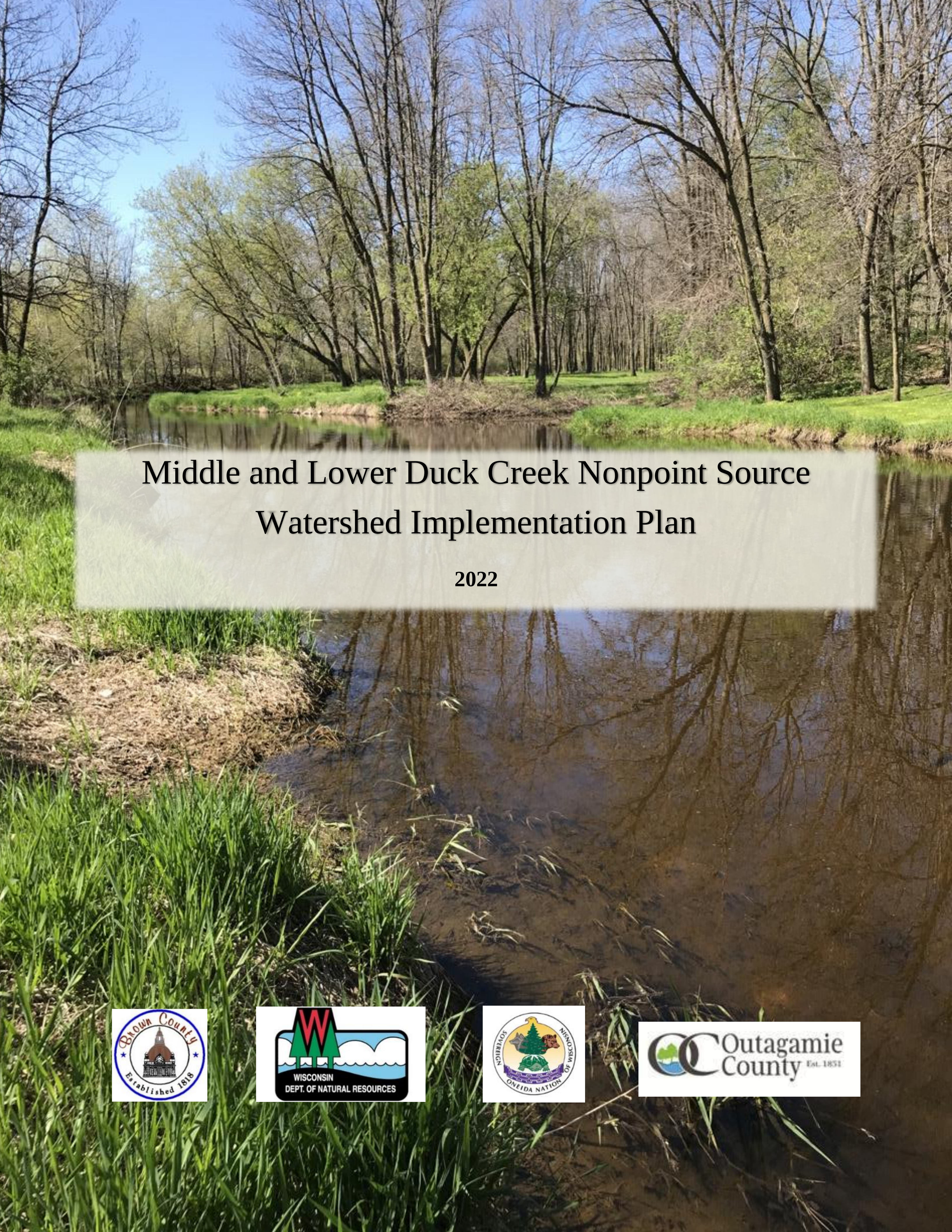

Middle and Lower Duck Creek Nonpoint Source Watershed Implementation Plan

2022

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Middle and Lower Duck Creek Nonpoint Source Watershed Implementation Plan

Prepared By:

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2022

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Acknowledgements

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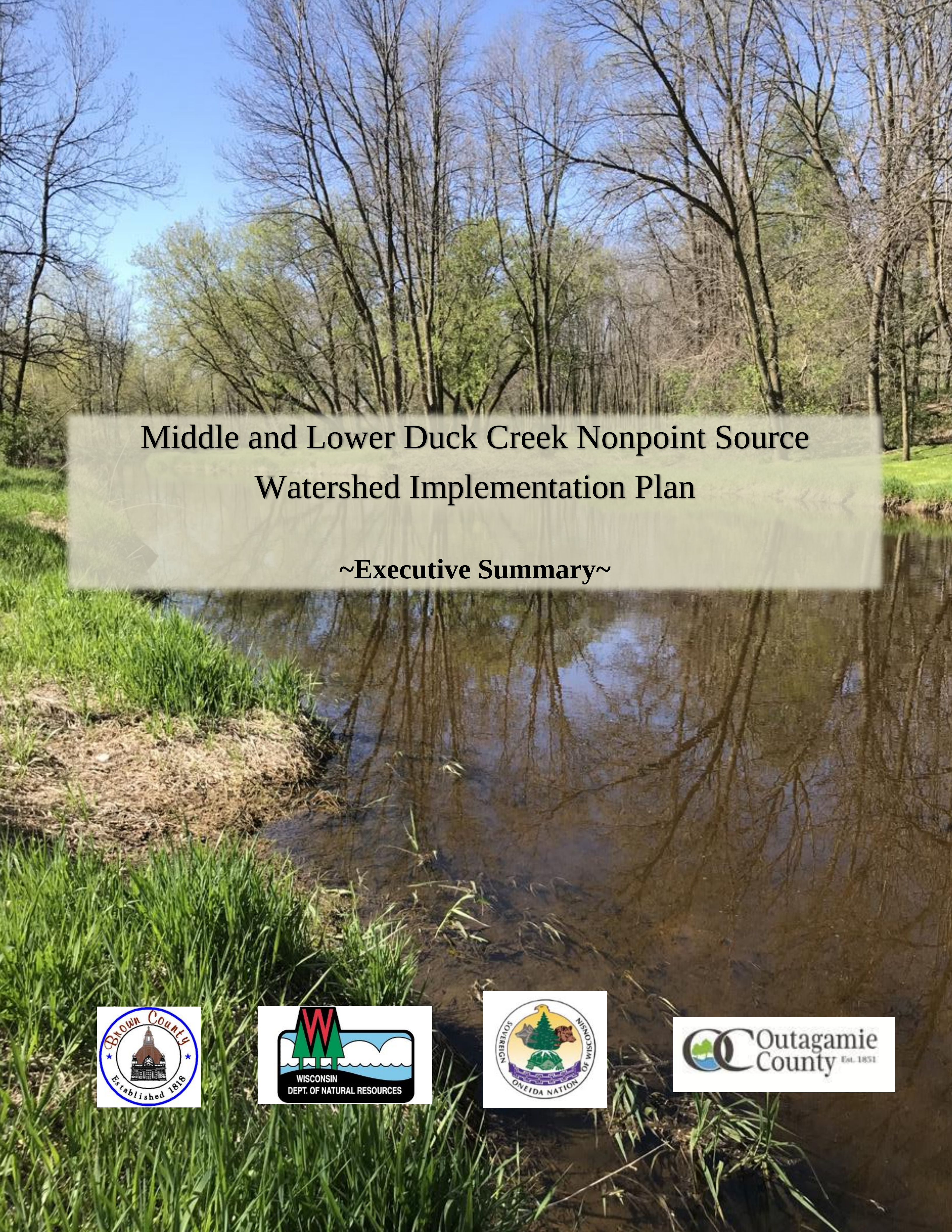
*All photos in plan taken by Outagamie Land Conservation Department staff unless otherwise noted.



Middle and Lower Duck Creek Nonpoint Source Watershed Implementation Plan

~Executive Summary~

Brown County Established 1818

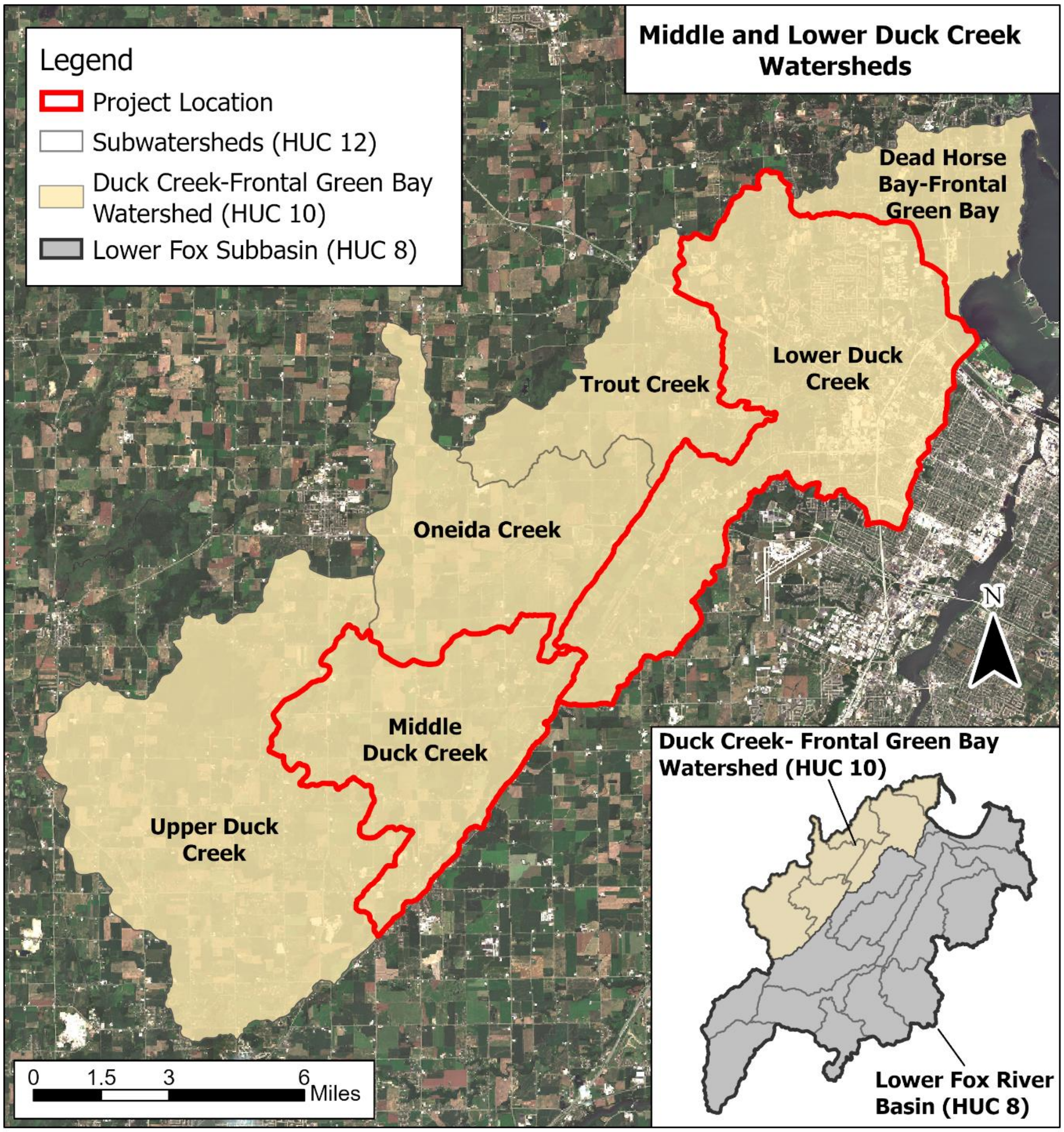
Wisconsin Dept. of Natural Resources

Sovereign Oneida Nation of Wisconsin

Outagamie County Est. 1851

Introduction

The Middle and Lower Duck Creek Watersheds are subwatersheds of the Duck Creek Watershed within the Lower Fox River Basin and are located in east central Wisconsin in Outagamie and Brown County. Duck Creek starts in the Town of Black Creek, flows through the Town Center, Osborn, Freedom and Oneida before flowing into the Bay of Green Bay in Howard. The Duck Creek watershed is divided into the Upper, Middle and Lower Duck Creek subwatersheds; the Oneida and Trout Creek subwatersheds and Dead Horse Bay- Frontal Green Bay subwatershed. The Middle Duck Creek watershed drains approximately 14,755 acres and Lower Creek drains about 27,616 acres.



Prior to European settlement (early 1800s), the land in this area was forested with approximately 9,275 acres of wetlands and was home to Native Americans. The farming and paper industry in the area has led to clearing of forests and natural areas and draining of wetlands in the Lower Fox River Basin. Approximately 72% of the wetlands in the Middle Duck Creek watershed and 25% of the wetlands in the Lower Duck Creek watershed have been lost. Changes in land use, runoff, and discharges to the Fox River due to farming, industry, and urban development in the Lower Fox River Basin has led to poor water quality in the Fox River and Bay of Green Bay.

Excessive sediment loads and increased algal blooms in the Lower Fox River and Bay of Green Bay prompted the need for action to be taken in the Lower Fox River Basin. A Total Maximum Daily Load (TMDL) was approved for the Lower Fox River and Lower Green Bay and its tributaries in 2012. The development of implementation plans for the subwatersheds of the Lower Fox River Basin are necessary to meet the assigned daily loads of the TMDL.

What is a TMDL?

A Total Maximum Daily Load (TMDL) is the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards.

Lower Fox River Basin Total Maximum Daily Load Allowance and Reductions for Duck Creek Subbasin

Loading Summary	Total Phosphorus (lbs/yr)	Total Suspended Solids (lbs/yr)
Baseline	63,172	25,394,165
TMDL	23,252	11,416,475
Reduction	39,920	13,977,690
% Reduction Needed	**63.19%**	**55.04%**

Challenges and Sources in the Watershed

Approximately 55% of the land use within the Middle Duck Creek watershed is agriculture. The dominant land use in the Lower Duck Creek watershed is urban and developed area (53.4%). Wetlands and natural areas in the watersheds have been cleared and drained for development and to increase agricultural production. According to the TMDL, agriculture is responsible for 78% of the TP load in the Duck Creek subbasin and urban land use is approximately 16% of the TP load in the subbasin. The amount of urban area in the watershed is predicted to increase. If local construction and post construction ordinances required by municipal MS4 permits are enforced, development of land may not contribute to a net increase in TSS and TP loading to Middle and Lower Duck Creek.

Increased runoff, flooding and lack of native riparian vegetation has led to significant erosion of streambanks during high flow periods. The main stem and major tributaries of Duck Creek were inventoried to determine if streambank erosion was a significant source of the TP and TSS load in the watersheds. Using NRCS Streambank Erosion prediction methodology, moderate to very severe streambank erosion was identified to be occurring along of the main stem and major tributaries of Duck Creek. TSS load estimates based on field inventory of streambank erosion was significantly higher than what was assumed for TMDL watershed modeling. Streambank erosion was not specifically modeled in the TMDL due to lack of available data, therefore it was assumed that it was not a significant source based on local knowledge at the time. Streambank erosion load contributions were lumped in with upland sources (agriculture, urban, and natural background) for TMDL modeling.

Photos Left to Right: Eroding streambank on Duck Creek, concentrated flow erosion in crop field, scour at urban stormwater outlet on a Duck Creek tributary

Watershed Implementation Plan

To support meeting the goals of the TMDL for this watershed, a 10-year nine key element implementation plan was developed. The action plan recommends best management practices, information and education activities, and needed restoration to achieve the goals of the watershed project. The plan includes estimated cost, potential funding sources, agencies responsible for implementation, and measures of success.

Implementation Plan Goals

Goal #1: Improve surface water quality by meeting the TMDL reductions for total phosphorus (TP) and total suspended solids (TSS).

Goal #2: Increase citizens' awareness of water quality issues and active participation in stewardship of the watershed.

Goal #3: Reduce runoff rate, runoff volume and flood levels during peak storm events.

Goal #4: Improve streambank stability and reduce amount of streambank degradation.

Goal #5: Conserve and restore aquatic and terrestrial habitat.

Recommended Management Practices:

- Regenerative Agriculture Practices
  - Reduced Tillage Methods (Strip/Zone-till, No-till, Mulch-till)
  - Cover Crops
  - Low Disturbance Manure Injection and/or other alternative manure management methods
  - Grazing
- Buffers/Vegetated Filter Strips
- Wetland Restoration/Treatment Wetlands
- Grassed/Lined Waterways
- Nutrient Management
- Streambank and Riparian Corridor Restoration
- Two-Stage Ditch/Channel
- Water and Sediment Control Basins/Grade Stabilization
- Critical Area Planting
- Tile Drainage Water Management
- Agriculture Runoff Treatment Systems (ARTS)
- Exploring new technologies/practices (soil amendments, phosphorus removal structures, etc.).

Information and Education Recommendations

- Utilize educational workshops, tours, field days, social media platforms, newsletters, and press/media releases to provide information on water quality and best management practices and to share updates on conservation efforts and progress in the watershed.
- Engage landowners in planning and implementing conservation on their land and provide information on the technical tools and financial support available to them via one on one site visits and group meetings.
- Increase elected official support for plan implementation by educating local, county, state and federal officials on watershed issues and needs and provide information support for local comprehensive planning, zoning, and resource protection strategies that improve soil and water resource protection.

Lower Fox Demonstration Farms Field Day- 9/20/2017

Conclusion

Watershed planning and implementation is primarily a voluntary effort that will need to be supported by focused technical and financial assistance. Widespread adoption of regenerative agriculture cropping practices that improve soil health along with implementation of practices that manage water on the landscape will be needed to restore the hydrology of the watershed and provide significant TSS and TP load reductions. Successful implementation will require widespread cooperation and commitment of the watershed community to improve the water quality and condition of the watershed. Acquiring adequate funding for staff and management practice implementation will be critical to the success of this plan. This plan needs to be adaptable to the many challenges, changes and lessons found in this watershed area as implementation moves forward.

Cover Crops being interseeded into corn-6/19/2020

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1.0 Introduction

1.1 Middle and Lower Duck Creek Watershed Setting

The Middle Duck Creek and Lower Duck Creek watersheds are subwatersheds (HUC 12) of the Duck Creek Watershed (HUC 10) and the Lower Fox River Basin (HUC 8) in Wisconsin (Figure 1). The Middle and Lower Duck Creek watersheds are located in Brown and Outagamie Counties and drain a total area of 42,391 acres (Figure 2). The Middle and Lower Duck Creek watersheds include portions of the City of Green Bay, Village of Hobart, Village of Howard, Town of Freedom, Town of Oneida, Town of Osborn, Town of Pittsfield, Village of Suamico and the Village of Ashwaubenon. The Middle Duck Creek watershed is mostly rural and dominated by agriculture land use. The majority of the Lower Duck Creek watershed is developed except in the southwest finger of the watershed, which has significant amount of agricultural land. From here on out, the two subwatersheds will be referred to collectively as the Middle and Lower Duck Creek watershed.

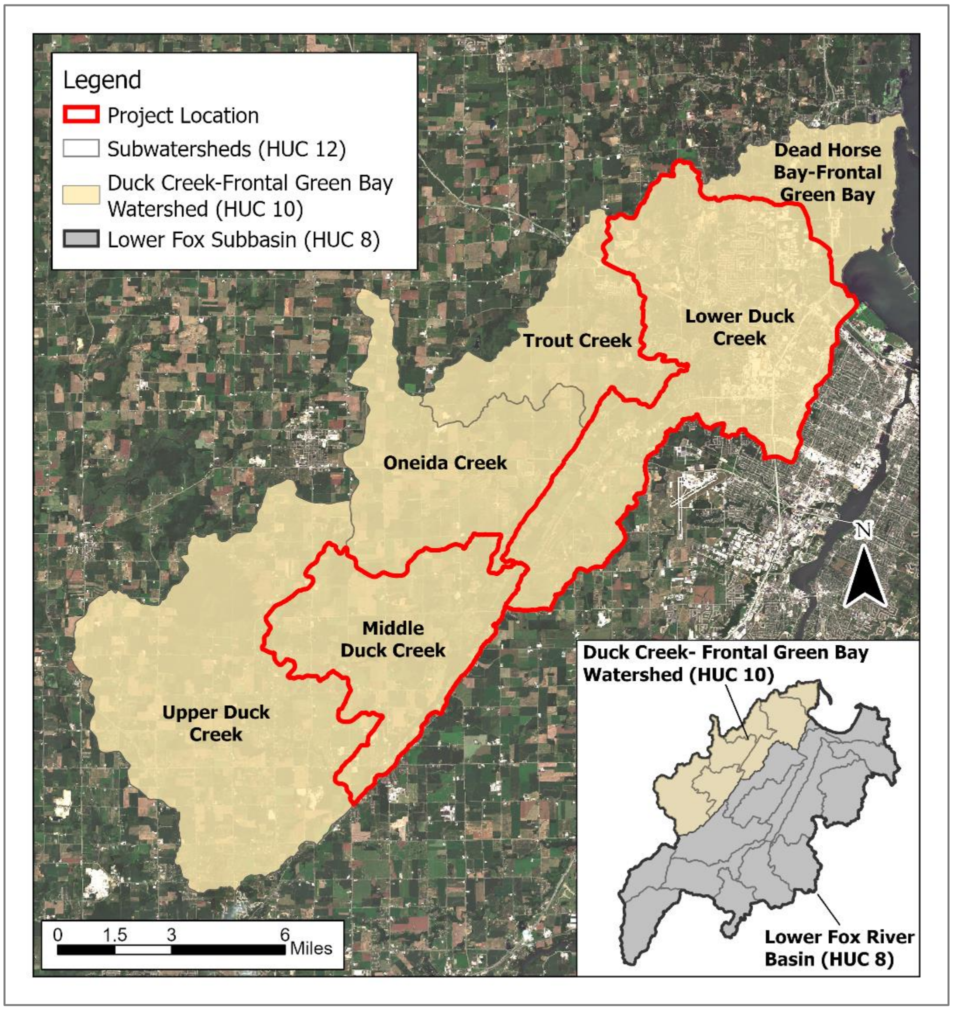

Figure 1. Middle and Lower Duck Creek watershed location.

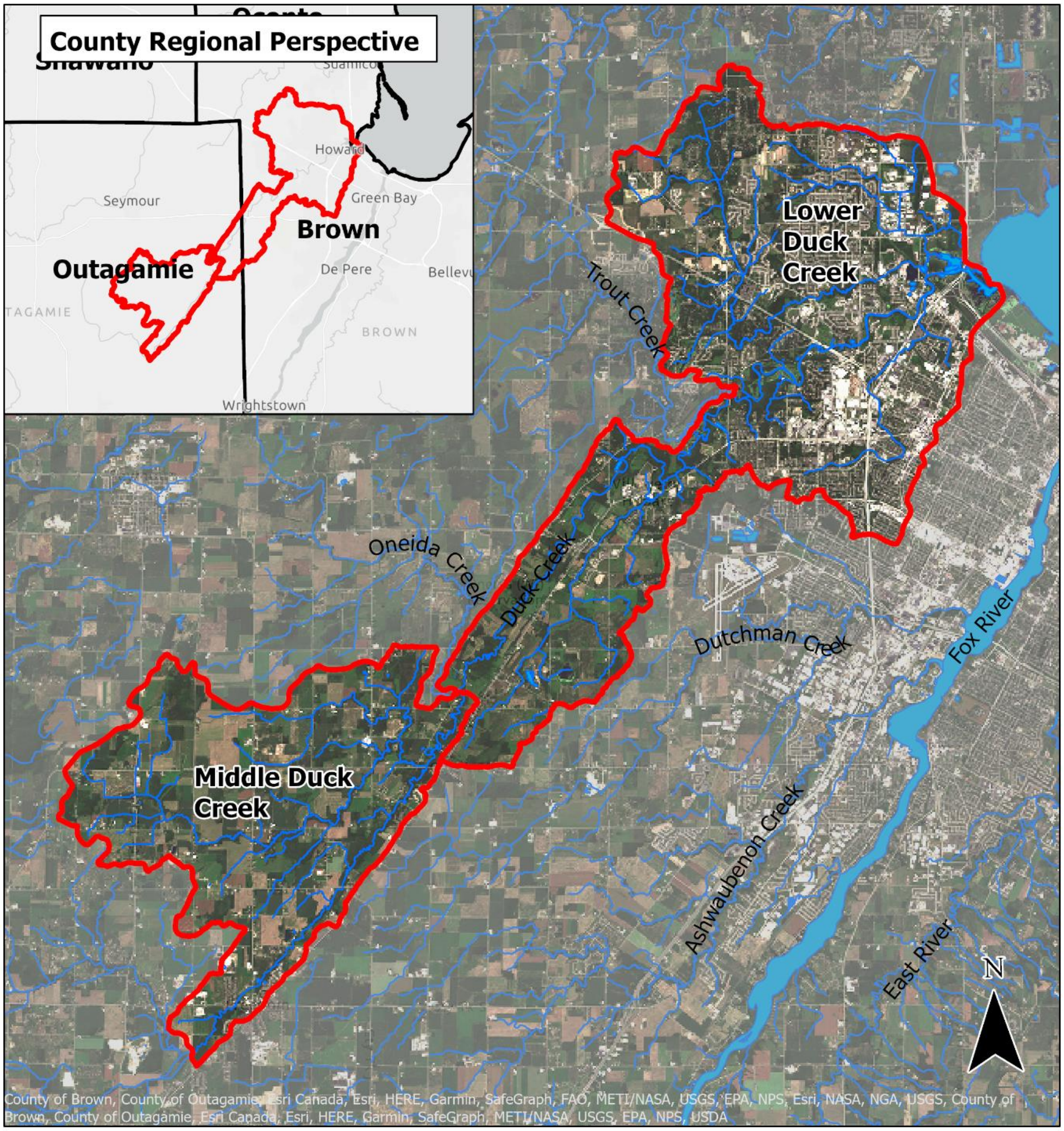

Figure 2. Middle and Lower Duck Creek hydrology and regional perspective.

The Lower Fox River basin was delineated into 69 subwatersheds for analysis based on surface hydrology, land use and the placement of monitoring stations for the Lower Fox River Total Maximum Daily Load (TMDL) (WDNR, 2012). The loads at the subwatershed scale were then aggregated and reported out in the TMDL report at the sub-basin scale. The subwatersheds were aggregated into 15 major sub-basins that make up the Lower Fox Basin. The sub-basin referred to as the Duck Creek Sub-basin in the TMDL report includes Upper, Middle, and Lower Duck Creek and the Oneida Creek subwatersheds (HUC12) (Figure 3). The sub-basin and subwatershed delineations for the TMDL do not align exactly with the equivalent national Watershed Boundary Dataset hydrologic unit levels.[1] This watershed plan summarizes watershed analysis using the national Watershed Boundary Dataset HUC 12 level boundaries for Middle and Lower Duck Creek (Figure 3). A watershed plan for the Upper Duck (HUC12) watershed was completed in 2016 where implementation is currently in progress.

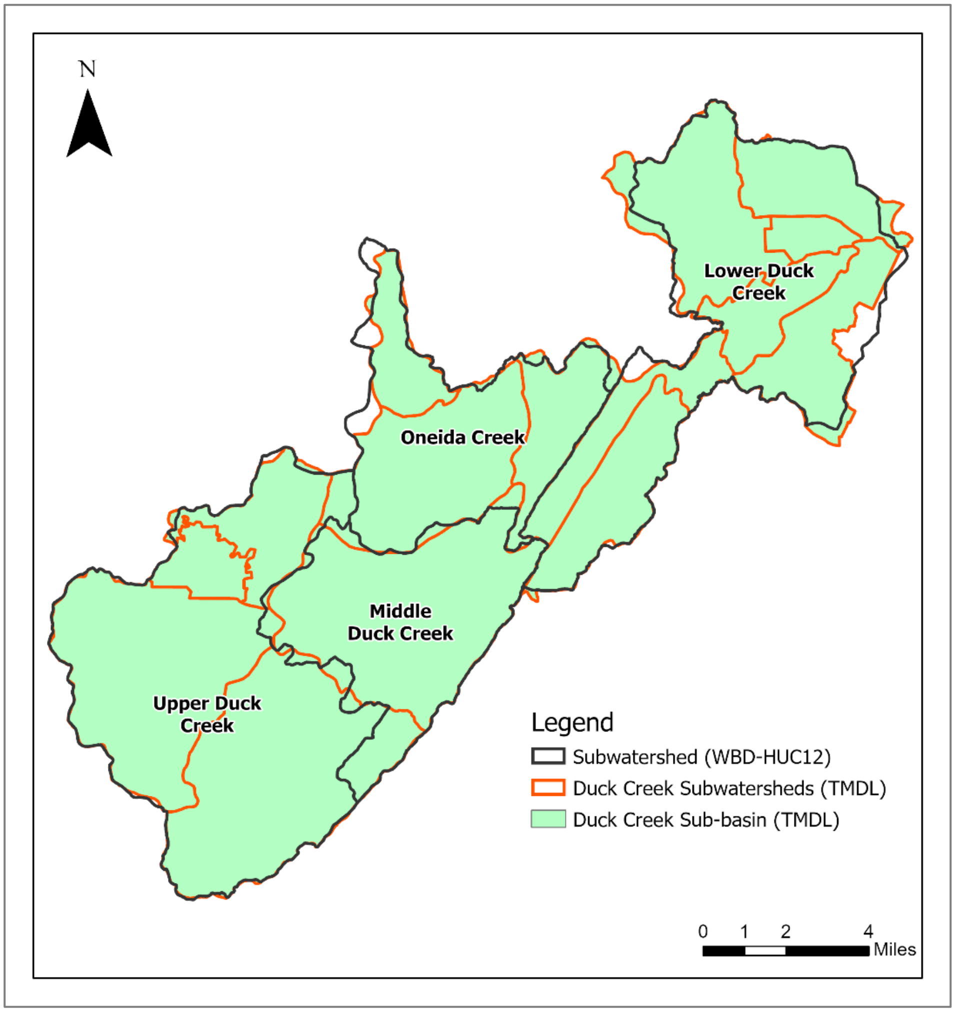

Figure 3. Lower Fox River TMDL Duck Creek sub-basin and subwatershed delineations compared to Watershed Boundary Dataset subwatersheds (HUC12).

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[1] For additional information on the Watershed Boundary Dataset see https://www.usgs.gov/core-science-systems/ngp/national-hydrography/watershed-boundary-dataset?qt-science_support_page_related_con=4#qt-science_support_page_related_con

1.2 Purpose

Excessive sediment and nutrient loading to the Lower Fox River and Bay of Green Bay has led to increased algal blooms, oxygen depletion, water clarity issues, and degraded habitat. Algal blooms can be toxic to humans and costly to a local economy. An economic impact analysis conducted in the Upper Yahara watershed region in Wisconsin found that every excess kilogram of phosphorus runoff from livestock waste results in an estimated economic loss of 74.5 USD (Sampat et al., 2021). Due to the impairments of the Lower Fox River Basin, a TMDL (Total Maximum Daily Load) was developed for the Lower Fox River basin and its tributaries, and was approved in 2012. The purpose of this project is to develop an implementation plan for the Middle and Lower Duck Creek watershed to meet the requirements of the TMDL. The Lower Fox River TMDL requires that any tributaries to the Lower Fox River meet a median summer total phosphorus (TP) limit of 0.075 mg/l or less. A median total suspended solids (TSS) limit has not been determined for tributaries but is set at 18 mg/l for the outlet of the Fox River.

Figure 4. Mouth of the Fox River emptying into the Bay of Green Bay, April 2011. Photo Credit: Steve Seilo.

1.3 US EPA Watershed Plan Requirements

In 1987, Congress enacted the Section 319 of the Clean Water Act that established a national program to control nonpoint sources of water pollution. Section 319 grant funding is available to states, tribes, and territories for the restoration of impaired waters and to protect unimpaired/high quality waters. Watershed plans funded by Clean Water Act section 319 funds must address nine key elements that the EPA has identified as critical for achieving improvements in water quality (USEPA, 2008). The nine elements from the USEPA Nonpoint Source Program and Grants Guidelines for States and Territories are as follows:

1. Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan. Sources that need to be controlled should be identified at the significant subcategory level along with estimates of the extent to which they are present in the watershed

2. An estimate of the load reductions expected from management measures.

3. A description of the nonpoint source management measures that will need to be implemented to achieve load reductions in element 2, and a description of the critical areas in which those measures will be needed to implement this plan.

4. Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.

5. An information and education component used to enhance public understanding of the plan and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.

6. Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.

7. A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.

8. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.

9. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under element 8.

1.4 Prior Studies, Projects, and Existing Resource Management and Comprehensive Plans

Various studies have been completed in the Lower Fox River Basin and Lake Michigan Basin describing and analyzing conditions in the area. Management and Comprehensive plans as well as monitoring programs have already been developed for the Lower Fox River Basin and Lake Michigan Basin. A list of known studies, plans, prior projects and monitoring programs are listed below:

Total Maximum Daily Load & Watershed Plan for Total Phosphorus and Total Suspended Solids in the Lower Fox River Basin and Lower Green Bay -2012

The *TMDL & Watershed Plan for Total Phosphorus and Total Suspended Solids in the Lower Fox River Basin and Lower Green Bay* was prepared by the Cadmus Group for the EPA and WDNR and was approved in 2012. This plan set a TMDL for the Lower Fox River and its tributaries as well as estimated current pollutant loading and loading reductions needed to meet the TMDL for each subwatershed in the Lower Fox River Basin.

Lake Michigan Lakewide Management Plan-2008

This Plan was developed by the Lake Michigan Technical Committee with assistance from the Lake Michigan Forum and other agencies and organizations. The plan focuses on improving water quality and habitat in the Lake Michigan basin including reducing pollutant loads from its tributaries.

Lower Green Bay Remedial Action Plan-1988-2021

The Lower Green Bay Remedial Action Plan is a long- term strategy for restoring water quality to the Lower Green Bay and Fox River. Two of the top five priorities for the Remedial Action Plan are to reduce suspended sediments and phosphorus. The remedial action plan is updated on annual basis by the Wisconsin Department of Natural Resources Office of Great Waters.

Nonpoint Source Control Plan for Duck, Apple and Ashwaubenon Creeks Priority Watershed Project

Nonpoint watershed plan developed for the Duck, Apple, and Ashwaubenon Creeks Watersheds that focused on phosphorus and sediment reduction. The Wisconsin Nonpoint Source Water Pollution Abatement Program provided cost sharing to landowners who voluntarily implemented best management practices in priority watershed areas. Plan implementation began in 1995 and ended in 2010. A moratorium on signing agreements for non-structural practices was placed on September 5, 2001, which put the upland sediment goal of the plan out of reach. A final project report also concluded that the watershed would also benefit from more buffered areas between cropland and streams.

Hydrology, Phosphorus, and Suspended Solids in Five Agricultural Streams in the Lower Fox River and Green Bay Watersheds, Wisconsin, Water Years 2004-2006

A 3-year study completed by the U.S. Geological Survey and University of Wisconsin-Green Bay to characterize the hydrology, phosphorus, and suspended solids in five agricultural streams (East River, Apple Creek, Baird Creek, Ashwaubenon Creek, Duck Creek) in the Lower Fox River basin and provided information to assist in the calibration of a watershed model for the area.

Non-Point Source Runoff Storage Capacity Opportunities for Sediment & Nutrient Reduction in the Lower Fox River Basin- 2020

Analysis completed by the Outagamie County Land Conservation Department in collaboration with WDNR to quantify the water storage capacity needed to return to pre-settlement land use runoff conditions. The analysis will be used to guide the implementation of conservation practices that will permanently restore water storage capacity while trapping sediment and phosphorus.

The State of the Bay- The Condition of the Bay of Green Bay/Lake Michigan-2013

The 2013 State of the Bay report is the third edition that has been published since 1990. The first edition was published in 1990 and the second edition in 1993. The State of the Bay reports identify chemical, physical, biological, and social indicators of the "health" of the bay and assess the current status and how it is changing. The third edition identified the following areas as needing work: high phosphorus concentrations, increasing nitrate/nitrite concentrations, high suspended solids concentrations, high chlorophyll A levels, poor water clarity, unacceptable levels of toxic chemicals (PCB, dioxins, DDT, arsenic, and mercury), aquatic invasive species, and low benthic macroinvertebrate levels. The following areas of progress from earlier years (1970s and 1980s) were identified in the third edition: decrease in ammonia levels, improvement in dissolved oxygen levels, improvements in walleye, spotted musky and northern pike populations, decrease in amount of beach closings.

Exploration of the Use of Treatment Wetlands as a Nutrient Management Strategy in Wisconsin-2016

A study completed by The Nature Conservancy (TNC) to explore, evaluate, and advance the role of treatment wetlands (created and re-established) as a potential component of agricultural nutrient management strategies. The Nature Conservancy explored scientific literature and conducted interviews with experts in the field on the effectiveness of using wetlands to reduce phosphorus and nitrogen loads in agricultural systems. The study identified additional research needs and provided recommendations for reducing non-point source pollution.

Lower Green Bay and Fox River Area of Concern (AOC) Fish and Wildlife Habitat Assessment-Wildlife Habitat and Water Quality Opportunities-2018

A report by The Nature Conservancy on the Lower Fox River and Green Bay Area of Concern (LFRGB AOC) watershed to support removal of the "Degradation of Fish and Wildlife Populations" and "Loss of Fish and Wildlife Habitat" beneficial use impairments (BUIs) of LFRGB AOC. The report is a companion to the report produced by University of Wisconsin-Green Bay "Phase 1 of the Lower Green Bay and Fox River AOC Fish and Wildlife Habitat and Populations Assessment". The Nature Conservancy assessed wetland projects that can benefit water quality in the AOC, fish connectivity and barriers for tributaries of the AOC, and habitat opportunities in the East River and Duck Creek riparian corridors. Results from the three assessments can be viewed in an online decision support tool "Wildlife Recovery: Lower Green Bay & Fox River AOC Explorer" accessible at https://maps.freshwaternetwork.org/wisconsin/.

Silver Creek Watershed Pilot Project- 2014-2021

In 2014, NEW Water, the brand of the Green Bay Metropolitan Sewerage District, pursued an Adaptive Management Pilot Project in the Silver Creek Watershed, which is a subwatershed of the Lower Duck Creek watershed. NEW Water undertook the project to gain experience in reducing phosphorus and sediment through partnerships with nonpoint sources. NEW Water partnered with state, local, and tribal government agencies and other non-governmental organizations to implement a variety of best management practices during this time period. Additional information on the project can be found at https://www.newwater.us/projects/silver-creek .

Stream Corridor Sources of Suspended Sediment and Phosphorus from an Agricultural Tributary to the Great Lakes-2019

In 2016-2018, an integrated sediment fingerprinting and stream corridor-based sediment budget study was conducted by the USGS in Plum Creek, WI to help quantify the upland and stream corridor sources of suspended sediment and phosphorus. Study results showed that the proportion of upland and stream corridor sources varied by season and the amount of runoff. However, streambank and gully erosion accounted for 51% and 24% of the suspended sediment annual load. Cropland and woodland sources accounted for small proportions of the suspended sediment. Relative source proportions for sediment-bound phosphorus were similar to suspended sediment. The high proportion of sources from banks and gullies is partially due to the deeply entrenched valley and steep eroding bluffs between the cropland and the Plum Creek monitoring station. Conference paper details at https://pubs.er.usgs.gov/publication/70217015 .

Stream Corridor and Upland Sources of Fluvial Sediment and Phosphorus from a Mixed Urban-Agricultural Tributary to the Great Lakes- Draft 2021

In 2017-2018 an integrated stream sediment budget and sediment fingerprinting study was conducted in Apple Creek, WI to quantify upland and stream corridor sources of suspended sediment and sediment bound phosphorus. The relative proportion of suspended sediment varied by season and streamflow. Cropland and streambank erosion accounted for 54% and 23% of the suspended sediment when weighted by an estimate of the proportion for representative streamflow.

1.5 Wisconsin Ecoregion

Ecoregions are based on biotic and abiotic factors such as climate, geology, vegetation, wildlife, and hydrology. The mapping of ecoregions is beneficial in the management of ecosystems and has been derived from the work of James M. Omernik of the USGS. The Middle and Lower Duck Creek watershed is located in the Southeastern Wisconsin Till Plains ecoregion and in the Lake Michigan Lacustrine clay sub ecoregion (Figure 5). The Southeastern Wisconsin Till Plains supports a variety of vegetation types from hardwood forests to tall grass prairies. Land used in this region is mostly for cropland and has a higher plant hardiness value than in ecoregions to the north and west.

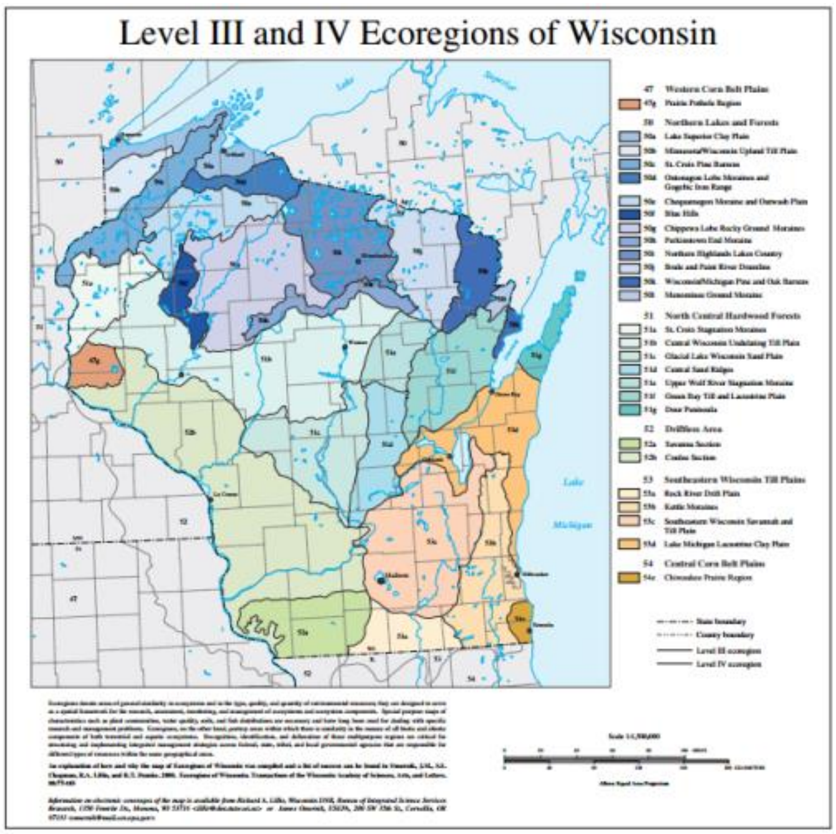

Figure 5. Map of Ecoregions of Wisconsin. (Omernik et al, 2000)

1.6 Climate

Wisconsin has a continental climate that is affected by Lake Michigan and Lake Superior. Wisconsin typically has cold, snowy winters and warm summers. The average annual temperature ranges from 39°F in the north to about 50°F in the south. Temperatures can reach minus 30°F or colder in the winter and above 90°F in the summer. Average annual precipitation is about 30 inches a year in the watershed area. The climate in central and southern Wisconsin is favorable for dairy farming, where corn, small grains, hay, and vegetables are the primary crops.

1.7 Topology and geology

The Middle and Lower Duck Creek watershed lies in the Eastern Ridges and Lowlands geographical province of Wisconsin. The watershed area was part of the glaciated portion of Wisconsin. During the last Ice Age the Laurentide Ice Sheet began to advance into Wisconsin where it expanded for 10,000 years before it began to melt back after another 6,500 years. Glaciers have greatly influenced the geology of the area. The topography is generally smooth and gently sloping with some slopes steepened by postglacial stream erosion. The main glacial landforms are ground moraine, outwash, and lake plain.

Figure 6. Ice Age Geology of Wisconsin. (Mickelson & Attig, 2017)

The highest elevations near 840 ft above sea level in the Northwest portion of the Middle Duck Creek and the lowest elevations are around 550 feet above sea level near Green Bay where Duck Creek outlets (Figure 7). There is a 290-foot change in elevation from highest and lowest point in the watershed area.

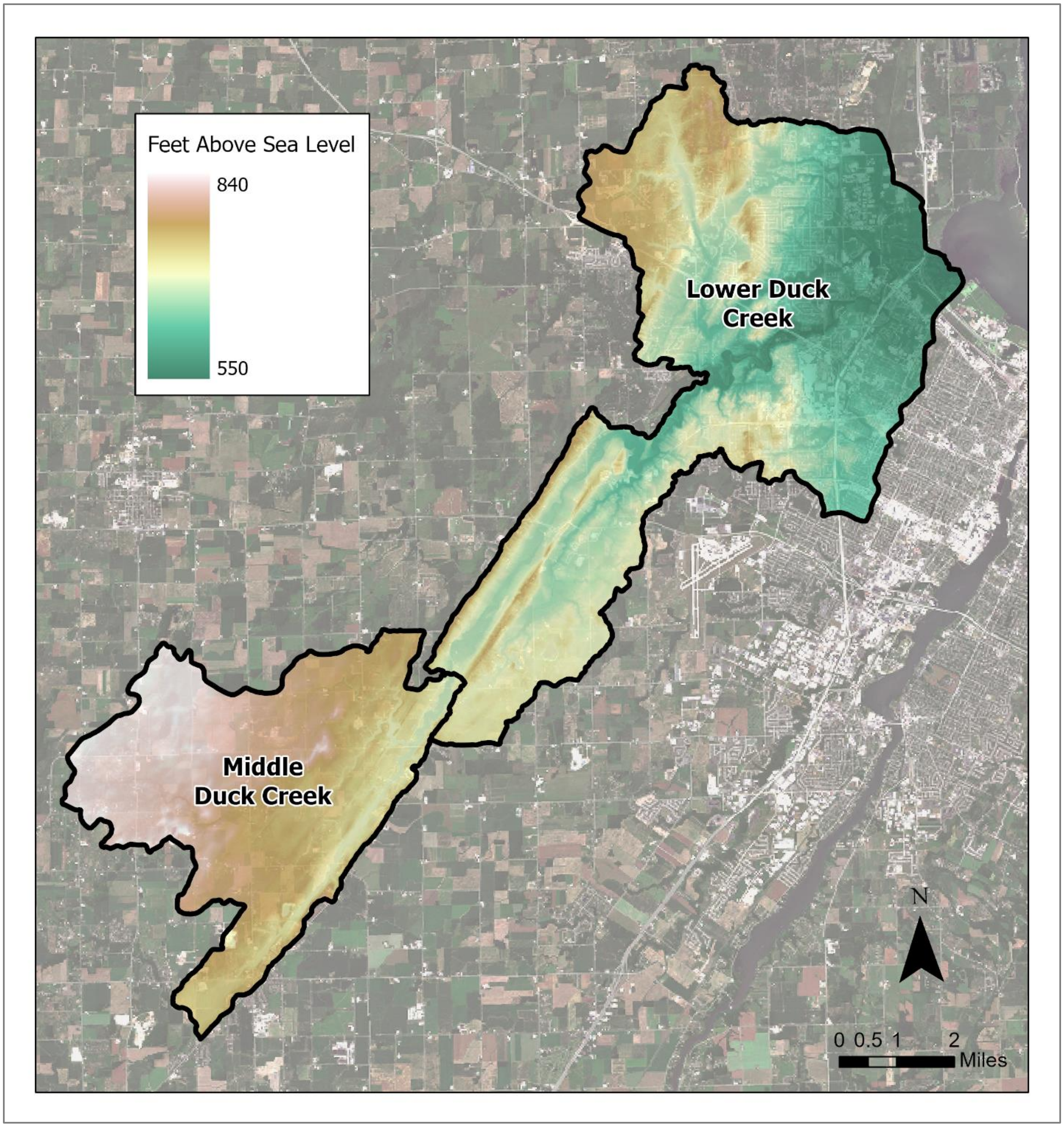

Figure 7. Digital elevation model Middle and Lower Duck Creek Watershed.

1.8 Soil Characteristics

Soil data for the watershed was obtained from the Natural Resources Conservation Service (SSURGO) database. The type of soil and its characteristics are important for planning management practices in a watershed. Factors such as erodibility, hydric group, slope, and hydric rating are important in estimating erosion and runoff in a watershed.

The dominant soil types in the Middle Duck Creek watershed are Hortonville Silt Loam (33.4%), Symco Silt Loam (20.0%) and Hortonville-Symco Silt Loams (10.7%). In the Lower Duck Creek watershed, the dominant soil types are Kewaunee Silt Loam (7.2%), Oshkosh Silt Loam (6.5%), Boyer Fine Loamy Sand (6.5%), Shawano Loamy Fine Sand (5.2%) and Sisson Fine Sandy Loam (5.0%).

Hydrologic Soil Group

Soils are classified into hydrologic soil groups based on soil infiltration and transmission rate (permeability). Hydrologic soil group along with land use, management practices, and hydrologic condition determine a soil's runoff curve number. Runoff curve numbers are used to estimate direct runoff from rainfall. There are four hydrologic soil groups: A, B, C, and D. Descriptions of Runoff Potential, Infiltration Rate, and Transmission rate of each group are shown in Table 1. Some soils fall into a dual hydrologic soil group (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and water table depth when drained. The first letter applies to the drained condition and the second letter applies to the undrained condition. Table 2 summarizes the acreage and percent of each group present in the watershed and Figure 8 shows the location of each hydrologic soil group. The dominant hydrologic soil group in each watershed is Group C (54.5% Middle, 32.1% Lower). Group D soils have the highest runoff potential followed by group C.

Table 1. Hydrologic soil group description.

HSG	Runoff Potential	Infiltration Rate	Transmission Rate
A	Low	High	High
B	Moderately Low	Moderate	Moderate
C	Moderately High	Low	Low
D	High	Very Low	Very Low

Table 2. Hydrologic soil group.

HSG	Middle Duck		Lower Duck	
	Acres	Percent	Acres	Percent
A	625	4.2%	4,436	16.1%
A/D	680	4.6%	1,789	6.5%
B	889	6.0%	3,530	12.8%
B/D	1,238	8.4%	2,516	9.1%
C	8,051	54.5%	8,867	32.1%
C/D	3,118	21.1%	2,267	8.2%
D	107	0.7%	2,291	8.3%
Not Classified	68	0.5%	1,922	7.0%
Total	**14,775**	**100.0%**	**27,616**	**100.0%**

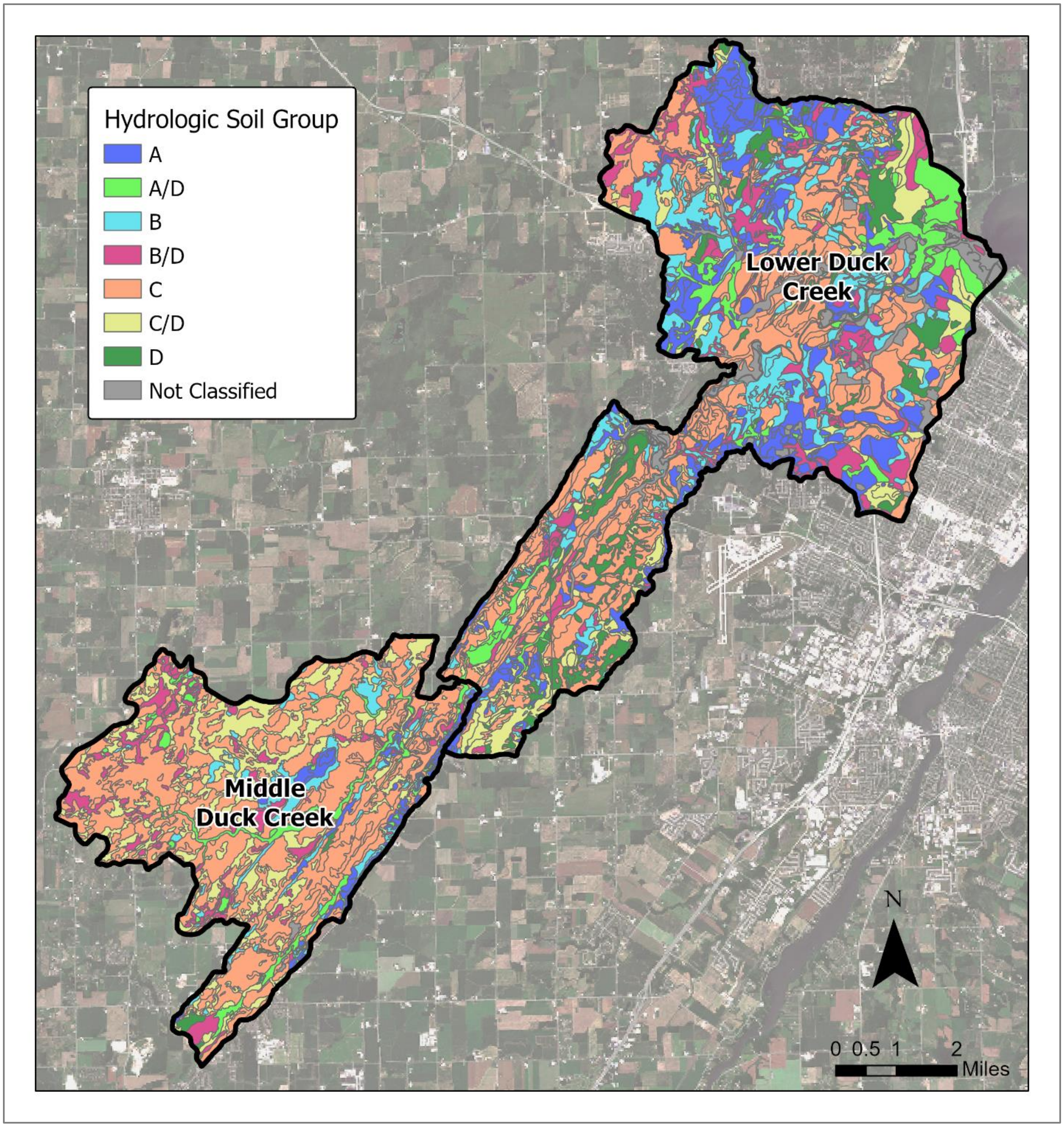

Figure 8. Hydrologic soil group.

Soil Erodibility

The susceptibility of a soil to wind and water erosion depends on soil type and slope. The soil erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. It is one of the six factors used in the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons/acre/year. Soils high in clay have low K values because they resist detachment, while coarse textured soils (sand) have low K values because of low runoff. Soils with a high silt content are most erodible since they are easily detached and produce high rates of runoff. Values of K factor range from 0.02 for least erodible soils to 0.64 for the most erodible. Values of K for the Middle and Lower Duck Creek watershed range from 0.02 to 0.55. Soil erodibility factors for Middle and Lower Duck Creek watershed are shown in Figure 9, soils with high erodibility are indicated by orange and red.

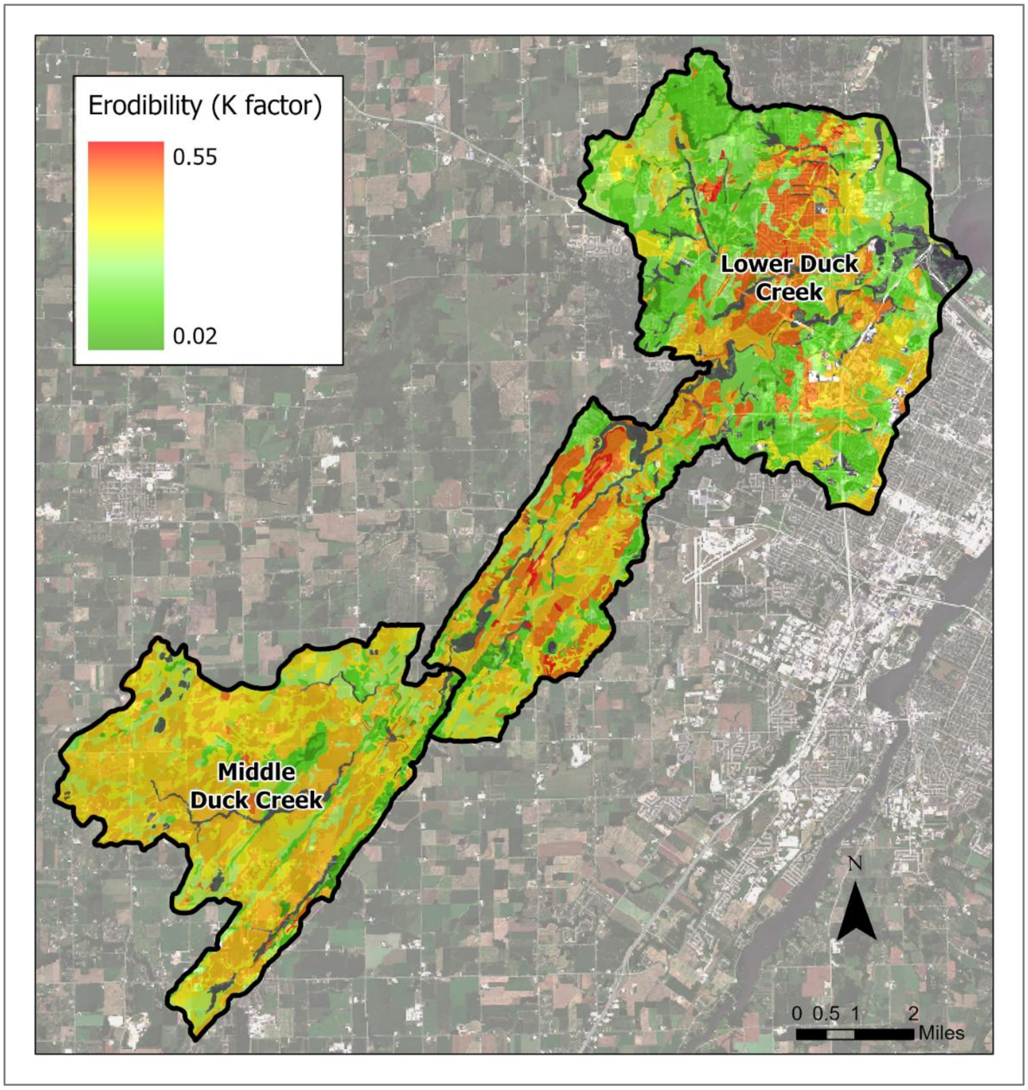

Figure 9. Soil erodibility.

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2.0 Watershed Jurisdictions, Demographics, and Transportation Network

2.1 Watershed Jurisdictions

The Middle and Lower Duck Creek watershed is located in Brown and Outagamie Counties. The City of Green Bay, Village of Howard, Village of Hobart, Village of Ashwaubenon, Village of Suamico, Town of Freedom, Town of Osborn, Town of Oneida, and Town of Pittsfield are located in the watershed area (Figure 10). The Oneida Nation also encompasses a significant portion of the Middle and Lower Duck Creek Watershed.

