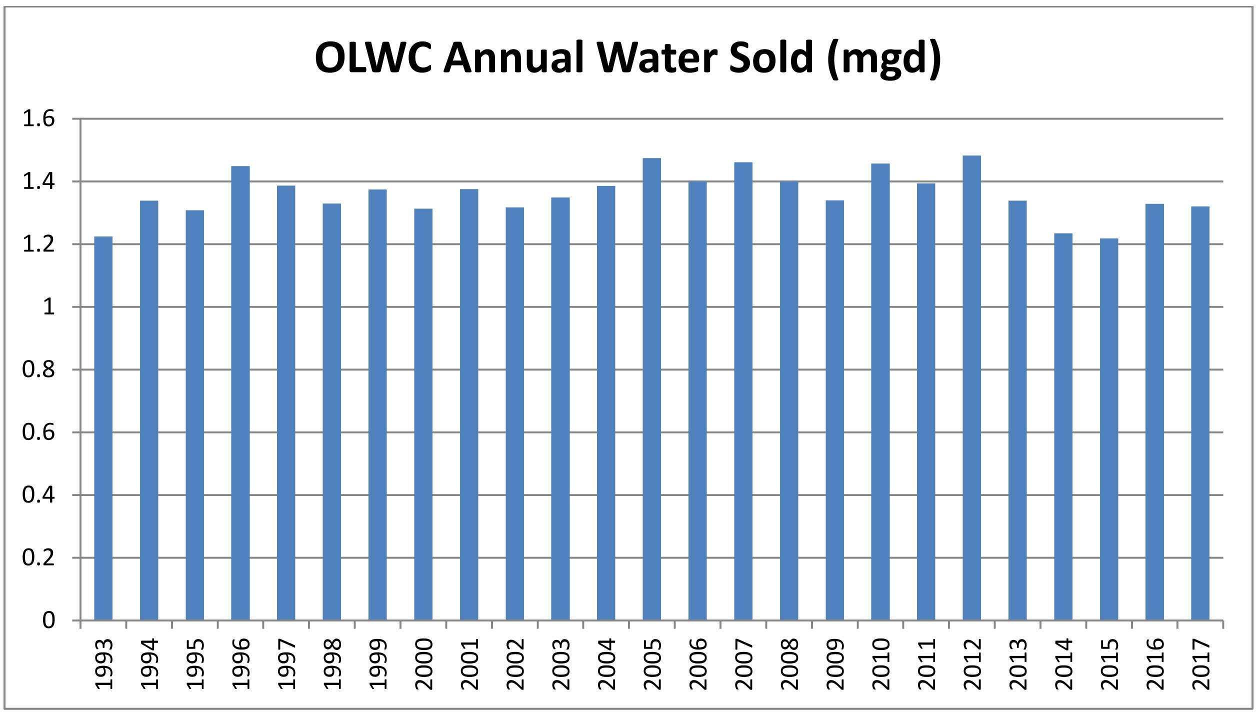


Figure 21 - 1993 - 2017 Otter Lake Annual Water Sold

3.10.2 Stream Channelization

Recent aerial imagery from 2015 was evaluated to determine the extent of stream channelization for perennial streams in the Otter Lake watershed. Out of a total of 70,554 ft, or 13 miles of open water perennial streams, 8%, or 1 mile, can be considered channelized. A seasonal, channelized drainage ditch in the headwaters of the West Fork of Otter Creek makes up another 9,350 ft, or 1.8 miles. See Figure 22.

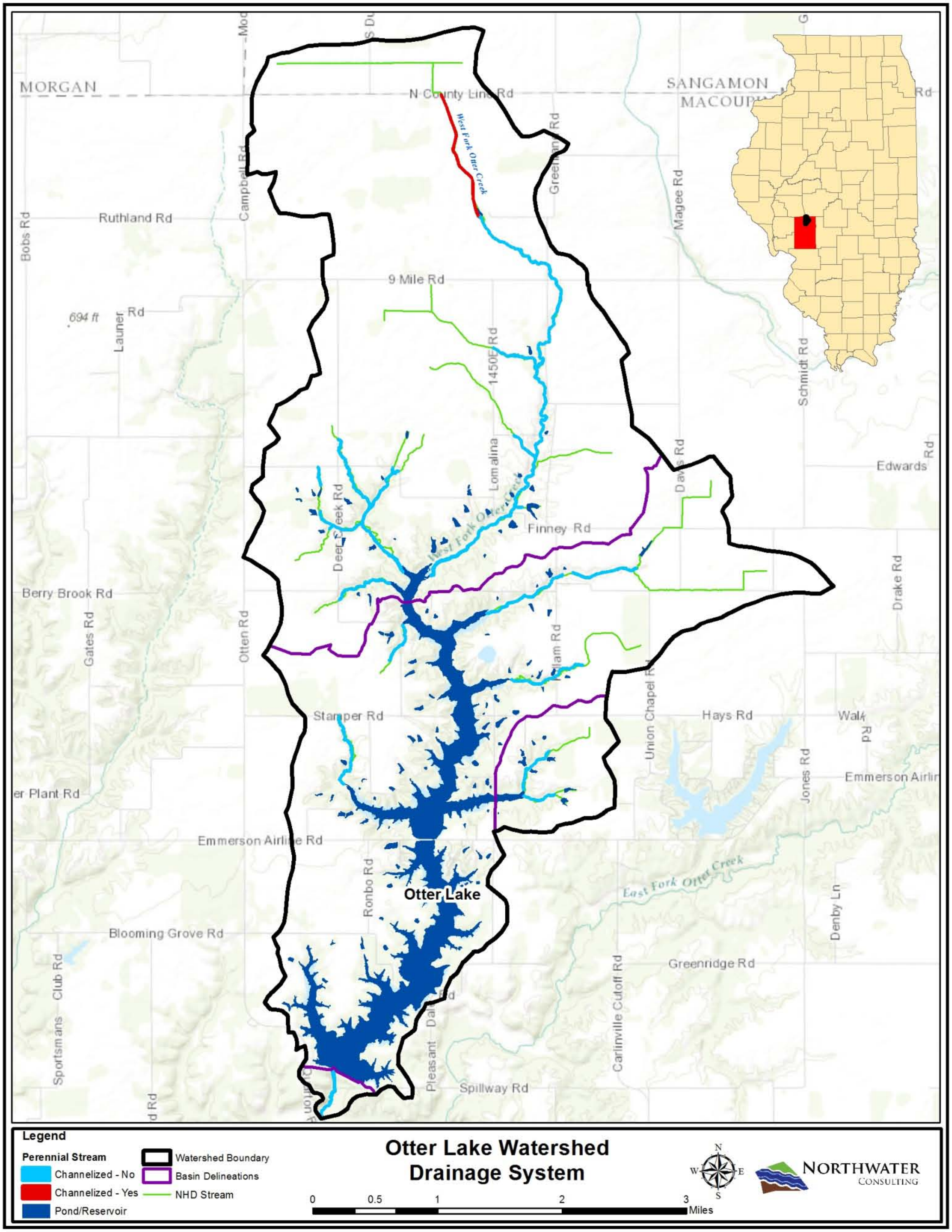


Figure 22 - Otter Lake Watershed Drainage System

3.10.3 Tile Drainage

The true extent of tile drainage in the watershed is largely unknown. Extensive tile systems in adjoining watersheds, combined with observations made during a watershed field assessment, discussions with watershed landowners, and a stream survey, indicate that compared to another adjoining watershed, tile drainage is moderate to low. It is estimated that, 5,208 acres, or 58% of all cropped soils in the Otter Lake watershed, are likely tile drained (Figure 23).

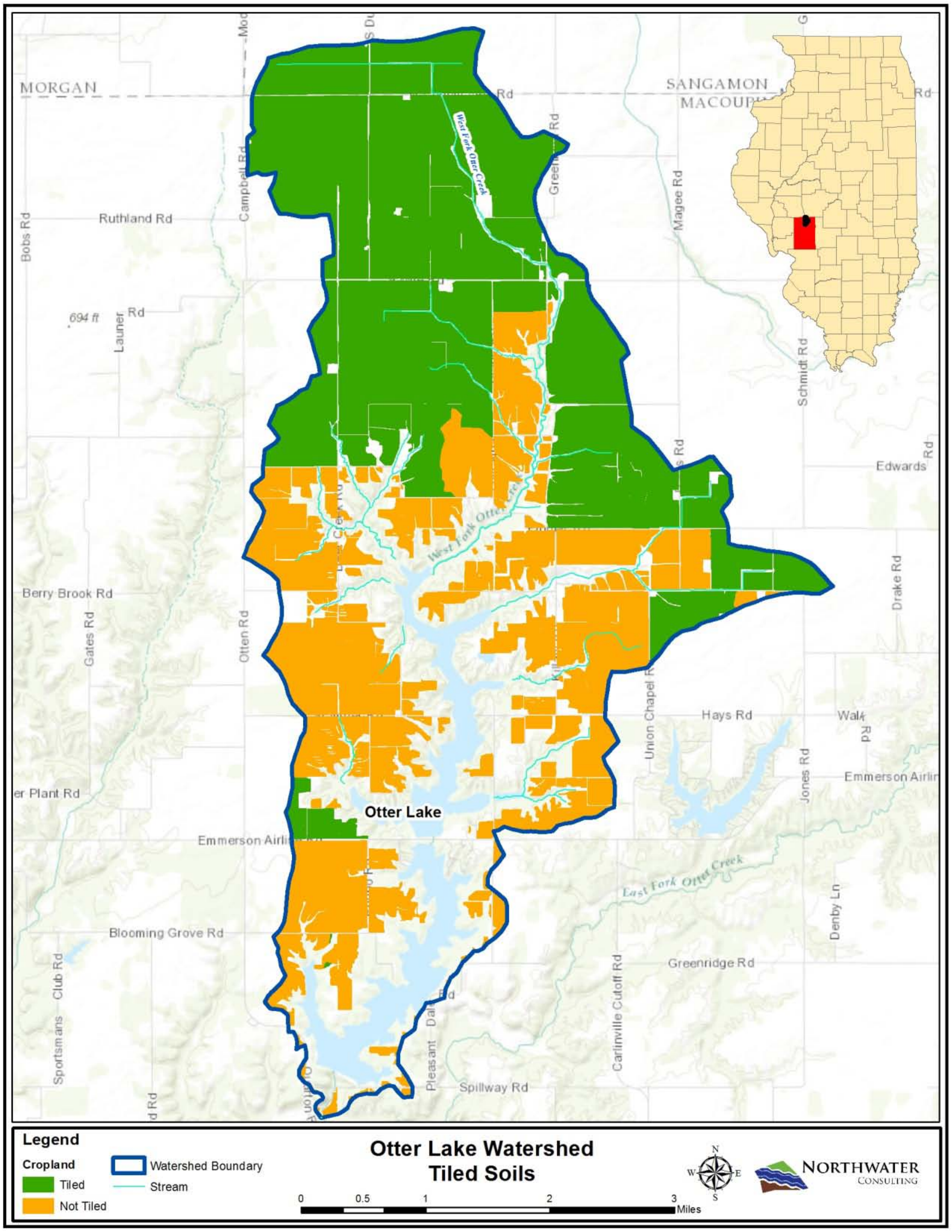


Figure 23 - Otter Lake Watershed Estimated Tile Drainage

3.10.4 Riparian Areas & Stream Buffers

Substantial riparian and buffer areas exist adjacent to streams within the watershed. As noted in Section 3.10.2, there is some evidence of stream channelization; subsurface drainage is also found in the headwaters. A GIS analysis was performed to evaluate the extent and general quality of riparian zones adjacent to major open water streams within the watershed. Excluding subsurface and intermittent forested drainage ways, a total of 120,615 ft, or 22.8 miles, of perennial and intermittent streams were evaluated for riparian buffer extent and quality (Figure 24). Table 30 lists results of the buffer analysis; a reach specific table is provided in Appendix B.

A buffer quality ranking system was developed by Northwater Consulting and applied to individual stream reaches. Three categories of buffer quality include:

1. High quality – greater than 50 ft of un-impacted riparian or buffer area, either forest or grass.
2. Moderate quality – 30 to 50 ft of un-impacted riparian or buffer area, either forest or grass.
3. Low quality (inadequate) – less than 30 ft riparian or buffer area, impacted or degraded. Low quality buffer areas consist of row crops or pasture where livestock have access to the stream.

Table 30 - Riparian Area Buffer Quality Summary Table

	West Fork Otter Creek			Unnamed Tributary		
Buffer Condition	Bank Length (Feet)	Length (Miles)	% Total Bank Length/W. Fork	Bank Length (Feet)	Length (Miles)	% Total Bank Length/Unnamed
High	44,049	8.3	37%/86%	58,531	11	49%/85%
Moderate	4,729	0.9	4%/9%	1,823	0.3	2%/3%
Low	2,756	0.5	2%/5%	8,726	1.7	7%/13%
Total	51,535	10	43%/100%	69,080	13	57%/100%

Eighty-six percent of all streams evaluated in the watershed have high quality adequate buffers; 6% are moderately buffered, and 9% have low quality buffers. By stream, 86% of the West Fork of Otter Creek and 85% of all Unnamed Tributaries have high quality buffer areas; Unnamed Tributaries contain the most percentage low quality or inadequate buffers, or 13%. Overall, the streams in the Otter Lake watershed are well buffered and of high quality, though a few areas could use improvement.

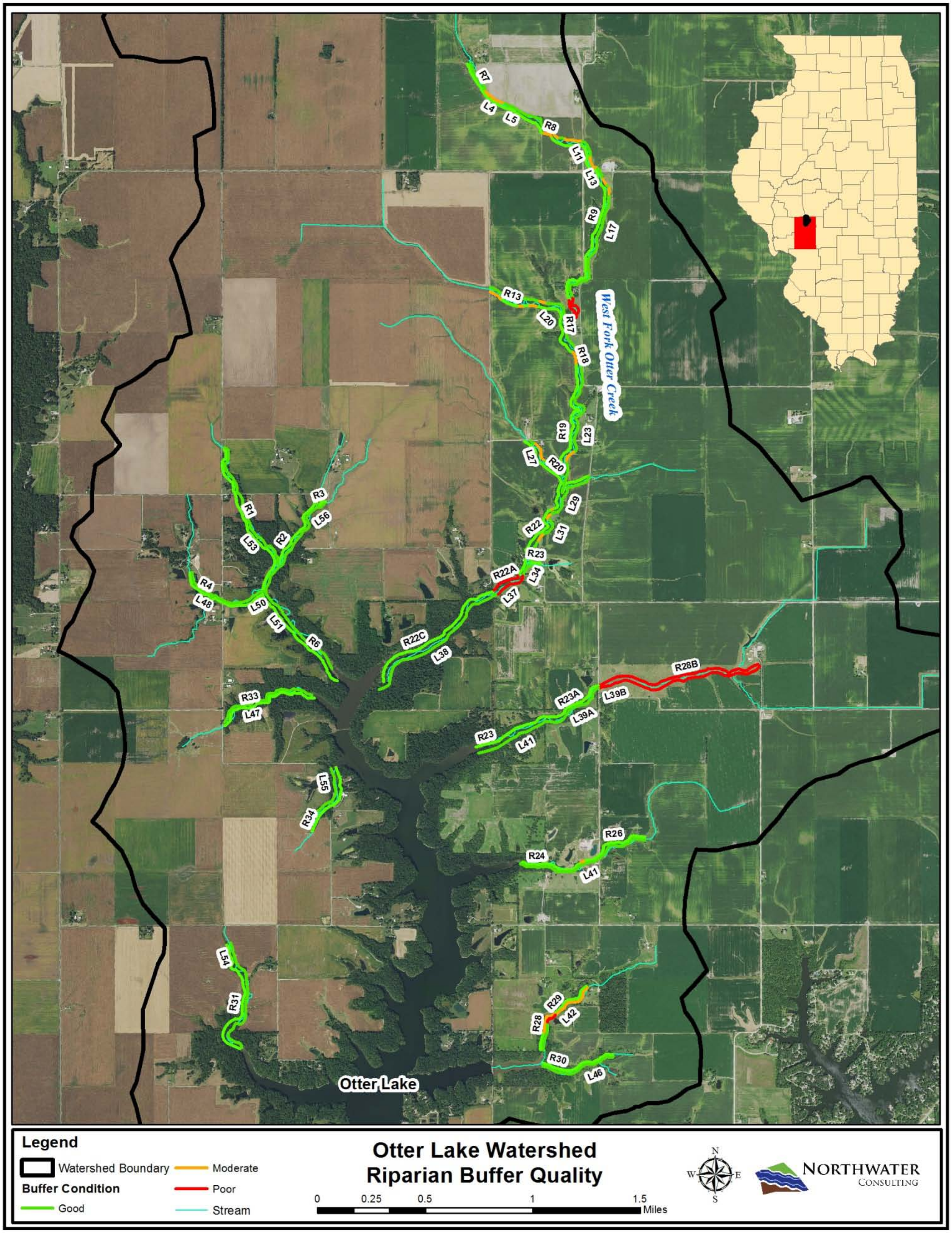


Figure 24 - Otter Lake Watershed Riparian Buffer Quality

3.10.5 Lake Shoreline Buffers

Otter Lake is well buffered, containing large, contiguous riparian areas. An assessment of lake shoreline buffers performed by Northwater Consulting in the spring of 2016 indicates that 97%, or 5.8 out of 6 miles of shoreline, is well buffered. Only 2,000 ft (0.38 miles) contain an inadequate buffer zone. Table 31 lists buffer quality and extent by reach and Figure 25 depicts the spatial extent of shoreline buffers

An assessment of the Otter Lake shoreline was completed using aerial imagery and previous shoreline assessments to determine the adequacy of existing buffer areas. Slightly over 90% (28 miles) of the shoreline has adequate or good buffer quality while just less than 10% (3 miles) is inadequate or of poor quality. The majority of well-buffered shoreline is forested which can help to slow and filter runoff. Shoreline areas consisting of turf grass/lawns were considered inadequate or of poor quality. Camp grounds adjacent to the lake contain the majority of inadequate buffer zones. Due to the lack of available space and maintenance concerns, no good options exist to enhance poor buffer areas along Emmerson Airline Road and the dam on the south end of the lake.

Table 31 - Lake Shoreline Buffers

Reach	Adequate Buffer (Y,N)	Buffer Condition	Feet	Miles	% Shoreline
1	**Y**	Good - Forested	50,176	9.5	31%
2	**N**	Poor - Turf/Grass	2,082	0.39	1.3%
3	**Y**	Good - Forested	1,115	0.21	0.69%
4	**Y**	Good - Grassland	54	0.01	0.03%
5	**Y**	Good - Forested	14,986	2.8	9.2%
6	**Y**	Good - Grassland	64	0.01	0.04%
7	**Y**	Good - Forested	13,888	2.6	8.6%
8	**N**	Poor - Turf/Grass	5,177	0.98	3.2%
9	**Y**	Good - Forested	410	0.08	0.25%
10	**N**	Poor - Turf/Grass	2,862	0.54	1.8%
11	**Y**	Good - Forested	2,299	0.44	1.4%
12	**N**	Poor - Turf/Grass	379	0.07	0.23%
13	**Y**	Good - Forested	8,987	1.7	5.5%
14	**N**	Poor - Turf/Grass	211	0.04	0.13%
15	**Y**	Good - Forested	21,883	4.1	14%
16	**N**	Poor - Turf/Grass	315	0.06	0.19%
17	**Y**	Good - Forested	29,790	5.6	18%
18	**N**	Poor - Turf/Grass	2,572	0.49	1.6%
19	**Y**	Good - Forested	287	0.05	0.18%
20	**N**	Poor - Turf/Grass	2,016	0.38	1.2%
21	**Y**	Good - Forested	890	0.17	0.55%
22	**N**	Poor - Turf/Grass	128	0.02	0.08%
23	**Y**	Good - Forested	1,211	0.23	0.75%
24	**N**	Poor - Turf/Grass	296	0.06	0.18%
		Total	**162,077**	**31**	**100%**

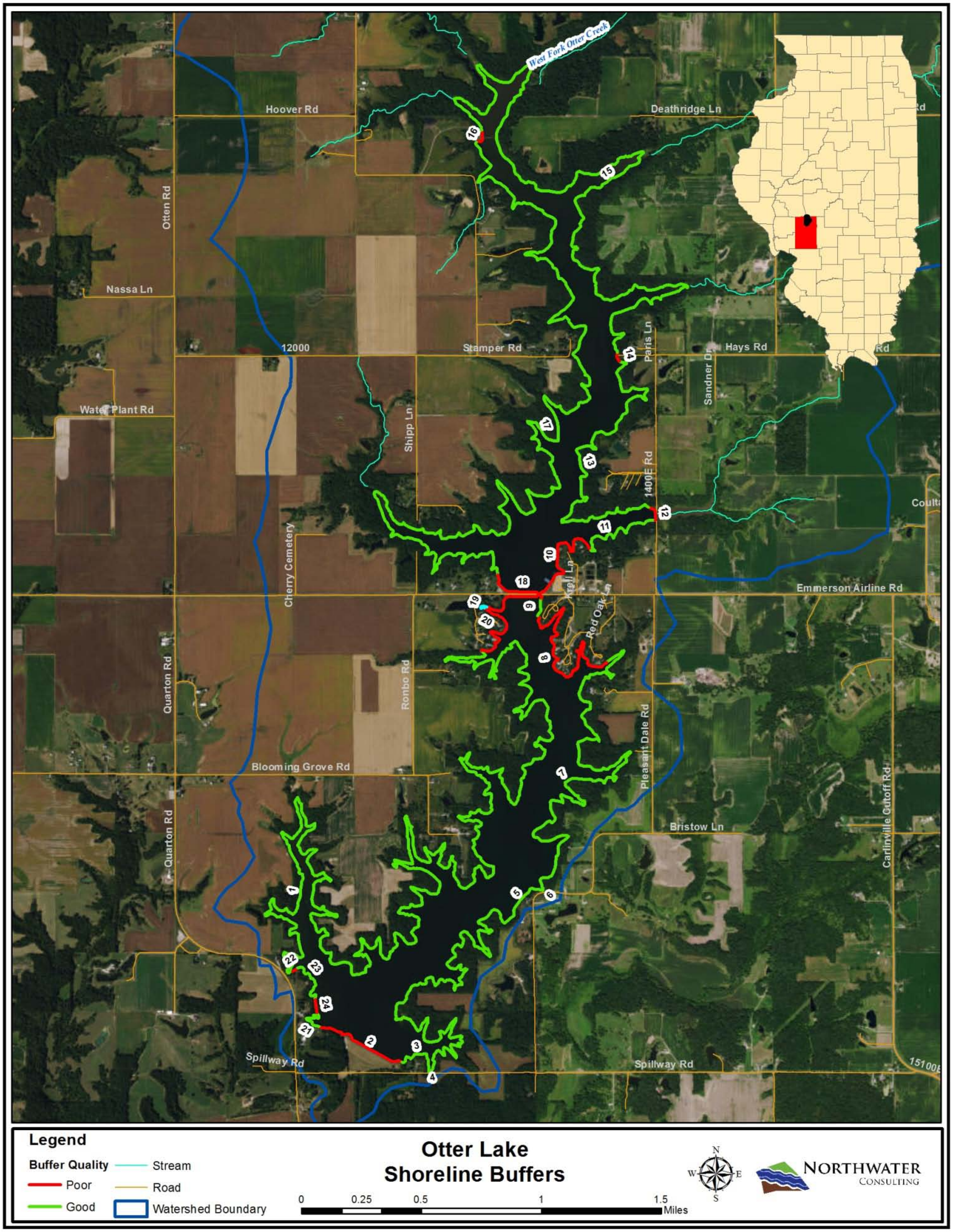


Figure 25 - Otter Lake Shoreline Buffer Quality

3.10.6 Wetlands

Wetlands provide numerous valuable functions that are necessary for the health of the watershed (Figure 26). They play a critical role in protecting and moderating water quality through a combination of filtering and stabilizing processes. Additionally, wetland vegetation removes pollutants through the natural filtration that occurs from absorption and assimilation. This effective treatment of nutrients and physical stabilization leads to an increase in overall water quality to downstream reaches.

In addition, wetlands have the ability to increase stormwater detention capacity, increase stormwater attenuation, and moderate high flows. These benefits help to reduce flooding and erosion. Wetlands also facilitate groundwater recharge by allowing water to seep slowly into the ground, thus replenishing underlying aquifers. This groundwater recharge is also valuable to wildlife during the summer months when precipitation is low and the base flow of the river draws on the surrounding groundwater table.

Restored Wetland

The United States Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) indicates there are a total of 864 acres (7% of the watershed) of wetlands within the watershed. These wetlands can be classified into 15 unique types (U.S. Fish and Wildlife Service, 2017):

1. Freshwater Emergent Wetland: Palustrine Emergent Seasonally Flooded, Diked/Impounded (PEMCH).
2. Freshwater Forest/Shrub Wetland: Palustrine Forested, Broad-Leaved Deciduous, Temporarily Flooded (PFO1A).
3. Freshwater Forest/Shrub Wetland: Palustrine Forested, Broad-Leaved Deciduous, Temporarily Flooded, Diked/Impounded (PFO1Ah).
4. Freshwater Pond: Palustrine, Unconsolidated Bottom, Semi-permanently Flooded, Diked/Impounded (PUBFh).
5. Lake: (L1UBHh).
6. Freshwater Forest/Shrub Wetland: Palustrine, Aquatic bed, Water Regime Intermittently Exposed (PABG).
7. Freshwater Emergent Wetland: Palustrine Emergent Seasonally Flooded, Persistent Flora Diked/Impounded (PEM1Ch).
8. Freshwater Pond: Palustrine, Unconsolidated Bottom, Intermittently Exposed, Diked/Impounded (PUBGh).
9. Freshwater Pond: Palustrine, Unconsolidated Bottom, Intermittently Exposed (PUBG)
10. Freshwater Forest/Shrub Wetland: Palustrine, Broad-Leaved Deciduous, Seasonally Flooded (PFO1C).

11. Freshwater Forest/Shrub Wetland: Palustrine, Broad-Leaved Deciduous, Seasonally Flooded, Diked/Impounded (PF01Ch).
12. Freshwater Forested/Shrub Wetland: Palustrine, Emergent, semi-permanently flooded (PEMAF).
13. Freshwater Forested Wetland: Palustrine, Forested, Broad-leafed Deciduous, Diked/Impounded (PFO1/EMCh).
14. Freshwater Forest/Shrub Wetland: Palustrine, Emergent, Seasonally flooded, Diked/Impounded (PSS1/EMCh).
15. Unconsolidated Bottom, Diked/Impounded (PUB/EMCh).

Table 32 provides a breakdown of wetland types in the watershed. The watershed is dominated by Otter Lake which takes up 772 acres (90%) of all NWI wetland areas. Ponds make up the second largest category of NWI wetlands with 57 acres (6.7%). There are 14 additional wetland types in the watershed that combine for only 3% of the entire NWI wetland area. Of these, freshwater forested wetlands (PFO1/EMCh) account for the greatest area, or 6.4 acres (0.75%).

Table 32 – Otter Lake NWI Wetlands

Wetland Type	Acres	% Wetland Area
L1UBHh	772	90%
PUBGh	57	6.8%
PFO1/EMCh	6.4	0.75%
PFO1Ah	5.6	0.65%
PSS1/EMCh	4.5	0.52%
PEMCh	2.4	0.28%
PFO1Ch	1.8	0.21%
PUBFh	0.91	0.11%
PUBG	0.83	0.10%
PFO1A	0.70	0.08%
PEM1CH	0.62	0.07%
PABG	0.58	0.07%
PUB/EMGH	0.43	0.05%
PFO1C	0.42	0.05%
PEMAF	0.37	0.04%
Total	**864**	**100%**

Considering the outdated nature of the NWI dataset, an analysis was performed on existing landuse data for the watershed to better understand the current extent of watershed wetlands. Excluding open water ponds and lakes, only 31.8 acres of wetlands are believed to exist within the watershed and would fall into the categories of: freshwater forested/shrub wetland and freshwater emergent wetland. A further analysis of NWI wetlands data, combined with an interpretation of aerial imagery, indicates that approximately 2.3 acres of previously delineated wetlands have either been drained or modified; opportunities exist to restore these historical wetlands.

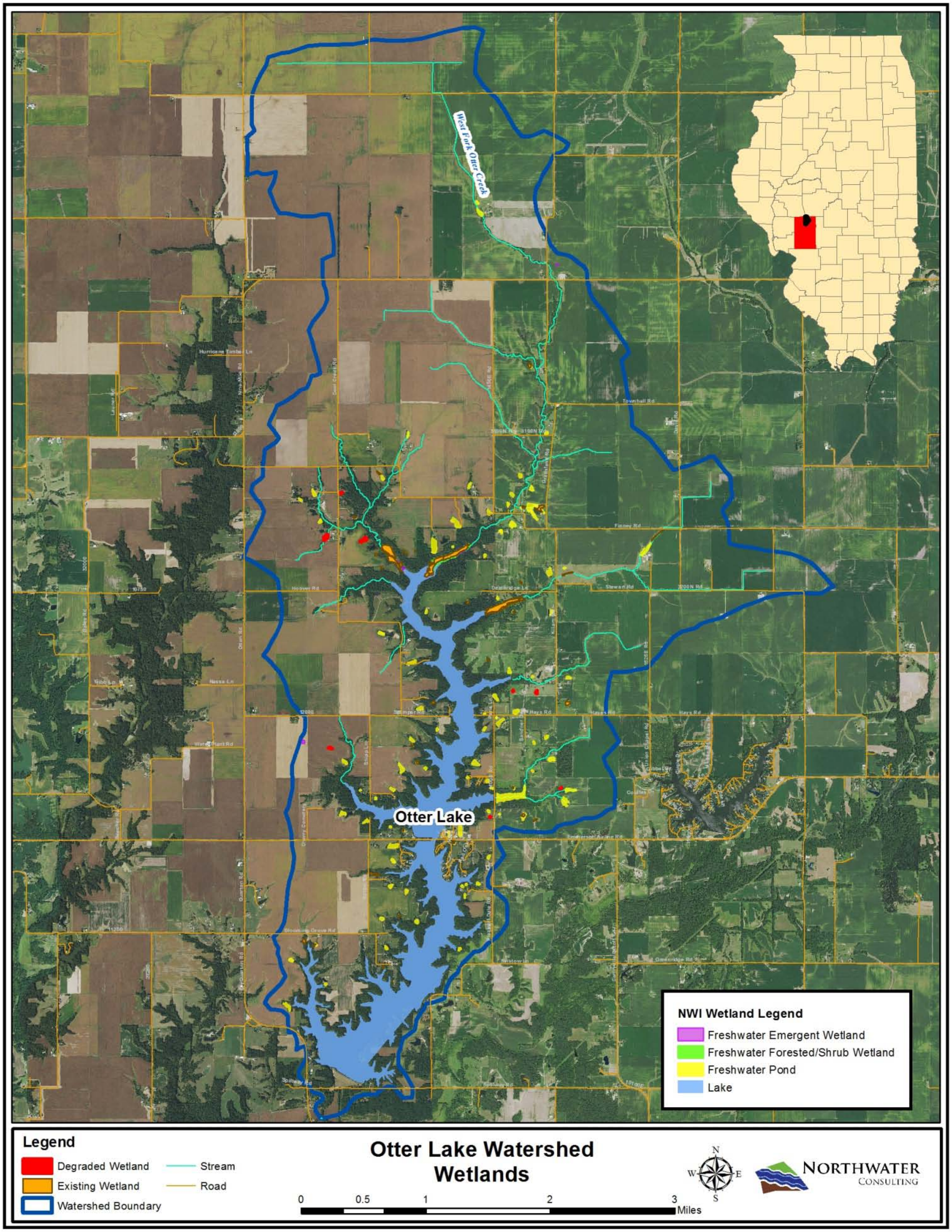


Figure 26 - Otter Lake Watershed Wetlands

3.10.7 Floodplain

A review and analysis of the most recent Federal Emergency Management Agency's (FEMA) Digital Flood Insurance Rate Maps (DFIRM) indicates there are no areas of floodplain within the Otter Lake watershed.

3.11 Lake Shoreline & Streambank/Streambed Erosion

Lake shoreline and streambank/streambed erosion is a source of sediment and nutrients within the watershed. An evaluation of the extent and severity of lake bank and streambank erosion was performed to identify critical areas requiring attention and to quantify sediment and nutrient loading. The main stem of the West Branch of Otter Creek and ten tributaries were assessed for streambank erosion; Otter Lake was assessed for shoreline erosion using previously inventoried data.

Stream stability was evaluated through direct observations during a stream and watershed inventory performed by Northwater Consulting in the fall of 2016 and the spring of 2017, combined with a previous stream survey performed in 2006 and the 2005 IDOA aerial stream assessment report. Nine miles (44,966 feet) of the West Fork of Otter Creek and 15 miles (79,048 feet) of tributary channels were assessed and data captured with a GPS receiver, where applicable. Due to property access concerns, some tributary channels and sections of the West Fork of Otter Creek were evaluated by extrapolating observations at road crossings and results from similar assessed segments. Data captured in the field included:

1. Eroding bank height and an estimate of lateral recession rates using the NRCS Rapid Assessment, Point Method (RAP-M).
2. Locations of significant channel bed instability or "headcutting" or "knickpoints."
3. Critical project locations based on need and feasibility.
4. Other information, such as tile locations, recommended BMPs and gully locations.

Data collected in the field was transferred into GIS to create a map database representing location-specific estimates of annual soil loss from streambank erosion and recommended project locations.

Lake banks were first evaluated in 2010 and again in 2014. Data points collected in the field were transferred into ArcMap (Geographic Information Software - GIS) and processed into a line file representing erosion severity. A GIS model was used to quantify soil loss and nutrient loading from eroding banks. Total net erosion in tons/year and estimates of nitrogen and phosphorus loading in pounds were calculated using GIS and equations derived from IEPA's load reduction spreadsheet. A total of 10 soil cores were obtained from various lake banks in 2017 and results used to establish soil nutrient concentrations; an average value for the North half of the lake and an average value for the South half of the lake. See Figure 30 for the location of soil cores and Appendix B for associated laboratory reports. The most recent shoreline erosion report is summarized in Section 3.11.3.

Quantities of sediment and nutrient loading from stream (left and right banks) and lake banks were estimated using GIS tools. Annual sediment, nitrogen and phosphorus loads were calculated using the methods outlined in the EPA Region 5 Load Reduction Model. Eroding bank height, bank length and lateral recession rates were measured and estimated in the field and transferred to GIS. The following equations were used to estimate total annual loads for sediment, nitrogen and phosphorus:

Total Tons (sediment) = Bank length (ft) * Eroding bank height (ft) * Lateral recession rate (ft/yr) * Dry soil density (tons/ft^3)

Nitrogen Load (lbs) = Soil mass (tons) * 2000 lbs/ton * N concentration in soil (0.00208 lbs/lbs for streambanks) (0.000565 lbs/lbs for lake banks in the North half of the lake and 0.00006 for lake banks in the Southern half of the lake)

Phosphorus Load (lbs) = Soil mass (tons) * 2000 lbs/ton * P concentration in soil (0.000366 lbs/lbs for streambanks) (0.00042 lbs/lbs for lake banks in the North half of the lake and 0.000284 for lake banks in the Southern half of the lake)

3.11.1 Streambed Erosion

For the purposes of this report, streambed erosion can be classified by the presence or absence of channel incision or downcutting, and the location of "knickpoints." A knickpoint is a location in the stream channel where there is a sharp change in channel slope; these knickpoints migrate upstream and can lead to an increase in bank erosion along the affected reach. Streambed erosion in the Otter Lake Watershed was evaluated through direct observation during the stream inventory in the fall of 2016 and the spring of 2017, combined with a previous stream survey performed in 2006. The location of active knickpoints was recorded with GPS. Due to property access concerns, only the West Fork of Otter Creek was assessed.

Data collected during the stream survey indicate that a total of 10 active knickpoints exist over roughly 4 miles of the West Fork; 3 of these are also located at or near a log jam. One additional log jam was observed. Each location is depicted in Figure 27.