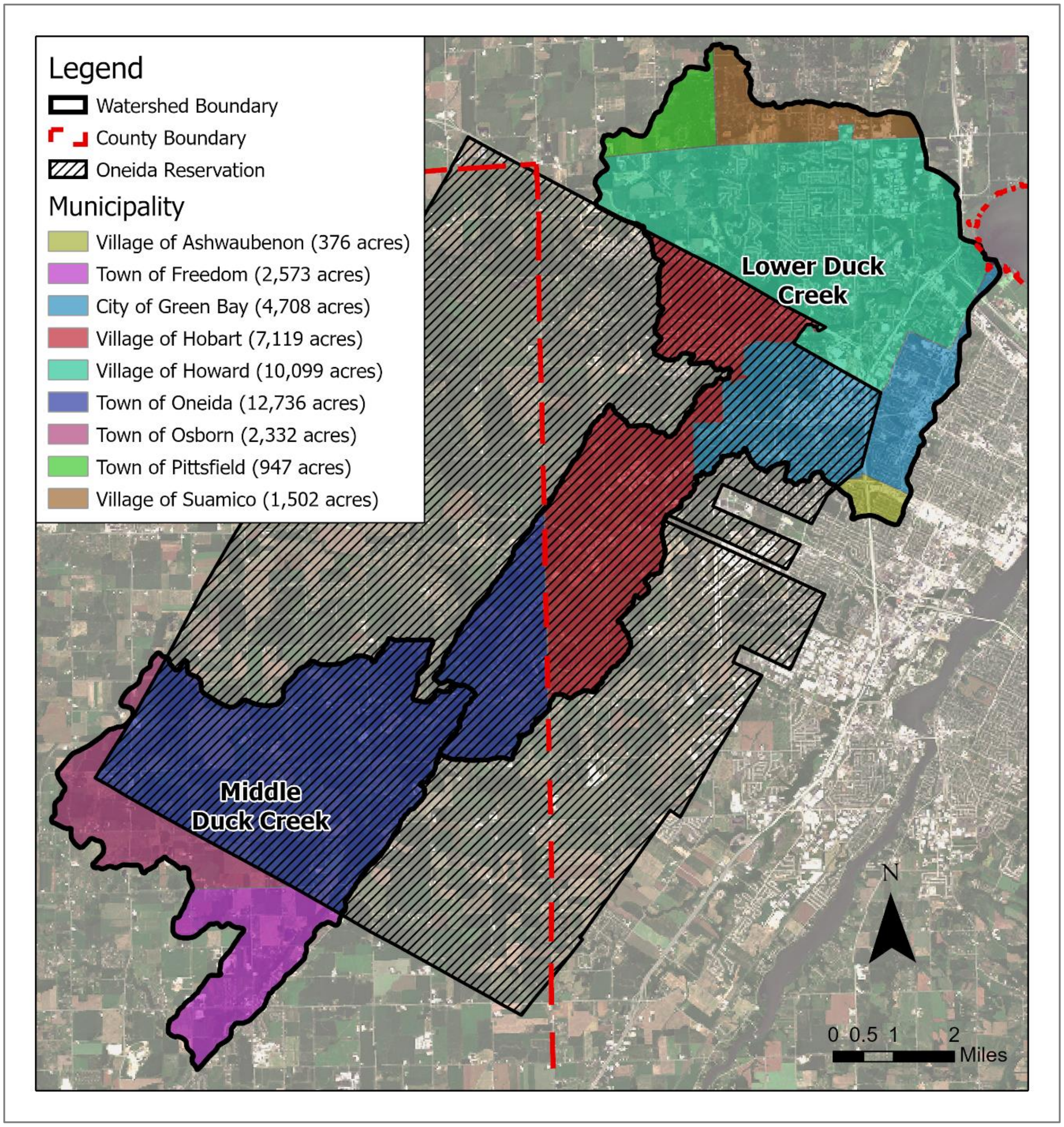

Figure 10. Watershed jurisdictions.

2.2 Jurisdictional Roles and Responsibilities

Natural resources in the United States are protected to some extent under federal, state, and local law. The Clean Water Act is the strongest regulating tool at the national level. In Wisconsin, the Wisconsin Department of Natural Resources (WDNR) has the authority to administer the provisions of the Clean Water Act. The U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers work with the WDNR to protect natural areas, wetlands, and threatened and endangered species. The Safe Drinking Water Act also protects surface and groundwater resources.

Counties and other local municipalities in the watershed area have established ordinances regulating land development and protecting surface waters. Many municipalities in the watershed have ordinances relating to shoreland and wetland zoning, erosion control and storm water. Municipalities have to meet the minimum requirements of county ordinances; however, they have the ability to adopt higher levels of protection. In addition to urbanization-level regulations, Outagamie and Brown Counties both have Animal Waste Management & Runoff Management ordinances and the implementation of the Farmland Preservation Program[2] to provide additional watershed protection beyond existing ordinances under local municipal codes. Brown County also has an Agricultural Shoreland Management ordinance.

The Oneida Nation has jurisdiction on a significant portion of the watershed area. The Oneida Nation has intergovernmental service agreements with the Town of Oneida, Village of Ashwaubenon, City of Green Bay, Outagamie County and Brown County. The Oneida Nation works with Outagamie and Brown County on the implementation of land and water conservation work on Oneida owned land.

The Northeast Wisconsin Stormwater Consortium (NEWSC) is a private entity in the watershed area that provides a technical advisory role to local municipalities and engineering consultants. In 2002, Fox Wolf Watershed Alliance began exploring the creation of an organization to assist local and county governments in cooperative efforts to address storm water management, which led to the creation of NEWSC. Brown County, Outagamie County, the City of Green Bay, Village of Howard, Village of Ashwaubenon, Village of Suamico and the Village of Hobart have representatives in the organization. NEWSC facilitates efficient implementation of storm water programs that meet WDNR and EPA regulatory requirements and maximize the benefit of storm water activities in the watershed by fostering partnerships, and by providing technical, administrative, and financial assistance to its members.

Other governmental and private entities with watershed jurisdictional or technical advisory roles include: Natural Resources Conservation Service (NRCS), Department of Agriculture, Trade, and Consumer Protection (DATCP), Bay Lake Regional Planning Commission (BLRPC), East

[2] Additional information on the Farmland Preservation Program can be found at https://datcp.wi.gov/Pages/Programs_Services/FarmlandPreservation.aspx.

Central Wisconsin Regional Planning Commission (ECWRPC) and the Wisconsin Department of Transportation (WDOT).

2.3 Transportation

The major roads that run through the Middle and Lower Duck Creek watershed include WI State Highways 172, 29/32, 54, 55; County Highways J, S, C, EE, H, E, U, FF, EB, GE; and Interstate I-41(Figure 11). The Canadian National Railway and Escanaba and Lake Superior Railway run through the Lower Duck Watershed. The Mountain Bay State Trail also runs through the Lower Duck Watershed all the way up to Weston, WI.

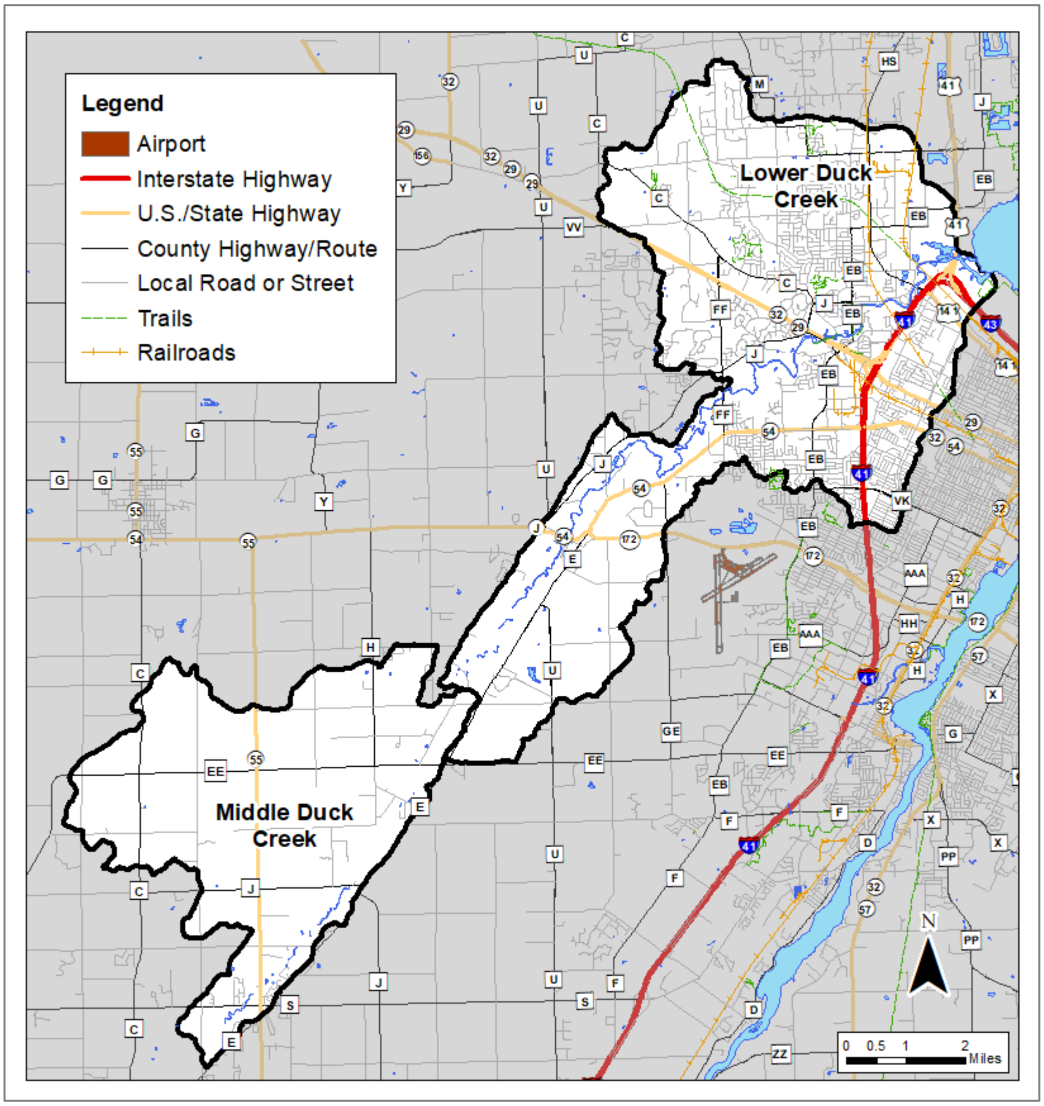

Figure 11. Transportation.

2.4 Population Demographics

The Middle Duck Creek watershed is mostly rural. In contrast, the northeast portion of Lower Duck Creek is urbanized and highly populated. The population in the Village of Howard and Village of Hobart in the Lower Duck Watershed is expected to continue to grow in population, based on ESRI's (Environmental Systems Research Institute) estimated population changes from 2021-2026 (Figure 12). Predictions on population change were based on the 2010 Census. Urban sprawl from the City of Green Bay and neighboring areas could further impact the amount of land available for agriculture in the area in the future.

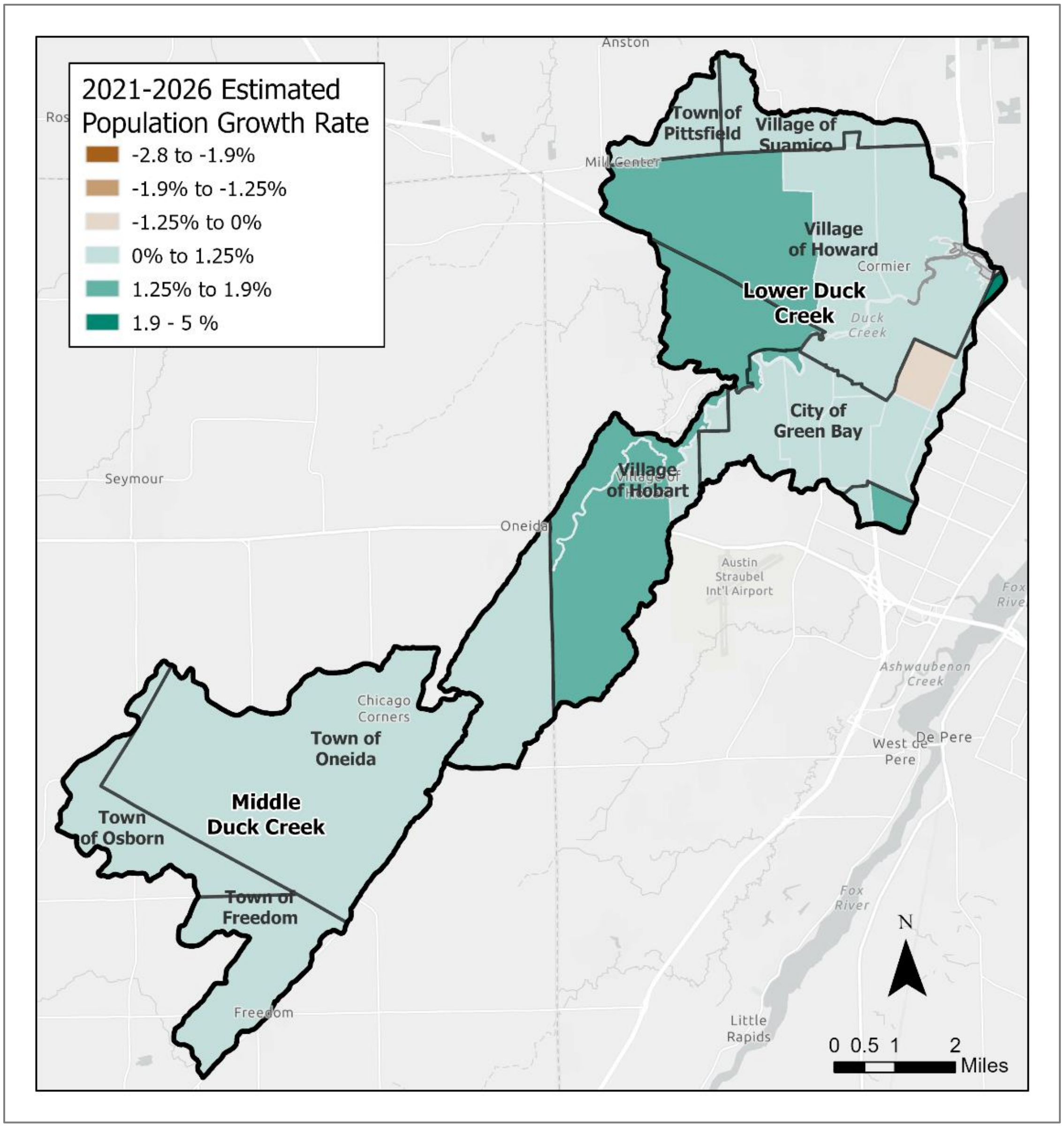

Figure 12. Estimated population growth 2021-2026 (Source: ESRI).

Median annual income and population data was collected from 2015-2019 by the American Community Survey. Median annual income and population for municipalities in the watershed is shown in Table 3.

Table 3. Population and median house hold income. Source: U.S. Census Bureau (2019 American Community Survey 5 Year Estimates)

Municipality	Population	Median Household Income	Percent Land Area of Jurisdiction in Watershed
City of Green Bay	104,777	$49,251	11.1%
Village of Hobart	9,053	$80,364	16.8%
Village of Howard	19,658	$70,385	23.8%
Village of Ashwaubenon	17,149	$59,413	0.9%
Village of Suamico	12,701	$101,479	3.5%
Town of Pittsfield	2,758	$86,750	2.2%
Town of Freedom	6,149	$83,935	6.1%
Town of Osborn	1,221	$101,354	5.5%
Town of Oneida	4,729	$58,783	30.0%

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3.0 Land Use/Land Cover

3.1 Existing Land Use/Land Cover

Existing land use and land cover in the Middle and Lower Duck Creek watershed was determined in GIS (geographic information system) using digital aerial photography and several spatial land use datasets (See Appendix B). Land use was broken down into four categories: Agriculture, Natural Background (forests, wetlands, grassland), Urban (industrial, residential, transportation and commercial), and Water (Figure 13). Agriculture is the dominant land use in the Middle Duck watershed while Urban/Developed is the dominant land use in the Lower Duck watershed (Table 4).

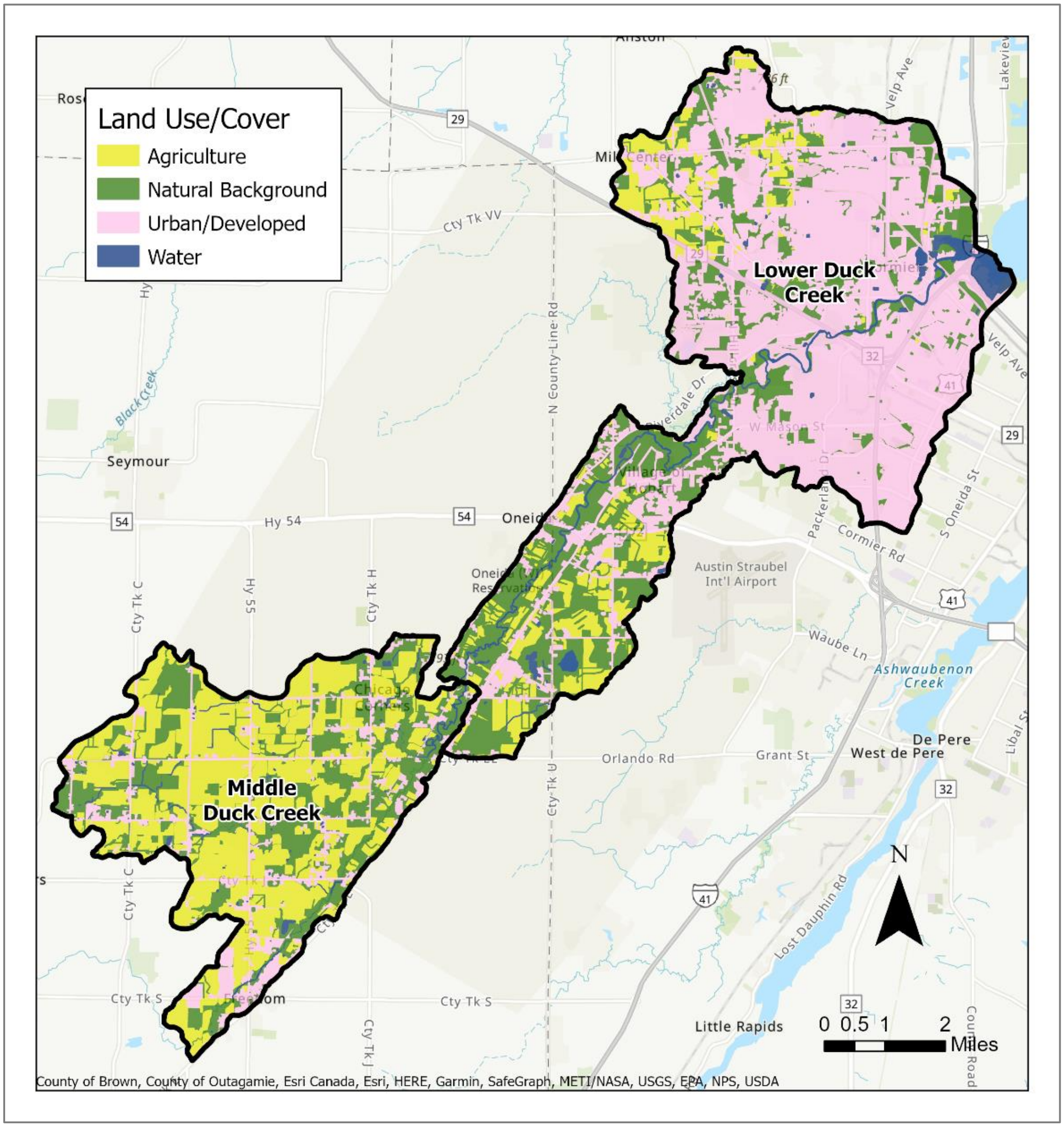

Figure 13. Current land use in Middle and Lower Duck Creek Watershed.

Table 4. Summary of land use in the Middle and Lower Duck Creek watershed.

Land Use/Cover	Middle Duck		Lower Duck	
	Acres	Percent	Acres	Percent
Agriculture	8,152	55.2%	3,803	13.8%
Urban/Developed	2,094	14.2%	14,829	53.7%
Natural Background	4,338	29.4%	8,346	30.2%
Water	192	1.3%	638	2.3%
Total	**14,776**		**27,616**	

3.2 Crop Rotation

Cropland data was obtained from the USDA National Agriculture Statistics Service (NASS). NASS produced the Cropland Data Layer using satellite images at 30 meter observations, Resourcesat-1 Advanced Wide Field Sensor, and Landsat Thematic mapper. Data from 2016 to 2020 was analyzed using the WDNR EVAAL[3] tool to obtain a crop rotation. Crop rotations for the watershed are shown in Table 5 and Figure 14.

Dairy is the dominant crop rotation at 53.5% in Middle Duck and 45.7% in Lower Duck Creek watershed followed by cash grain at 32.2% and 37.5% respectively. Different crop rotations can affect the amount of erosion and runoff that is likely to occur on a field. Corn is often grown in dairy rotations and harvested for corn silage; harvesting corn silage leaves very little residue on the field making the field more susceptible to soil erosion and nutrient loss. Changing intensive row cropping rotations to a conservation crop rotation can decrease the amount of soil and nutrients lost from a field. Increasing the conservation level of crop rotation can be achieved by adding years of grass and/or legumes, adding diversity of crops grown, or adding annual crops with cover crops.

Table 5. Crop rotation in Middle and Lower Duck watershed.

Crop Rotation	Middle Duck		Lower Duck	
	Acres	Percent	Acres	Percent
Dairy Rotation	4,335	53.5%	1,725	45.7%
Cash Grain	2,612	32.2%	1,414	37.5%
Pasture/Hay/Grassland	1,054	13.0%	460	12.2%
Continuous Corn	93	1.1%	82	2.2%
Potato/Grain/Vegetable	15	0.2%	12	0.3%
Other	0	0.0%	77	2.0%
Total	**8,109**		**3,770**	

[3] Additional information on EVAAL can be found at http://dnr.wi.gov/topic/nonpoint/evaal.html.

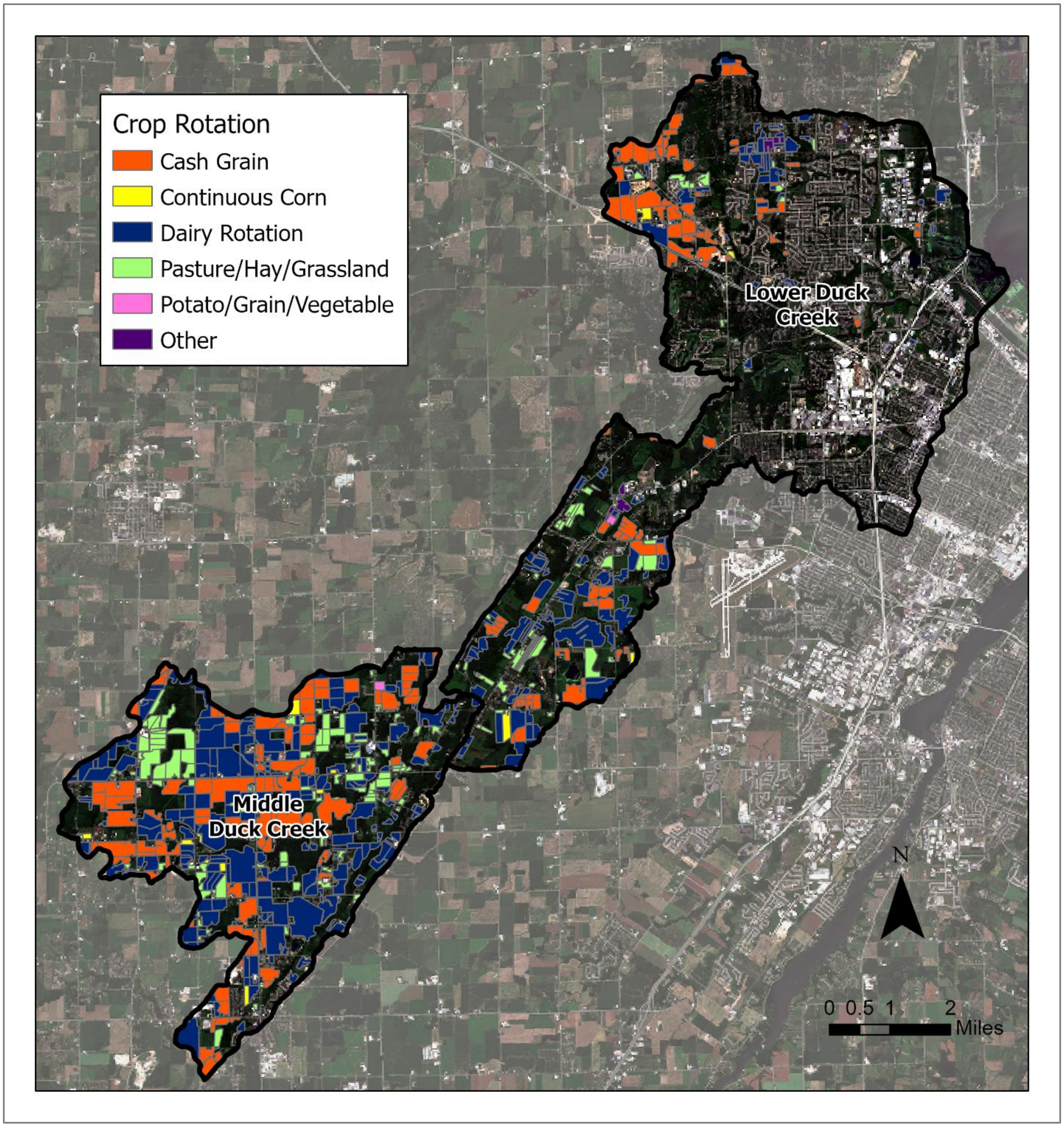

Figure 14. Crop rotation (2016-2020).

3.3 Future Land Use

Communities near Green Bay are rapidly developing and expanding. Future land use data for 2040 was obtained from Brown County; 2030 data was obtained from Outagamie County. Future land use planning data for 2040 for Brown County shows large portions of agricultural land in the Village of Howard and Village of Hobart in Lower Duck being converted to residential and other urban land uses. Approximately 1,230 acres of agricultural land in Lower Duck is expected to be developed by 2040. Future land use data for Outagamie County, updated in 2020, shows agricultural land (approximately 649 acres) in the Town of Freedom being converted to residential and other urban land uses in the Middle Duck Watershed with little change elsewhere in the watershed. Figure 15 shows existing agricultural land and natural background (forest, wetland, or grassland) expected to be converted to urban land uses shown in red hatching.

If urbanization continues as predicted and land currently used for agriculture continues being converted for urban use, then TP and TSS loads attributed to agricultural runoff would decrease, with a net decrease in phosphorus and sediment runoff expected due to storm water management requirements for developed areas. However, less available agricultural land may lead to increased phosphorus runoff from remaining agricultural land. A decrease in agricultural land may lead to increased manure application rates on remaining acres if animal unit numbers in the watershed stay the same or increase, likely increasing nutrient runoff potential if not managed properly. Additionally, the loss of farmland may lead to encroachment or conversion of existing natural areas to farmland, which may also negatively impact water quality.

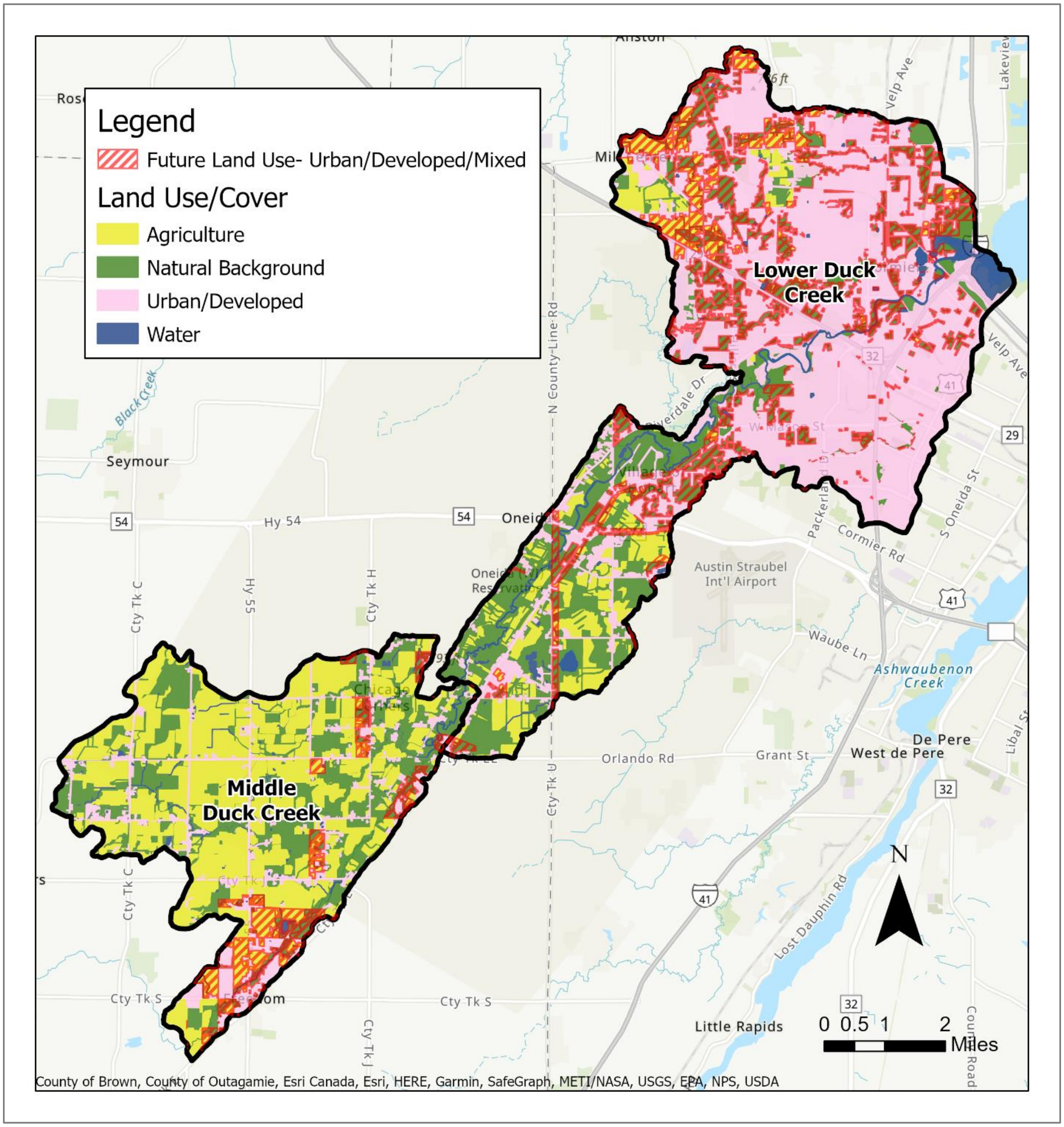

Figure 15. Future urban land use.

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4.0 Water Quality

The federal Clean Water Act requires states to adopt water quality criteria that the EPA publishes under 304(a) of the Clean Water Act, modify 304(a) criteria to reflect site-specific conditions, or adopt criteria based on other scientifically defensible methods. Water quality standards require assigning a designated use to the water body.

4.1 Designated Use and Impairments

A 303(d) list is comprised of waters impaired or threatened by a pollutant, and needing a TMDL. States submit a separate 303(b) report on conditions of all waters. The EPA recommends that states combine the threatened and impaired waters list, 303(d) report, with the 303(b) report to create an "integrated report". Duck Creek was first listed as an impaired waterway for total phosphorus in 1998 and sediment in 2008. Figure 16 shows stream segments in the Middle and Lower Duck Creek watershed listed as impaired.

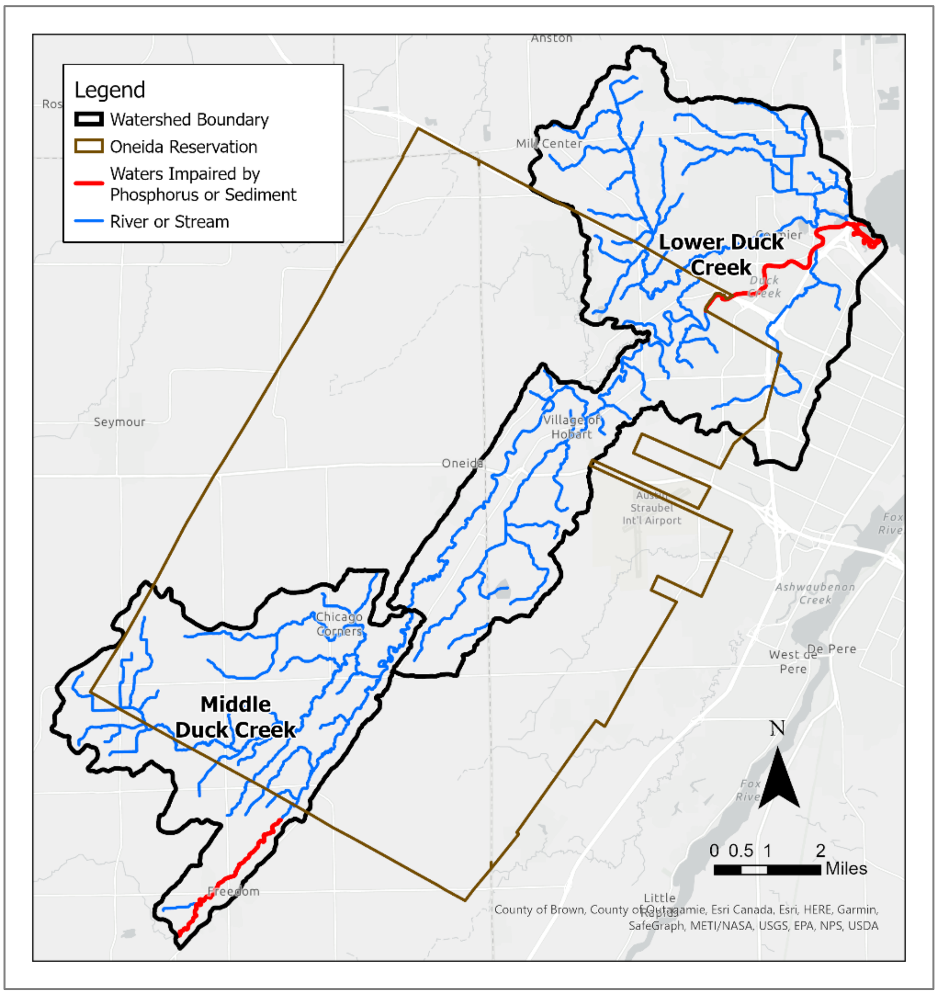

Figure 16. Waters impaired by phosphorus or sediment.

In Figure 16, Duck Creek is not shown as impaired in the Oneida Nation boundary because the State of Wisconsin does not have the authority to develop TMDLs for these waters. The Oneida Nation does not currently have Water Quality Standards Program authorization from EPA. TMDLs can only be developed for waters that are not meeting EPA-approved water quality standards. However, the mainstem of Duck Creek exhibits the same impairments due to phosphorus and sediment in the Oneida Nation boundary as it does outside the boundary.

Streams and Rivers in Wisconsin are assessed for the following use designations: Fish and Aquatic Life, Recreational Use, Fish Consumption (Public Health and Welfare), and General Uses. The Middle and Lower Duck Creek are designated for Fish and Aquatic Life. The Fish and Aquatic Life (FAL) designations for streams and rivers are categorized into subcategories. Middle and Lower Duck Creek are currently capable of supporting a Warmwater Dependent Forage Fishery (WWFF) Community. Aquatic life communities in this category usually require cool or warm temperatures and concentrations of Dissolved Oxygen (DO) that do not drop below 5 mg/l. The streams and rivers are also being evaluated for placement in a revised aquatic life use classification system where the subclasses are referred to as Natural Communities. The mainstem of Middle and Lower Duck Creek's natural community is classified as a Cool-Cold Headwater/Cool-Warm Headwater.

4.2 Point Sources

Point sources of pollution are discharges that come from a pipe or point of discharge that can be attributed to a specific source. In Wisconsin, the Wisconsin Pollutant Discharge Elimination System (WPDES) regulates and enforces water pollution control measures. The WI DNR Bureau of Water Quality issues the permits with oversight of the US EPA. There are four types of WPDES permits: Individual, General, Storm Water, and Agricultural permits.

Individual

Individual permits are issued to municipal and industrial wastewater treatment facilities that discharge to surface and/or groundwater. WPDES permits include limits that are consistent with the approved TMDL Waste Load Allocations. There is one municipal and one industrial wastewater treatment facility in the Middle Duck Creek watershed.

Agricultural

State and federal laws also require that Concentrated Animal Feeding Operations (CAFO) have water quality protection permits. An animal feeding operation is considered a CAFO if it has 1,000 animal units or more. A smaller animal feeding operation may be designated a CAFO by the WDNR if it discharges pollutants to a navigable water or to groundwater. There is currently only one permitted CAFO in the Middle Duck Creek watershed. Permits for CAFO's require that the production area (areas where animals are housed or otherwise confined, manure is stored and feed is stored) have zero discharge. Permitted CAFO's are also expected to have the fields that they own and operate meet state runoff standards.

General

General permits are issued for specific categories - industrial, municipal and other wastewater discharges. A list of current WPDES general permits available can be found at https://dnr.wi.gov/topic/wastewater/GeneralPermits.html.

Storm Water

To meet the requirements of the federal Clean Water Act, the WDNR developed a state Storm Water Permits Program under Wisconsin Administrative Coded NR 216. The Storm Water Permits Program regulates discharges from construction sites, industrial facilities and municipalities.

Municipal Separate Storm Sewer Systems

A Municipal Separate Storm Sewer System (MS4) permit is required for a municipality that is either located within a federally designated urbanized area, has a population of 10,000 or more, or the DNR designates the municipality for permit coverage. Municipal permits require storm water management programs to reduce polluted storm water runoff. Brown and Outagamie Counties both have a general MS4 permit # WI-S050075-2. The general permit requires an MS4 holder to develop, maintain, and implement storm water management programs to prevent pollutants from the MS4 from entering state waters.

Once the EPA approves a TMDL that includes permitted MS4s, the next permit issued must contain an expression of Waste Load Allocations (WLA) consistent with the assumptions and requirements contained in the TMDL. MS4 permittees will have the primary role in establishing benchmarks for each 5-year permit term. It is expected that the 2nd reissuance of an MS4 permit after the TMDL is approved include a compliance schedule to meet applicable TMDL reductions in the MS4 permit. The compliance schedule will require the permittee to show progress by meeting "benchmarks" of performance within each permit term. It is expected that MS4 permittees will have the primary role in establishing their own benchmarks for each 5-year permit term. MS4 permittees are not assigned a defined timeline for compliance; therefore, the implementation schedule of MS4s may not align with the timelines assigned to point source permits in the basin or nonpoint watershed implementation schedules.

There are only MS4 urban municipalities in the Lower Duck Creek watershed. Urban MS4 municipalities in the Lower Duck Creek watershed include the City of Green Bay, Village of Ashwaubenon, Village of Howard, Village of Suamico and the Village of Hobart. The Village of Hobart is entirely within the Oneida Reservation; therefore, it must be permitted by the EPA rather than the State of Wisconsin. A permit for Village of Hobart has yet to be issued by the

EPA. TMDL waste load allocations and required reductions for each MS4 are shown in Table 6 and Table 7.

Table 6. Urban MS4 TMDL TSS allocations for Duck Creek Sub-basin**.**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline
	Baseline	Allocated	Reduction	
Duck Creek Subbasin				
Appleton*	456	274	182	40.00%
Ashwaubenon	123,637	74,182	49,455	40.00%
Green Bay	189,004	113,402	75,602	40.00%
Hobart	-	-	-	-
Howard	1,164,267	698,560	465,707	40.00%
Suamico	178,567	107,140	71,427	40.00%
Oneida Reservation				
Appleton*	-	-	-	-
Ashwaubenon	-	-	-	-
Green Bay	514,879	308,928	205,952	40.00%
Hobart	363,933	218,360	145,573	40.00%
Howard	5,838	3,503	2,335	40.00%
Suamico	-	-	-	-

*Appleton MS4 area is located in Upper Duck subwatershed area of Duck Creek Subbasin.

Table 7. Urban MS4 TMDL TP TMDL allocations for Duck Creek Sub-basin**.**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline
	Baseline	Allocated	Reduction	
Duck Creek Subbasin				
Appleton*	2	1.40	0.60	30.00%
Ashwaubenon	302	211.39	90.61	30.00%
Green Bay	474	331.79	142.21	30.00%
Hobart	-	-	-	-
Howard	2,790	1,952.92	837.08	30.00%
Suamico	508	355.58	152.42	30.00%
Oneida Reservation				
Appleton*	-	-	-	-
Ashwaubenon	-	-	-	-
Green Bay	1,290	903	387	30.00%
Hobart	1,316	921.2	394.8	30.00%
Howard	14	9.8	4.2	30.00%
Suamico	-	-	-	-

*Appleton MS4 area is located in Upper Duck subwatershed area of Duck Creek Subbasin.

MS4 permittees subject to TMDL WLAs are required by the WDNR to complete a TMDL implementation and analysis plan that should be incorporated in the Storm Water Management Plan as required by the permittee's MS4 permit. MS4 permits for storm water management programs contain requirements for the following:

- Public Education and Outreach
- Public Involvement and Participation
- Illicit Discharge Detection and Elimination
- Construction Site Pollutant Control
- Post-Construction Storm Water Management
- Pollution Prevention Practices for the Municipality
- Developed Urbanized Area Standard
- Storm Sewer System Maps
- Impaired Waters

Examples of storm water best management practices used by municipalities to meet permits include: detention basins, street sweeping, filter strips, porous pavement, rain barrels, water quality inlets, grassed swales/ditches, green roofs, and rain gardens. Several of these BMP's work by intercepting urban storm water prior to entering into the MS4 system. The use of these types of practices is recommended and will be beneficial in urban and suburban areas to reduce the load of storm water and pollutants entering MS4 systems. Often times the use of green infrastructure that simulates natural hydrology by capturing storm water where it falls and infiltrating, evapotranspiring, or harvesting and using it does not directly implement the terms of a WPDES Storm water permit. In these cases, best management practices that intercept the water from entering the MS4 system may be fundable under EPA 319 funds.

MS4 municipalities in the watershed have been working toward achieving TMDL goals through developing and implementing storm water management plans and updating storm water ordinances. These plans identify BMP's needed and estimated costs to achieve TMDL compliance. The Northeast Wisconsin Stormwater Consortium (NEWSC) works with many of these communities to facilitate efficient implementation of stormwater programs that meet WDNR and EPA regulatory requirements.

Construction Site Storm Water Permits

Certain types of construction projects are regulated by the WDNR through construction site storm water permits. Construction site general permits require landowners to install practices to help decrease the amount of erosion and sediment runoff during storm events. WDNR permits are required for construction projects that disturb one acre or more of land through: clearing, grading, excavating, or stockpiling of fill material. The construction permit requires permit holders to meet waste load allocations of a TMDL if applicable in their erosion control and storm water management plans. In addition, all of the MS4 communities in the watershed also have local ordinances requiring construction site erosion control and storm water permits. Many of the MS4 communities have recently updated ordinances in an effort to comply with TMDL WLAs. Some communities have more stringent ordinances than the state standard that require permits for disturbed areas that are 4,000 sq ft or more. Construction activities in the watershed are considered in compliance with the TMDL if they obtain a WPDES construction general permit or meet local construction storm water requirements if they are more restrictive than the general permit.

Industrial

Certain types of industries in the state are required to obtain storm water discharge permits. There are two types of industrial storm water permits - general permits and industry specific permits. General permits are issued under a tiered system that groups industries by type and by how likely they are to contaminate storm water. There are industry specific permits for dismantling of vehicles for salvage, recycling of scrap and waste materials, and nonmetallic mining operations. Industrial storm water activities are considered in compliance with the TMDL if they obtain a permit under the program and install and maintain all BMPs required under the permit.

4.3 Nonpoint Sources

The majority of phosphorus and sediment pollutants in the Duck Creek Sub-basin come from nonpoint sources. A nonpoint source cannot be traced back to a single point of discharge. Runoff from agricultural and non-regulated urban areas is an example of a nonpoint source. The dominant land uses in the watershed are urban and agriculture. According to the TMDL, agriculture accounts for approximately 78% of the TP loading and 82 % of the TSS load in the Duck Creek Sub-basin.

The main stem and major tributaries of Middle and Lower Duck Creek were inventoried to determine if streambank erosion was a significant source of phosphorus and sediment in the watersheds. Using NRCS Streambank Erosion prediction methodology, moderate to severe streambank erosion was identified as occurring along the main stem and tributaries of Duck Creek. TSS loading estimates based on field inventory of streambank erosion was significantly higher than what was assumed for TMDL watershed modeling. Streambank erosion was not specifically modeled in the TMDL due to lack of available data, therefore it was assumed that it was not a significant source based on local knowledge at the time.

Nonpoint sources in the watershed include:

- Erosion from stream banks and construction sites
- Runoff from lawns and impervious surfaces
- Failing septic systems
- Pet/animal waste

- Erosion/runoff from agricultural lands
- Tile drainage
- Runoff from fertilizer and manure application

The TMDL requires a 76.9% reduction in TP load and a 58.6% reduction in TSS load from agricultural sources (Table 8). The TMDL modeling framework lumped contributions from streambank erosion with the upland land use categories (agricultural, urban, natural background). The TMDL does not require any reduction from non-regulated urban sources.

Table 8. TMDL nonpoint TSS & TP source loads and allocations for the Duck Creek Sub-basin.

Nonpoint Source	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline
	Baseline	Allocated	Reduction		Baseline	Allocated	Reduction	
Duck Creek Subbasin								
Agriculture	30,382	7,028	23,354	76.90%	12,724,387	5,273,111	7,451,276	58.60%
Urban (non-regulated)	2,070	2,070	-	-	478,796	478,796	-	-
Natural Background	790	790	-	-	114,410	114,410	-	-
Oneida Reservation								
Agriculture	18,937	4,380	14,557	76.90%	7,931,075	3,286,715	4,644,360	58.60%
Urban (non-regulated)	1,372	1,372	-	-	317,456	317,456	-	-
Natural Background	707	707	-	-	102,270	102,270	-	-

Relevant Nonpoint Source Regulations

Wisconsin Administrative Code Chapter NR 151 regulates runoff management in the state. Agricultural runoff is regulated under subchapter 2. This chapter describes regulations relating to phosphorus index, manure storage & management, nutrient management, soil erosion and tillage setbacks. Implementation and enforcement procedures are also described in this chapter. Conservation practices used to meet performance standards in Ch. NR 151.2 are identified in Chapter ATCP 50 of the Wisconsin Administrative Code. A major limitation to implementing NR151 is that statutorily, an offer of cost sharing is required to bring existing croplands and facilities into compliance. In NR 151 a facility or cropland is considered existing if it was in existence prior to the effective date of the performance standard. Subchapter 3 of NR 151 describes non-agricultural performance standards relating to construction sites, developed urban areas, turf and garden nutrient management, total suspended solids, peak discharge, infiltration, fueling and vehicle maintenance. Subchapter 4 describes similar performance standards as subchapter 3 but applies to transportation facilities.

In addition, Outagamie and Brown Counties have local ordinances to provide additional watershed protection. In Outagamie County, the Agricultural Performance Standards and Livestock Waste Management Ordinance (Ch.4) regulates agricultural facilities and lands. Brown County has an Agricultural Shoreland Management Ordinance (Ch. 10) and an Animal Waste Management Ordinance (Ch. 26) that regulates agricultural facilities and lands in the County.

4.4 Water Quality Monitoring

Wisconsin statues and administrative code set numeric water quality standards for phosphorus. The numeric phosphorus water quality criterion for tributaries is 0.075 mg/l. The Lower Fox River TMDL set TP and TSS loading rates for each subwatershed. The TMDL target for TSS concentration for the mouth of the Fox River is 18 mg/l. Since no water quality criterion currently exists for tributaries, 18 mg/l will be used as a recommendation for TSS in Duck Creek. Recent water quality data shows phosphorus levels are currently higher than the allowable limits.

There are several active water quality monitoring programs in the Middle and Lower Duck Creek watersheds. The WDNR Lower River Tributary Volunteer Monitoring Program, Oneida Nation Water Quality Monitoring Program and the Silver Creek program are discussed in further detail in the following sections. The location of the surface water monitoring sites from these programs in the watersheds are shown in Figure 17 and a summary table is shown in Appendix C.

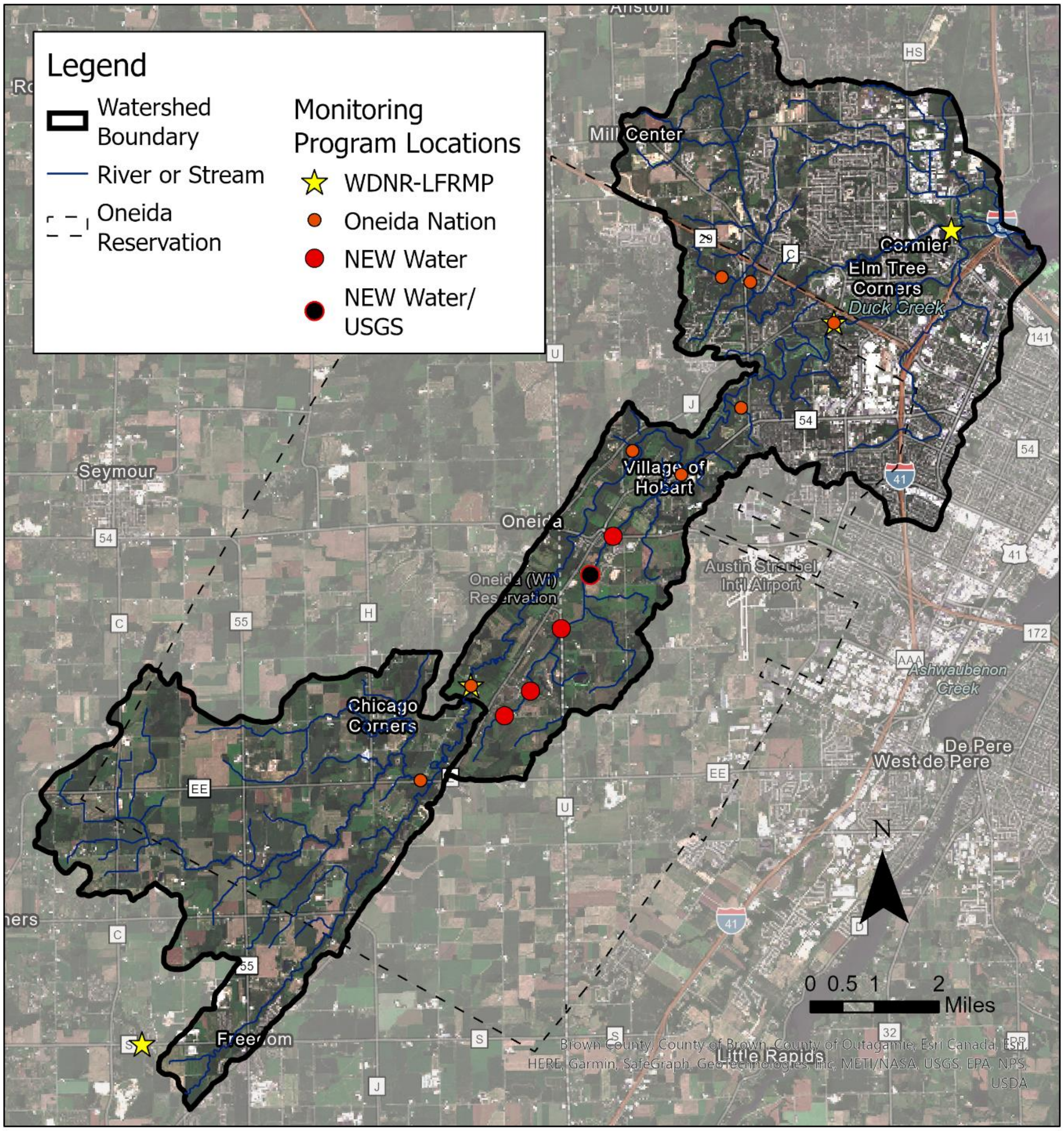

Figure 17. Surface water quality monitoring sites in Middle and Lower Duck Creek watershed.

Lower Fox River Tributary Volunteer Monitoring Program (WDNR)[4]

In 2013, the Wisconsin Department of Natural Resources (WDNR) convened a Lower Fox Monitoring Committee to develop and subsequently implement a surface water monitoring plan to evaluate the effectiveness of TMDL implementation in the Lower Fox River Basin. The committee developed a plan to monitor 3 to 4 locations on the Lower Fox River Main Stem and one location on each of the 13 tributaries flowing into the Fox River. Figure 18 shows the tributary monitoring locations for the program for the Duck Creek sub-basin.

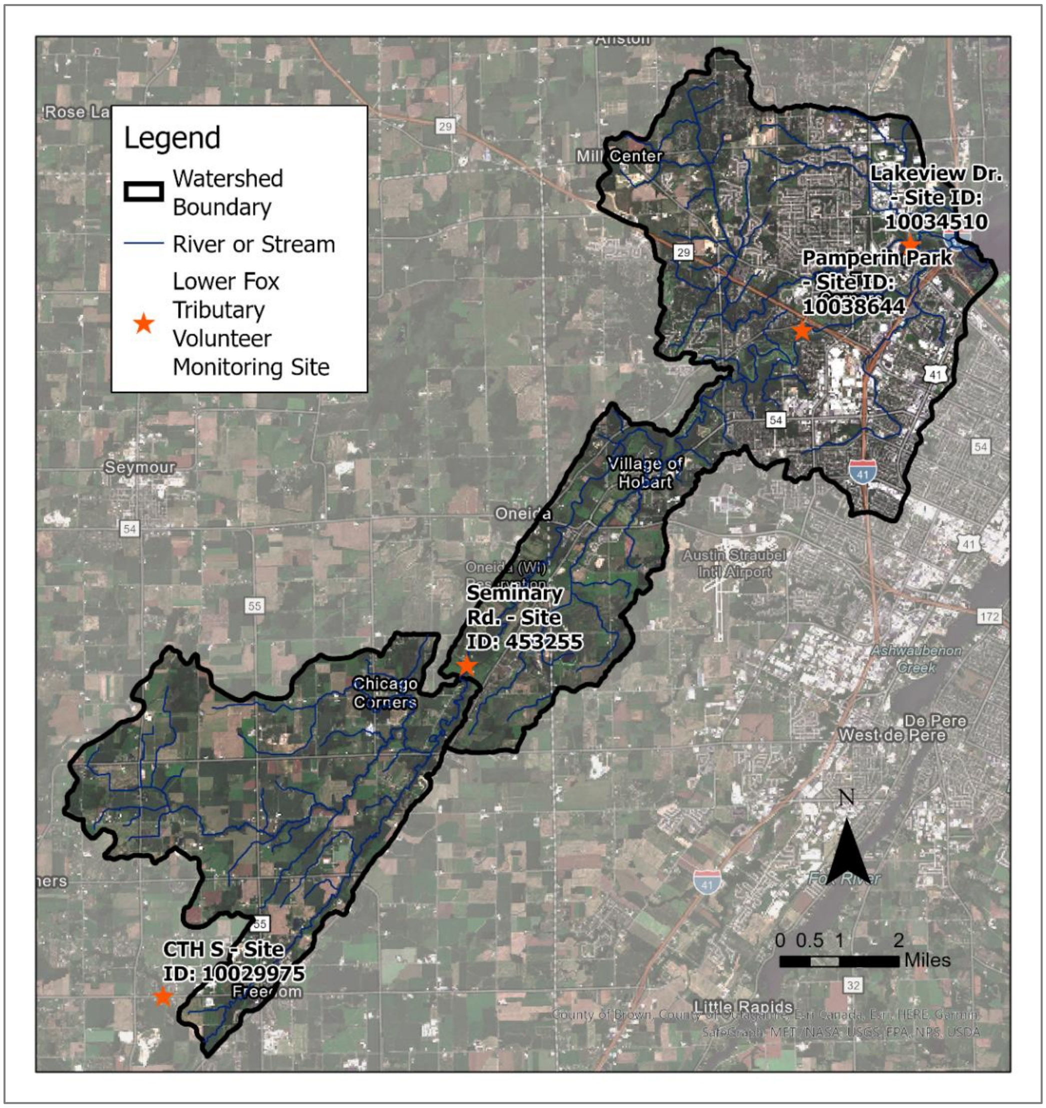

Figure 18. Lower Fox River Tributary Volunteer Monitoring Program sites in Duck Creek Sub-basin.

[4] Additional information on this program can be found at https://dnr.wisconsin.gov/topic/TMDLs/LowerFox/VolunteerMonitoring.html .

Water Quality

Starting in 2015, volunteers began collecting water quality samples on a monthly basis from May-October at the tributary sites. On each sampling date, volunteers collect and ship surface water samples to the Wisconsin State Laboratory of Hygiene for the analysis of TP, TSS, and dissolved reactive phosphorus (DRP). Sampling began at two of the Duck Creek sites in 2015. An additional two monitoring sites were added in 2018. Nitrogen analysis was added to the program in 2020. Median growing season TP and TSS values calculated from WDNR data from 2015 to 2021 are shown in Figure 19 and Figure 20.

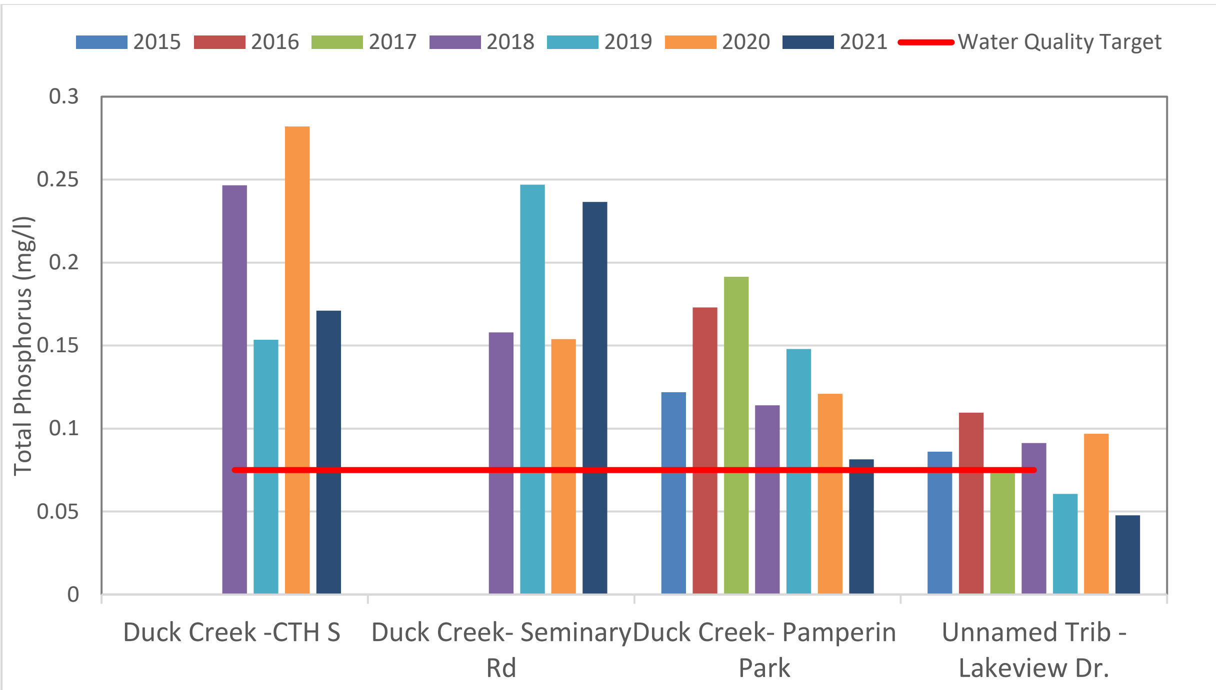

Figure 19. Growing season (May-October) median TP at Duck Creek WDNR LFR monitoring program locations.

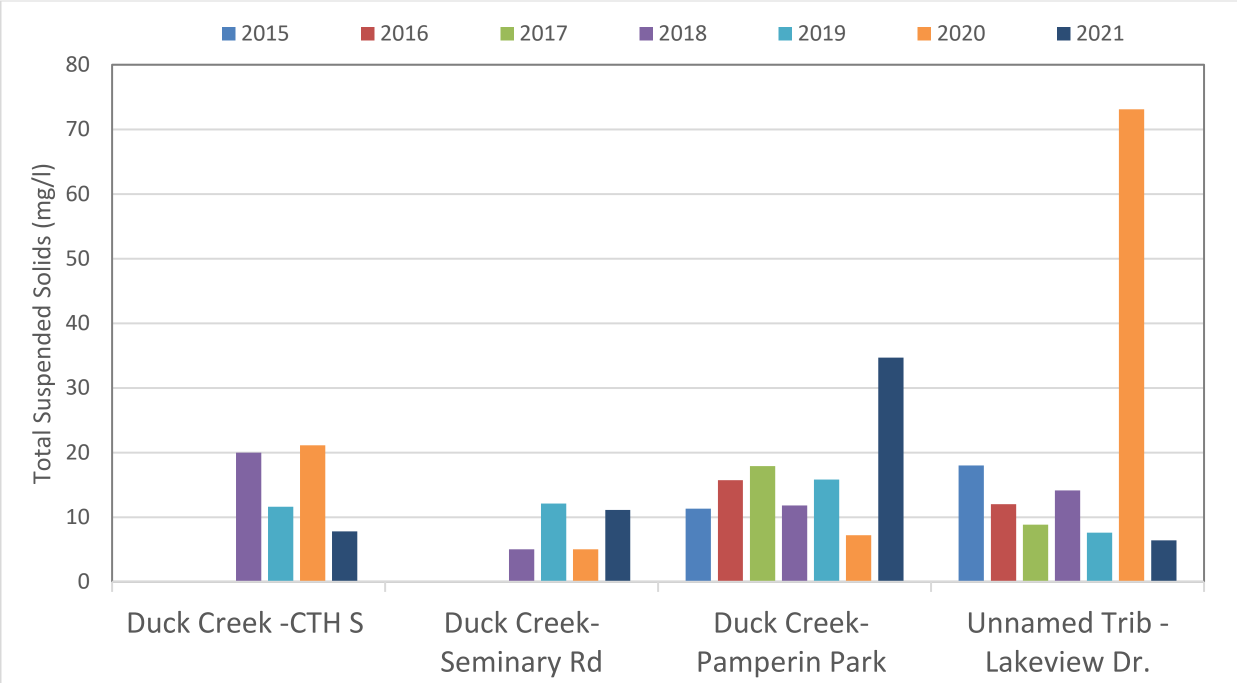

Figure 20. Growing season (May-October) median TSS at Duck Creek WDNR LFR monitoring program locations.

Biological

The macroinvertebrate index of biotic integrity (M-IBI) is a biological indicator for impairment classification. Different types of macroinvertebrates are more tolerant of poor water quality than other macroinvertebrates. The number and type of macroinvertebrate present in a stream can provide and indicator of water quality. Table 9 summarizes the most recent M-IBI survey results for each monitoring site in Duck Creek.

Table 9. Macroinvertebrate Index of Biotic Integrity (IBI) for LFR Tributary monitoring sites.

Monitoring Site	Year	M-IBI	Rating	Project
Duck Creek -CTH S - Site ID: 10029975	2012	2.1	Poor	WAV Citizen Monitoring Macroinvertebrate Biotic Index
Duck Creek-Seminary Rd. - Site ID: 453255	2015	4.6	Fair	Apple-Duck-Ashwaubenon-West Plum TWA
Duck Creek-Pamperin Park - Site ID: 10038644	2015	3.4	Fair	Lower Fox tributary volunteer monitoring
Unnamed Trib - Lakeview Dr. - Site ID: 10034510	2016	2.7	Fair	Apple-Duck-Ashwaubenon-West Plum TWA

Oneida Nation Water Quality Monitoring Program

The Oneida Nation has a water quality program that gathers water quality information for the purpose of assessing the condition of Reservation surface waters, evaluating trends and identifying problems. The current monitoring strategy includes 14 fixed monitoring sites. Eight of these sites are located in the Middle and Lower Duck watershed (Figure 21). Six of the sites are stream monitoring locations and two are small lake monitoring sites. The current water quality monitoring strategy includes monthly sampling from April to October at the stream sites in Duck Creek for Total Phosphorus and Total Suspended Solids. Total phosphorus sampling data for 5 of the 6 stream sampling sites in the watersheds are shown in Figure 22.

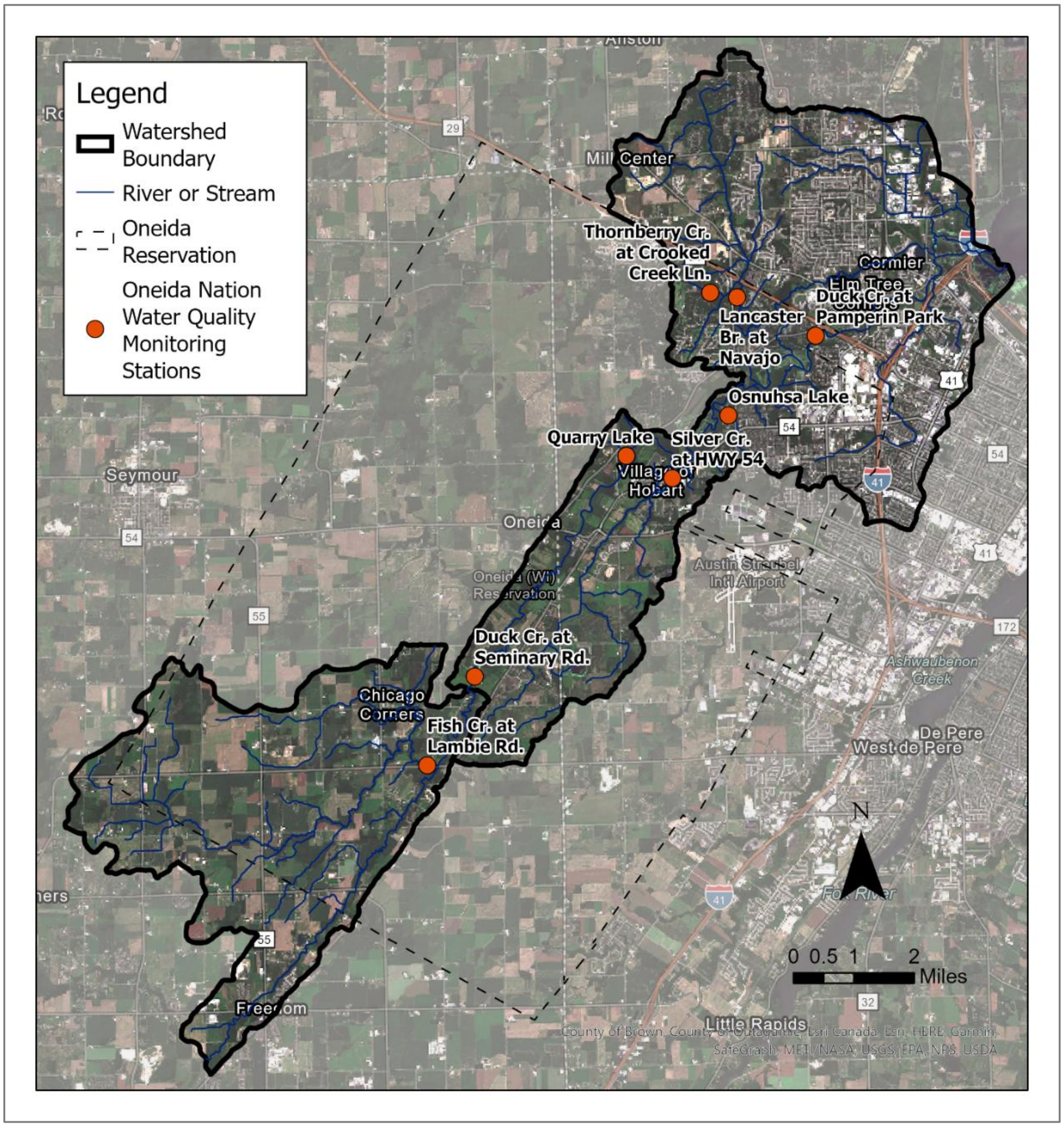

Figure 21. Oneida Nation water quality monitoring locations.

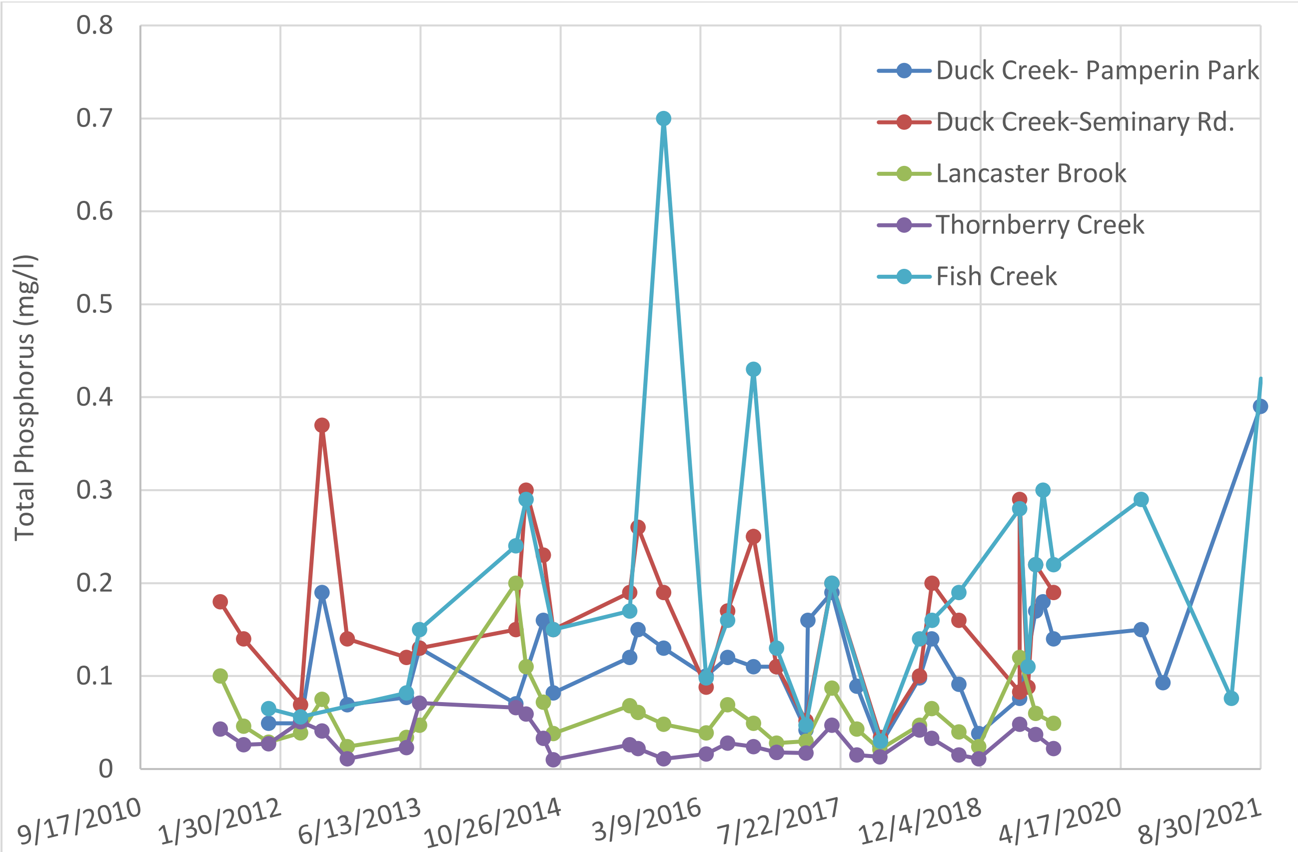

Figure 22. Total phosphorus sample results at stream sites monitored by Oneida Nation 2011-2021.

Silver Creek Pilot Project

Silver Creek is a tributary to Duck Creek that is located 1 mile west of the Austin Straubel airport and flows from Outagamie County into Brown County. NEW Water lead an agricultural-based Adaptive Management (AM) pilot project in Silver Creek to evaluate if it is more cost effective to spend money to undertake wastewater treatment plant improvements or work with agriculture to reduce phosphorus and sediment reaching Green Bay. Water quality monitoring began in 2014 in the watershed. Silver Creek stream sampling sites are shown in Figure 23. Total Phosphorus and Total Suspended Sediment data from 2014-2021 for the Silver Creek sites are shown in Figure 24 and Figure 25. Even though the pilot project BMP implementation phase has ended, continued monitoring is planned at all the monitoring sites except SL-172 to monitor the long term water quality response to installation of practices.

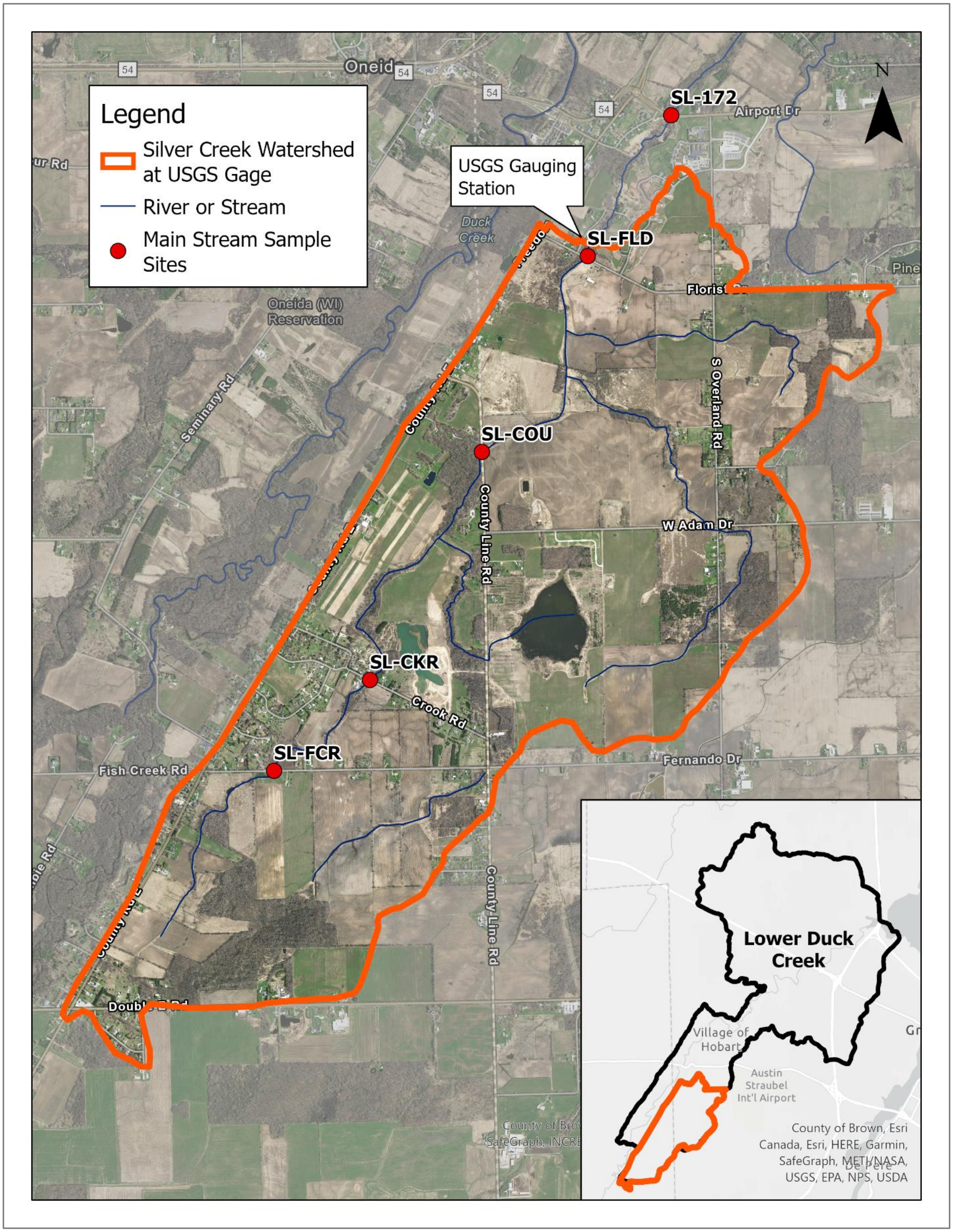

Figure 23. Water quality monitoring locations in Silver Creek.

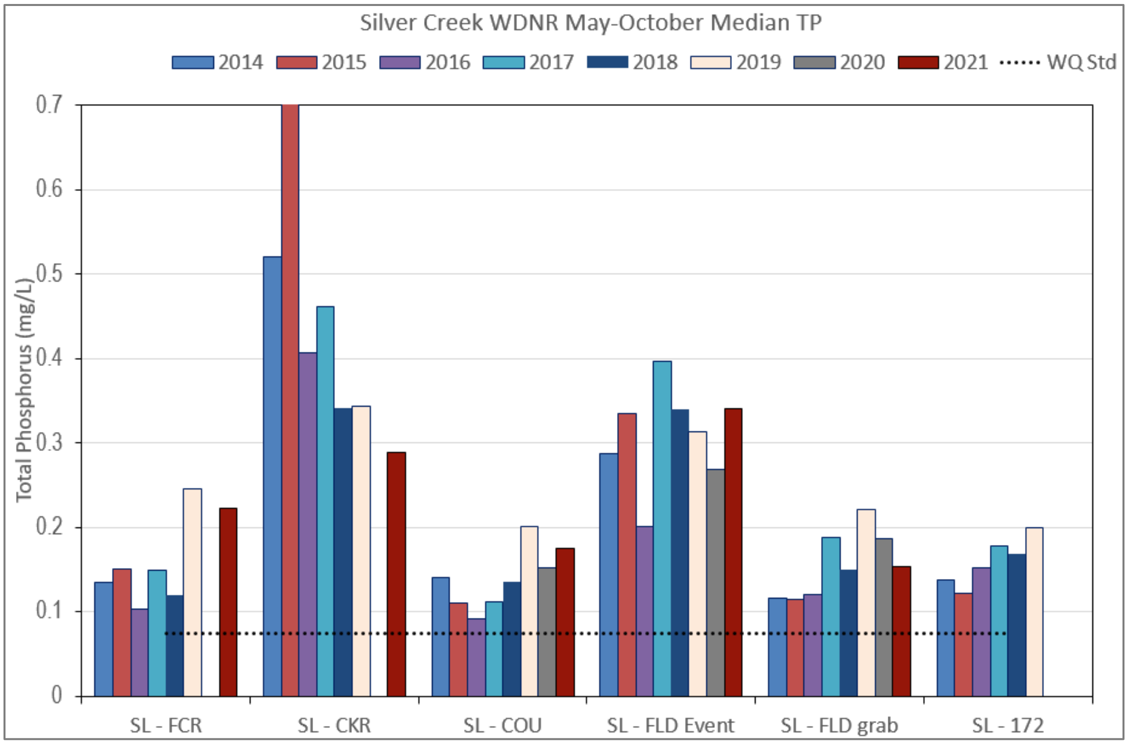

Figure 24. Growing season (May-October) median TP at Silver Creek stream monitoring locations. (Source: NEW Water)

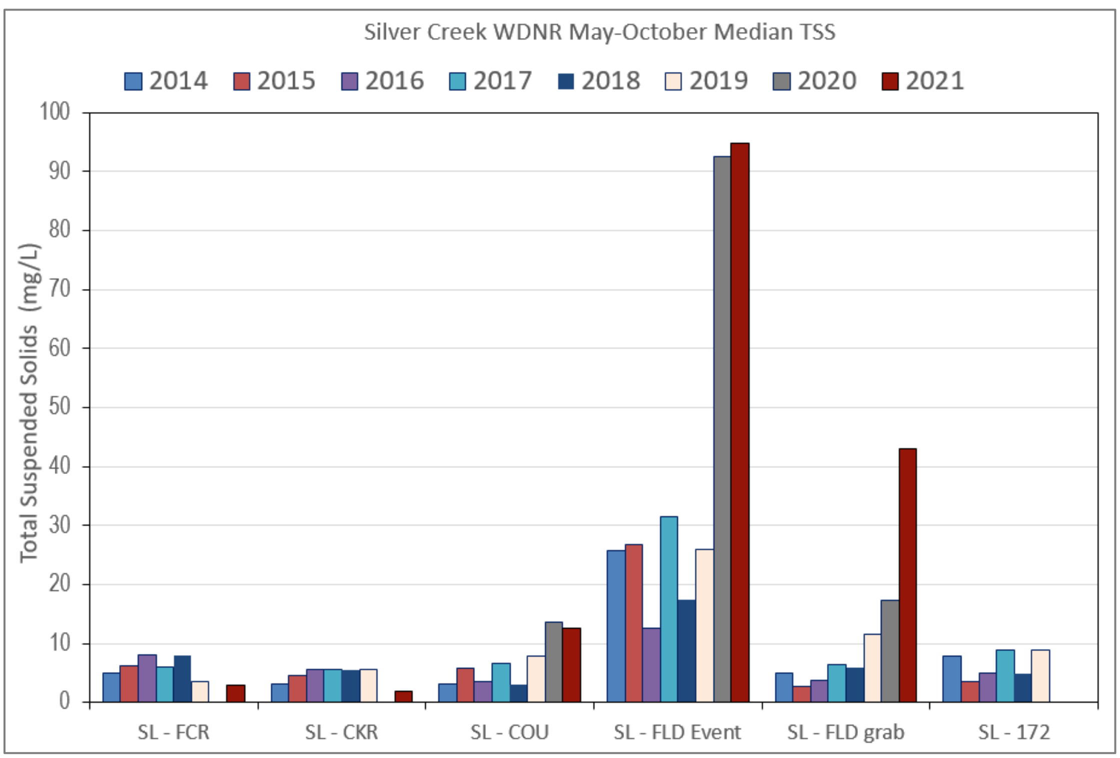

Figure 25. Growing season (May-October) median TSS at Silver Creek stream monitoring locations. (Source: NEW Water)

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5.0 Pollutant Loading Model

The developers of the Lower Fox River TMDL plan ran the Soil and Water Assessment Tool (SWAT[5]) for all sub-basins in the Lower Fox River Basin. The SWAT model is able to predict the impact of land use management on the transport of nutrients, water, sediment, and pesticides. Actual cropping, tillage and nutrient management practices typical to Wisconsin were input into the model. Other data inputs into the model include: climate data, hydrography, soil types, elevation, land use, contours, political/municipal boundaries, MS4 boundaries, vegetated buffer strips, wetlands, point source loads, and WDNR-Enhanced USGS 1:24K DRG topographic maps. The model was calibrated with water quality data taken at USGS sites from the East River, Duck Creek, Baird Creek, Ashwaubenon Creek, and Lower Fox River in the Lower Fox River Basin. Much of the input data used for the TMDL SWAT model analysis is now over 15 years old. TMDL load sources were categorized as Urban MS4, Urban (Non-regulated), Agriculture, Point Source, Natural Background, General Permits and Construction. Streambank erosion was not modeled with SWAT and was effectively lumped with upland sources (Agriculture, Urban (regulated & non-regulated), and Natural Background) due to lack of data and estimates from local officials as not being a significant source.

The TMDL reports TP and TSS loads for the entire Duck Creek Sub-basin which includes Upper, Middle & Lower Duck Creek and Oneida Creek subwatersheds. To characterize the loading from agricultural sources (cropland, gully erosion, pastureland), natural background, and non-MS4 urban land use in just the Middle and Lower Duck subwatersheds, the Spreadsheet Tool for Estimating Pollutant Load (STEPL[6] V4.4) model was used along with NRCS tools. Baseline and current conditions modeling was done to quantify reductions from agricultural land being developed since the development of the TMDL SWAT model and to quantify reductions already achieved in the Lower Duck Creek subwatershed from the implementation of BMPs through the Silver Creek Adaptive Management Pilot program. Baseline and current condition inputs for the STEPL model are shown in Appendix D.

STEPL is another watershed model that calculates nutrient loads based on land use, soil type, and agricultural animal concentrations. NRCS spreadsheet tools were used to estimate phosphorus loads from livestock facility areas in the watershed and the NRCS direct volume method was used to estimate sediment loss from streambanks. The STEPL model was not used to estimate urban loading from MS4 communities. Updated WinSLAMM (Source Loading and Management Model for Windows) modeled loads were obtained from MS4 communities in the watershed where available. Recent WinSLAMM modeled loads were not available for the Village of Hobart, therefore TMDL calculated loads were assumed for this community. Modeled phosphorus and sediment loads and reductions from STEPL, WinSLAMM, and NRCS spreadsheets/tools are directly comparable to modeled TMDL TSS and TP loads and reductions.

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[5] Additional information on SWAT can be found at https://swat.tamu.edu/ .
[6] Additional information on STEPL can be found at http://it.tetratech-ffx.com/steplweb/default.htm.

Estimated pollutant loading results based on current land use conditions are shown in Table 10. Baseline loading condition estimates using these methods can be seen in Appendix E.

Based on current conditions, the Middle and Lower Duck Creek watershed contributes an estimated 20,353 lbs of TP and 5,335 tons of TSS to the Bay of Green Bay per year (Table 10). Agriculture sources including cropland, pastureland, gully erosion, and animal lots contribute 79% of the TP in Middle Duck and 28% of the TP load in Lower Duck. Streambank erosion in Middle and Lower Duck Creek is also a significant source of the TP (Middle-9% and Lower-16%) and TSS (Middle-29% and Lower- 48%) load. Urban MS4 communities contribute 41 % of the TP load and 21% of the TSS load in the Lower Duck Creek watershed. Load contributions by source percent are shown in Figure 26 and Figure 27.

Table 10. Current conditions TP & TSS loading results.

Source	**Middle**		**Lower**	
	TP (lbs/year)	**TSS (tons/yr)**	**TP (lbs/year)**	**TSS (tons/yr)**
WWTF	542	1	0	0
Urban (MS4)	0	0	4,235	608
Urban (non-regulated)	731	116	411	70
Natural Background	362	39	1,068	216
Cropland	6,581	1,311	2,673	541
Pasture/Hay	281	40	238	50
Animal Lots	234	0	0	0
Gully Erosion	373	217	97	56
Streambank Erosion	845	692	1,682	1,379
Total	9,949	2,416	10,404	2,919

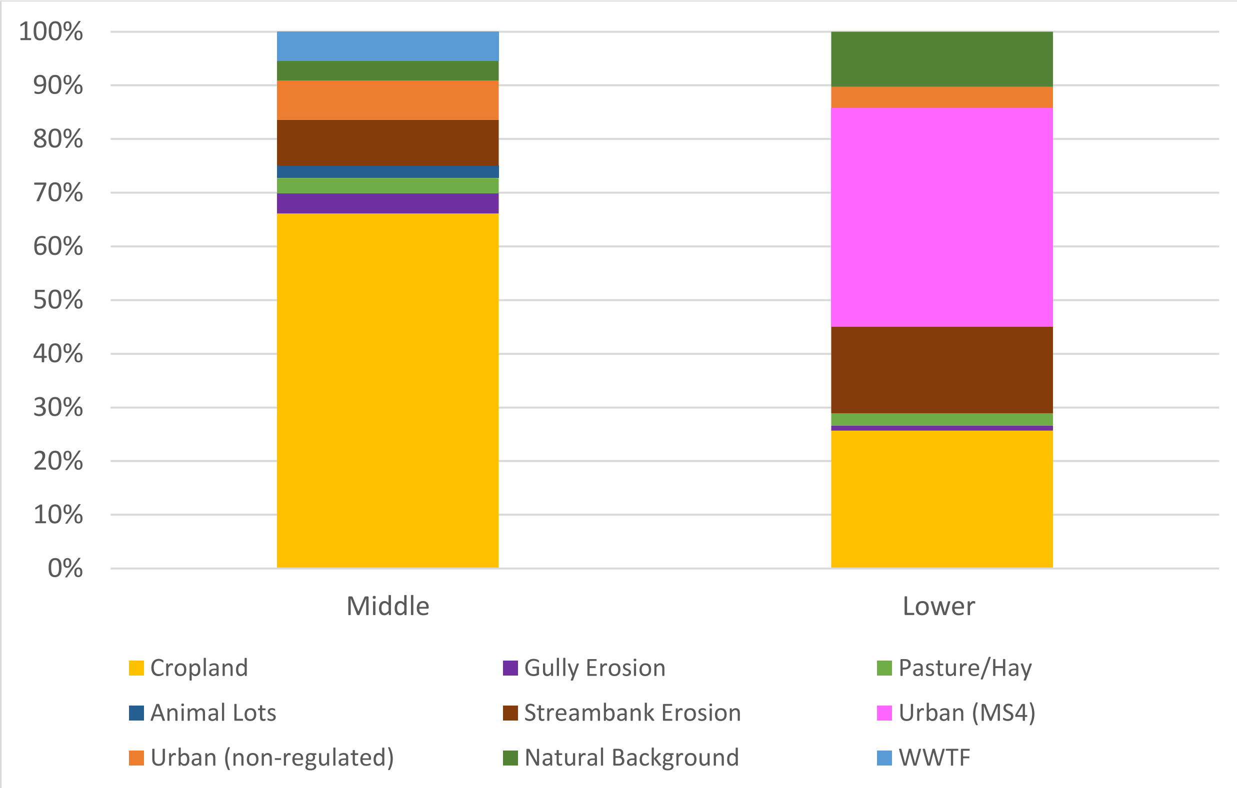

Figure 26. Phosphorus load contribution percent by source (current conditions).

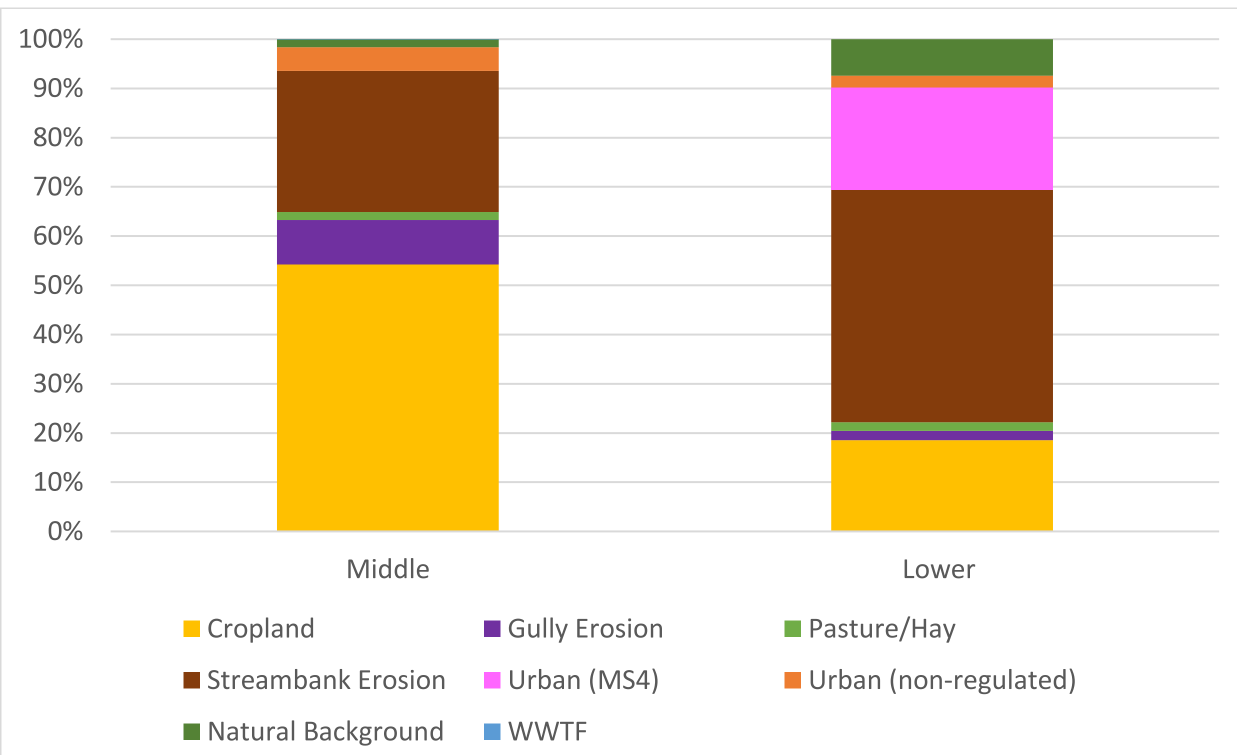

Figure 27. Sediment load contribution percent by source (current conditions).

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6.0 Watershed Inventory

6.1 Livestock Facilities Inventory Results

Location and data on current livestock operations was compiled through existing Land and Water Conservation Department data, air photo interpretation, and windshield surveys. There are a total of 7 active livestock operations in the Lower Duck watershed and 23 livestock operations in the Middle Duck watershed, with an estimated combined 5,515 animal units (AU) including dairy, beef, sheep, and horses. One of these sites in the Middle Duck watershed is a permitted facility (CAFO). CAFO's in the watershed account for approximately 40% of all animal units. All CAFO's were assumed to have zero discharge from their production area. Locations of livestock operations in the watershed are shown in Figure 28.

Livestock facility data was entered into NRCS spreadsheet tools (BARNY)[7] to estimate phosphorus loading. According to NRCS spreadsheet calculations an estimated 234 lbs of TP per year can be attributed to barnyard runoff. Barnyard runoff accounts for approximately 2% of the TP loading from agriculture. The majority of farm sites have already had runoff management measures and waste storage installed during the Duck, Apple, and Ashwaubenon Priority Watershed Project that ended in 2010. There are a few livestock sites in the watershed that will need practices to control barnyard runoff such as filter strips, fencing, waste storage, and roof gutters to reduce their phosphorus load. Barnyard runoff is not a significant source of phosphorus in this watershed. Individual barnyards that discharge to waters of the state will be eligible for cost share assistance to obtain necessary reductions in phosphorus loading.

There are 5 inactive waste storage facilities identified that should be further analyzed to see if they are meeting current NRCS design standards. If the waste storage facility is meeting current design standards it may have the potential to become a site where other farmers in the watershed could store their manure in wet weather years where it may be difficult to empty their pits and risk the possibility of an overflow and manure spill. Waste storage facilities that do not meet current design standards should be properly abandoned to prevent potential contamination of surface water or ground water.

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[7] NRCS spreadsheets can be found at:
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/wi/technical/engineering/?cid=nrcs142p2_025422

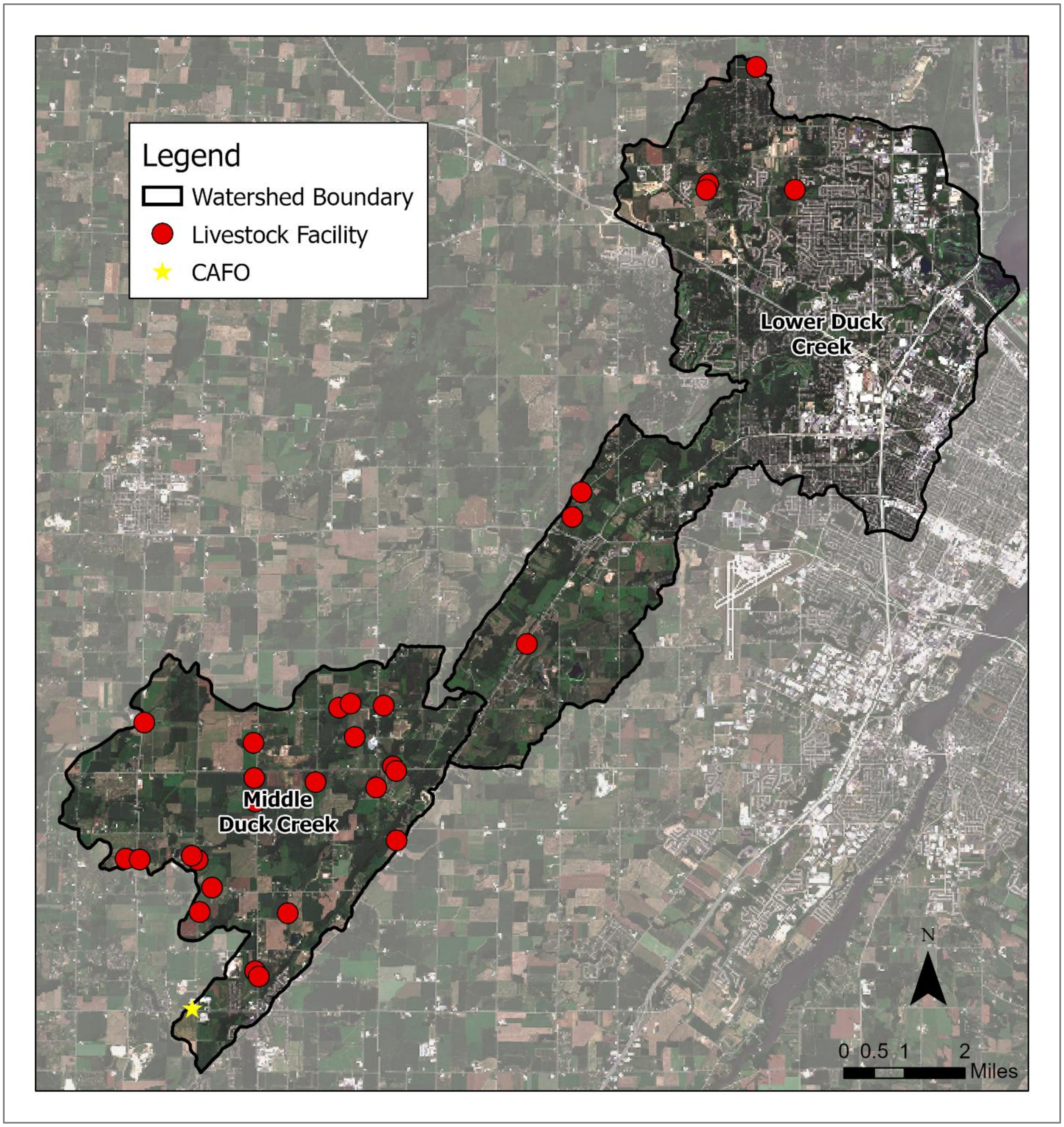

Figure 28. Livestock facilities in the Middle and Lower Duck Creek watershed.

6.2 Stream Corridor Inventory Results

The USGS National Hydrography Dataset (NHD) was used to determine the location of perennial and intermittent streams in the watershed area. In spring of 2021, several sections of the main stem Middle and Lower Duck Creek and their tributaries were inventoried by staff from the Outagamie County LCD for stream bank erosion.

Stream bank erosion was inventoried by walking the stream with a mobile device using the ArcCollector application. Information on lateral recession, soil type, height, and length were collected with the app as well as GPS located photos. Additional features noted during the stream corridor inventory include debris/vegetation obstruction, gully erosion, stream/road crossings, dumping sites, invasive species, tile drain outlets and other pipe outlets.

A total of 24 miles of stream were inventoried using the ArcCollector App in the field. Additional stretches of stream not inventoried where significant erosion may be occurring were identified by air photo interpretation. Inventory results show significant bank erosion occurring along main stem Duck Creek and its tributaries in both agricultural and urban land use settings. Inventoried streambank erosion sites are shown in Figure 29. Inventory data indicates that stream bank erosion is a significant source of TSS in the watersheds.

Sediment loss was calculated for eroding streambanks using the NRCS Direct Volume Method (Appendix F):

$$[(eroding\ area)(lateral\ recession\ rate)(density)] \div \left(2000\,\frac{lbs}{ton}\right) = erosion\ in\ tons/year$$

The amount of sediment actually delivered to the Fox River depends on factors such as channelization, straightening, modification, and amount of disturbed channels. By using the NRCS Field Office Technical Guide for Erosion and Sediment Delivery, a sediment delivery ratio of 80% was assumed (NRCS, 1998). An estimated 880 tons of TSS per year is estimated to be coming from eroding streambanks identified in the field (Table 11). An additional 1,191 tons/yr of TSS is estimated to be coming from eroding streambanks not inventoried identified by air photo interpretation. The estimated amount of annual gross TSS load due to stream bank erosion in Middle and Lower Duck Creek is approximately 2,071 tons/year. Phosphorus loads from streambank erosion were estimated using a soil phosphorus concentration of 610 ppm. This was the average soil phosphorus concentration found in streambanks in the nearby Apple Creek Watershed. The annual phosphorus load from stream bank erosion is 2,527 lbs/year.

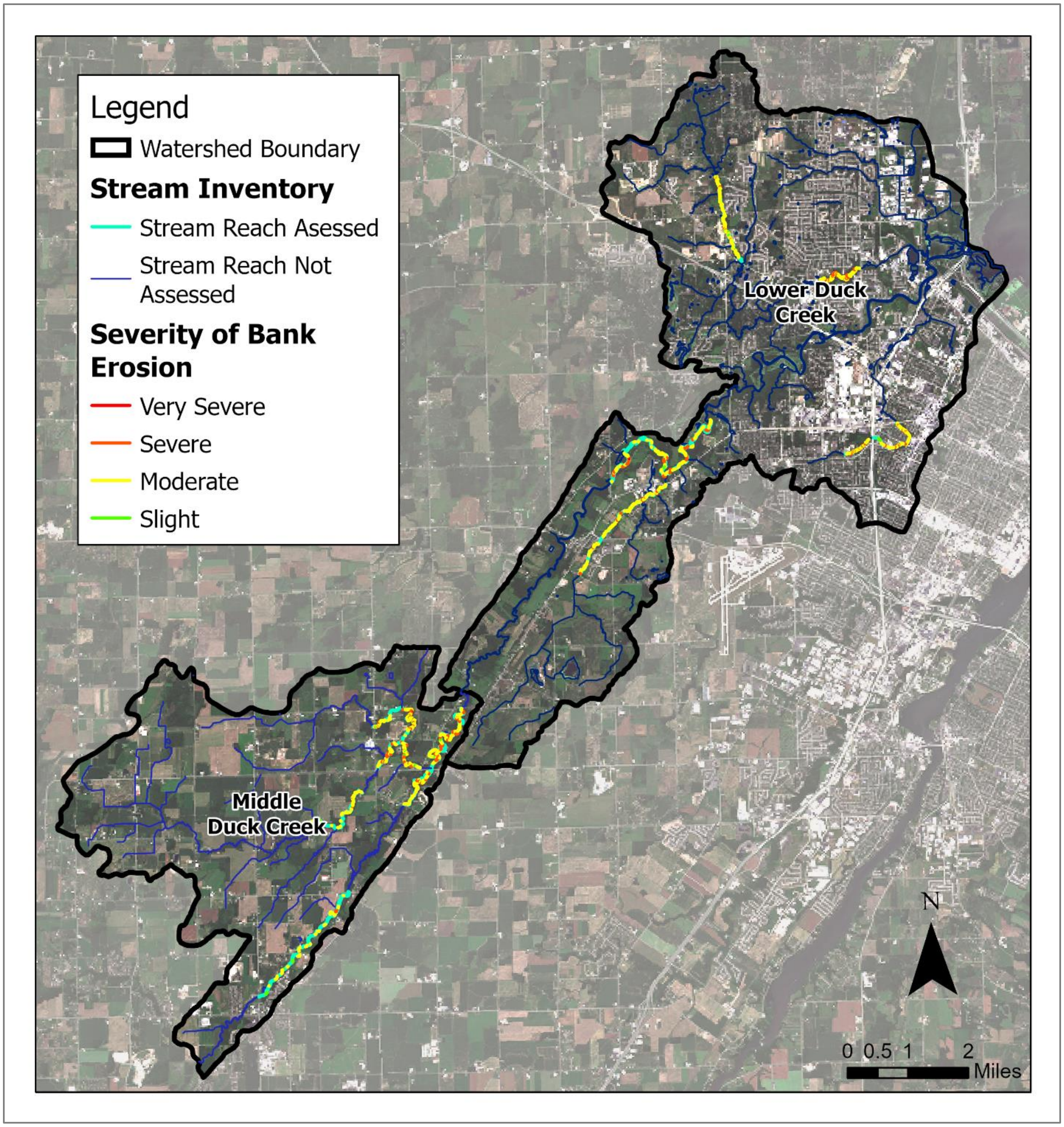

Figure 29. Streambank erosion inventory results. *Note: Stream reaches that were assessed but did not have active erosion present are shown in light blue/cyan.*

Table 11. Estimated TSS load from areas with observed erosion.

Watershed	Lateral Recession Rate			
	Very Severe *(0.5 ft/yr)*	Severe *(0.3 ft/yr)*	Moderate *(0.06 ft/yr)*	Slight *(0.01 ft/yr)*
Middle Duck				
length (ft)	69	6,137	19,054	1,140
sediment load (tons/yr)	5	252	114	1
Lower Duck				
length (ft)	112	7,358	33,779	815
sediment load (tons/yr)	11	296	200	1

Structures such as urban storm water outlets, agricultural tile drain outlets, equipment crossings, road crossings and debris build up in the stream corridor can cause or exacerbate bank erosion or gully erosion in the stream corridor. Lack of adequate vegetative buffers along the stream corridor can also destabilize streambanks. Figure 30 highlights structures and other areas of concern inventoried during the stream corridor inventory.

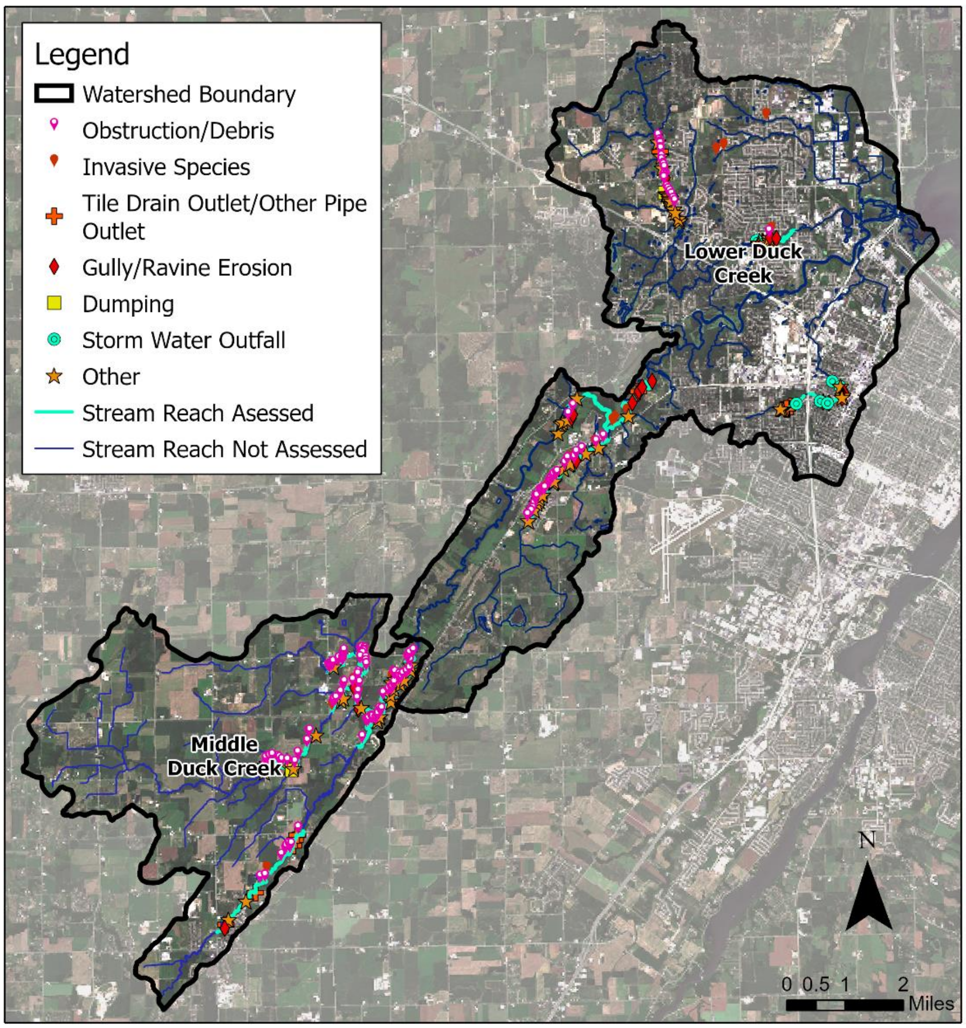

Figure 30. Other areas of interest and resource concerns inventoried along the stream corridor**.**

Urban development, straightening of streams, poor soil health, increase in use of tile drainage in fields, and ditching for drainage has increased the amount of runoff entering the Duck Creek and its tributaries. These practices increase the peak discharge and water velocity of a stream. Increase in the peak discharge and velocity is likely the cause of the majority of the stream erosion occurring. Practices that slow the flow of water to the stream and its tributaries as well as store water will be necessary to prevent further streambank degradation. Agricultural runoff treatment systems (ARTS) provide a significant opportunity for water storage on the landscape. Other practices that slow the flow of runoff and store water include wetland restoration/creation, buffers, grassed waterways, water and sediment control basins, reduced tillage, and cover crops in agricultural areas. In urban areas, these practices include using rain gardens, rain barrels, pervious pavement, storm water ponds, etc.

Streambank instability, erosion and bank failure also results from a lack or loss of natural vegetation along streambanks. Development, row cropping without buffers, and historic livestock grazing has contributed to the loss of natural riparian vegetation in the watershed. The riparian forested corridors in the Middle and Lower Duck watershed contain a mix of tree species including ash, box elder, cottonwood, elm, hard maple, and some oaks. The understory is vegetated with species such as common buckthorn (invasive), prickly ash (native- potentially invasive), garlic mustard (invasive) and Eurasian bush honeysuckles (invasive). There is lack of an herbaceous layer along the banks in many areas due to the density of undesirable tree and shrub species, which prevent sunlight from reaching the forest floor. These wooded riparian corridors should be managed by selective tree thinning, planting of desirable tree species, and seeding the floodplain with native seed mix where there is a lack of herbaceous vegetation. Establishment of a quality herbaceous layer along the banks will aid in improving streambank stability.

Stabilizing eroding streambanks and restoring riparian corridors will help decrease the amount of sediment loading coming from the watershed as well as improve riparian habitat. Stream segments with significant moderate to very severe erosion occurring are high priority sites for stabilization. An example of a stream segment of a tributary to Duck Creek with significant moderate to very severe erosion that would be high priority for streambank restoration and stabilization is shown in Figure 31.

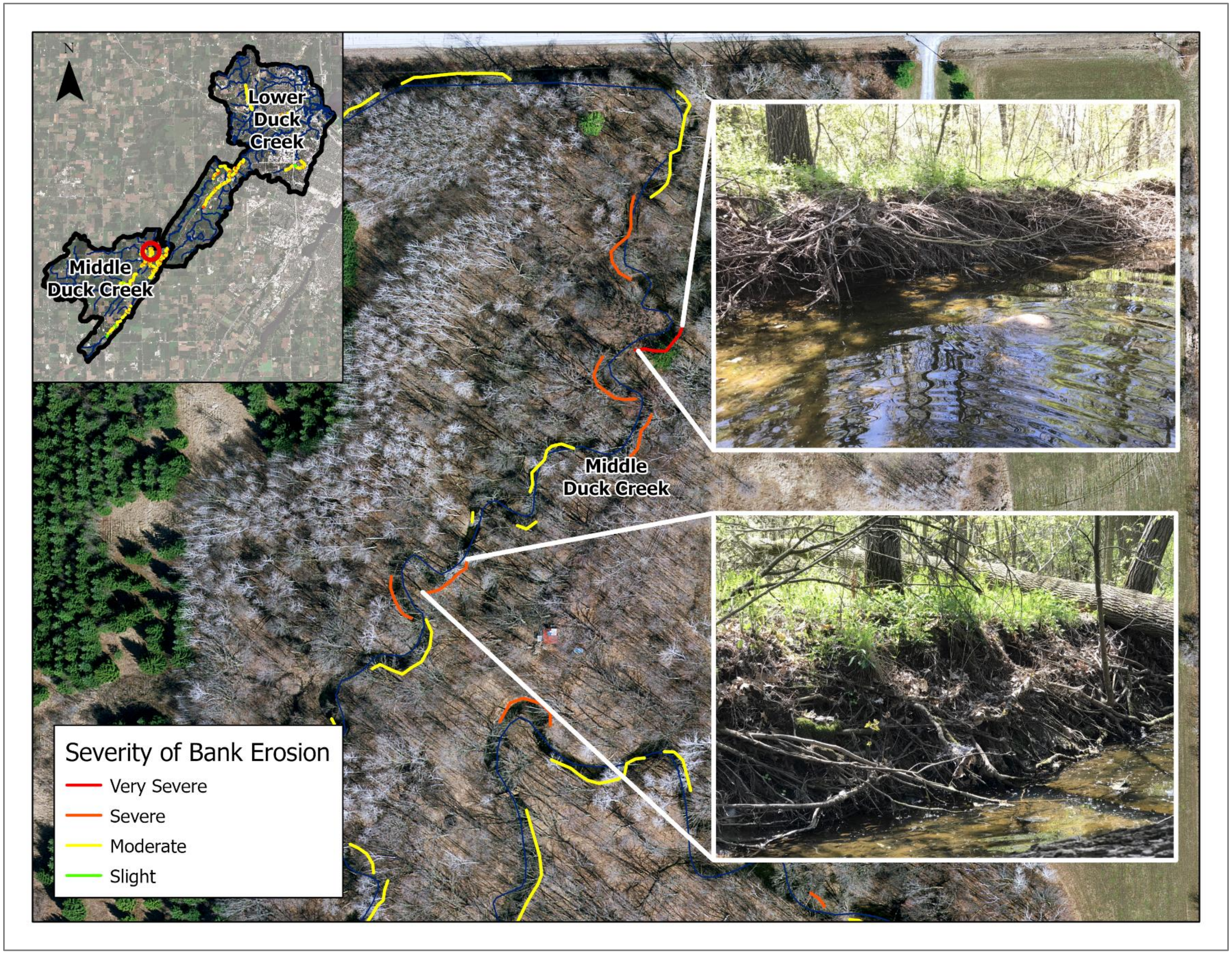

Figure 31. High priority segment for streambank restoration on tributary to Duck Creek south of Fish Creek Rd.

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Channel/Ditch Erosion

Several miles of agricultural drainage ditches and unnamed tributaries in the Middle and Lower Duck watershed have been significantly altered from their natural state. Traditional drainage ditches are prone to erosion, channelization, and bank failure due to high volumes of water they must handle during peak flows. These ditches do little to prevent the flow of nutrients and other contaminants from farm fields downstream. Recent research into two-stage ditches (Figure 32) has shown that they can be an effective way to stabilize ditch and stream channels and reduce nutrient loads. A two-stage ditch is a drainage ditch that has been modified by adding benches that serve as floodplain for the channel. The vegetated benches reduce the velocity of high flows and retain nutrients and sediment. The vegetated benches can also provide treatment of tile drainage water. Two-stage ditches can also be designed to improve habitat for wildlife. Agricultural drainage ditches and channels in the watershed that could potentially be modified with the two-stage ditch design are shown in Figure 33. While a two-stage ditch design can be used for streambank stabilization, our evaluation of potential drainage channels and ditches were identified in Figure 33 for the purpose of treatment of agriculture runoff in the vegetated benches.

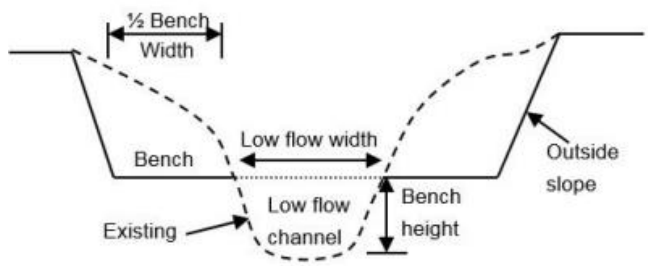


Figure 32. Typical two-sided, two-stage ditch. (NRCS, 2018)

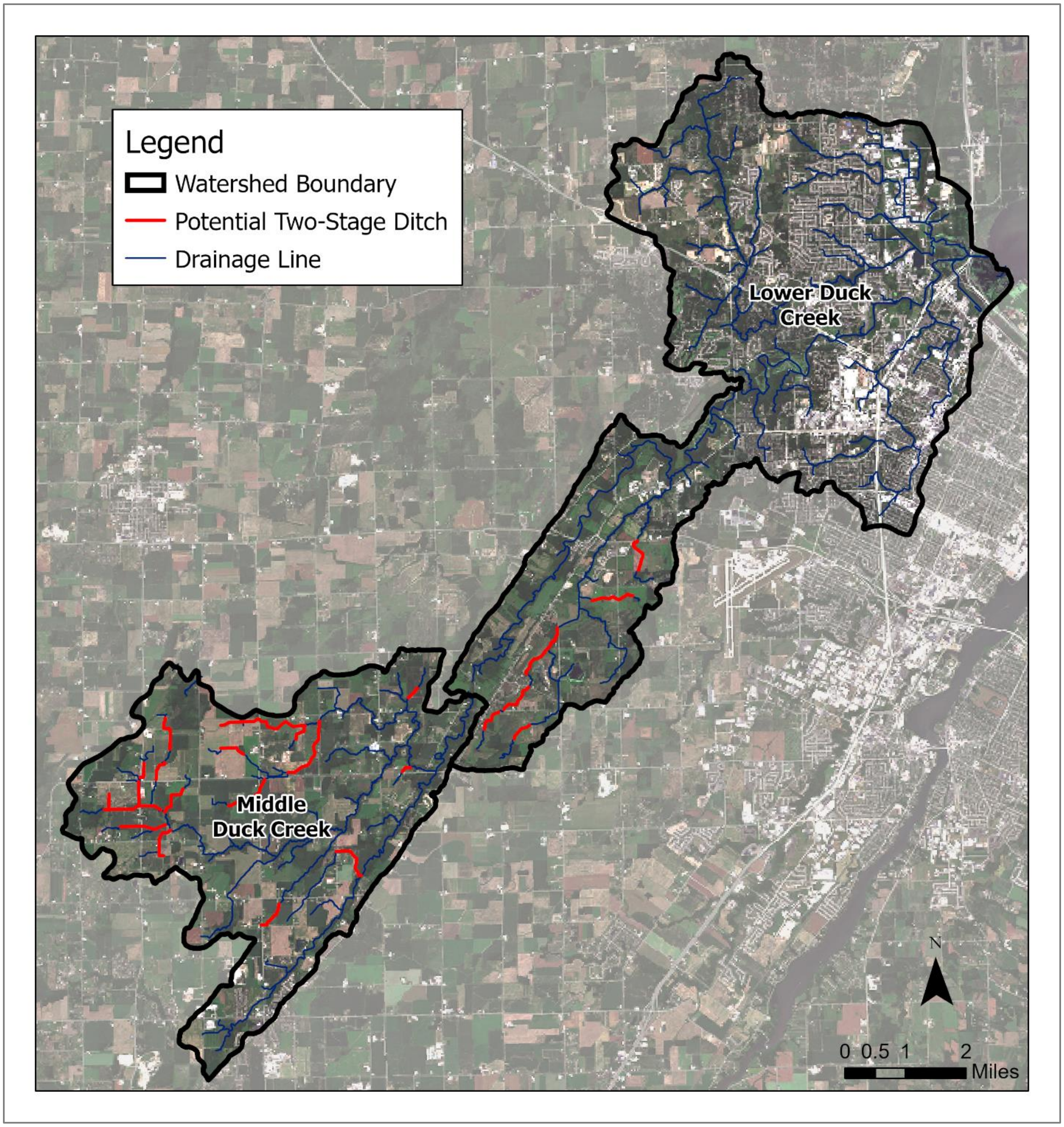


Figure 33. Potential locations for two-stage ditch modification.