Knickpoint

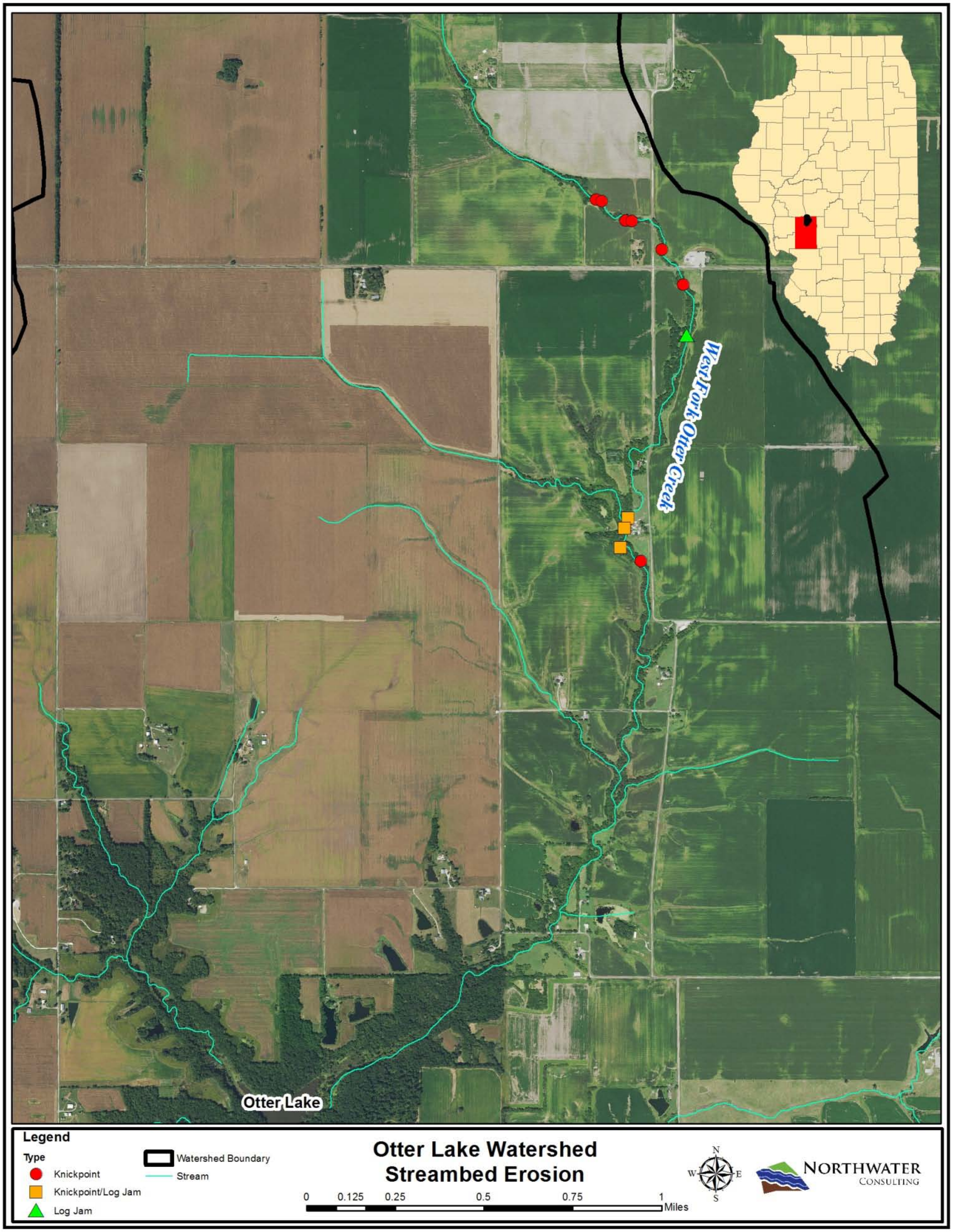


Figure 27 - Otter Lake Watershed Streambed Erosion

3.11.2 Streambank Erosion

Streambank erosion is a natural process but the rate at which it occurs is often increased by anthropogenic or human activities, such as urbanization and agriculture. Bank erosion is typically a result of streambed incision and channel widening. Field observations indicate that the West Fork of Otter Creek and its tributaries are relatively stable with localized sections of high and very high instability. Bank erosion appeared more severe in the West Fork which appears to be attempting to accommodate higher flows; this could be the result of the high density of drainage tiles.

Accounting for the trapping efficiency of the In-lake dam and two additional tributary structures (20%), results indicate that bank erosion within the watershed is responsible for contributing 558 tons of sediment annually to Otter Lake. Streambank erosion also contributes approximately 2,322 pounds of nitrogen and 408 pounds of phosphorus each year. Sixty-three percent of all streambank erosion originates from the West Fork of Otter Creek. Table 33 is a summary of results for the West Fork and all unnamed tributary drainages.

Table 33 - Streambank Erosion Summary

Stream	Bank Length (miles)	Average Eroding Bank Height (ft)	Average Lateral Recession Rate (ft/yr)	Sediment Load (tons)	Nitrogen Load (lbs)	Phosphorus Load (lbs)
West Fork Otter Creek	9	1.65	0.16	350	1,456	256
Unnamed Tributary	15	0.9	0.09	208	866	152
Total (avg)	**24**	**(1.3)**	**(0.13)**	**558**	**2,322**	**408**

Greater than two-thirds, or 80%, of all bank erosion in the watershed can be classified as low erosion, 19% as moderate and 1% as high or very high as depicted in Figures 28 and 29.

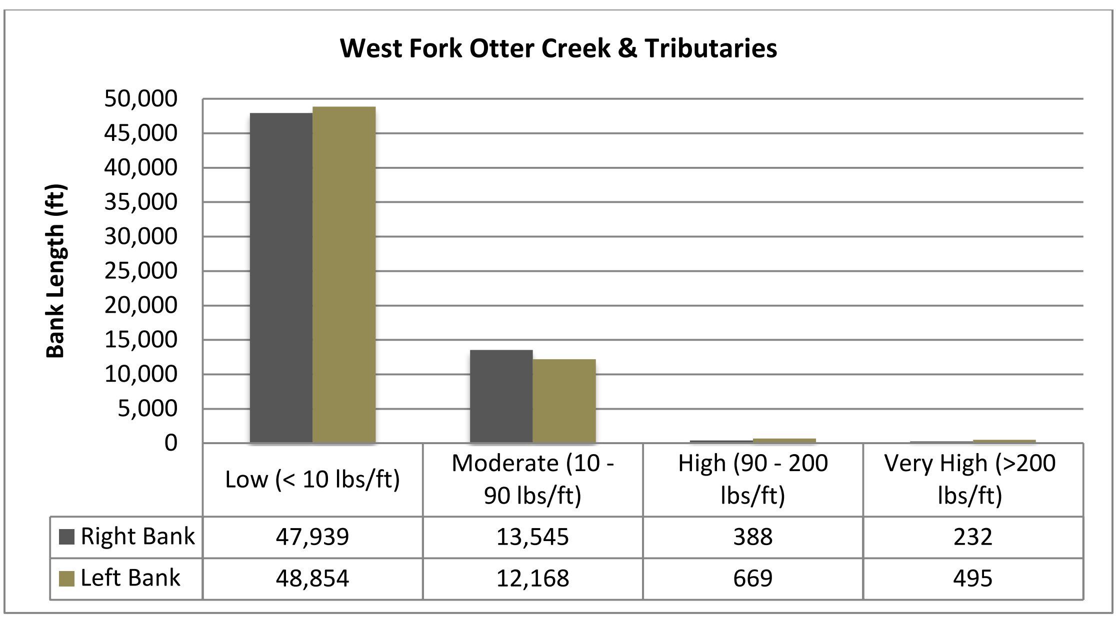


Figure 28 - Streambank Erosion Severity; West Fork Otter Creek & Tributaries

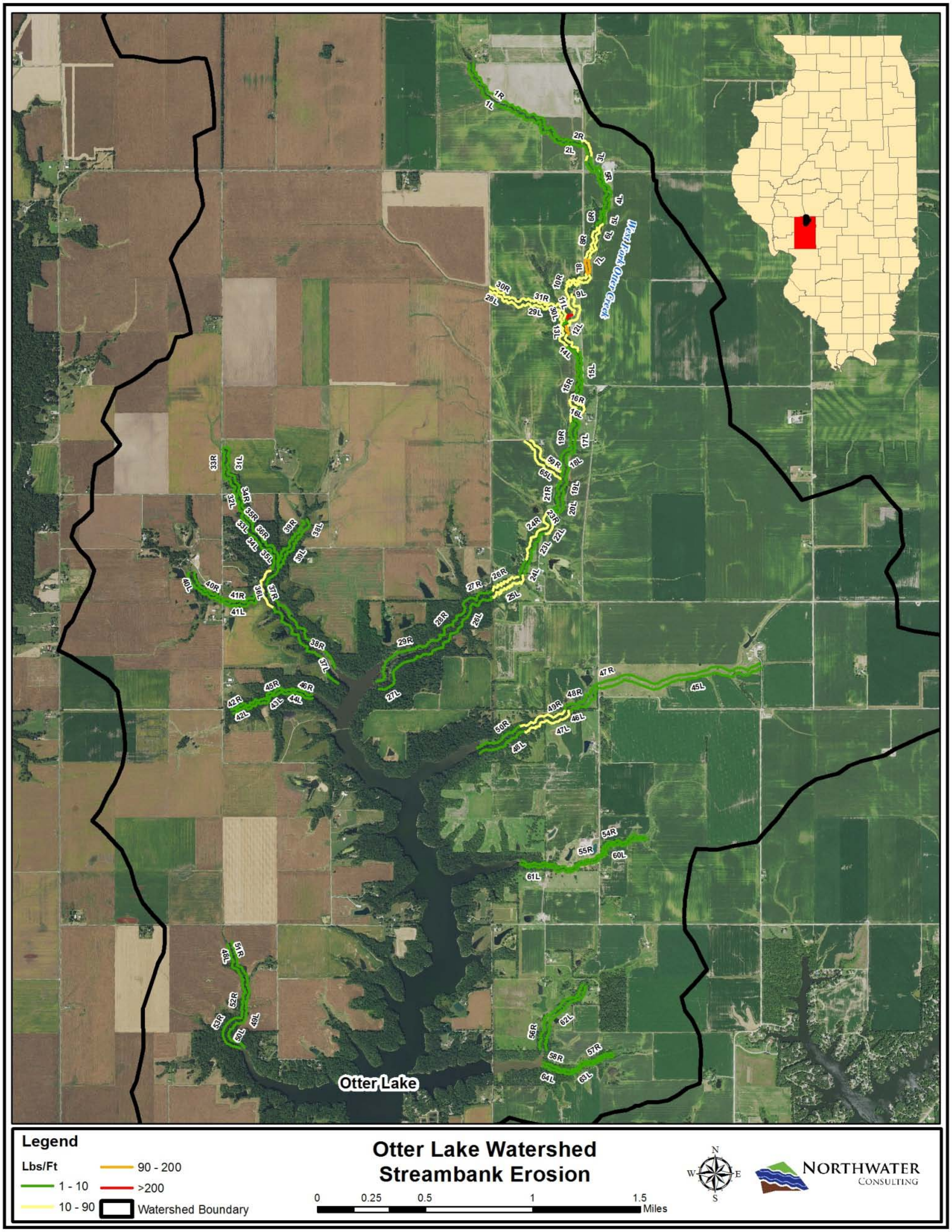


Figure 29 - Otter Lake Watershed Streambank Erosion

3.11.3 Otter Lake Shoreline Erosion

A total of 157,943 feet, or 30 miles of shoreline, were evaluated once in 2010 and again in 2014 to evaluate shoreline stabilization progress. Within Otter Lake, shorelines are moderately stable overall due to a significant amount of shoreline stabilization. Thirty-four percent of all shoreline, or 10 miles, has been stabilized.

Table 35 provides a breakdown of lake shoreline assessment results; bank rankings are depicted in Figure 30 and Table 34. A more detailed shoreline mapping report can be obtained through the OLWC. Annually, shoreline erosion contributes 1,671 lbs of nitrogen, 2,805 lbs of phosphorus and 4,395 tons of sediment to Otter Lake.

Table 34 - Otter Lake Shoreline Severity Rankings

Bank Rank	Description		Lateral Recession Rate (ft/yr)
1		Mechanical stabilization completed	0.001
2		Hand laid stabilization completed with no maintenance required	0.005
3		Hand laid stabilization completed with maintenance required; not adequately preventing bank erosion	0.4
4		Natural and stable banks	0.001
5		Low overhanging/undercut bank; relatively stable	0.03
6		Intact bank vegetation but slight-moderate bank undercut – trees at a slight angle	0.1
7		Severe undercut bank; vegetation at an extreme angle or falling in	0.5
8		Active erosion and severe; exposed banks	0.8
9		Active erosion and very severe; large exposed banks with recent evidence of erosion	1.0

Table 35 - Otter Lake Shoreline Assessment Results

Bank Rank	Bank Length (ft)	Average Height (ft)	Average Lateral Recession Rate (ft/yr)	Nitrogen Load (lbs/yr)	Phosphorus Load (lbs/yr)	Sediment Load (tons/yr)
1	29,981	4.3	0.294	4.2	3.6	4.6
2	25,709	2.5	0.005	6.0	8.7	13
3	4,842	6.9	0.4	149	357	593
4	9,193	1.1	0.001	0.3	0.3	0.5
5	23,537	1.4	0.03	26	27	38
6	40,889	2.0	0.1	96	196	318
7	15,071	3.7	0.5	369	712	1,145
8	8,123	7.0	0.8	1,003	1,409	2,126
9	598	6.9	1.0	19	90	158
Total	**157,943**	**4.0 (avg)**	**0.35 (avg)**	**1,671**	**2,805**	**4,395**

Otter Lake; Severe Shoreline Erosion

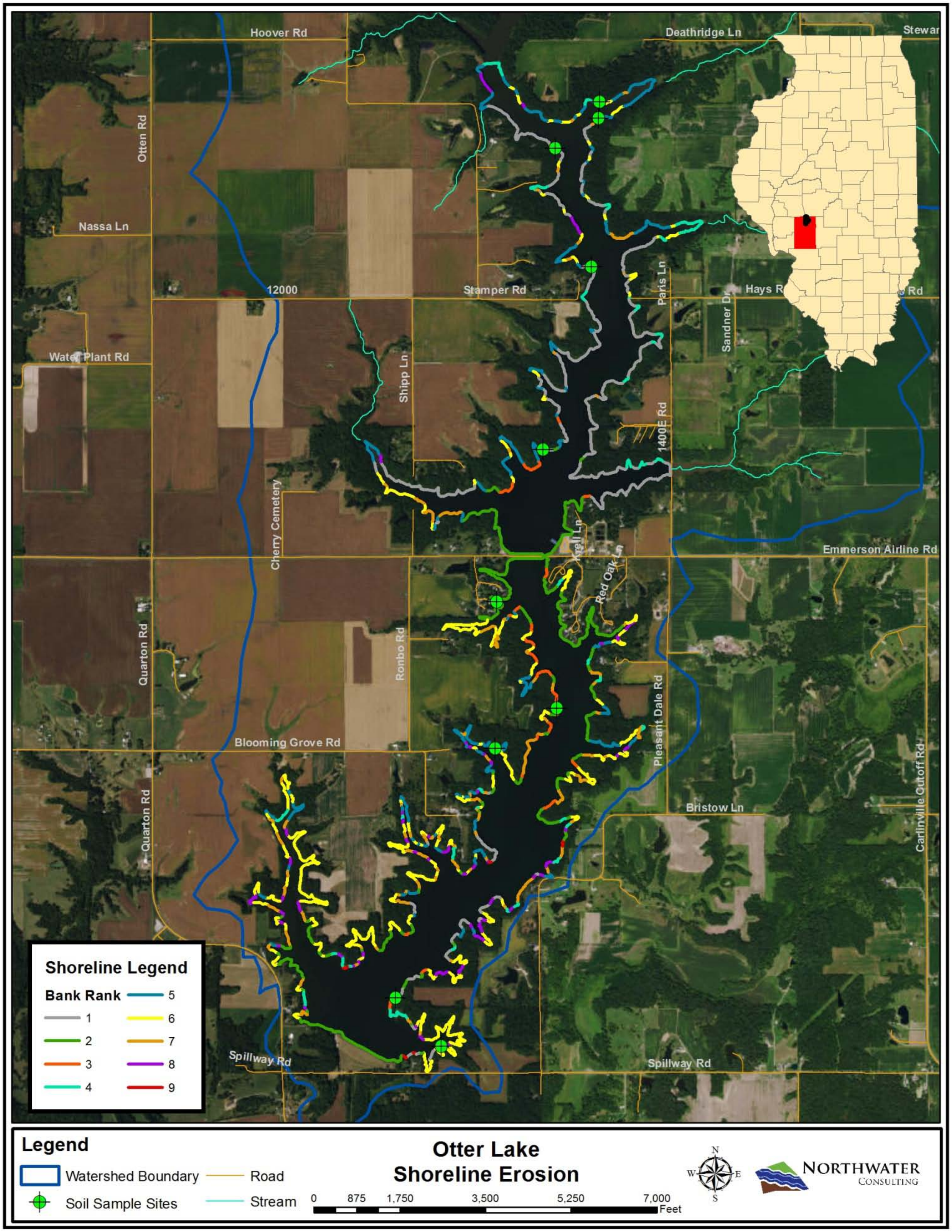


Figure 30 - Otter Lake Shoreline Erosion

3.12 Urbanization, Septic Systems & Wastewater Treatment

Urbanization of the watershed is nonexistent, containing only scattered rural residential homes. The majority of the watershed is sparsely populated, although camp grounds owned and operated by the OLWC do attract a number of seasonal visitors. There is no current indication that the watershed will experience any significant development pressure in the future, as the population is likely to remain flat or experience minor declines.

All 147 residences in the watershed are thought to be on septic systems. Wastewater generated from the OLWC camp grounds is collected and disposed of off-site. There are no Waste Water Treatment Plants (WWTPs) in the watershed.

3.12.1 Septic Systems

Septic systems provide treatment of all wastewater from individual properties. Failing septic systems are typically an active source of pollutants. Faulty or leaking septic systems are sources of bacteria, nitrogen, and phosphorus. Typical national septic system failure rates are 10-20% and no failure rates are reported specifically for Illinois (U.S. EPA 2002). However, reported failure rates vary widely depending on the local definition of failure (U.S. EPA 2002). A 15% failure rate was used to analyze the Otter Lake watershed.

Every home in the watershed was located and mapped using GIS, which was applied to estimate the number of individual residential homes using septic systems. A corresponding nitrogen and phosphorus load was then estimated using the Spreadsheet Tool for Estimating Pollution Loading (STEPL). Assuming a septic system failure rate of 15%, it is possible that 22 homes within the watershed have failing septic systems; due to the planning nature of this analysis, the exact locations of these systems are unknown. Phosphorus and nitrogen loading from potentially failing septic systems is presented in Table 36. Potentially failing systems contribute phosphorus loads of 268 lbs/yr and nitrogen loads of 686 lbs/yr. For the purposes of this report, it is assumed that these loadings do make it to the lake. However, loading is likely a function of location to a waterway and it is possible that septic water from a portion of failing systems may be absorbed or filtered prior to entering the lake.

Table 36 - Nutrient Loading; Potentially Failing Septic Systems

Number of Septic Systems	Population per Septic System	Septic System Failure Rate (%)	Number of Homes on Failing Septic	Phosphorus Load (lbs/yr)	Nitrogen Load (lbs/yr)
147	2.43	15	22	268	686

3.13 Gully Erosion

Gully erosion is the removal of soil along drainage lines by surface water runoff. Once started, gullies will continue to move by headward erosion or by slumping of the side walls unless steps are taken to stabilize the disturbance. Gully erosion occurs when water is channeled across unprotected land and washes away the soil along the drainage lines. Under natural conditions, runoff is moderated by vegetation which generally holds the soil together, protecting it from excessive runoff and direct rainfall. To repair gullies, the object is to divert and modify the flow of water moving into and through the gully so that scouring is reduced, sediment accumulates and vegetation can establish. Stabilizing the gully head is important to prevent damaging water flow and headward erosion. In most cases, gullies can be prevented by good land management practices (Water Resources Solutions, 2014).

Gully erosion in the watershed was evaluated during a watershed windshield survey, a forested gully assessment, individual property evaluations, and estimated using GIS. Gully erosion presented in this section represents 82 eroding gullies, both ephemeral (those that form each year) and permanent (those that receive intermittent streamflow and expand over time, such as a forested ditch or channel).

For those ephemeral gullies not visible from a road or observed during site assessment, GIS was used to estimate their location and extent. Gullies were delineated in GIS using aerial imagery, and conservative width (1 ft), depth (0.5 ft), and years eroding (1 yr) were applied to each gully. For gullies observed in the field, dimensions were directly measured in the field and transferred to GIS for analysis.

Total net erosion in tons/year and estimates of nitrogen and phosphorus loading were calculated using GIS and equations derived from IEPA's load reduction spreadsheet. A distance-based delivery ratio was applied to account for distance to a receiving waterbody. Sediment trapping efficiency was accounted for, if the gully drained to a retention or detention structure.

The following equations were applied to estimate gully erosion:

Sediment (tons/yr) = Length (ft) * Width (ft) * Depth (ft) / Years Eroding * Soil Weight Dry Density (tons/ft3)
Nitrogen (lbs/yr) = Sediment (tons/yr) * N concentration in soil (0.00208 lbs/lb) * 2,000 (lbs/ton) * Corr. Factor
Phosphorus (lbs/yr) = Sediment (tons/yr) * P concentration in soil (0.000143-000411 lbs/lbs) X 2,000 (lbs/ton) * Corr. Factor
Delivery Ratio = Gully distance from lake or receiving perennial stream (ft) ^-0.2069

Gully erosion in the watershed is prevalent, especially in steep forested draws or ephemeral water courses adjacent to major perennial drainage ways. Gully erosion is also evident on crop ground; conservation practices observed in the watershed, such as WASCBs or grassed waterways and other grade control structures, have been widely implemented to address this type of erosion.

Results indicate that there are 13 miles of eroding gullies in the watershed, 2 miles (21%) which drain to an existing pond or detention structure. Furthermore, many of the historical gullies in the watershed have been addressed with conservation measures initiated by the OLWC. It is estimated that gully erosion is responsible for the annual delivery of 713 tons of sediment, 270 pounds of phosphorus and 2,964 pounds of nitrogen to Otter Lake. Table 37 provides results of the gully assessment and Figure 31 depicts the locations within the watershed.

Table 37 - Otter Lake Watershed Gully Erosion

Gully Length (ft/mi)	Average Gully Width (ft)	Average Gully Depth (ft)	Nitrogen (lb/yr)	Phosphorus (lbs/yr)	Sediment (tons/yr)
50,182/9.5	2.1	1.4	2,964	270	713

Eroding Forested Gully

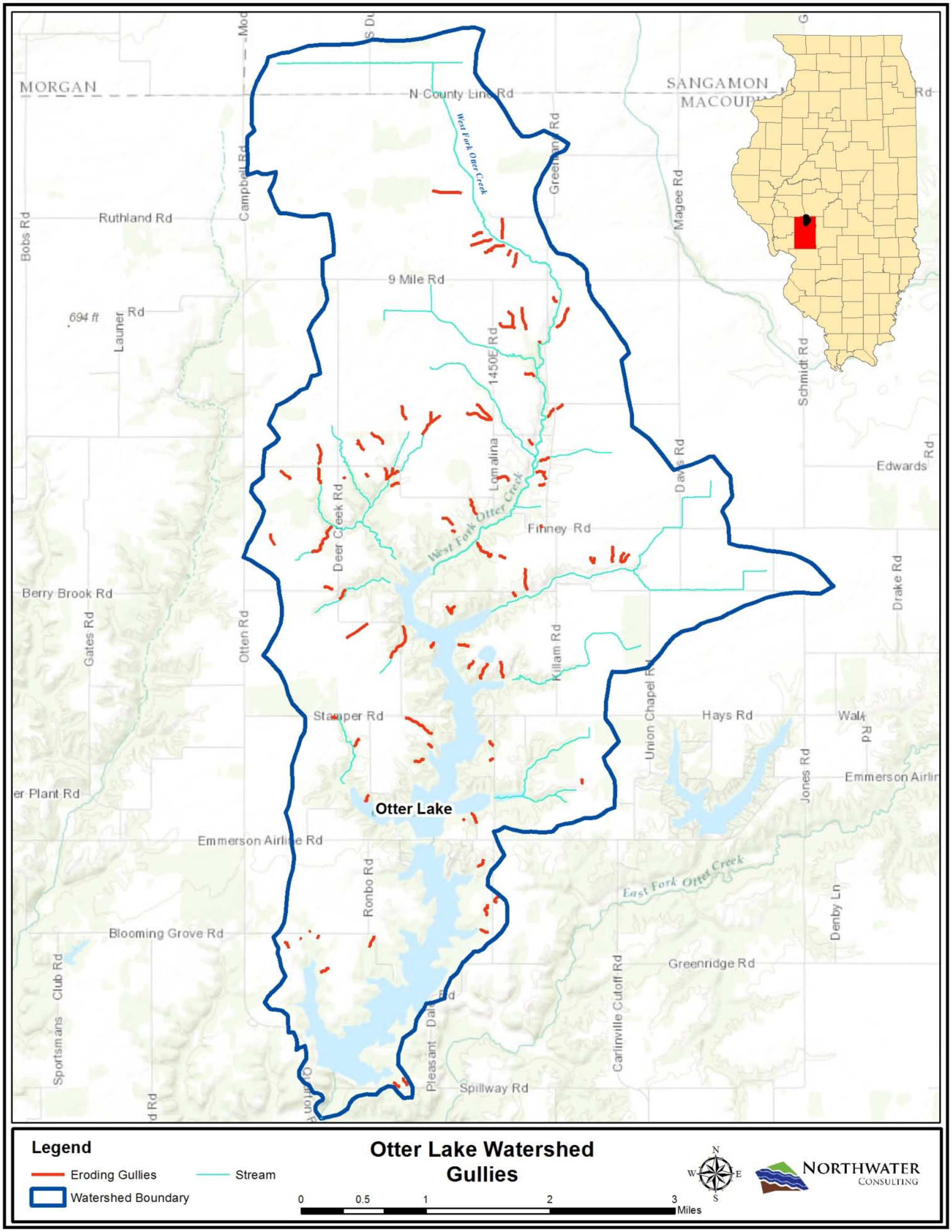


Figure 31 - Otter Lake Watershed Eroding Gullies

3.14 Sheet & Rill Erosion

Sheet Erosion

Through rain and shallow water flows, sheet erosion removes the thin layer of topsoil. When sheet flows begin to concentrate on the surface through increased water flow and velocity, rill erosion occurs. Rill erosion scours the land even more, carrying off rich nutrients and adding to the turbidity and sedimentation of waterways. The extent of sheet and rill erosion in the Otter Lake watershed was calculated using the Universal Soil Loss Equation (USLE) which is widely used to estimate rates of soil erosion caused by rainfall and associated overland flow. This method relies on soil properties, precipitation, slope, cover types and conservation practices (if applicable). A map-based USLE model was developed for all cropped soils within the watershed and used to quantify sediment loading from agricultural ground and identify locations with the potential for excessive erosion.

In the Otter Lake watershed, sheet and rill erosion from crop ground is responsible for 8,038 tons of sediment delivered to the lake on an annual basis. This translates into 0.62 tons/ac/yr delivered from crop ground alone. Modeled results indicate that the majority of sheet and rill erosion delivered to the lake is originating from conventionally or reduced tillage fields; tilled HEL soils and those fields closest to a stream or the lake.

Cropped soils that have the greatest per-acre loads, or are eroding at greater than 1 ton/ac/yr, are responsible for the annual delivery of 4,666 tons, or 58%, of the entire sediment load from crop ground; these areas represent only 18% of all crop ground in the watershed. Nutrient loading from sheet and rill erosion, as well as a more detailed discussion on pollutant loading, is presented in Section 4.

4.0 Pollutant Loading

4.1 Introduction & Methodology

A survey was completed to gain an understanding of watershed conditions and features, collect field-specific data, and discuss management measures with interested landowners. Data collected in the field included:

- Tillage practices.
- Cover types.
- Project (BMP) locations and site suitability.
- Sources of sediment and gully erosion.

A watershed windshield survey was performed and combined with data collected during individual landowner site visits prior to 2017. The windshield survey and site visits, combined with an interpretation of aerial imagery, resulted in the identification of site-specific BMP locations. Drainage areas were then delineated for each location.

A spatially explicit and field-specific GIS-based pollution loading model (SWAMM) was then developed to estimate loading from direct runoff. A model methodology is provided in Appendix A. This supporting model simulates surface runoff using the curve number approach, local precipitation, the Universal Soil Loss Equation (USLE), and Event Mean Concentrations (EMCs) specific to land use and soil types in the watershed. A customized and accurate land use layer was developed for the watershed to ensure model inputs represented actual watershed characteristics. In addition, information collected in the field was incorporated into the model, such as tillage practices, gully erosion, and existing conservation practices.

4.2 Pollutant Loading

Pollutant load estimates are presented in this section. Estimates are provided for loading resulting from direct runoff, observed gully erosion, septic systems, internal phosphorus release from lake sediment, and streambank and lake shoreline erosion. Gully erosion was observed in the field to the extent it was visible. Streambank and lake shoreline erosion was directly assessed. Loading from septic systems was estimated based on those homes not connected to a WWTP and phosphorus loading released from lake bed sediment was generated from the 2005 TMDL study. Nitrogen releases from internal regeneration was calculated using release rates reported in the literature. The estimated releases of ammonia-nitrogen from sediment were based on rates determined by Nurnberg (1984) and USEPA (1980). A rate of 120.0 mg/m2/day (1.07 lbs/acre/day) for ammonia-nitrogen was used to calculate estimated internal nutrient loads for the period that dissolved oxygen levels were less than 1.0 mg/l. Loading from direct runoff or surface runoff accounts for what is contributed to the lake just from overland flow. These values were multiplied by the approximate surface area of the lake bottom that had summertime dissolved oxygen levels below 1.0 mg/l to arrive at a total internal nutrient load. There were approximately 290 acres in Otter Lake that were determined to be anoxic during the summer stratification period of approximately 150 days. The water plant intake basin area has a maximum depth of 27 feet and has approximately 80 acres that remain anoxic throughout the summer and the deeper basin to the south extending to the dam has about 210 anoxic acres. Results from the GIS-based direct runoff pollution load model are illustrated in Figures 32 through 34.

As presented in Table 38, total annual nitrogen loading to Otter Lake from all sources is 151,591 lbs/yr; 20,352 lbs/yr of phosphorus and 13,801 tons/yr of sediment is delivered to the lake annually. Direct runoff is responsible for 93% of the total nitrogen load, 49% of the phosphorus load and 59% of the sediment load. Phosphorus release from lake sediment is thought to be responsible for 32% of the total load. Lake bank erosion contributes a modest percentage of the total watershed phosphorus load, accounting for 16%. Lake bank erosion is also responsible for a relatively high percentage of the sediment load at 32%. Streambank, gully erosion, and septic systems contribute low overall percentages of the total annual sediment and nutrient loading.

Table 38 - Pollution Loading Summary

Source	Total Nitrogen (lbs/yr)	% of Total Load	Total Phosphorus (lbs/yr)	% of Total Load	Total Sediment (tons/yr)	% of Total Load
Direct Runoff	96,782	64%	10,047	49%	8,135	59%
Streambank Erosion	2,322	1.5%	408	2%	558	4%
Lake Bank Erosion	1,671	1.1%	2,805	14%	4,395	32%
Gully Erosion	2,964	2%	270	1%	713	5%
Septic Systems	686	1%	268	1%	0	0%
Internal Release of Nutrients from Lake Bed[1]	47,166	31%	6,554	32%	0	0%
Total	**151,591**		**20,352**		**13,801**	

1 – From 2005 TMDL.

Modeled pollution loading from direct or surface runoff is further quantified in Table 39; per-acre results are calculated by dividing the total annual load of a given landuse category by the total number of acres present in the watershed. Results clearly show that row crops contribute the greatest total and per-acre load of nitrogen, the greatest total phosphorus load and the greatest total and per-acre sediment load generated from surface runoff. Crop ground delivers annual nitrogen loads of 88,903 lbs, or 10 lbs/ac/yr; annual phosphorus loads of 9,295 lbs, or 1 lbs/ac/yr; and 8,038 tons, or 0.9 tons/ac/yr. It is important to note that these results represent delivered loads for all fields in the watershed combined; individual fields deliver soil and nutrients at different rates based on tillage practices, soil and slope characteristics, proximity to a waterbody, and whether or not a BMP is in place.

Modeled per-acre sediment delivery rates from crop ground in the watershed range from 0.0002 tons/ac/yr to 56 tons/ac/yr. Phosphorus delivery rates range from 0.006 lbs/ac/yr to 27 lbs/ac/yr and nitrogen delivery rates range from 0.07 lbs/ac/yr to as high as 189 lbs/ac/yr. As noted in a previous section, on tiled soils, up to 47% of the crop nitrogen load can be expected from tile flow.

Other landuse categories, such as forest open water areas, are responsible for the second and third highest total nutrient and sediment loads from direct or surface runoff. Although per-acre loading from forested areas is low compared to other landuse categories, the watershed contains a high percentage of forested area and, therefore, cumulative loading is higher.

Livestock feed areas, pastures, roads, and camp grounds are responsible for high per-acre nitrogen, sediment, and phosphorus loads, however, total loadings from these three landuse categories only account for a very small percentage of the overall load. Loading from open water ponds or reservoirs within the watershed is largely a result of direct delivery and area. Roads can deliver relatively high per-acre sediment and nitrogen loads; this is primarily a function of higher runoff rates and negligible infiltration.

Table 39 - Loading from Direct Runoff by Landuse Category

Landuse Category	Acres	Nitrogen Load (lbs/yr)	Per Acre	Phosphorus Load (lbs/yr)	Per Acre	Sediment Load (tons/yr)	Per Acre
Row Crops	8,948	**88,903**	**10**	**9,295**	**1.0**	**8,038**	**0.90**
Open Water Pond/Reservoir	817	**2,577**	3.2	**172**	0.21	5.2	0.01
Forest	1,533	**1,892**	1.2	**209**	0.14	**38**	0.03
Pasture	145	957	**6.6**	93	0.64	10	0.07
Urban Open Space	352	773	2.2	45	0.13	7.7	0.02
Roads	89	609	**6.8**	90	**1.0**	17	**0.19**
Grassland	854	401	0.5	73	0.09	**11**	0.01
Open Water Stream	22	236	11	21	0.92	0.29	0.01
Farm Building	23	132	5.7	8.1	0.35	1.6	0.07
Rural Residential	51	129	2.5	18	0.35	2.4	0.05
Camp Ground	17	88	5.3	11	0.64	2.7	**0.16**
Feed Area	2.6	33	13	5.6	**2.1**	0.32	0.12
Wetland	32	31	1.0	2.2	0.07	0.35	0.01
Utilities	10	20	2.0	4.7	0.46	0.48	0.05
Cemetery	0.92	0.69	0.75	0.10	0.11	0.01	0.01
Total	**12,898**	**96,782**	**7.5**	**10,047**	**0.78**	**8,135**	**0.63**

Table 40 compares the loadings originating from direct runoff with the summed watershed load from all sources, including streambank and lake bank erosion, gully erosion, internal phosphorus release, and failing septic systems. Compared to all sources, row crops are responsible for 59% of the total nitrogen load, 46% of the total phosphorus and 58% of the total sediment load delivered to the lake. Although low overall, forest and open water contribute the second and third highest percentage of the total nutrient loading and forest and roads the second and third highest sediment load.