6.3 Upland Inventory

Agricultural land was inventoried and analyzed to determine current tillage practices, identify priority locations for best management practices, and to identify the extent of current BMP implementation in the watershed. Agricultural uplands were inventoried by windshield survey, use of GIS data and tools, and with aerial photography. The use of the WDNR EVAAL (Erosion Vulnerability Assessment for Agricultural Lands) and USDA-ARS ACPF [8](Agricultural Conservation Planning Framework) toolboxes were used to determine priority areas for best management practices in the watershed.

Tillage Practices and Residue Management

During the development of the TMDL, data was analyzed from the Conservation Technology Information Center (CTIC) Conservation Tillage Reports (Transect Surveys) from 1999, 2000 and 2002 from Brown, Outagamie, Calumet, and Winnebago Counties and compared with a tillage survey done in spring of 2008 in Brown County by the NRCS and the Lower Fox River Watershed Monitoring Program (LFRWMP). The compared results were found to be essentially the same except for in the Duck Creek watershed. Therefore, the 2008 data was utilized for the Duck Creek baseline tillage conditions. The baseline tillage conditions used for the Duck Creek Watershed were 69.4% conventional tillage, 27.4% mulch-till and 3.2% no-till for a dairy rotation and 56.3% conventional tillage, 36.5% mulch-till and 7.2% no-till for a cash crop rotation. (WDNR, 2012). Based on crop rotation data from 2003 to 2007 and TMDL baseline tillage percentages by rotation type, approximately 35% of cropland in the Lower Duck and Middle Duck was using conservation tillage (mulch-till + no-till) at the time of the TMDL SWAT model development.

Crop residue levels and tillage intensity can now be analyzed from readily available satellite imagery. Since tillage takes place at different times, a series of satellite images were chosen for analysis. Sentinel 2 satellite photos from the fall time period 11/01/2020-12/15/2020 and spring time period 5/18/2021-6/10/2021 were used to calculate a minimum Normalized Difference Tillage Index (NDTI). The NDTI estimates crop residue and cover levels based on shortwave infrared wavelengths. The mean minNDTI values per agricultural field going into crop year 2021 are shown in Figure 34.

[8] Additional information on ACPF can be found at http://northcentralwater.org/acpf/.

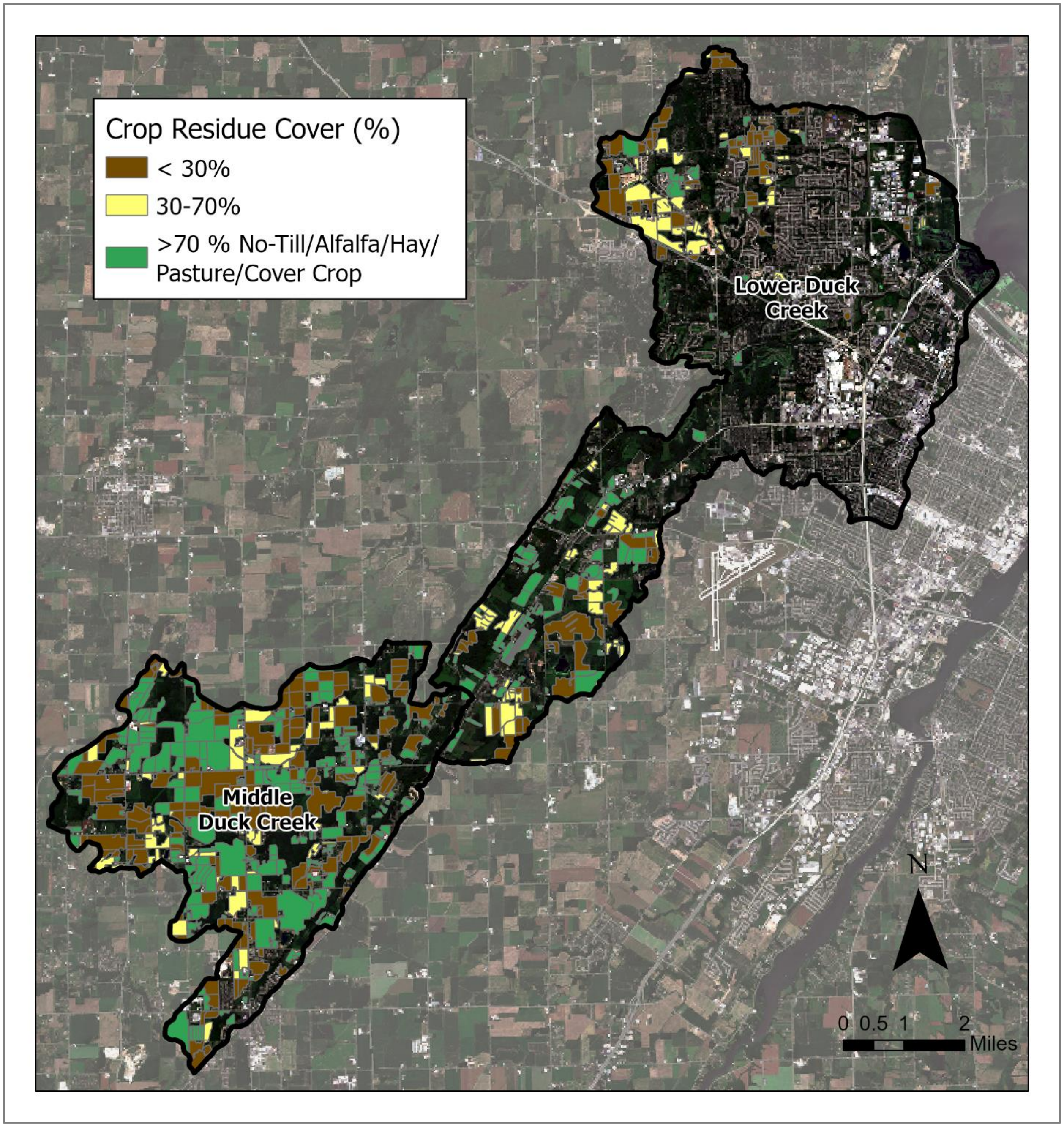


Figure 34. Crop residue cover estimates based on Normalized Difference Tillage Index (November-December 2020 and May-June 2021 Sentinel 2 Satellite Images)

A further analysis was done by overlaying the 2020 cropland data layer and EVAAL crop rotation layer to extract fields that were classified as hay or pasture rotation or were in the alfalfa years of a dairy crop rotation in 2020 to get a more accurate estimate of tillage practices. It was estimated that approximately 43% of the crop fields were using conservation tillage methods (meeting at least 30% residue) in Lower Duck Creek and 22% of crop fields in Middle Duck Creek were using conservation tillage methods. The estimates for Lower Duck Creek are higher than the baseline estimate used for the TMDL and the estimates for Middle Duck Creek were lower than the baseline estimate for the TMDL.

It is likely the priority watershed program in Duck Creek from 1997 to 2009 may have resulted in the higher percent of conservation tillage seen in the 2008 spring survey in comparison to the other Lower Fox Basin subwatersheds. It is likely that this level of conservation tillage decreased for both the Lower and Middle Duck watershed after the program ended. Efforts from the Silver Creek pilot project from 2016 to today have helped boost the amount of conservation tillage and cover crop use occurring on the cropland in the Lower Duck Creek watershed. Spring of 2021 was the last time that cost share funding was available for Silver Creek landowners through NEW Water. NEW Water has referred some of the landowners over to NRCS to continue these practices while others are now implementing cover crops and reduced tillage on their own.

In order to meet TMDL reductions, implementing a combination of practices together such as no-till, cover crops, and low disturbance manure application as a system or converting cropland to well managed grazing that provides vegetative cover year round will be necessary on the majority of cropland. This emerging system of farming, known as regenerative agriculture[9], is designed to mimic nature by providing year round vegetative cover, building soil health and improving infiltration and water retention.

The mean minNDTI can help easily identify fields that would be good candidates for implementation of regenerative agricultural practices such as reduced tillage practices and cover crops or managed grazing. This analysis of imagery can also be used as a way to track implementation of cropping practice systems that provide year round vegetative cover as more years of imagery is collected, since satellites regularly circle the earth.

[9] Additional information of regenerative agriculture can be found at: https://regenerationinternational.org/why-regenerative-agriculture/

Erosion Vulnerability

The EVAAL (Erosion Vulnerability Analysis for Agricultural Lands) tool was used to determine areas in the watershed that are more prone to sheet, rill, and gully erosion. The tool analyzes the watershed based on precipitation, land cover, soils, and elevation data. The resulting outputs of the tool are an erosion vulnerability index, stream power index, and soil loss index. Figure 35 shows the EVAAL erosion vulnerability index indicating which fields are more susceptible to erosion based on the Universal Soil Loss Equation (USLE)[10], stream power index, and internally draining areas. By running the EVAAL tool twice for the USLE and using the high C-factor for "worst case" and low C-factor for "best case" scenarios, the worst case can be subtracted from the best case which indicates areas with the greatest potential for improvement (Figure 36). These maps are an important tool in indicating which fields are contributing the most sediment and phosphorus in comparison to other fields in the watershed, therefore indicating where best management practices such as cover crops and residue management implemented together as a system are going to benefit the most in the watershed.

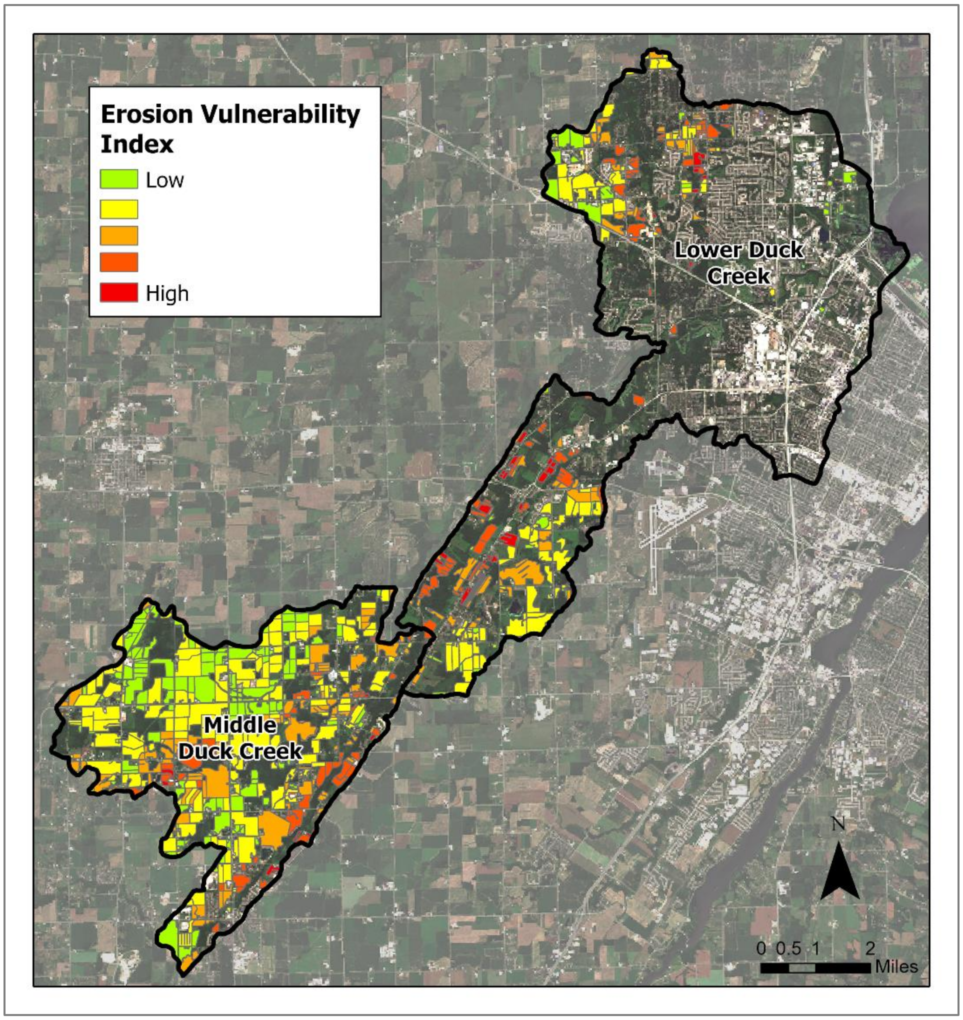


Figure 35. Erosion vulnerability index by field.

[10] USLE refers to the Universal Soil Loss Equation that estimates average annual soil loss caused by sheet and rill erosion base on the following factors: rainfall and runoff (A), soil erodibility factor (K), slope factor (LS), crop and cover management factor (C), and conservation practice factor (P).

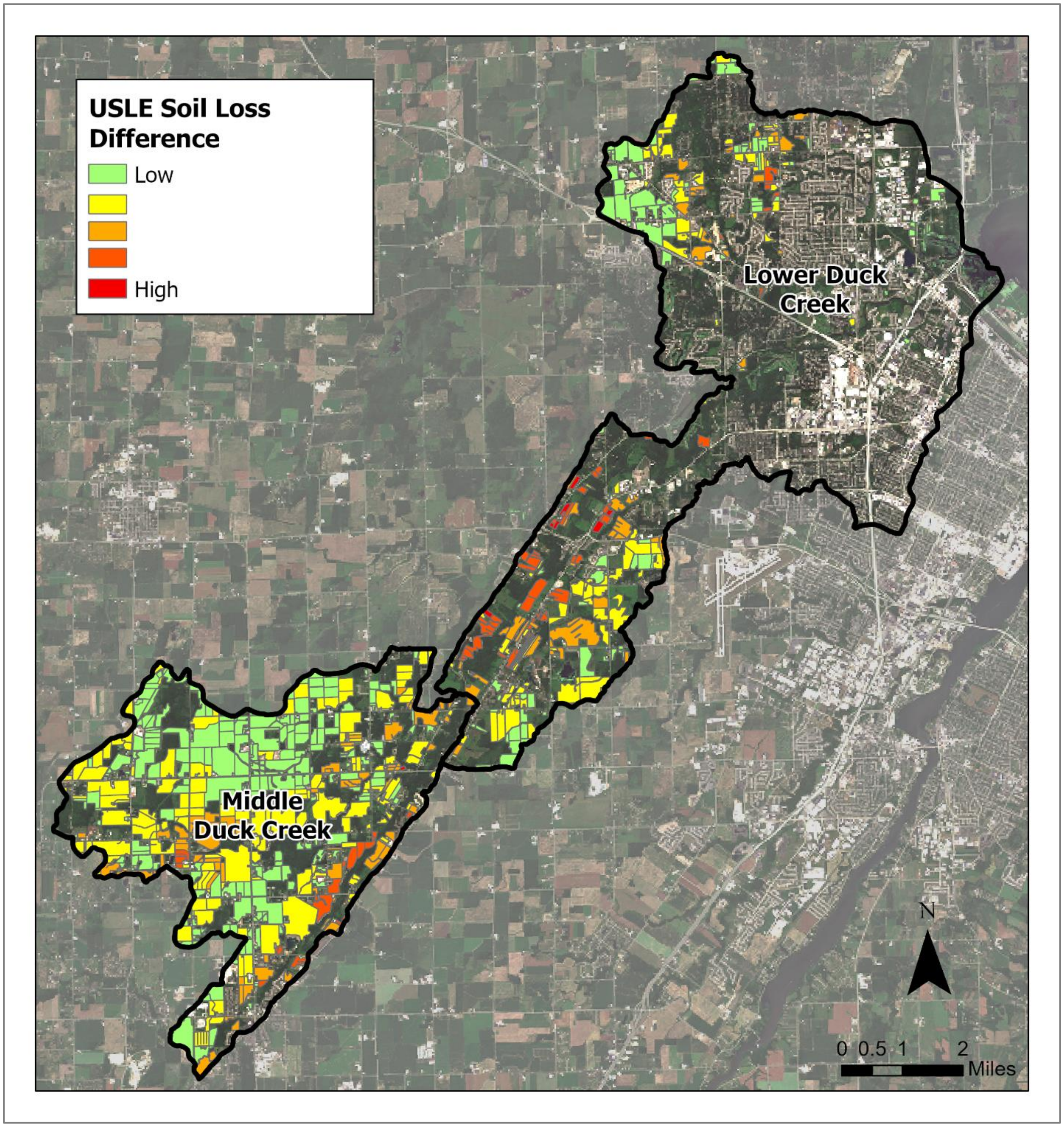


Figure 36. USLE Soil Loss Difference.

Nutrient Management Planning

Nutrient management plans (NMPs) are a whole-farm conservation plan that accounts for all crops, field management decisions and nutrients for the crop rotation. NMPs address concerns related to soil erosion, manure management, and nutrient applications. NMPs must meet requirements of Wisconsin NRCS 590 Standard, ATCP 50, and NR 151. Approximately 58% (4,733 acres) of the cropland and pastureland in Middle Duck Creek and 46% (1,756 acres) of the cropland and pastureland in Lower Duck Creek is covered under a NMP. NMP coverage is shown by field in Figure 37.

Even though a large amount of land in these watersheds is covered by NMPs, water quality remains poor. This indicates that the statewide standards established in NR 151, ATCP 50, and NRCS 590 are not aligned with the TMDL requirements of these waterbodies. To compound the disparity between water quality and NMP coverage, the amount of livestock in this area has remained steady while the amount of farmland has decreased due to urbanization (USDA, 2017). Furthermore, the widespread use of liquid manure via incorporation to fertilize crops and the corn silage/alfalfa crop rotations leaves little crop residue to prevent soil erosion and phosphorus loss in runoff. Alternative ways of handling manure and improved nutrient management in this watershed will need to be implemented to meet TMDL reductions in phosphorus.

NMPs that factor in soil health principles, for example: cover crops, conservation tillage/no-till, and low disturbance manure applications, may need to be implemented to meet TMDL reductions in TSS and TP. Healthy soils will infiltrate more water and sequester more nutrients, reducing erosion and nutrient losses. Healthy soils also require agronomic rates of liquid manure application to maintain soil biota. Examples of new alternative ways of applying manure at agronomic rates include: low disturbance application, split-application, variable rate application based on soil test phosphorus, and inline manure sensing technology to apply at a variable rate based on “live” nutrient content of manure.

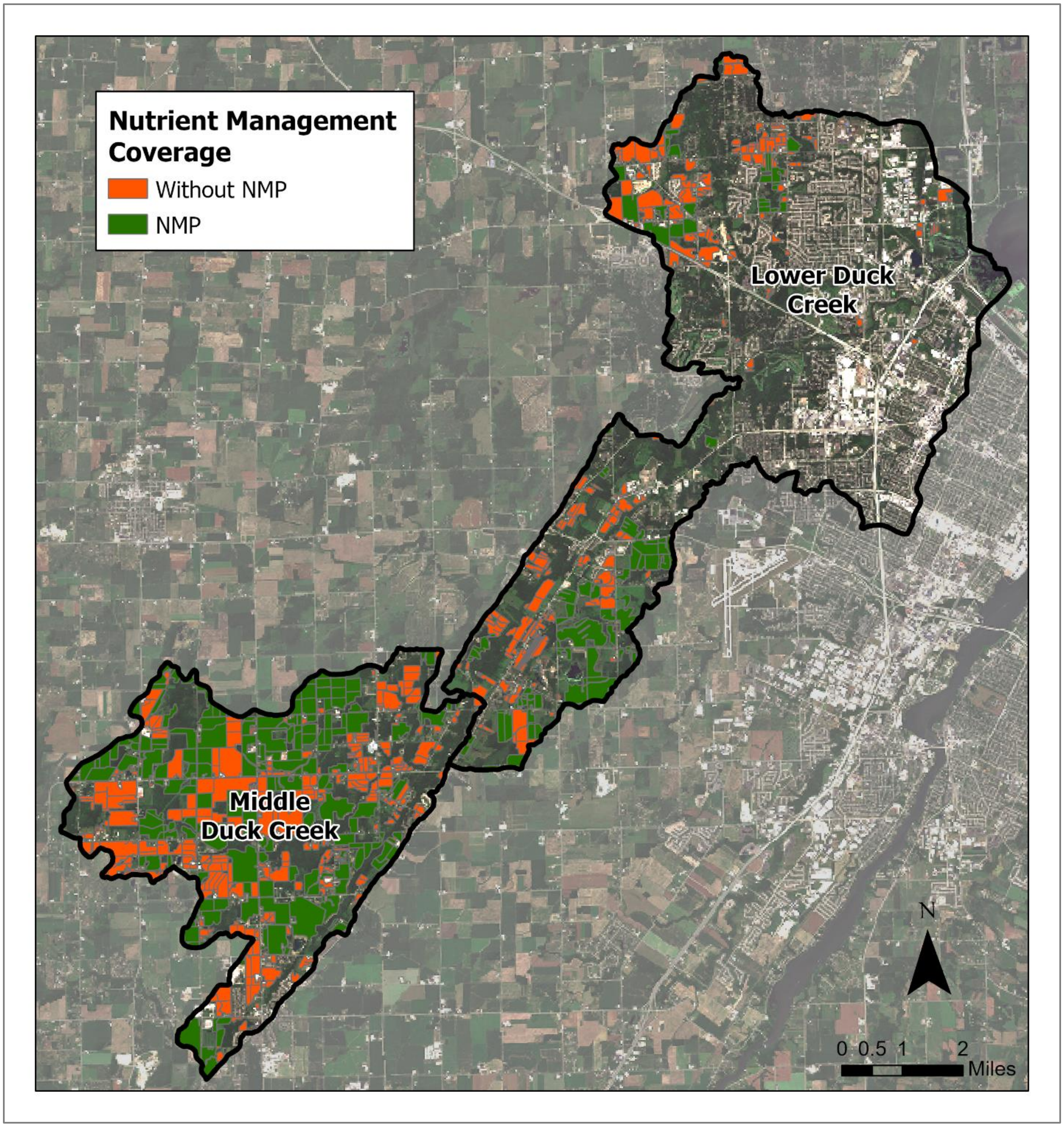


Figure 37. Nutrient management coverage (2020-2021).

Soil Test Phosphorus

Outagamie LCD and Brown County LWCD map average soil test phosphorus concentrations for fields and pasture under Nutrient Management plans. Average soil test phosphorus concentrations of fields with Nutrient Management in the Middle and Lower Duck Creek watershed are shown in Figure 38. UW-Extension Nutrient Application guidelines indicate that average soil test phosphorus values above 25 ppm are high for the crops and soil type found in the Middle and Lower Duck watershed (Laboski, C. and Peters, J., 2012). Approximately 47% (Middle) and 67% (Lower) of the cropland/pastureland acres that have nutrient management have average soil test phosphorus values that are high to excessive. Soil test phosphorus concentrations in the watershed will be useful in prioritizing fields for improved management practices and identifying trends in soil phosphorus levels over time. Implementing cropping practice systems that improve soil health along with improved manure management methods will be needed to reduce excess levels of phosphorus in cropland soils in the watershed.

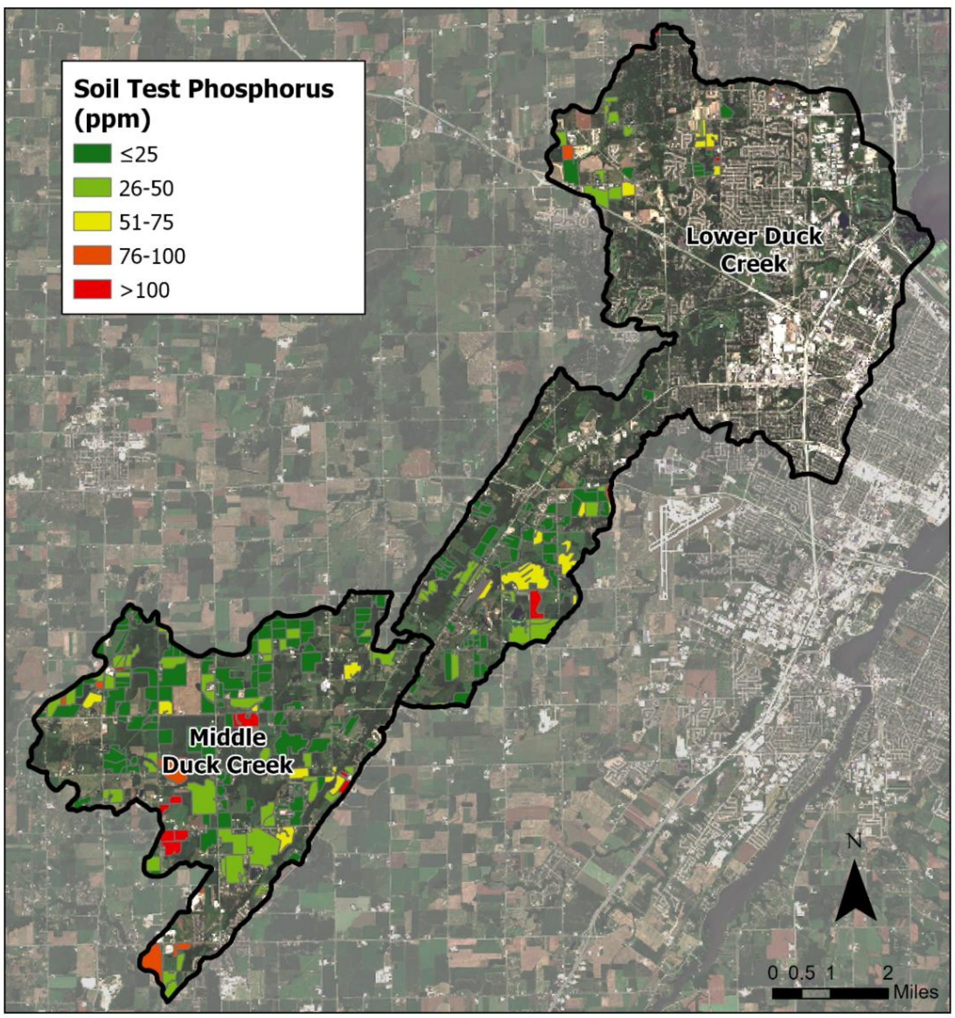


Figure 38. Average soil test phosphorus (ppm) by field.

Grazing/Pastureland Management

Land used for pasture was analyzed using recent aerial imagery of the watershed area and using the NASS cropland data layer. Approximately 7% of agricultural land in the Middle Duck and Lower Duck Creek watershed is pastureland for livestock. Several farms that are operated by the Oneida Nation have started grazing livestock in recent years.

Encouraging farms to convert cropland or land used for hay to managed grazing land could result in significant pollutant reductions. Grazing can also benefit farmers financially by saving them money on fuel costs associated with harvesting, planting, and transportation. Better management of current pastureland can reduce pollutant loading as well.

Tile Drainage

Fields with tile drainage were inventoried by using aerial photographs and then mapped using ArcGIS. There were 3,203 acres of tile-drained fields in Middle Duck and 341 acres in Lower Duck (Figure 39), which is approximately 45% and 10% of the cropland in the watersheds, respectively. Tile drains in fields can act as a conduit for nutrient transport to streams if not managed properly. An average of 0.9 lbs P/acre/yr and 240 lbs sediment/acre/yr was found to be leaving via tile drainage on a UW Discovery Farm study in Kewaunee County, Wisconsin (Cooley et al, 2010). The UW Discovery Farm study compared surface phosphorus loss to tile phosphorus loss and found that the tile drainage was 34% of the TP lost (Cooley et al, 2010).

Treating tile drainage at the outlet and better management of nutrient/manure applications on fields can reduce the amount of phosphorus reaching Duck Creek. Additional options for treating tile drainage at the outlet include constructing treatment wetlands, saturated buffers, phosphorus removal structures, two-stage ditches and installation of water control structures to stop the flow of drainage water during poor conditions. The Agricultural Conservation Planning Framework (ACPF) Model has a drainage water management analysis tool component that identifies areas of tile-drained fields that are suitable for the drainage water management practice (NRCS Code 554) (Porter et al, 2015). Suitable areas for tile drainage water management identified by the tool are shown in Figure 40.

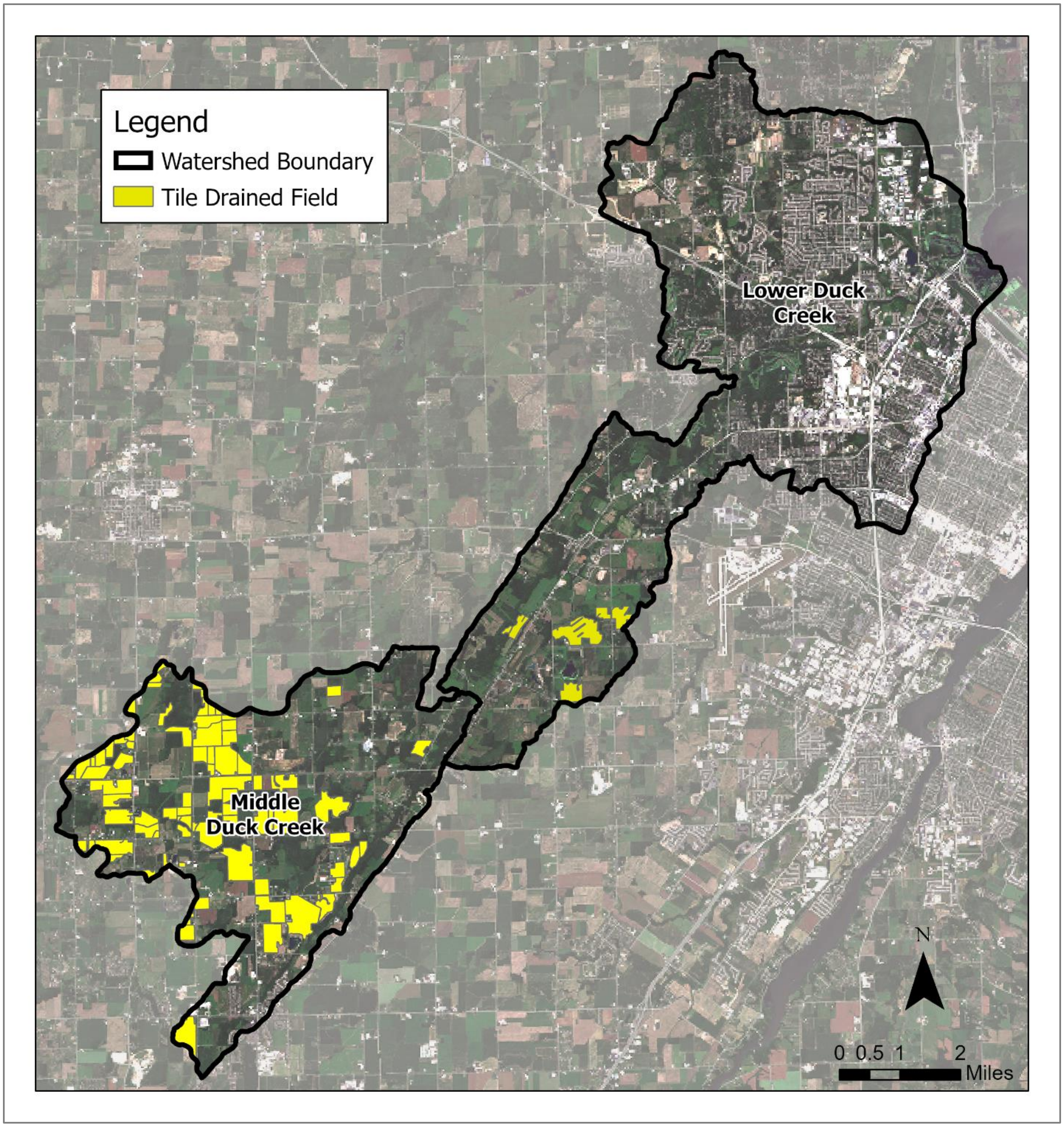


Figure 39. Tile drained fields.

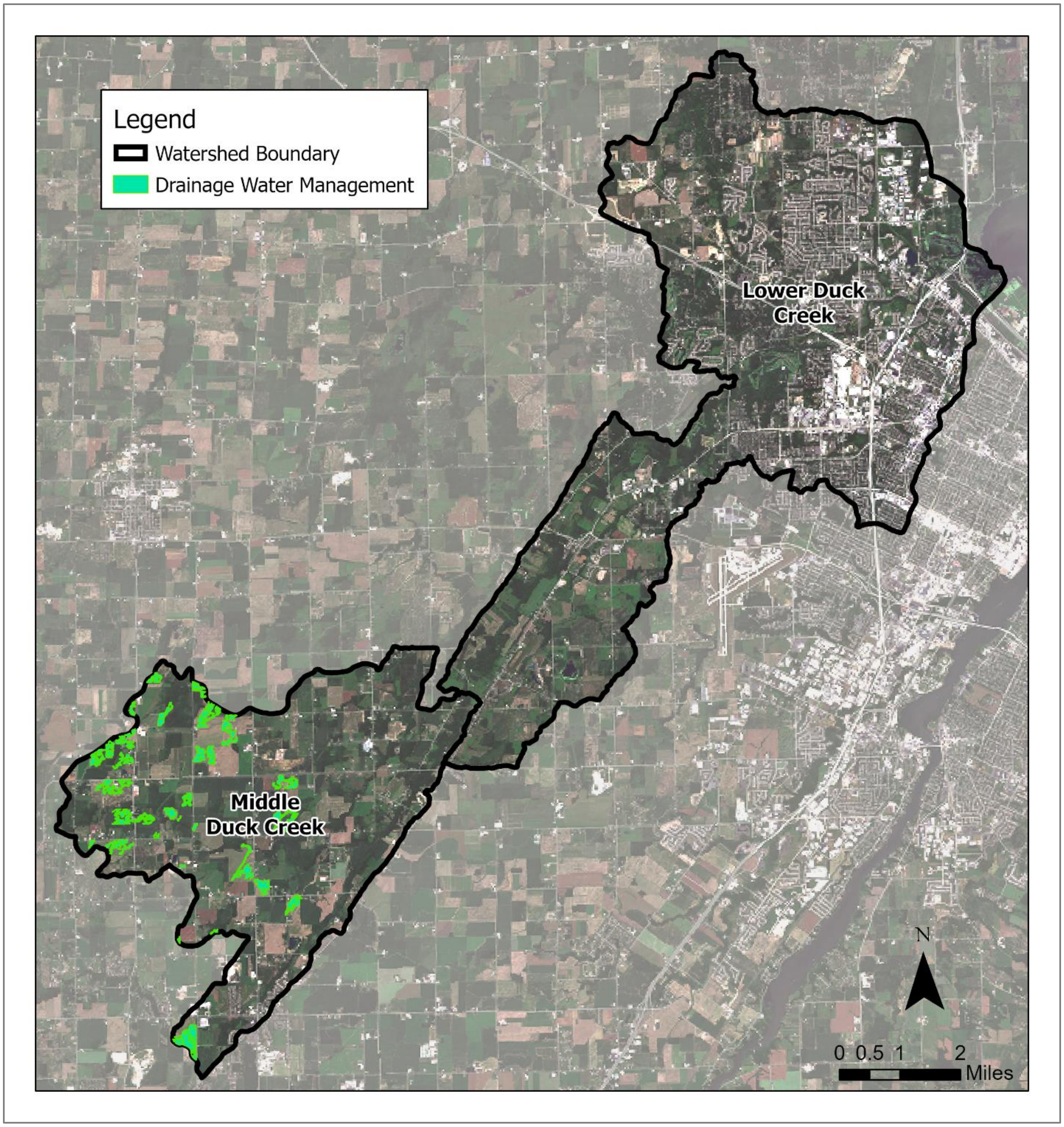


Figure 40. Potential locations for drainage water management of tile drained fields.

Priority Buffer Areas

Vegetated buffers can provide various functions in a watershed. Buffers filter out sediment and nutrients from water before reaching a stream channel, reduce the amount of runoff volume, provide wildlife habitat, regulate stream temperature, and stabilize and protect streambanks from erosion. Buffers can occur in a variety of forms, including herbaceous or grassy buffers, forested riparian buffers, or designed filter strips. The ability of a buffer to provide various functions (e.g. water quality protections, habitat, reduced runoff volume) depends on factors such as width, length, type of vegetation, fragmentation, soil type, and slope.

A minimum of a 35 ft. riparian buffer for streams is recommended for water quality protection, but can be much higher based on slope, upland tributary area and cover and cropping conditions. A GIS analysis and windshield survey was completed to identify streams in the watershed with less than the minimum 35 ft of vegetative buffer. Drainage areas were then delineated using GIS for the areas identified as needing vegetative buffers. Buffers only provide the function of sediment and nutrient retention from overland sheet flow. Therefore, areas where the predominant source of runoff was concentrated flow were removed from the contributing area delineations. These concentrated flow areas are discussed in the next section.

Recommended buffer areas with significant overland sheet flow draining to the proposed buffer should be designed to meet WI NRCS Technical Standard 393 for filter strips. Due to the predominant soils in the watershed, filter strips will likely need to be 40-70 ft in width to provide adequate phosphorus and sediment retention to meet the NRCS standard and TMDL reduction goals. Filter strips also allow for the harvesting of vegetation, which increases nutrient removal and makes the practice more appealing to some landowners.

In areas that lack a large overland flow contributing area, a minimum of a 35 ft vegetative buffer is recommended. These areas still provide the functions of floodplain storage, streambank stabilization, and riparian habitat. This plan recommends enhancing existing riparian buffers and any new buffers that are established with native plants and pollinators whenever possible to provide additional habitat benefits. In areas where additional habitat benefits are desired the WI NRCS Technical Standard 391 for Riparian forest buffer should be followed.

Brown County has an Agriculture Shoreland Management ordinance that requires buffers for navigable streams. The ordinance requires agriculture to comply with the following provisions:

a) A minimum of 35 feet of land free of row crops and seeded to grass, alfalfa, or other close-growing crop shall be maintained between the farmed area and the edge of the navigable stream; navigable stream crossings shall be permitted for livestock and shall be of a design deemed appropriate by the Brown County LWCD. A farmer may be exempt from this section if soil and water conservation practices are deemed sufficient and no pollution is occurring in the opinion of the Brown County LWCD.

b) If there is a pollution problem resulting from the grazing or pasturing of livestock, the farmer/operator will be required to erect a fence no closer than 16-1/2 feet of the edge of the navigable stream or otherwise abate the pollution in such a manner as may be determined by the Brown County LWCD. If a fence has to be erected, provision will be allowed for watering livestock in the navigable stream.

Priority buffer locations were determined by using aerial photography, field inventory, Outagamie and Brown County Hydrography data, ACPF modeling, and WDNR Hydrography data (Figure 41).

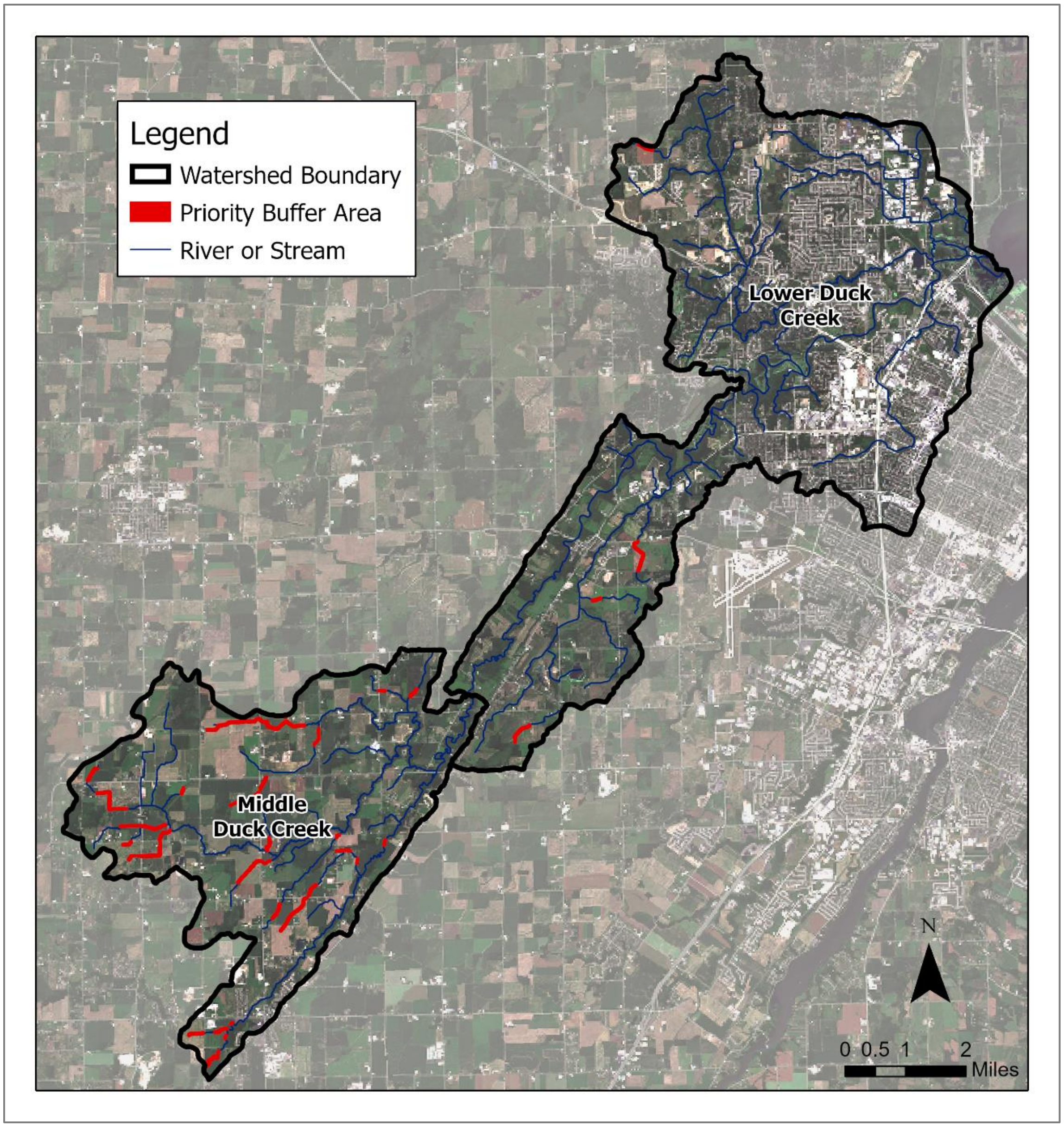


Figure 41. Priority locations for riparian buffers.

Gully and Concentrated Flow Stabilization

Gullies and concentrated flow areas were identified by GIS analysis, windshield survey and field inventory. Elevation and flow direction data is used to develop a stream power index (SPI) that can indicate areas of concentrated flows that might be gullies. An example of high stream power values are shown in Figure 42. A high stream power index along with air photo interpretation was used to determine where concentrated flow and gully erosion is occurring in crop fields in the watershed. Classic gullies (channel formed by concentrated flow erosion too deep for normal tillage operations to erase) occurring in the riparian corridor were identified during the stream corridor inventory (Figure 30). Recommended concentrated flow and gully stabilization practices for cropland include regenerative agriculture practices, grassed waterways, water and sediment control basins (WASCOB), and critical area plantings. For more severe classic gullies in the riparian corridor, recommended practices include lined waterways, grade stabilization, water and sediment control basins (WASCOBS) and terraces.

Figure 42. High stream power index indicating potential gully erosion.

Regenerative agriculture is an emerging system of farming designed to mimic nature that builds soil health. By implementing a combination of practices together such as no-till, cover crops, and low disturbance manure application or converting cropland to well managed grazing, provides vegetative cover year round, builds soil health, improves infiltration and water retention. This system of farming reduces the likelihood of gully erosion to occur in concentrated flow paths due to year around vegetative cover and improved soil health thus reducing the need for traditional gully stabilization practices mentioned above (e.g. grassed waterways and critical area plantings).

The Agricultural Conservation Planning Framework WASCOB tool was used to site areas for Water and Sediment Control Basins. The tool evaluates potential WASCOB locations approximately every 200 ft along flow paths within a drainage range of 2-50 acres (Porter et al, 2015). Priority areas for gully and concentrated flow stabilization on cropland determined by GIS methods and windshield survey are shown in Figure 43.

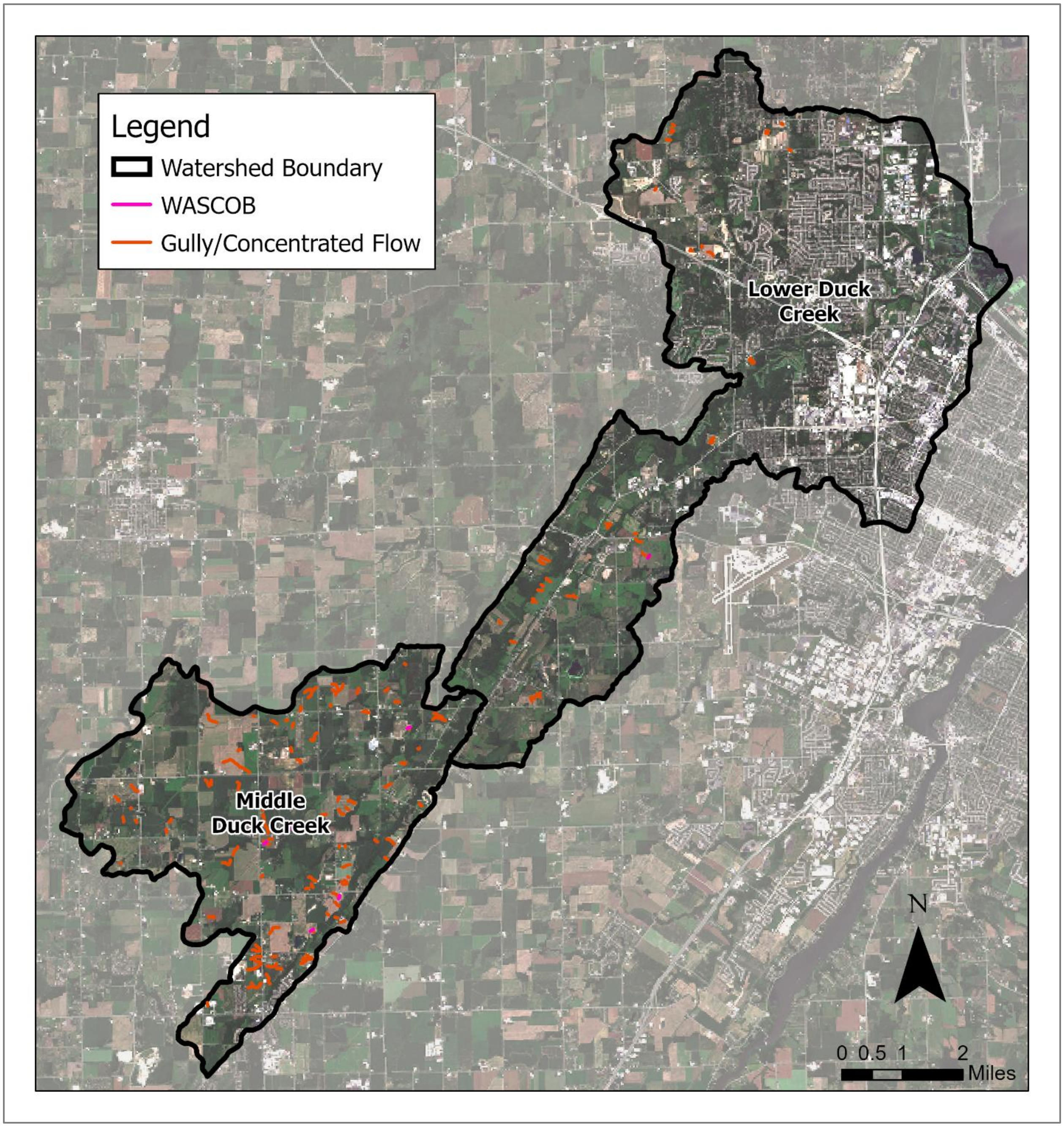


Figure 43. Priority locations for gully/concentrated flow stabilization practices.

6.4 Current Management Practices/Projects

There have been a number of conservation practices installed within the Middle and Lower Duck Creek watershed through prior watershed projects, grants, and by landowners at their own expense. These practices include barnyard runoff control, grassed waterways, grade stabilization, waste storage facilities, buffers, wetland restoration, cover crops, conservation tillage, and nutrient management planning. Nutrient management coverage in the watershed is shown in Figure 37 in Section 6.3. Many of the conservation practices were installed during the Duck, Apple, and Ashwaubenon Priority Watershed Project or through the Silver Creek Adaptive Management Pilot Project. Figure 44 shows conservation practices installed through various programs in the Middle and Lower Duck Creek watershed. Figure 45 shows only the conservation practices installed in the Silver Creek subwatershed during the Adaptive Management Pilot project. (*Note: The figures below do not show the annual cropping practices such as residue management and cover crops that were cost shared through the various programs.*)

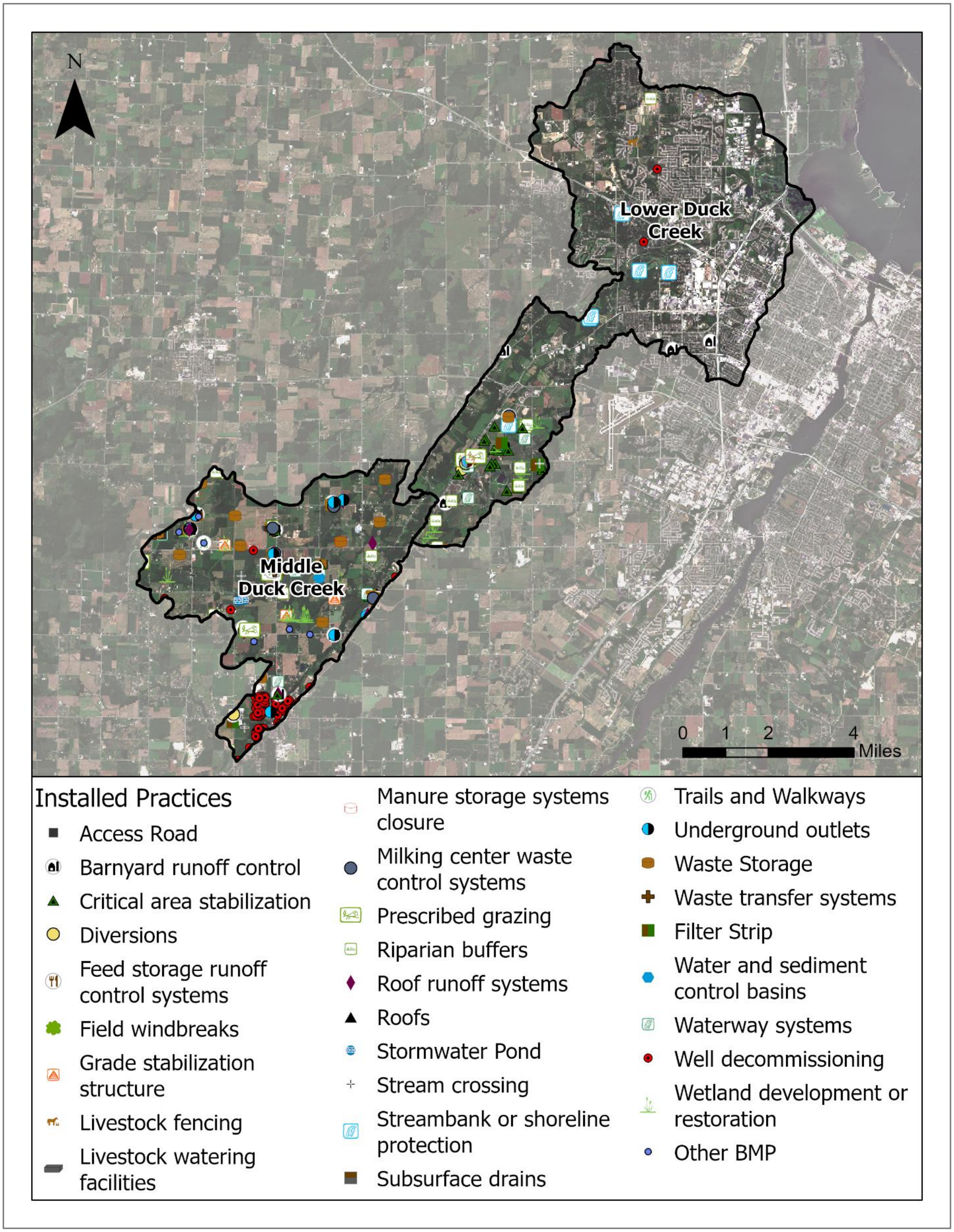


Figure 44. Conservation practices installed in Middle and Lower Duck Creek watershed.

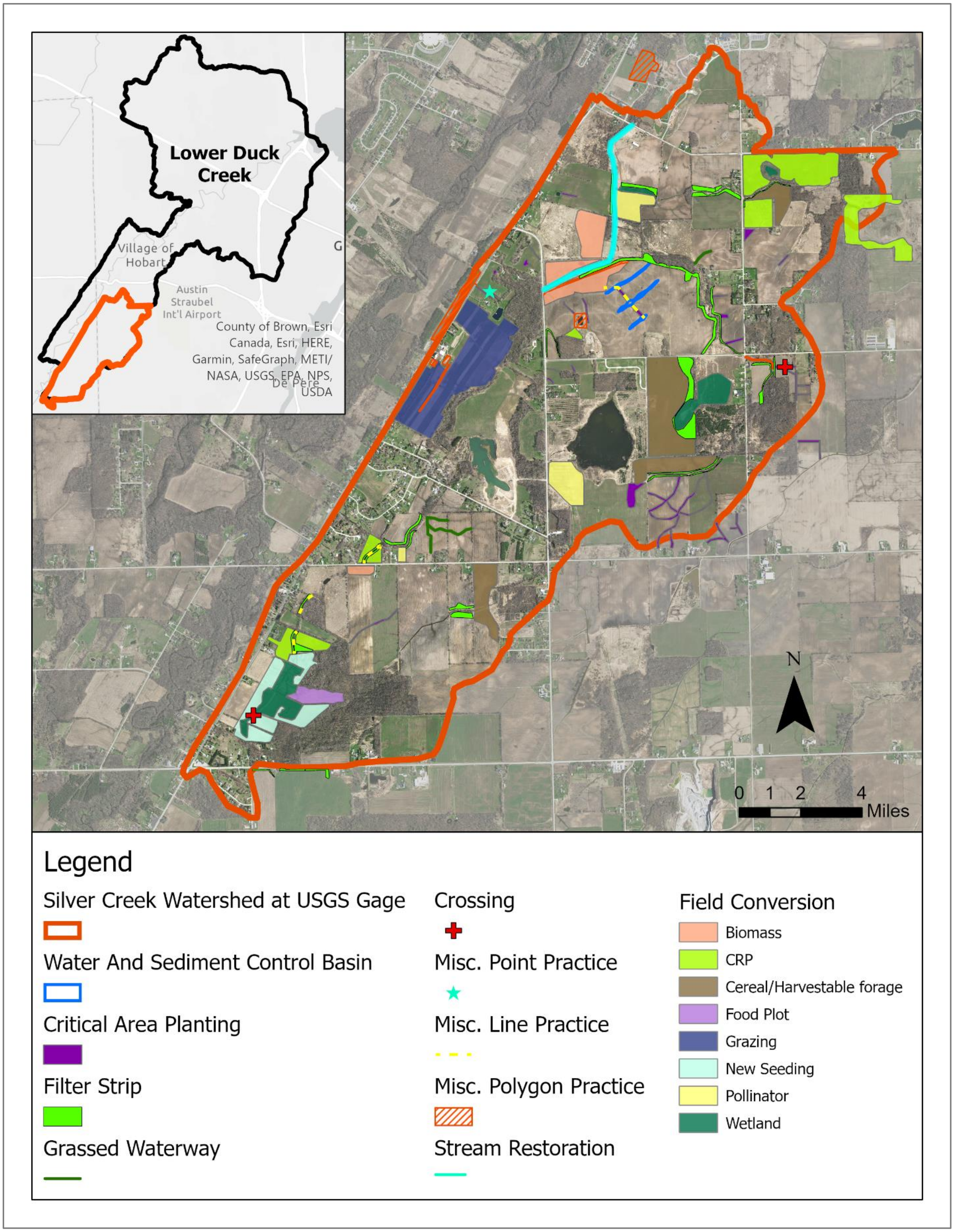


Figure 45. Conservation practices installed in Silver Creek Subwatershed during adaptive management pilot project.

6.5 Wetland Inventory

Wetlands are an important feature of a watershed. Wetlands provide a number of benefits such as water quality improvement, wildlife habitat, recreation opportunities, shoreline protections, and flood control. Many of the wetlands in this area have been lost to development and agriculture. Restoring, enhancing, and creating wetlands in the watershed area will provide water storage, reduce sediment and phosphorus loading, and improve wildlife habitat.

Existing wetland and potentially restorable wetland GIS spatial data was obtained from the Wisconsin Department of Natural Resources (WDNR). A potentially restorable wetland is any wetland that was historically a wetland but has since been drained due to tiling and ditching or has been filled in. The WDNR considers an area a potentially restorable wetland (PRW) if it meets hydric soil criteria and is not in an urban area. There are 1,232 acres of existing wetlands in the Middle Duck Creek and 3,600 acres in Lower Duck Creek according to the WDNR wetland layer (Figure 46). There are 3,166 acres of potentially restorable wetlands in the Middle Duck Creek watershed and 1,217 acres in Lower Duck Creek watershed (Figure 46). Assuming these potentially restorable wetlands were all historic wetlands on the landscape pre-settlement, approximately 72% of the wetlands in the Middle Duck Creek watershed and 25% of the wetlands in Lower Duck Creek watershed have been lost.

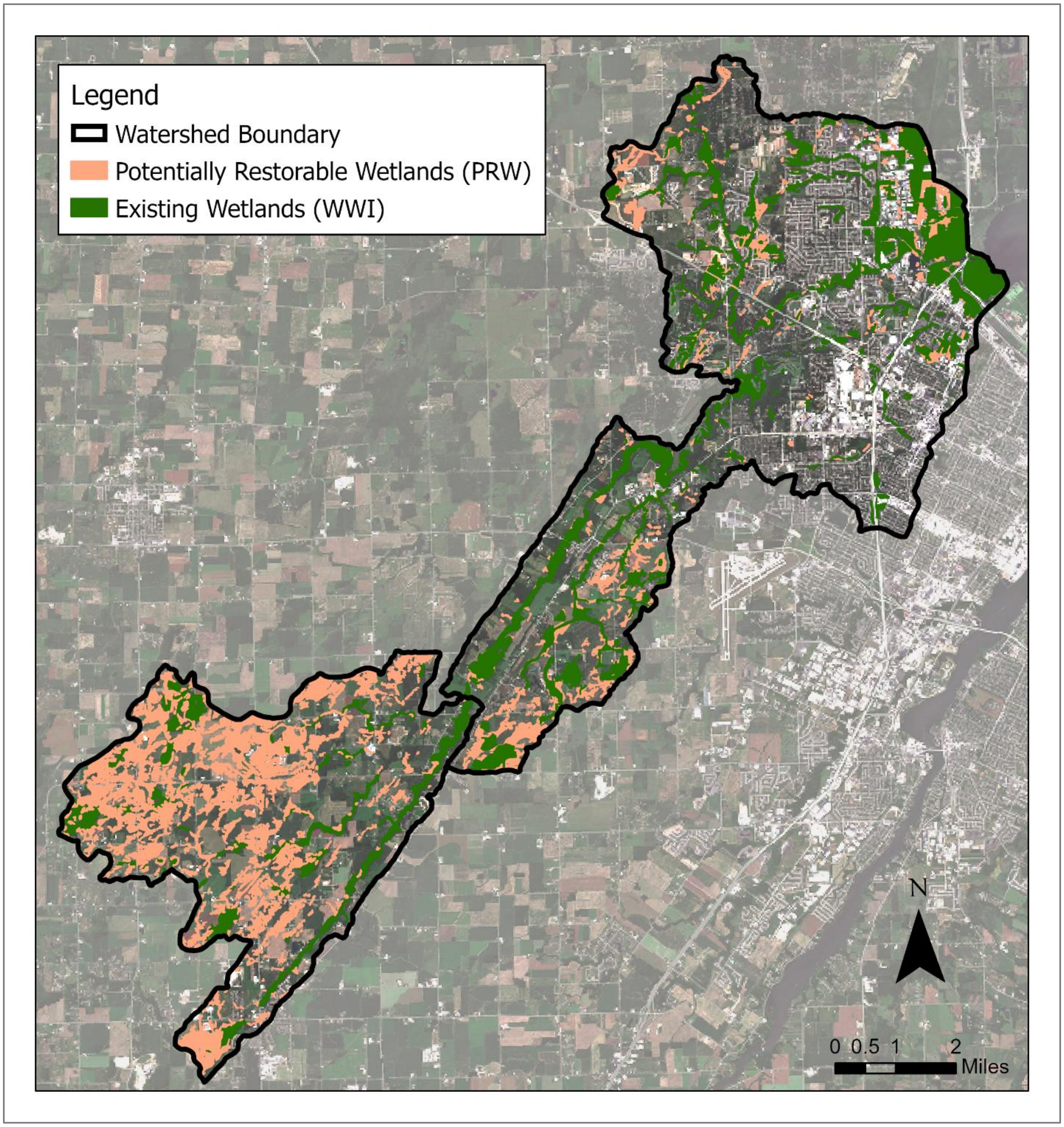


Figure 46. Existing and potentially restorable wetlands. (Wisconsin Department of Natural Resources)

Wetland Restoration

In December of 2017, The Nature Conservancy, Wisconsin Department of Natural Resources, and Conservation Strategies Group finished the *Wetlands by Design: A Watershed Approach for Wisconsin* project. *Wetlands by Design* was developed to support a watershed approach to wetland mitigation and to support voluntary wetland conservation efforts. *Wetlands by Design*[11] ranks watersheds, existing wetlands, and potentially restorable wetlands based on landscape position and the amount of services or potential services provided. At a watershed level, the following services were evaluated: flood abatement, fish and aquatic habitat, sediment reduction, nutrient transformation, and surface water supply. Additional services were evaluated at the site level: carbon storage, floristic integrity, and shoreline protection. Rankings can be viewed through a web-based tool at Wetlands and Watersheds Explorer.

The *Wetlands by Design* data for the Middle and Lower Duck Creek watershed was overlain on the land use GIS data to identify any potentially restorable wetlands that were now urbanized. Any PRW that was urbanized was clipped from the data set. This dataset will be useful in prioritizing sites for wetland restoration based on each sites potential for the services mentioned above. Figure 47 shows PRWs in the watershed ranked moderate-high for potential to improve water quality and Figure 48 shows PRWs ranked moderate to high for potential to improve fish and aquatic habitat.

Wetland Creation/Constructed Treatment Wetlands

Wetland creation opportunities including constructed treatment wetlands sites generally require hydrologic alteration in uplands where hydric soils do not exist. Constructed treatment wetlands are designed to treat wastewater and storm water runoff. The USEPA and WDNR recommends these systems generally be engineered and constructed outside of the waters of the United States[12] and outside of floodplains or floodways to avoid damage to natural wetlands and other aquatic resources. The PRW dataset can also be used to identify potential sites for constructed treatment wetlands. Existing wetland, hydrology, and floodplain GIS data will be used to identify areas that should be excluded for consideration for wetland creation/constructed treatment wetland sites.

[11] More information on methodology used can be found at http://www.wetlandsbydesign.org/.
[12] Waters that are to be protected under the Clean Water Act. Additional information can be found at https://www.epa.gov/cwa-404/definition-waters-united-states-under-clean-water-act

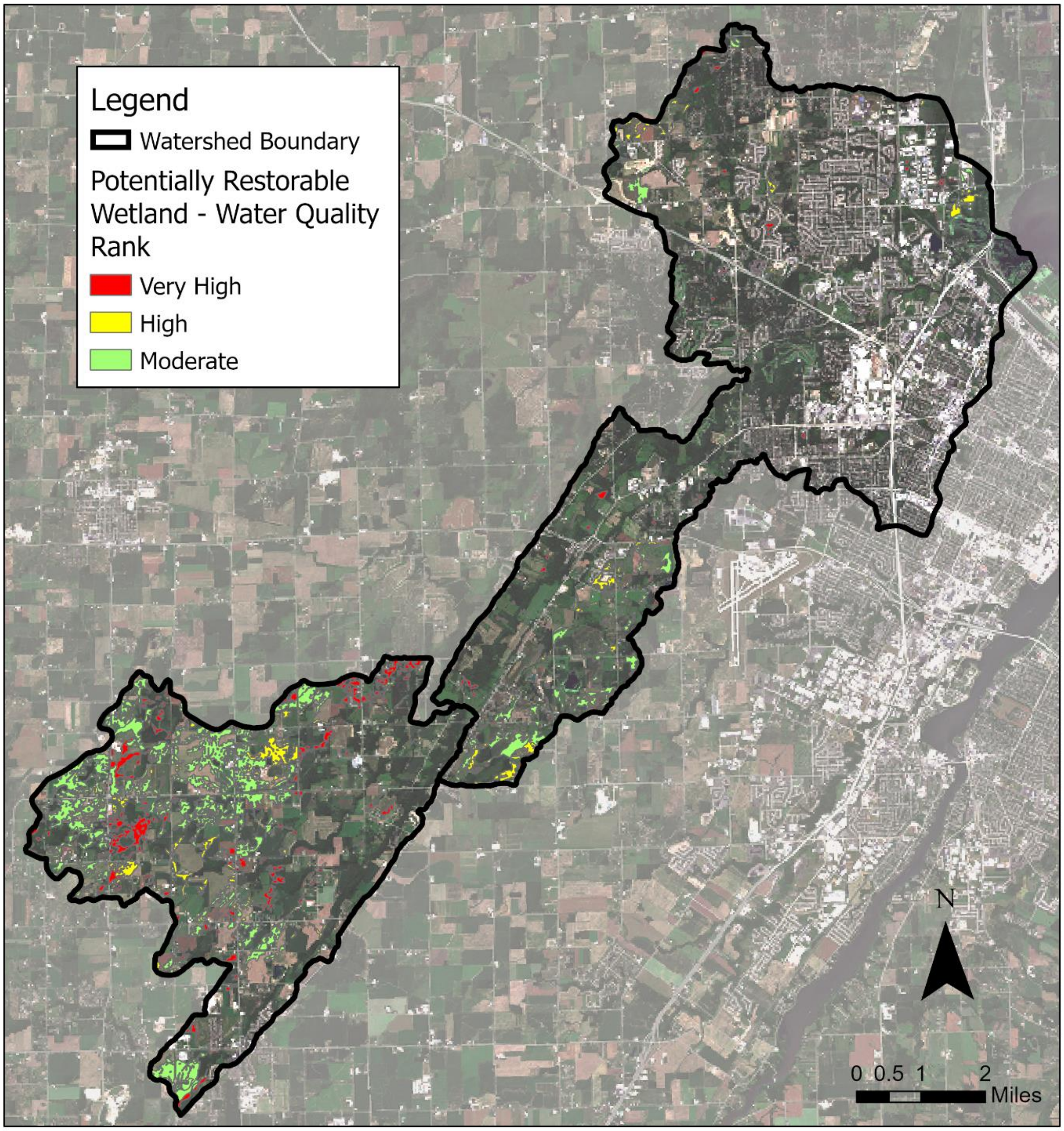


Figure 47. Potentially restorable wetlands ranked moderate to very high for water quality benefits. (*Wetlands by Design*)

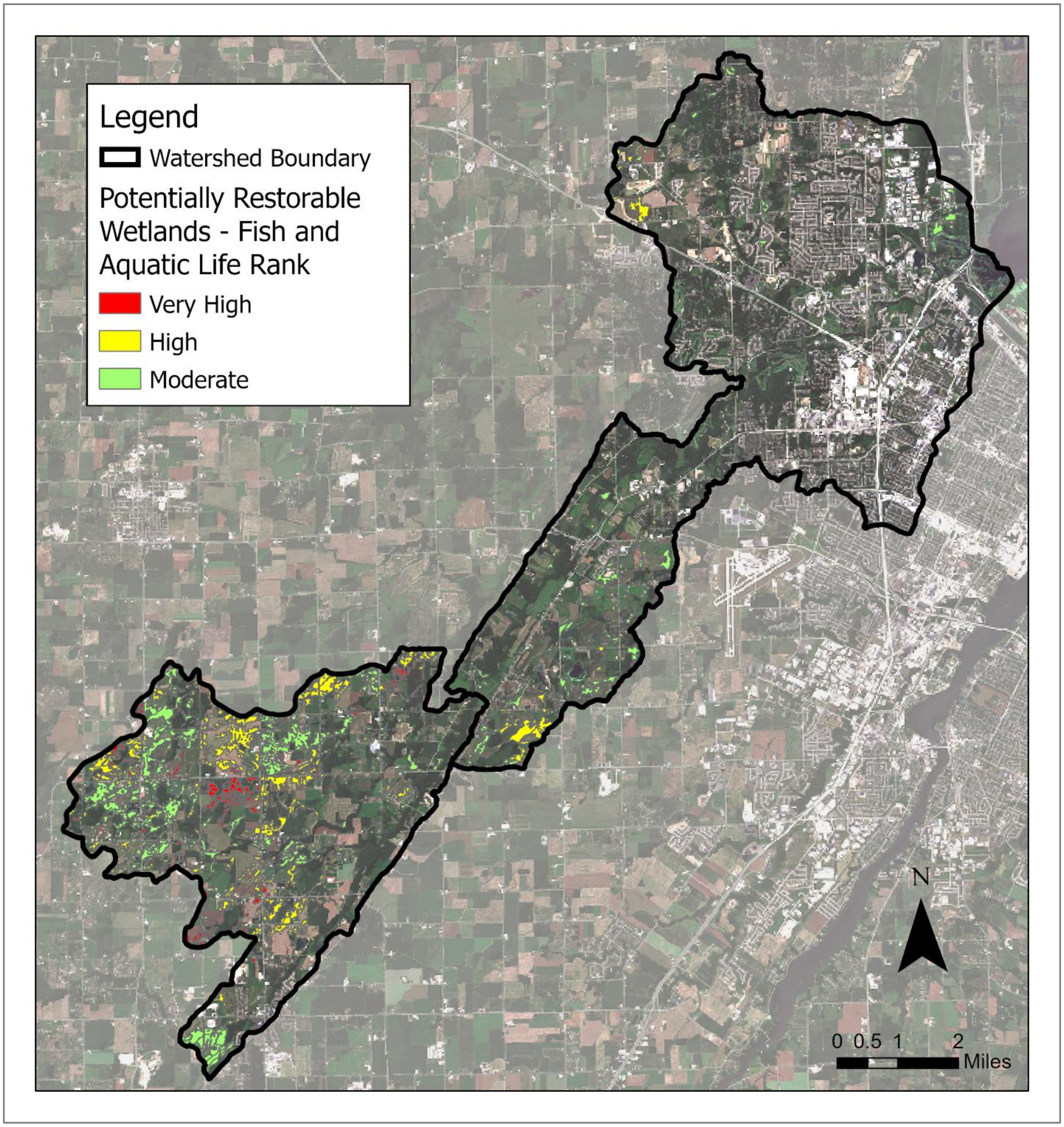


Figure 48. Potentially restorable wetlands ranked moderate to very high for fish and aquatic habitat. (*Wetlands by Design*)

6.6 Water Storage Capacity Analysis

Land use changes in the Lower Fox River Basin have resulted, in part, in significant nutrient and sediment loading to the Lower Green Bay and Fox River Area of Concern (AOC). In addition to the land use change from woodlands and oak savannah to agriculture and urbanization, several of the watersheds in the region have experienced substantial conversion of wetlands. These watersheds have lost the associated water storage capacity the wetlands historically provided. Lost wetland storage coupled with the change in land use has led to an increase in sediment and nutrient runoff, increased flashiness of streams, and streambank erosion.

In 2019, WDNR collaborated with Outagamie County to determine the impacts of land use change and converted wetlands on the hydrologic response of the subwatersheds (HUC12) of the Lower Fox Basin. The resulting calculations from the study provided the volume of water storage needed along with estimated cost and reductions in TP and TSS. The Middle and Lower Duck watersheds were both included in this study.

It is commonly accepted that peak discharge control on the 2-yr storm design will help control streambank erosion (Donovan et al, 2010). Because streambank erosion is a significant source of nutrients and sediment, controlling the rate of erosion is important. Therefore, the 2-yr rainfall event (Brown County- 2.37 in, Outagamie County- 2.45 in) was chosen as the basis for the volume needed to be retained in the subwatersheds to restore hydrology for the analysis. The study focused on the 2-yr MSE-4 24-hour rainfall event for the purpose of identifying and determining the need for increasing water storage capacity to improve water quality by reducing nutrient and sediment load reductions for the BUIs. The study also includes numbers for larger storm events as well with the potential to help mitigate regional flooding issues.

The focus of the analysis was on agricultural dominant headwater drainages. Outlets for catchment delineation were selected if the majority land use was agricultural land and that the topography of the catchment was suitable for large-scale treatment. Runoff curve number is a parameter used in hydrology for predicting runoff or infiltration from rainfall. The runoff curve number is calculated based on hydrologic soil group, land use, treatment, and hydrologic condition. The runoff curve number for current conditions was calculated using gSSURGO soils data and cropland data layers from 2014-2018 in the EVAAL Create Curve Number Raster tool. To calculate a curve number for pre-settlement conditions the historic land cover was assumed to be woods in good condition based on Wisconsin Land Survey data from the mid-1800s. Once the hydrologic parameters of each subwatershed were determined, the EFH2 runoff method was used to estimate runoff volume and peak discharge for each catchment. Inputs into the EFH2 model include drainage area, runoff curve number, watershed length, and watershed slope.

As mentioned in the previous section, approximately 72% of historic wetlands have been lost in the Middle Duck and 25 % in the Lower Duck watershed. Current and historic flow rates from the EFH2 were adjusted based on the amount of wetlands in a catchment. The adjustment factor for pond and swamp areas from Technical Release 55-Urban Hydrology for Small Watersheds was used to adjust the flow rates. The maximum adjustment factor is 0.72 for 5% pond and swamp areas in a catchment.

The hydrologic analysis modeled runoff and storage needs for the 1-yr, 2-yr, 5-yr, 10-yr, 25-yr, 50-yr, and 100-yr MSE-4 rainfall events. Summary data for the analyzed area of the Middle and Lower Duck watershed using EFH2 are shown in Table 12 and Table 13. For the 2-year storm design, a total of 122,554,496 gallons of storage is needed for the analyzed area of the Middle and Lower Duck watershed. Assuming a 2-foot storage depth, a total of 188 acres of land would be needed to provide 122,554,496 gallons of storage in the watershed. Figure 49 shows the acres needed, assuming a 2-foot storage depth, to meet required volume retention and Figure 50 shows what percent of each catchment is required. The required volume retention needed quantified in gallons is shown in Figure 51.

Table 12. Summary data from study for Middle Duck for analyzed areas.

Rainfall Event	Current Flow Rate (cfs)	Historic Flow Rate (cfs)	% Reduction from Current Flow Rate	Water Storage Need (gallons)
1 yr	1,569	453	71%	64,691,869
2 yr	2,095	698	67%	77,683,616
5 yr	3,131	1,242	60%	101,349,362
10 yr	4,123	1,819	56%	122,885,188
25 yr	5,653	2,763	51%	154,908,567
50 yr	6,974	3,636	48%	181,484,159
100 yr	8,411	4,627	45%	209,480,034

Table 13. Summary data from study for Lower Duck Creek for analyzed areas.

Rainfall Event	Current Flow Rate (cfs)	Historic Flow Rate (cfs)	% Reduction from Current Flow Rate	Water Storage Need (gallons)
1 yr	578	118	80%	35,947,587
2 yr	804	197	75%	44,870,880
5 yr	1,256	387	69%	60,541,934
10 yr	1,698	601	65%	74,378,663
25 yr	2,412	976	60%	95,252,796
50 yr	3,043	1,333	56%	112,904,044
100 yr	3,735	1,744	53%	131,627,284

Best management practices (BMPs) with the greatest potential to store significant volumes of water for agriculture land use include agricultural runoff treatment systems (ARTS) and wetland restoration/creation. An Agricultural Runoff Treatment System is similar to a storm water pond in that it will be designed to retain water and settle out sediment. ARTS are designed with wetland cells that mimic wetland functions. TP and TSS reductions were estimated based on the installation of ARTS to store water volumes at the 2-year rainfall event level. For the purposes of the study, a 60% TP and 80% TSS reduction efficiency based on provisional data was used for ARTS. Table 14 shows the estimated reductions that could be achieved in the Middle and Lower Duck watershed, if all the volume of the 2-yr rainfall event were to be stored for all catchments analyzed using the ARTS practice. Wetland restoration and creation in the watershed will also help to achieve water storage goals and thus reduce downstream flow rates and erosion impacts. However, reductions were not estimated for wetland restoration/creation for this study.

Table 14. Estimated TP and TSS reductions if all storage required was implemented using ARTS during a 2-year storm.

Watershed (HUC12)	TP Reduction (lbs)	TSS Reduction (tons)
Middle Duck	3,776	1,004
Lower Duck	2,218	590

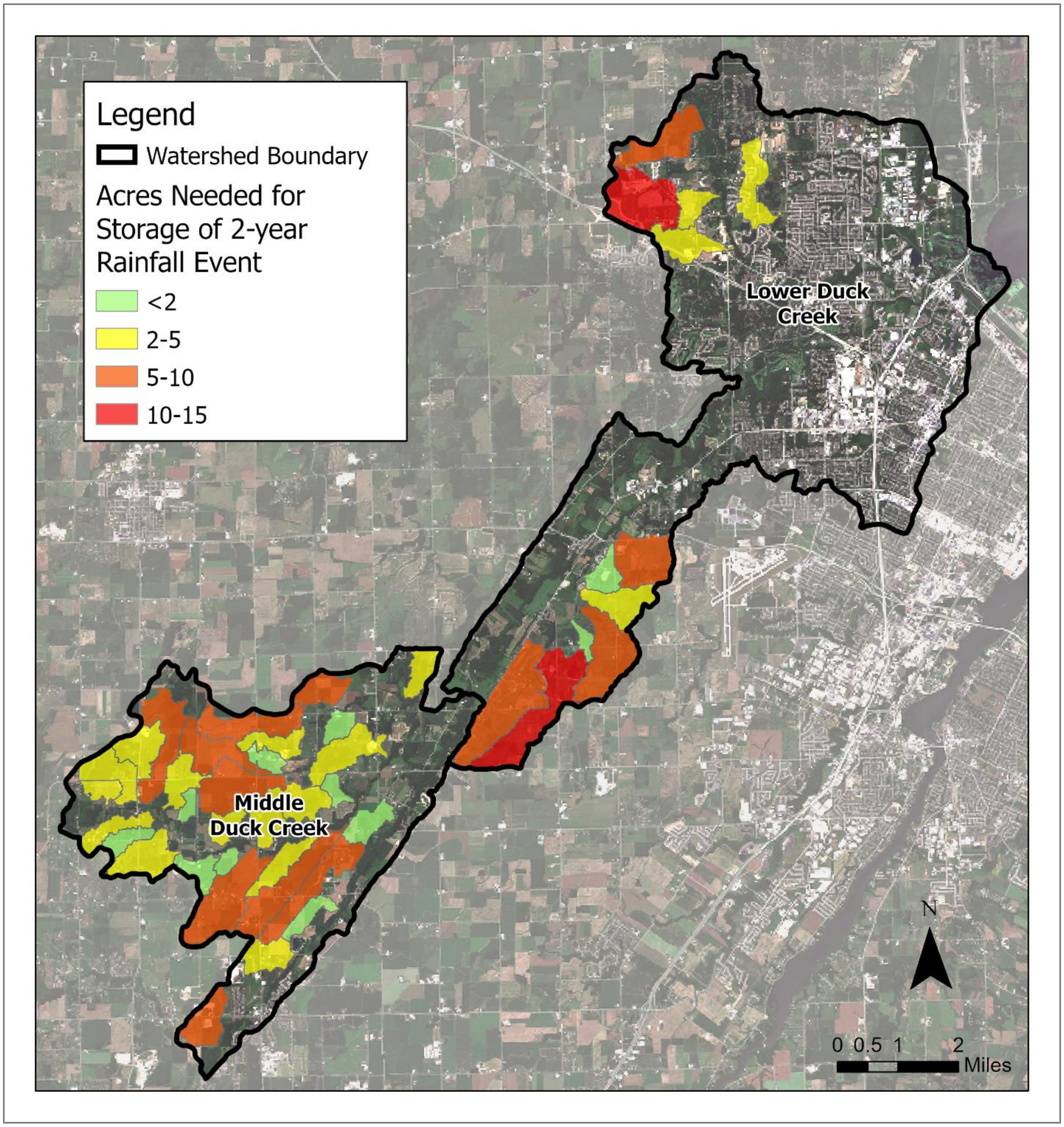


Figure 49. Acres needed for storage of 2-year rainfall event for catchments analyzed.

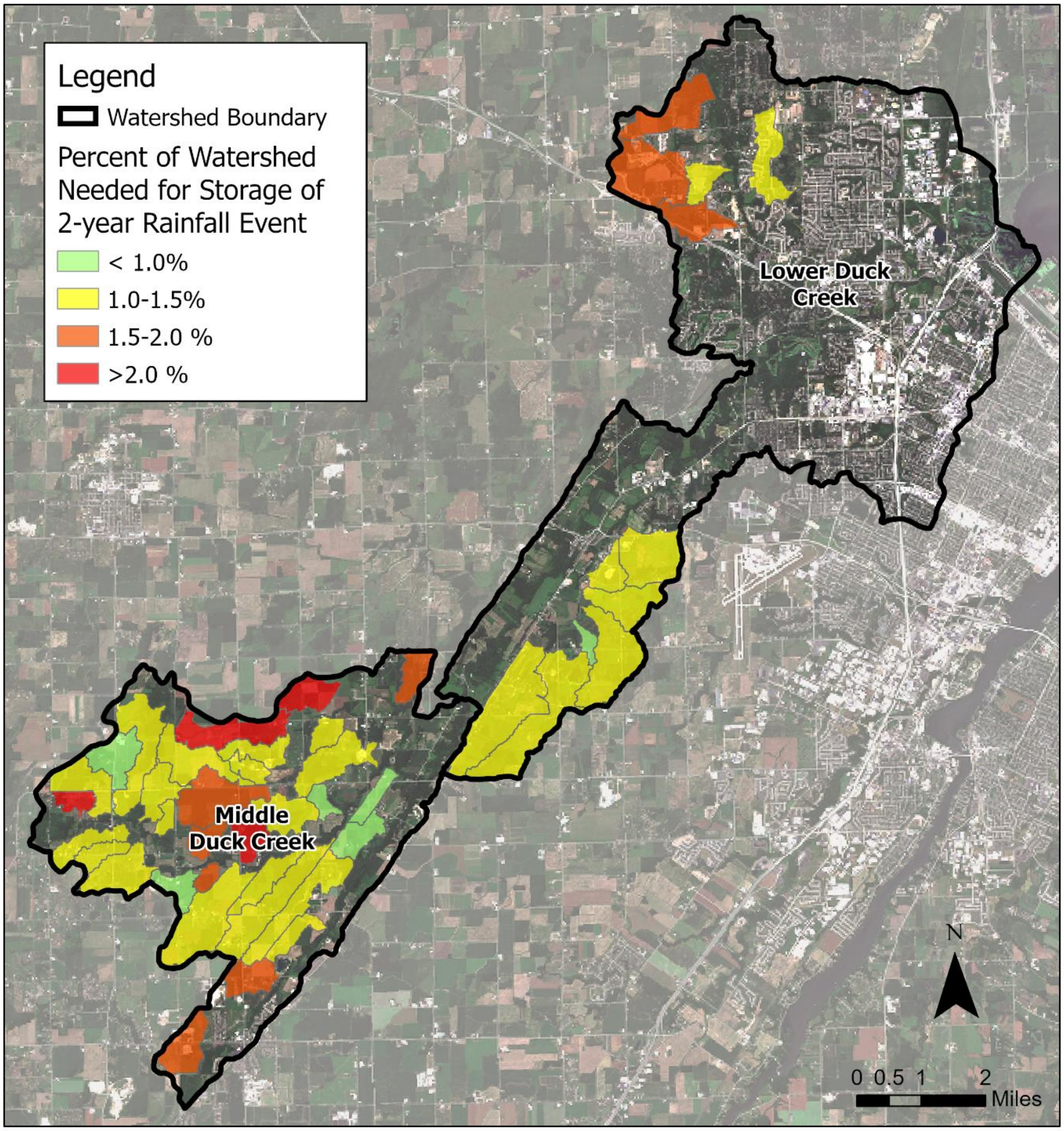


Figure 50. Percent of watershed needed for storage of 2- year rainfall event for catchments analyzed.

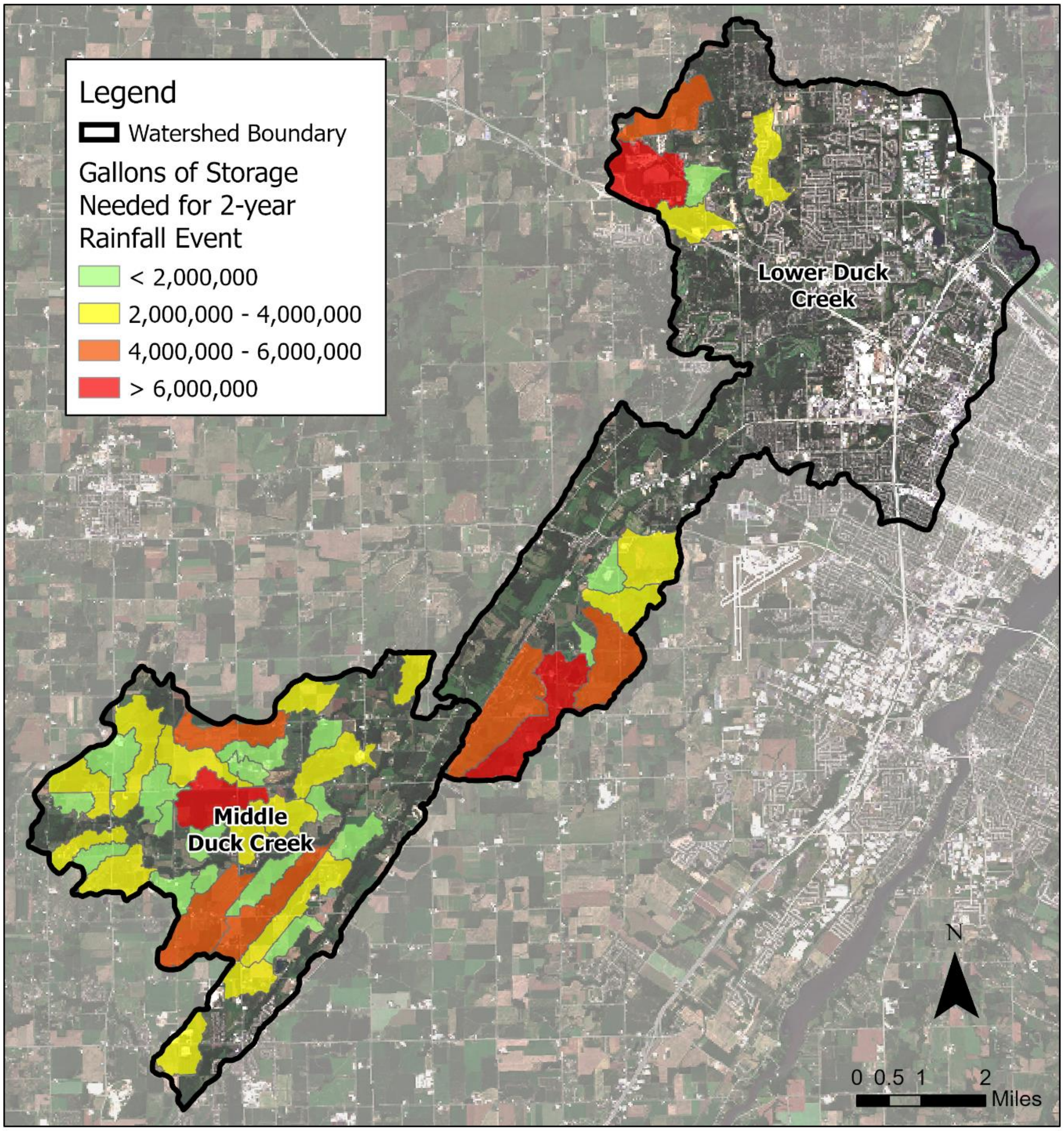


Figure 51. Gallons of storage needed for 2-year rainfall event.

Assuming all the storage needed for the 2-year rainfall event was implemented using ARTS in the Middle and Lower Duck Creek watershed, significant TP and TSS reductions would be achieved. The total area needed for storage practices (ARTS or Wetland Restoration/Creation with an assumed storage depth of 2 ft) is less than 1% of the total watershed area. The estimated cost to install all ARTS needed to restore the 2-yr hydrology in the analyzed areas of the watershed is $12,243,821. This cost takes into account the following costs: land acquisition, outreach, administration, design, survey, construction, construction oversight and operation, and maintenance. The average upfront cost to reduce a pound of phosphorus using ARTS is $2,025 and $10,672 to reduce a ton of sediment. It should be noted that these practices will be designed to achieve annual reductions for 20 years before needing maintenance to remove accumulated sediment.

In comparison, it is estimated that the upfront cost to reduce a pound of phosphorus is $1,960 for implementing a regenerative agriculture system of cropping on a farm field; this includes using no-till, cover crops, and low disturbance manure injection. This cost assumes 7 years of cost sharing at $280/acre is needed for a farmer to adopt these practices for the long term. Assuming the cropping system is adopted for 20 years after receiving 7 years of cost sharing initially, the annual cost for a pound of phosphorus reduced is $98 in comparison to $101 for the ARTS system. Currently, state and federal cost share programs available allow a maximum of 3-4 years of cost share for soft practices such as no-till, cover crops, and low disturbance manure injection. Current proposals for other funding sources needed include farmers agreeing to use the practices for another 14 years in order to receive the 7 years of funding.

When comparing the ARTS upfront cost to the upfront cost of conservation cover they are very similar. The upfront cost estimates do not include the cost benefit of reduced downstream flooding and streambank erosion from wide scale implementation of ARTS and conservation cover. ARTS once constructed are a permanent structure, while full adoption of conservation cover would be an entirely new way of farming and may not be fully resilient to change in climate. The option of implementing an ARTS system allows farmers the flexibility to choose between a regenerative agriculture system of farming and ARTS to reduce nutrient and sediment laden runoff from leaving their land. However, encouraging adoption of conservation cover is still an important strategy in meeting reduction goals in the basin. A combination of ARTs and wide scale adoption of regenerative agriculture BMPs (e.g. no-till and cover crops) will make the system more resilient to climate change.

The study focused on the 2-yr MSE-4 24-hour rainfall event for the purpose of identifying and determining the need for increasing water storage capacity to improve water quality by reducing nutrient and sediment load reductions for the BUIs. The study includes numbers for larger storm events as well with the potential to help mitigate regional flooding issues. The analysis data from the other rainfall events such as the 25-yr, 50-yr and 100-yr can also be used by local communities and other local entities looking for ways to reduce the impact of flooding. Local communities can use this data to identify priority watersheds for potential downstream storm water practices (detention basins) and to identify opportunities to work with upstream communities or agriculture producers to reduce runoff rates from headwaters of priority watersheds. Communities impacted by flooding from upstream may also want to partner with local land conservation departments to provide additional funding to increase the storage capacity of a potential ARTS system from a 2-yr rainfall to a 10-yr or 25-yr rainfall capacity if it benefits them downstream.

Additionally, the data can also be used to better plan urban development as communities in the watershed continue to expand by designing regional treatment that provides for both future development and create storage needed for this analysis. This approach ensures the BMPs are installed in optimal locations while providing the benefit to development of land that has the appropriate BMPs in place in advance.

The next step following the study is to reach out to conservation partners (e.g. The Nature Conservancy, NRCS, Ducks Unlimited, USFWS, etc.) that create storage on the landscape through projects such as wetland restoration and creation. Previously built projects will be evaluated for their potential to meet the methodology of the study and will be analyzed to determine cost effectiveness of altering. Additionally, potential projects in the watershed area will be evaluated for their ability to provide the storage identified in the study. If the project is a good candidate for providing storage, costs may be shared through more than one source/group.

Approximately 48 acres of wetlands were restored or created in the Silver Creek subwatershed of Lower Duck during the adaptive management pilot project. These recently implemented wetland restorations should be analyzed to determine the effective water storage capacity already achieved in these sub catchment areas with these projects.

Due to the Green Bay Austin Straubel International Airport being located near the Lower Duck Creek watershed, the siting and design of any ARTS practice within a 5 mile radius of the airport will require examination by the airport. The *Federal Aviation Administration (FAA) Advisory Circular 150/5200-33B, Hazardous Wildlife Attractants on or near Airports* states that it is inadvisable to locate wildlife attractants (wetlands, ponds, water impoundments) within 5,000 feet of air operation areas accommodating piston-type aircraft and within 10,000 feet of air operation areas accommodating turbine powered aircraft. It also states all proposed land uses that could potentially increase wildlife attractants should be examined within 5 miles of the airport.

The full analysis report can be accessed at:

https://www.outagamie.org/home/showdocument?id=73817

6.7 Area of Concern Habitat Opportunities

The area near the outlet of Lower Duck Creek watershed falls within the 1km buffer of the Lower Green Bay and Fox River Area of Concern (LGBFR AOC) boundary. In the 1980's Lower Green Bay and the Fox River below the De Pere Dam was listed as 1 of the 43 Great Lakes Areas of Concern by the International Joint Commission of Canada and the United States. There are 14 possible beneficial use impairments defined by the U.S. and Canadian governments. Of the 14 possible impairments, 11 were originally listed as "present" and two as "suspected" in the AOC. The following are the beneficial use impairments for the AOC:

- Restrictions on fish and wildlife consumption
- Tainting of fish and wildlife flavor (*suspected*) – Removed April 2020
- Degradation of fish and wildlife populations
- Fish tumors or other deformities (*suspected*)
- Bird or animal deformities or reproductive problems
- Degradation of benthos
- Restrictions on dredging activities- Removed September 2021
- Eutrophication or undesirable algae
- Restrictions on drinking water, or taste and odor problems
- Beach closings
- Degradation of aesthetics – Removed April 2022
- Degradation of phytoplankton and zooplankton populations
- Loss of fish and wildlife habitat

WDNR Office of Great Waters is working with several partners from various agencies and organizations to address the Degradation of Fish and Wildlife Populations and Loss of Fish and Wildlife Habitat BUIs. In 2017, University of Wisconsin-Green Bay and The Nature Conservancy completed a habitat assessment of the LGBFR AOC area[13]. The draft final report identified 18 habitat types in the LGBFR AOC and established baseline condition scores for each habitat type. The report provides general recommendations for management actions in priority areas that will potentially improve habitat condition. The LGBFR AOC project area and habitat types identified within the Lower Duck Creek watershed are shown in Figure 50. The LGBFR AOC Fish, Wildlife and Habitat Technical Advisory Committee completed a draft management action list in February 2020 that formally recommended a suite of 18 specific management actions (e.g. restoration projects). The final management action list was submitted to U.S. EPA in 2020 and is awaiting approval. This plan recommends implementing applicable management actions identified in the final management actions list once completed to protect, restore, and rehabilitate fish and wildlife habitat. Management action areas for the Lower Duck Creek watershed are shown in Figure 53 and Figure 54.

[13] For additional information see https://www.uwgb.edu/green-bay-area-of-concern/

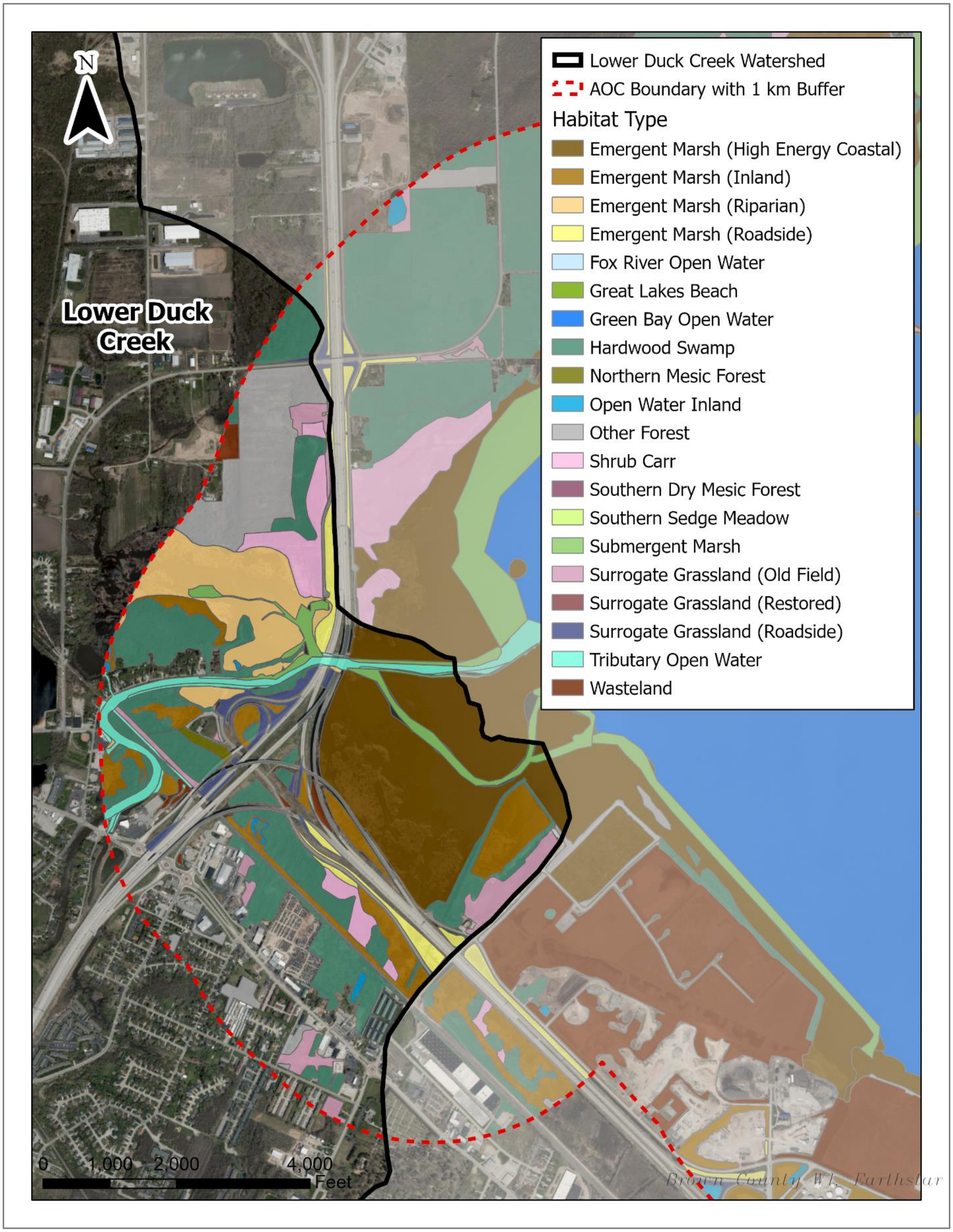


Figure 52. Habitat types in Lower Green Bay and Fox River Area of Concern.

Project: Duck Creek Delta

Rank: 3 of 18

Progress Towards Loss of F&W Habitats BUI Target

= 0.336/2.40 (14%)

Progress Towards Loss of F&W Populations BUI Target

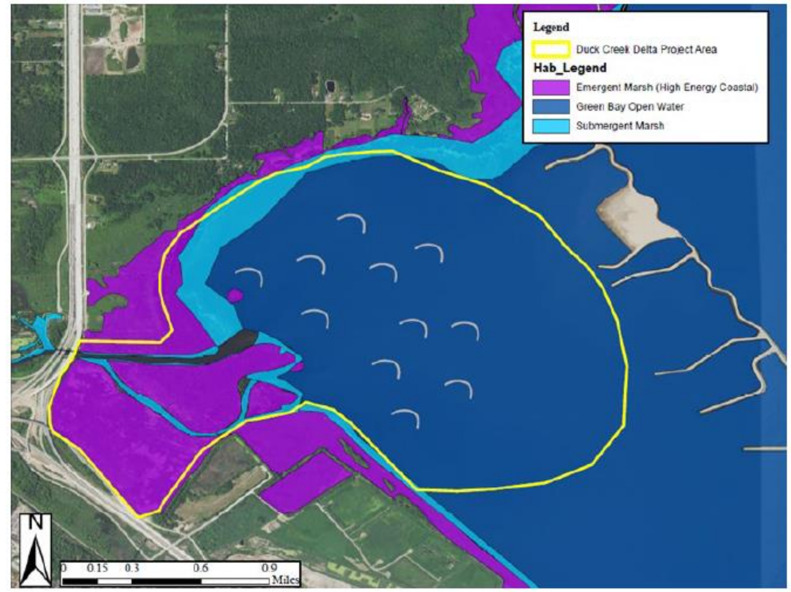
= 0.120/1.75 (7%)

Top Populations Impacted

Shoreline Fish	Wetland Terns	Muskrat	Marsh Breeding Birds	Wetland Macroinvertebrates
18%	11%	9%	9%	9%

Other Factors

Project Cost	Feasibility	Co-benefits
8.8/10	6.8/10	8.5/10



Habitat Project Elements

- 250 acres Coastal Emergent Marsh added
- 250 acres Submergent Marsh added
- 1 DCA unit for GB Open Water – fish

Figure 53. Duck Creek Delta LGBFR AOC habitat management actions area.

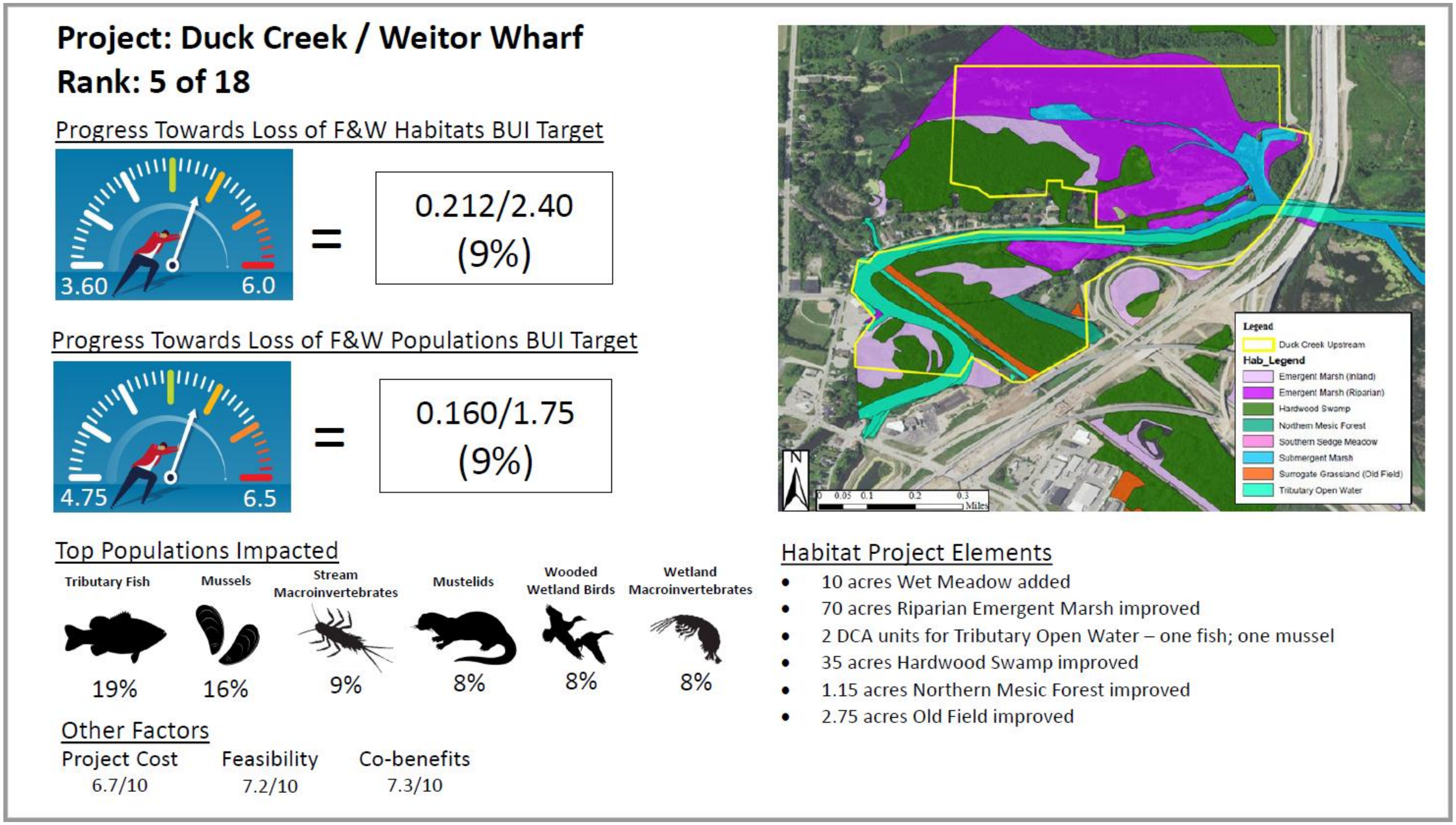


Figure 54. Duck Creek Weitor Wharf LGBFR AOC habitat management actions area.

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6.8 Green Bay Blueprint Habitat Conservation Opportunities and Needs

The Blueprint Working Group[14] analyzed mixed wetland, grassland, and forest landscapes that are 20 acres or larger along with several ecological metrics to provide recommendations for Conservation opportunities or needs. Mixed landscapes that are larger in size and contained several ecological metrics are classified as *High Conservation Opportunity* areas. Mixed landscapes that are smaller in size and provided few or no ecological metrics are identified as landscapes of *High Conservation Need*. Landscapes that fell in between these two categories are classified as *Medium Conservation Opportunity* areas. *Conservation Opportunity* areas identified are often close to existing protected lands, were historically ecologically significant habitats, often have records of threatened and endangered species and are otherwise in high-quality areas. *Conservation Need* areas are often degraded or have poor water quality where actions like wetland restoration, reestablishing riparian areas, and/or other best management practices would provide great benefit for conservation dollars invested. Conservation Opportunity and Need areas identified in Middle and Lower Duck by this working group are shown in Figure 55.

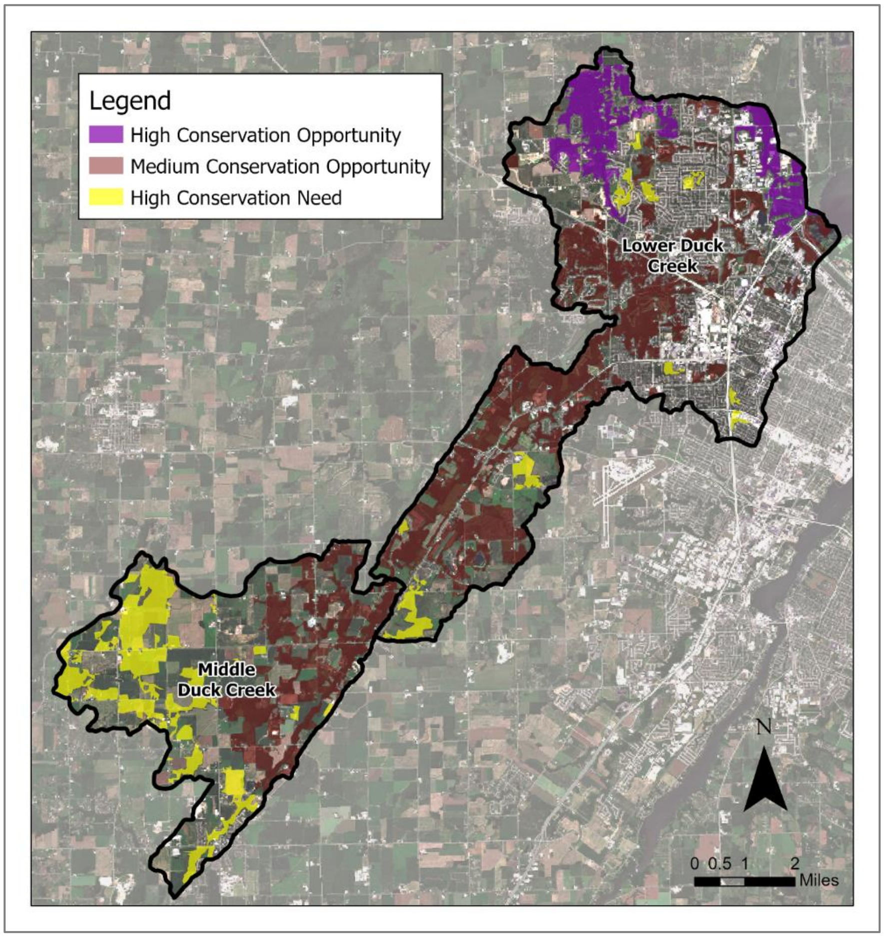

Figure 55. Recommended Conservation Opportunity or Conservation Need areas. (Source: *Conservation Blueprint for the Fox, Wolf, and Green Bay Region*)

[14] The Blueprint Working Group is a dedicated community of conservation practitioners who work in the Wolf, Upper Fox, Pool Lakes, Lower Fox, and Green Bay ecosystems of Wisconsin. Additional information can be found at https://www.gbconservationpartners.org/blueprint/

6.9 Urban Non-MS4

There are approximately 2,094 acres of urban non-regulated land in the Middle Duck Creek watershed and 1,597 acres in the Lower Duck Creek Watershed. The distribution of regulated (MS4) and non-regulated (Non-MS4) urban land use in the watersheds is shown in Figure 56.

The TMDL, approved in 2012, did not recommend a reduction from baseline for either TP or total suspended solids for urban non-regulated areas for sub-basins of the Lower Fox River Basin. Recent STEPL models run on the watershed by Outagamie County LCD staff identify urban non-regulated inputs as 8% (Middle) and 4% (Lower) of the TP load and 5% (Middle) and 2% (Lower) of the suspended solids load in the watersheds.

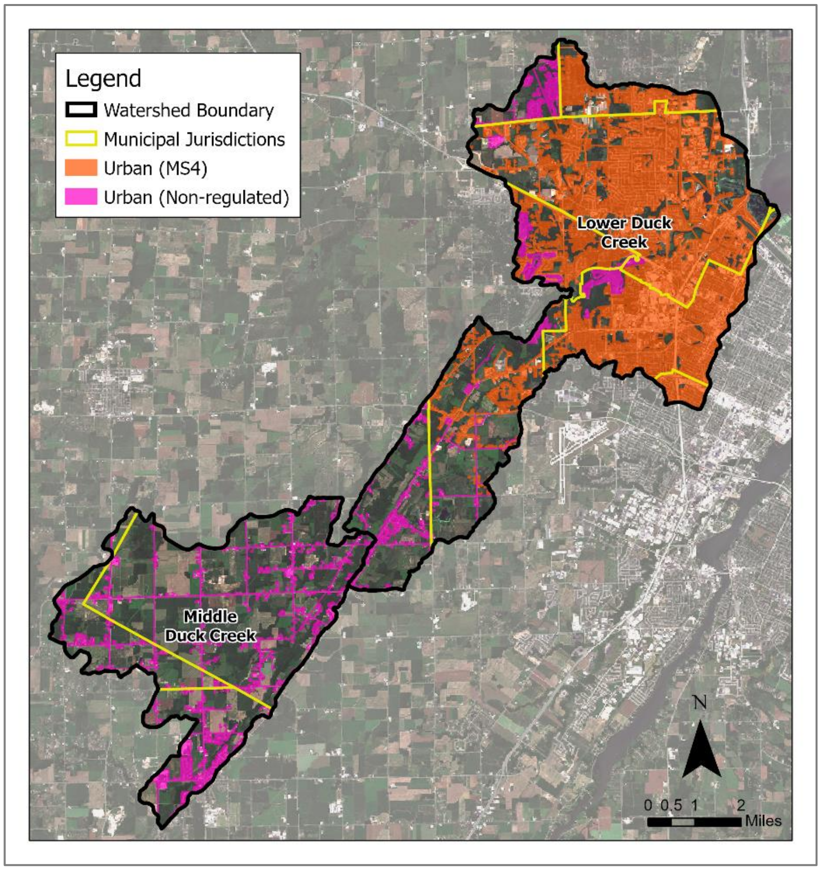

Figure 56. Urban land use distribution.

As urban non-regulated land use continues to increase in this watershed, the amount of impermeable area will increase, resulting in an increase in runoff. Increased runoff may increase flooding and exacerbate erosion downstream in the watershed. To ensure TMDL goals are realized, it is recommended that townships that fall within the urban non-regulated area assess their stormwater contribution and develop plans for stormwater control and develop or update local ordinances for stormwater management and erosion control.

Solutions that may be identified in urban non-regulated stormwater management plans include but are not limited to detention basins, bio-filters, street sweeping, filter strips, green roofs, porous pavement, rain barrels, and rain gardens. Additionally, as mentioned in the previous section, regional stormwater treatment BMPs constructed in advance of planned growth areas would be an option for communities.

7.0 Watershed Goals and Management Objectives

The main focus of the watershed plan is to meet the TP and TSS reductions set by the Lower Fox River TMDL. Additional goals were set that address other critical issues (degraded habitat/natural areas) identified in the watershed area based on watershed inventory results. Management objectives address the sources that need to be addressed in order to meet the watershed goals.

Table 15. Watershed goals and management objectives.

Goal	Indicators	Cause or Source of Impact	Management Objective
Improve surface water quality to achieve WDNR/EPA water quality standards.	Total Phosphorus, Total Suspended Solids	High phosphorus levels causing algal growth and decreased dissolved oxygen. Cropland erosion and runoff, barnyard runoff, streambank erosion, and urban runoff.	Reduce the amount of sediment and phosphorus loads from cropland, barnyard runoff, streambank erosion, and urban runoff.
Citizens of the watershed area are aware of water quality issues and are involved in the stewardship of the watersheds.	Interview/Questionnaire results. Current cropland management practices.	Lack of awareness of environmental issues and their impact.	Increase public awareness of water quality issues and increase participation in watershed conservation activities.
Reduce runoff rates, runoff volume and flood levels during peak storm events.	Peak flow discharges and flash flooding of the creeks and their tributaries occurring during heavy precipitation events.	Increased impervious area, tile drainage, and ditching. Inadequate storm water practices. Poor soil health.	Reduce the flow of runoff from upland areas to streams. Increase soil infiltration. Increase water-holding capacity.
Improve streambank stability and reduce amount of streambank degradation.	Moderate to severe erosion characterized by undercutting, vertical banks, and slumping. Meandering and redirection of flow.	High peak flows to stream, flooding, and inadequate riparian vegetation.	Restore and stabilize degraded streambanks and riparian corridors.
Conserve and restore aquatic and terrestrial habitat.	Populations of plant and animal species. Connectivity, aerial extent, patch size.	Wetland and natural area degradation due to development and agriculture.	Restore wetlands, riparian corridors, and other natural areas to improve habitat. Control invasive plant species.

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8.0 Management Measures Implementation

The Middle and Lower Duck Creek watershed plan presents the following recommended plan of actions needed over the next 10 years in order to make progress towards achieving water quality targets and watershed goals if adequate funding and staff can be acquired. The management measures implementation matrix (Table 16) provides a guideline to what kinds of conservation practices are needed in the watershed and an estimate to what extent they are needed to achieve the watershed goals based on the watershed inventory and modeling. Additional details on the implementation scenario and modeling used to create the matrix can be found in Appendix G. The management measures implementation matrix (Table 16) provides a timeline for practice implementation, possible funding sources, and potential agencies/collaborators for implementation.