Table 40 – Loading from Direct Runoff by Landuse as a Percentage of Total Watershed Load

Landuse Category	Nitrogen Load (lbs/yr)	% Total Watershed & Internal Load	Phosphorus Load (lbs/yr)	% Total Watershed & Internal Load	Sediment Load (tons/yr)	% Total Watershed & Internal Load
Row Crops	88,903	**59%**	9,295	**46%**	8,038	**58%**
Open Water Pond/Reservoir	2,577	**1.7%**	172	**0.84%**	5.2	0.04%
Forest	1,892	**1.2%**	209	**1.0%**	38	**0.28%**
Pasture	957	0.6%	93	0.46%	10	0.08%
Urban Open Space	773	0.5%	45	0.22%	7.7	0.06%
Roads	609	0.4%	90	0.44%	17	**0.12%**
Grassland	401	0.3%	73	0.36%	11	0.08%
Open Water Stream	236	0.2%	21	0.10%	0.29	0.00%
Farm Building	132	0.1%	8.1	0.04%	1.6	0.01%
Rural Residential	129	0.1%	18	0.09%	2.4	0.02%
Camp Ground	88	0.1%	11	0.05%	2.7	0.02%
Feed Area	33	0.02%	5.6	0.03%	0.32	0.002%
Wetland	31	0.02%	2.2	0.01%	0.35	0.003%
Utilities	20	0.01%	4.7	0.02%	0.48	0.003%
Cemetery	0.69	0.0005%	0.10	0.001%	0.01	0.0001%
Total	**96,782**	**64%**	**10,047**	**49%**	**8,135**	**59%**

Note: Percentages do not add up to 100% because direct runoff is not the only source of loading in the watershed. Streambank and lake bank, gully erosion, internal lake nutrient release, and septic systems are responsible for the remaining percentage.

Gully erosion in the watershed

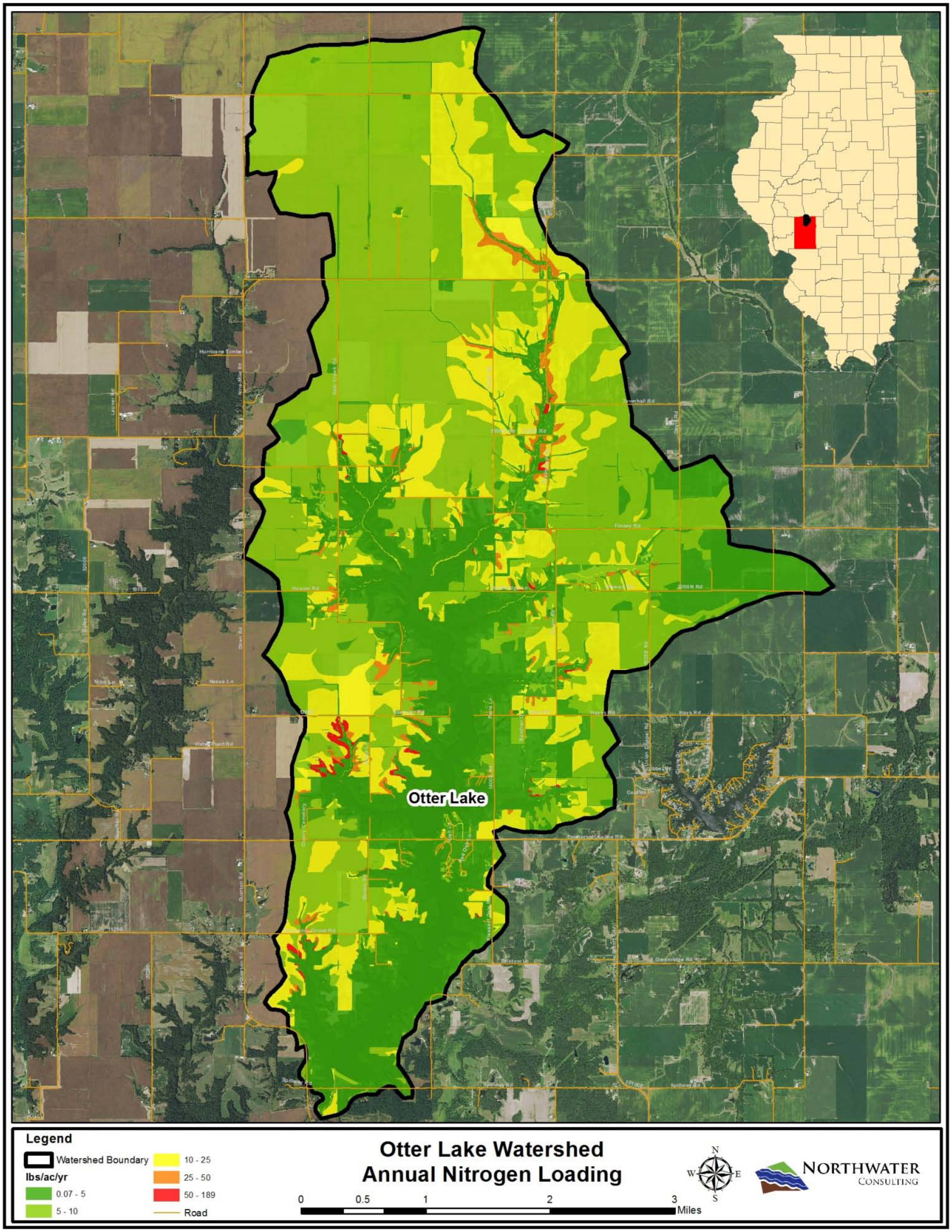


Figure 32 - Otter Lake Watershed Annual Nitrogen Loading from Direct Runoff (lbs/ac/yr)

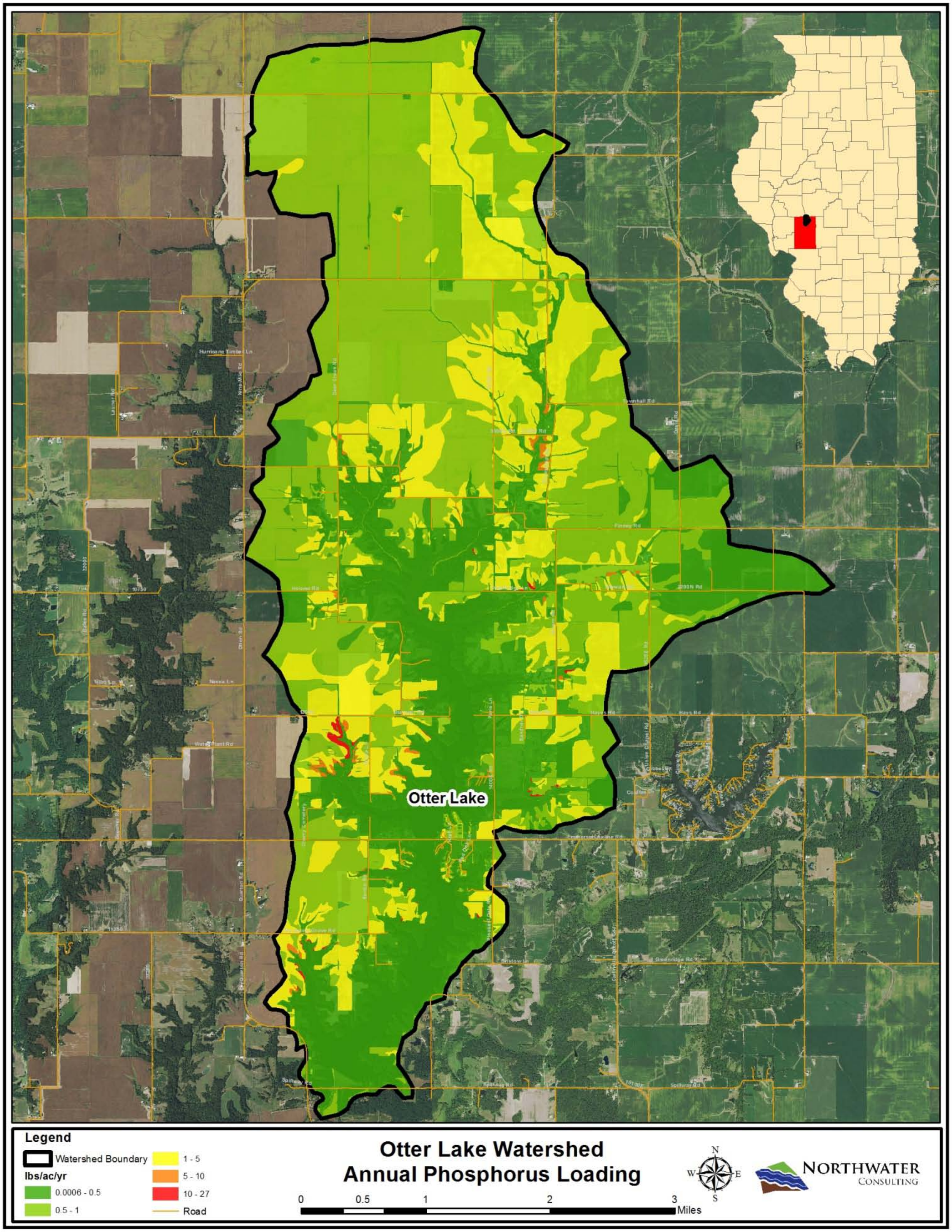


Figure 33 – Otter Lake Watershed Annual Phosphorus Loading from Direct Runoff (lbs/ac/yr)

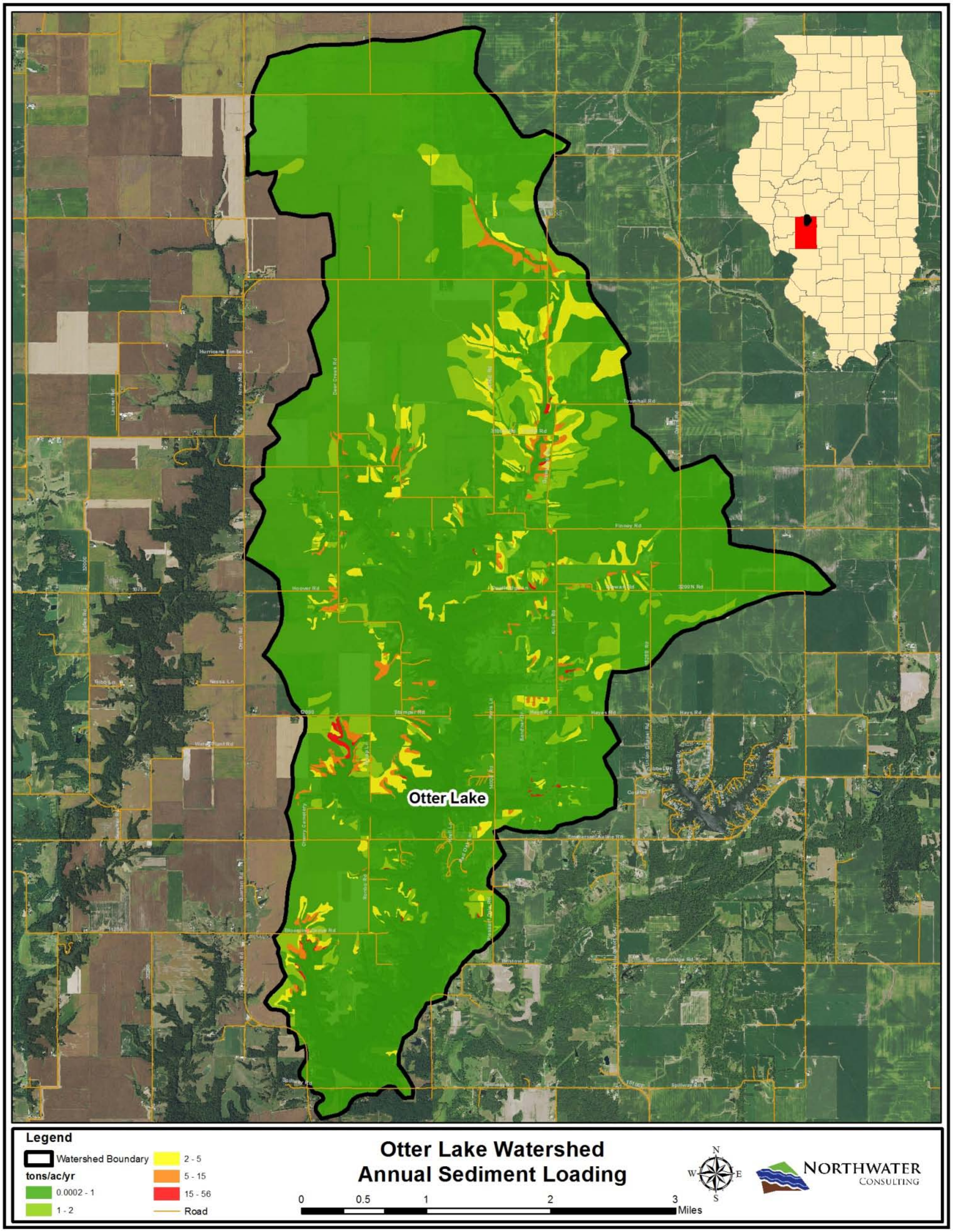


Figure 34 - Otter Lake Watershed Annual Sediment Loading from Direct Runoff (tons/ac/yr)

5.0 Sources of Watershed Impairments

Watershed impairments originate from either nonpoint source (NPS) pollution or point source pollution. The term "point source" is defined as any discernible, confined and discrete conveyance, including, but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture (US EPA, 2016).


Forested Gully

Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification. The term "nonpoint source" is defined to mean any source of water pollution that does not meet the legal definition of "point source." Unlike pollution from industrial and sewage treatment plants, NPS pollution comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters (US EPA, 2016). There is only one point source discharge in the watershed, issued to the OLWC filter backwash. Its contribution to lake loading is negligible or nonexistent and, therefore, any lake impairments are believed to be originating entirely from NPS pollution.

Sources of sediment and nutrients are thought to be originating from crop ground, gullies in steep forested areas within the watershed, streambank erosion, lake shoreline erosion, and lake sediment (internal phosphorus and nitrogen). Leaking or improperly maintained septic systems may also be a source of nutrients in the watershed.

5.1 Analysis of Pollution Sources

The following section provides pollutant source descriptions identified at the significant subcategory level, along with estimates to the extent they are present in the watershed. The section looks at the greatest contributions and spatial extent of loading by each major source.

5.1.1 Phosphorus & Nitrogen

The primary source of both nitrogen and phosphorus in the watershed is from crop ground which is responsible for 59% of the total watershed nitrogen and 46% of the phosphorus load delivered to the lake. Internal release of phosphorus and nitrogen from lake sediment is estimated to be 32% and 31% of the total watershed load and, therefore, is a primary source of nitrogen and phosphorus. Secondary sources include eroding gullies, stream and lake bank erosion, and septic systems.

Crop Ground

The amount of nutrients originating from crop ground depends on tillage practices, proximity to a receiving waterbody, and the presence or absence of conservation practices; although tiling was not specifically assessed in this study, tile flow can have large impacts on nitrogen loading. A modeling effort performed for the Lake Springfield watershed indicated that loading from tile systems accounted for 47% of the entire watershed nitrogen load.

An analysis was performed to better understand the extent of nutrient loading based on tillage practices and HEL designation and results are presented in Table 41. Results indicate that the majority of crop ground nitrogen and phosphorus is from non-HEL reduced/spring/conventionally tilled fields (84% and 81%). It should be noted that a relatively high percentage of the total load is originating from a small percentage of cropped HEL ground. See Figure 35.

Table 41 - Nutrient Load Allocation by Tillage & HEL

Tillage/HEL	Acres	% of Total Crop Area	Nitrogen Load (lbs/yr)	% Total Crop Ground Load	Phosphorus Load (lbs/yr)	% Total Crop Ground Load
Conventional/Spring/Reduced HEL	261	3%	8,519	9.6%	1,122	12%
Conventional/Spring/Reduced Non-HEL	8,001	89%	74,825	84%	7,536	81%
No-Till/ Strip-Till HEL	65	0.7%	1,323	1.5%	203	2.2%
No-Till/ Strip-Till Non-HEL	621	7%	4,236	4.8%	434	4.7%
Total	**8,948**	**100%**	**88,903**	**100%**	**9,295**	**100%**

Gullies, Lake Shoreline, Streambanks, Septic Systems, & Lake Sediment

The 82 known eroding gullies in the watershed are responsible for 3% of the total watershed nitrogen load and 1% of the total phosphorus load. Streambank erosion delivers 2% of the total watershed nitrogen and phosphorus. Lake shoreline erosion accounts for 2% of the total watershed nitrogen load and 14% of the total watershed phosphorus load. It is possible that if the estimated 22 failing septic systems exist in the watershed, they would contribute 1% of the total nitrogen and phosphorus load.

The 52 gullies (63%) that contribute more than 1 pound of phosphorus per year to the lake contribute 254 lbs/yr of phosphorus, or 94% of the entire gully phosphorus load; these same gullies are also responsible for 94% of the entire gully nitrogen load.

Streambanks with high or very severe rates of erosion (greater than 90 lbs/ft/yr) are responsible for 22% of the entire phosphorus and 23% of the entire nitrogen load originating from streambank erosion; these banks only make up 1.3% of the entire stream length in the watershed. Nutrient loading from lake shoreline erosion is concentrated at locations where erosion rates are high. Only 15% of the shoreline that is considered to be high in terms of erosion contributes 83% of the entire shoreline nitrogen load and 79% of the phosphorus load (Figure 35). Internal phosphorus loading from lake sediment is 32% of the entire phosphorus load, or 6,554 lbs/yr and nitrogen release from within the lake is 31% of the entire load, or 47,166 lbs/yr.

5.1.2 Sediment

The primary sources of sediment in the watershed is cropped agricultural soils; crop ground is responsible for 59% of the entire sediment load. Secondary sources include actively eroding gullies on crop ground and in steep forested areas and eroding streambanks and lake banks.

Crop Ground

The amount of sediment originating from crop ground depends on tillage practices, proximity to a receiving waterbody, the presence or absence of conservation practices, and land slope. As noted in Section 3.14, crop ground that delivers greater than 1 ton/ac/yr of sediment to the lake is responsible for a significant portion of the overall sediment load; 34% of the entire watershed sediment load and 58% of the sediment load from crop ground. An analysis was performed to better understand the extent of loading based on tillage practices and HEL designation and results are presented in Table 42. Non-HEL reduced/conventionally tilled fields are responsible for the majority of the total crop ground sediment load (71%), however, reduced/conventionally tilled HEL fields contribute 23% of the total crop ground sediment load at only 3% of the total crop ground acreage. Addressing soil loss from reduced/conventionally tilled fields is likely an efficient means of reducing overall sediment loads to the lake.

Table 42 - Sediment Load Allocation by Tillage & HEL

Tillage/HEL	Acres	% of Total Crop Area	Sediment Load (tons/yr)	% Total Crop Ground Load
Conventional/Spring/Reduced HEL	261	3%	1,847	23%
Conventional/Spring/Reduced Non-HEL	8,001	89%	5,670	71%
No-Till/ Strip-Till HEL	65	0.7%	271	3.4%
No-Till/ Strip-Till Non-HEL	621	7%	249	3.1%
Total	**8,948**	**100%**	**8,037**	**100%**

Gullies, Lake Shoreline, Streambanks

Gully, lake shoreline and streambank erosion combined is responsible for 41% of the watershed sediment load. As with nutrients, the majority of the sediment for these sources can be traced back to a relatively small number of locations. The 63% of known eroding gullies that contribute greater than 1 ton of sediment per year are responsible for 94% of the entire sediment load from gully erosion. Streambanks exhibiting high or severe rates of erosion are responsible for 21% of the entire streambank load, or 116.5 tons/yr (Figure 35). As with nutrient loading, a very large percentage of the entire sediment load from shoreline erosion can be allocated to only 15% of the total length. This 15%, or 23,792 feet, contributes 3,429 tons/yr, or 78% of the entire shoreline sediment load. Targeting these areas first is an efficient means of reducing sediment loads from lake banks.

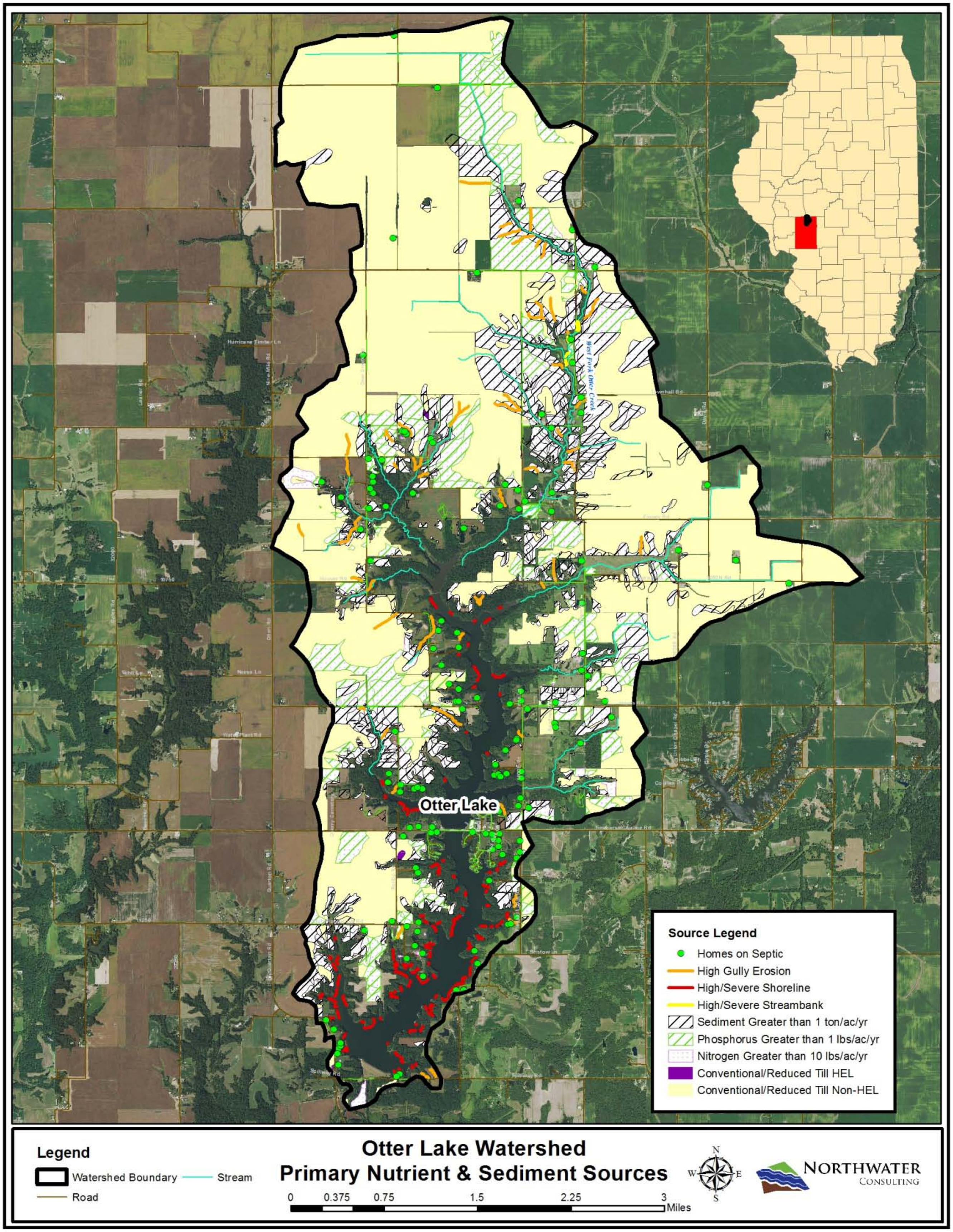


Figure 35 - Otter Lake Watershed Primary Nutrient & Sediment Sources

6.0 Nonpoint Source Management Measures & Load Reductions

This section details the recommended BMPs for the watershed, their applicable quantities and expected annual pollution load reductions. Although reductions presented below include nitrogen, phosphorus and sediment, special attention is given to phosphorus. Phosphorus is the only parameter for which a state water quality standard exists and the only applicable parameter addressed in the 2006 TMDL. According to the 2006 TMDL, a 66% reduction in annual phosphorus loading is needed for Otter Lake to meet the water quality standard of 0.05 mg/L. Extensive work in the watershed and the lake since the 2006 TMDL has likely resulted in a cumulative 20% reduction in nutrient and sediment loads and, therefore, it is reasonable to assume that a lower percent reduction in phosphorus loads will achieve the water quality standard. Practices that continue to reduce phosphorus and sediment loading should receive priority.

BMPs can be described as a practice or procedure to prevent or reduce water pollution and address stakeholder concerns. BMPs typically include treatment requirements, operating procedures, and practices to control runoff and abate the discharge of pollutants. This section of the plan describes all site-specific BMPs needed to achieve measurable load reductions in phosphorus, nitrogen and sediment.

Estimates of the expected pollution load reductions associated with recommended practices are included in this section. Load reductions are calculated using average pollutant reduction percentages based on existing literature and local expertise. Average pollutant reduction percentages can be found in Table 43.

Table 43 - Average Pollutant Reduction Percentages

BMP	Reduction % Nitrogen	Reduction % Phosphorus	Reduction % Sediment
WASCB/Terrace[1,3]	20%	60%	70%
Grade Control/Riffle[1]	2%	5-10%	10-15%
Detention Basin/Pond	22-31%	34-50%	60-70%
Pasture Management System	40%	45%	65%
Feed Area Waste System	80%	90%	90%
Grassed Waterway[3]	30%	25%	45%
Filter Strip/Field Border	10%	40%	65%
Saturated Buffer[4]	50%	0%	0%
In-Lake/Low Flow Dam	10-40%	10-45%	20-50%
Livestock Stream Fencing	40%	45%	65%
Wetland[2]	20-90%	10-90%	38-95%
No-Till/Strip Till	10%	50%	70%
Cover Crop	30%	30%	40%
Nutrient Management (Plan)[4]	15%	7%	0%
Bioreactor[4]	40%	0%	0%
In-Lake Management Treatments	90%	90%	0%

[1] – Controls 100% of gully erosion
[2] – Reduction percentage variable based on drainage area and inflow loads; max removal efficiency applied for small drainage areas and wetlands that include a upstream sediment trap.
[3] – Reduction percentage includes BMP maintenance of existing structures
[4] – Reduction percentage for nitrogen only applies to tile nitrogen

6.1 Best Management Practices & Expected Load Reductions

Load reductions were calculated for each recommended BMP using the GIS-based loading model. Where applicable, a drainage area was delineated for each individual practice location and, therefore, expected load reductions are spatially explicit; all estimated reductions represent delivered pollutants and are calculated independently for each BMP and, therefore, do not consider cumulative reductions of upstream practices.

Table 44 lists all proposed BMPs, quantities, area treated, and expected annual load reductions. Project or BMP locations are shown in Figures 36 and 37. The largest total expected reductions are realized from tillage practices, in-lake nutrient management, and a series of in-lake/low-flow dams, however, these practices may be costly or difficult to implement due to landowner willingness and cost. Section 7, cost estimates, evaluates cost per unit of pollutant reduction; Section 8, Water Quality Targets, compares each BMP against TMDL and water quality targets; Section 9, Priority BMPs & Critical Areas, details priority implementation actions. Individual BMP load reductions and details by BMP number are available upon request through the OLWC.

Table 44 – Recommended BMP & Load Reduction Summary

Type	Quantity	Area Treated (ac)	Nitrogen Reduction (lbs/yr)	Phosphorus Reduction (lbs/yr)	Sediment Reduction (tons/yr)
Cover Crop	85 locations	658	1,636	188	207
No-Till/Strip-Till	443 locations	8,263	8,334	4,329	5,262
Saturated Buffer	13 structures	628	1,653	0	0
Denitrifying Bioreactor	76 locations/82 structures	4,097	6,622	0	0
Filter Strip	15 locations / 24.2 ac	774	841	331	319
Field Border	47 locations/73.6 ac	1,989	1,681	662	769
Grade Control	5 locations/10 structures	481	297	45	93
Livestock Waste System	4	1.03	9.5	1.9	0.1
Pasture Management/ Fencing	2,695 ft / 2 locations	11.3	99.41	10.37	2.20
Grassed Waterway	11,006 ft/12.51 ac	789	2,498	238	385
New In-Lake / Low-flow Dam	4 structures	9,230	27,079	3,073	3,004
Existing In-Lake / Low-flow Dam	13.6 ac	6,944	6,360	664	1,098
WASCB/Terrace	36 structures/ 5,540 ft	87	520	111	158
Constructed Wetland	14 locations/22.8 ac	2,149	4,412	283	667
Pond	17 structures	782	2,669	361	598
Nutrient Management (Plans)	8,948 ac	8,948	13,335	651	0
Streambank Stabilization / Riffle	14 locations/26 riffles/1,550 ft	N/A	631	171	159
Lake Shoreline Stabilization	23,792 ft	N/A	1,391	2,211	3,429
Septic Systems	22 (#)	N/A	686	268	0
In-Lake Management / Aeration/ Alum Treatment	290 ac	290	42,449	5,899	0
Total		**46,121**	**123,203**	**16,703**	**16,704**

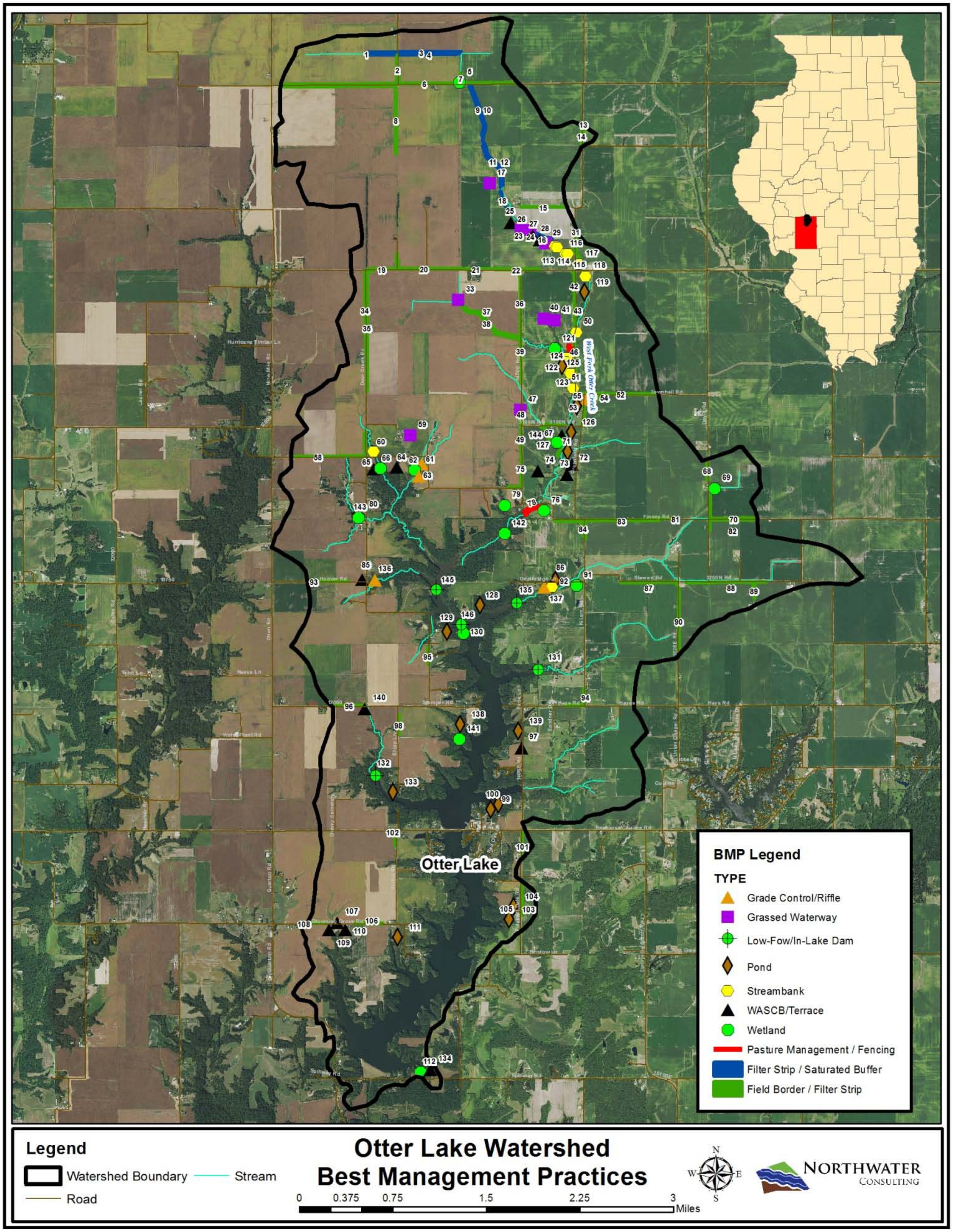


Figure 36 - Otter Lake Watershed BMPs (1)

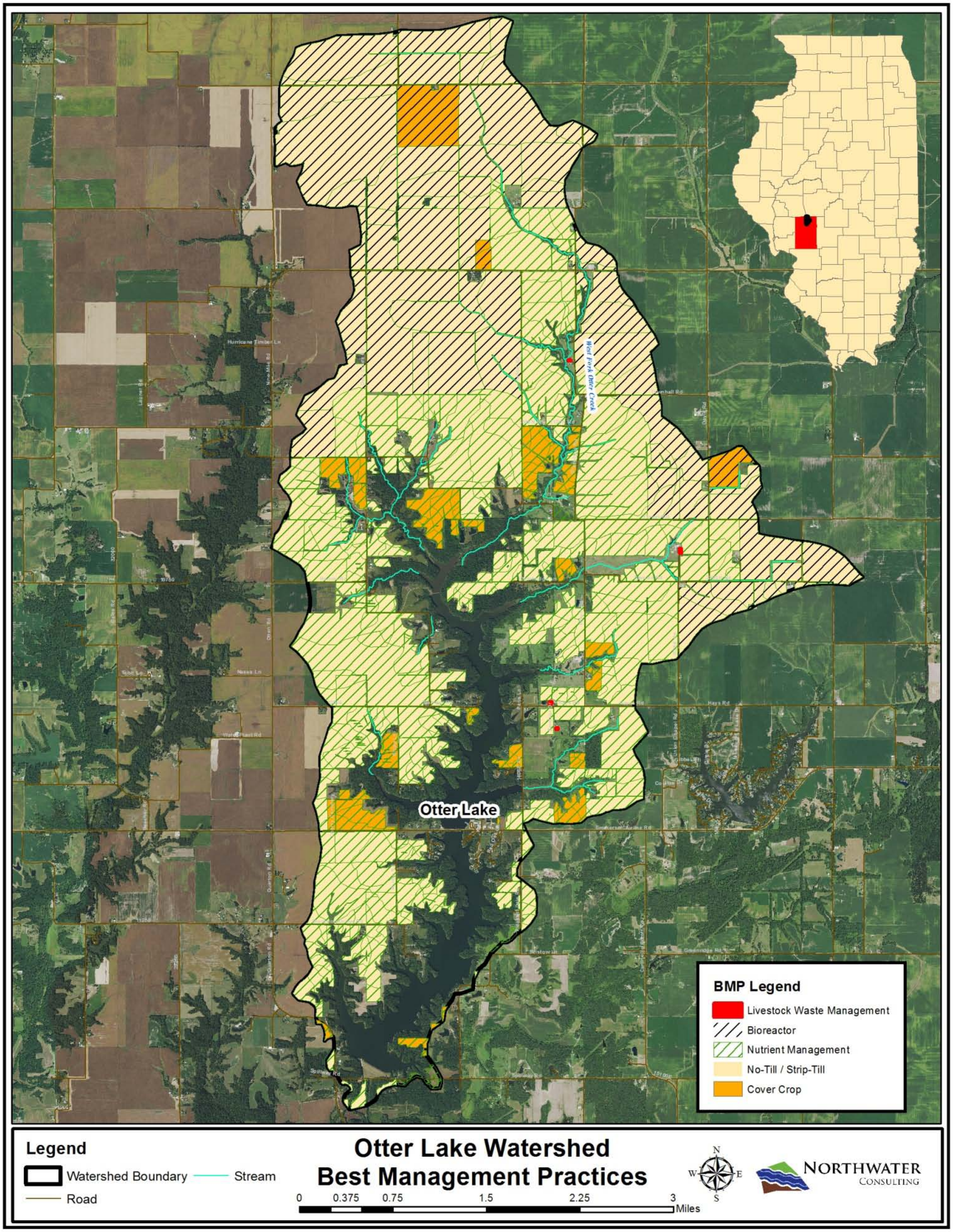


Figure 37 - Otter Lake Watershed BMPs (2)

6.1.1 Best Management Practice Summary & Load Reductions

This section provides a brief description of each BMP and its expected load reductions.

Cover Crops

A cover crop is a temporary vegetative cover that is grown to provide protection for the soil and improve soil conditions. Cover crops can be applied over a broad area in the watershed. Cover crops are only recommended for fields where no-till or strip-till is currently being practiced or where willing landowners expressed interest.

Cover Crops

Cover Crops are proposed at 85 locations in the watershed for a total of 658 acres. If all 658 acres of cover crops are implemented, the following load reductions are expected:

- 1,636 lbs/yr of nitrogen
- 188 lbs/y of phosphorus
- 207 tons/yr of sediment

It is believed that as more producers shift toward non-conventional tillage systems, such as strip-till or no-till, the acreage of farm ground where cover crops can be reasonably implemented will also increase.

No-Till or Strip-Till

No-till can be defined as farming where the soil is left relatively undisturbed from harvest to planting. During the planting operation, a narrow seedbed is prepared or holes are drilled in which seeds are planted. A switch from conventional tillage to no-till is often a prerequisite for the installation of cover crops and, therefore, is recommended for all fields in the watershed where conventional or reduced tillage is occurring. Strip-till is a good alternative to no-till, especially for those producers that are not willing to move to no-till. Strip-till is a minimum tillage system that combines the soil drying and warming benefits of conventional tillage with the soil-protecting advantages of no-till by disturbing only the portion of the soil that is to contain the seed row.

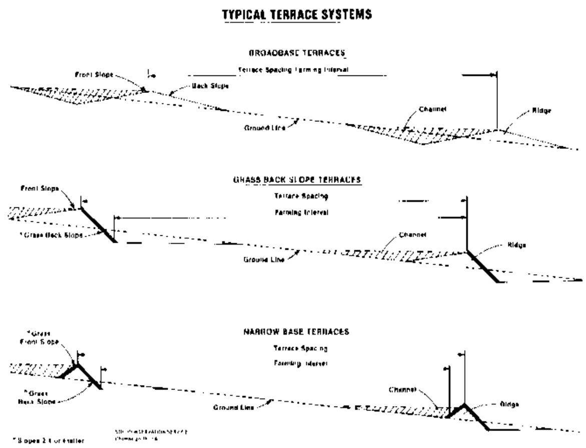
No-till

No-Till or strip till is proposed for all fields where conventional and reduced tillage is occurring (Figure 37). These BMPs are recommended at 443 locations in the watershed for a total of 8,263 acres. If all 8,263 acres are treated, the following load reductions are expected:

- 8,334 lbs/yr nitrogen
- 4,329 lbs/yr phosphorus
- 5,262 tons/yr sediment

Water and Sediment Control Basins (WASCB)/Terrace

Earth embankment and/or channel constructed across a slope to intercept runoff water and trap soil. WASCBs are often constructed to mitigate gully erosion where concentrated flow is occurring and where drainage areas are relatively small. Terraces, similar to a WASCB in design, are placed in areas where concentrated flow paths are less defined, such as long, wide-sloping fields. These practices are both popular with landowners in the watershed and applicable in many situations.

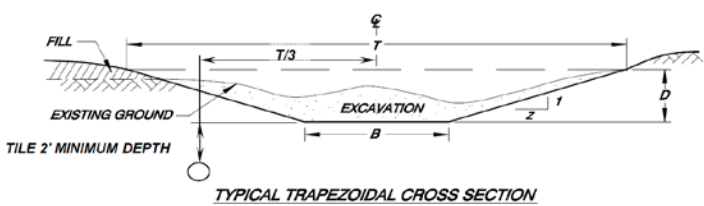


WASCBs are recommended at 15 locations for a total of 35 basins or 5,250 ft (150-foot length average) to treat 84 acres. One 290-foot terrace is recommended to treat 3 acres. If all WASCBs and the terrace are implemented to treat 87 acres, expected load reductions, including gully stabilization, will total:

- 520 lbs/yr of nitrogen
- 111 lbs/yr of phosphorus
- 158 tons/yr of sediment

Water & Sediment Control Basin

Grassed Waterways



A grassed waterway is a grassed strip in a field that acts as an outlet for water to control silt, filter nutrients and limit gully formation. Grassed waterways are applicable in the watershed in areas with very large drainage areas and low-moderate slopes. Although these practices are not popular with local producers, they are often the only feasible practice in a field that drains a very large area.

Grassed waterways are recommended at 9 locations for a total of 11,006 ft, or 12.51 acres (30-60 ft wide). One recommended waterway includes the maintenance of the existing structure; widening, shaping and re-seeding (0.8 acres). If implemented to treat 789 acres, the load reductions, including gully stabilization for all grassed waterways, are expected to be:

- 2,498 lbs/yr of nitrogen
- 238 lbs/yr of phosphorus
- 385 tons/yr of sediment

Constructed Wetland

A constructed wetland is a shallow water area constructed by creating an earth embankment or excavation area. Constructed wetlands can include a water control structure and are designed to mimic natural wetland hydrology, store sediment and filter nutrients. Constructed wetlands have been identified in areas where hydric soils support their establishment or where local topography does not allow for the construction of a pond.

Wetlands are recommended at 14 locations in the watershed for a total wetland area of 22.8 acres. If implemented to treat 2,149 acres, expected load reductions, including gully stabilization, are:

- 4,412 lbs/yr of nitrogen
- 283 lbs/yr of phosphorus
- 667 tons/yr of sediment

Filter Strip & Field Border

Field Border

A filter strip is a narrow band of grass or other permanent vegetation used to reduce sediment, nutrients, pesticides and other contaminants. Only those areas directly adjacent to an openly flowing ditch or stream where existing buffer areas are either inadequate or nonexistent were selected for the placement of filter strips. Field borders are similar to filter strips but are located along field edges adjacent to timbered areas; they can range in width from 30 – 120 feet.

In the Otter Lake Watershed, **field borders** are recommended at 47 locations for a total of 73.6 acres. If all 73.6 acres are planted to treat 1,989 acres, the following load reductions are expected:

- 1,681 lbs/yr of nitrogen
- 662 lbs/yr of phosphorus
- 769 tons/yr of sediment

Filter Strip

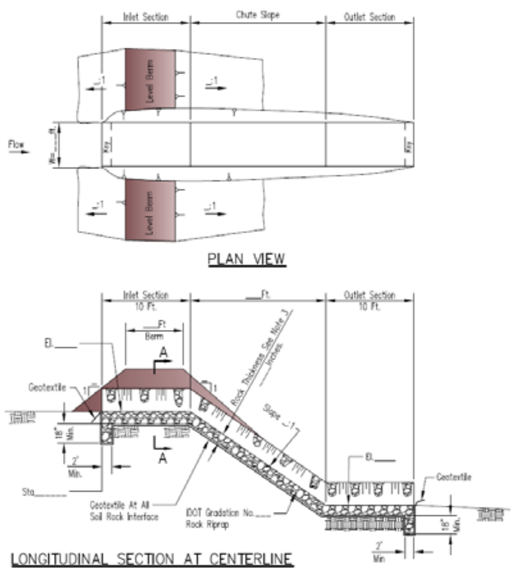
Filter strips are recommended at 15 locations for a total of 24.2 acres. If implemented to treat 774 acres, the following load reductions are expected:

- 841 lbs/yr of nitrogen
- 331 lbs/yr of phosphorus
- 319 tons/yr of sediment

Grade Control Structure

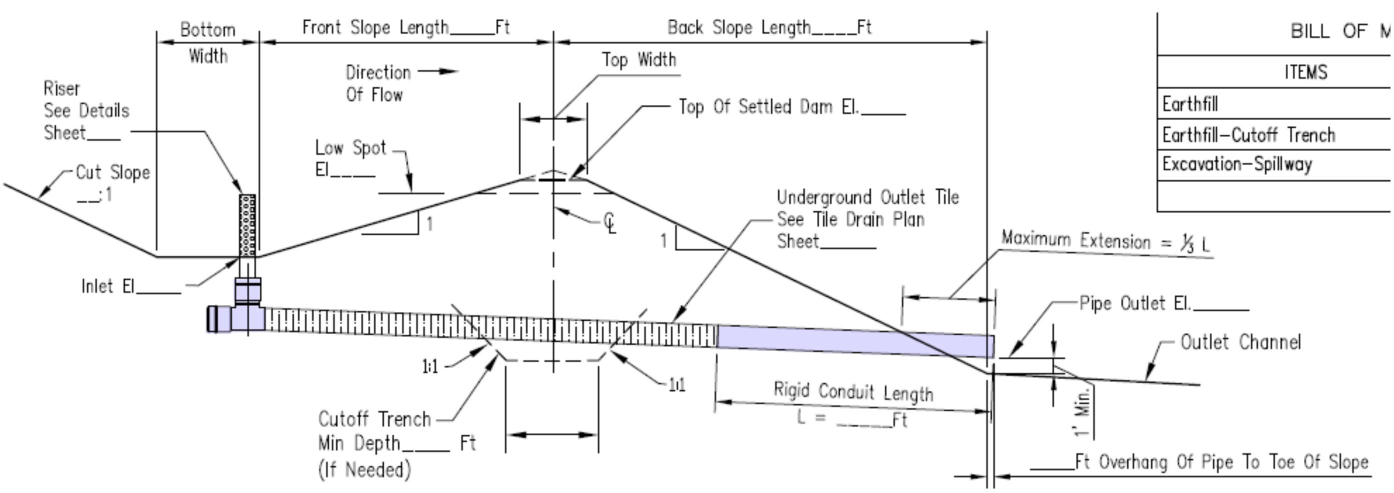
A grade control structure consists of a constructed berm or a rock/modular block structure (NRCS detail provided below) designed to address gully erosion and control vertical downcutting. In the Otter Lake watershed, grade control structures are recommended at locations where slopes are very steep and gully erosion is considered very severe; areas where other practices are just not feasible. Rock riffles are also possible at locations where grade control is required and can be used in place of the practices below; rock riffles are further described below in the section on streambank stabilization.

NRCS Grade Control Detail



Grade control structures are recommended at 5 locations for a total of 10 individual structures. If implemented to treat 481 acres, the expected load reductions, including gully stabilization, are:

- 297 lbs/yr of nitrogen
- 45 lbs/yr of phosphorus
- 93 tons/yr of sediment



CROSS SECTION OF DAM ON ℄ OF PIPE PRINCIPAL SPILLWAY

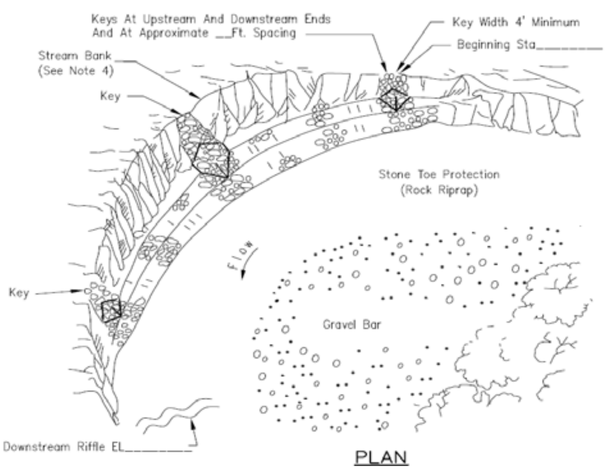
Streambank Stabilization; Stone-Toe Protection & Riffle

Streambank stabilization consists of both the placement of rock riffles and the installation of stone-toe protection to stabilize eroding streambanks and control stream grade, if necessary. Stream channel incision or deepening can lead to bank erosion and, oftentimes, grade control or rock riffles are needed in combination with stone-toe protection. In the Otter Lake Watershed, 1,550 feet of stone-toe protection and 26 stream riffles are recommended at 14 locations. Locations were selected based on sediment load, accessibility, and cost effectiveness. Streambank stabilization is not feasible or required throughout much of the heavily forested areas of the West Fork of Otter Creek and other major tributaries where accessibility is a major concern.

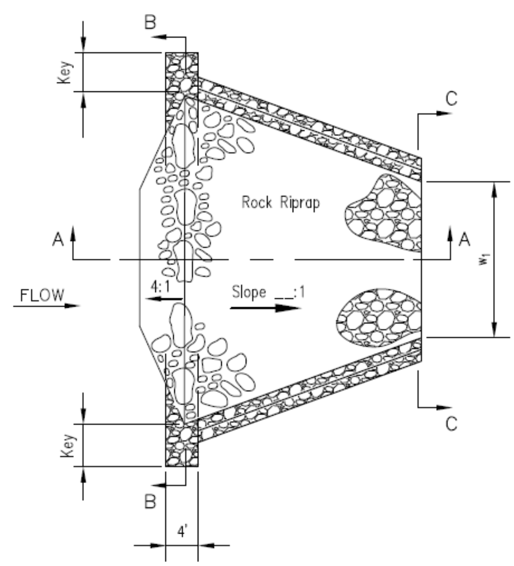
If implemented, expected load reductions for all stone-toe protection and riffles are:

- 631 lbs/yr of nitrogen
- 171 lbs/yr of phosphorus
- 159 tons/yr of sediment

NRCS Stone-Toe Detail



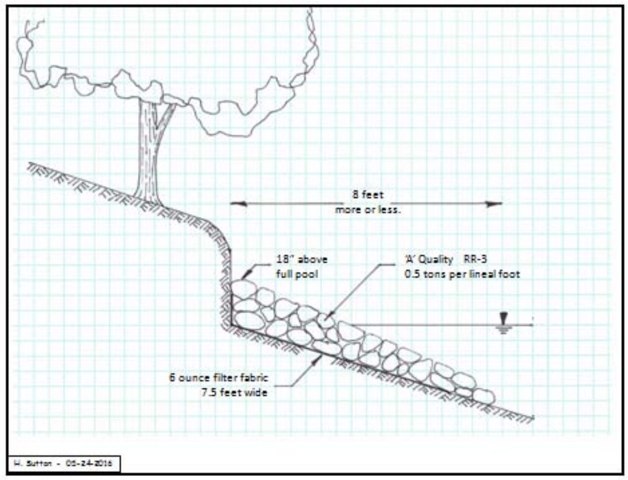
Stone-Toe Protection



Rock Riffle

NORTHWATER CONSULTING

Shoreline Stabilization



Stabilizing sections of shoreline to reduce in-lake sediment delivery should be targeted to those areas with the highest rates of erosion. This can be accomplished by installing rip-rap or another form of armoring at the base of each bank. Typically, shoreline stabilization consists of placing rock on or directly adjacent to the eroding lake bank to dissipate wave energy and eliminate erosion. For shallower areas with more gradual slopes, rock can be placed away from the bank creating breakwater. Where water depths are greater and the littoral zone slope is too great, rock is placed on the bank and above the lakes' full pool elevation. Shoreline stabilization is recommended for 23,792 ft within Otter Lake (See Figure 36). The OLWC has the ability to perform shoreline stabilization on their own through the use of a mechanical barge and may be one of the only similar entities in the state that can do so. Stabilizing all recommended shoreline areas will result in annual load reductions of:

- 1,391 lbs/yr of nitrogen
- 2,211 lbs/yr of phosphorus
- 3,429 tons/yr of sediment

Detention Basin/Pond

A detention basin or pond is a sediment or water impoundment made by constructing an earthen dam. In the Otter Lake watershed, 17 ponds are recommended to treat 782 acres. These structures will trap sediments and nutrients from runoff and will control gully erosion in steep forested draws.

If all ponds are installed in the watershed, expected load reductions are:

- 2,669 lbs/yr of nitrogen
- 361 lbs/yr of phosphorus
- 598 tons/yr of sediment

Pond; Otter Lake, IL

In-Lake/Low Flow Dam

An in-lake or low flow dam is an embankment or sheet-pile wall installed within the lake or within major lake tributaries to trap sediment and nutrients while still maintaining flow to the lake. These structures are installed only a few feet above normal pool elevation and at locations where a large storage area is available. Four structures are recommended, three at tributary inflows immediately adjacent to the lake and one approximately 2,000 ft downstream of the existing in-lake dam at the North end of the lake. The total estimated length of these dams is 1,398 feet. Dredging or maintenance of the existing northern in-lake dam is also recommended to maximize sediment and nutrient trapping efficiency. As described in Section 8.2.3, it is estimated that maintenance of the existing structure is likely to achieve an additional 10% reduction in nutrient loads and an additional 20% reduction in sediment loading. This will be achieved by removing approximately 44,548 cubic yards over 13.6 acres.

Lake and watershed sediment is predominately fine-grained silt and clay faction with little coarse-grained sediment. As a result, sediment trapping with a low-flow dam will require significant storage capacity to achieve desired trapping efficiency. Sediment trapping is dependent on the ratio of inflow to storage capacity; a minimum trap efficiency of 30% is desired. According to Brune's Curve, a ratio of 0.012 is needed to achieve a 30% trapping efficiency for fine-grained sediments. Excavation of a small area up to 6 ft is recommended immediately behind each dam to enhance trapping efficiency. Each basin should also be periodically cleaned out to maintain storage capacity and trapping efficiency over time; maintenance cleaning is recommended every 10-15 years.

In order to proceed with construction of sediment dams, an engineering study is necessary to gather more accurate estimates of storage volume, areas of inundation, and to develop plans and cost estimates for permitting and construction. Also to be considered and further analyzed are factors related to disposal and dewatering of dredged or excavated material. Upstream effects would also need to be more closely analyzed.

If all four structures are installed to treat 9,229 acres, expected annual load reductions are:

- 27,079 lbs/yr of nitrogen
- 3,073 lbs/yr of phosphorus
- 3,004 tons/yr of sediment.

Maintenance of the existing structure will treat 6,944 acres and will result in the following expected annual load reductions:

- 6,360 lbs/yr of nitrogen
- 664 lbs/yr of phosphorus
- 1,098 tons/yr of sediment.

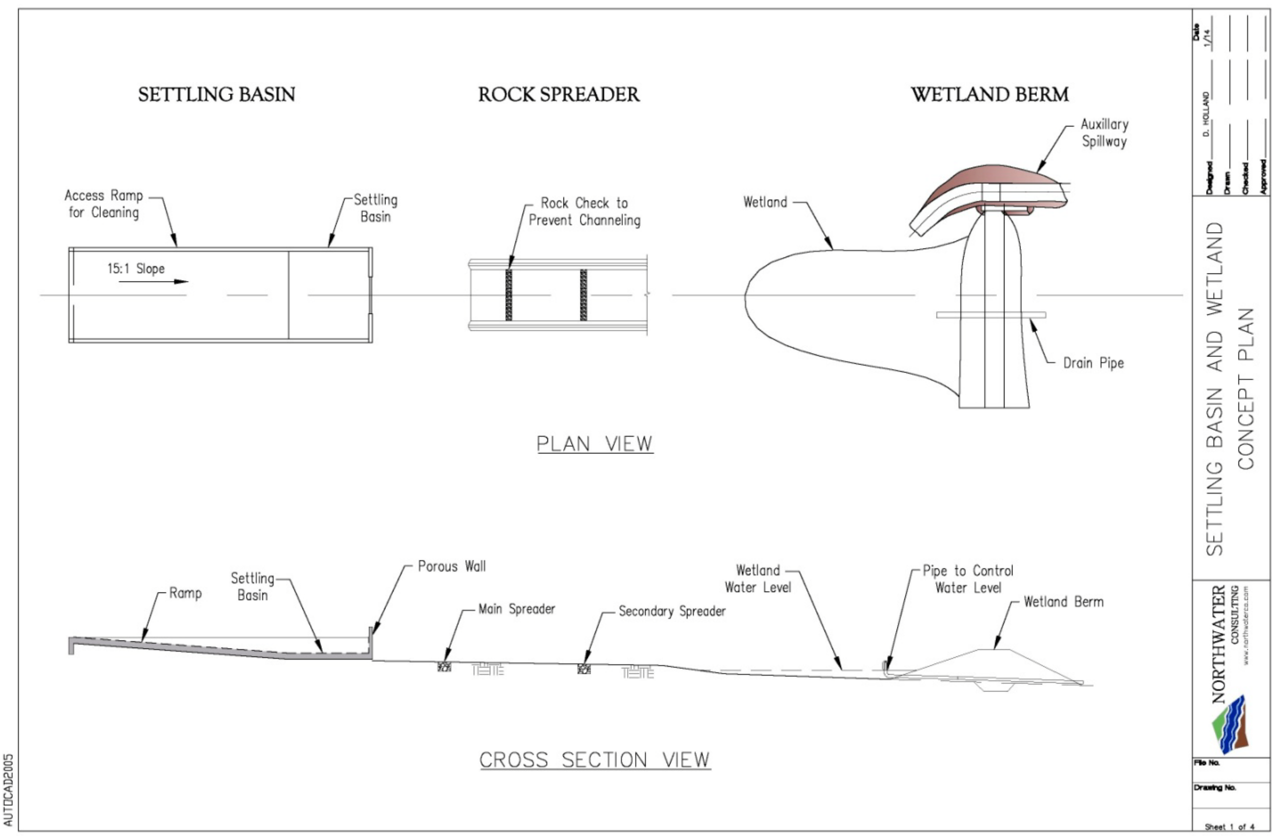
It is important to note that removal of the sediment in the existing in-lake basin will also remove existing sediment laden phosphorus susceptible to re-suspension and transport to the main body of the lake.

Livestock Feed Area Waste System

Once a site has been identified in the watershed, an integrated system can be constructed to manage livestock waste. The feed area system includes three individual practices working in series; a settling basin to capture solids, a rock spreader and vegetated swale for initial waste treatment and, finally, a treatment wetland to capture and treat the remaining waste. A conceptual design is presented below.

Only four systems are recommended to treat 1.03 acres in the watershed. If these systems are implemented, the following load reductions are expected:

- 9.5 lbs/yr nitrogen
- 1.9 lbs/yr phosphorus
- 0.1 tons/yr sediment



Pasture Management & Fencing

Pasture management consists of stream fencing to exclude livestock from the stream, stream crossings and an alternate water supply (if needed). Stream fencing is placed back from the stream edge to allow for a vegetated buffer to filter runoff.

Stream fencing

Stream fencing is recommended for two pastures in the watershed; 2,695 ft of fence, 3 crossings, one water system, and some minor riparian area restoration.

If these systems are implemented to treat 11.3 acres, the following load reductions are expected:

- 99 lbs/yr of nitrogen
- 10 lbs/yr of phosphorus
- 2.2 tons/yr of sediment

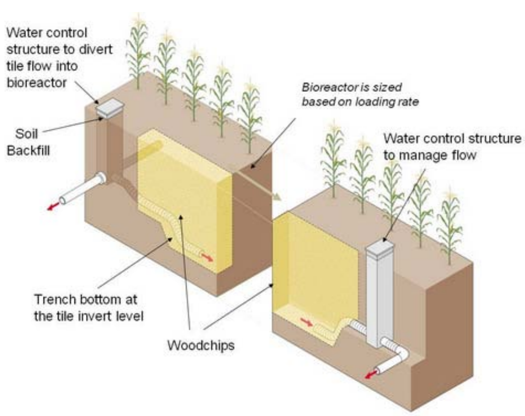
Saturated Buffers

A saturated buffer is one of the new emerging BMPs in which drainage water is diverted as shallow groundwater flow through a riparian buffer primarily for nitrate removal. A saturated buffer system can treat approximately 40 acres and consists of a control structure for diversion of drainage water from the outlet to a lateral distribution line that runs parallel to the buffer. Only areas draining directly adjacent to a stream or existing grass buffer were chosen for the placement of saturated buffers.

A total of 13 systems (10 sites) are recommended for the Otter lake watershed; this represents a treatment area of 628 acres. Load reductions expected, if all sites are implemented total:

- 1,653 lbs/yr nitrogen from tile runoff

Denitrifying Bioreactor



A denitrifying bioreactor is a structure containing a carbon source, installed to reduce the concentration of nitrate nitrogen in subsurface agricultural drainage flow via enhanced denitrification. One bioreactor system will treat approximately 50 acres. Bioreactor locations were identified by direct observation during a watershed windshield survey and by an interpretation of aerial imagery.

Eighty-two bioreactors at 76 locations can likely be applied in the Otter Lake watershed; these bioreactors will treat 4,097 acres.

Load reductions expected, if all bioreactors are implemented total:

- 6,622 lbs/yr nitrogen from tile runoff

6.1.2 In-Lake Dam Maintenance

A complete report is included in Appendix B. An in-lake basin was constructed by installing a rock and articulated concrete block weir structure at the North end of Otter Lake in 2002 to manage sediment and nutrient contributions originating from the watershed. This basin was evaluated in June of 2017 to determine the extent of sediment accumulation and to evaluate its current storage capacity relative to its original dimensions. A total of 41 measurements were taken along 7 established cross-sections, as well as midpoint locations between each cross section. Three sediment cores were also obtained to determine sediment composition and chemistry; results are presented in Table 45.

The survey results indicate that substantial sediment accumulation has occurred within the basin, reducing its current trapping efficiency and capacity. An estimated 41.3% of the basin's storage capacity has been lost due to sediment deposition and measurements obtained downstream of the structure indicate that a significant percentage of the sediment deposited within the basin has occurred since the structure was installed in 2002. The shallow water depths, combined with soft, flocculent sediment, likely increase the frequency of sediment and nutrient remobilization to the main body of the lake, especially during high flow events. This primarily fine grained and phosphorus-rich sediment then becomes a source of nutrients within the lake. Current characteristics of the basin include:

1. Average measured water depth of 2.8 ft with a maximum recorded depth of 3.8 ft and a minimum depth of 1.6 ft.
2. Sediment thickness to original hard bottom ranges from 4.3 ft near the dam to 0.6 ft near the shore in the upstream reaches of the basin. Average sediment thickness is 2.1 ft.

Laboratory analysis indicates that both nitrogen and phosphorus are in the mean range for normal Illinois lake sediment; percent solids averages roughly 46.2% and bulk density is similar at approximately 50 lbs/cf, or 1,350 lbs per cy, which equals 0.675 tons per cubic yard removed and measured in-situ.

Table 45 - In-Lake Dam Sediment Core Sample Analyses

Station	Total Nitrogen (mg/Kg dry)	Total Phosphorus (mg/Kg dry)	Organic Matter (%)	Percent Solids
1	2,610	725	8.03	39.0
2	1,400	570	5.95	59.3
3	2,120	621	7.95	40.4
Average	**2,043**	**639**	**7.31**	**46.2**

Management Options & Recommendations: A total of 44,548 cubic yards of sediment was measured within the surveyed area of the basin using the Average End Area Method. Maintenance dredging of the soft, accumulated sediment is recommended within this survey boundary, which covers an area of 13.7 acres (See Figure 38). Hydraulic dredging using a small, portable cutterhead dredge and pumping the sediment via pipeline to the designated sediment storage and dewatering area located on Otter Lake Water Commission property is recommended (Figure 38). Construction of an earthen dewatering basin is recommended. Pumping distance to the designated sediment storage site from the proposed dredging area ranges from 1,100 to 2,300 ft to an elevation 35 to 40 ft higher than the lake. Therefore, an 8-inch or 10-inch diameter dredge and pipeline is recommended. If a smaller, 6-inch dredge is desired, a booster pump should be considered.

According to the survey data collected, the existing storage capacity of the surveyed basin area is 63,442 cubic yards or 39.3 acre-feet. After the 44,548 cubic yards of soft accumulated sediment are removed by hydraulic dredging, the storage capacity would be increased to an estimated 107,991 cubic yards, or 66.9 acre-feet. By increasing storage capacity and removing soft, flocculent sediment from shallow water areas, the sediment and nutrient trapping efficiency would increase and provide improved water quality protection for the main body of Otter Lake. It is estimated that maintenance of the existing structure will result in the following annual load reductions:

- 6,300 lbs/yr of nitrogen
- 664 lbs/yr of phosphorus
- 1,098 tons/yr of sediment

Cost estimates are provided in Table 46. Considering the cost of dredging and dewatering, mobilization and materials, and permitting and oversight, it is estimated that the removal of 44,548 cubic yards will cost approximately **$723,672.00**.

Table 46 - In-Lake Dam Maintenance Cost Estimates

Item	Unit Cost	Total Cost
Dredging & Dewatering	$14/CY	$623,672
Mobilization & Piping	$50,000 (LS)	$50,000
Permitting & Construction Phase Assistance	$50,000 (LS)	$50,000
Total		**$723,672**

A similar sediment survey and dredging study is recommended for the in-lake dam or impoundment at the Proctor Road crossing, immediately north of the water plant on an Unnamed Tributary. Over the years, sediment and nutrients have likely built up behind this crossing and, although only 530 acres drains to this location, additional sediment storage capacity could be obtained through a selective dredging program, similar to that recommended for the in-lake dam at the north end of the lake.

Existing In-Lake Dam – North End of Lake

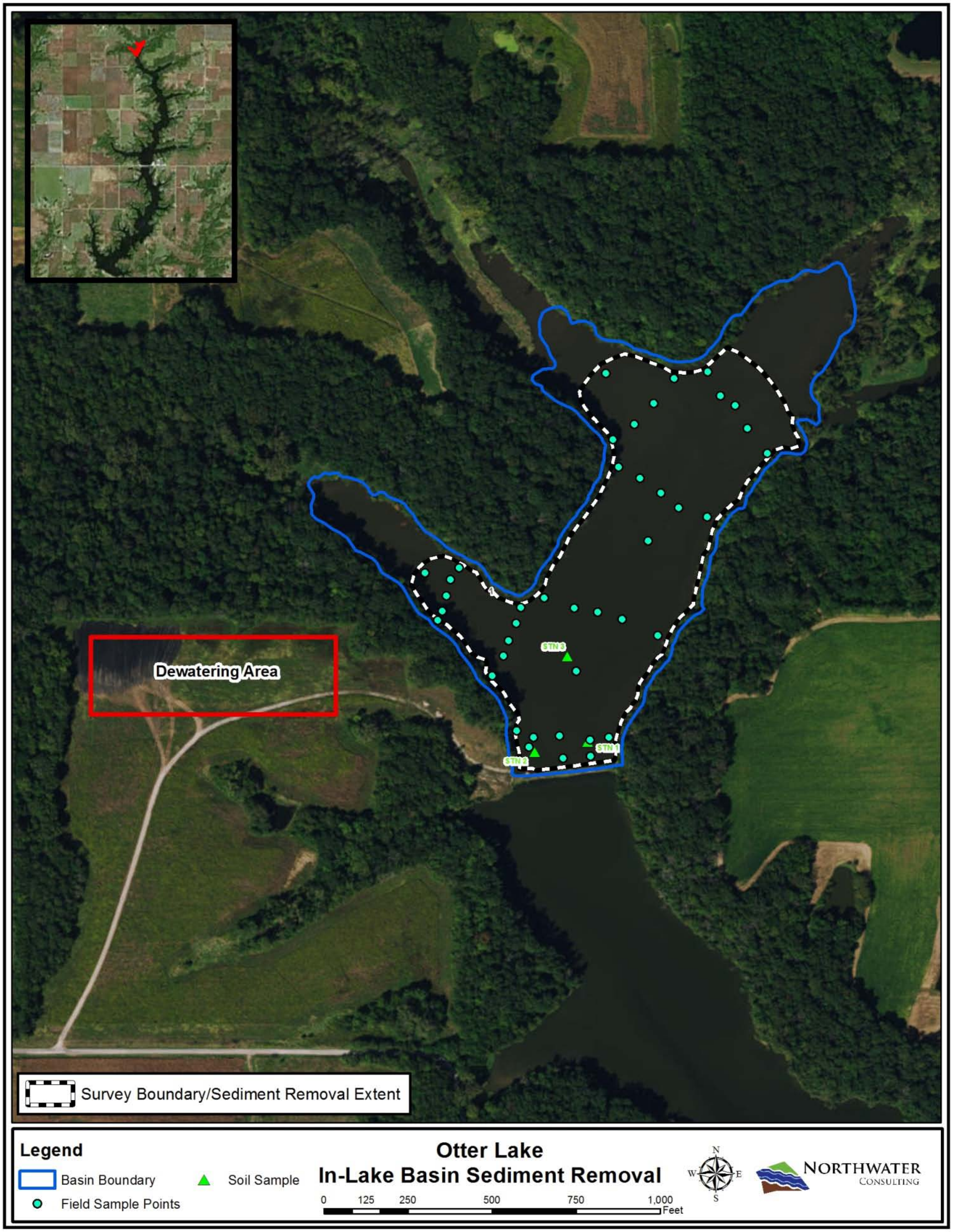


Figure 38 - In-Lake Basin Maintenance Removal Extent

6.1.3 Supplemental Nonpoint Source Management Measures

Three additional management measures are proposed and should be considered to help achieve water quality targets. These measures focus on in-lake management, specifically, aeration and alum treatment, nutrient management, and septic systems. In Otter Lake, dredging is not an effective means of addressing the internal release of nutrients from lake sediment.

In-Lake Management – Maintenance Dredging, Aeration, & Alum Treatment

A combination of phosphorus precipitation and inactivation with alum (aluminum sulfate) and various forms of aeration and/or artificial circulation are needed to mitigate nitrogen and phosphorus-rich sediment from the lake bottom. Given the progress being made to reduce watershed loads, it is likely that, at some point, these techniques will become the most effective technique at reducing overall nutrient concentrations. An immediate priority is the dredging/maintenance of the existing in-lake dam. It is estimated that 6,554 lbs/yr of phosphorus and 47,166 lbs/yr of nitrogen is originating from lake sediment (32% and 31% of total).

In-lake management measures will help to substantially reduce internal nutrient loading. Approximately 290 acres in Otter Lake were determined to be anoxic during the summer stratification period of approximately 150 days. The water plant Intake basin area has a maximum depth of 27 ft and has approximately 80 acres that remain anoxic throughout the summer; the deeper basin to the south, extending to the dam, has about 210 anoxic acres. Total loading from sediment nutrient release is expected to be occurring from these areas and, therefore, treatments are recommended for 290 acres. Treatment of all 290 acres may not be feasible or realistic, however, estimated reductions and costs are based on the entire area. If all 290 acres are addressed, expected load reductions are:

- 42,449 lbs/yr of nitrogen
- 5,899 lbs/yr of phosphorus

Phosphorus Precipitation & Inactivation with Aluminum Sulfate: A method of physically precipitating and subsequently removing phosphorus from the water column is phosphorus precipitation with aluminum sulfate or commonly referred to as alum. Aluminum sulfate retains its ability to absorb and/or flocculate phosphorus in a wide variety of environmental conditions and can initiate “clear” water within a relatively short amount of time. The precipitated phosphorus-laden particles settle on the bottom of the lake and, depending on the dosage applied, can form a bottom layer of aluminum hydroxide thick enough to function as a barrier that can prevent or minimize phosphorus release into the overlying water column during anoxic conditions. Properly applied alum treatments can result in relatively long-term reductions of phosphorus in lakes where inflowing sources of phosphorus have been sufficiently controlled and re-suspension of bottom sediments is minimal. The cost of alum treatments noted in the 2005 TMDL range $1,000 to $1,300 per acre in recent years for similar sized projects, plus any design and monitoring costs that will be incurred. It should be noted that alum treatments do not control nitrogen release from anoxic bottom sediments.

Since the total surface area of anoxic bottom water in Otter Lake is approximately 290 acres, the cost for a whole lake alum treatment (290 acres) could be $377,000 plus design and monitoring costs. Since there is a relatively moderate drainage area from the surrounding watershed, and significant efforts to reduce external sediment and nutrient loads have been or are in the process of being implemented, it appears alum may be an effective long-term alternative for controlling nutrient concentrations within the lake system. It is likely that follow-up applications would be required every 5-10 years depending on the frequency and magnitude of future storm events. If only the 80-acre anoxic basin north of the water plant bridge were treated, the estimated cost could be $104,000 plus design and monitoring costs.

Aeration: Artificial aeration or circulation of lakes during the summer thermal stratification period is a practice commonly used to improve water quality conditions and limit nutrient release from bottom sediments. The two primary methods of aeration/circulation include artificial circulation and hypolimnetic aeration. Any system that is designed to completely mix or circulate the entire lake or provide aeration without maintaining the normal thermal structure is classified as an artificial circulation technique. Systems within this category include compressed air and/or mechanical devices capable of lifting anoxic hypolimnetic water and circulating oxic surface waters in order to evenly distribute oxygenated water throughout the lake. A compressed air system is typically used to initiate rising air bubbles sufficient to reach the surface and fan out horizontally. The cold, dense water eventually sinks to a level of equal density and eventually establishes a whole lake mixing if the system is sufficiently sized and designed. Hypolimnetic aeration is a method of providing dissolved oxygen to the bottom waters of a lake without disrupting the normal pattern of thermal stratification, thereby maintaining the cooler temperatures that are desirable for cool and coldwater fisheries.