A significant focus of this plan is to collaborate with landowners, agricultural producers, municipal governments, and state and federal agencies to meet the plan goals. Because participation in this plan is voluntary, involvement by Brown County LWCD, Outagamie County LCD, Oneida Nation, NRCS and other non-governmental stakeholders such as the Fox-Wolf Watershed Alliance will be critical for comprehensive conservation practice implementation. Landowners will be educated on programs and funding available to them as well as current state and local agricultural regulations.

This plan will utilize existing statewide runoff management standards such as state Administrative Code Chapter NR 151 for runoff management standards and prohibitions for agriculture, and existing local ordinances and regulations, such as the Brown County Agriculture Shoreland Management Ordinance, to implement conservation practices. This plan recommends enforcement of the local ordinances and state runoff standards when implementing this plan. This will require significant commitments from the state of Wisconsin, through the WDNR and Department of Agriculture Trade and Consumer Protection (DATCP), the lead state agencies that are mandated with enforcing the Clean Water Act, and Oneida Nation for tribal lands. This will also require support from Brown County LWCD, Outagamie County LCD, and the NRCS.

Watershed inventory results show that the majority of cropland and pastureland in the watersheds (58% of Middle and 46% of Lower) are covered under nutrient management plans. This indicates that approximately half of the cropland and pastureland in the watersheds should be compliant with NR 151 cropland and pastureland standards if they are following their 590 Nutrient Management Plan (NMP). Current conditions and water quality in the watersheds suggest that having all cropland in compliance with the state NR 151 standards will not be enough to meet TMDL goals. Additionally, concentrated flow and gully erosion was identified to be occurring throughout the watershed in crop fields covered under NMPs, suggesting that some of the NMP standards are not being followed. In order to meet TMDL goals, wide scale adoption of regenerative agricultural practices that provide year around vegetative cover on the landscape and go beyond the minimum state and local standards will be needed. Practices that store and treat runoff such as Agriculture Runoff Treatment Systems will also be necessary because landowners may be more willing to install and pay for practices that trap and treat the runoff from their land rather than adopt a new way of farming.

As previously mentioned the TMDL SWAT model did not explicitly model streambank erosion, the loads from streambank could be attributed to any of the upland sources (agriculture, natural background, urban (regulated & non-regulated). This is due in part to the level of effort needed to inventory the stream systems, which was not completed during the TMDL process. The low amount of TP and TSS load contributions from urban non-regulated and natural background estimated by TMDL modeling suggest that it is likely that a large portion of the streambank load was lumped in with the agriculture source category. For this plan, 24 miles of stream channel were inventoried and estimated loads were calculated for streambank erosion using NRCS methodology (Appendix E). This plan has included streambank restoration practices in the management plan recommendations since it is a nonpoint source. For this reason, we strongly recommend BMPs that restore the hydrologic response of the watersheds such as regenerative agriculture practices, wetland restoration, and ARTS. However, both agriculture and urban land use are contributing to the degradation of the stream channels in these watersheds. In the Lower Duck watershed, the contributing drainage areas to the degraded Beaver Dam Creek and Lancaster Brook tributaries to Lower Duck Creek are almost entirely urban land use. Therefore, urban BMPs that restore the hydrologic response of the watershed are also recommended in these areas.

In addition to agricultural nonpoint implementation, continued efforts from MS4 communities to meet reduction requirements will be necessary. MS4 communities have made significant progress in achieving TSS and TP reductions but some are not yet in compliance with the TMDL. Since the DNR requires MS4 communities to do a TMDL implementation analysis and plan that evaluates all potentially cost-effective alternatives to meet TMDL reductions, urban MS4 management measures are not included in this plan.

This plan recommends coordination efforts among the municipalities, Brown County LWCD, Outagamie County LCD, and Oneida Nation where applicable. Applicable projects may include streambank stabilization identified in urban areas in this plan as well as implementation of agricultural practices on cropland that may drain to MS4 outfalls and treatment systems.

Many alternative and new conservation technologies and management strategies are currently being developed and evaluated within the basin. Incorporation of new and alternative technologies and management methods into the implementation plan may be necessary to achieve desired water quality targets if planned management measures are not implemented or as effective as expected. New conservation technologies and management strategies may prove to be more cost effective than current recommended BMPs. Newer practices will need to be evaluated for effectiveness and feasibility before incorporation into the plan.

Examples of new technologies and management methods that may be needed to reach reduction goals in the Middle and Lower Duck Creek watershed include the following, but are not limited to:

- Regenerative agriculture system: a system of farming principles and practices that increases biodiversity, improves soil health, enhances ecosystem services, and improves water quality. Regenerative agriculture practices include: conservation tillage, cover crops, crop rotations, composting, and well managed grazing/silvopasture. The goal of a regenerative agriculture system is to use the practices above as a system to mimic nature.
- Phosphorus removal system: System installed to intercept subsurface or surface runoff to remove phosphorus. The system uses a solid phosphorus sorption material that can be removed and replaced after it is no longer effective.
- Manure management technology/methods (Split-application, variable rate application based on soil test phosphorus, inline manure sensing technology to apply at a variable rate based on "live" nutrient content of manure, manure digester (on farm or regional scale)).
- Agriculture Runoff Treatment Systems (ARTS)- An Agricultural Runoff Treatment System is similar to a storm water pond in that it is designed to retain water and settle out sediment. ARTS are designed with wetland cells that mimic wetland functions.

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Table 16. Management measures implementation plan matrix.

10 Year Management Measures Plan Matrix											
Recommendations	*Indicators (Units)*	*Sub-watershed*	*Milestones*						*Timeline*	*Funding Sources*	*Implementation*
			0-3 years		*3-7 years*		*7-10 years*				
			New	*Total*	*New*	*Total*	*New*	*Total*			
1) Management Objective: Reduce the amount of sediment and phosphorus loading from agricultural sources.											
a) NMP, Conservation tillage (No till, Strip till, Mulch till. Fields must meet minimum 30% residue) & Cover Crops*	# acres cropland with combination practices applied	Middle	855	855	1,140	1,995	855	2,850	0-10 years	EQIP, TRM, GLRI, CSP, AM, WQT, MDV, SWRM, GLSNRP, Food Companies	LWCD/LCD, Oneida Nation, NRCS, FWWA
		Lower	198	198	264	462	198	660			
b) NMP Cover Crop, Low Disturbance Manure Application & Conservation Tillage (No till, Strip till, Mulch till. Fields must meet minimum 30% residue)*	# acres cropland with combination practices applied	Middle	750	750	1,000	1,750	750	2,500	0-10 years		
		Lower	270	270	360	630	270	900			
c) Prescribed Grazing	# acres of cropland converted to grazing	Middle	75	75	100	175	75	250	0-10 years		
		Lower	15	15	20	35	15	50			
d) Modify drainage ditches and other headwater channels to two-stage ditch design	# linear feet of drainage ditches converted to two- stage ditch	Middle	2,595	2,595	3,460	6,055	2,595	8,650	0-10 years	EQIP, TRM, GLRI, GLSNRP, AM, WQT, MDV, SWRM	
		Lower	2,411	2,411	3,215	5,626	2,411	8,037			
	# acres cropland treated by two-stage ditch	Middle	150	150	200	350	150	500	0-10 years		
		Lower	90	90	120	210	90	300			
e) Manage tile drainage water in fields	# acres of fields with drainage water management	Middle	60	60	80	140	60	200	0-10 years	EQIP, TRM, GLRI, AM, WQT, MDV, SWRM	
		Lower	0	0	0	0	0	0			
f) Stabilization of gullies/concentrated flow paths (grassed/lined waterway, WASCOB, critical area planting, grade stabilization structure, regenerative agriculture practices (cover crops & no-till, well managed grazing), etc.)	# linear feet stabilized	Middle	12,808	12,808	17,078	29,886	12,808	42,694	0-10 years	EQIP, CREP/CRP, AM, WQT, MDV	
		Lower	3,373	3,373	4,498	7,871	3,373	11,244			
g) Installation of vegetative buffers along perennial and intermittent streams.	# acres of buffers installed	Middle	22	22	29	50	22	72	0-10 years	CREP/CRP, EQIP, GLRI, AM, WQT, MDV	
		Lower	3	3	4	7	3	10			
	# of acres of cropland treated by buffers	Middle	204	204	272	476	204	680	0-10 years		
		Lower	35	35	46	81	35	115			
h) Install Water and Sediment Control Basins to reduce gully erosion, trap sediment and reduce/manage runoff	# of WASCOBS installed	Middle	2	2	2	4	2	5	0-10 years	EQIP, GLRI, TRM, SWRM, AM, WQT, MDV	
		Lower	0	0	0	0	0	0			
i) Install agriculture runoff treatment systems (ARTS)	# acres of ARTS	Middle	6	6	8	14	6	20	0-10 years	GLRI, AM, WQT, GLSNRP	
		Lower	1	1	2	3	2	5			

10 Year Management Measures Plan Matrix											
Recommendations	*Indicators (Units)*	*Sub-watershed*	*Milestones*						*Timeline*	*Funding Sources*	*Implementation*
			0-3 years		*3-7 years*		*7-10 years*				
			New	*Total*	*New*	*Total*	*New*	*Total*			
	# of cropland acres treated by ARTS	Middle	420	420	560	980	420	1,400	0-10 years	GLRI, AM, WQT, GLSNRP	
		Lower	30	30	40	70	30	100			
j) Retrofit barnyard sites with necessary runoff control structures (gutters, filter strips, settling basins, clean water diversions)	# of barnyard sites addressed and retrofitted with necessary runoff control measures	Middle	3	3	N/A	N/A	N/A	N/A	0-3 years	EQIP, AM, WQT, TRM, MDV, SWRM	
		Lower	0	0	N/A	N/A	N/A	N/A			
k) Waste management on livestock operation sites.	# of new or updated waste storage facilities	Middle	2	2	N/A	N/A	N/A	N/A	0-3 years	EQIP, AM, WQT, TRM, MDV	
		Lower	N/A	N/A	N/A	N/A	N/A	N/A			
l) Inventory inactive waste storage facilities to determine if they meet engineering standards and may serve as a potential overflow storage for other farmers in watershed	N/A	Middle & Lower	Inventory complete.	N/A	N/A	N/A	N/A	N/A	0-3 years	N/A	
m) Waste Storage Abandonment	# of Waste Storage Abandonments	Middle	0	0	2	2	3	5	3-10 years	EQIP, AM, WQT, TRM, MDV, SWRM	
		Lower	N/A	N/A	N/A	N/A	N/A	N/A			
n) Use of new technologies and methods to reduce phosphorus loading from cropland. (Examples: New manure management technology, phosphorus removal structures/filters, etc.)	# of sites where new technologies/methods have been used and assessed for effectiveness and feasibility	Middle & Lower	1	1	2	3	0	3	0-7 years	EQIP, AM, TRM, GLRI, Fund for Lake Michigan	
o) Achieve compliance with NR 151 performance standards on a majority (>70%) of agricultural acres/operations in the watershed.[1]	% of watershed agricultural acres/operations in watershed compliant with NR 151	Middle & Lower	N/A	50%	N/A	70%	N/A	>70%	0-10 years	EQIP, TRM, GLRI, CSP, AM, WQT, MDV, SWRM	
2) Management Objective: Reduce the flow of runoff from upland areas to streams. Increase soil infiltration. Increase water-holding capacity.											
a) Increase water storage by restoring and/or creating wetlands.	# of acres of wetlands restored/created	Middle	3	3	4	7	3	10	0-10 years	EQIP, CREP/CRP, WQT, FWP, AM, MDV, GLRI, NRDA, DU, Fund for Lake Michigan	NRCS, LWCD/LCD, FWS, DU, TNC, NRDA, Oneida Nation
		Lower	1	1	2	3	2	5			
b) Increase soil infiltration and water storage by implementing practices (a-i) under Management Objective 1.	–	Middle & Lower	—	—	—	—	—	—	—	—	—

10 Year Management Measures Plan Matrix												
Recommendations	*Indicators (Units)*	*Sub-watershed*	*Milestones*						*Timeline*	*Funding Sources*	*Implementation*
			0-3 years		*3-7 years*		*7-10 years*				
			New	*Total*	*New*	*Total*	*New*	*Total*			
c) Determine the water storage capacity of the wetlands created and restored during the Silver Creek pilot project. Compare the water storage already created to the needs of the Silver Creek subcatchments analyzed for water storage needs to determine progress made and additional storage needs.	N/A	Lower (Silver Creek)	Analysis Completed.	N/A	N/A	N/A	N/A	N/A	0-3 years	N/A	LWCD/LCD, NEW Water, Oneida Nation
3) Management Objective: Restore and stabilize degraded streambanks and riparian corridors.											
a) Streambank restoration/stabilization. (shaping, seeding, rip rap, biostabilization, obstruction removal, two-stage channel design)	# of linear feet of streambank stabilized/restored	Middle	6,150	6,150	8,200	14,350	6,150	20,500	0-10 years	EQIP, GLRI, WQT, TRM, AM, MDV, Fund for Lake Michigan	NRCS,LWCD/LCD, Local Municipality, Oneida Nation
		Lower	9,150	9,150	12,200	21,350	9,150	30,500			
b) Install stream crossings to prevent further degradation	# of stream crossings installed	Middle	1	1	1	2	1	3	0-10 years	EQIP, TRM, GLRI, MDV, AM	NRCS,LWCD/LCD, Oneida Nation
		Lower	1	1	2	3	2	5			
c) Riparian corridor restoration. (weed/invasive species control, brush management, tree/shrub establishment, forest stand improvement, conservation cover)	# of acres of improved riparian area	Middle	15	15	20	35	15	50	0-10 years	EQIP, GLRI, WQT, TRM, AM, MDV, Fund for Lake Michigan	NRCS, LWCD/LCD, FWS, TNC, NRDA, Oneida Nation, Local Municipality
		Lower	21	21	28	49	21	70			
4) Management Objective: Restore wetlands, riparian corridors, and other natural areas to improve habitat. Control invasive plant species.											
a) Restore and/or create wetlands to provide fish and other wildlife habitat.	# of acres of wetlands restored	Middle & Lower	see 2) a)						0-10 years	EQIP, CREP/CRP, WQT, FWP, AM, MDV, GLRI, NRDA, DU, Fund for Lake Michigan	NRCS, LWCD/LCD, FWS, DU, TNC, NRDA, Oneida Nation
b) Riparian corridor restoration. (weed/invasive species control, brush management, forest stand improvement, tree/shrub establishment, conservation cover)	# of acres of improved riparian area	Middle & Lower	see 3) c)						0-10 years	EQIP, GLRI, WQT, TRM, AM, MDV, Fund for Lake Michigan	NRCS, LWCD/LCD, FWS, TNC, NRDA, Oneida Nation
c) Create or improve upland habitat for wildlife and restore or maintain native plant communities.	# of acres upland habitat created or improved	Middle	5	5	10	15	5	20	0-10 years	EQIP,TRM, NRDA, AM, Fund for Lake Michigan	NRCS, LWCD/LCD, FWS, TNC, NRDA, Oneida Nation
		Lower	5	5	10	15	5	20			

10 Year Management Measures Plan Matrix											
Recommendations	*Indicators (Units)*	*Sub-watershed*	*Milestones*						*Timeline*	*Funding Sources*	*Implementation*
			0-3 years		*3-7 years*		*7-10 years*				
			New	*Total*	*New*	*Total*	*New*	*Total*			
d) Implement applicable Lower Green Bay and Fox River Area of Concern Fish and Wildlife Habitat plan management actions.	# acres coastal emergent marsh added	Lower (Weitor Wharf and Duck Creek Delta)	—	—	170	170	N/A	N/A	0-7 years	GLRI, NRDA, GLFT, WCMP, Fund for Lake Michigan	LWCD/LCD, FWS, TNC, NRDA, DU, Great Lakes Audubon, Village of Howard, City of Green Bay, UW- Green Bay
	# acres submergent marsh added		—	—	22	22	N/A	N/A	0-7 years		
	# acres riparian emergent marsh improved		—	—	70	70	N/A	N/A	0-7 years		
	# DHA[2] units for tributary open water		—	—	2	2	N/A	N/A	0-7 years		
	# DHA units for Green Bay open water		—	—	1	1	N/A	N/A	0-7 years		
	# acres hardwood swamp improved		—	—	35	35	N/A	N/A	0-7 years		
	# acres of Surrogate Grassland (Old Field) improved		—	—	2.75	2.75	N/A	N/A	0-7 years		
	# acres Wet Meadow added		—	—	10	10	N/A	N/A	0-7 years		
	# acres Northern Mesic Forest improved		—	—	1.15	1.15	N/A	N/A	0-7 years		

** To achieve TMDL reductions, modeling shows that the majority of fields will need to implement a combination of conservation cropping practices as a system. Most of these fields already have NMP and need to implement conservation tillage. cover crops and/or low disturbance manure application methods. A portion of these fields, especially in Silver Creek area, are already doing a combination of both, but these practices need to be maintained and fully adopted to achieve and maintain reductions. See Appendix G for more details on current and proposed implementation BMP scenarios.*

1. After a majority of agricultural acres/operations are found to be in compliance with existing NR 151 standards, then adoption of additional practices on agricultural acres/operations already in compliance with NR 151 is completed to further reduce pollutant loads from agricultural sources in watershed.

2. Designated Habitat Area (DHA)

9.0 Load Reductions

Load reductions for recommended conservation management practices were estimated using STEPL (Spreadsheet Tool for Estimating Pollutant Loading) and NRCS spreadsheet tools. Streambank stabilization load reductions were estimated using NRCS streambank erosion equations (Appendix F). Percent reduction was based on the baseline loading estimates from STEPL model agricultural sources and streambank erosion contributions. This plan has included the streambank loading contributions in with the agricultural source load reduction calculations since it is a nonpoint source. However, both agriculture and urban land use (regulated & non-regulated) are contributing to the degradation of the stream channels in these watersheds.

A current conditions and baseline conditions STEPL model was created for each watershed to account for land use changes that have occurred since the TMDL modeling was completed and to account for the BMP implementation efforts that occurred in the Silver Creek subwatershed. The Lower Fox River TMDL calls for a 76.9% reduction of TP for and a 58.6% reduction in TSS for agriculture sources for the Duck Creek Sub-basin. Estimated load reductions from recommended activities are shown in Table 17. Additional details on the implementation scenario and modeling used to calculate reductions are shown in Appendix G.

In order to achieve required TMDL reductions, modeling shows that a majority of cropland (>90%) will need to have regenerative agriculture cropping practice systems (cover crops, conservation tillage and low disturbance manure injection or well managed grazing) implemented as year round system applied in combination with practices that treat cropland runoff such as ARTS and vegetative riparian buffers. The reductions estimated from these practices in STEPL assume a uniform rate of phosphorus and soil loss per acre of cropland and pasture/hay land. This plan identifies priority fields in the watershed that are likely contributing more phosphorus and sediment than other fields. Targeting conservation practices to the highest contributing crop fields will likely result in needing less than 90% of the cropland in the watershed to implement the recommended combinations of practices.

Wide scale implementation of regenerative agricultural cropping practice systems that improve soil health and provide year round vegetative cover and implementation of agricultural runoff treatment systems will reduce the volume and flow rates contributing to downstream streambank erosion, which will reduce the amount of streambank stabilization needed. Implementation of urban stormwater practices that reduce runoff volume and flow rates will also reduce the amount of streambank stabilization needed in the Duck Creek tributaries where urban land use is dominant in the headwaters. Additionally, implementing conservation cropping practices such as cover crops and no-till on a field as a system will likely resolve most ephemeral gully erosion issues and reduce the amount traditional structural practices needed such as grassed waterways or water and sediment control basins.

In summary, the recommended implementation scenario is meant as a guideline for implementation and is meant to be flexible. The combination of implemented BMPs is infinite, and heavily relies on volunteer adoption of non-traditional cropping systems. For example, if the amount of cropland converted to prescribed grazing is greater than what is in the estimated implementation scenario (Appendix F) then the amount of conservation tillage and cover crops implemented as a system or other practice combination in the scenario needed would then be reduced to meet the reduction goal. Another example would be a landowner does not choose to alter their cropping system, however, they are willing to install ARTS at the edge of field to meet TMDL load reductions as well as decrease the amount of streambank and erosion downstream. Additionally, new technologies are always being discovered for nutrient capture, low-disturbance agriculture, and cover crop knowledge. And to counter advances in technology, the dairy feed ration is always changing; the recent change to more corn silage in dairy feed rations is an example of cropping change that increases loading due to more land not being in perennial cover.

Table 17. Estimated reductions from recommended management practices.

Management Measure Category		Total Units (size/length)	Total Cost	Estimated Load Reduction			
				TP (lbs/yr)	Percent	TSS (t/yr)	Percent
Middle	***Streambank/Riparian Corridor Restoration***	20,500 ft	$1,805,000	600	6.8%	492	21.1%
	Barnyard Retrofits *(barnyard runoff management, waste storage/transfer, fencing, maintenance/repair of existing practices, filter strip, etc.)*	3 Sites	$150,000	64	1.8%	NA	NA
	Practices applied to Cropland *(Cover Crops, Conservation Tillage/Residue Management, Nutrient Management, Low Disturbance Manure Application, Prescribed Grazing, Two Stage Ditch/Channel, Drainage Water Management, Agriculture Runoff Treatment Systems (ARTS), Vegetative Buffer)*[1,2]	6,382 acres	$5,280,272	4,621	52.6%	916	39.3%
	Gully/Concentrated Flow Stabilization *(Grassed/lined Waterway, Critical Area Planting, WASCOB, Regenerative Agriculture Practices (Cover Crop & No-Till, Well Managed Grazing, etc.)*	42,694 ft/ 5 WASCOBs	$158,325	251	2.9%	146	6.3%
	Estimated Reductions from agriculture land being developed since TMDL development	522 acres	N/A	478	5.4%	71	3.0%
	Estimated Reductions from loss of agriculture land due to future urban development	649 acres	N/A	658	7%	162	0
		Total	**$7,393,597**	**6,671**	**76.9%**	**1,787**	**76.6%**

Management Measure Category		Total Units (size/length)	Total Cost	Estimated Load Reduction			
				TP (lbs/yr)	Percent	TSS (t/yr)	Percent
Lower	***Streambank/Riparian Corridor Restoration***	30,500 ft	$2,755,000	856	12.2%	702	26.2%
	Practices applied to Cropland *(Cover Crops, Conservation Tillage/Residue Management, Nutrient Management, Low Disturbance Manure Application, Prescribed Grazing, Two Stage Ditch/Channel, Drainage Water Management, Agriculture Runoff Treatment Systems (ARTS), Vegetative Buffer)*[1,2]	2,070 acres	$1,409,031	1,050	15.0%	210	7.9%
	Gully/Concentrated Flow Stabilization *(Grassed/lined Waterway, Critical Area Planting, WASCOB, Regenerative Agriculture Practices (Cover Crop & No-Till, Well Managed Grazing, etc.)*	11,244 ft	$37,550	63	0.9%	37	1.4%
	Estimated Reductions from agriculture land being developed since TMDL development and Silver Creek Pilot Project BMPs	1,742 acres /Various BMPs	N/A	2,326	33.2%	649	24.3%
	Estimated Reductions from loss of agriculture land due to future urban development	1,230 acres	N/A	1,098	15.7%	233	9%
	Total		**$4,201,581**	**5,394**	**76.9%**	**1,831**	**68.5%**

1. *A combination of conservation practices applied to and/or providing treatment to a majority of the cropland in the watershed is necessary to get the desired pollutant load reductions suggested by the TMDL. The BMP Efficiency Calculator was used to determine efficiencies of different combinations of practices such as Conservation Tillage, Cover Crops and Nutrient Management. A weighted average pollutant*

reduction efficiency was determined for this category based on a scenario of estimated implementation rates of combinations of practices. See Appendix G.

2. *In STEPL V4.3 there is a BMP practice of "Filter Strip" that has a reduction efficiency of 75% TP and 65% TSS. In the newer version 4.4, that practice has been removed but "Buffer-Grass (35 ft-wide)" has been added with reduction efficiency of 43.5% TP and 53.3% TSS. The values in the table are modeled with the more conservative "Buffer-Grass (35 ft-wide)" efficiency. For buffers at the edge of field that are designed to the NRCS filter strip standard (393) it is likely that the greater V4.3 "Filter strip" efficiencies can be achieved.*

Legacy Phosphorus and Sediment

A challenge that presents itself in achieving in stream water quality is legacy phosphorus in the watershed soil and in-stream sediment. In recent years, scientists and watershed managers are finding that water quality is not responding as rapidly as expected to implemented conservation practices (Sharpley et al, 2013). They are attributing this slower and smaller response to legacy phosphorus. Legacy phosphorus is used to describe the accumulated phosphorus that can serve as a long-term source of contributing phosphorus to surface waters. Legacy phosphorus in a soil occurs when phosphorus in topsoil builds up much more rapidly than the decline due to vegetation uptake or natural transport through a river system. In stream channels, legacy phosphorus accumulation can result from sediment deposition of particulate phosphorus, sorption of dissolved phosphorus onto riverbed sediments or suspended sediments, or by incorporation into the water column (Sharpley et al, 2013). Release of legacy phosphorus back into the water column can happen through mechanisms such as resuspension of the sediments or through release from the sediments during anaerobic or anoxic conditions. Anaerobic or anoxic conditions can be pervasive in low gradient watersheds with high organic loadings, such as in flat watersheds like Middle and Lower Duck Creek that have high organic runoff from the dominant agricultural land uses.

An analysis of legacy phosphorus in the soil and in-stream sediment should be considered on Middle and Lower Duck Creek. If management goals are being met but improvements in water quality are not occurring, or are at a rate slower than expected, this investigation should be accelerated. An example analysis, similar to the methods deployed in sediment fingerprinting, may include the collection and analysis of soil samples from streambed, ditches, floodplains, wetlands and cropland throughout the watershed area to identify phosphorus hotspots. Soil test phosphorus data from several years of nutrient management plan data may also be analyzed to identify trends in soil test phosphorus over years of implementation. As part of the river corridor inventory survey completed spring of 2021, significant sediment deposition areas were found throughout the Duck Creek and in headwater tributaries. This suggests that large or isolated sources of legacy phosphorus in the stream may be an issue, like what was observed as part of the Yahara Watershed Improvement Network (WINS) project[15] that includes significant dredging of deposited sediment within the river and lake systems.

[15] Additional information on Dane County's Legacy Sediment Removal Project can be found at https://lwrd.countyofdane.com/Legacy-Sediment-Project.

10.0 Information and Education

This information and education plan is designed to increase participation in conservation programs and implementation of conservation practices by informing the landowners of assistance and tools available to them and providing information on linkages between land management and downstream effects on water quality.

10.1 Alliance for the Great Lakes Survey

The Alliance for the Great Lakes developed an interview and questionnaire that was given to landowners in the Lower Fox River basin in spring and summer of 2014 by County Land and Water Conservation Departments and local agronomists. Data from the questionnaires and interviews were analyzed by subwatershed. The survey and questionnaire gathered information on the knowledge of conservation and water quality issues, willingness to participate in conservation programs, and where landowners obtain their information. Many landowners of all farm sizes did not recognize the severity of water quality issues impacting the Lower Fox River Basin and the extent to which agricultural sources contribute to nutrient and sediment loadings to the River and the Bay of Green Bay. A summary of survey and questionnaire results can be found in Appendix H. Providing information on available conservation programs, technical assistance, and education will be a very critical component of implementing the management plan.

10.2 Silver Creek Pilot Project

NEW Water and project collaborators held several stakeholder meetings and used a wide variety of outreach tools in the Silver Creek subwatershed of Lower Duck during the project time period of 2014-2020. Outreach methods used during this time period include presentations, website, factsheets, social media (Twitter and Facebook), and one on one visits with landowners. Project updates and outreach materials for Silver Creek can be found at https://www.newwater.us/projects/silver-creek .

10.3 Recommended Information and Education Campaigns

An effective Information and Education Plan includes the following components as referenced in USEPA's "*Handbook for Developing Watershed Plans to Restore and Protect our Waters*" (USEPA, 2008):

- Define I&E goals and objectives
- Identify and analyze the target audiences
- Create the messages for each audience
- Package the message to various audiences

- Distribute the message
- Evaluate the I&E program

Goals of the information and education plan: Create public awareness of water quality issues in the watershed, increase public involvement in watershed stewardship, and increase communication and coordination among elected officials, community leaders, businesses, agricultural community, and other stakeholders.

Objectives:

- Educate elected officials, community leaders and the public about the watershed plan and watershed issues.
- Encourage state, counties, and local municipalities to adopt the Watershed Plan and/or reference the goals, objectives, and recommendations of the Plan in their own outdoor recreation plans, comprehensive plans, and other related plans.
- Encourage policy and funding actions that support the goals of the watershed plan at local municipal, township, county, and state levels.
- Develop targeted educational materials to appropriate audience in the watershed.
- Host workshops, meetings, tours, and events that watershed citizens can attend to learn about the benefits of conservation practices and to highlight the ongoing conservation efforts in the watershed.
- Encourage and support watershed citizens to support watershed stewardship through installation of best management practices on their private land.

Target Audience

Multiple target audiences will need to be addressed in this watershed. Target audiences in this watershed include but are not limited to agricultural landowners and operators, local government officials, community leaders, agricultural businesses and organizations, urban homeowners, and other private landowners of non-agricultural land.

I&E Plan Recommended Actions

An Information and Education Plan matrix (Table 18) was developed as a tool to help implement the I&E plan. The matrix includes recommended action campaigns, target audience, package for delivery of message, schedule, outcomes, and supporting organizations.

Table 18. Information and education plan matrix.

Information and Education Plan Implementation Matrix					
Information and Education Action	**Target Audience**	**Recommendations**	**Schedule**	**Outcomes**	**Implementation**
Inform general public that watershed plan has been developed.	General Public	• Completed plan posted on county and/or Oneida Nation website and shared via social media pages. • Develop exhibits for use at libraries, government offices, and local events (County Fairs and Farm Shows).	0-3 years	• General public is aware of watershed implementation plan and have better understanding of how they can impact water quality.	LWCD/LCD, Fox Wolf Watershed Alliance, UWEX, Oneida Nation
Educate landowners on watershed plan and progress of conservation efforts.	Private landowners, agricultural landowners/operators	• Continued distribution of "Basin Buzz", “Keepers of the Fox”, and "The Source" newsletters. • Use social media (Facebook, You Tube, Twitter, etc.) to provide information and updates relating to watershed project. • Placement of signs to highlight conservation efforts in watershed. • Submit press/media releases to highlight ongoing conservation efforts and progress.	0-10 years	• Watershed landowners are informed on implementation progress. • Landowners can stay up to date on new practices and strategies available.	LWCD/LCD, Fox Wolf Watershed Alliance, UWEX, Oneida Nation

Information and Education Plan Implementation Matrix					
Information and Education Action	**Target Audience**	**Recommendations**	**Schedule**	**Outcomes**	**Implementation**
Educate agricultural landowners and operators about the plan, its recommendation actions, and technical assistance and funding available. Encourage and support agricultural landowners and operators to implement recommended actions in watershed plan.	Agricultural landowners/ operators	• Distribute targeted educational materials on conservation practices and programs. • One on one contact with individual landowners and operators to provide tools and resources. • Orchestrate group meetings with agricultural landowners/operators in watershed to share knowledge and foster community connections for long term solutions (Lower Fox Farmer Roundtable/Subwatershed meetings). • Offer workshops to agricultural landowners/operators to educate them on conservation practices that should be used to preserve the land and protect water resources. • Tour local demonstration farms and other sites that have implemented conservation practices (Lower Fox Demonstration Farm Network). • Submit press/media releases to announce upcoming events and to highlight ongoing conservation efforts and progress.	0-10 years	• Agricultural landowners and operators are informed about conservation practices, cost share programs, and technical assistance available to them. • Increase in interest in utilizing and installing conservation practices. • Improved communication between agricultural landowners and operators, willingness to share ideas, and learn from other agricultural landowners and operators. • Agricultural landowners and operators recognize the benefit of conservation farming practices and how it improves water quality. • Agricultural landowners and operators see success of conservation practices as well as problems that can be expected.	LWCD/LCD, NRCS,UWEX, Fox Wolf Watershed Alliance, Alliance for the Great Lakes, Oneida Nation

Information and Education Plan Implementation Matrix					
Information and Education Action	**Target Audience**	**Recommendations**	**Schedule**	**Outcomes**	**Implementation**
Educate private landowners about the plan, its recommendation actions, and technical assistance and funding available. Encourage and support private landowners to implement recommended restoration actions in watershed plan.	Private landowners of land identified as priority for streambank stabilization/ restoration, wetland restoration, and AOC habitat restoration projects.	• Distribute targeted educational materials on restoration practices and programs. • One on one contact with individual landowners to provide tools and resources. • Offer workshops to private landowners to educate them on restoration practices that should be used to preserve the land and protect water resources. • Tour other sites that have implemented similar restoration practices. • Submit press/media releases to announce upcoming events and to highlight ongoing conservation efforts and progress.	0-10 years	• Private landowners are informed about restoration practices/projects, cost share programs, and technical assistance available to them. • Increase in interest in implementing restoration practices. • Improved communication between landowners, willingness to share ideas, and learn from other landowners. • Private landowners see success of restoration projects as well as problems that can be expected.	LWCD/LCD, NRCS,UWEX, Fox Wolf Watershed Alliance, Alliance for the Great Lakes, Oneida Nation, UW- Green Bay, DU, TNC, Great Lakes Audubon, FWS, WDNR

Information and Education Plan Implementation Matrix					
Information and Education Action	**Target Audience**	**Recommendations**	**Schedule**	**Outcomes**	**Implementation**
Inform elected officials and community leaders about the completed plan, watershed issues, and conservation efforts needed. Encourage amendments of municipal comprehensive plans, codes, and ordinances to include watershed plan goals and objectives.	Local, county, state, and federal officials and community leaders.	• Present project plan and conduct meetings with government officials and community leaders. • Provide local, county, state, and federal officials with information support for local comprehensive planning, zoning, and resource protection strategies that improve soil and water resource protection. • Utilize educational events/field days to highlight conservation efforts being done in the watershed and to build support for conservation amongst elected officials and community leaders.	0-3 years	• Local municipalities adopt or amend ordinances, codes, and plans to include watershed plan goals and objectives. • Policy changes enacted that support watershed plan goals. • Increase in funding support of implementation efforts.	LCD/LWCD, Fox Wolf Watershed Alliance, NEWSC, Clean Bay Backers, Green Bay Conservation Partners
Encourage and support the formation of partnerships and coordination on conservation implementation efforts with government agencies, local communities, Oneida Nation, non-profit organizations, businesses, universities, schools and other groups.	Community leaders, government agency officials, Oneida Nation, non-profits, businesses, schools, and universities	• Utilize educational events, field days, and/or tours to highlight conservation efforts being done in the watershed and to build support for conservation amongst watershed stakeholders. • Orchestrate meetings and networking events to share knowledge and highlight ongoing conservation efforts and progress.	0-10 years	• Partnerships formed between organizations on conservation projects. • Increased funding for implementation of conservation projects.	LCD/LWCD, Fox Wolf Watershed Alliance, NEWSC, Clean Bay Backers, Green Bay Conservation Partner

Information and Education Plan Implementation Matrix					
Information and Education Action	**Target Audience**	**Recommendations**	**Schedule**	**Outcomes**	**Implementation**
Inform homeowners on actions they can take to reduce stormwater runoff from their yards.	Homeowners	Distribute educational materials to homeowners on how to reduce storm water runoff from their yards.	0-5 years	Homeowners are aware of the impact they can have on water quality and actions they can take to reduce pollution from their yards.	UWEX, LWCD, Fox Wolf Watershed Alliance, Local Municipalities, Oneida Nation
Inform local agricultural businesses and organizations on objectives of watershed project.	Agronomists, Co-ops, Seed dealers, Farm equipment dealers	Meetings with local agricultural organizations and businesses to share goals of project and planned conservation practices and outreach needed.	0-3 years	Local agricultural organizations are aware of watershed project and can assist landowners with conservation needs as well as help deliver common message to protect water quality in watershed area.	LCD/LWCD, UWEX, Oneida Nation

Existing Education Campaigns:

There are several existing educational campaigns and organizations operating in the Lower Fox Basin. This plan calls for the continuation of current efforts and continued support of existing programs.

Fox-Wolf Watershed Alliance (FWWA): A nonprofit organization that identifies issues and advocates for effective policies and actions to protect and restore the water resources of Wisconsin's Fox-Wolf River watershed. They hold events such as river clean-ups, workshops, presentations at Annual Watershed Conferences, and meetings with other organizations to outreach to the public. The Fox- Wolf Watershed Alliance works with local organizations to produce several newsletters "The Source", "Basin Buzz", "Keepers of the Fox" and "Winnebago Waterways" to inform and update the public on current projects, programs, funding, and research in the Fox-Wolf Basin. "The Source" is an online newsletter distributed by email whose target audience is the general public. "Winnebago Waterways" and "Keepers of the Fox" are online newsletters distributed by email focused on the Winnebago Waterways Recovery area and the Lower Fox Recovery area. The "Basin Buzz" is a newsletter distributed by mail that's geared toward agricultural land owners in the Lower Fox Basin. Current and previous issues of newsletters can be found on the FWWA website. For more information go to http://fwwa.org/.

Northeast Wisconsin Stormwater Consortium (NEWSC): A subsidiary of the Fox-Wolf Watershed Alliance composed of municipal members and business partners working to address storm water issues and to educate residents on best management practices, ordinances and other storm water concerns and programs. For more information go to www.newsc.org.

Lower Fox Demonstration Farms Network: Currently there is a demonstration farm project with eight established demonstration farms in the Lower Fox River Watershed. The goal of the demonstration farms network is to test new and innovative conservation methods and to educate other farmers. The demonstration farm network holds field days for local farmers and agency members to learn about the different practices being tested. For more information go to www.foxdemofarms.org or follow them on Facebook and Twitter (https://www.facebook.com/FoxDemoFarms/ or https://twitter.com/FoxDemoFarms).

Figure 57. Lower Fox Demo Farm team. Photo Credit: Lower Fox Demo Farms.

Fox Watershed Farmer Roundtable: Beginning in January of 2016, an annual Fox Watershed Farmer Roundtable event was launched. The annual farmer roundtable event was created to provide updates on the demonstration farm projects, local on-farm case studies and to have small group and panel discussions amongst farmers and conservation professionals. The annual event is a collaborative effort put together by the Alliance for the Great lakes, Lower Fox Demonstration Farms Network, UW-Madison-Division of Extension, Fox-Wolf Watershed Alliance and local counties. At the 2017 Farmer Roundtable event, farmers were asked to fill out a questionnaire and were polled on various topics relating to conservation and water quality similar to Alliance for the Great Lakes Survey done in 2014. Information from the poll and questionnaire was also taken into account when developing the I&E plan. Results from poll and questionnaire can be seen in Appendix I. Figure 58 summarizes participation in the annual event from 2016-2022.

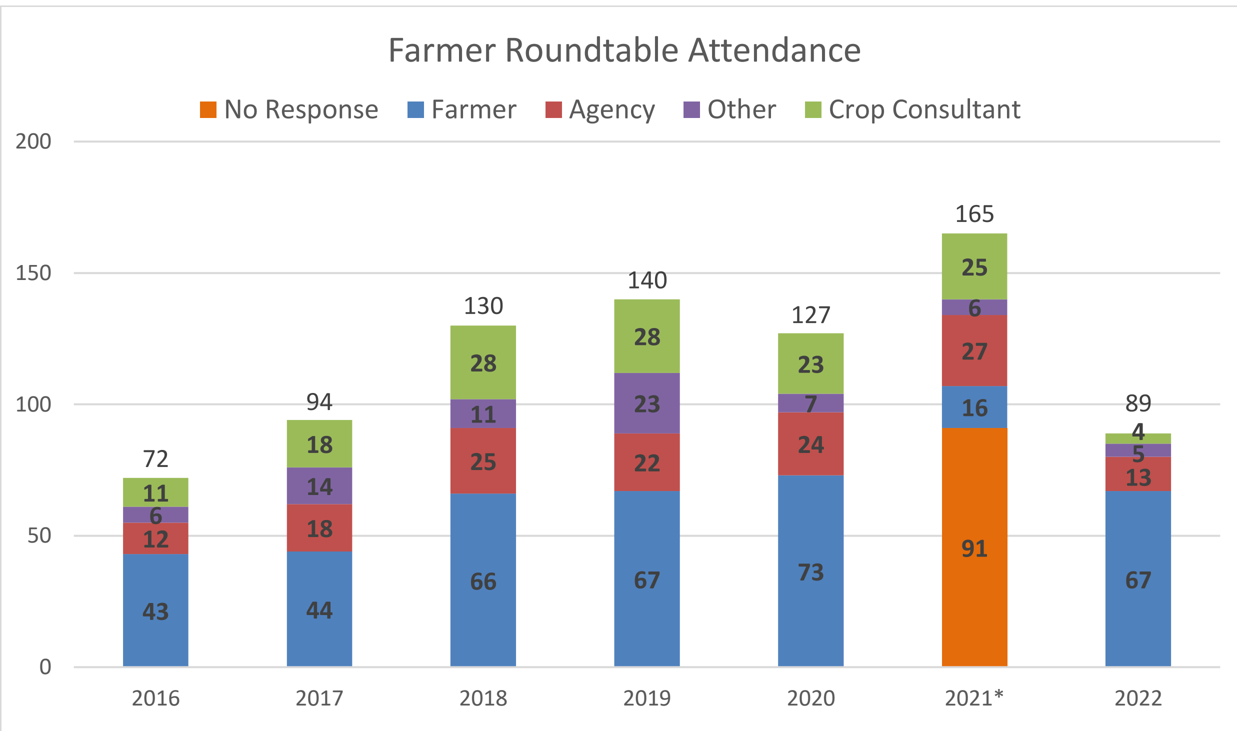

Figure 58. Participation in Fox Watershed Farmer Roundtable from 2016-2022. **The 2021 roundtable event was held virtually over several weeks.*

Save the Bay: A collaborative initiative where agriculture, academia, industry, government, and nonprofit leaders identify, share and promote conservation practices to reduce phosphorus, nitrogen and sediment flowing into the waters of Green Bay and Lake Michigan. For more information go to https://gallagher.house.gov/issues/save-bay .

Clean Bay Backers: The Clean Bay Backers are a diverse group of public, private and non-profit members who act as the Citizen Advisory Committee to the WDNR for the Lower Green Bay and Fox River AOC. They represent the community's interest in restoring the health of the

Lower Fox River and Green Bay. They help develop, provide feedback on, and advocate for project plans and strategies to restore the Lower Green Bay and Fox River AOC. For more information go to https://www.facebook.com/CleanBayBackers .

Green Bay Conservation Partners:

A group created in 2014 as a self –sustaining regional conservation partnership to facilitate coordinated conservation efforts in northeast Wisconsin region of the Green Bay watershed. The group consists of individuals working on natural resource issues for government agencies, tribal nations, universities, non-profit groups and others. For more information go to https://www.gbconservationpartners.org/ .

NEW Water Adaptive Management Program & Public Affairs and Education Program:

NEW Water, through its Public Affairs & Education program, takes an active role in collaborating with organizations through Northeast Wisconsin to help promote public health and welfare, encourage pollution prevention, and support programs to help ensure water contaminated by human activity is returned clean to the environment. Additional information on NEW Water's Public Affairs & Education Program can be found at https://www.newwater.us/communityoutreach .

Evaluation

The I&E plan should be evaluated regularly to provide feedback regarding the effectiveness of the outreach campaigns. Section 11.3 describes milestones related to watershed education activities that can be used to evaluate I&E plan implementation efforts.

11.0 Measuring Plan Progress and Success

Monitoring of plan progress and adaptively managing implementation will be an essential component of achieving the desired water quality goals. Plan progress and success will be tracked by water quality improvement, progress of best management practice implementation, and by participation rates in public awareness and education efforts.

11.1 Water Quality Monitoring

In order to measure the progress and effectiveness of the watershed plan, water quality monitoring will need to be conducted throughout the plan term. Physical, chemical, and biological data will need to be collected to see if the water quality standards and TMDL reductions are being met. This plan calls for the continuation of current monitoring programs.

<u>Water Quality Monitoring</u>

As mentioned in Section 4.4, surface water samples are collected on a monthly basis from four locations in the Middle and Lower Duck Creek watershed from May through October as part of the Lower Fox River Tributary Volunteer Monitoring program (Figure 59). On each sampling date, volunteers collect and ship surface water samples to the Wisconsin State Laboratory of Hygiene for the analysis of TP, TSS, and DRP. Volunteers utilize transparency tubes to assess and document the water clarity of the stream on each date. All sampling is conducted in accordance with WDNR protocol.

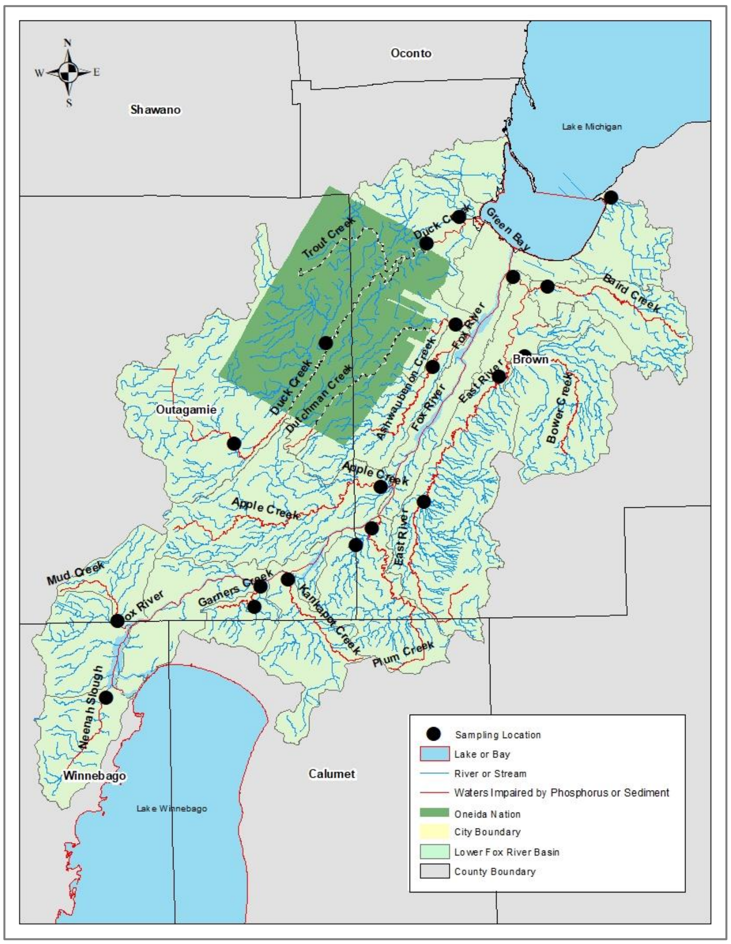

Figure 59. WDNR Lower Fox River monitoring program locations.

At minimum, this plan calls for the continued monitoring of the site locations currently being monitored for Lower Fox River Volunteer Monitoring program on Middle and Lower Duck Creek for TP, TSS, DRP, water clarity, and macroinvertebrates. Two of these sites are also part of the Oneida

Nation’s water quality monitoring program. Water quality monitoring sampling should be continued on an annual basis with samples collected monthly from May-October for TP, DRP, and TSS. Macroinvertebrate sampling by WDNR staff and volunteers is proposed for year 7 or year 10, and will be based upon practice adoption rates.

Milestone:

- Oneida Nation and Outagamie County LCD will consult with the area WDNR Water Quality biologist every two years to review current and planned water quality monitoring activities for the watersheds.

Streambank Erosion Monitoring

Streambank lateral recession rates should be tracked in the watersheds by using erosion pins. Erosion pins are metal rods that are inserted into the bank perpendicular and flush. Figure 60 shows a follow up inspection that indicates 8” of soil has eroded from the bank since installing it flush. Pins should be measured at least 3 times a year and after significant storm events to determine trends in erosion. An initial survey of the streambank of selected sites should also be conducted to serve as benchmark. A minimum of 3 sites should be surveyed in each watershed. The long term tracking of streambank erosion rates will help refine phosphorus and sediment loss estimates from streambank erosion and help to determine if practices implemented in the headwaters of the watershed are having an impact on streambank erosion rates downstream. Drone and aerial imagery should also be used as a tool to assess bank erosion rates over the implementation period. A decrease in observed lateral recession rate over the 10 year time period will demonstrate plan progress. If lateral recession rates are observed to be increasing or remaining the same after several years of implementation, it may indicate that the plan may need to be reevaluated for effectiveness.

Figure 60. Erosion pin inserted into a streambank showing 8” of soil eroded after inspection in Kankapot Creek, Calumet County, Wisconsin.

11.2 Tracking of Progress and Success of Plan

Progress and success of the Middle and Lower Duck Creek Watershed Plan will be tracked by the following components:

1) Information and education activities and participation
2) Pollution reduction evaluation based on BMP's installed
3) Water quality monitoring
4) Administrative review

Oneida Nation, Brown County LWCD and other implementation collaborators will support Outagamie County LCD's leadership in tracking progress of the Nine Key Element Plan. Project collaborators will also need to work with other entities (e.g. NRCS, US FWS) that do work in the watershed to track progress and implement projects. Reports will be completed annually, and a final report will be prepared at the end of the project.

1) Information and education reports will include:
   a) Number of landowners/operators in the watershed plan area.
   b) Number of eligible landowners/operators in the watershed plan area.
   c) Number of landowners/operators contacted.
   d) Number of cost-share agreements signed.
   e) Number and type of information and education activities held, who lead the activity, how many invited, how many attended, and any measurable results of I&E activities.
   f) Number of informational flyers/brochures distributed per given time period.
   g) Number of one on one contacts made with landowners in the watershed.
   h) Number of radio broadcasts and newspaper articles related to water quality protection.
   i) Percent change in attendance at information and education activities held.
   j) Comments or suggestions for future activities.

2) Installed best management practices will be mapped using GIS. Pollution reductions from completed projects will be evaluated using models and spreadsheet tools such as STEPL and SnapPlus for upland practices and the BARNY model for barnyard practices. Installation dates, design specifications, operation and maintenance periods, practice inspections, estimated load reductions and cost share sources/amounts will also be tracked in a GIS database.

   The methods outlined in the US EPA technical memo, "Adjusting for Depreciation of Land Treatment When Planning Watershed Projects" will be used when evaluating BMP effectiveness and identifying factors that may affect BMP performance levels and implementation. For additional information on BMP depreciation, see Appendix J.

Report parameters for pollutant reduction evaluation for BMPs installed:

a) Planned and completed BMP's.
b) Pollutant load reductions and percent of goal planned and achieved.
c) Cost-share funding source of planned and installed BMP's.
d) Numbers of checks to make sure management plans (nutrient management, grazing management) are being followed by landowners.
e) Number of checks to make sure practices are being operated and maintained properly.
f) The fields and practices selected and funded by a point source (adaptive management or water quality trading) compliance options will be carefully tracked to assure that Section 319 funds are not being used to implement practices that are part of a point source permit compliance strategy.
g) Number of new and alternative technologies and management measures assessed for feasibility, used, and incorporated into plan.
h) Changes in land use or land management in watershed that may impact BMP effectiveness.
i) Variations in weather that may have influenced implementation of BMPs or effectiveness of installed BMPs.
j) Normalized Difference Tillage Index (NDTI) and Normalized Difference Vegetation Index (NDVI) for tracking residue management and cover crop implementation.

3) Water Quality Monitoring Reporting Parameters:
   a) Total phosphorus, dissolved reactive phosphorus, total suspended solids, nitrogen and water clarity/turbidity.
   b) Macroinvertebrate, fish, and habitat assessments.
   c) Streamflow.

4) Administrative Review tracking and reporting will include:
   a) Status of grants relating to project.
   b) Status of project administration including data management, staff training, and BMP monitoring.
   c) Annual meetings with WDNR Nonpoint Source and TMDL staff to review and discuss NR151 implementation efforts in watershed. Items for review will include, but not be limited to, 1-6 below:

      1. Do plan implementation efforts for agricultural cropland/operations in the watershed reflect the following priorities?

         - Priority 1 - Achieve compliance with NR 151 performance standards on a majority (>70%) of agricultural acres/operations in the watershed*

- Priority 2 – After a majority of agricultural cropland or operations in the watershed* are found in compliance with existing NR 151 standards, then adoption of additional practices on agricultural acres/operations already in compliance with NR 151 is completed to further reduce pollutant loads from agricultural sources in watershed.

* = *NR 151 Implementation/Compliance rates may vary within the watershed and require dividing the watershed into sub-basins.*

2. If Priority 1 is not met, then how and when can plan implementation efforts change to meet Priority 1?
3. Complete annual watershed inventory to determine current number agricultural cropland acres/farms - out of total number of cropland acres/farms in watershed - that are complying with NR151.
4. Identify how many cropland acres/farms in watershed have received/been documented in compliance with NR 151 via letter.
5. Share/Review copies of NR 151 compliance letters with WDNR staff.
6. Summarize NR 151 priorities, compliance inventory and documentation efforts within annual 9 key element plan progress reports.

d) Status of nutrient management planning, and easement acquisition and development.
e) Number of cost-share agreements.
f) Total amount of money on cost-share agreements.
g) Total amount of landowner reimbursements made.
h) Staff salary and fringe benefits expenditures.
i) Staff travel expenditures.
j) Information and education expenditures.
k) Equipment, materials, and supply expenses.
l) Professional services and staff support costs.
m) Total expenditures for the county.
n) Total amount paid for installation of BMP’s and amount encumbered for cost-share agreements.
o) Number of Water Quality Trading/Adaptive Management contracts.

Water Quality Indicators

Plan progress will also be measured by water quality data. Median summer TP concentrations and macroinvertebrate index of biotic integrity are example metrics that will be used to determine improvement in water quality. Water quality monitoring indicators for success, measured at the recommended four sites in the watersheds, are shown in Table 19. Estimated load reductions from implemented best management practices will also be used to determine if interim water quality goals are being met (Table 20).

Table 19. Water quality monitoring indicators for success.

Monitoring Site	Indicators	Estimated Current Value	Target Value or Goal	Implementation
Duck Creek -CTH S - Site ID: DNR: 10029975	Summer Median Total Phosphorus (mg/l)	0.187	0.075	WDNR/LCD/ Volunteers
	Macroinvertebrate Index of Biological Integrity	Poor	Good	
Duck Creek- Seminary Rd. - Site ID: DNR: 453255/Oneida: DCSM	Summer Median Total Phosphorus (mg/l)	0.172	0.075	WDNR/LCD/ LWCD/Oneida Nation/Volunteers
	Macroinvertebrate Index of Biological Integrity	Fair	Good	
Duck Creek- Pamperin Park - Site ID: DNR:10038644/Oneida: DCPP	Summer Median Total Phosphorus (mg/l)	0.156	0.075	WDNR/LCD/ LWCD/Oneida Nation/Volunteers
	Macroinvertebrate Index of Biological Integrity	Fair	Good	
Unnamed Trib - Lakeview Dr. - Site ID: DNR: 10034510	Summer Median Total Phosphorus (mg/l)	0.071	0.075	WDNR/LCD/ LWCD/Volunteers
	Macroinvertebrate Index of Biological Integrity	Fair	Good	

Table 20. Interim TP and TSS reduction goals for Middle and Lower Duck Creek watershed.

Indicators	Target Reduction[1]		Milestones from Implementation					
			Short Term (3yrs)		Medium Term (7 yrs)		Long Term (10 yrs)	
	Middle	Lower	Middle	Lower	Middle	Lower	Middle	Lower
# lbs phosphorus/yr	6,761	5,395	2,028	1,619	4,733	3,777	6,761	5,395
#tons total suspended sediment/yr	1,366	1,567	410	470	956	1,097	1,366	1,567

1. Target reduction numbers from modeling methods (STEPL & NRCS Spreadsheets/Equations) used for Nine Key Watershed plan development.

11.3 Progress Evaluation

Due to the uncertainty of models and the efficiency of best management practices, an adaptive management approach should be taken with this subwatershed (Figure 61). Milestones are essential when determining if management measures are being implemented and how effective they are at achieving plan goals over given time periods. Plan milestones are based on the implementation schedule with short term (0-3 years), medium term (3-7 years), and long term (7-10 years) milestones. After the implementation of practices and monitoring of water quality, plan progress and success should be evaluated after each milestone period. In addition to the annual report, an additional progress report should be completed at the end of each milestone period. The progress report will be used to identify and track plan implementation to ensure that progress is being made and to make corrections as necessary. Plan progress will be determined by minimum progress criteria for management practices, water quality monitoring, and information and education activities held. If lack of progress is demonstrated, factors resulting in milestones not being met should be included in the report. Adjustments should be made to the plan based on plan progress and any additional new data and/or watershed tools.

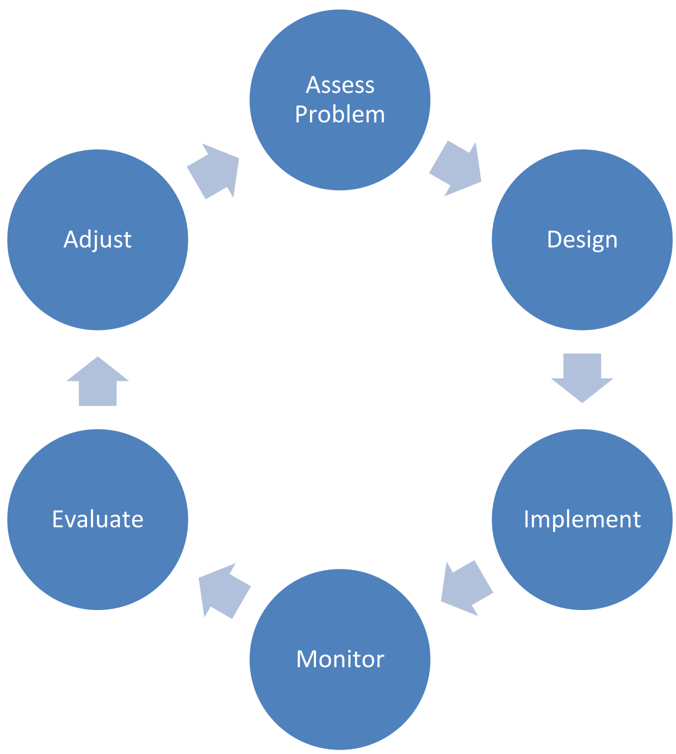

Figure 61. Adaptive management process.

Water Quality Monitoring Progress Evaluation

This implementation plan recognizes that estimated pollutant load reductions and expected improvement in water quality or aquatic habitat may not occur immediately following implementation of practices due to lag time and other factors (described below) that will need to be taken into consideration when evaluating water quality data. Lag time is described as the time elapsed between adoption of management changes and the detection of measurable improvement in water quality (Meals et al, 2010). A review of lag time by Meals et al. (2010) concluded that it might take years to decades to see a water quality response in watersheds that have excessive legacy phosphorus levels in agricultural soils and sediment accumulated in river systems. These factors can affect or mask progress that plan implementation has made elsewhere.

Consultation with the WDNR and Water Quality biologists will be critical when evaluating water quality or aquatic habitat monitoring results. Milestones for pollutant load reductions are shown in Table 20. If the target values/goals for water quality improvement for the milestone period are not being achieved, the water quality targets or timetable for pollutant reduction will need to be evaluated and adjusted as necessary.

The following criteria will be evaluated when water quality and aquatic habitat monitoring is completed after implementation of practices:

- Changes in land use or crop rotations within the same watershed where practices are implemented. (Increase in cattle numbers, corn silage acres, and/or urban areas can negatively impact stream quality and water quality efforts)
- Location in watershed where land use changes or crop rotations occur. (Where are these changes occurring in relation to implemented practices?)
- Watershed size, location where practices are implemented and location of monitoring sites.
- Climate, precipitation and soil conditions that occurred before and during monitoring periods. (Climate and weather patterns can significantly affect growing season, soil conditions, and water quality)
- Frequency and timing of monitoring.
- Percent of watershed area (acres) or facilities (number) meeting NR 151 performance standards and prohibitions.
- Percent of watershed area (acres) or facilities (number) that maintain implemented practices over time.
- Extent of gully erosion on crop fields within watershed over time. How many are maintained in perennial vegetation vs. plowed under each year?
- Stability of bank sediments and how much this sediment may be contributing P and TSS to the stream.

- How “Legacy’ sediments already within the stream and watershed may be contributing P and sediment loads to stream?
- Presence and extent of drain tiles and other drainage features (e.g. plow furrows used to drain wet spots in fields) in watershed area in relation to monitoring locations. Do these drainage systems contribute significant P and sediment loads to receiving streams?
- Does monitored stream meet IBI and habitat criteria but does not meet TMDL water quality criteria?
- Are targets reasonable? Load reductions predicted by models could be overly optimistic.

Management Measures/Information and Education Implementation Progress Evaluation

Implementation milestones for management measures are shown in the 10 Year Management Measures Plan Matrix (Table 16) and milestones for Information and Education Plan implementation are shown in Table 21. If less than 70% of the implementation milestones are being met for each milestone period, the plan will need to be evaluated and revised to either change the milestone(s) or to implement projects or actions to achieve the milestone(s) that are not being met.

Table 21. Information and education plan implementation milestones.

Information and Education Plan Implementation Goal Milestones
Short Term (0-3 years)
a) Completed watershed plan posted on county and/or Oneida Nation website/Facebook page. b) Watershed information and updates posted on county and/or Oneida Nation website or social media page. c) 1 exhibit displayed or used at local library, government office, and/or local event. d) Distribution of informational materials on watershed project and conservation practices to all eligible landowners. e) At least 30 one on one contacts made with agricultural landowners/operators. f) At least 10 one on one contacts made with private landowners of land identified as priority for streambank stabilization/restoration, wetland restoration, and AOC habitat restoration projects. g) At least 2 meetings held with agricultural landowners/operators. h) At least 2 educational workshops/tours held at a demonstration farm. i) At least three issues of "Basin Buzz" newsletter distributed. j) At least 1 meeting to share goals of watershed project have been held with local agricultural businesses and organizations. k) At least one media/press release highlighting conservation efforts or upcoming event submitted. l) At least 2 meetings and/or educational/networking events have been held with watershed stakeholders to share knowledge and build partnerships.

Information and Education Plan Implementation Goal Milestones
Medium Term (3-7 years)
a) At least one field event held for community leaders and elected officials to highlight conservation efforts being done.
b) At least 4 educational workshops held for agricultural landowners/operators.
c) At least 3 meetings held with agricultural landowners.
d) Hold at least two events for citizens of the watershed to promote and highlight conservation efforts in the watershed.
d) At least 2 municipalities/governing bodies in watershed adopt/amend current code or ordinance to match goals of watershed plan or reference watershed plan goals, objectives or recommendations in their own outdoor recreation plans, comprehensive plans, or other related plans.
e) At least 10 people attend each educational workshop and meeting.
f) At least two media/press releases highlighting conservation efforts or upcoming event submitted.
g) At least 4 issues of "Basin Buzz" newsletter distributed.
Long Term (7-10 years)
a) At least 75% of agricultural landowners are educated about water quality in the watershed and methods to protect water quality.
b) At least three issues of "Basin Buzz" newsletter distributed.

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12.0 Cost Analysis

Cost estimates were based on current cost-share rates, incentive payments to get necessary participation, and current conservation practice installation rates. Landowners will be responsible for maintenance costs associated with installed practices. The total cost to implement the watershed plan over 10 years is estimated to be $19,962,159. Implementing the Area of Concern habitat management actions in the Duck Creek Delta and Weitor Wharf area is estimated to cost an additional $17,500,000. Detailed cost estimates for BMP implementation, technical/programmatic assistance, and water quality monitoring are shown in Table 22 and Table 23. A summary of the cost analysis breakdown is shown below.

Summary of Cost Analysis:

- $14,997,178 to implement best management practices.
- $2,544,981 needed for technical and administrative support.
- $265,000 needed for information and education.
- $85,000 for water quality monitoring at four sites.
- $70,000 legacy phosphorus/sediment analysis.
- $2 million for new technologies/equipment and practices.
- ~ $17,500,000 for implementing AOC habitat management actions in Duck Creek Delta and Weitor Wharf area.

Table 22. Cost estimates for implementation of best management practices.

BMP	Quantity	Cost /Unit	Total Cost
Cropland Control			
Conservation Tillage (ac)[1]	4,565	$ 20.00	$ 365,222
Cover Crops (ac)[1]	6,562	$ 75.00	$ 1,968,480
Grass Waterways (ln ft)	22,640	$ 5.00	$ 113,200
Lined Waterway (ln ft)	1,195	$ 35.00	$ 41,825
Concentrated Flow Area Seeding/Critical Area Planting (ac)	13	$ 450.00	$ 5,850
Riparian Buffers/Filter Strips (ac)	82	$ 10,000.00	$ 815,000
Nutrient Management (ac)[1]	1,751	$ 10.00	$ 70,044
Wetland Restoration/Creation (ac)	15	$ 20,000.00	$ 300,000
Water and Sediment Control Basin (ea)	5	$ 7,000.00	$ 35,000
Low Disturbance Manure Application (ac)[1]	3,400	$ 105.00	$ 1,428,000
Prescribed Grazing (ac)[2]	300	$ 270.00	$ 81,000
Two-Stage Ditch/Channel (ln ft)	16,687	$ 11.00	$ 183,557
Drainage Water Management (ac)	200	$ 10.00	$ 2,000

BMP	Quantity	Cost /Unit	Total Cost
Agriculture Runoff Treatment System (ac)	80	$ 60,000.00	$ 4,800,000
Barnyard Runoff/Livestock Facility Control			
Waste Storage Abandonment (ea)	5	$ 10,000.00	$ 50,000
Barnyard Runoff Management (fencing, filter strip, roof runoff, critical area planting, leachate collection/treatment, etc) (ea)	3	$ 50,000.00	$ 150,000
Streambank\Riparian Corridor Restoration			
Streambank Restoration (shaping, seeding, rip rap, biostabilization, obstruction removal) (ln ft)	52,000	$ 80.00	$ 4,160,000
Riparian Corridor Restoration (weed/invasive species control, brush management, tree/shrub establishment, conservation cover) (ac)	120	$ 3,000.00	$ 360,000
Crossing (ea)	8	$ 5,000.00	$ 40,000
Other Natural Area Restoration			
Upland habitat improvement/creation (forest stand improvement, upland wildlife habitat management/wildlife habitat planting, pollinator habitat)	40	$ 700.00	$ 28,000
Technical Assistance			
Conservation/Project Technician[3]	1	$ 96,000.00	$ 1,100,532
Agronomist[3]	1	$ 96,000.00	$ 1,100,532
Administrative Support[3]	0.5	$ 30,000.00	$ 343,916

1.Cost based on cost sharing for 4 year time period. These practices become an option during the corn silage years of a typical dairy rotation as well as anytime in a cash grain rotation. Within the 10-years of this plan implementation, it is assumed that all dairy rotation land will have a 4-yr window to implement these soil health strategies. It is also assumed that after 4 years of cost share that these practices will be adopted perpetually.

2.Cost estimate based on 3 years of grazing plan and forage and biomass planting.

3.Cost based on 10 years of employment including benefits and 3% increase per year for salary and fringe costs.

Table 23. Water quality monitoring costs.

Water Quality Monitoring Activity	Cost ($)
Phosphorus, Sediment, Macroinvertebrate Sampling & Analysis (Duck Creek at CTHS, Seminary Rd., and Pamperin Park & Unnamed Trib at Lakeview Dr.)	85,000

Operation & Maintenance

Typical state and federal cost share programs require a land owner to agree to a 10-year maintenance period for practices such as vegetated filter strips, grassed waterways, water and sediment control basins, treatment wetlands, wetland restoration, barnyard runoff control, manure storage, streambank stabilization, crossings, and fencing. For annual practices that require re-installation of management each year such as conservation tillage and cover crops, landowners are typically required to maintain the practice for each period that cost sharing is available. Therefore, annual assistance may be required for certain practices. For practices that bring a landowner into compliance with NR 151 rules (e.g. Nutrient Management), it is expected of the landowner to continue that practice even after cost share agreement period has expired. Upon completion of the operation and maintenance period of practices cost shared through state or federal sources, point sources may be able to work with operators and landowners to continue implementation of the BMPs under a pollutant trading agreement (non EPA 319 monies).

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13.0 Funding Sources

Many state and federal programs currently provide funding sources for conservation practices. Recently the option of adaptive management, water quality trading, and phosphorus variance has become another option for funding of practices. There are also several non-profit entities that collaborate with governmental agencies and provide funding for conservation work.

13.1 Federal and State Funding Sources

Examples of federal and state funding sources and their acronyms are listed below:

Great Lakes Restoration Initiative (GLRI) - Program is the largest funding program investing in the Great Lakes. Currently the Lower Fox River watershed is one of three priority watersheds in the Great Lakes Restoration Initiative Action Plan. Under the initiative, nonfederal governmental entities (state agencies, interstate agencies, local governments, non- profits, universities, and federally recognized Indian tribes) can apply for funding for projects related to restoring the Great Lakes.

Targeted Runoff Management Grant Program (TRM) - Program offers competitive grants for local governments for controlling nonpoint source pollution. Grants reimburse costs for agriculture or urban runoff management practices in critical areas with surface or groundwater quality concerns. The cost-share rate for TRM projects is up to 70% of eligible costs.

Environmental Quality Incentives Program (EQIP) - Program provides financial and technical assistance to implement conservation practices that address resource concerns. Farmers receive flat rate payments for installing and implementing runoff management practices.

Great Lakes Sediment and Nutrient Reduction Program (GLSNRP) - provides grants to local and state units of government and nonprofit organizations to install erosion and sediment control practices in the Great Lakes Basin. The program is able to support projects that are not typically funded by other U.S. EPA or USDA cost share programs, allowing the program to fund innovative and unique projects.

Conservation Partners Program (CPP) – A collaborative effort between U.S. Department of Agriculture's Natural Resource's Conservation Service (NRCS) and the National Fish and Wildlife Foundation (NFWF) to provide grants on a competitive basis to increase technical assistance capacity to advance the implementation of NRCS/NFWF initiatives and Farm Bill conservation programs.

Conservation Reserve Program (CRP) - A land conservation program administered by the Farm Service Agency. Farmers enrolled in the program receive a yearly rental payment for environmentally sensitive land that they agree to remove from production. Contracts are 10-15 years in length. Eligible practices include buffers for wildlife habitat, wetlands buffer, riparian buffer, wetland restoration, filter strips, grass waterways, shelter belts, living snow fences, contour grass strips, and shallow water areas for wildlife.

Conservation Reserve Enhancement Program (CREP) - Program provides funding for the installation, rental payments, and an installation incentive. A 15-year contract or perpetual contract conservation easement can be entered into. Eligible practices include filter strips, buffer strips, wetland restoration, tall grass prairie and oak savanna restoration, grassed waterway, and permanent native grasses.

Agricultural Conservation Easement Program (ACEP) - New program that consolidates three former programs (Wetlands Reserve Program, Grassland Reserve Program, and Farm and Ranchlands Protection Program). Under this program, NRCS provides financial assistance to eligible partners for purchasing Agricultural Land Easements that protect the agriculture use and conservation values of eligible land.

Conservation Stewardship Program (CSP) – Program offers funding for participants that take additional steps to improve resource condition. Program provides two types of funding through 5-year contracts; annual payments for installing new practices and maintaining existing practices as well as supplemental payments for adopting a resource conserving crop rotation.

Soil and Water Resource Management Grant Program (SWRM) - The Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) awards annual grants to county land conservation committees to help pay for county conservation staff and finance cost sharing for installation of conservation practices with county assistance.

Farmable Wetlands Program (FWP) - Program designed to restore previously farmed wetlands and wetland buffer to improve both vegetation and water flow. The Farm Service Agency runs the program through the Conservation Reserve Program with assistance from other government agencies and local conservation groups.

Wisconsin Coastal Management Program (WCMP) - The Wisconsin Department of Administration (DOA) administers WCMP grants in collaboration with the Wisconsin Coastal Management Council (WCMC) and the Office for Coastal Management (OCM), U.S. Department of Commerce, through funding provided under the Coastal Zone Management Act of 1972. Grant funds are available for coastal wetland protection and habitat restoration, nonpoint source pollution control, coastal resource and community planning, Great Lakes education, and public access and historic preservation projects.

North American Wetlands Conservation Act (NAWCA) - NAWCA grant program supports public-private partnerships carrying out projects that involve long-term protection, restoration and/or enhancement of wetlands and associated uplands habitats.

13.2 Adaptive Management and Water Quality Trading

Adaptive management and water quality trading are potential sources of funding in this watershed if there are interested point sources. Adaptive management and water quality trading can be easily confused (Table 24). Adaptive management and water quality trading can provide an option for point source dischargers to meet their waste load allocation limits. Point sources provide funding for best management practices to be applied in a watershed and receive acknowledgement for the reduction from that practice. Adaptive management focuses on compliance with phosphorus criteria while water quality trading focuses on compliance with a discharge limit.

Table 24. Comparison of adaptive management and water quality trading.

Adaptive Management	Water Quality Trading
Receiving water is exceeding phosphorous or sediment loading criteria.	The end of pipe discharge is exceeding the allowable limit.
More flexible and adaptive to allow cropland practices to show reductions over an extended time period.	Not as flexible, needs to show stable reductions year to year.
Does not use "trade ratios" as modeling factor.	Uses "trade ratios" as margin of error factor.
Uses stream monitoring to show compliance.	Uses models such as SNAP+ or BARNY to show compliance with reduction in loading.
Typically used for phosphorus or total suspended solids compliance only.	Can be used for a variety of pollutants, not just phosphorus.
Can be used to quantify phosphorus reductions for up to 20 years (4 permit terms).	Can be used to demonstrate compliance indefinitely as long as credits are generated.
Wetland restoration, bank stabilization, and other similar practices can count towards compliance.	Wetland restoration, bank stabilization, and other similar practices can count towards compliance if reductions are quantifiable.

13.3 Phosphorus Multi- Discharger Variance (MDV) (Wisconsin Act 378)

In April of 2014, Act 378 was enacted; this act required the Wisconsin Department of Administration in consultation with the Department of Natural Resources to determine if complying with phosphorus limits causes Wisconsin substantial and economic hardship. It was determined that costs associated with wastewater treatment to remove phosphorus would cause a substantial and widespread economic impact on the state.

The DNR is working with the EPA to implement a Multi-Discharger Phosphorus Variance to help point sources comply with phosphorus standards in a more economically viable way. A multi- discharger variance extends the timeline for complying with low-level phosphorus limits. In exchange, point sources agree to step wise reduction of phosphorus within their effluent as well as helping to address nonpoint source of phosphorus from farm fields, cities or natural areas by paying $50 per pound plus inflation that has occurred since 2015 to implement projects designed to improve water quality. A permittee that chooses to make payments for phosphorus reduction will make payments to each county that is participating in the program and has territory within the basin in which the point source is located in proportion to the amount of territory each county has within the basin. A county will then use the payments to provide cost sharing for projects to reduce the amount of phosphorus entering the waters of the state, for staff to implement phosphorus reduction projects, and/or for modeling or monitoring to evaluate the amount of phosphorus in the waters of the state for planning purposes. The final Multi-Discharger Variance package was submitted to the EPA on March 30, 2016 and approved by the EPA on February 6, 2017.

13.4 Other Funding Sources

Examples of additional potential project collaborators and sources of funding listed below:

Land Trusts- Landowners also have the option of working with a land trust to preserve land. Land trusts preserve private land through conservation easements, purchase land from owners, and accept donated land.

Great Lakes Fishery Trust (GLFT) - The Great Lakes Fishery Trust provides funding to nonprofit organizations, educational institutions, and government agencies to enhance, protect, and rehabilitate Great Lakes fishery resources.

Fox River/Green Bay Natural Resource Trustee Council (NRDA)- Council provides funding for projects that restore, rehabilitate, replace and/or acquire the equivalent of the natural resources that have been injured by the release of PCB's in Wisconsin and Upper Michigan.

Fund for Lake Michigan – Grant program that supports organizations and communities that seek to restore and protect Lake Michigan. The Fund for Lake Michigan gives priority to on-the-ground projects that have near-term, direct and quantifiable impacts on water quality in the Lake Michigan watershed. These projects include protecting critical natural habitats, reducing polluted runoff and generally making water resources more swimmable, fishable and drinkable.

Ducks Unlimited (DU) - A non-profit organization that works to conserve, restore, and manage wetlands and associated habitats for North America's waterfowl.

The Nature Conservancy (TNC) - A non-profit organization that works around the world to protect ecologically important lands and waters.

Wisconsin Waterfowl Association (WWA) - A non-profit organization, founded by hunters in 1984, that works to conserve and restore Wisconsin's waterfowl and wetland resources.

Community Foundation for the Fox Valley Region- A non-profit organization that manages charitable funds that generate grants for the benefit of people in the Fox Valley region of Wisconsin. The Foundation provides grants for the following focus areas and priorities: Arts &

Culture, Basic Needs and Self-Sufficiency, Community Development, Environmental Sustainability, and Nonprofit Effectiveness.

Agriculture Supply Chain- In recent years, food companies (e.g General Mills and Danone) have started to finance programs that incentivize the use of regenerative and organic agriculture for the farmers in their supply chains.

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Appendices

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Appendix A. Glossary of terms and acronyms.

Animal Unit (AU) - a standard unit used in calculation of the relative grazing impact of different kinds and classes of livestock. One animal unit is defined as a 1,000 lb beef cow.

BARNY- Wisconsin adapted version of the ARS feedlot runoff model that estimates amount of phosphorus runoff from feedlots.

Baseline - An initial set of observations or data used for comparison or as a control.

Bay Lake Regional Planning Commission (BLRPC) - Multi-service public entity that delivers a variety of federal, state, and local programs and provides planning and technical assistance to member local governments in Northeast Wisconsin.

Beneficial Use Impairment (BUI) - An impairment of beneficial uses means a change in the chemical, physical or biological integrity of the Great Lakes system sufficient to cause significant environmental degradation.

Best Management Practice (BMP) - A method that has been determined to be the most effective, practical means of preventing or reducing pollution from nonpoint sources.

Concentrated Animal Feeding Operation (CAFO) - A Wisconsin animal feeding operation with 1,000 animal units or more.

Classic Gully- also referred to as a permanent gully, is a channel formed by concentrated flow erosion too deep for normal tillage operations to erase.

Cost-Sharing- Financial assistance provided to a landowner to install and/or use applicable best management practices.

Dissolved Reactive Phosphorus (DRP) - the portion which is dissolved and can immediately support plant and algae growth.

Ducks Unlimited- A non-profit organization that works to conserve, restore, and manage wetlands and associated habitats for North America's waterfowl.

East Central Wisconsin Regional Planning Commission (ECWRPC)- Multi-service public entity that delivers a variety of federal, state, and local programs and provides planning and technical assistance to member local governments in East Central Wisconsin.

Ephemeral gully- Voided areas that occur in the same location every year by concentrated flow erosion that are crossable with farm equipment and are often partially filled in by tillage.

United States Fish and Wildlife Service (US FWS) - Government agency dedicated to the management of fish, wildlife, and natural habitats.

Geographic Information System (GIS) - A tool that links spatial features commonly seen on maps with information from various sources ranging from demographics to pollutant sources.

Hydrologic Unit Code (HUC) - The United States is divided and sub-divided into successively smaller hydrologic units, which are classified into four levels: regions, sub-regions, accounting units, and cataloging units. Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system.

Index of Biotic Integrity - An indexing procedure commonly used by academia, agencies, and groups to assess watershed condition based on the composition of a biological community in a water body.

Lateral Recession Rate- the thickness of soil eroded from a bank surface (perpendicular to the face) in an average year, given in feet per year.

MSE4 - A specific precipitation distribution developed by the United States Department of Agriculture, Natural Resources Conservation Service, using precipitation data from Atlas 14.

Natural Resources Conservation Service (NRCS) - Provides technical expertise and conservation planning for farmers, ranchers, and forest landowners wanting to make conservation improvements to their land.

Phosphorus Index (PI) - The phosphorus index is used in nutrient management planning. It is calculated by estimating average runoff phosphorus delivery from each field to the nearest surface water in a year given the field's soil conditions, crops, tillage, manure and fertilizer applications, and long term weather patterns. The higher the number the greater the likely hood that the field is contributing phosphorus to local water bodies.

Riparian - Relating to or located on the bank of a natural watercourse such as a river or sometimes of a lake or tidewater

Soil Nutrient Application Manager (SNAP) - Wisconsin's nutrient management planning software.

Spreadsheet Tool for Estimating Pollutant Load (STEPL) - Model that calculates nutrient loads (Phosphorus, Nitrogen, and Biological Oxygen Demand) by land use type and aggregated by watershed.

Soil and Water Assessment Tool (SWAT) – A small watershed to river basin-scale model to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and climate change. Model is widely used in assessing soil erosion prevention and control, non-point source pollution control and regional management in watersheds.

Stream Power Index (SPI) - Measures the erosive power of overland flow as a function of local slope and upstream drainage area.

The Nature Conservancy (TNC) - Nonprofit organization that works around the world to protect ecologically important lands and waters.

Total Phosphorus (TP) - Measure of all forms of phosphorus.

Total Suspended Solids (TSS) - The organic and inorganic material suspended in the water column and greater than 0.45 micron in size.

Total Maximum Daily Load (TMDL) - A calculation of the maximum amount of pollutant that a water body can receive and still meet water quality standards.

United States Geological Survey (USGS) - Science organization that collects, monitors, analyzes, and provides scientific understanding about natural resource conditions, issues, and problems.

United States Environmental Protection Agency (USEPA) - Government agency to protect human health and the environment.

University of Wisconsin Madison-Division of Extension (Extension) – UW Madison-Divison of Extension works with UW- System campuses, Wisconsin counties, tribal governments, and other public and private organizations to help address economic, social, and environmental issues.

Waste Load Allocation (WLA) - a portion of a receiving water's assimilative capacity that is allocated to one of its existing or future point sources of pollution. WLAs establish water quality based effluent limits for point source discharge facilities.

Wisconsin Department of Natural Resources (WDNR) – State organization that works with citizens and businesses to preserve and enhance the natural resources of Wisconsin.

Wisconsin Pollutant Discharge Elimination System (WPDES) - System used by Wisconsin Department of Natural Resources to regulate the discharge of pollutants to waters of the state.

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Appendix B. GIS data sources for maps and analysis.

GIS/Data Type	Source Agency	Source Location/Metadata Link
Land Use/Land Cover	Brown County Planning Dept.	Land Use/Future Land Use. Available upon request to data source. GIS website: https://www.browncountywi.gov/services/maps-and-gis-apps/
	Outagamie County Development and Land Services Dept.	Land Use/Future Land Use. Available upon request to data source. GIS website: http://www.outagamie.org/government/departments-a-e/development-and-land-services/gis-land-information
	UW- Green Bay	Lower Fox 2004 Land Use used for TMDL SWAT Model. Available upon request to data source.
Cropland Data	USDA-National Agricultural Statistics Service (NASS)	https://nassgeodata.gmu.edu/CropScape/
Ortho-photos/Satellite Imagery	Brown County Planning & Land Services Dept.	1938-2020 ortho-photos. GIS website: https://www.browncountywi.gov/services/maps-and-gis-apps/
	Outagamie County Development and Land Services Dept.	1938-2021 ortho-photos. Available upon request to data source. GIS website: http://www.outagamie.org/government/departments-a-e/development-and-land-services/gis-land-information
	European Space Agency	2020-2021 Sentinel 2 satellite imagery. https://cophub.copernicus.eu/dhus/#/home
	Google Earth Pro	1992-2021 ortho-photos. Website: https://www.google.com/earth/
Soil Types (SSURGO)	USDA-NRCS	http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx
Elevation (LIDAR)	Brown County Planning & Land Services Dept.	http://www.co.brown.wi.us/departments/?department=85713eda4cdc
	Outagamie County Development and Land Services Dept.	http://www.outagamie.org/government/departments-a-e/development-and-land-services/gis-land-information
Hydrography-303(d) Impaired surface waters	WI Dept. of Natural Resources	https://data-wi-dnr.opendata.arcgis.com/datasets/303d-impaired-rivers-and-streams-listed

GIS/Data Type	Source Agency	Source Location/Metadata Link
Hydrography	WI Dept. of Natural Resources (watershed boundary)	https://data-wi-dnr.opendata.arcgis.com/datasets/hydrologic-units-12-digit-subwatersheds
	WI Dept. of Natural Resources (surface waters-24K hydro)	https://www.arcgis.com/home/item.html?id=cb1c7f75d14f42ee819a46894fd2e771
	Brown County Planning & Land Services Dept. (HydroLine)	https://www.browncountywi.gov/services/maps-and-gis-apps/
	Outagamie County Development and Land Services Dept. (Navigable Streams)	http://www.outagamie.org/government/departments-a-e/development-and-land-services/gis-land-information
Political/municipal boundaries	Wisconsin State Legislature	Wisconsin State Legislature Open Data Portal: https://data-ltsb.opendata.arcgis.com
Wetlands	WI Department of Natural Resources	https://data-wi-dnr.opendata.arcgis.com/
	The Nature Conservancy	http://maps.freshwaternetwork.org/wisconsin/
Area of Concern Habitat Types	University of Wisconsin- Green Bay	GIS layer available upon request. https://www.uwgb.edu/green-bay-area-of-concern/fish-wildlife-habitats/maps/

Appendix C. Water quality monitoring sites summary table.

Stream Monitoring Site Location	Monitoring Entity	Site ID	Monitoring Parameters				
			Total Phosphorus	Total Suspended Sediment	Macroinvertebrates	Nitrogen	Current Status
Duck Creek -CTH S	WDNR	10029975	X	X	X	X	Active
Duck Creek- Seminary Rd	WDNR Oneida Nation	453255 DCSM	X	X	X	X	Active
Duck Creek- Pamperin Park	WDNR Oneida Nation	10038644 DCPP	X	X	X	X	Active
Unnamed Trib -Lakeview Dr.	WDNR	10034510	X	X	X	X	Active
Lancaster Brook - Navajo Rd	Oneida Nation	LBN	X	X	X	X	Active
Silver Creek - Hwy 54	Oneida Nation	SLV	X	X	X	X	Active
Thornberry Creek - Crooked Creek Ln	Oneida Nation	THCC	X	X	X	X	Active
Silver Creek- Fish Creek Rd.	NEW Water	SL-FCR	X	X			Active
Silver Creek- Crook Rd.	NEW Water	SL-CKR	X	X			Active
Silver Creek- County Line Rd	NEW Water	SL-COU	X	X			Active
Silver Creek - Florist Drive.	NEW Water USGS	SL-FLD 4072076	X	X	X[1]		Active
Silver Creek- HWY 172	NEW Water	SL-172	X	X			Inactive- Sampling ended in 2020

1. Macroinvertebrate sampling done by Jim Snitjen at Oneida Nation for the pilot project.

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Appendix D. Baseline and current conditions STEPL model inputs.

A baseline STEPL model was created for each watershed to reflect the land use conditions used for the Lower Fox TMDL SWAT model. The Lower Fox TMDL land use GIS dataset, historic air photos (2005), and NASS cropland data layers (2003-2007) where used to determine the baseline land use conditions. A current conditions STEPL model was created to quantify BMP reductions achieved from the Silver Creek Pilot project and to account for the reductions from the loss of agricultural land due to urban development since the development of the TMDL SWAT model. The Lower Duck STEPL model was broken down by Silver Creek subwatershed area and the remaining Lower Duck subwatershed area to better model the practices implemented during the Silver Creek Pilot Project. STEPL model inputs are shown in Tables D-1, D-2 and D-3.

Table D- 1. Baseline and current conditions STEPL model inputs.

STEPL Inputs	Middle Duck		Lower Duck- Silver Creek		Lower Duck- Excluding Silver Creek	
	Baseline	Current	Baseline	Current	Baseline	Current
Weather & Rain						
Station:	WI Green Bay WSO					
Rain Correction Factors	0.821, 0.349					
Annual Rainfall	28					
Rain Days	119					
Average Rain/Event	0.551					
Land Use						
Urban (MS4)[1]	0	0	65	90	12,245	13,143
Urban (NonMS4)	1,952	2,094	375	384	1,156	1,213
Cropland	8,010	7,067	1,735	1,119	3,240	2,202
Pastureland/Hay	644	1,065	70	204	490	267
Forest/Natural Background	3,960	4,338	1,017	1,455	6,667	6,891
Agriculture Animals[2]						
Beef	965	965	40	40	66	66
Dairy	2306	2306	137	137	22	22
Horse	4	4	0	0	70	70
# of months manure applied	1	1	1	1	1	1
USLE Parameters						
Cropland						
R	100	100	100	100	100	100
K	0.37	0.37	0.39	0.39	0.33	0.33
LS	0.22	0.22	0.23	0.23	0.35	0.35
C	0.17	0.17	0.18	0.18	0.16	0.16

STEPL Inputs	Middle Duck		Lower Duck- Silver Creek		Lower Duck- Excluding Silver Creek	
	Baseline	Current	Baseline	Current	Baseline	Current
P	1	1	0.982	0.982	0.982	0.982
Pastureland/Hay						
R	100	100	100	100	100	100
K	0.37	0.37	0.36	0.36	0.37	0.37
LS	0.23	0.23	0.6	0.6	0.72	0.72
C	0.03	0.03	0.036	0.036	0.036	0.036
P	1	1	1	1	1	1
Forest/Natural Background						
R	100	100	100	100	100	100
K	0.35	0.35	0.36	0.36	0.32	0.32
LS	0.288	0.288	0.45	0.45	1.2	1.2
C	0.006	0.006	0.006	0.006	0.006	0.006
P	1	1	1	1	1	1
Soil P Concentration						
Cropland	0.086	0.086	0.086	0.086	0.086	0.086
Pastureland/Hay	0.086	0.086	0.086	0.086	0.086	0.086
Forest/Natural Background	0.069	0.069	0.069	0.069	0.069	0.069
Runoff Curve Number						
Cropland	81	81	79	79	79	79
Pastureland/Hay	69	69	68	68	68	68
Forest/Natural Background	70	70	69	69	69	69

1. Urban MS4 land use acres were included in the STEPL model to have an accurate sediment delivery ratio. STEPL estimates a delivery ratio based on watershed size to calculate the watershed loads for each land use category. Actual MS4 loads were obtained from MS4 stormwater plans for current conditions where available. The TMDL SWAT model estimate loads were used for baseline condition.

2. Animal units for STEPL inputs are calculated based on amount of land that a farm operates in a watershed. (Ex. Farm A located in watershed has 1,000 AU's at facility, but only 50% of their land operated is in watershed. Therefore, only 500 AU's from this farm are applied to the total for the watershed assuming manure from all animals is evenly distributed on all operated cropland acres.) Animal units were assumed to be relatively unchanged for these watersheds since the time of TMDL SWAT model development, therefore the same units were used for current and baseline modeling.

Table D- 2. Agriculture land practice condition scenarios applied in baseline STEPL model.

Practice Combination	Acres applied to or treated by practice	% Implementation on agriculture land	% reduction (phosphorus)	Weighted % reduction phosphorus	% reduction (sediment)	Weighted % reduction sediment
Middle Duck Baseline Agriculture Conditions						
Cropland						
NMP	2,539	31.7	45	21.4	0.0	0.0
Conservation Tillage (30-59%)	1,177	14.7	35.6	7.8	40.3	8.9
NMP & Conservation Tillage (30-59%)	1,626	20.3	64.6	19.7	40.3	12.3
Total	**5,342**	**75.2**		**48.9**		**21.1**
Pasture/Hay Land						
NMP	**58**	**9.0**	45	**45.0**	NA	**NA**
Lower Duck Exclude Silver Creek Baseline Agriculture Conditions						
Cropland						
NMP	1,009	31.1	45	21.2	0.0	0.0
Conservation Tillage (30-59% Residue)	782	24.1	35.6	13.0	40.3	14.7
NMP & Conservation Tillage (30-59% Residue)	352	10.9	64.6	10.6	40.3	6.6
Total	**2,143**	**66.1**		**44.8**		**21.3**
Lower Duck - Silver Creek Baseline Agriculture Conditions						
Cropland						
NMP	829	47.8	45.0	26.0	0.0	0.0
Conservation Tillage (30-59% Residue)	291	16.8	35.6	7.2	40.3	8.2
NMP & Conservation Tillage (30-59% Residue)	316	18.2	64.6	14.2	40.3	8.9

Practice Combination	Acres applied to or treated by practice	% Implementation on agriculture land	% reduction (phosphorus)	Weighted % reduction phosphorus	% reduction (sediment)	Weighted % reduction sediment
Total	**1,436**	**82.8**		**47.4**		**17.0**
Pasture/Hay Land						
NMP	**29**	**42.0**	45	**45.0**	0.0	**0.0**

Table D- 3. Agriculture land practices and other BMP condition scenarios applied in current condition STEPL model.

Practice Combination	Acres applied to or treated by practice	% Implementation on agriculture land	% reduction (phosphorus)	Weighted % reduction phosphorus	% reduction (sediment)	Weighted % reduction sediment
Middle Duck Current Agriculture Conditions						
Cropland						
NMP	3,338	47.0	45	30.7	0	0.0
Conservation Tillage (30-59% residue)	653	9.2	35.6	5.0	40.3	5.7
NMP & Conservation Tillage (30-59% residue)	902	12.7	64.6	12.6	40.3	7.9
Total	**4,893**	**68.9**		**47.4**		**12.8**
Pasture/Hay Land						
NMP	**490**	**46.0**	45	**NA**	NA	**NA**
Lower Duck Exclude Silver Creek Current Agriculture Conditions						
Cropland						
NMP	388	17.6	45	12.3	0	0.0
Conservation Tillage (30-59% Residue)	652	29.6	35.6	16.3	40.3	18.5
NMP & Conservation Tillage (30-59% Residue)	383	17.4	64.6	17.4	40.3	10.8

Practice Combination	Acres applied to or treated by practice	% Implementation on agriculture land	% reduction (phosphorus)	Weighted % reduction phosphorus	% reduction (sediment)	Weighted % reduction sediment
Total	**1,423**	**64.6**		**46.0**		**29.3**
Pasture/Hay Land						
NMP	**64**	**24.0**	45	**NA**	NA	**NA**
Lower Duck - Silver Creek Current Agriculture Conditions						
Cropland						
Conservation Tillage (Average) and Cover Crop	107	9.6	69.4	8.1	76.8	9.0
NMP	352	31.5	45.0	17.3	0.0	0.0
NMP & Conservation Tillage (Average) & Cover Crop	119	10.6	83.1	10.8	76.8	10.0
NMP, Buffer-Grass (35 ft), Conservation Tillage (Average) & Cover Crop	89	8.0	90.5	8.8	89.2	8.7
Buffer-Grass (35 ft)	20	1.8	43.5	1.0	53.3	1.2
Buffer-Grass (35 ft) & NMP	89	8.0	68.9	6.7	53.3	5.2
Buffer-Grass (35 ft) & Conservation Tillage (Average) & Cover Crop	12	1.1	82.7	1.1	89.2	1.2
Wetland, Buffer-Grass (35 ft) & NMP	126	11.3	82.6	11.4	89.5	12.3
Total	**914**	**81.7**		**65.2**		**47.5**
Pasture/Hay Land						
NMP	30	14.8	45	**22.9**	NA	**NA**
Buffer-Grass (35 ft) & NMP	29	14.2	87.1	**42.8**	64.8	**31.9**
Total	**59**	**29.0**		**65.7**		**31.9**

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Appendix E. Modeling scenario results for Middle and Lower Duck Creek watersheds.

Table E- 1and Table E- 2 below show the estimated phosphorus and sediment loads by source for each modeling scenario for the Middle and Lower Duck watersheds.

Table E- 1. Modeling scenario results for baseline conditions, current conditions, future agriculture to urban land use conditions, and proposed BMP scenario for Middle Duck Creek watershed.

Source	Baseline		Current		Future Agriculture to Urban Land Use Conversion*		Future Agriculture to Urban Land Use Conversion with Proposed Agriculture BMPs		Model/Source Estimate
	TP (lbs/yr)	TSS (tons/yr)	TP (lbs/yr)	TSS (tons/yr)	TP (lbs/yr)	TSS (tons/yr)	TP (lbs/yr)	TSS (tons/yr)	
WWTP	542	1	542	1	542	1	542	1	TMDL
Urban (MS4)	0	0	0	0	0	0	0	0	WinSLAMM/TMDL SWAT
Urban (non-regulated)	688	109	731	116	1,009	168	1,009	168	STEPL
Natural Background	331	35	362	39	316	34	316	34	STEPL
Cropland	7,152	1,398	6,581	1,311	6,024	1,200	1,406	284	STEPL
Pasture/Hay	188	24	281	40	265	38	262	38	STEPL
Animal Lots	234	0	234	0	234		78	0	NRCS BARNY
Gully Erosion	373	217	373	217	279	162	28	16	STEPL
Streambank Erosion	845	692	845	692	845	692	245	200	NRCS Direct Volume Method
Total	**10,353**	**2,476**	**9,949**	**2,416**	**9,514**	**2,295**	**3,886**	**741**	

** This scenario assumes the same residue and tillage and nutrient management conditions percentage as current conditions and only estimates the change in loads from current agriculture land being developed in the future.*

Table E- 2. Modeling scenario results for baseline conditions, current conditions, future agriculture to urban land use conditions, and proposed BMP scenario for Lower Duck Creek watershed.

Source	Baseline		Current		Future Agriculture to Urban Land Use Conversion*		Future Agriculture to Urban Land Use Conversion with Proposed Agriculture BMPs		Model/Source Estimate
	TP (lbs/yr)	TSS (tons/yr)	TP (lbs/yr)	TSS (tons/yr)	TP (lbs/yr)	TSS (tons/yr)	TP (lbs/yr)	TSS (tons/yr)	
Urban (MS4)	6,694	1,270	4,235	608	4,235	608	4,235	608	WinSLAMM/TMDL SWAT
Urban (non-regulated)	394	68	411	70	440	77	440	77	STEPL
Natural Background	998	204	1,068	216	540	105	540	105	STEPL
Cropland	4,496	926	2,673	541	1,647	333	597	123	STEPL
Pasture/Hay	314	65	238	50	192	40	192	40	STEPL
Animal Lots	0	0	0	0	0	0	0	0	NRCS BARNY
Gully Erosion	524	305	97	56	70	41	7	4	STEPL
Streambank Erosion	1,682	1,379	1,682	1,379	1,682	1,379	826	678	NRCS Direct Volume Method
Total	**15,102**	**4,217**	**10,404**	**2,919**	**8,806**	**2,583**	**6,837**	**1,635**	

** This scenario assumes the same residue and tillage and nutrient management conditions percentage as current conditions and only estimates the change in loads from current agriculture land being developed in the future. These numbers were not modeled in WinSLAMM based on future urban MS4 land base. This plan is for nonpoint sources, therefore this modeling of land use change (loss of cropland & pastureland) was only done to quantify the redistribution of pollutant loading from the nonpoint sources. As urban MS4 areas continue to develop they are required to meet MS4 compliance requirements. Permittees are required to submit annual reports and compliance documents to the DNR to document progress with permit requirements.*

Streambank Erosion

Field Measurement Procedure

The best way to quantify streambank erosion is to measure it directly in the field. The basic procedure in measuring streambank erosion is to survey, flag, or in some way fix a “before" image of the channel you are evaluating. This establishes the baseline condition. Changes due to erosion can then be monitored over time by going back to the study area and re-measuring from your fixed reference points.

Channel cross-sections can be surveyed and plotted on a periodic basis to monitor change. Stakes or pins can be driven into channel banks flush with the surface. The amount of stake or pin exposed due to erosion is the amount of change at the streambank erosion site between your times of observation.

Field Estimate Procedure (Direct Volume Method)

The field measurement procedure is the most accurate way to measure streambank erosion. However, the time involved in monitoring your site, in wet years and dry years, often precludes this method of data collection. The Direct Volume Method can be used to estimate streambank erosion at your site. The Direct Volume Method is summarized in the following equation:

$$\frac{\text{(eroding area) (lateral recession rate) (density)}}{\text{2000 lbs/ton}} = \text{erosion in tons/year}$$

The eroding area is in square feet, the lateral recession rate is in feet/year, and density is in pounds/cubic feet (pcf).

Determining Eroding Area

Eroding areas are channel banks that are bare, rilled or gullied. They generally have sloughed soil at their bases. A grassed bank or rock bank is considered to be non-eroding. The actual eroding area is defined by multiplying the height and the length to obtain square feet of eroding area. The height is measured on the bank surface as the slope height; not the vertical height.

Average Annual Lateral Recession Rate

The average annual recession rate is the thickness of soil eroded from a bank surface (perpendicular to the face) in an average year. Recession rates are measured in feet per year. Channel erosion often occurs as chunk or blowout type erosion. A channel bank may not erode for a period of years when no major runoff events occur. When a major storm does occur, the bank may be cut back tens of feet for short distances. It is necessary to assign recession rates to banks with such a process in mind. When a bank is observed after a flood and ten feet of bank has been eroded, that ten feet must be averaged with the years when no erosion occurred. This will result in a much lower average annual recession rate than a recession rate for one storm.

Selecting the average annual lateral recession rate is the most critical step in estimating channel erosion using the direct volume method. A historical perspective is needed in many instances. Old photographs, old survey records, and any other information that helps to determine the bank condition at known times in the past are very useful data. In most instances, such information is lacking and field observations and judgement are needed to estimate recession rates.

Cultural features are often helpful in determining recession rates. Exposed bridge piers, suspended outfalls or culverts, suspended fence lines are all possible indicators of lateral recession. Discoloration on the bridge piers may show the original channel bottom elevation. Given the date of the bridge installation, a recession rate can be calculated for that reach of stream. Culverts are generally installed flush with a bank surface. The amount of culvert exposed and age of the culvert allows for the calculation of a recession rate.

Exposed tree root is probably the most common field evidence of lateral recession. Roots will not grow towards a well-drained, exposed, eroding channel bank. The amount of root exposed should be increased by at least a factor of two to account for soil that was in the bank and that the root was growing in. By dividing the length of root exposed

and the thickness of soil around the root by the age of the tree, a recession rate can be estimated.
Much experience and professional judgement are required to estimate channel recession rates. It is often not possible to directly measure recession rates in the field. Therefore, the following table has been included which relates recession rates to narrative descriptions of banks eroding at different rates.

Lateral Recession Rate (ft/yr)	Category	Description
0.01-0.05	Slight	Some bare bank but active erosion not readily apparent. Some rills but no vegetative overhang. No exposed tree roots.
0.06-0.2	Moderate	Bank is predominantly bare with some rills and vegetative overhang. Some exposed tree roots but no slumps or slips.
0.3-0.5	Severe	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees and slumps or slips. Some changes in cultural features such as fence corners missing and realignment of roads or trails. Channel cross section becomes U-shaped as opposed to V-shaped.
0.5+	Very Severe	Bank is bare with gullies and severe vegetative overhang. Many fallen trees, drains and culverts eroding out and changes in cultural features as above. Massive slips or washouts common. Channel cross section is U-shaped and stream course may be meandering.

Volume Weight Conversions

The volume (cubic feet) of eroded material is obtained by multiplying eroding areas by a lateral recession rate. To convert this volume of eroded material to a weight, the dry density of the soil must be known. The following table lists soil textures with corresponding volume weights.

Soil Texture	Volume-Weight
Gravel	110
Sand	105
Fine Sandy Loam	100
Loamy Sand	100
Sandy Loam	100
Loam	90
Sandy Clay Loam	90
Clay Loam	85
Silt Loam	85
Silty Clay	85
Silty Clay Loam	85
Silt	80
Clay	65
Organic	22

Example

Farmer Brown's cattle have access to the stream running through his pasture. On the south side of the stream, 700 feet of bank is bare with rills and overhanging vegetation. Exposed tree roots are evident with many fallen trees and slumps. Bank height is 8 feet measured along the bank. Soil type is predominantly sandy loam. On the north side of the stream, 300 feet of bank is predominantly bare with some rills and vegetative overhang. There are some exposed tree roots but no slumps are evident. Bank height is 10 feet and the soil texture is a loam.

Annual erosion at the site using the Direct Volume Method:

$$\frac{\text{(eroding area) (lateral recession rate) (density)}}{\text{2000 lbs/ton}} = \text{erosion in tons/year}$$

South bank:

$$\frac{\text{700 ft x 8 ft x 0.4 ft/yr x 100 pcf}}{\text{2000 lbs/ton}} = \text{112 t/yr}$$

North bank:

$$\frac{\text{300 ft x 10 ft x 0.1 ft/yr x 90 pcf}}{\text{2000 lbs/ton}} = \text{13.5 t/yr}$$

112 t/yr + 13.5 t/yr = 125.5 tons/year eroding at the site

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Appendix G. Model inputs & reduction results for best management practices.

Table G- 1. BMP practice efficiencies used for baseline and current conditions STEPL modeling and proposed BMP scenario reduction calculations.

Practice	Practice Efficiency		Source
	Phosphorus (%)	Sediment (%)	
Individual Practices			
Cover Crops	35.9	43.9	SnapPlus[1]
Conservation Tillage (30-59% Residue)	35.6	40.3	STEPL V4.4
Conservation Tillage (≥60%) Residue)	68.7	77	STEPL V4.4
Conservation Tillage (Average)*	52.2	58.7	STEPL V4.3
Cropland Buffer-Grass (35 ft-wide)	43.5	53.3	STEPL V4.4
Pastureland Buffer-Grass (35 ft - wide)	76.6	64.8	STEPL V4.4
Manure Injection (Low Disturbance)	20	N/A	Kansas State University[2]
Nutrient Management	45	N/A	STEPL V4.4
Prescribed Grazing/Rotational Grazing	75	49	Land Stewardship Project[3]
Wetland Detention	44	75	STEPL V4.3/4.4
Land Retirement	80.8	95	STEPL V4.4
Tile Drainage Water Management	35	N/A	STEPL V4.4
Agriculture Runoff Treatment System (ARTS)	60	80	Outagamie County LCD[4]
Two Stage Ditch	28	NA	STEPL V4.4
Practice Systems			
Cover Crops & Conservation Tillage (Average)	69.3	76.8	STEPL BMP Calculator
Cover Crop, Conservation Tillage (Average), & Manure Injection (Low Disturbance)	75.5	76.8	STEPL BMP Calculator
Nutrient Management, Cover Crop, & Conservation Tillage (Average)	83.1	76.8	STEPL BMP Calculator
Nutrient Management, Cover Crop, Conservation Tillage (Average) & Manure Injection (Low Disturbance)	86.5	76.8	STEPL BMP Calculator

Practice	Practice Efficiency		Source
	Phosphorus (%)	Sediment (%)	
Cover Crops, Conservation Tillage (Average) & Drainage Water Management & NMP	89.0	76.8	STEPL BMP Calculator
Nutrient Management & Cover Crops & Conservation Tillage (Average)	83.1	76.8	STEPL BMP Calculator
Two Stage Ditch, Cover Crops & Conservation Tillage (Average)	77.9	76.8	STEPL BMP Calculator
Two Stage Ditch, Nutrient Management, Cover Crops & Conservation Tillage (Average)	87.9	76.8	STEPL BMP Calculator
Two Stage Ditch, Cover Crops, Manure Injection (Low Disturbance) & Conservation Tillage (Average)	82.3	76.8	STEPL BMP Calculator
Two Stage Ditch, Nutrient Management, Cover Crops, Conservation Tillage (Average) & Manure Injection (Low Disturbance)	90.3	76.8	STEPL BMP Calculator
ARTS, Cover Crops & Conservation Tillage (Average)	87.7	95.4	STEPL BMP Calculator
Buffer-Grass (35 ft- wide), Cover Crops & Conservation Tillage (Average)	82.7	89.2	STEPL BMP Calculator
Buffer-Grass (35 ft- wide),Cover Crops, Conservation Tillage (Average) & Nutrient Management	90.5	89.2	STEPL BMP Calculator
Buffer-Grass (35 ft- wide) & Nutrient Management	68.9	53.3	STEPL BMP Calculator
Wetland Detention, Buffer-Grass (35 ft-wide) & Nutrient Management	82.6	89.5	STEPL BMP Calculator

1. SnapPlus was used to estimate the average practice efficiency from implementing cover crops in the nearby East River Watershed based on soil test phosphorus data, soil types, and crop rotations in the watershed.
2. Peter Tomlinson et al. August 2015. Water Quality Best Management Practices, effectiveness, and Cost for Reducing Contaminant Losses from Cropland. Kansas State University Research and Extension.
3. Efficiency of conversion of cropland to grazing system. Boody, G. and Krinke, M. 2001. The Multiple Benefits of Agriculture: An Economic, Environmental & Social Analysis. Saint Paul, Minnesota: Land Stewardship Project.

4. Outagamie County Land Conservation Department. 2020. Non-Point Source Runoff Storage Capacity Opportunities for Sediment & Nutrient Reduction In the Lower Fox River Basin. Outagamie County Land Conservation Department. Appleton, WI.

**Average value used from Conservation Tillage (30-59% Residue) and Conservation Tillage (≥60% Residue).*

Practices applied to Cropland:

A weighted best management practice efficiency for phosphorus and sediment reductions was used for conservation practices applied to and/or treating cropland based on a proposed implementation scenario. These proposed implementation scenarios show that a combination of practices will need to be applied to the majority of the crop fields in the watersheds. Proposed implementation scenarios of practice combinations needed to meet TMDL reductions are shown in Table G-2, G-3 and G-4. (Note: These scenarios include existing practices on the landscape. To estimate the reductions, the difference between the current condition cropland practice scenarios and the proposed cropland condition scenario was calculated. See Appendix E for cropland load estimates for each scenario.)

Table G- 2. Middle Duck cropland best management practices implementation scenario reduction efficiencies.

Practice Combination	Acres applied to or treated by practice	% Implementation on cropland	% reduction (phosphorus)	Weighted % reduction phosphorus	% reduction (sediment)	Weighted % reduction sediment
NMP, Conservation Tillage (Average) & Cover Crops	500	7.7	83.1	6.5	76.8	6.0
Cover Crop & Low Disturbance Manure Injection & Conservation Tillage (Average) & NMP	2,500	38.6	86.5	33.9	76.8	30.1
Cover Crop & Drainage Water Management & Conservation Tillage (Average) & NMP	200	3.1	89.0	2.8	76.8	2.4
Two Stage Ditch & Conservation Tillage (Average) & Cover Crops & NMP	500	7.7	87.9	6.9	76.8	6.0
Prescribed Grazing	250	3.9	75.0	2.9	49.0	1.9
Buffer-Grass (35 ft) & Conservation Tillage (Average) & Cover Crops & NMP	400	6.2	90.5	5.7	89.2	5.6
Buffer- Grass (35 ft) & NMP	280	4.3	68.9	3.0	53.3	2.3
Buffer-Grass (35 ft) - Land Out of Production	72	1.1	80.8	0.9	95.0	1.1
Agriculture Runoff Treatment System (ARTS) & NMP	400	6.2	78.0	4.9	80.0	5.0

Practice Combination	Acres applied to or treated by practice	% Implementation on cropland	% reduction (phosphorus)	Weighted % reduction phosphorus	% reduction (sediment)	Weighted % reduction sediment
ARTS & Conservation Tillage (Average) & Cover Crops & NMP	1,000	15.4	93.3	14.6	95.4	14.9
ARTS - Land Out of Production	20	0.3	80.8	0.3	95.0	0.3
Wetland Restoration -Land Out of Production	10	0.2	80.8	0.1	95.0	0.1
Wetland Restoration & Cover Crop & Conservation Tillage (Average) & NMP	250	3.9	92.5	3.6	94.8	3.7
Total	**6,382**	**98.5**		**86.1**		**79.6**

Table G- 3. Lower Duck excluding Silver Creek cropland best management practices implementation scenario reduction efficiencies.

Practice Combination	Acres applied to or treated by practice	% Implementation on cropland	% reduction (phosphorus)	Weighted % reduction phosphorus	% reduction (sediment)	Weighted % reduction sediment
NMP, Conservation Tillage (Average) & Cover Crops	220	20.0	83.1	17.4	76.8	16.1
NMP, Conservation Tillage (Average), Cover Crops & Low Disturbance Manure Injection	400	36.3	86.5	33.0	76.8	29.3
Two Stage Ditch & Conservation Tillage (Average) & Cover Crops & Low Disturbance Manure Injection & NMP	100	9.1	90.3	8.6	76.8	7.3
Prescribed Grazing	50	4.5	75.0	3.6	49.0	2.3
Buffer-Grass (35 ft), Conservation Tillage (Average), Cover Crops & NMP	65	5.9	82.7	5.1	89.2	5.5
Buffer-Grass (35 ft)- Land Out of Production	5	0.4	80.8	0.3	95.0	0.4

Practice Combination	Acres applied to or treated by practice	% Implementation on cropland	% reduction (phosphorus)	Weighted % reduction phosphorus	% reduction (sediment)	Weighted % reduction sediment
Agriculture Runoff Treatment System (ARTS) & NMP	50	4.5	78.0	3.7	80.0	3.8
ARTS & Conservation Tillage (Average) & Cover Crops & NMP	50	4.5	93.3	4.4	95.4	4.5
ARTS - Land Out of Production	5	0.5	80.8	0.4	95.0	0.5
Wetland Restoration -Land Out of Production	5	0.5	80.8	0.4	95.0	0.5
Wetland Restoration & NMP	100	9.1	69.2	6.6	77.5	7.4
Total	**1,050**	**95.3**		**83.6**		**77.6**

Table G- 4. Lower Duck-Silver Creek cropland best management practices implementation scenario reduction efficiencies.

Practice Combination	Acres applied to or treated by practice	% Implementation on cropland	% reduction (phosphorus)	Weighted % reduction phosphorus	% reduction (sediment)	Weighted % reduction sediment
NMP & Conservation Tillage (Average) & Cover Crop	230	21.4	83.1	18.7	76.8	17.3
NMP, Buffer, Conservation Tillage (Average) & Cover Crop	92	8.6	90.5	8.2	89.2	8.0
Buffer Land Out of Production	5	0.5	80.8	0.4	95.0	0.5
Buffer & NMP	135	12.5	68.9	9.1	53.3	7.1
Buffer & Conservation Tillage (Average) & Cover Crop	32	3.0	82.7	2.6	89.2	2.8
Wetland, Buffer & NMP	126	11.7	82.6	10.2	89.5	11.1
NMP, Conservation Tillage (Average), Cover Crops & Low Disturbance Manure Injection	200	18.6	86.5	17.0	76.8	15.1

Practice Combination	Acres applied to or treated by practice	% Implementation on cropland	% reduction (phosphorus)	Weighted % reduction phosphorus	% reduction (sediment)	Weighted % reduction sediment
Two Stage Ditch & Conservation Tillage (Average) & Cover Crops & Low Disturbance Manure Injection & NMP	200	18.6	90.3	17.7	76.8	15.1
Total	**1,020**	**94.8**		**83.9**		**76.9**

Ephemeral Gully/Concentrated Flow Stabilization:

Load reductions from grassed/lined waterways, WASCOBS, critical area plantings, and regenerative agriculture practices (cover crops & no-till, well managed grazing) used to treat ephemeral gully erosion were estimated by assuming an average height and width for gullies identified by the stream power index, windshield survey, and air photo interpretation. Concentrated flow paths are not active "gullies" but for the sake of calculations, "Gully2" assumptions were used. A 53% (Middle) and 40% (Lower) sediment delivery ratio was applied to the load reduction with the assumption that not all sediment from eroding gullies will reach the Middle and Lower Duck Creek and make its way to the Fox River. These delivery ratios were derived by averaging ACPF Sediment Delivery Ratios for fields with gullies and concentrated flow erosion identified.

Table G- 5. STEPL inputs for gully dimensions and load reductions from grassed waterway, critical area plantings, WASCOB's, etc.

Watershed	Gully	Top Width (ft)	Bottom Width (ft)	Depth (ft)	Length (ft)	Years to Form	BMP Efficiency (0-1)	Soil Textural Class	Soil Dry Weight (ton/ft3)	Load Reduction TSS (ton)	Load Reduction TP (lbs)
Middle	Gully1	0.7	0.5	0.5	18,274	1	1	Silt Loam	0.0425	111	191
	Gully2	0.5	0.2	0.2	24,420	1	1	Silt Loam	0.0425	34.7	59.6
Lower	Gully1	0.7	0.5	0.5	5,558	1	1	Silt Loam	0.0425	29.8	51.2
	Gully2	0.5	0.2	0.2	5,686	1	1	Silt Loam	0.0425	7.1	12.2

Streambank Stabilization

An average sediment load per foot of eroding streambank was calculated from the inventoried Moderate to Very Severely eroding streambank sites. This number was then multiplied by the proposed length of streambank to be stabilized to get a sediment load reduction. The assumed phosphorus concentration for eroding streambank sediment was 610 ppm.

Table G- 6. Streambank stabilization estimated reductions.

Watershed	Proposed Stabilization Length (ln ft)	Average Sediment Load (tons) per ln ft	TP (lbs/yr)	TSS (tons/yr)
Middle	21,000	0.024	615	504
Lower	31,000	0.023	870	713

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Appendix H. Social Factors and Conservation Behavior: A Survey of Agricultural Landowners in the Lower Fox River Basin in 2014 (Alliance for the Great Lakes).

Thank you to everyone who participated. To learn more about the above opportunities, survey results, or how to become more involved please contact County Conservation departments.