Otter Lake is currently using 4 Solar Bee in- lake mixing devices within the water plant intake basin to limit blue-green algae growth. These solar powered systems circulate warmer water from the epilimnion and do not disrupt the thermocline. Therefore, the hypolimnion becomes anoxic during the summertime. Any aeration option to be used within this portion of the lake would be designed to supplement the Solar Bees and work in conjunction with them.

According to Lorenzen and Fast, and many other aeration system experts, the general design requirement for sizing an aeration system is based on an optimum rate of compressed air delivery of 1.3 cubic feet per minute (CFM) per lake surface acre. This optimum formula has been observed to be effective at lower delivery rates, but the typical minimum rate is believed to be as low as 0.65 CFM per surface acre. This rationale can vary of course depending on the morphometry of the lake and the type of system being employed. Based on Lorenzen and Fast's findings and recommendations, a suitable system for Otter Lake is capable of providing in the range of 98 to 195 CFM with an estimated power rating of 40 to 80 horsepower. Since hypolimnetic aerators concentrate on the waters below the thermocline, a much smaller surface area is impacted and a lower CFM/horsepower rating is required.

A compressed air destratification system suitably sized for both anoxic basins would be installed with two rotary screw compressors in the 40 to 50 horsepower range. A desirable system would include a weighted air hose and high-efficiency diffusers with a well-ventilated and a sound-proofed air compressor house located appropriately. The installed cost of a suitably sized Aspir-Air Venturi-type system with two aerator units in each lake is estimated to be approximately $250,000 to $300,000, plus annual operation and maintenance costs. The primary advantage of the Aspir-Air system is the greatly reduced space requirement on land for an appropriate power base and a reduced noise level. However, the primary disadvantage is the requirement of surface buoys to fasten the necessary air hoses. Both systems essentially are destratification systems, with compressed air being the less expensive of the two alternatives.

When considering a hypolimnetic aeration system, a choice can be made to focus on aerating a particular layer below the thermocline or the entire hypolimnion could be aerated. There are two alternatives that would be suitable for Otter Lake. A true hypolimnetic aeration system would be capable of maintaining the normal thermally stratified regime with an oxygenated epilimnion, a thermocline, and an oxygenated hypolimnion. The cold water of the deepest areas of the hypolimnion would be drawn into the aerator assembly, aerated, released at a depth slightly below the thermocline and allowed to plunge due to the negative buoyancy factor. The oxygen transfer would occur by this colder, denser, aerated water moving down through the water column.

The Layer-Air type system would also maintain the oxic epilimnion, but would essentially target a vertical layer within the water column to establish a second oxic layer with a thermocline above and below the second layer. This can be selectively accomplished by drawing water from several depths and temperatures in order to then disperse neutrally buoyant water laterally into the targeted layer. This type of system, which is designed and supplied by Ecosystem Consulting Service, Inc. of Coventry, Conn., can effectively provide an efficiently aerated layer that supplements the compressed air delivery with oxic water for the lower limits of the photic zone without disrupting the thermocline. This capability adds to the efficiency of the system and lowers the operational cost required for the air compressors. A target layer could range from 14-30 ft with a lower concentration of dissolved oxygen maintained within the deepest waters of the hypolimnion sufficient to limit phosphorus release from the bottom sediments.

Septic Systems

The Macoupin County Health Department only conducts inspections immediately following the installation of a new system or when a complaint is filed. No formal inspection and maintenance program exists within the county, however, the Health Department will periodically host workshops for septic system contractors. The primary recommendation to address septic systems includes a watershed-wide inspection and maintenance program directed to all homes not currently connected to a WWTP. Educating homeowners may also be effective at addressing issues relating to septic systems. The development of a brochure or existing literature regarding septic maintenance should be distributed to stakeholders throughout the watershed.

As noted in Section 3.12.1, there are an estimated 22 failing septic systems within the watershed. It can be assumed that an inspection and maintenance program targeted at homes on septic will capture all or most of the failing septic systems within the watershed.

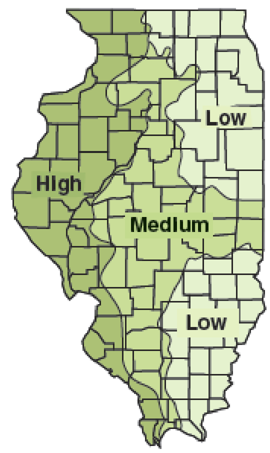
It can also be assumed that addressing failing septic systems will result in 100% reduction in phosphorus and nitrogen and no reductions in sediment. If all potentially failing septic systems are addressed, it is estimated that annual load reductions total 268 lbs/yr for phosphorus and 686 lbs/yr for nitrogen.

Nutrient Management

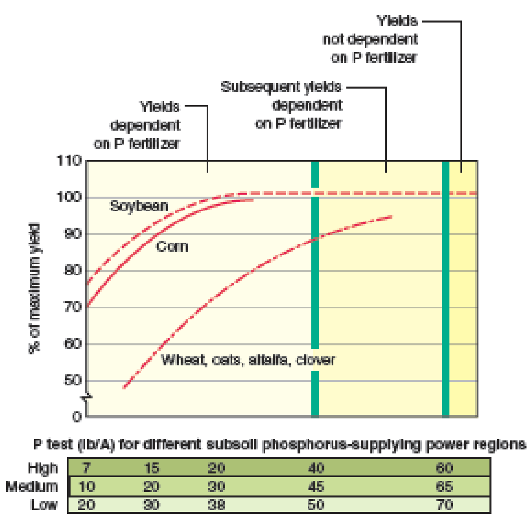
Nutrient management is the practice of using nutrients essential for plant growth, such as nitrogen and phosphorus fertilizers, in proper quantities and at appropriate times for optimal economic and environmental benefits. Nutrient management is a non-structural practice that can be applied to all fields in the watershed, primarily to address nitrogen; it is well-suited to the flat topography and productive nature of soils in the watershed although, if a field is being farmed, nutrient management should be practiced regardless of these factors. The nutrient management system now being promoted by the Illinois Council on Best Management Practices (IL CBMP) utilizes the approach commonly called the "4Rs":

- Right Source: Matches fertilizer type to crop needs.
- Right Rate: Matches amount of fertilizer to crop needs.
- Right Time: Makes nutrients available when crops need them.
- Right Place: Keeps nutrients where crops can use them.

Promoting smart soil testing is also important as the spatial variability of available nutrients in a field makes soil sampling the most common and greatest source of error in a soil test (University of Illinois, 2012). Proper soil testing is the foundation of good nutrient management as it relates to nitrogen and phosphorus.



As described in the Chapter 8 of the Illinois Agronomy Handbook, regional differences in P-supplying power shown in the adjacent figure were broadly defined primarily by parent material and degree of weathering factors. Within a region, variability in parent material, degree of weathering, native vegetation, and natural drainage cause differences in the soil's P-supplying power. For example, soils developed under forest cover appear to have more available subsoil P than those developed under grass.



Minimum soil test levels required to produce optimal crop yields vary depending on the crop to be grown and the soil's P-supplying power (See adjacent Figure). Near maximal yields of corn and soybeans are obtained when levels of available P are maintained at 30, 40, and 45 pounds per acre for soils in the high, medium, and low P-supplying regions, respectively. Since these are minimal values, to ensure soil P availability will not restrict crop yield, it is recommended that soil test results be built up to 40, 45, and 50 pounds per acre for soils in the high, medium, and low P-supplying regions, respectively. This is a practical approach because P is not easily lost from the soil, other than through crop removal or soil erosion.

Several methods described in Chapter 8 of the Illinois Agronomy Handbook can be used to manage crop nutrient loss: variable rate technology (VRT) and deep fertilizer placement. VRT can improve the efficacy of fertilization and promote more environmentally sound placement of fertilizer compared to single-rate applications derived from the conventional practice of collecting a composite soil sample to represent a large area of the field. Research has shown that this technology often reduces the amount of fertilizer applied over an entire field. However, one of the drawbacks of this placement method is the expense associated with these technologies. Also, VRT can only be as accurate as the soil test information used to guide the application rate (University of Illinois, 2012).

Deep fertilizer placement is where any combination of nitrogen, phosphorus, and potassium can be injected at a depth of 4 to 8 inches. Subsurface applications may be beneficial (as long as the subsurface band application does not create a channel for water and soil movement) when the potential for surface water runoff is high (University of Illinois, 2012).

Implementing a nutrient management plan can reduce phosphorus losses by up to 7% and 15% for nitrogen. If nutrient management was applied to all 8,948 acres of crop fields within the watershed, expected annual load reductions would total 13,335 lbs for nitrogen and 651 lbs for phosphorus.

7.0 Cost Estimates

BMP costs were calculated based on professional judgment and expertise, rates provided by the NRCS, and unit costs used in other similar watershed plans. Many of the estimates are based on previous work in the watershed and known quantities for a particular practice. Cost estimates should be considered as estimates only and revisited during implementation as required.

7.1 Cost Estimates

General cost estimates and assumptions include:

1. Estimates for filter strips, field borders, and grass conversion include land prep and seeding at $700/ac.
2. No-Till and strip-till assume $40/ac for 1 year.
3. Cover crops assume $40/ac for 1 year.
4. Streambank stabilization assumes $85/ft.
5. Shoreline stabilization assumes $85/ft.
6. Riffles, cattle crossings, and grade control structures range from $3,000 – $8,000 plus engineering.
7. Grass waterways assume $4,000 per acre plus tile and engineering.
8. WASCBs/terraces are estimated at $3.00/ft of embankment construction plus tile and engineering.
9. Wetlands are based on professional judgment and previous wetland work in the watershed; they include a water control structure and engineering. Wetlands are estimated at $16,000 each. At one site, only a water control structure is needed.
10. Ponds are based on professional judgment and include engineering. Costs for ponds can range from $25,000 - $60,000 depending on the size of the berm and primary spillway pipe, the extent of clearing needed, and size of rock at outfall structures.

11. Low-flow/low-head dams are based on estimates provided in Section 8.2.3 for maintenance of the existing structure plus construction costs of $1,000 per foot for new embankments, including a 25% contingency for engineering and permitting and $750,000 for excavating a larger sediment deposition area behind each dam.
12. Livestock Management: stream fencing assumes $3.50/ft plus some riparian area restoration cost and engineering. Crossings are estimated at $5,000 each and wells at $15,000 each, including the watering system.
13. Saturated Buffers are estimated to cost approximately $4,000 per installation; including plastic drain tile, control structure, and design. This cost is based on McLean County, Illinois area contractor prices and cost reported by the Agricultural Drainage Management Coalition. The analysis assumes such a saturated buffer would treat an area of 40 acres.
14. A Livestock waste area system is based on professional judgment at a cost of $40,000/facility.
15. Bioreactors cost an estimated $50.00 per cubic yard to install, including labor and materials. This figure, which is somewhat higher than the $43.96/cubic yard NRCS cost estimate, is based on input from a local drainage contractor in McLean County. Based on a surface area of 20' x 50' and a 4' depth, the cost is estimated to be about $7,500 for a system sized to treat 50 acres.
16. Nutrient Management Plan cost is estimated to be $16.00 an acre, based on the Sangamon County SWCD rates.
17. Costs for alum treatment were generated from the 2005 TMDL; $1,300/ac was used. Aeration (2 units) was estimated at $300,000 plus a 25% contingency.

Table 47 provides a detailed breakdown of cost estimates for all BMPs, as well as cost per unit of loading reduced. The total cost of implementing all BMPs is estimated to be **$8,251,328.20**. Average cost per pound of nitrogen removed is $71.01; average cost per pound of phosphorus removed is $448.72 and the average cost for a ton of sediment removed is $541.71. Overall, cover crops, filter strips, no-till/strip-till, nutrient management, and field borders appear to be the most cost-effective practices. No-till and strip-till are both cost effective and will result in large, overall load reductions, if adopted throughout the watershed. In-Lake/low-flow dams and in-lake nutrient management are costly projects, however, these practices treat very large areas and will result in large overall load reductions; despite the cost, these measures should be considered as effective lake management tools to meet short- to medium-term objectives.

Table 47 - Otter Lake Watershed BMP Cost Summary

TYPE	Quantity	Total Cost	Cost/lb Nitrogen Reduction	Cost/lb Phosphorus Reduction	Cost/ton Sediment Reduction
Cover Crop	658 (ac)	$26,320	**$16.09**	$140.00	$127.15
No-Till/Strip-Till	8,263 (ac)	$330,520	$39.66	**$76.35**	**$62.81**
Saturated Buffer	13 (#)	$52,000	$31.46	N/A	N/A
Denitrifying Bioreactor	82 (#)	$615,000	$92.87	N/A	N/A
Filter Strip	24.2 (ac)	$16,940	**$20.14**	**$51.18**	**$53.10**
Field Border	73.6 (ac)	$51,520	$30.65	**$77.82**	**$67.00**
Grade Control	10 (#)	$50,000	$168.35	$1,111.11	$537.63

TYPE	Quantity	Total Cost	Cost/lb Nitrogen Reduction	Cost/lb Phosphorus Reduction	Cost/ton Sediment Reduction
Livestock Waste System	4 (#)	$140,000	$14,736.84	$73,684.21	$1,400,000.00
Pasture Management / Fencing	2,695 (ft) / 3 crossings / 1 Well	$39,432.50	$396.68	$3,800.82	$17,919.74
Grassed Waterway	12.51 (ac)	$84,253.20	$33.73	$354.01	$218.84
New In-Lake / Low-flow Dam	4 (#) / 1,398 (ft)	$2,497,500	$92.23	$812.72	$831.39
Existing In-Lake / Low-flow Dam	13.6 (ac)	$723,672	$113.78	$1,089.87	$659.08
WASCB/Terrace	5,540 (ft)	$35,932.50	$69.10	$323.72	$227.42
Constructed Wetland	22.8 (ac)	$210,500	$47.71	$743.82	$315.59
Pond	17 (#)	$680,000	$254.78	$1,883.66	$1,137.12
Nutrient Management (Plans)	8,948 (ac)	$143,168	**$10.74**	$219.92	N/A
Streambank Stabilization / Riffle	1,550 (ft) / 16 riffles	$227,750	$360.94	$1,331.87	$1,432.39
Lake Shoreline Stabilization	23,792 (ft)	$2,022,320	$1,453.86	$914.66	$589.77
Septic Systems[1]	22 (#)	$50,000	$72.89	$186.57	N/A
In-Lake Management / Aeration/ Alum Treatment	290 (ac)	$752,000	$17.72	$127.48	N/A
Total		**$8,748,828.20**	**$71.01**	**$448.72**	**$541.71**

1 – Cost estimate for implementation of inspection and outreach program only

In addition to the costs presented in this section for BMP implementation, there will be costs associated with education and outreach. It is estimated that costs for education and outreach (Section 12) could range from $10,000 - $20,000 per year, which includes staff time to contact and educate landowners, organize workshops, and develop grant applications, for example.

Monitoring costs associated with recommendations in Section 13 could range from $5,000 - $10,000 per year depending on the frequency of sampling with another $50,000 to develop an online management, tracking, and collaboration tool as described in Section 12.

8.0 Water Quality Targets

This section will describe water quality targets and those implementation actions required to meet targets. Water quality targets are generated using TMDL reductions and the Illinois Nutrient Loss Reduction Strategy. Phosphorus targets are based on TMDL estimates, whereas the nitrogen reduction target is based on the Illinois Nutrient Loss Reduction Strategy target of 45%. Given that much of the phosphorus is likely a function of eroded sediment, a sediment reduction percentage representing the phosphorus target is recommended.

In order to meet standards for Otter Lake, a 66% reduction in phosphorus is required. Additionally, a 45% reduction in nitrogen and a 66% reduction in sediment are recommended. Table 48 compares water quality targets to expected BMP load reductions. Results indicate that widespread and overlapping BMP implementation, combined with in-lake management measures, will result in the attainment of the water quality standard for phosphorus, exceeding the target by up to 30%. It should be noted that reductions do not account for the cumulative effect of upstream practice and, therefore, the total reductions achieved will likely be somewhat lower if all recommended practices are considered as a "system;" it is estimated that this situation could reduce reduction estimates by up to 30%. Despite this, it is still reasonable to assume that targets can be met. Furthermore, as described in Section 6.1, widespread efforts to curb sediment and nutrient loading since completion of the TMDL may have resulted in a lower percent reduction needed to meet the phosphorus standard; the large percentage of phosphorus released from lake sediment (32% of the total load) is still a concern and is likely still a major limiting factor. Lake water quality results show only negligible lake-wide reductions in average phosphorus concentrations since 2010, reinforcing this conclusion.

Addressing the internal load through aeration and alum treatments should ensure an attainment of the standard, especially considering the uncertainty related to private landowner participation in the widespread adoption of BMPs. Eliminating a large percentage of the internal load (5,899 lbs/yr), alongside all other BMPs, could result in a 66-96% reduction in total annual phosphorus loads. Reducing the scope of the in-lake management measures to half of the recommended acres should be more than sufficient to meet the 66% reduction target, if combined with other BMPs.

By factoring in conservative pollutant removal efficiencies associated with recommended BMPs, it is reasonable to conclude that widespread implementation will meet and exceed the current reduction targets for nitrogen and sediment. Nitrogen can be reduced by 61-81% and sediment loading by 87-100%. Furthermore, installing upstream practices will not only reduce total watershed loadings but will have the added and cumulative benefit of extending the lifespan and pollutant removal efficiency of downstream BMPs, such as the recommended low-flow or in-lake dams.

The conversion of conventional and reduced tillage systems to no-till or strip-till will result in large overall percentage reductions to nutrients and sediment. It is believed that the largest benefit to water quality will be realized with a large-scale shift away from conventional tillage, especially on HEL ground. Although costly, installing a series of in-lake or low-flow dams will treat the majority of the watershed and achieve large overall reductions in phosphorus and sediment. Lake shoreline stabilization and other in-lake management measures will eliminate a large percentage of the lakes' internal nutrient and sediment load. Grassed waterways, ponds, WASCBs, filter strips, and field borders combined can reduce phosphorus loads by 8.5% and sediment loads by 16%; these structural practices will address major sources of watershed nutrients and sediment and should be considered a priority if grant funds are available. Maintenance of the existing in-lake dam will also result in relatively large reductions and should receive attention in the short term.

Table 48 – Otter Lake BMP Load Reductions & Water Quality Targets

TYPE	Quantity	N Reduction (% of total load)	P Reduction (% of total load)	Sediment Reduction (% of total load)
Cover Crop	658 (ac)	1.1%	0.9%	1.5%
No-Till/Strip-Till	8,263 (ac)	5.5%	21%	38%
Saturated Buffer	13 (#)	1.1%	0%	0%
Denitrifying Bioreactor	82 (#)	4.4%	0%	0%
Filter Strip	24.2 (ac)	0.55%	1.6%	2.3%
Field Border	73.6 (ac)	1.1%	3.3%	5.6%
Grade Control	10 (#)	0.20%	0.22%	0.67%
Livestock Waste System	4 (#)	0.01%	0.01%	0.001%
Pasture Management / Fencing	2,695 (ft) / 3 crossings / 1 Well	0.07%	0.05%	0.02%
Grassed Waterway	12.51 (ac)	1.7%	1.2%	2.8%
New In-Lake / Low-flow Dam	4 (#) / 1,398 (ft)	18%	15%	22%
Existing In-Lake / Low-flow Dam	13.6 (ac)	4.2%	3.3%	8.0%
WASCB/Terrace	5,540 (ft)	0.34%	0.55%	1.1%
Constructed Wetland	22.8 (ac)	2.9%	1.4%	4.8%
Pond	17 (#)	1.8%	1.8%	4.3%
Nutrient Management	8,948 (ac)	8.8%	3.2%	0%
Streambank Stabilization / Riffle	1,550 (ft) / 16 riffles	0.42%	0.84%	1.2%
Lake Shoreline Stabilization	23,792 (ft)	0.92%	11%	25%
Septic Systems	22 (#)	0.45%	1.3%	0%
In-Lake Management / Aeration/ Alum Treatment	290 (ac)	28%	29%	0%
Total[1]		**51-81%**	**66-96%**	**70-100%[2]**

[1] – A range is provided to account for the cumulative effects of BMPs implemented as a "system."
[2] - Summed total sediment reductions are 117% of the total load when considered individually

9.0 Critical Areas & Priority Projects

Critical areas are those BMP locations throughout the watershed where implementation activities should be focused. These areas provide the greatest "bang-for-the-buck" and benefit to lake water quality. Fields with conventional and reduced tillage delivering greater than 1 lbs/ac of phosphorus were selected as critical or priority no-till/strip-till areas; these locations also produce some of the highest nitrogen and sediment loads from crop ground. Total load reduction, ability to implement, and ownership boundaries were used to prioritize critical areas for all other BMPs.

9.1 No-Till/Strip-Till

Fields with conventional and reduced tillage are responsible for the majority of the nutrient and sediment load from crop ground. Per-acre loading rates are significantly higher on HEL ground that is in a conventional or reduced tillage system. Critical locations were selected based on per-acre phosphorus loads greater than 1 pound per acre and under a conventional or reduced tillage system. Two thousand six hundred and fifty-two (2,652) acres meet this criterion and represent the potential for annual reductions of 4,203 lbs of nitrogen, 2,329 lbs of phosphorus, and 3,537 tons of sediment. Of the 2,652 recommended acres, 259 acres, or 10% of the area, is considered HEL.

Table 49 summarizes expected reductions from priority sites and compares results to the total expected load reductions for all recommended no-till/strip-till. Results indicate that addressing 32% (2,652 acres) of the total BMP area will accomplish 50% of the total expected no-till/strip-till nitrogen reduction, 54% of the phosphorus reduction and 67% of the sediment reduction. The estimated annual cost to address 2,652 acres is $106,080.00. Figure 39 depicts the location of these priority areas.

Table 49 - Load Reduction Summary; Priority No-Till/Strip-Till

Acres	% of BMP Area	N reduction (lbs/yr)	% of Total Load Reduction	P Reduction (lbs/yr)	% of Total Load Reduction	Sediment Reduction (tons/yr)	% of Total Load Reduction
2,652	32%	4,203	50%	2,329	54%	3,537	67%

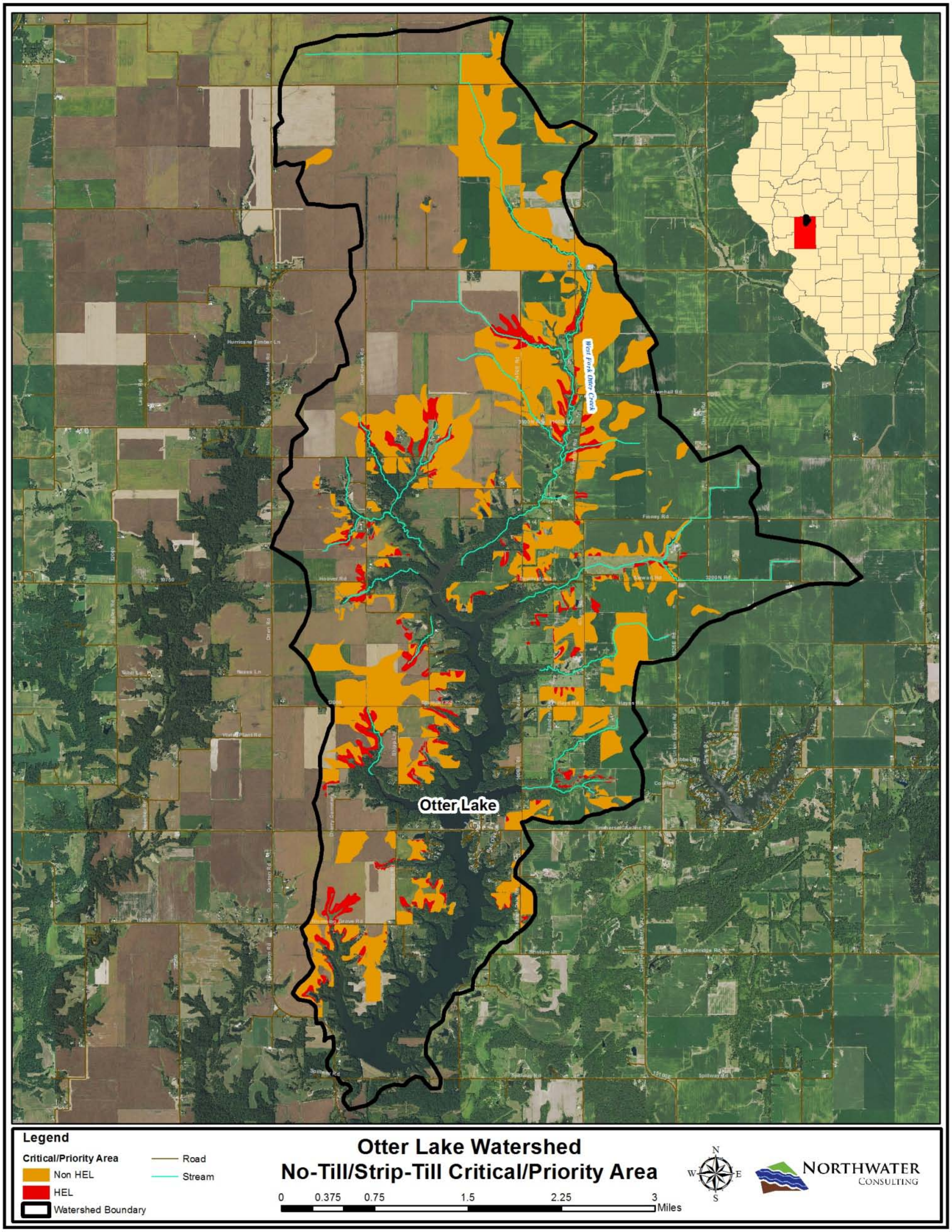


Figure 39 - Otter Lake Watershed Priority Areas - No-Till/Strip-Till

9.2 Watershed BMPs

Priority locations presented in this section are either owned by the OLWC or represent those BMPs, on private ground where cost-share dollars are likely eligible and where expected load reductions are the greatest. Practices that generate the following annual load reductions were selected:

- Greater than 50 lbs/yr phosphorus.
- Greater than 300 lbs/yr nitrogen.
- Greater than 50 tons/yr of sediment.

These BMPs exclude no-till/strip-till recommendations presented in the previous section.

It is more likely than not that the projects summarized below will have the greatest chance of being implemented and, therefore, should receive consideration. Further prioritization should be based on cost and expected load reductions. Appendix C contains a table that includes load reductions, cost estimates, quantities by BMP type and number and can be used to select those individual practices that will achieve the greatest total load reductions or lowest cost per pound/ton of pollutant reduced.

OLWC practices include:

- 3 wetlands totaling 2.2 acres.
- 4 in-lake/low flow dams and maintenance dredging of the existing dam.
- 290 acres of in-lake management (alum and aeration).
- 6 ponds.
- 3 stream riffles.

Private BMP practices include:

- 16.2 acres of field borders.
- 3.6 acres filter strips with 3 saturated buffer systems.
- 3 ponds.
- 7 riffles / 500 feet of streambank stabilization.
- 5 WASCBs.
- 10 acres grassed waterways.
- 6 wetlands totaling 11 acres.
- 23 bioreactors.

Table 50 summarizes nitrogen, phosphorus and sediment reductions for all priority BMPs. Results indicate that the majority of expected load reductions for all BMPs can be achieved at locations where annual load reductions are the greatest or where the OLWC has jurisdiction (Figure 40).

The OLWC and private landowners have the potential to make substantial reductions in nutrient and sediment loading to the lake, however, cost must be considered. Working with willing private landowners in the watershed will result in high overall load reductions at a much lower cost, given that other funding sources are available for private ground. The high cost associated with practices on OLWC-owned property is a result of shoreline stabilization, the construction of all in-lake/low flow dams, maintenance of the existing dam (dredging behind dam), and other in-lake measures. Despite the high cost, the OLWC should move forward with maintenance of the existing in-lake dam, consider exploring the installation of at least one new in-lake/low flow dams, at least two ponds, and all high-priority shoreline stabilization concurrent with efforts on private ground (Figure 40). Following this, in-lake measures, such as aeration and alum treatments, should be seriously considered.

Table 50 - Load Reduction & Cost Summary; Priority Watershed BMPs

Responsible Entity	Total Cost	N Reduction (lbs/yr)	% Total Load Reduction	P Reduction (lbs/yr)	% Total Load Reduction	Sediment Reduction (tons/yr)	% Total Load Reduction
Otter Lake Water Commission	$4,441,172	77,266	63%	11,940	61%	7,724	46%
Private Landowner	$588,150	10,848	9%	1,120	6%	1,685	10%
Total	**$5,029,322**	**88,114**	**72%**	**13,060**	**67%**	**9,409**	**56%**

Existing field runoff control

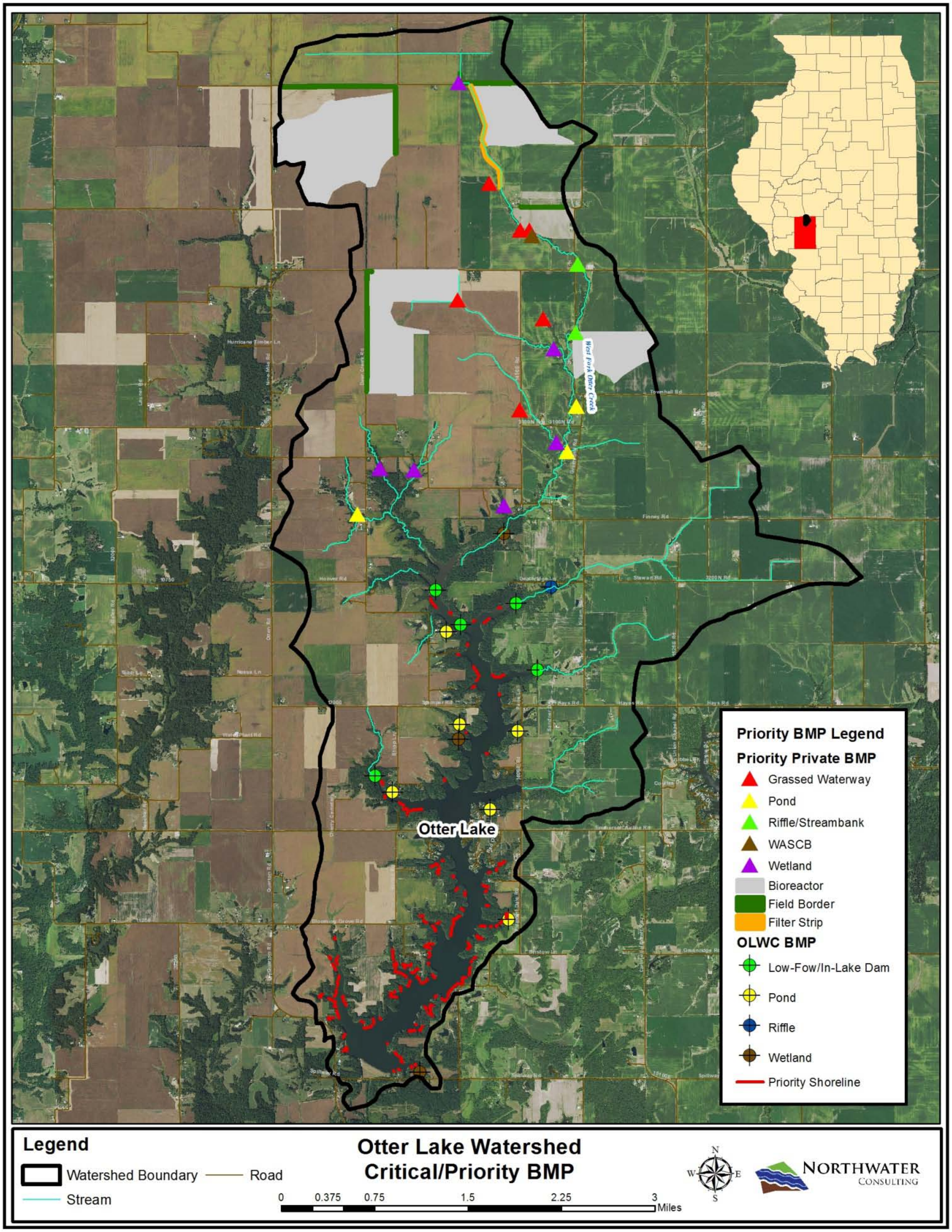


Figure 40 – Otter Lake Watershed Priority BMPs

10.0 Technical & Financial Assistance

Seven entities are listed below, each potentially responsible for project implementation and some, a likely source of funding. For those that can provide funding specific to the Otter Lake watershed, descriptions of the programs or financial assistance mechanisms are provided. Entities that may not have a direct avenue to a funding apparatus are listed under the Technical Assistance section.

With implementation, primary responsibility lies with the owner of the land first; any agency or entity also providing a role in implementation will need to work with willing landowners but do not have the primary decision-making authority. All implementation is completely voluntary.

Otter Lake Water Commission (OLWC) The OLWC is the owner of Otter Lake and has ownership and stewardship responsibility for the lake, as well as surrounding forested areas. A map of BMPs on OLWC-owned property is presented in the previous section.

> **Financial Assistance:** The OLWC has resources it can allocate to be used as match for 319 funds, EQIP cost-share or as contributions to watershed or in-lake conservation practices. The OLWC can also provide direct funding for projects or capital improvements on land it owns and manages, such as Otter Lake and its adjacent forested ground.

Farmer/Landowner In the Otter Lake watershed, there are varying business arrangements on who farms the land and makes important conservation decisions. If the farmer is the landowner, then the farmer–landowner is considered the primary responsible party. If the person/entity who owns the land is an absentee owner, then it could be either the farmer-tenant or the absentee landowner is the responsible party. In some cases, the conservation practices decisions are made together in a collaborative fashion by the tenant and landowner. Frequently, the lease terms will determine who makes conservation decisions on the agricultural parcel.

> **Financial Assistance:** Private funds can come from foundations, individual farmers, and landowners and can be used as cash match for Section 319 funds or as private contributions to Otter Lake conservation activity.

Natural Resources Conservation Service (NRCS) The United States Department of Agriculture has local offices in most Illinois counties which include the NRCS. The Macoupin County NRCS office services the Otter Lake watershed. The NRCS provides both conservation technical assistance and financial assistance to farmers and landowners. One of the programs frequently used for financial assistance is the Environmental Quality Incentive Program (EQIP). Most applicable to the Otter Lake watershed, the EQIP program provides cost sharing for implementation of approved conservation program practices. The farmer/landowner applies to the NRCS for conservation program funds and they are assisted by NRCS staff to complete the application process, certify the practices and make payments. It is important to note that NRCS funds cannot be used on OLWC-owned property.

Three additional programs administered by the NRCS are also relevant to the watershed and are discussed below; the Conservation Stewardship Program (CSP); the Regional Conservation Partnership Program (RCPP) and the Agricultural Conservation Easement Program (ACEP).

Financial Assistance:

NRCS EQIP: EQIP is a cost-share program for farmers and landowners to share the expenses of implementation and maintenance of approved soil and water conservation practices on farmland for qualified entities and is a dedicated source of funding available in the watershed through the Macoupin County NRCS office.

http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/

NRCS/USDA RCPP: The Regional Conservation Partnership Program (RCPP) promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners. NRCS provides assistance to producers through partnership agreements and through program contracts or easement agreements. RCPP combines the authorities of four former conservation programs – the Agricultural Water Enhancement Program, the Chesapeake Bay Watershed Program, the Cooperative Conservation Partnership Initiative and the Great Lakes Basin Program. Assistance is delivered in accordance with the rules of other NRCS programs. RCPP encourages partners to join in efforts with producers to increase restoration and sustainable use of soil, water, wildlife and related natural resources on regional or watershed scales. Through RCPP, NRCS and its partners help producers install and maintain conservation activities in selected project areas. A RCPP project application was submitted for the Otter Lake watershed in 2017 and awarded in 2018.

http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/farmbill/rcpp/

NRCS CSP: Through CSP, the NRCS provides conservation program payments. CSP participants will receive an annual land use payment for operation-level environmental benefits they produce. Under CSP, participants are paid for conservation performance: the higher the operational performance, the higher their payment.

http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/

NRCS ACEP: The ACEP provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits. Under the Agricultural Land Easements component, NRCS helps American Indian tribes, state and local governments and non-governmental organizations protect working agricultural lands and limit non-agricultural uses of the land. Under the Wetlands Reserve Easements component, NRCS helps to restore, protect and enhance enrolled wetlands.

http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/acep/

Farm Service Agency (FSA) Included in the USDA local offices are officials of the FSA who also provide some conservation-oriented programs; specifically, they provide the administrative structure for the federal Conservation Reserve Program (CRP) and also support the state Conservation Reserve and Enhancement Program.

Financial Assistance:

USDA/FSA CRP: CRP is a land conservation program administered by the FSA. In exchange for a yearly rental payment, farmers enrolled in the program agree to remove environmentally sensitive land from agricultural production and plant species that will improve environmental health and quality. Contracts for land enrolled in CRP are 10-15 years in length. The long-term goal of the program is to re-establish valuable land cover to help improve water quality, prevent soil erosion, and reduce loss of wildlife habitat. Land in the watershed is already enrolled in CRP and additional, eligible land is available for enrollment.

https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/index

USDA FSA CREP: CREP is an offshoot of the CRP. Administered on the federal level by the FSA, CREP targets high-priority conservation issues identified by local, state, or tribal governments or non-governmental organizations. In exchange for removing environmentally sensitive land from production and introducing conservation practices, farmers and agricultural land owners are paid an annual rental rate. Participation is voluntary, and the contract period is typically 10–15 years, along with other federal and state incentives as applicable per each CREP agreement. In Illinois, the CREP administrative agency is the Illinois Department of Natural Resources. IDNR provides additional and generous financial incentives on top of a FSA CREP contract, including payments for additional 15-35 year contract extensions; IDNR also offers a permanent easement option. Farmers and landowners locally apply for support through the county SWCD for CREP consideration and funding.

https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-enhancement/index

US Fish and Wildlife Service (USFWS) The USFWS provides technical assistance to local watershed protection groups. It also administers several grant and cost-share programs that fund habitat restoration. The USFWS also administers the federal Endangered Species Act and supports a program called Endangered Species Program Partners, which features formal or informal partnerships for protecting endangered and threatened species and helping them to recover. These partnerships include federal partners, as well as states, tribes, local governments, nonprofit organizations, and individual landowners.

Financial Assistance: The **USFWS Partners program** restores, improves, and protects fish and wildlife habitat on private lands through alliances between the USFWS, other organizations and individuals, while leaving the land in private ownership. Opportunities may exist within the watershed to utilize financial assistance from the partners program for wetland or prairie restoration projects.

https://www.fws.gov/partners/

Illinois Environmental Protection Agency (IEPA) In Illinois, the IEPA Bureau of Water's Watershed Management Section provides program direction and financial assistance for water quality protection through the Clean Water Act Section 319 program. The OLWC has already been successful in raising millions of dollars through the Section 319 program and will continue to do so moving forward.

Financial Assistance: Administered by the IEPA, the **Section 319 program** provides funds for addressing NPS pollution. The purpose of Illinois EPA's 319 program is to work cooperatively with units of local government and other organizations toward the mutual goal of protecting the water quality in Illinois through the control of NPS pollution. The program includes providing funding to these groups to implement projects that utilize cost-effective BMPs on a watershed scale.

Projects may include structural BMPs, such as detention basins and filter strips, non-structural BMPs such as construction erosion control ordinances and setback zones to protect community water supply wells. Technical assistance and information/education programs are also eligible. Section 319 funds are reimbursable and require a match of either cash or in-kind services, or a combination of both cash and in-kind contributions, and will be a major source of funding for implementation activities in the Otter Lake watershed. Applications for Section 319 funding are due August 1st of each year.

http://www.epa.illinois.gov/topics/water-quality/watershed-management/nonpoint-sources/section-319/index.

Trees Forever They work with communities to empower people through hands-on planting projects. Trees Forever is a nonprofit charitable organization, headquartered in Marion, Iowa, and founded in 1989. They help communities with local tree-planting projects by providing technical, planning, and financial assistance. They also assist local committees to engage others in the projects they work on.

Financial Assistance: Trees Forever manages the Illinois Buffer Partnership Program. The Illinois Buffer Partnership promotes and showcases the voluntary conservation efforts of Illinois farmers and landowners. Each year, 10-20 Illinois Buffer Partnership participants are selected to receive financial and technical assistance. Types of conservation projects eligible for the Illinois Buffer Partnership Program include: riparian buffers, livestock buffers, streambank stabilization projects, wetland development, pollinator habitat, rain gardens and agroforestry projects. Cost-share funds are available in an amount up to $2,000 for 50 percent of the expenses that remain after Conservation Reserve Program (CRP) or other federal, state or local funding has been applied to their project.

http://www.treesforever.org/

10.1 Technical Assistance

Illinois Department of Agriculture (IDOA) The IDOA's Bureau of Land and Water Resources distributes funds to Illinois' 98 soil and water conservation districts for programs aimed at reducing soil loss and protecting water quality. It also helps to organize the state's soil survey every two years to track progress toward the goal of reducing soil loss on Illinois cropland to tolerable levels. If funding becomes available, the Bureau may be able to provide technical and financial support for streambank stabilization.

Soil Water Conservation District (SWCD) In many Illinois counties, it is the local county SWCD that takes a lead role in providing information, guidance and funding arrangements for local conservation practices on farmland in the county.

Illinois Department of Natural Resources (IDNR) IDNR provides technical assessments of streams for the IDOA's streambank stabilization program. The request for local assessment assistance comes through the local SWCD. The IDNR also manages other state programs related to wildlife and forestry, and oversees the state portion of the Conservation Reserve and Enhancement Program.

Illinois Stewardship Alliance The ISA is a membership-based organization whose mission it is promotes environmentally sustainable, economically viable, socially just local food systems through policy development, advocacy, and education. Most relevant to the Otter Lake watershed is ISA's work to promote cover crops and educate producers on their benefits. ISA is already active in the watershed and was responsible for organizing a local cover crop and soil health workshop. ISA staff can assist with landowner outreach and education programs related to conservation.

Illinois Council on Best Management Practices The C-BMP is a coalition of agricultural organizations and agribusinesses, including Illinois Farm Bureau, Illinois Corn Growers Association, Illinois Soybean Association, Illinois Pork Producers Association, Illinois Fertilizer and Chemical Association, Syngenta, GROWMARK, and Monsanto. C-BMP was founded in 1999 and works to assist and encourage adoption of BMPs to protect and enhance natural resources and the sustainability of agriculture in Illinois. C-BMP can assist with producer outreach and education, as well as research.

American Farmland Trust The mission of the AFT is to protect farmland, promote sound farming practices, and keep farmers on the land. AFT advocates for programs and policies that protect farmland, food and the environment; they conduct education and outreach and promote conservation. AFT can assist with producer outreach and education and can help to foster local partnerships.

Illinois Department of Public Health (IDPH) Malfunctioning or improperly constructed and maintained private sewage disposal systems can pose serious health hazards. The Illinois Department of Public Health (IDPH) regulates the installation of all private sewage disposal systems that have no surface discharge (such as septic tanks and seepage fields), as well as those that discharge treated effluent up to 1,500 gallons per day to the ground surface (such as sand filters and aerobic treatment systems). Staff also review and approve plans for private sewage disposal systems and alternative private sewage disposal systems before construction. IDPH can help provide information on existing septic systems and assist with education and outreach.

In addition to the programs of conservation technical assistance provided by the SWCD, NRCS, EPA, IDOA, FSA, USFWS and IDNR, there are conservation technical assistance resources provided through the University of Illinois Cooperative Extension Service (Coop Ext.) and by private professional consultants. Many producers rely upon private consultants: certified crop advisors (CCA) or Technical Service Providers (TSP) for technical expertise. Technical assistance relevant to Otter Lake can also come from non-profit organizations, such as the Illinois Stewardship Alliance (ISA), the Illinois Council on Best Management Practices (C-BMP) and the American Farmland Trust (AFT).

11.0 Implementation Milestones, Objectives & Schedule

Implementation milestones and goals are intended to be measured by NRCS EQIP and CRP contracts, RCPP program funding, 319 funded cost-share measures, OLWC, and NRCS/SWCD-initiated projects. The goals are meant to be both measurable and realistic. Specific milestones and a schedule/timeframe are presented in Table 51. Direct outreach and communication one-on-one with landowners is vital to the success of future implementation activities and will be a component of every effort to secure the adoption of the BMPs listed below. This communication and outreach will also help to ensure practices are maintained over time.

An aggressive 10-year implementation schedule is presented in Table 51. Some practices described in years 1 and 2 are accompanied by a commitment from the OLWC contingent on funding. Furthermore, a RCPP project application has been approved and will result in the establishment of a formal water quality monitoring program and targeted education and outreach, followed by the installation of numerous practices on private ground. The implementation milestones or objectives presented in this section are intended to be achievable and realistic over a 10-year period.

Grade/Control/Riffle

Milestones noted after 10 years are considered long-term and will require significant capital expenditures. Long-term milestones focus more on in-lake management measures and the wide-spread adoption of strip-till/no-till. These practices will help to ensure water quality targets are met and maintained.

Table 51 - Implementation Milestones & Timeframe

Timeframe	Milestone
Years 1-2	1. Conduct existing in-lake dam maintenance dredging. 2. Engage watershed producers through the Otter Lake RCPP. 3. Stabilize 5,400 feet of lake shoreline at critical locations. 4. Install 5 WASCBs on private ground. 5. Plant 200 acres of cover crops. 6. Convert conventional tillage to strip-till or no-till on 500 acres. 7. Complete nutrient management (plans) on 500 acres. 8. Install 4 ponds; 2 on OLWC property. 9. Install 10 acres of grassed waterways. 10. Install 16.2 acres of field borders. 11. Install 3.6 acres of filter strips with 3 saturated buffer systems. 12. Install 4 bioreactors. 13. Install 1 pasture management system. 14. Install 1 wetland on private property and 1 wetland on OLWC property. 15. Install 2 grade control structures 16. Develop an online watershed management, tracking, and collaboration tool
Years 3-5	1. Continue one-one-one communication with willing producers. 2. Stabilize 5,000 feet of lake shoreline at critical locations. 3. Install 31 WASCBs. 4. Plant 300 acres of cover crops. 5. Convert conventional tillage to strip-till or no-till on 1,000 acres. 6. Complete nutrient management (plans) on 1,000 acres. 7. Install 4 ponds; 2 on OLWC property 8. Install 1 pasture management system. 9. Install 2.5 acres of grassed waterways. 10. Install 2 wetlands on private property and 2 wetlands on OLWC property. 11. Install 10 rock riffles and 500 feet of stone-toe protection. 12. Install 10 acres of field borders. 13. Install 5 acres of filter strips with 5 saturated buffer systems. 14. Install 5 bioreactors. 15. Install 5 grade control structures. 16. Install 1 in-lake/low flow dam on OLWC property. 17. Implement septic system maintenance and inspection program
Years 6 -10	1. Continue one-one-one communication with willing producers. 2. Stabilize 5,000 feet of shoreline protection at critical locations. 3. Plant 158 acres of cover crops. 4. Convert conventional tillage to strip-till or no-till on 1,000 acres. 5. Complete nutrient management (plans) on 1,000 acres. 6. Install 6 ponds; 2 on OLWC property. 7. Install 4 wetlands on private property. 8. Install 16 rock riffles and 1,050 feet of stone-toe protection. 9. Install 23 acres of field borders. 10. Install 10 acres of filter strips with 10 saturated buffer systems. 11. Install 10 bioreactors. 12. Install 3 grade control structures. 13. Install 1 in-lake/low flow dam on OLWC property. 14. Initiate planning for future dredging.
10 + Years	1. Continue one-one-one communication with willing producers. 2. Stabilize 5,000 feet of lake shoreline at critical locations. 3. Convert conventional tillage to strip-till or no-till on 3,000 acres. 4. Complete nutrient management (plans) on 3,000 acres.

Timeframe	Milestone
	5. Install 3 ponds; 1 on OLWC property. 6. Install 4 wetlands on private property. 7. Install 23 acres of field borders. 8. Install 5 acres of filter strips with 5 saturated buffer systems. 9. Install 10 bioreactors. 10. Install 1 livestock waste system. 11. Install 2 in-lake/low flow dams on OLWC property. 12. Treat 145 acres with alum and aeration.

Table 52 summarizes BMP milestones or objectives, those responsible entities and the primary technical/financial assistance available. The implementation milestones or objectives presented below will meet water quality targets and are divided between those that are realistic within a 10-year period and those that should be pursued as long-term management measures. Given the high cost and limited resources available, it is anticipated that more than 10 years will be required to fully meet water quality targets and maintain water quality over time.

Table 52 - Summary Table; Implementation Objectives, Responsible Parties & Technical Assistance

BMP/Objective	Responsible Party	Primary Technical Assistance/Funding Mechanism
Watershed BMPs/Education & Outreach/Monitoring (1-10 years)		
BMP: Cover Crops **Objective:** Install 658 acres	Landowner/SWCD/NRCS	**Technical Assistance**: SWCD/NRCS/AFT/ISA **Funding Mechanism**: 319 Grant/Private Funds/OLWC/NRCS & USDA Programs (RCPP)
BMP: No-Till/Strip Till **Objective**: Convert 2,500 acres	Landowner/SWCD/NRCS	**Technical Assistance:** SWCD/NRCS/C-BMP/ISA **Funding Mechanism**: 319 Grant/Private Funds/ OLWC/NRCS & USDA Programs (RCPP)
BMP: Ponds **Objective:** Install 14 ponds	Landowners/OLWC	**Technical Assistance:** NRCS/SWCD/Consultants **Funding Mechanism:** 319 Grant/Private Funds
BMP: Wetland Creation **Objective:** Install 10 wetlands	Landowner/SWCD/NRCS/OLWC	**Technical Assistance**: SWCD/NRCS/Consultants/ USFWS **Funding Mechanism**: 319/Private Funds/ OLWC/NRCS & USDA Programs (RCPP)
BMP: Shoreline Stabilization **Objective:** Stabilize 15,400 feet of shoreline	OLWC	**Technical Assistance:** Consultant **Funding Mechanism:** 319 Grant/OLWC Funds
BMP: Grassed waterway **Objective:** Install 12.5 acres	Landowner/SWCD/NRCS	**Technical Assistance:** SWCD /NRCS /FSA / Consultants **Funding Mechanism**: 319/Private Funds/ OLWC/NRCS & USDA Programs (RCPP)
BMP: Filter strips **Objective:** Install 18.6 acres	Landowner/SWCD/NRCS	**Technical Assistance:** SWCD /NRCS /FSA/ Consultants **Funding Mechanism**: 319/Private Funds/ OLWC/NRCS & USDA Programs (RCPP)/Trees Forever
BMP: Saturated Buffer **Objective:** Install 18 systems	Landowner/SWCD/NRCS	**Technical Assistance:** SWCD /NRCS /Consultants

BMP/Objective	Responsible Party	Primary Technical Assistance/Funding Mechanism
		Funding Mechanism: 319/Private Funds/ OLWC/NRCS & USDA Programs (RCPP)
BMP: Field Borders **Objective:** Install 49 acres	Landowner/SWCD/NRCS	**Technical Assistance:** SWCD /NRCS /FSA /Consultants **Funding Mechanism**: 319/Private Funds/ OLWC/NRCS & USDA Programs (RCPP)
BMP: Bioreactor **Objective:** Install 19 bioreactors	Landowner/NRCS	**Technical Assistance:** NRCS /Consultants **Funding Mechanism**: NRCS & USDA Programs (RCPP)/319 Grant/Private Funds/OLWC
BMP: Streambank Stabilization/Riffle **Objective:** Install 1,550 ft stone-toe protection and 26 riffles	Landowners SWCD/NRCS/IDOA/OLWC	**Technical Assistance:** SWCD/NRCS/Consultants **Funding Mechanism:** 319 Grant/Private Funds/OLWC
BMP: Grade Control **Objective:** Install 10 structures	Landowners/NRCS	**Technical Assistance:** NRCS/Consultants **Funding Mechanism:** 319 Grant/NRCS & USDA Programs (RCPP)/Private Funds/OLWC
BMP: WASCB **Objective:** Install 36 WASCBs	Landowner/SWCD/NRCS	**Technical Assistance**: SWCD/NRCS/Consultant **Funding Mechanism:** NRCS Programs (RCPP)/Private Funds/OLWC
BMP: Pasture Management **Objective:** Install 2,695 feet, 3 crossings, and 1 well	Landowners/NRCS	**Technical Assistance:** NRCS/Consultants **Funding Mechanism:** NRCS EQIP and RCPP/319 Grant/Trees Forever/OLWC
BMP: Nutrient Management (plans) **Objective:** On 2,500 acres	Landowner/SWCD/NRCS	**Technical Assistance:** SWCD/NRCS/C-BMP/ISA **Funding Mechanism**: 319 Grant/Private Funds/ OLWC/NRCS & USDA Programs (RCPP)
BMP: Septic System Maintenance **Objective:** Initiate Septic System Inspection & Maintenance Program	Landowner/ IDPH	**Technical Assistance**: IDPH **Funding Mechanism**: 319 Grant/Private Funds/ OLWC
BMP: In-Lake/Low Flow Dam **Objective:** Install 3, maintenance of existing basin	OWLC	**Technical Assistance**: Consultant **Funding Mechanism**: 319 Grant/OLWC Funds
BMP: Education and Outreach **Objective:** Stakeholder engagement	AFT/ISA/SWCD/NRCS/Coop Ext.	**Technical Assistance:** SWCD/NRCS/ISA/AFT/C -BMP/Coop Ext. **Funding Mechanism:** 319 Grant/OLWC/ NRCS RCPP funds
BMP: Monitoring/Tracking **Objective:** Establish formal water quality monitoring program to support the Otter Lake RCPP and develop an online management, tracking, and collaboration tool	OLWC/AFT	**Technical Assistance:** Consultant **Funding Mechanism:** 319 Grant/OLWC/ Private funds
Long-Term Management Measures (10+ years)		
BMP: Education and Outreach **Objective:** Stakeholder engagement	AFT/ISA/SWCD/NRCS/Coop Ext.	**Technical Assistance:** SWCD/NRCS/ISA/AFT/C-BMP /Coop Ext. **Funding Mechanism:** 319 Grant/OLWC
BMP: Shoreline Stabilization **Objective:** Stabilize 5,000 feet of shoreline	OLWC	**Technical Assistance:** Consultant **Funding Mechanism:** 319 Grant/OLWC

BMP/Objective	Responsible Party	Primary Technical Assistance/Funding Mechanism
BMP: No-Till/Strip Till **Objective:** Convert 3,000 acres	Landowner/SWCD/NRCS	**Technical Assistance:** SWCD/NRCS/C-BMP/ISA **Funding Mechanism**: 319 Grant/Private Funds/ NRCS & USDA Programs (RCPP)/OLWC
BMP: Nutrient Management (plans) **Objective:** On 3,000 acres	Landowner/SWCD/NRCS	**Technical Assistance:** SWCD/NRCS/C-BMP/ISA **Funding Mechanism**: 319 Grant/Private Funds/ OLWC/NRCS & USDA Programs
BMP: Ponds **Objective:** Install 3 ponds	Landowners/OLWC	**Technical Assistance:** NRCS/SWCD/Consultants **Funding Mechanism:** 319 Grant/Private Funds/OLWC
BMP: Wetland Creation **Objective:** Install 4 wetlands	Landowner/SWCD/NRCS/OLWC	**Technical Assistance**: SWCD/NRCS/Consultants/ USFWS **Funding Mechanism**: 319/Private Funds/ OLWC/NRCS & USDA Programs (RCPP)
BMP: Field Borders **Objective:** Install 23 acres	Landowner/SWCD/NRCS	**Technical Assistance:** SWCD /NRCS /FSA /Consultants **Funding Mechanism**: 319/Private Funds/ OLWC/NRCS & USDA Programs (RCPP)
BMP: Filter strips **Objective:** Install 5 acres	Landowner/SWCD/NRCS	**Technical Assistance:** SWCD /NRCS /FSA/ Consultants **Funding Mechanism**: 319/Private Funds/ OLWC/NRCS & USDA Programs (RCPP)/Trees Forever
BMP: Saturated Buffer **Objective:** Install 5 systems	Landowner/SWCD/NRCS	**Technical Assistance:** SWCD /NRCS /Consultants **Funding Mechanism**: 319/Private Funds/ OLWC/NRCS & USDA Programs (RCPP)
BMP: Bioreactor **Objective:** Install 10 bioreactors	Landowner/NRCS	**Technical Assistance:** NRCS /Consultants **Funding Mechanism**: NRCS & USDA Programs (RCPP)/319 Grant/Private Funds/OLWC
BMP: Livestock Waste System **Objective:** Install 1 system	Landowner/NRCS	**Technical Assistance**: NRCS/ Consultant **Funding Mechanism**: 319 Grant / NRCS EQIP/ Private Funds/OLWC
BMP: In-Lake/Low Flow Dam **Objective:** Install 2	OLWC	**Technical Assistance**: Consultant **Funding Mechanism**: 319 Grant/OLWC
BMP: Alum Treatment & Aeration **Objective:** 290 acres	OLWC	**Technical Assistance**: Consultant **Funding Mechanism**: OLWC

12.0 Information & Education

Northwater Consulting, in partnership with the OLWC, actively conducted education and outreach throughout the watershed. Outreach and education activities included:

1. A meeting with the OLWC board on September 12th to describe the watershed plan, results, and next steps. This meeting was attended by 9 individuals representing the OLWC. A watershed fact sheet and plan executive summary was distributed to attendees.
2. A RCPP application was prepared and submitted in September of 2017 and awarded in 2018. Coordination with local entities such as the SWCD, NRCS, and Farm Bureau was performed.
3. A total of six Individual, one-on-one landowner/producer meetings on-site to discuss resource concerns and to gauge willingness to implement specific BMPs.
4. Regular progress updates provided to the OLWC.
5. A half-day cover crop workshop on November 21st, 2017. Twenty-four people were in attendance. The workshop included a panel discussion with local producers using cover crops followed by presentations on soil heath and a discussion on the Otter Lake RCPP application and process.

November 21st Cover Crop Workshop

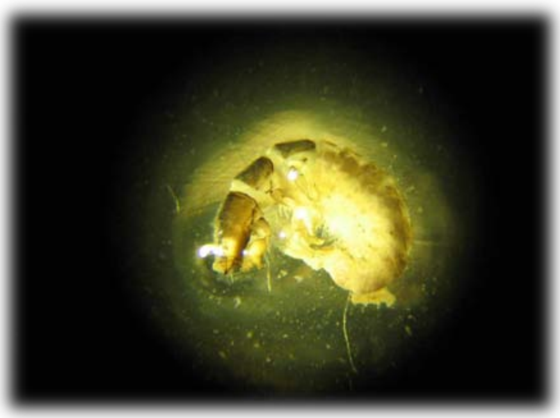
Moving forward into implementation, outreach with watershed landowners should continue. Relationships exist with those producers who participated in previous Section 319 projects and the recently awarded Otter Lake RCPP project; dialog and communication will continue as practices are designed and ultimately constructed. An online collaboration and project tacking and evaluation tool is being considered by the OLWC and RCPP partners. This online tool will allow watershed managers, stakeholders and partners to: navigate watershed data and characteristics within a secure system, view and share existing and proposed BMPs, view, query and calculate nutrient and sediment loading, calculate estimated load reductions from BMPs, generate custom reports, and track progress toward water quality and project specific goals.

The OLWC, NRCS, and SWCD will continue outreach efforts into the future to encourage the adoption of additional BMPs; work is currently underway to enroll producers in cover crops and strip-till and this effort will continue. Enrollment into existing programs, such as CRP and EQIP, will also continue, guided by the local NRCS and SWCD and supported by the OLWC. The OLWC will work to implement recommended supplemental management measures on its property as resources permit following completion of any near-term grants, such as a Section 319 grant for targeted BMP implementation.

13.0 Water Quality Monitoring Strategy

The purpose of the monitoring strategy for Otter Lake is to utilize existing monitoring data (existing IEPA stations) and continue to monitor the condition and health of the lake and watershed in a consistent and on-going manner. Given the recent large-scale efforts to address sediment and nutrient loading in the watershed, it is now critical that a more rigorous monitoring program be implemented to better understand the effects of these efforts and prioritize projects moving forward that will achieve the greatest "bank-for-the-buck" in terms of in-lake nutrient concentrations. In addition, the strategy seeks to add four watershed monitoring stations to isolate inflows from major lake tributaries where stream monitoring data is absent and to evaluate the long-term effectiveness of the in-lake dam; monitoring data is only available within the lake.

The strategy allows for evaluation of the overall health of the watershed and its changes through time. Another key purpose is to assess the effectiveness of plan implementation projects, and their cumulative watershed-scale contribution towards achieving the goals and objectives of the plan. While programmatic monitoring tracks progress through achievement of actions, this section outlines a strategy to directly monitor the effectiveness of the actions.



Hydrosychidae sp.

Monitoring environmental criteria, as outlined in this strategy, is an effective way to measure progress toward meeting water quality objectives. One potential problem with in-stream indicators is the issue of isolating dependent variables. There are likely many variables influencing the monitoring results, so making conclusions with regard to one specific constituent should be done with caution. It should be noted, however, that the indicators are excellent for assessing overall changes in a watershed's condition.

Four IEPA monitoring stations exist within Otter Lake (Table 53 and Figure 41). The OLWC has recently initiated additional lake and watershed monitoring at three locations; at the in-lake dam, one on an unnamed tributary at Killam Rd. immediately below an overflow weir structure, and one on the West Fork of Otter Creek at Finney Rd. One additional site on a major tributary (ST-6) noted in Figure 41 is proposed to evaluate watershed and stream conditions and establish a baseline. Continued monitoring of the in-lake dam is critical to determine its effectiveness over time and guide maintenance activities; the in-lake dam was surveyed and assessed in 2017 and results described in a previous section. In addition to water quality, physical components, including sediment depth and characteristics (density, structure), should be evaluated every two years; a bathymetric survey should be conducted for water depth. A minimum of two soil samples at existing locations should be collected from within the area upstream of the in-lake dam to track soil nutrient concentrations and identify any contaminants that would impact the ability to safely dispose of sediment.

Given the historical data currently available, it is recommended that monitoring continue at existing lake sites, ideally, under direction from the IEPA. The proposed monitoring categories and associated recommendations are summarized in Table 54. The OLWC should coordinate monitoring activities with the IEPA and additional resources should be sought, such as the RiverWatch program through the National Great Rivers Research and Education Center (NGRREC) or through volunteers, as needed. Physical and biological data should be collected at the West Fork of Otter Creek monitoring site to augment water quality information, since no biological data exists.

Due to the uncertainty in securing resources for edge-of-field monitoring to measure the effectiveness of BMPs, it is recommended that a more detailed monitoring plan be developed alongside future implementation actions such as the recent RCPP project, if funding permits.

Table 53 - Existing & Proposed Monitoring Sites & Description

Station ID	Site Description	Notes
RDF-1	Otter Lake, approximately 800 ft North of dam spillway	Existing IEPA monitoring site
RDF-2	Otter Lake, approximately 2,000 ft South of Emerson Rd Bridge	Existing IEPA monitoring site
RDF-3	Otter Lake, approximately 2,200 ft Southeast of In-lake dam	Existing IEPA monitoring site
RDF-4	Otter Lake near intake	Existing IEPA monitoring site
ST-5	Otter Lake, immediately upstream of in-lake dam	Recent lake monitoring site established by the OLWC to evaluate effectiveness of in-lake dam
ST-6	Unnamed Tributary, approximately 1,800 ft East of Deer Creek Rd	New tributary monitoring site
ST-7	West Fork Otter Creek at Finney Rd	Recent monitoring site on West Fork of Otter Creek established by the OLWC

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Station ID	Site Description	Notes
ST-8	Unnamed Tributary at Deathridge Ln	New tributary monitoring site
ST-9	Unnamed Tributary at Killam Rd immediately below overflow weir structure	Recent monitoring site on Unnamed Tributary established by the OLWC to monitor water quality over weir structure

Table 54 - Summary of Monitoring Categories & Recommendations

Monitoring Category	Summary of Recommendations
Stream flow	Measure stream flow during every sample event, if conditions permit.
Ambient water quality	Utilize IEPA and local volunteers or OLWC staff to execute regular monitoring for water quality at all stream and lake sites.
Physical & biologic assessment	Develop and execute stream monitoring for fish, macroinvertebrates, habitat, and channel morphology on West Fork of Otter Creek. Continue bathometric surveys of the in-lake dam impoundment area combined with sediment depth measurements to quantify trends in the volume of deposited sediment; collect up to three sediment samples and analyze for nutrients, water content, organic material, and other contaminants, such as heavy metals.
BMP effectiveness	Monitor BMP effectiveness of specific practices or cluster of practices. Develop a detailed monitoring plan in combination with implementation activities.
Storm event runoff monitoring	Conduct monitoring during storm event at each stream site.
Trends in water quality	Establish baseline conditions for stream sites. Monitor/track changes and trends in lake water quality; continue to evaluate lake water quality parameters as IEPA data becomes available.

Orangethroat Darter

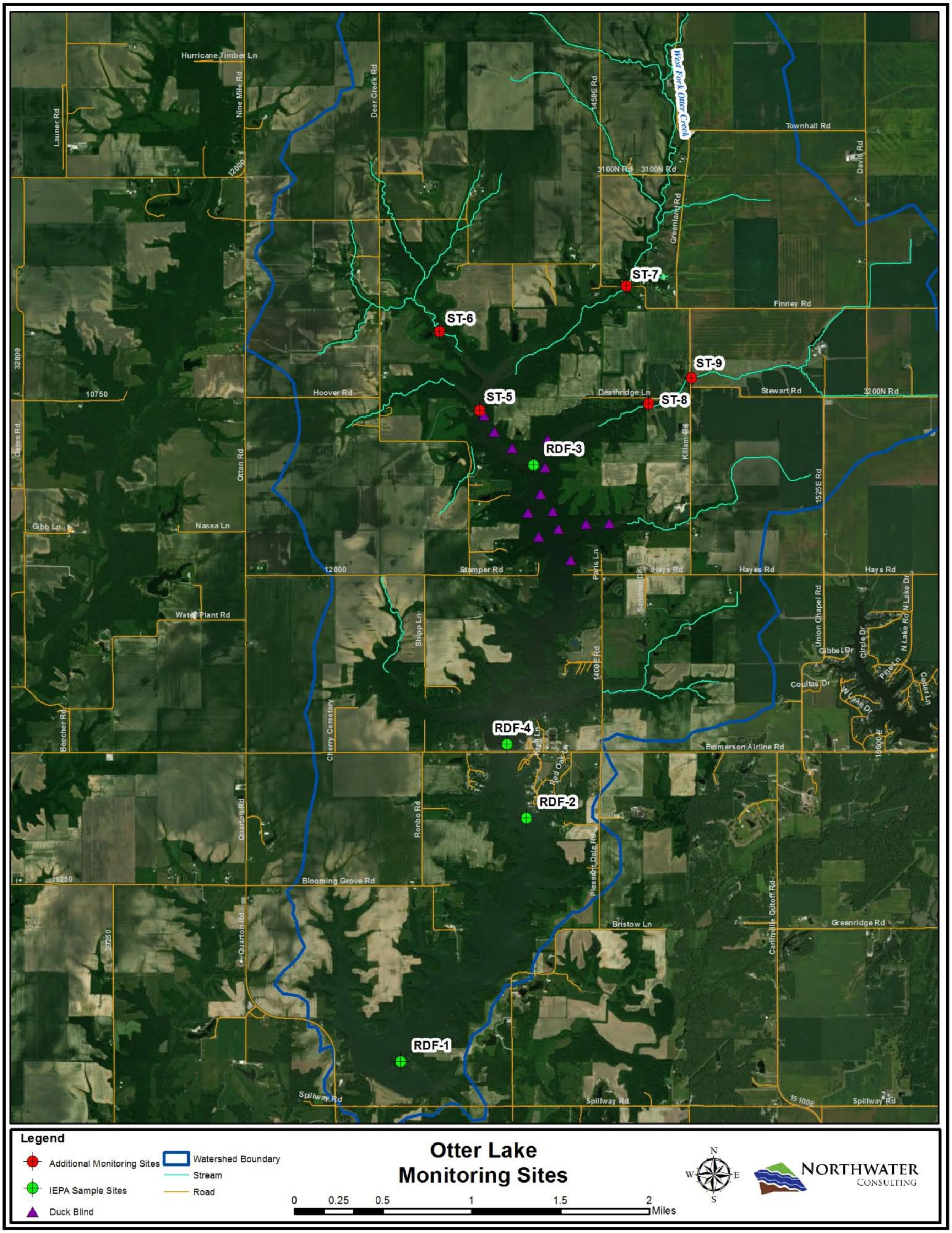

Figure 41 - Monitoring Locations

13.1 Water Quality Monitoring

Seasonal or monthly and storm-event water quality monitoring should be considered for all four stream monitoring stations in the watershed (Figure 41). The lake monitoring site at the in-lake dam should be monitored in conjunction with data collection efforts at the other four lake sites. Efforts should focus initially on collecting base-flow and storm-event data, followed by a regular sampling program. Regular monitoring should occur at a minimum of three times per year to capture seasonal variations in water quality; conduct storm event monitoring to supplement results. Monthly monitoring is preferred, if funding permits.

Table 55 includes the minimum parameters that should be considered for monitoring at each tributary site; additional lake sampling should follow established lake monitoring protocols. Quantitative benchmarks that indicate impairment conditions are also illustrated in this table. The establishment of baseline conditions is important in order to evaluate trends and changes in water quality over time through implementation. Parameters, such as total phosphorus, total suspended sediment, and total nitrogen, should be analyzed considering flow volumes in order to make relative comparisons year to year, as concentrations of pollutants vary with flow volumes. The water quality monitoring results may also be used to calibrate the nonpoint source pollution load model and make revised annual loading estimates throughout implementation.

Table 55 - Baseline Water Quality Analysis Parameters

Analyte	Benchmark Indicators
Total Phosphorus	Less than 0.05 mg/l (IL standard)
Total Nitrogen	Less than 10 mg/L (based on IL Nitrate standard)
Total Suspended Sediment (TSS)	Less than 15 mg/L (based on AQI max value)
Turbidity	Less than 14 NTU (IL Lake Assessment Criteria)
Dissolved Oxygen	No less than 6.0 mg/l (IEPA standards)
Temperature	Less than 90° F (IEPA standards)
pH	Between 6.5 – 9.0 (IEPA standards)
Flow	--

13.2 Stream Bioassessment

Aquatic stream monitoring should be considered annually or at the maximum of 3- to 5-year increments. One station on the West Fork of Otter Creek is recommended. Table 56 shows the typical stream bioassessment techniques that can be applied to the monitoring program.

Table 56 - Stream Bioassessment Metrics

Monitoring	Definition	Benchmark Indicators
Fish Index of Biologic Integrity (fIBI)[1]	Index based on presence and populations of non-native and native fish species and their tolerance to degraded stream conditions.	**No Impairment** ($\geq$41) – good resource quality and fully supporting aquatic life **Moderate Impairment** (<41 and >20) – fair resource quality and not supporting aquatic life **Severe Impairment** ($\leq$20) – poor resource quality and not supporting aquatic life

Monitoring	Definition	Benchmark Indicators
Macroinvertebrate Index of Biologic Integrity (mIBI)[1]	Index indicative of stream quality based on the macroinvertebrate species and populations.	**No Impairment** ($\geq$41.8) – good resource quality and fully supporting aquatic life **Moderate Impairment** (<41.8 and >20.9) – fair resource quality and not supporting aquatic life **Severe Impairment** ($\leq$20.9) – poor resource quality and not supporting aquatic life
Qualitative Habitat Evaluation Index (QHEI)[2]	Index indicative of habitat quality that incorporates substrate, in-stream cover, channel morphology, riparian zone, bank erosion and riffle/pool condition.	**Excellent** (>70) **Good** (55-69) **Fair** (43-54) **Poor** (30-42) **Very Poor** (<30)
Channel Morphology	Establish fixed cross-section and longitudinal profile of channel along a 1,500-foot-long fixed reach. Monitor regularly to assess changes in channel.	Entrenchment ratio Width/depth ratio bankfull Bed material Cross-sectional area Water slope

1 – From: IEPA Illinois Integrated Water Quality Report and Section 303(d) List, 2016; Guidelines for using Biological Information
2 – From: State of Ohio Environmental Protection Agency Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)

Flow monitoring

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Appendix A: Nonpoint Source Pollution Load Model Methodology (SWAMM)

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Otter Lake Watershed SWAMM Pollutant Load Model Methodology

sWAMM™

Spatial Watershed Assessment & Management Model

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Pollutant Loading Model Methodology

1.0 Introduction

A GIS spatially based pollution load model or SWAMM (Spatial Watershed Assessment and Management Model) was developed to estimate field level annual pollutant loading from, phosphorus, nitrogen, and sediment. Constructed using soils, landuse and precipitation data the model provides annual loading for individual land parcels within the Otter Lake watershed. Results are organized through a unique combination of landuse and soils, delineated into individual units of pollution loading. Accepted equations for calculating runoff and soil erosion are integrated into the model to provide realistic estimations of the quantity and distribution of annual pollution loading throughout the study area. A time period of 1/1/2001 to 1/1/2016 was used for generating rainfall values.

The GIS data set is organized in such a way that results can easily be queried by landuse. Results can also be analyzed based on user defined boundaries and presented in map format, easily overlaid on existing base maps. The model includes 6,663 unique records from which to assess pollution loading. The following methodology document provides key model equations and values and references.

2.0 Methodology

The custom SWAMM model consists of two primary components:

- Universal Soil Loss Equation (USLE) Component
- Event Mean Concentration (EMC) Component for surface runoff and tile flow

2.1 USLE Component

The overall analysis methodology modified by Northwater from*:*

Mitasova and Lubos Mitas: Modeling soil detachment with RUSLE3d using GIS, 1999; University of Illinois. http:/skagit.meas.ncsu.edu/~helena/gmslab/erosion/usle.html

The Universal Soil Loss Equation (USLE) component of the model is applied to agricultural land uses within the watershed (Row Crops). The USLE methodology incorporated into the model is summarized below:

- 1:24,000 NRCS Soil Survey Geographic Database (SSURGO) Digital Soils.
- Selected appropriate soil types and relevant USLE factors identified and calculated from SSURGO soils dataset.
- USLE erosion calculated with the following equation: LS * K * C * R *P.

Table 1 - USLE factors

C factor	K factor	LS factor	R factor	P factor
C factors Spring-Till/Mulch-Till/Reduced-Till = 0.25 Alfalfa & Wheat = 0.02 No-Till = 0.12 Strip-Till = 0.16 No-Till and Cover Crop = 0.04 Hay/Other Ag = 0.01 Conventional = 0.42	Values included in SSURGO tabular data	Values calculated from average slope and slope lengths in SSURGO tabular data or county frozen soils lists	185 (Macoupin Co.)	0.4-1

2.2 EMC Component

A) All formulas and selected variables are derived from: *STEPL (Spreadsheet Tool for Estimation of Pollutant Load) Version 3, Tetra Tech, 2004.*

B) Event Mean Concentration Values and Curve Numbers were derived from the following sources:

1. *Nonpoint Source Pollution and Erosion Comparison Tool (N-SPECT) Technical Guide, Version 1.0 Release 1, November 2004.*
2. *Lower DuPage River Watershed Plan Pollution Load Model Methodology, 2010.*
3. *V3 Companies, 2008. Elkhart River Watershed Management Plan, Appendix J; Pollutant Load Model Documentation for Critical Areas.*
4. *Price, Thomas H., 1993. Unit Area Pollutant Load Estimates for Lake County Illinois Lake Michigan Watersheds.*
5. *Todd D. Stuntebeck, Matthew J. Komiskey, Marie C. Peppler, David W. Owens, and Dennis R. Frame 2011. Precipitation-Runoff Relations and Water-Quality Characteristics at Edge-of-Field. Stations, Discovery Farms and Pioneer Farm, Wisconsin, 2003–08.*
6. *Northwater Consulting. 2013. Spatial Watershed Assessment and Management Model. Prepared for Chicago Metropolitan Agency for Planning, Chicago, IL.*
7. *Northwater Consulting. 2014. Spatial Watershed Assessment and Management Model. Prepared for Steuben County SWCD, Angola, IN.*
8. *Northwater Consulting. 2014 Spatial Watershed Assessment and Management Model. Prepared for the Agricultural Watershed Institute, Decatur, IL.*
9. *Northwater Consulting, 2016. Spatial Watershed Assessment and Management Model. Prepared for City of Springfield, Lake Springfield, Illinois.*
10. *Northwater Consulting, 2016. Spatial Watershed Assessment and Management Model. Prepared for City of Waverly, Waverly Lake, Illinois.*

C) Precipitation: annual precipitation, number of rain days and correction factors using the following weather stations: 1) Virden Station ID 00118860. A period of 15 years was used (2001-2016).

Table 2 – Rainfall Factors

Station	Average Number of Rain Days	Rain Days Correction Factor	P Value (inches)
Virden	91	0.544	0.75

D) Delivery Ratio; distance based delivery ratio: *Minnesota Board of Water & Soil Resources, "Pollution Reduction Estimator Water Erosion - Microsoft Excel® Version September 2010."*

Polygon distance from major stream (ft) $^{\wedge -0.2069}$

Table 3 - Pollutant Load Model Values

Rain days	Correction Factor (precipitation and rain days)	Curve Number (by soil hydrologic group)	Runoff (by soil hydrologic group in inches)	N Concentration in sediment (only for erosion from crop ground)	P Concentration in sediment (only for erosion from crop ground)	EMC for N, P, TSS
See Table 2	Table 2	Table 4	Calculated using the following equation: $Q = \frac{(P - (Ia \times S))^2}{P + 0.8 \times S}$ $S = \frac{1000}{CN} - 10$ Q = Runoff (inches) P = Precipitation (inches) S = Potential max retention (inches) CN = Curve Number Ia = Initial abstraction factor; set to 0.05 for annual runoff	0.0016%	Hay - 0.00018 Crop (No-till/all other cover types) – 0.00030475 Crop (Reduced/Mulch/Spring-till) – 0.0002625 Crop (Conventional-till) – 0.0002325	Table 4

Table 4 - Event Mean Concentrations & Curve Numbers

Landuse Category	EMC N (mg/l)	EMC P (mg/l)	EMC TSS (mg/l)	Curve # A Group	Curve # B Group	Curve # C Group	Curve # D Group
Camp Ground (high)	3.3	0.4	260	77	85	90	92
Camp Ground (high with detention)	1.98	0.24	130	72	80	85	87
Camp Ground (medium)	3.2	0.39	150	61	75	83	87
Camp Ground (low)	3.1	0.39	65	51	68	79	84
Camp Ground (low with detention)	1.86	0.25	40	46	65	77	82
Cemetery (Low with detention)	1.86	0.276	50	34	56	69	75
Farm Building (high)	6.8	0.42	280	89	88	91	93
Farm Building (high with detention)	4.1	0.25	168	77	85	87	92
Farm Building (medium)	6.8	0.42	160	61	75	83	87
Farm Building (medium with detention)	4.1	0.25	96	57	72	81	86
Farm Building (low)	6.8	0.42	72	51	68	79	84
Farm Building (low with detention)	4.1	0.25	43	46	65	77	82
Feed Area (high)	13.5	2.6	390	89	92	94	95
Feed Area (high with detention)	8.1	1.6	195	72	81	86	89
Feed Area (medium)	10.1	1.5	240	77	85	90	92
Feed Area (medium with detention)	6.06	0.9	120	71	80	85	88
Feed Area (low)	6.75	0.75	120	68	79	86	89
Feed Area (low with detention)	4.04	0.45	60	63	74	81	84
Forest	1.4	0.15	60	36	60	73	79
Forest (with detention)	1	0.105	36	32	56	69	75
Forest (restored)	0.7	0.13	30	30	55	70	77
Grassland (prairie)	0.7	0.13	30	30	58	71	78
Grassland (prairie with detention)	0.5	0.08	18	26	54	67	74
Grassland (waterway)	0.8	0.15	40	49	69	79	84
Grassland (waterway with detention)	0.6	0.1	20	45	65	75	80
Grassland (filter)	0.7	0.13	30	30	58	71	78
Grassland (filter with detention)	0.5	0.08	18	26	54	67	74

Landuse Category	EMC N (mg/l)	EMC P (mg/l)	EMC TSS (mg/l)	Curve # A Group	Curve # B Group	Curve # C Group	Curve # D Group
Open Water - Pond/Reservoir	0.375	0.025	1.5	100	100	100	100
Open Water - Stream	1.25	0.11	3.1	100	100	100	100
Pasture (high)	10.1	0.9	300	75	84	89	91
Pasture (high with detention)	6.06	0.54	120	70	79	84	86
Pasture (medium)	6	0.6	150	68	79	86	89
Pasture (medium with detention)	3.6	0.36	75	63	75	81	84
Pasture (low)	3.6	0.36	70	39	58	71	78
Pasture (low with detention)	2.16	0.22	43	34	53	66	73
Rural Residential (high)	3.3	0.5	260	77	85	90	92
Rural Residential (high with detention)	1.98	0.3	130	72	80	85	87
Rural Residential (medium)	3.1	0.42	130	61	75	83	87
Rural Residential (medium with detention)	1.86	0.25	70	57	71	79	83
Rural Residential (low)	3.1	0.42	65	51	68	79	84
Rural Residential (low with detention)	1.86	0.25	40	47	64	75	80
Roads	2.3	0.34	153	98	98	98	98
Roads (with detention)	1.61	0.24	107	94	94	94	94
Row Crops (conventional tillage high)	7.1	0.6	N/A*	73	82	89	92
Row Crops (conventional tillage)	7.1	0.6	N/A*	72	81	88	91
Row Crops (conventional tillage with detention)	5.3	0.42	N/A*	67	76	83	87
Row Crops (reduced-till)	7.1	0.6	N/A*	71	80	87	90
Row Crops (reduced-till with detention)	5.3	0.42	N/A*	67	76	82	86
Row Crops (spring-till)	7.1	0.6	N/A*	71	80	87	90
Row Crops (spring-till with detention)	5.3	0.42	N/A*	67	76	82	86
Row Crops (no-till/strip-till)	6	0.5	N/A*	67	78	85	89
Row Crops (no-till/strip-till with detention)	4.5	0.35	N/A*	63	74	81	85
Row Crops (no-till and cover crop)	5	0.42	N/A*	64	75	82	85
Row Crops (no-till wheat)	5	0.42	N/A*	58	72	81	85
Row Crops (no-till wheat with detention)	3.75	0.3	N/A*	54	68	77	81
Row Crops (hay)	4.6	0.33	N/A*	39	58	71	78
Urban Open Space	2.5	0.15	60	49	69	79	84
Urban Open Space (with detention)	1.9	0.1	36	45	65	75	80
Utilities (medium)	1.3	0.3	77	77	85	90	92
Utilities (low)	1.3	0.3	65	57	72	81	86
Wetland (forested)	1	0.105	36	31	55	68	74
Wetland (open water)	0.7	0.01	1	85	85	85	85
Wetland (needs restoration)	1.9	0.1	36	49	69	79	84
Wetland (forested with detention)	0.6	0.063	18	27	51	64	70
Wetland (open water with detention)	0.42	0.006	0.5	80	80	80	80
Wetland (needs restoration with detention)	1.14	0.06	18	44	64	74	79

USLE equation used

3.0 Model Calibration

No direct model calibration was performed due to the lack of any in-stream data. Model verification was performed by comparing model results against average per acre loading results for similar watershed in the Midwest. The verification served three purposes:

1. Quality Assurance / Quality Control – to find and correct user errors in the model scripts and algorithms.
2. To evaluate whether stream-flow (runoff) and pollutant loading were in the correct ranges based on existing data and literature.
3. To calibrate model by adjusting parameters so that cumulative model results represent regional averages.

The model is estimating accumulated/delivered pollutant loading, represented mostly in the literature. Important notes on the model include:

- The model does not directly account for point source pollution.
- The model estimates annual pollutant mobilization from individual parcels of land and does not take into account fate and transport watershed processes.

The model used a distance based delivery ratio and accounts for differences between the delivery of sediment versus the delivery of dissolved pollutants. Since the delivery ratio is based on studies of sediment transport and not dissolved pollutants, an adjustment or multiplier of **1.25** was applied to the delivery ratio for nitrogen and phosphorous to get the results within acceptable regional ranges. The assumption was made that dissolved pollutants are delivered at a slightly higher rate than that of sediment.

4.0 Additional Model Notes

1. A custom landuse layer was created for the watershed by digitizing recent aerial imagery and labeling polygons.
2. Data on field specific tillage practices and existing BMPs was incorporated.
3. High, medium and low areas were determined based on a visual interpretation of density. Very high areas generally represented 85 - 100%, high areas generally represented 60 - 85% impervious, medium 40-60% impervious and low, 20-40%.
4. Model accounts for areas with detention in place including in-lake/low flow dams.
5. Pasture was classified into high, medium and low based on pasture quality and the observed impact to water quality during a windshield survey.
6. A custom generated stream/waterbody file was used to run proximity calculations for the purposes of determining a delivery ratio.

Appendix B: In-Lake Dam Dredging Report, Stream Buffer Table, & Laboratory Reports

Otter Lake
In-lake Sediment Control Basin Evaluation

An in-lake basin was constructed by installing a rock and articulated concrete block weir structure at the North end of Otter Lake in 2002 to manage sediment and nutrient contributions originating from the watershed. This basin was evaluated in June of 2017 to determine the extent of sediment accumulation and to evaluate its current storage capacity relative to its original dimensions. A total of 41 measurements were taken along 7 established cross-sections as well as midpoint locations between each cross section (see Figure 2). The extent of the survey measurements was based on field observations of water depth and corresponding sediment depths. Water depth measurements were recorded using a sounding pole fitted with a 6 inch diameter disk to measure water depths to the top of sediment and a one inch diameter aluminum range pole to measure the depth to hard bottom. The measurements were then transferred to GPS. Three sediment cores were also obtained to determine sediment composition and chemistry; results are presented in Table 1.

The survey results indicate that substantial sediment accumulation has occurred within the basin, reducing its current trapping efficiency and capacity. An estimated 41.3% of the basin's storage capacity has been lost due to sediment deposition and measurements obtained downstream of the structure indicate that a significant percentage of the sediment deposited within the basin has occurred since the structure was installed in 2002. The shallow water depths combined with soft, flocculent sediment likely increase the frequency of sediment and nutrient remobilization to the main body of the lake, especially during high flow events. This primarily fine grained and phosphorus rich sediment then becomes a source of nutrients within the lake. Current characteristics of the basin include:

1. Average measured water depth of 2.8 feet with a maximum recorded depth of 3.8 feet and a minimum depth of 1.6 feet.
2. Sediment thickness to original hard bottom ranges from 4.3 feet near the dam to 0.6 feet near the shore in the upstream reaches of the basin. Average sediment thickness is 2.1 feet.

Laboratory analysis indicates that both nitrogen and phosphorus are in the mean range for normal Illinois lake sediment; percent solids averages roughly 46.2% and bulk density is similar at approximately 50 lbs/cf , or 1,350 lbs per cy, which equals 0.675 tons per cubic yard removed and measured in-situ.

Table 1. Summary of Sediment Core Sample Analyses

Station	Total Nitrogen (mg/Kg dry)	Total Phosphorus (mg/Kg dry)	Organic Matter (%)	Percent Solids
1	2,610	725	8.03	39.0
2	1,400	570	5.95	59.3
3	2,120	621	7.95	40.4
Average	**2,043**	**639**	**7.31**	**46.2**

Management Options & Recommendations

A total of 44,548 cubic yards of sediment was measured within the surveyed area of the basin using the Average End Area Method. Maintenance dredging of the soft, accumulated sediment is recommended within this survey boundary, which covers an area of 13.7 acres (See Figure 2). Hydraulic dredging using a small, portable cutterhead dredge and pumping the sediment via pipeline to the designated sediment storage and dewatering area located on Otter Lake Water Commission property is recommended (see Figure 1). Construction of an earthen dewatering basin is recommended. Pumping distance to the designated sediment storage site from the proposed dredging area ranges from 1,100 to 2,300 feet. to an elevation 35 to 40 feet higher than the lake. Therefore, an 8 inch or 10 inch diameter dredge and pipeline is recommended. If a smaller, 6 inch dredge is desired, a booster pump should be considered.

According to the survey data collected, the existing storage capacity of the surveyed basin area is 63,442 cubic yards or 39.3 acre-feet. After the 44,548 cubic yards of soft accumulated sediment are removed by hydraulic dredging, the storage capacity would be increased to an estimated 107,991 cubic yards or 66.9 acre-feet. By increasing storage capacity and removing soft, flocculent sediment from shallow water areas, the sediment and nutrient trapping efficiency would increase and provide improved water quality protection for the main body of Otter Lake.

Cost estimates are provided in Table 2. Considering the cost of dredging and dewatering, mobilization and materials, and permitting and oversight, it is estimated that the removal of 44,548 cubic yards will cost approximately **$723,672.00**.

Table 2. Cost Estimates

Item	Unit Cost	Total Cost
Dredging & Dewatering	$14/CY	$623,672
Mobilization & Piping	$50,000 (LS)	$50,000
Permitting & Construction Phase Assistance	$50,000 (LS)	$50,000
Total		**$723,672**

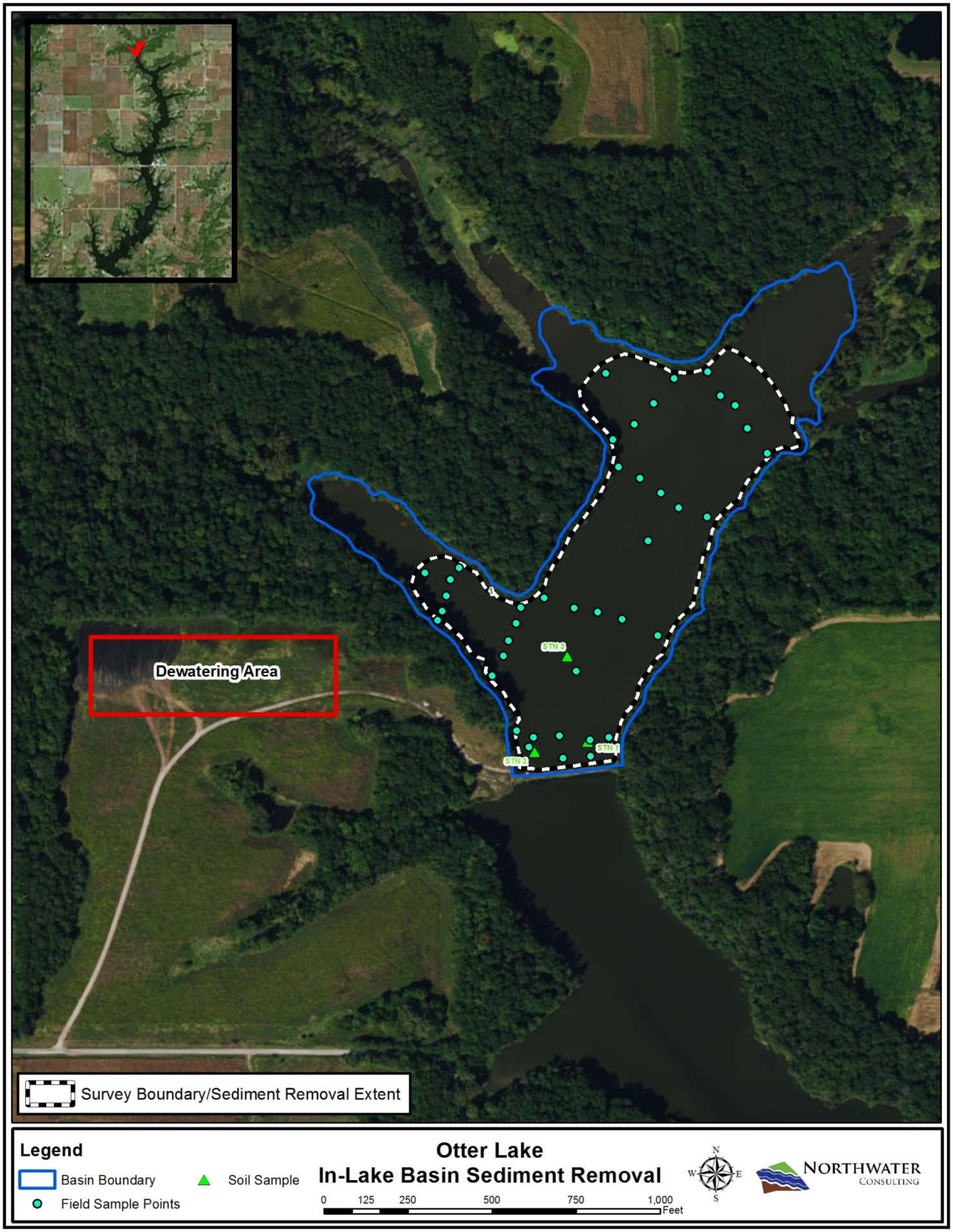


Figure 1. In-Lake Basin Survey Plan & Overview

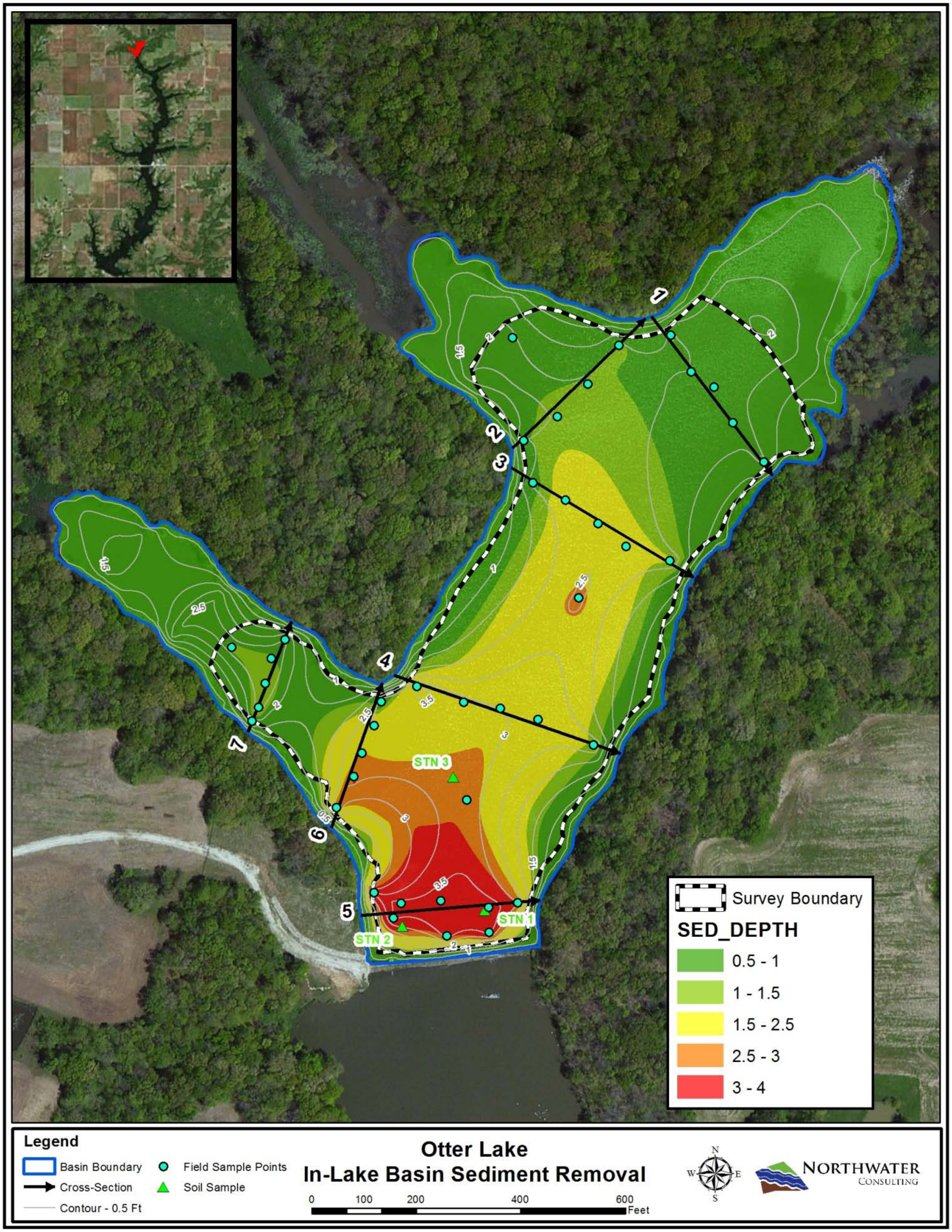
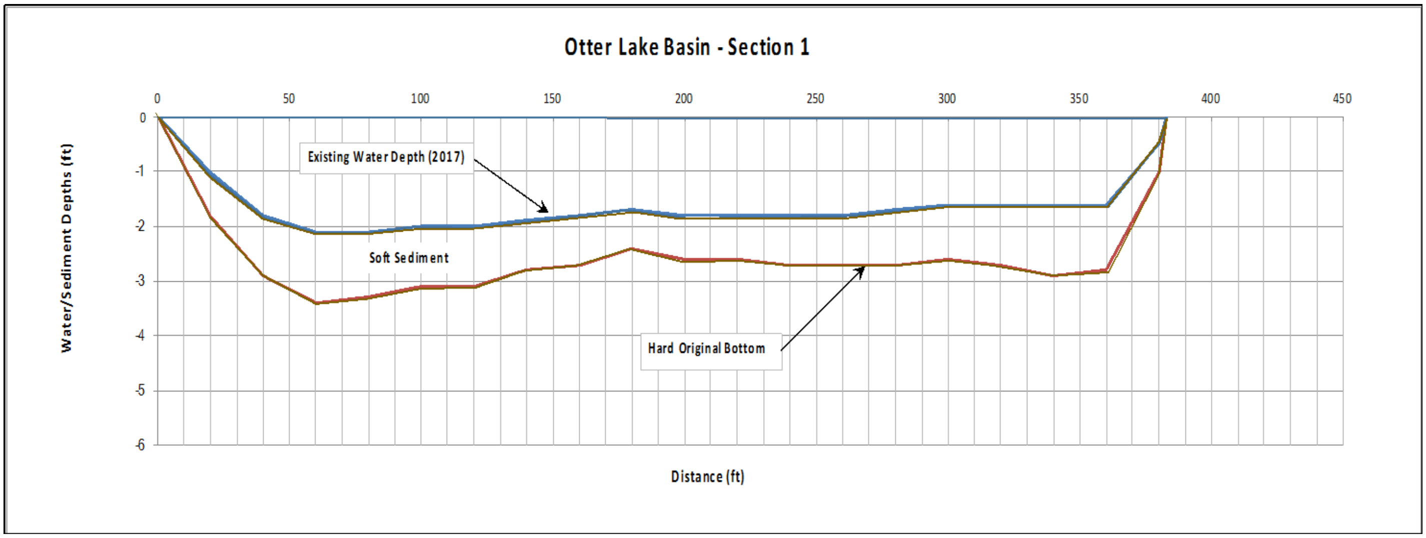
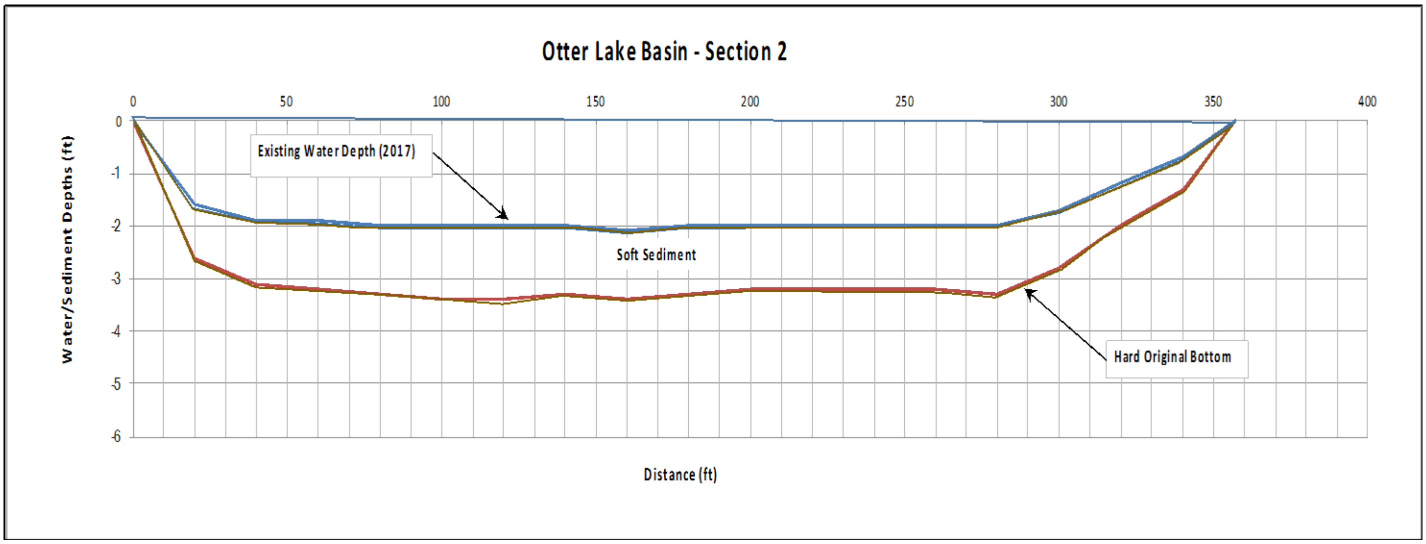
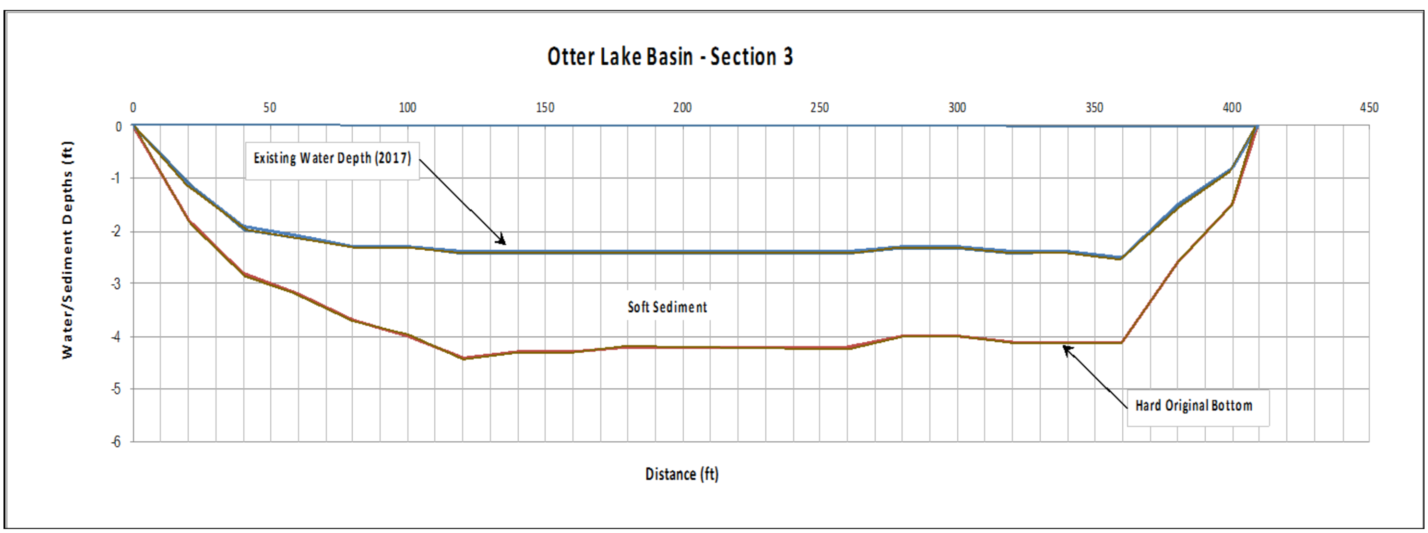


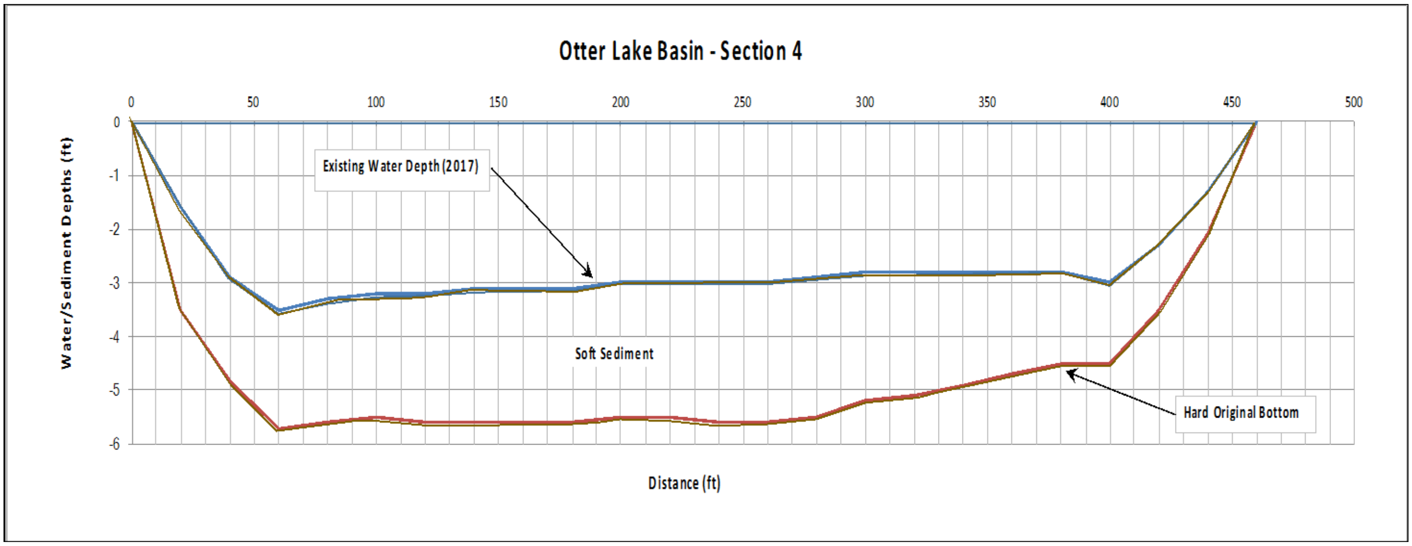
Figure 2. In-Lake Basin Contours and Recommended Dredging Extents

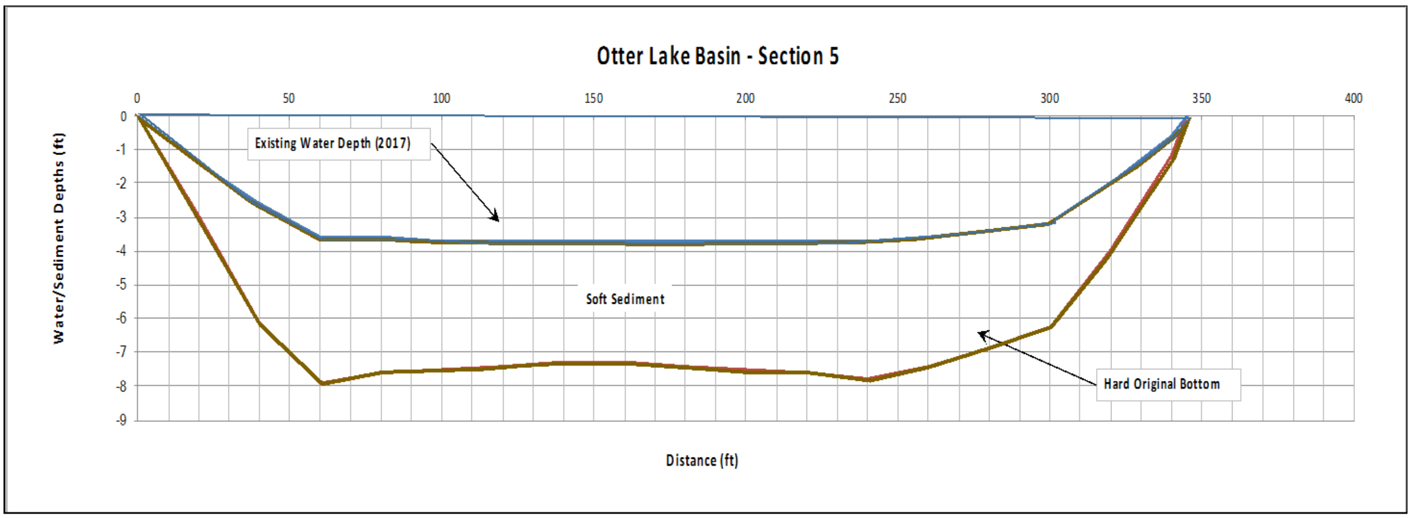
In-Lake Basin Cross Sections

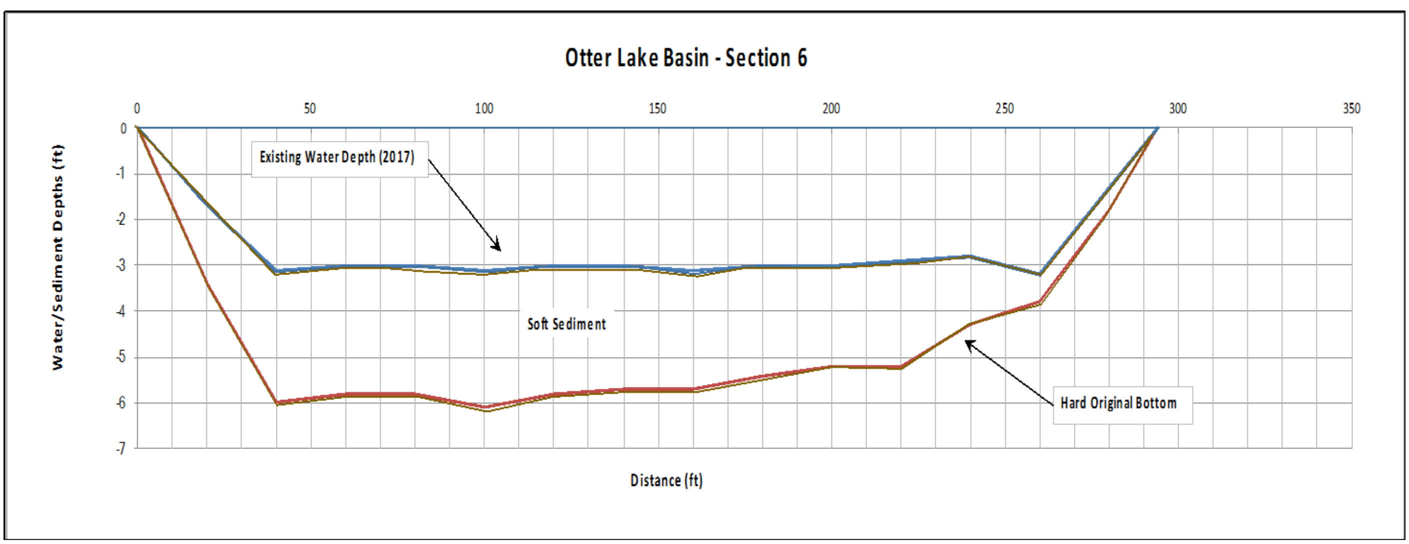


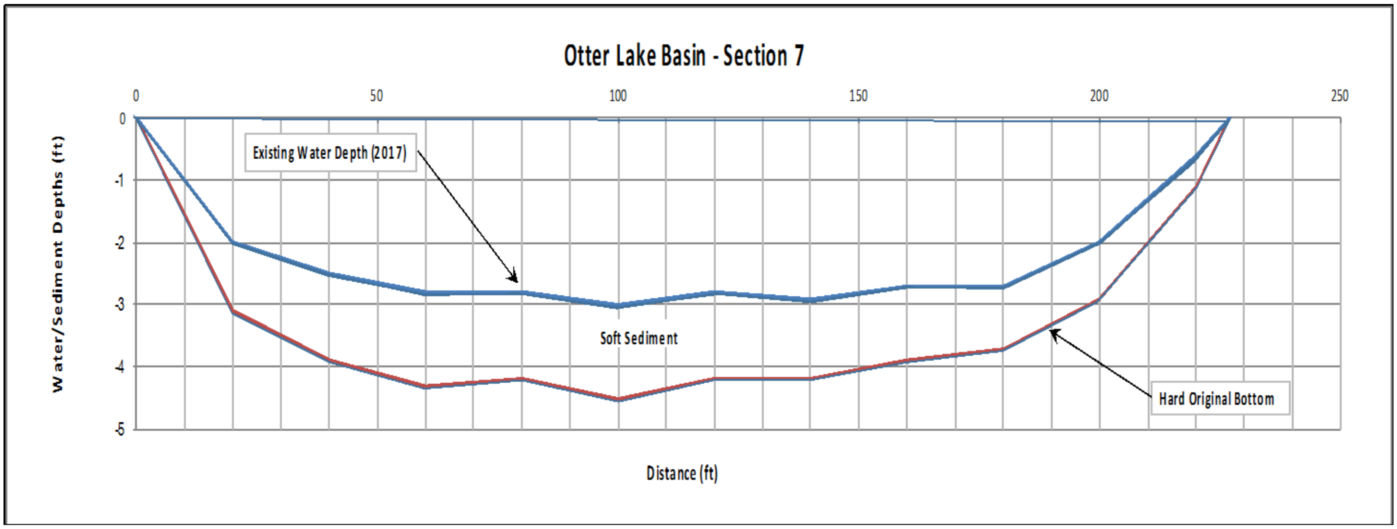





Otter Lake Basin - Section 4
0
50
100
150
200
250
300
350
400
450
500
0
-1
-2
-3
-4
-5
-6
Water/Sediment Depths (ft)
Existing Water Depth (2017)
Soft Sediment
Hard Original Bottom
Distance (ft)


Otter Lake Basin - Section 5
0
50
100
150
200
250
300
350
400
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
Water/Sediment Depths (ft)
Existing Water Depth (2017)
Soft Sediment
Hard Original Bottom
Distance (ft)


Otter Lake Basin - Section 6
0
50
100
150
200
250
300
350
0
-1
-2
-3
-4
-5
-6
-7
Water/Sediment Depths (ft)
Existing Water Depth (2017)
Soft Sediment
Hard Original Bottom
Distance (ft)


Otter Lake Basin - Section 7
0
50
100
150
200
250
0
-1
-2
-3
-4
-5
Water/Sediment Depths (ft)
Existing Water Depth (2017)
Soft Sediment
Hard Original Bottom
Distance (ft)

Otter Lake Stream Buffer Quality Reach Table

Length (Feet)	Reach Code	Buffer Condition	Landuse	Stream Name	Sub Code
474	L11	High	Forest	West Fork Otter Creek	N/A
297	L13	High	Forest	West Fork Otter Creek	N/A
73	L15	High	Forest	West Fork Otter Creek	N/A
3,078	L17	High	Forest	West Fork Otter Creek	N/A
266	L19	High	Forest	West Fork Otter Creek	N/A
867	L20	High	Forest	West Fork Otter Creek	N/A
1,302	L22	High	Forest	West Fork Otter Creek	N/A
3,595	L23	High	Forest	West Fork Otter Creek	N/A
1,251	L25	High	Forest	West Fork Otter Creek	N/A
142	L26	High	Forest	West Fork Otter Creek	N/A
591	L28	High	Forest	West Fork Otter Creek	N/A
1,526	L29	High	Forest	West Fork Otter Creek	N/A
196	L3	High	Forest	West Fork Otter Creek	N/A
525	L31	High	Forest	West Fork Otter Creek	N/A
564	L33	High	Forest	West Fork Otter Creek	N/A
612	L34	High	Forest	West Fork Otter Creek	N/A
4,010	L38	High	Forest	West Fork Otter Creek	N/A
1,200	L5	High	Forest	West Fork Otter Creek	N/A
170	L7	High	Forest	West Fork Otter Creek	N/A
115	L9	High	Forest	West Fork Otter Creek	N/A
441	L10	Moderate	Grassland	West Fork Otter Creek	N/A
366	L12	Moderate	Grassland	West Fork Otter Creek	N/A
187	L14	Moderate	Grassland	West Fork Otter Creek	N/A
142	L16	Moderate	Grassland	West Fork Otter Creek	N/A
147	L2	Moderate	Row Crops	West Fork Otter Creek	N/A
149	L21	Moderate	Grassland	West Fork Otter Creek	N/A
303	L24	Moderate	Grassland	West Fork Otter Creek	N/A
474	L27	Moderate	Urban Open Space	West Fork Otter Creek	N/A
172	L30	Moderate	Grassland	West Fork Otter Creek	N/A
176	L32	Moderate	Row Crops	West Fork Otter Creek	N/A
574	L4	Moderate	Row Crops	West Fork Otter Creek	N/A
148	L6	Moderate	Grassland	West Fork Otter Creek	N/A
230	L8	Moderate	Grassland	West Fork Otter Creek	N/A
738	L18	Low	Pasture	West Fork Otter Creek	N/A
806	L37	Low	Pasture	West Fork Otter Creek	N/A
1,089	L48	High	Forest	Unnamed Tributary	A
242	L49	High	Forest	Unnamed Tributary	A
1,045	L50	High	Forest	Unnamed Tributary	A
4,180	L51	High	Forest	Unnamed Tributary	A
241	L52	High	Forest	Unnamed Tributary	A
3,497	L53	High	Forest	Unnamed Tributary	A
836	L56	High	Forest	Unnamed Tributary	A
349	L57	High	Forest	Unnamed Tributary	A

Length (Feet)	Reach Code	Buffer Condition	Landuse	Stream Name	Sub Code
2,659	L47	High	Forest	Unnamed Tributary	B
1,730	L55	High	Forest	Unnamed Tributary	C
3,161	L54	High	Forest	Unnamed Tributary	D
1,920	L46	High	Forest	Unnamed Tributary	E
1,130	L42	Moderate	Forest	Unnamed Tributary	F
278	L43	Low	Pasture	Unnamed Tributary	F
257	L44	High	Forest	Unnamed Tributary	F
446	L45	High	Forest	Unnamed Tributary	F
3,446	L41	High	Forest	Unnamed Tributary	G
1,014	L39A	High	Grassland	Unnamed Tributary	H
4,236	L39B	Low	Pasture	Unnamed Tributary	H
2,550	L41	High	Forest	Unnamed Tributary	H
2,679	R7	High	Forest	West Fork Otter Creek	N/A
213	R8	Moderate	Grassland	West Fork Otter Creek	N/A
5,426	R9	High	Forest	West Fork Otter Creek	N/A
486	R10	Low	Pasture	West Fork Otter Creek	N/A
316	R11	High	Forest	West Fork Otter Creek	N/A
321	R12	Moderate	Urban Open Space	West Fork Otter Creek	N/A
505	R13	High	Forest	West Fork Otter Creek	N/A
137	R14	Moderate	Grassland	West Fork Otter Creek	N/A
104	R15	High	Forest	West Fork Otter Creek	N/A
190	R16	Moderate	Grassland	West Fork Otter Creek	N/A
1,792	R17	High	Forest	West Fork Otter Creek	N/A
296	R18	Moderate	Grassland	West Fork Otter Creek	N/A
3,220	R19	High	Forest	West Fork Otter Creek	N/A
2,203	R20A	High	Forest	West Fork Otter Creek	N/A
63	R20B	Moderate	Grassland	West Fork Otter Creek	N/A
832	R21	High	Forest	West Fork Otter Creek	N/A
2,041	R22	High	Forest	West Fork Otter Creek	N/A
727	R22A	Low	Pasture	West Fork Otter Creek	N/A
3,825	R22C	High	Forest	West Fork Otter Creek	N/A
254	R23A	High	Forest	West Fork Otter Creek	N/A
4,083	R1	High	Forest	Unnamed Tributary	A
2,067	R2	High	Forest	Unnamed Tributary	A
232	R3	High	Forest	Unnamed Tributary	A
877	R4	High	Forest	Unnamed Tributary	A
376	R5	High	Forest	Unnamed Tributary	A
3,978	R6	High	Forest	Unnamed Tributary	A
2,756	R33	High	Forest	Unnamed Tributary	B
1,889	R34	High	Forest	Unnamed Tributary	C
3,243	R31	High	Forest	Unnamed Tributary	D
1,887	R30	High	Forest	Unnamed Tributary	E
448	R27	High	Forest	Unnamed Tributary	F
614	R28A	Moderate	Grassland	Unnamed Tributary	F

Length (Feet)	Reach Code	Buffer Condition	Landuse	Stream Name	Sub Code
1,108	R28B	High	Forest	Unnamed Tributary	F
1,580	R24	High	Forest	Unnamed Tributary	G
79	R25	Moderate	Urban Open Space	Unnamed Tributary	G
1,788	R26	High	Forest	Unnamed Tributary	G
2,439	R23B	High	Forest	Unnamed Tributary	H
1,115	R23C	High	Forest	Unnamed Tributary	H
4,212	R29	Low	Pasture	Unnamed Tributary	H

Friday, June 2, 2017

Jeff Boeckler

Northwater Consulting
960 Clocktower Drive, Suite F
Springfield, IL 62704

TEL: (217) 725-3181

FAX: NA

RE: Otter Lake Soils

PAS WO: 17E0532

Prairie Analytical Systems, Inc. received 10 sample(s) on 5/18/2017 for the analyses presented in the following report.

All applicable quality control procedures met method specific acceptance criteria unless otherwise noted.

If you have any questions, please feel free to contact me at (224) 253-1348.

Respectfully submitted,

Christina E. Pierce
Project Manager

Certifications: NELAP/NELAC - IL #100323

LABORATORY RESULTS

Client:	Northwater Consulting		
Project:	Otter Lake Soils	**Lab Order:**	17E0532
Client Sample ID:	OS 1	**Lab ID:**	17E0532-01
Collection Date:	5/18/17 9:45	**Matrix:**	Solid

Analyses	Result	Limit	Qual	Units	DF	Date Prepared	Date Analyzed	Method	Analyst
Anions by Ion Chromatography									
Nitrate (as N)	U	2.98		mg/Kg dry	10	5/24/17 16:49	5/24/17 22:11	SM4110B	KSH
Nitrite (as N)	U	2.98		mg/Kg dry	10	5/24/17 16:49	5/24/17 22:11	SM4110B	KSH
Conventional Chemistry Parameters									
Total Nitrogen	**1270**	605		mg/Kg dry	10	5/24/17 16:49	5/25/17 17:37	SM4110B/SM	KSB
Total Kjeldahl Nitrogen	**1270**	599		mg/Kg dry	10	5/24/17 10:20	5/25/17 17:37	SM4500NH3-	KSB
Phosphorus	**374**	30.0		mg/Kg dry	25	5/22/17 10:44	5/23/17 15:34	SM4500P-E (	KSB
Percent Solids	**83.4**	0.100		%	1	5/22/17 12:03	5/23/17 9:04	ASTM D2974	HJG

LABORATORY RESULTS

Client: Northwater Consulting
Project: Otter Lake Soils **Lab Order:** 17E0532
Client Sample ID: OS 2 **Lab ID:** 17E0532-02
Collection Date: 5/18/17 9:55 **Matrix:** Solid

Analyses	Result	Limit	Qual	Units	DF	Date Prepared	Date Analyzed	Method	Analyst
Anions by Ion Chromatography									
Nitrate (as N)	U	2.74		mg/Kg dry	10	5/24/17 16:49	5/24/17 22:30	SM4110B	KSH
Nitrite (as N)	U	2.74		mg/Kg dry	10	5/24/17 16:49	5/24/17 22:30	SM4110B	KSH
Conventional Chemistry Parameters									
Total Nitrogen	**187**	60.5		mg/Kg dry	10	5/30/17 17:15	6/2/17 16:29	SM4110B/SM	ADH
Total Kjeldahl Nitrogen	**187**	55.0		mg/Kg dry	1	5/30/17 17:15	6/2/17 16:29	SM4500NH3-	ADH
Phosphorus	**438**	27.5		mg/Kg dry	25	5/22/17 10:44	5/23/17 15:34	SM4500P-E (.	KSB
Percent Solids	**90.9**	0.100		%	1	5/22/17 12:03	5/23/17 9:04	ASTM D2974	HJG

LABORATORY RESULTS

Client: Northwater Consulting
Project: Otter Lake Soils **Lab Order:** 17E0532
Client Sample ID: OS 3 **Lab ID:** 17E0532-03
Collection Date: 5/18/17 10:15 **Matrix:** Solid

Analyses	Result	Limit	Qual	Units	DF	Date Prepared	Date Analyzed	Method	Analyst
Anions by Ion Chromatography									
Nitrate (as N)	U	2.77		mg/Kg dry	10	5/24/17 16:49	5/24/17 22:49	SM4110B	KSH
Nitrite (as N)	U	2.77		mg/Kg dry	10	5/24/17 16:49	5/24/17 22:49	SM4110B	KSH
Conventional Chemistry Parameters									
Total Nitrogen	**565**	562		mg/Kg dry	10	5/24/17 16:49	5/25/17 17:37	SM4110B/SM	KSB
Total Kjeldahl Nitrogen	**565**	556		mg/Kg dry	10	5/24/17 10:20	5/25/17 17:37	SM4500NH3-	KSB
Phosphorus	**493**	27.8		mg/Kg dry	25	5/22/17 10:44	5/23/17 15:34	SM4500P-E (	KSB
Percent Solids	**89.9**	0.100		%	1	5/22/17 12:03	5/23/17 9:04	ASTM D2974	HJG

LABORATORY RESULTS

Client: Northwater Consulting
Project: Otter Lake Soils
Lab Order: 17E0532
Client Sample ID: OS 4
Lab ID: 17E0532-04
Collection Date: 5/18/17 10:20
Matrix: Solid

Analyses	Result	Limit	Qual	Units	DF	Date Prepared	Date Analyzed	Method	Analyst
Anions by Ion Chromatography									
Nitrate (as N)	U	2.95		mg/Kg dry	10	5/24/17 16:49	5/24/17 23:08	SM4110B	KSH
Nitrite (as N)	U	2.95		mg/Kg dry	10	5/24/17 16:49	5/24/17 23:08	SM4110B	KSH
Conventional Chemistry Parameters									
Total Nitrogen	**218**	64.8		mg/Kg dry	10	5/30/17 17:15	6/2/17 16:29	SM4110B/SM	ADH
Total Kjeldahl Nitrogen	**218**	58.9		mg/Kg dry	1	5/30/17 17:15	6/2/17 16:29	SM4500NH3-	ADH
Phosphorus	**420**	29.4		mg/Kg dry	25	5/22/17 10:44	5/23/17 15:34	SM4500P-E (:	KSB
Percent Solids	**84.9**	0.100		%	1	5/22/17 12:03	5/23/17 9:04	ASTM D2974	HJG

LABORATORY RESULTS

Client:	Northwater Consulting		
Project:	Otter Lake Soils	**Lab Order:**	17E0532
Client Sample ID:	OS 5	**Lab ID:**	17E0532-05
Collection Date:	5/18/17 10:35	**Matrix:**	Solid

Analyses	Result	Limit	Qual	Units	DF	Date Prepared	Date Analyzed	Method	Analyst
Anions by Ion Chromatography									
Nitrate (as N)	U	3.07		mg/Kg dry	10	5/24/17 16:49	5/25/17 1:40	SM4110B	KSH
Nitrite (as N)	U	3.07		mg/Kg dry	10	5/24/17 16:49	5/25/17 1:40	SM4110B	KSH
Conventional Chemistry Parameters									
Total Nitrogen	**843**	624		mg/Kg dry	10	5/24/17 16:49	5/25/17 17:37	SM4110B/SM	KSB
Total Kjeldahl Nitrogen	**843**	618		mg/Kg dry	10	5/24/17 10:20	5/25/17 17:37	SM4500NH3-	KSB
Phosphorus	**280**	30.9		mg/Kg dry	25	5/22/17 10:44	5/23/17 15:34	SM4500P-E (	KSB
Percent Solids	**80.9**	0.100		%	1	5/22/17 12:03	5/23/17 9:04	ASTM D2974	HJG

LABORATORY RESULTS

Client:	Northwater Consulting		
Project:	Otter Lake Soils	**Lab Order:**	17E0532
Client Sample ID:	OS 6	**Lab ID:**	17E0532-06
Collection Date:	5/18/17 10:55	**Matrix:**	Solid

Analyses	Result	Limit	Qual	Units	DF	Date Prepared	Date Analyzed	Method	Analyst
Anions by Ion Chromatography									
Nitrate (as N)	U	3.09		mg/Kg dry	10	5/24/17 16:49	5/25/17 1:59	SM4110B	KSH
Nitrite (as N)	U	3.09		mg/Kg dry	10	5/24/17 16:49	5/25/17 1:59	SM4110B	KSH
Conventional Chemistry Parameters									
Total Nitrogen	U	627		mg/Kg dry	10	5/24/17 16:49	5/25/17 17:37	SM4110B/SM	KSB
Total Kjeldahl Nitrogen	U	620		mg/Kg dry	10	5/24/17 10:20	5/25/17 17:37	SM4500NH3-	KSB
Phosphorus	**315**	31.0		mg/Kg dry	25	5/22/17 10:44	5/23/17 15:34	SM4500P-E (	KSB
Percent Solids	**80.6**	0.100		%	1	5/22/17 12:03	5/23/17 9:04	ASTM D2974	HJG

LABORATORY RESULTS

Client: Northwater Consulting
Project: Otter Lake Soils **Lab Order:** 17E0532
Client Sample ID: OS 7 **Lab ID:** 17E0532-07
Collection Date: 5/18/17 11:05 **Matrix:** Solid

Analyses	Result	Limit	Qual	Units	DF	Date Prepared	Date Analyzed	Method	Analyst
Anions by Ion Chromatography									
Nitrate (as N)	U	2.77		mg/Kg dry	10	5/24/17 16:49	5/25/17 2:18	SM4110B	KSH
Nitrite (as N)	U	2.77		mg/Kg dry	10	5/24/17 16:49	5/25/17 2:18	SM4110B	KSH
Conventional Chemistry Parameters									
Total Nitrogen	**598**	559		mg/Kg dry	10	5/24/17 16:49	5/25/17 17:37	SM4110B/SM	KSB
Total Kjeldahl Nitrogen	**598**	554		mg/Kg dry	10	5/24/17 10:20	5/25/17 17:37	SM4500NH3-	KSB
Phosphorus	**319**	27.7		mg/Kg dry	25	5/22/17 10:44	5/23/17 15:34	SM4500P-E (	KSB
Percent Solids	**90.3**	0.100		%	1	5/22/17 12:03	5/23/17 9:04	ASTM D2974	HJG

LABORATORY RESULTS

Client: Northwater Consulting
Project: Otter Lake Soils **Lab Order:** 17E0532
Client Sample ID: OS 8 **Lab ID:** 17E0532-08
Collection Date: 5/18/17 11:20 **Matrix:** Solid

Analyses	Result	Limit	Qual	Units	DF	Date Prepared	Date Analyzed	Method	Analyst
Anions by Ion Chromatography									
Nitrate (as N)	U	2.76		mg/Kg dry	10	5/24/17 16:49	5/25/17 3:15	SM4110B	KSH
Nitrite (as N)	U	2.76		mg/Kg dry	10	5/24/17 16:49	5/25/17 3:15	SM4110B	KSH
Conventional Chemistry Parameters									
Total Nitrogen	U	61.2		mg/Kg dry	10	5/24/17 16:49	5/25/17 17:37	SM4110B/SM	KSB
Total Kjeldahl Nitrogen	U	55.6		mg/Kg dry	1	5/24/17 10:20	5/25/17 17:37	SM4500NH3-	KSB
Phosphorus	**284**	27.8		mg/Kg dry	25	5/22/17 10:44	5/23/17 15:34	SM4500P-E (:	KSB
Percent Solids	**89.9**	0.100		%	1	5/22/17 12:03	5/23/17 9:04	ASTM D2974	HJG

LABORATORY RESULTS

Client: Northwater Consulting
Project: Otter Lake Soils **Lab Order:** 17E0532
Client Sample ID: OS 9 **Lab ID:** 17E0532-09
Collection Date: 5/18/17 11:30 **Matrix:** Solid

Analyses	Result	Limit	Qual	Units	DF	Date Prepared	Date Analyzed	Method	Analyst
Anions by Ion Chromatography									
Nitrate (as N)	U	3.14		mg/Kg dry	10	5/24/17 16:49	5/25/17 3:34	SM4110B	KSH
Nitrite (as N)	U	3.14		mg/Kg dry	10	5/24/17 16:49	5/25/17 3:34	SM4110B	KSH
Conventional Chemistry Parameters									
Total Nitrogen	U	69.4		mg/Kg dry	10	5/24/17 16:49	5/25/17 17:37	SM4110B/SM	KSB
Total Kjeldahl Nitrogen	U	63.1		mg/Kg dry	1	5/24/17 10:20	5/25/17 17:37	SM4500NH3-	KSB
Phosphorus	**83.5**	31.5		mg/Kg dry	25	5/22/17 10:44	5/23/17 15:34	SM4500P-E (:	KSB
Percent Solids	**79.2**	0.100		%	1	5/22/17 12:03	5/23/17 9:04	ASTM D2974	HJG

LABORATORY RESULTS

Client: Northwater Consulting
Project: Otter Lake Soils **Lab Order:** 17E0532
Client Sample ID: OS 10 **Lab ID:** 17E0532-10
Collection Date: 5/18/17 11:45 **Matrix:** Solid

Analyses	Result	Limit	Qual	Units	DF	Date Prepared	Date Analyzed	Method	Analyst
Anions by Ion Chromatography									
Nitrate (as N)	U	3.43		mg/Kg dry	10	5/24/17 16:49	5/25/17 3:53	SM4110B	KSH
Nitrite (as N)	U	3.43		mg/Kg dry	10	5/24/17 16:49	5/25/17 3:53	SM4110B	KSH
Conventional Chemistry Parameters									
Total Nitrogen	U	75.7		mg/Kg dry	10	5/24/17 16:49	5/25/17 17:37	SM4110B/SM	KSB
Total Kjeldahl Nitrogen	**75.4**	68.8		mg/Kg dry	1	5/24/17 10:20	5/25/17 17:37	SM4500NH3-	KSB
Phosphorus	**122**	34.4		mg/Kg dry	25	5/22/17 10:44	5/23/17 15:34	SM4500P-E (	KSB
Percent Solids	**72.6**	0.100		%	1	5/22/17 12:03	5/23/17 9:04	ASTM D2974	HJG

LABORATORY RESULTS

Client: Northwater Consulting
Project: Otter Lake Soils **Lab Order:** 17E0532

Anions by Ion Chromatography - Quality Control

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch A002877 - EPA300.0/SM4110B/SW9056A Anions										
Blank (A002877-BLK1)				Prepared: 05/24/2017 Analyzed: 05/25/2017						
Nitrate (as N)	U	0.250	mg/Kg wet							
Nitrite (as N)	U	0.250	mg/Kg wet							
LCS (A002877-BS1)				Prepared: 05/24/2017 Analyzed: 05/25/2017						
Nitrate (as N)	1.04	0.250	mg/Kg wet	1.1295		92	90-110			
Nitrite (as N)	1.55	0.250	mg/Kg wet	1.5223		102	90-110			
Matrix Spike (A002877-MS1)	**Source: 17E0532-07**			Prepared: 05/24/2017 Analyzed: 05/25/2017						
Nitrate (as N)	1.42	2.77	mg/Kg dry	1.2511	ND	113	90-110			S
Nitrite (as N)	1.89	2.77	mg/Kg dry	1.6862	ND	112	90-110			S
Matrix Spike Dup (A002877-MSD1)	**Source: 17E0532-07**			Prepared: 05/24/2017 Analyzed: 05/25/2017						
Nitrate (as N)	1.42	2.77	mg/Kg dry	1.2511	ND	113	90-110	0	20	S
Nitrite (as N)	1.91	2.77	mg/Kg dry	1.6862	ND	113	90-110	0.6	20	S

LABORATORY RESULTS

Client: Northwater Consulting
Project: Otter Lake Soils **Lab Order:** 17E0532

Conventional Chemistry Parameters - Quality Control

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch A002757 - EPA 365.2/SM 4500-P B Phosphorus Modified										
Blank (A002757-BLK1)				Prepared: 05/22/2017 Analyzed: 05/23/2017						
Phosphorus	U	25.0	mg/Kg wet							
LCS (A002757-BS1)				Prepared: 05/22/2017 Analyzed: 05/23/2017						
Phosphorus	209	25.0	mg/Kg wet	250.00		84	80-120			
LCS Dup (A002757-BSD1)				Prepared: 05/22/2017 Analyzed: 05/23/2017						
Phosphorus	222	25.0	mg/Kg wet	250.00		89	80-120	6	20	
Duplicate (A002757-DUP1)	**Source: 17E0453-02**			Prepared: 05/22/2017 Analyzed: 05/23/2017						
Phosphorus	5550	2050	mg/Kg dry		5420			2	20	
Matrix Spike (A002757-MS1)	**Source: 17E0453-02**			Prepared: 05/22/2017 Analyzed: 05/23/2017						
Phosphorus	6990	2050	mg/Kg dry	511.56	5420	308	80-120			S
Matrix Spike Dup (A002757-MSD1)	**Source: 17E0453-02**			Prepared: 05/22/2017 Analyzed: 05/23/2017						
Phosphorus	6730	2050	mg/Kg dry	511.56	5420	257	80-120	4	20	S
Batch A002763 - ASTM D2974 Solids										
Blank (A002763-BLK1)				Prepared: 05/22/2017 Analyzed: 05/23/2017						
Percent Solids	U	0.100	%							
Duplicate (A002763-DUP1)	**Source: 17E0550-11**			Prepared: 05/22/2017 Analyzed: 05/23/2017						
Percent Solids	81.0	0.100	%		80.9			0.09	20	
Batch A002823 - EPA 351.4/SM 4500-Norg C TKN Modified										
Blank (A002823-BLK1)				Prepared: 05/24/2017 Analyzed: 05/25/2017						
Total Kjeldahl Nitrogen	U	500	mg/Kg wet							

LABORATORY RESULTS

Client: Northwater Consulting
Project: Otter Lake Soils **Lab Order:** 17E0532

Conventional Chemistry Parameters - Quality Control

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch A002823 - EPA 351.4/SM 4500-Norg C TKN Modified										
LCS (A002823-BS1)				Prepared: 05/24/2017 Analyzed: 05/25/2017						
Total Kjeldahl Nitrogen	4800	500	mg/Kg wet	5000.0		96	70-120			
LCS Dup (A002823-BSD1)				Prepared: 05/24/2017 Analyzed: 05/25/2017						
Total Kjeldahl Nitrogen	4790	500	mg/Kg wet	5000.0		96	70-120	0.2	20	
Duplicate (A002823-DUP1)	**Source: 17E0532-01**			Prepared: 05/24/2017 Analyzed: 05/25/2017						
Total Kjeldahl Nitrogen	1200	599	mg/Kg dry		1270			6	20	
Matrix Spike (A002823-MS1)	**Source: 17E0532-01**			Prepared: 05/24/2017 Analyzed: 05/25/2017						
Total Kjeldahl Nitrogen	6630	599	mg/Kg dry	5993.0	1270	89	70-130			
Matrix Spike Dup (A002823-MSD1)	**Source: 17E0532-01**			Prepared: 05/24/2017 Analyzed: 05/25/2017						
Total Kjeldahl Nitrogen	6590	599	mg/Kg dry	5993.0	1270	89	70-130	0.5	20	
Batch A002963 - EPA 351.4/SM 4500-Norg C TKN Modified										
Blank (A002963-BLK1)				Prepared: 05/30/2017 Analyzed: 06/02/2017						
Total Kjeldahl Nitrogen	U	500	mg/Kg wet							
LCS (A002963-BS1)				Prepared: 05/30/2017 Analyzed: 06/02/2017						
Total Kjeldahl Nitrogen	5000	500	mg/Kg wet	5000.0		100	70-120			
LCS Dup (A002963-BSD1)				Prepared: 05/30/2017 Analyzed: 06/02/2017						
Total Kjeldahl Nitrogen	4890	500	mg/Kg wet	5000.0		98	70-120	2	20	
Duplicate (A002963-DUP1)	**Source: 17E0647-05**			Prepared: 05/30/2017 Analyzed: 06/02/2017						
Total Kjeldahl Nitrogen	117	58.9	mg/Kg dry		115			2	20	

LABORATORY RESULTS

Client: Northwater Consulting
Project: Otter Lake Soils **Lab Order:** 17E0532

Conventional Chemistry Parameters - Quality Control

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch A002963 - EPA 351.4/SM 4500-Norg C TKN Modified										
Matrix Spike (A002963-MS1)	**Source: 17E0647-05**		Prepared: 05/30/2017 Analyzed: 06/02/2017							
Total Kjeldahl Nitrogen	296	58.9	mg/Kg dry	5889.3	115	3	70-130			I, S
Matrix Spike Dup (A002963-MSD1)	**Source: 17E0647-05**		Prepared: 05/30/2017 Analyzed: 06/02/2017							
Total Kjeldahl Nitrogen	310	58.9	mg/Kg dry	5889.3	115	3	70-130	5	20	I, S

LABORATORY RESULTS

Client: Northwater Consulting
Project: Otter Lake Soils **Lab Order:** 17E0532

Notes and Definitions

S	Spike recovery outside acceptance limits.
I	Matrix interference.
*	NELAC certified compound.
U	Analyte not detected (i.e. less than RL or MDL).

Chain of Custody Record

Central IL - 1210 Capital Airport Drive - Springfield, IL 62707-8490 - Phone (217) 753-1148 - Facsimile (217) 753-1152
Chicago IL Office - 9114 Virginia Rd., Ste 112 - Lake in the Hills, IL 60156 - Phone (847) 651-2604 - Facsimile (847) 458-9680
Central/Southern IL Office - Phone (217) 414-7762 - Facsimile (217) 223-7922

Prairie Analytical Systems, INCORPORATED
www.prairieanalytical.com

Client	Northwater Consulting
Address	960 Clocktower Dr. Suite F
City, State, Zip Code	Springfield IL 62704
Phone / Facsimile	217-725-3181
Project Name / Number	Otter Lake Soils
Project Location	Otter Lake
P.O. # or Invoice To	Northwater Consulting
Contact Person	Jeff Boeckler

Reporting: TACO ☐ Resid ☐ Ind/Comm; CALM ☐ A ☐ B ☐ C ☐ D ☐ E ☐ F; RISC ☐ Resid ☐ Indust

Sample Description	Sampling Date	Sampling Time	Matrix Code	Preserv Code	No. of Containers	Sample Type Comp	Sample Type Grab	TOTAL Nitrogen	Total Phosphorus	Sampler Comments
OS1	5/18/17	0945	S	0	1		X	X	X	
OS2	5/18/17	0955	S	0	1		X	X	X	
OS3	5/18/17	1015	S	0	1		X	X	X	
OS4	5/18/17	1020	S	0	1		X	X	X	
OS5	5/18/17	1035	S	0	1		X	X	X	
OS6	5/18/17	1055	S	0	1		X	X	X	
OS7	5/18/17	1105	S	0	1		X	X	X	
OS8	5/18/17	1120	S	0	1		X	X	X	
OS9	5/18/17	1130	S	0	1		X	X	X	
OS10	5/18/17	1145	S	0	1		X	X	X	

Matrix Code	A - Aqueous	DW - Drinking Water	GW - Ground Water	NA - Non-Aqueous Liquid	S - Solid	O - Oil	X - Other (Specify)
Preserv Code	0 - None	1 - HCl	2 - H2SO4	3 - HNO3	4 - NaOH	5 - 5035 Kit	X - Other (Specify)

Relinquished By	Date	Time	Received By	Date	Time	Method of Shipment
Jeff Boeckler	5/18/17	1341				
			[signature]	5/18/17	1341	HAND

Special Instructions:

Turnaround Time: Standard ☒ Rush ☐
Date Required:

QC Level: 1 ☐ 2 ☒ 3 ☐ 4 ☐
On wet ice? Yes ✓ No
Temperature (°C): 2.7

PAS COC Rev. 3

Copies: White - Client / Yellow - PAS, Inc. / Pink - Sampler