Brown County Land and Water Conservation Department: (920) 391-4620
Calumet County Land and Water Conservation Department: (920) 849-1442
Outagamie County Land Conservation Department: (920) 832-5073
Winnebago County Land and Water Conservation Department: (920) 232-1950

The survey was funded by the Wisconsin Coastal Management Program and the National Oceanic and Atmospheric Administration, Office of Ocean and Coastal Resource Management under the Coastal Zone Management Act.

ALLIANCE FOR THE GREAT LAKES
ENSURING A LIVING RESOURCE FOR ALL GENERATIONS

Social Factors and Conservation Behavior:

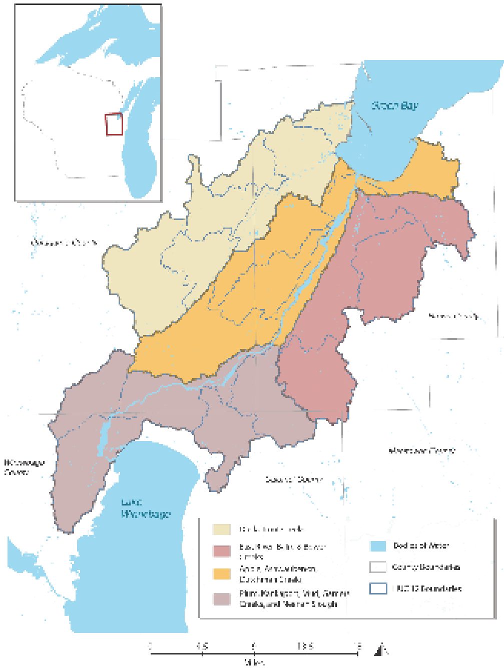
A Survey of Agricultural Landowners in the Lower Fox River Basin in 2014

All photos by Lloyd Degrane in the Lower Fox River Basin

In spring 2014, Brown and Outagamie County Conservation departments, Tilth Agronomy and the Alliance for the Great Lakes partnered to survey farmers in the Lower Fox River Basin to better understand the farming community regarding conservation, nutrient management, and water quality. This was done using both paper surveys and "kitchen side table" interviews.

The following is a summary of those results. While this is not comprehensive of all feedback, included are percentage responses, surveyed farmers' direct quotes, as well as thoughts and suggestions categorized by popular themes. While these responses do not represent every farmer in the Lower Fox River Basin, they do provide valuable insights moving forward. With this summary, we draw attention to the importance of providing all stakeholders in the basin a chance to express their views on improving water, agriculture, and natural resources.

There are 332 total farm operations in the watershed. 108 interviews were conducted and 69 questionnaires were received as part of the survey study.



Nutrient Management

Manure Storage
64% of farmers said they have enough room for manure storage. For the 14% who said 'no', several are interested in expanding storage or building new storage facilities

Time in Farming
50% of surveyed farmers said 'yes/maybe' to bringing manure to a central facility.

Farmers' Thoughts
Some surveyed farmers are reluctant to expand manure storage since they are either nearing retirement or are wary of new investments due to urban development. "We do it [nutrient management] to get the most cost effective yield of crops." "[It's] useful but I would like to develop a better filing system."

Moving Forward

Get Involved
Farmers want to have their voices heard and are a strong part of the fabric of the Lower Fox River community. As efforts to meet water quality standards increase, farmers will have increased opportunities for participation. Much like this survey, this work is a watershed based effort and will include nutrient reductions from urban, suburban and rural sources. Farmers will have more opportunities to share their perspective while learning with others. We recommend farmers take part in these discussions so they become an important part of the decision-making process that affect the long-term sustainability of farming and water quality in this region.

Participate/Implement Change
Subwatershed Plan Implementation in Plum Creek, Kankapot Creek, Upper Duck Creek, and Upper East River are opportunities for farmers to participate in conservation implementation and learn how effective conservation practices improve soil health and water quality by reducing soil and phosphorus run off. For those farmers in the Silver Creek area, you can take part in the Adaptive Management Option project being led by NEW Water (Green Bay Metropolitan Sewage District.) Stay tuned for farmer focus groups facilitated in the coming year. This will be a way for farmers to discuss improving soil health and water quality while sharing information about new farm technologies and learning with others.

Learn More
Demonstration Farm Days provides farmers with information regarding new conservation technologies such as cover crops to improve soil health, increase yields, and improve the water quality in watershed. Contact your county conservationist to find out when the next Demo Farm Day is scheduled.

Improve Soil Health
The survey suggested a strong sense of soil protection among farmers. By prioritizing measures that improve soil health, farmers have an opportunity to improve water quality by starting with actions that begin on their farm. Conservation science has firmly rooted improved soil health to increased yields, while remaining more resilient to negative impacts from weather, and improving downstream water quality impacts by reducing runoff.

Information & Communication

Preferred Methods to Getting Farmer Input on Conservation
(1) One-on-one engagements, (2) Small group meetings/small roundtable discussions, and (3) Field Days and farm shows.

Preferred Ways to Receive Water Quality Information
(1) Newsletters, (2) Magazines, (3) One-on-one hands-on demonstration, and (4) On-farm demonstration field days.

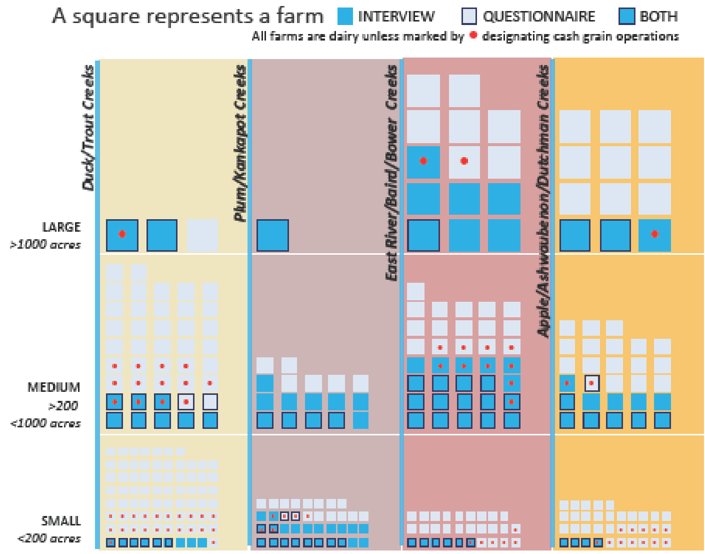
Preferred Organizations for Farm Improvement Tactics/Advice
(1) Local farm cooperatives/crop consultants, (2) Natural Resources Conservation Service, (3) County Conservation departments, (4) Other farmers.

Preferred Organizations for Water Quality Information
(1) Local farm cooperatives/crop consultants, (2) County Land and Water Conservation departments, (3) Natural Resources Conservation Service, (4) Farm Service Agency, (5) University of Wisconsin-Extension, and (6) Farmer-led watershed organization.

Demonstration Farms for Conservation Education
On demonstration farms, farmers would like to see: (1) Cover crops, (2) Tile-related technology such as filters, (3) Buffer strips, (4) Tillage-related practices (residue management), (5) Manure digesters, (6) Planting machinery, and (7) New conservation technologies and practices demonstrated. Also, majority of surveyed farmers are moderately or very interested in the demonstration farms and want to see "results from experimental plots if they are good and bad." "Seeing [practices] or thorough explanation of how practices are established and then how it works through seasons of the year."

Monitoring of Conservaion Practices
61% of surveyed farmers want to see more monitoring to ensure practices are effective, and 45% are willing to do monitoring on their land. For those who said 'no' to monitoring on their land, there is concern about too much government involvement and trust that the practices work as advertised. When it comes to actually conducting monitoring on their land, surveyed farmers alluded to practical concerns such as size of the farm or being too close to retirement to start something new.

Farmers' Thoughts
Farmers have questions regarding Total Maximum Daily Load timeline in the Lower Fox River. They are interested in the costs and effectiveness of conservation practices including performance in the short-term and long-term, and how monitoring is conducted. Several prefer a newsletter that focuses on the demonstration farms. There should be better access to information. "Show economically feasible ways to make conservation work." "Actual layout - cropping around practices, full explanation of what is done and how it will work."



Importance of Land & Water Resources

Prioritization of Lands
93% of surveyed farmers said 'yes/maybe' to prioritizing conservation efforts for highly erodible soils, and 76% said 'yes/maybe' to prioritizing land with high soil phosphorous.

What Conservation Means to Surveyed Farmers
Conservation is associated with the long-term health and stewardship of soil and land related issues. A majority indicates their drive for conservation to be either protecting/preserving natural resources or as an inherent quality of being a farmer.

Importance of Improving Water Quality
Over 90% of surveyed farmers feel that it is moderately to very important to be successful at improving water quality, whereas 80% feel that it is moderately to very important to meet water quality standards for their community.

Farmers' Suggestions
(1) There should be no winter spreading, (2) There should be monitoring of tile drainage, (3) Manure management should be prioritized over investing in farm equipment, and (4) Cover Crops should be used for erosion control.

Farmers' Thoughts
Generally surveyed farmers feel a common connection to water and are invested in protecting land and water resources. They are concerned about erosion and its causes. "We are stewards of the land and we take care of it for the next generation."

Implementing Conservation Practices

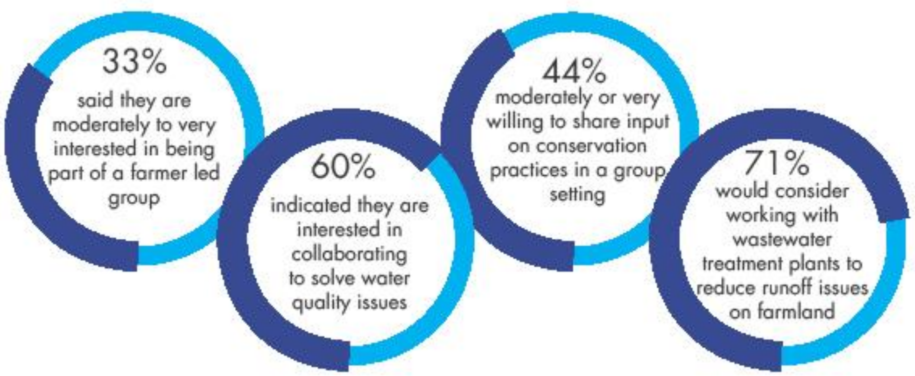
Considering Conservation Even if it Costs Extra Time and Money
84% of surveyed farmers said 'yes/maybe' to paying for conservation and shared themes related to: (1) Personal motivation, (2) Applicability of particular (conservation) practices to their farm, and (3) Being practical. Other motivators were: caring for farmland and soil, clean water, and a general conservation attitude.

Receiving Financial Compensation for Conservation Practices Already Installed
77% of surveyed farmers said 'yes/maybe', and 23% said 'no'. Some main reasons for 'yes' were: (1) Incentive is a good motivation for those already doing conservation, (2) Need help for the expenses associated with conservation practices, and (3) Compensation provided for acreage lost. The main themes for 'maybe' or 'no' are: (1) Hard to formulate this type of payment, (2) Conservation is owner's responsibility, (3) It leads to self-sufficiency/no special benefits, and (4) Conservation is beneficial on its own.

Farmers' Suggestions
Others might consider doing conservation if it is: (1) Cost effective/profitable/feasible, (2) If they know more about the conservation practices/programs/access to technical information, and (3) If the practical issues are dealt with. "If they [farmers] do it and you want them to keep doing it on their own, a little incentive goes a long way. Easiest way to get things done is to give a little incentive."

Sense of Community

Of the farmers surveyed:



Farmers' Thoughts
(1) It's important to continue engaging farmers/taking their input, and (2) dairy and crop farmers need to work together. "We all have to be on the same page and working on it together." "We are all after the same thing - to take care of the land and water."

Farmers' Suggestions Regarding Partnerships:
More information is needed regarding: (1) The nature of the group effort, (2) Its advantages, (3) The type of participation it would entail, (4) Who leads the efforts, and (5) The issues being dealt with.

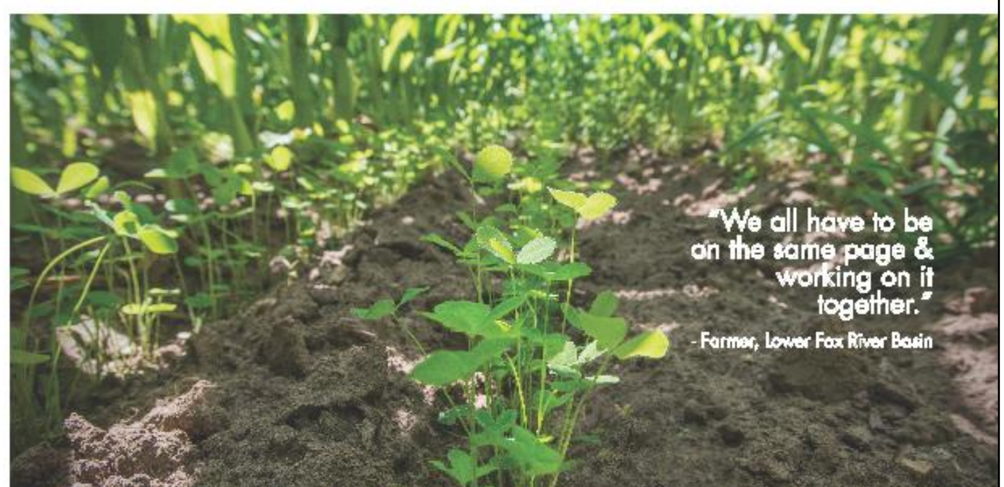
Future of Farming

Future of Farming in the Lower Fox River
The most frequent responses related to the outlook on the future of farming were related to the idea that future of agriculture is promising (41 mentions) and large farms are here to stay (37 mentions).

Time in Farming
50% of surveyed farmers have farmed for less than 35 years, and 50% of them have farmed for over 35 years, meaning that even though half are expected to retire in the coming years, the other half plan to continue farming into the future.

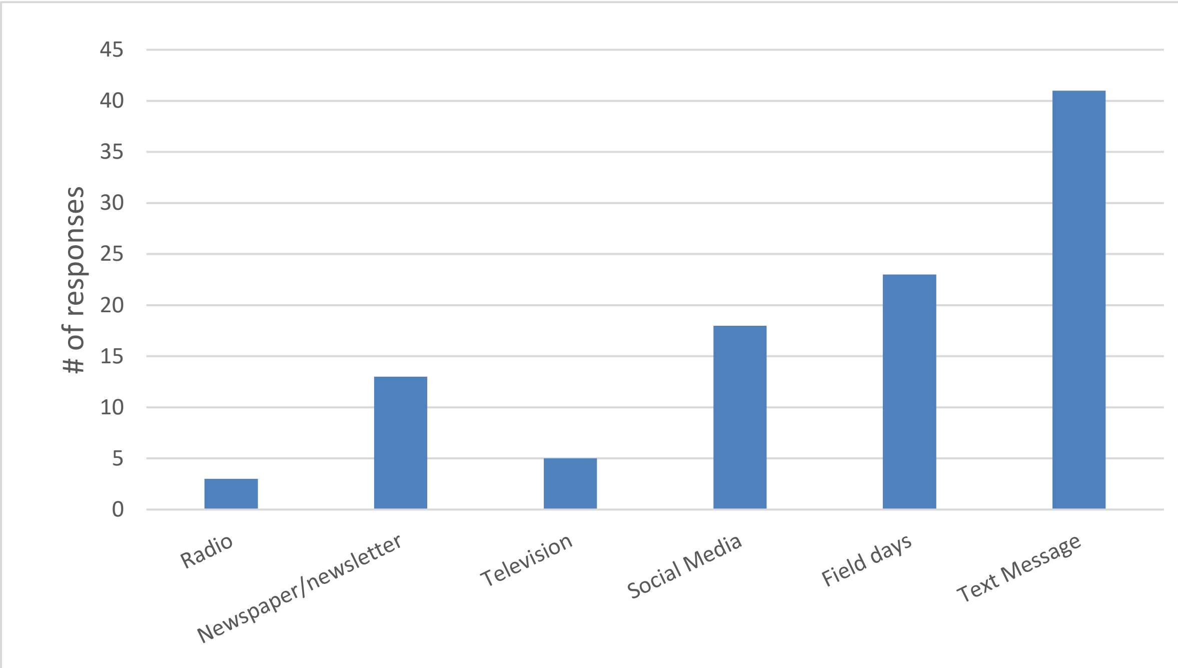
Farmers' Thoughts
There are increased constraints on farming due to urban concerns. 64% of surveyed farmers believe conservation will improve public perception of farmers by: (1) Increasing understanding of farming, (2) Leading to cleaner water, (3) It is a positive activity that leads to positive publicity, and (4) Conservation builds a sense of community. "If city residents think farmers are trying to reduce pollution, they will respect farmers more."

Farmers' Suggestions to Improve Perceptions
Some surveyed farmers feel what they do is not clearly visible to the community, so "need more education to public, and get success stories out, not just negative ones." "Unless you put up a billboard they don't realize what we are doing or accomplishing."

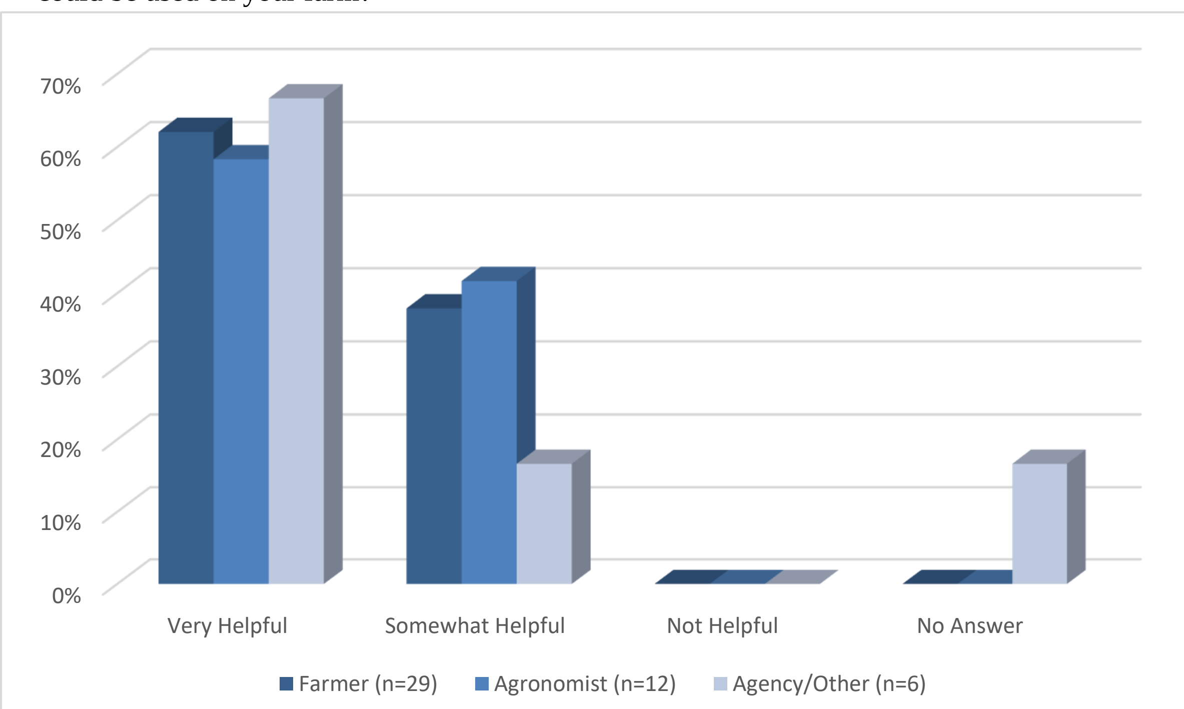


Appendix I. Selected Fox Watershed Farmer Roundtable questionnaire/poll results (2/2/2017).

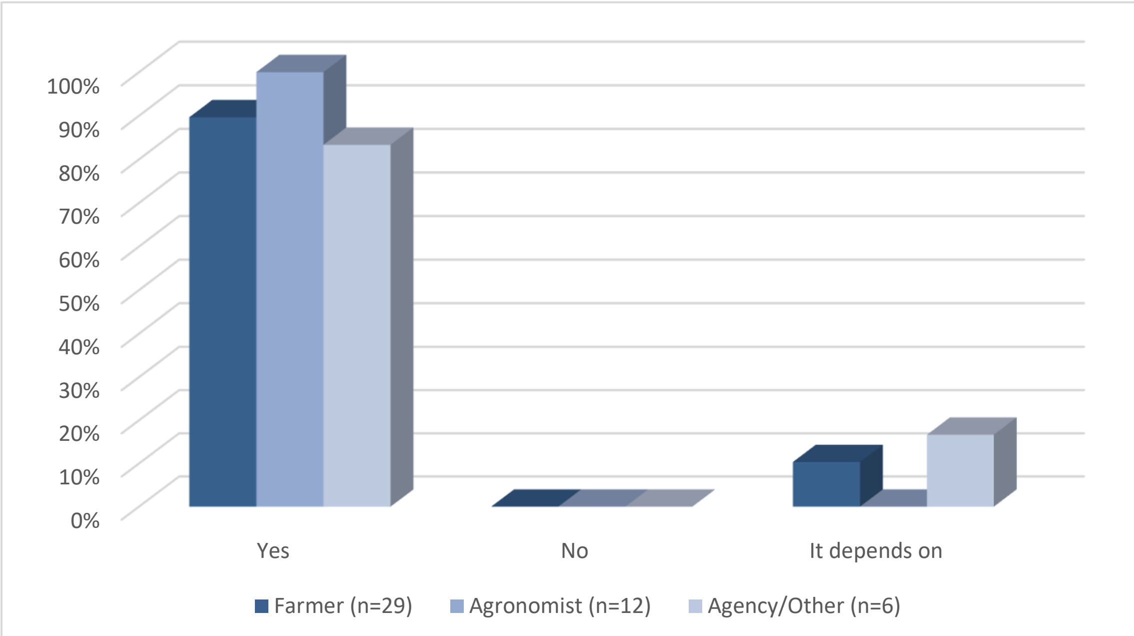
- For sharing information about the Demo Farms Network, which of the following outlets would work best to reach you?



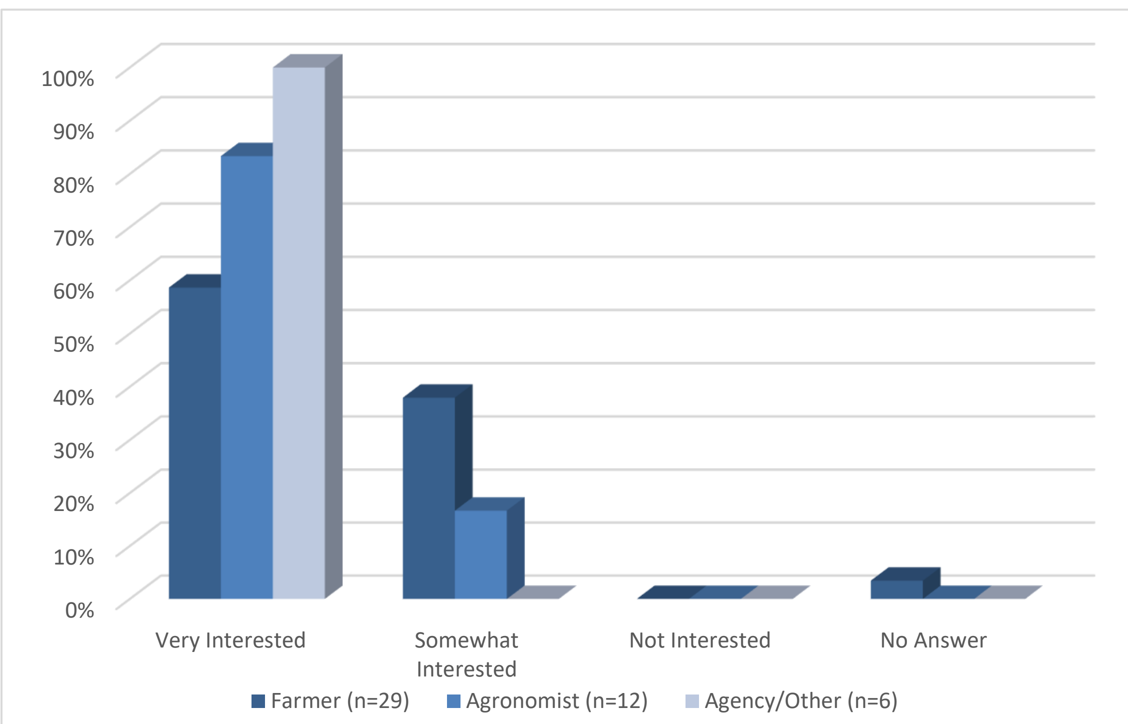
- How helpful was today's event for improving your understanding of conservation practices that could be used on your farm?



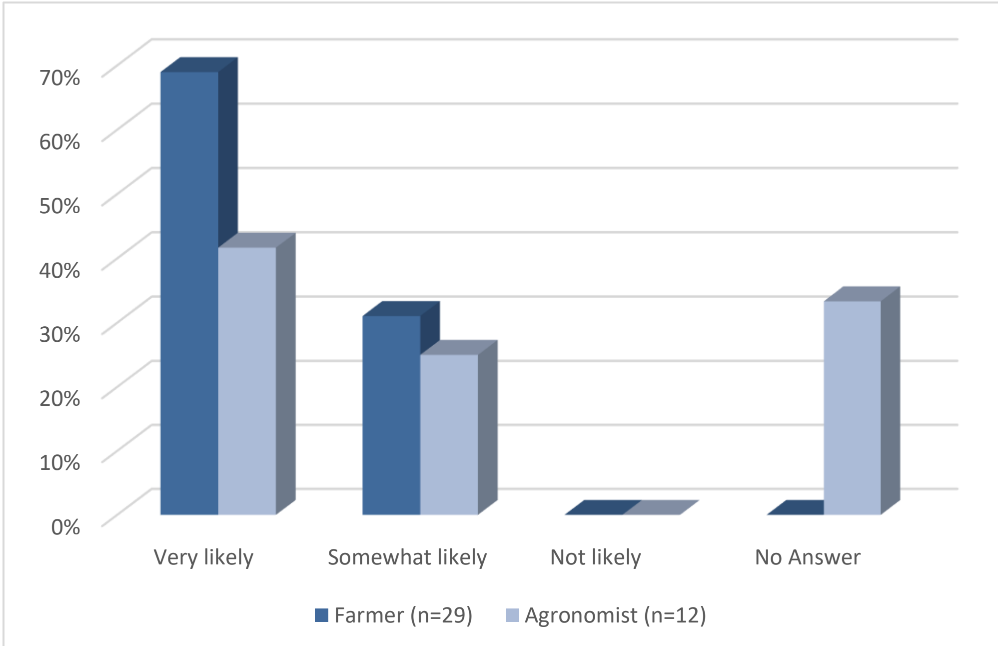
- Would you like to come to more events like this?



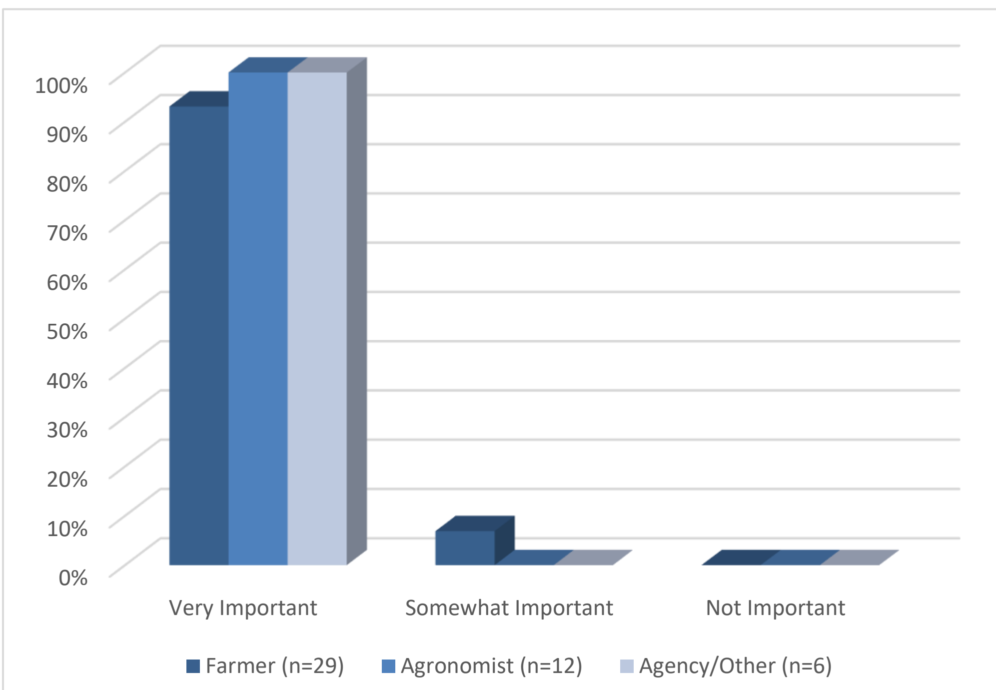
- How interested are you in farmer led groups focused on improving water quality in Lower Fox River as a result of today's meeting?



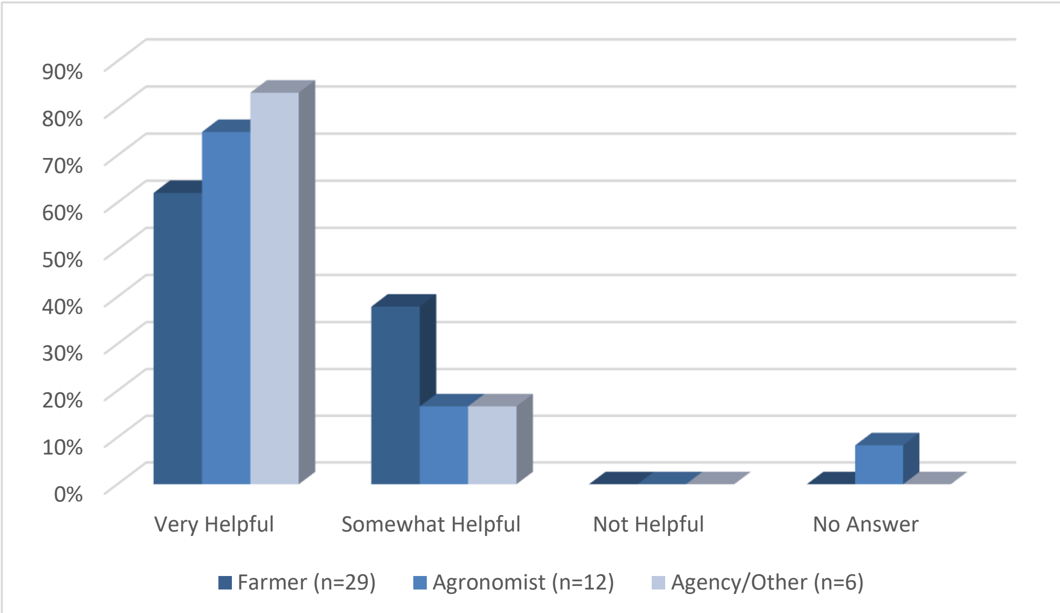
- How likely are you to start or expand conservation practices on your farm this growing season?



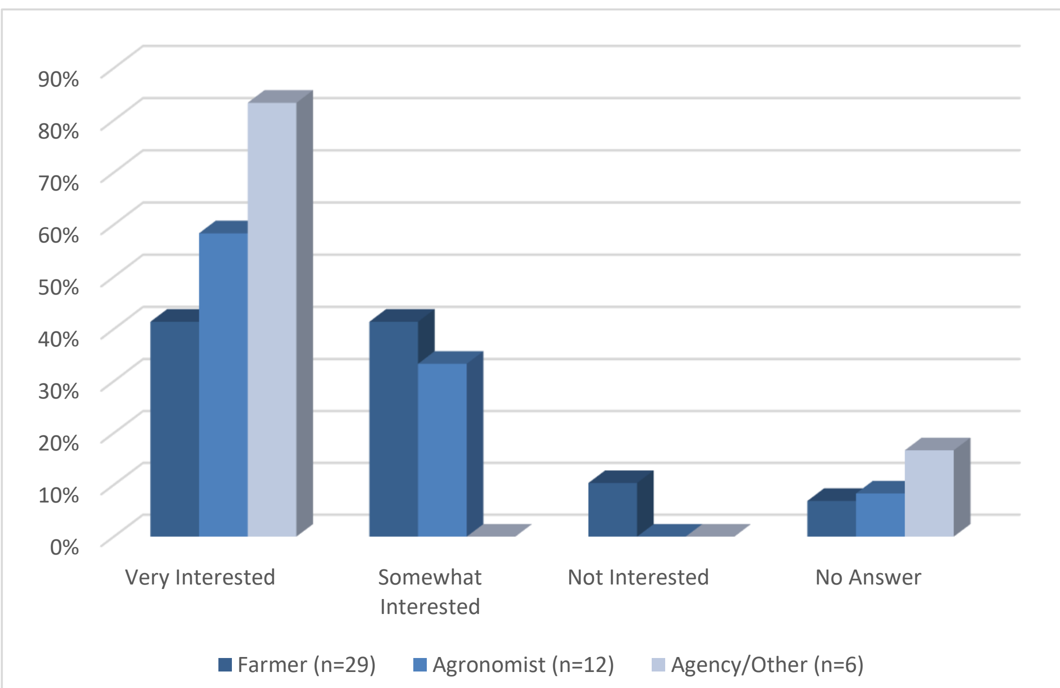
- How important is farmer conservation in improving water quality in the Lower Fox River and Bay of Green Bay?



- How helpful was today's event for improving your interest in learning more about issues affecting water quality in the Lower Fox River?



- How interested are you in taking part in smaller farmer focus groups in your subwatershed discussing conservation projects with traditional and nontraditional partners (i.e. wastewater treatment plants)?



Appendix J. EPA Technical Memorandum Adjusting for Depreciation of Land Treatment When Planning Watershed Projects.

EPA United States Environmental Protection Agency

This Technical Memorandum is one of a series of publications designed to assist watershed projects, particularly those addressing nonpoint sources of pollution. Many of the lessons learned from the Clean Water Act Section 319 National Nonpoint Source Monitoring Program are incorporated in these publications.

October 2015

Donald W. Meals and Steven A. Dressing. 2015. Technical Memorandum #1: Adjusting for Depreciation of Land Treatment When Planning Watershed Projects, October 2015. Developed for U.S. Environmental Protection Agency by Tetra Tech, Inc., Fairfax, VA, 16 p. Available online at https://www.epa.gov/polluted-runoff-nonpoint-source-pollution/watershed-approach-technical-resources.

Technical Memorandum #1

Adjusting for Depreciation of Land Treatment When Planning Watershed Projects

Introduction

Watershed-based planning helps address water quality problems in a holistic manner by fully assessing the potential contributing causes and sources of pollution, then prioritizing restoration and protection strategies to address the problems (USEPA 2013). The U.S. Environmental Protection Agency (EPA) requires that watershed projects funded directly under section 319 of the Clean Water Act implement a watershed-based plan (WBP) addressing the nine key elements identified in EPA's *Handbook for Developing Watershed Plans to Restore and Protect our Waters (USEPA 2008)*. EPA further recommends that all other watershed plans intended to address water quality impairments also include the nine elements. The first element calls for the identification of causes and sources of impairment that must be controlled to achieve needed load reductions. Related elements include a description of the nonpoint source (NPS) management measures—or best management practices (BMPs)—needed to achieve required pollutant load reductions, a description of the critical areas in which the BMPs should be implemented, and an estimate of the load reductions expected from the BMPs.

Fields near Seneca Lake, New York.

Once the causes and sources of water resource impairment are assessed, identifying the appropriate BMPs to address the identified problems, the best locations for additional BMPs, and the pollutant load reductions likely to be achieved with the BMPs depends on accurate information on the performance levels of both BMPs already in place and BMPs to be implemented as part of the watershed project. All too often, watershed managers and Agency staff have assumed that, once certified as installed or adopted according to specifications, a BMP continues to perform its pollutant reduction function at the same efficiency (percent pollutant reduction) throughout its design or contract life, sometimes longer. An important corollary to this assumption is that BMPs in place during project planning are performing as originally intended. Experience in NPS watershed projects across the nation, however, shows that, without diligent operation and maintenance, BMPs and their effects probably will depreciate over time, resulting in less efficient pollution reduction. Recognition of this fact is important at the project planning phase, for both existing and planned BMPs.

Knowledge of land treatment depreciation is important to ensure project success through the adaptive management process (USEPA 2008). BMPs credited during the planning phase of a watershed project will be expected to achieve specific load reductions or other water quality benefits as part of the overall plan to protect or restore a water body. Verification that BMPs are still performing their functions at anticipated levels is essential to keeping a project on track to achieve its overall goals. Through adaptive management, verification results can be used to inform decisions about needs for additional BMPs or maintenance or repair of existing BMPs. In a watershed project that includes short-term (3–5 years) monitoring, subtle changes in BMP performance level might not be detectable or critical, but planners must account for catastrophic failures, BMP removal or discontinuation, and major maintenance shortcomings. Over the longer term, however, gradual changes in BMP performance level can be significant in terms of BMP-specific pollutant control or the role of single BMPs within a BMP system or train. The weakest link in a BMP train can be the driving force in overall BMP performance.

Application of and methods for BMP tracking in NPS watershed projects are described in detail in *Tech Notes 11* (Meals et al. 2014).

This technical memorandum addresses the major causes of land treatment depreciation, ways to assess the extent of depreciation, and options for adjusting for depreciation. While depreciation occurs throughout the life of a watershed project, the emphasis is on the planning phase and the short term (i.e., 3–5 years).

Causes of Depreciation

Depreciation of land treatment function occurs as a result of many factors and processes. Three of the primary causes are natural variability, lack of proper maintenance, and unforeseen consequences.

Natural Variability

Climate and soil variations across the nation influence how BMPs perform. Tiessen et al. (2010), for example, reported that management practices designed to improve water quality by reducing sediment and sediment-bound nutrient export from agricultural fields can be less effective in cold, dry regions where nutrient export is primarily snowmelt driven and in the dissolved form, compared to similar practices in warm, humid regions. Performance levels of vegetation-based BMPs in both agricultural and urban settings can vary significantly through the year due to seasonal dormancy. In a single locale, year-to-year variation in precipitation affects both agricultural management and BMP performance levels. Drought, for example, can suppress crop yields, reduce nutrient uptake, and result in nutrient surpluses left in the soil after harvest where they are vulnerable to runoff or leaching loss despite careful nutrient management. Increasing incidence of extreme weather and intense storms can overwhelm otherwise well-designed stormwater management facilities in urban areas.

Lack of Proper Maintenance

Most BMPs—both structural and management—must be operated and maintained properly to continue to function as designed. Otherwise, treatment effectiveness can depreciate over time. For example, in a properly functioning detention pond, sediment typically accumulates in the forebay. Without proper maintenance to remove accumulated sediment, the capacity of the BMP to contain and treat stormwater is diminished. Similarly, a nutrient management plan is only as effective as its implementation. Failure to adhere to phosphorus (P) application limits, for example, can result in soil P buildup and increased surface and subsurface losses of P rather than the loss reductions anticipated.

Jackson-Smith et al. (2010) reported that over 20 percent of implemented BMPs in a Utah watershed project appeared to be no longer maintained or in use when evaluated just 5 years after project completion. BMPs related to crop production enterprises and irrigation systems had the lowest rate of continued use and maintenance (~75 percent of implemented BMPs were still in use), followed by pasture and grazing planting and management BMPs (81 percent of implemented BMPs were still in use). Management practices (e.g., nutrient management) were found to be particularly susceptible to failure.

Practices are sometimes simply abandoned as a result of changes in landowner circumstances or attitudes. In a Kansas watershed project, farmers abandoned a nutrient management program because of perceived restrictive reporting requirements (Osmond et al. 2012).

Abandoned waste storage structure.

In the urban arena, a study of more than 250 stormwater facilities in Maryland found that nearly one-third of stormwater BMPs were not functioning as designed and that most needed maintenance (Lindsey et al. 1992). Sedimentation was a major problem and had occurred at nearly half of the facilities; those problems could have been prevented with timely maintenance.

Hunt and Lord (2006) describe basic maintenance requirements for bioretention practices and the consequences of failing to perform those tasks. For example, they indicate that mulch should be removed every 1–2 years to both maintain available water storage volume and increase the surface infiltration rate of fill soil. In addition, biological films might need to be removed every 2–3 years because they can cause the bioretention cell to clog.

In plot studies, Dillaha et al. (1986) observed that vegetative filter strip-effectiveness for sediment removal appeared to decrease with time as sediment accumulated within the filter strips. One set of the filters was almost totally inundated with sediment during the cropland experiments and filter effectiveness dropped 30–60 percent between the first and second experiments. Dosskey et al. (2002) reported that up to 99 percent of sediment was removed from cropland runoff when uniformly distributed over a buffer area, but as concentrated flow paths developed over time (due to lack of maintenance), sediment removal dropped to 15–45 percent. In the end, most structural BMPs have a design life (i.e., the length of time the item is expected to work within its specified parameters). This period is measured from when the BMP is placed into service until the end of its full pollutant reduction function.

Unforeseen Consequences

The effects of a BMP can change directly or indirectly due to unexpected interactions with site conditions or other activities. Incorporating manure into cropland soils to reduce nutrient runoff, for example, can increase erosion and soil loss due to soil disturbance, especially in comparison

to reduced tillage. On the other hand, conservation tillage can result in accumulation of fertilizer nutrients at the soil surface, increasing their availability for loss in runoff (Rhoton et al. 1993). Long-term reduction in tillage also can promote the formation of soil macropores, enhancing leaching of soluble nutrients and agrichemicals into ground water (Shipitalo et al. 2000). Stutter et al. (2009) reported that establishment of vegetated buffers between cropland and a watercourse led to enhanced rates of soil P cycling within the buffer, increasing soil P solubility and the potential for leaching to watercourses.

Despite widespread adoption of conservation tillage and observed reductions in particulate P loads, a marked increase in loads of dissolved bioavailable P in agricultural tributaries to Lake Erie has been documented since the mid-1990s. This shift has been attributed to changes in application rates, methods, and timing of P fertilizers on cropland in conservation tillage not subject to annual tillage (Baker 2010; Joosse and Baker 2011). Further complicating matters, recent research on fields in the St. Joseph River watershed in northeast Indiana has demonstrated that about half of both soluble P and total P losses from research fields occurred via tile discharge, indicating a need to address both surface and subsurface loads to reach the goal of 41 percent reduction in P loading for the Lake Erie Basin (Smith et al. 2015).

Several important project planning lessons were learned from the White Clay Lake, Wisconsin, demonstration projects in the 1970s, including the need to accurately assess pollutant inputs and the performance levels of BMPs (NRC 1999). Regarding unforeseen consequences, the project learned through monitoring that a manure storage pit built according to prevailing specifications actually caused ground water contamination that threatened a farmer's well water. This illustrates the importance of monitoring implemented practices over time to ensure that they function properly and provide the intended benefits.

Control of urban stormwater runoff (e.g., through detention) has been widely implemented to reduce peak flows from large storms in order to prevent stream channel erosion. Research has shown, however, that although large peak flows might be controlled effectively by detention storage, stormflow conditions are extended over a longer period of time. Duration of erosive and bankfull flows are increased, constituting channel-forming events. Urbonas and Wulliman (2007) reported that, when captured runoff from a number of individual detention basins in a stream system is released over time, the flows accumulate as they travel downstream, actually increasing peak flows along the receiving waters. This situation can diminish the collective effectiveness of detention basins as a watershed management strategy.

Assessment of Depreciation

The first—and possibly most important—step in adjusting for depreciation of implemented BMPs is to determine its extent and magnitude through BMP verification.

BMP Verification

At its core, BMP verification confirms that a BMP is in place and functioning properly as expected based on contract, permit, or other implementation evidence. A BMP verification process that documents the presence and function of BMPs over time should be included in all NPS watershed projects.

At the project planning phase, verification is important both to ensure accurate assessment of existing BMP performance levels and to determine additional BMP and maintenance needs. Verification over time is necessary to determine if BMPs are maintained and operated during the period of interest.

Documenting the presence of a BMP is generally simpler than determining how well it functions, but both elements of verification must be considered to determine if land treatment goals are being met and whether BMP performance is depreciating. Although land treatment goals might not be highly specific in many watershed projects, it is important to document what treatment is implemented. Verification is described in detail in *Tech Notes 11* (Meals et al. 2014). This technical memorandum focuses on specific approaches to assessing depreciation within the context of an overall verification process.

Methods for Assessing BMP Presence and Performance Level

Whether a complete enumeration or a statistical sampling approach is used, methods for tracking BMPs generally include direct measurements (e.g., soil tests, onsite inspections, remote sensing) and indirect methods (e.g., landowner self-reporting or third-party surveys). Several of these methods are discussed in *Tech Notes 11* (Meals et al. 2014). Two general factors must be considered when verifying a BMP: the presence of the BMP and its pollutant removal efficiency. Different types of BMPs require different verification methods, and no single approach is likely to provide all the information needed in planning a watershed project.

Certification

The first step in the process is to determine whether BMPs have been designed and installed/adopted according to appropriate standards and specifications. Certification can either be the final step in a contract between a landowner and a funding agency or be a component of a permit requirement.

Certification provides assurance that a BMP is fully functional for its setting at a particular time. For example, a stormwater detention pond or water and sediment control basin must be properly sized for its contributing area and designed for a specific retention-and-release performance level. A nutrient management plan must account for all sources of nutrients, consider current soil nutrient levels, and support a reasonable yield goal. A cover crop must be planted in a particular time window to provide erosion control and/or nutrient uptake during a critical time of year. Some jurisdictions might apply different nutrient reduction efficiency credits for cover crops based on planting date. Some structural BMPs like parallel tile outlet terraces require up to 2 years to fully settle and achieve full efficiency; in those cases, certification is delayed until full stability is reached. Knowledge that a BMP has been applied according to a specific standard supports an assumption that the BMP will perform at a certain level of pollutant reduction efficiency, providing a baseline against which future depreciation can be compared. Practices voluntarily implemented by landowners without any technical or financial assistance could require special efforts to determine compliance with applicable specifications (or functional equivalence). Pollution reduction by practices not meeting specifications might need to be discounted or not counted at all even when first installed.

Depreciation assessment indicators

Ideally, assessment of BMP depreciation would be based on actual measurement of each BMP's performance level (e.g., monitoring of input and output pollutant loads for each practice). Except in very rare circumstances, this type of monitoring is impractical. Rather, a watershed project generally must depend on the use of indicators to assess BMP performance level.

The most useful indicators for assessing depreciation are determined primarily by the type of BMP and pollutants controlled, but indicators might be limited by the general verification approach used. For example, inflow and outflow measurements of pollutant load can be used to determine the effectiveness of constructed wetlands, but a verification effort that uses only visual observations will not provide that data or other information about wetland functionality. A central challenge, therefore, is to identify meaningful indicators of BMP performance level that can be tracked under different verification schemes. This technical memorandum provides examples of how to accomplish that end.

Nonvegetative structural practices

Performance levels of nonvegetative structural practices—such as animal waste lagoons, digesters, terraces, irrigation tailwater management, stormwater detention ponds, and pervious pavement—can be assessed using the following types of indicators:

- Measured on-site performance data (e.g., infiltration capacity of pervious pavement),
- Structural integrity (e.g., condition of berms or other containment structures), and
- Water volume capacity (e.g., existing pond volume vs. design) and mass or volume of captured material removed (e.g., sediment removed from stormwater pond forebay at cleanout).

In some cases, useful indicators can be identified directly from practice standards. For example, the Natural Resources Conservation Service lists operation and maintenance elements for a water and sediment control basin (WASCoB) (*USDA-NRCS 2008*) that include:

- Maintenance of basin ridge height and outlet elevations,
- Removal of sediment that has accumulated in the basin to maintain capacity and grade,
- Removal of sediment around inlets to ensure that the inlet remains the lowest spot in the basin, and
- Regular mowing and control of trees and brush.

These elements suggest that ridge and outlet elevations, sediment accumulation, inlet integrity, and vegetation control would be important indicators of WASCoB performance level.

Required maintenance checklists contained in stormwater permits also can suggest useful indicators. For example, the *Virginia Stormwater Management Handbook* (VA DCR 1999) provides an extensive checklist for annual operation and maintenance inspection of wet ponds. The list includes many elements that could serve as BMP performance level indicators:

- Excessive sediment, debris, or trash accumulated at inlet,
- Clogging of outlet structures,

- Cracking, erosion, or animal burrows in berms, and
- More than 1 foot of sediment accumulated in permanent pool.

Assessment of these and other indicators would require on-site inspection and/or measurement by landowners, permit-holders, or oversight agencies.

Vegetative structural practices

Performance levels of vegetative structural practices—such as constructed wetlands, swales, rain gardens, riparian buffers, and filter strips—can be assessed using the following types of indicators:

- Extent and health of vegetation (e.g., measurements of soil cover or plant density),
- Quality of overland flow filtering (e.g., evidence of short-circuiting by concentrated flow or gullies through buffers or filter strips),
- On-site capacity testing of rain gardens using infiltrometers or similar devices, and
- Visual observations (e.g., presence of water in swales and rain gardens).

Parking lot rain garden.

As for non-vegetative structural practices, assessment of these indicators would require on-site inspection and/or measurement by landowners, permit-holders, or oversight agencies.

Nonstructural vegetative practices

Performance levels of nonstructural vegetative practices—such as cover crops, reforestation of logged tracts, and construction site seeding—can be assessed using the following types of indicators:

- Density of cover crop planting (e.g., plant count),
- Percent of area covered by cover crop, and
- Extent and vitality of tree seedlings.

These indicators could be assessed by on-site inspection or, in some cases, by remote sensing, either from satellite imagery or aerial photography.

Management practices

Performance levels of management practices—such as nutrient management, conservation tillage, pesticide management, and street sweeping—can be assessed using the following types of indicators:

- Records of street sweeping frequency and mass of material collected,
- Area or percent of cropland under conservation tillage,

- Extent of crop residue coverage on conservation tillage cropland, and
- Fertilizer and/or manure application rates and schedules, crop yields, soil test data, plant tissue test results, and fall residual nitrate tests.

Illustration of line-transect method for residue.

Assessment of these indicators would generally require reporting by private landowners or municipalities, reporting that is required under some regulatory programs. Visual observation of indicators such as residue cover, however, can also be made by on-site inspection or windshield survey.

Data analysis

Data on indicators can be expressed and analyzed in several ways, depending on the nature of the indicators used. Indicators reporting continuous numerical data—such as acres of cover crop or conservation tillage, manure application rates, miles of street sweeping, mass of material removed from catch basins or detention ponds, or acres of logging roads/landings revegetated—can be expressed either in the raw form (e.g., acres with 30 percent or more residue cover) or as a percentage of the design or target quantity (e.g., percent of contracted acres achieving 30 percent or more of residue cover). These metrics can be tracked year to year as a measure of BMP depreciation (or achievement). During the planning phase of a watershed project, it might be appropriate to collect indicator data for multiple years prior to project startup to enable calculation of averages or ranges to better estimate BMP performance levels over crop rotation cycles or variable weather conditions.

Indicators reporting categorical data—such as maintenance of detention basin ridge height and outlet elevations, condition of berms or terraces, or observations of water accumulation and flow—are more difficult to express quantitatively. It might be necessary to establish an ordinal scale (e.g., condition rated on a scale of 1–10) or a binary yes/no condition, then use best professional judgment to assess influence on BMP performance.

In some cases, it might be possible to use modeling or other quantitative analysis to estimate individual or watershed-level BMP performance levels based on verification data. In an analysis of stormwater BMP performance levels, Tetra Tech (2010) presented a series of BMP performance curves based on monitoring and modeling data that relate pollutant removal efficiency to depth of runoff treated (Figure 1). Where depreciation indicators track changes in depth of runoff treated as the capacity of a BMP decreases (e.g., from sedimentation), resulting changes in pollutant removal could be determined from a performance curve. This type of information can be particularly useful during the planning phase of a watershed project to estimate realistic performance levels for existing BMPs that have been in place for a substantial portion of their expected lifespans.

The performance levels of structural agricultural BMPs in varying condition can be estimated by altering input parameters in the *Soil and Water Assessment Tool* (SWAT) model (Texas A&M University 2015a); other models such as the *Agricultural Policy/Environmental eXtender* (APEX) model (Texas A&M

University 2015b) also can be used in this way (including application to some urban BMPs). For urban stormwater, engineering models like *HydroCAD* (HydroCAD Software Solutions 2011) can be used to simulate hydrologic response to stormwater BMPs with different physical characteristics (e.g., to compare performance levels under actual vs. design conditions). Even simple spreadsheet models such as the Spreadsheet Tool for Estimating Pollutant Load (*STEPL*) (USEPA 2015) can be used to quantify the effects of BMP depreciation by varying the effectiveness coefficients in the model.

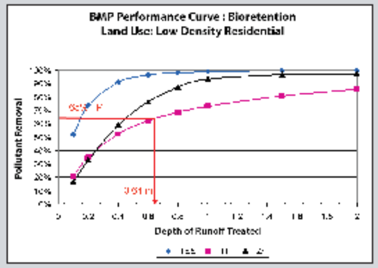


Figure 1. BMP Performance Curve for Bioretention BMP (Tetra Tech 2010).

Data from verification efforts and analysis of the effects of depreciation on BMP performance levels must be qualified based on data confidence. "Confidence" refers mainly to a quantitative assessment of the accuracy of a verification result. For example, the number of acres of cover crops or the continuity of streamside buffers on logging sites determined from aerial photography could be determined by ground-truthing to be within +10 percent of the true value at the 95 percent confidence level. Confidence also can refer to the level of trust that BMPs previously implemented continue to function (e.g., the proportion of BMPs still in place and meeting performance standards). For example, reporting that 75 percent of planned BMPs have been verified is a measure of confidence that the desired level of treatment has been applied.

While specific methods to evaluate data confidence are beyond the scope of this memo, it is essential to be able to express some degree of confidence in verification results—both during the planning phase and over time as the project is implemented. For example, an assessment of relative uncertainty of BMP performance during the planning phase can be used as direct follow-up to verification efforts to those practices for which greater quantification of performance level is needed. In addition, plans to implement new BMPs also can be developed with full consideration of the reliability of BMPs already in place.

Adjusting for Depreciation

Information on BMP depreciation can be used to improve both project management and project evaluation.

Project Planning and Management

Establishing baseline conditions

Baseline conditions of pollutant loading include not only pollutant source activity but also the influence of BMPs already in place at the start of the project. Adjustments based on knowledge of BMP depreciation can provide a more realistic estimate of baseline pollutant loads than assuming that existing land treatment has reduced NPS pollutant loads by some standard efficiency value.

Establishing an accurate starting point will make load reduction targets—and, therefore, land treatment design—more accurate. Selecting appropriate BMPs, identifying critical source areas, and prioritizing land treatment sites will all benefit from an accurate assessment of baseline conditions. Knowledge of depreciation of existing BMPs can be factored into models used for project planning (e.g., by adjusting pollutant removal efficiencies), resulting in improved understanding of overall baseline NPS loads and their sources.

While not a depreciation issue per se, when a BMP is first installed—especially a vegetative BMP like a buffer or filter strip—it usually takes a certain amount of time before its pollutant reduction capacity is fully realized. For example, Dosskey et al. (2007) reported that the nutrient reduction performance of newly established vegetated filter strips increased over the first 3 years as dense stands of vegetation grew in and soil infiltration improved; thereafter, performance level was stable over a decade. When planning a watershed project, vegetative practices should be examined to determine the proper level of effectiveness to assume based on growth stage. Also, because of weather or management conditions, some practices (e.g., trees) might take longer to reach their full effectiveness or might never reach it. The Stroud Preserve, Pennsylvania, section 319 National Nonpoint Source Monitoring Program (NNPSMP) project (1992–2007) found that slow tree growth in a newly established riparian forest buffer delayed significant NO_3–N (nitrate) removal from ground water until about 10 years after the trees were planted (Newbold et al. 2008).

The performance of practices can change in multiple ways over time. For example, excessive deposition in a detention pond that is not properly maintained could reduce overall percent removal of sediment because of reduced capacity as illustrated in Figure 1. The relative and absolute removal efficiencies for various particle size fractions (and associated pollutants) also can change due to reduced hydraulic retention time. Fine particles generally require longer settling times than larger particles, so removal efficiency of fine particles (e.g., silt, clay) can be disproportionally reduced as a detention pond or similar BMP fills with sediment and retention time deteriorates. Expert assessment of the condition and likely current performance level of existing BMPs, particularly those for which a significant amount of pollutant removal is assumed, is essential to establishing an accurate baseline for project planning.

Adaptive watershed management

Watershed planning and management is an iterative process; project goals might not all be fully met during the first project cycle and management efforts usually need to be adjusted in light of ongoing changes. In many cases, several cycles—including mid-course corrections—might be needed for a project to achieve its goals. Consequently, EPA recommends that watershed projects pursue a dynamic and adaptive approach so that implementation of a watershed plan can proceed and be modified as new information becomes available (USEPA 2008). Measures of BMP implementation commonly used as part of progress assessment should be augmented with indicators of BMP depreciation. Combining this information with other relevant project data can provide reliable progress assessments that will indicate gaps and weaknesses that need to be addressed to achieve project goals.

BMP design and delivery system

Patterns in BMP depreciation might yield information on systematic failures in BMP design or management that can be addressed through changes to standards and specifications, contract terms, or permit requirements. This information could be particularly helpful during the project planning phase when both the BMPs and their implementation mechanisms are being considered. For example, a cost-sharing schedule that has traditionally provided all or most funding upon initial installation of a BMP could be adjusted to distribute a portion of the funds over time if operation and maintenance are determined to be a significant issue based on pre-project information. Some BMP components, on the other hand, might need to be dropped or changed to make them more appealing to or easier to manage by landowners. Within the context of a permit program, for example, corrective actions reports might indicate specific changes that should be made to BMPs to ensure their proper performance.

Project Evaluation

Monitoring

Although short-term (3–5 year) NPS watershed projects will not usually have a sufficiently long data record to evaluate incremental project effects, data on BMP depreciation might still improve interpretation of collected water quality data. Even in the short term, water quality monitoring data might reflect cases in which BMPs have suffered catastrophic failures (e.g., an animal waste lagoon breach), been abandoned, or been maintained poorly. Meals (2001), for example, was able to interpret unexpected spikes in stream P and suspended sediment concentrations by walking the watershed and discovering that a landowner had over-applied manure and plowed soil directly into the stream.

Longer-term efforts (e.g., total maximum daily loads[1]) might engage in sustained monitoring beyond individual watershed project lifetime(s). The extended monitoring period will generally allow detection of more subtle water quality impacts for which interpretation could be enhanced with information on BMP depreciation. While not designed as BMP depreciation studies, the following two examples illustrate how changes in BMP performance can be related to water quality.

In a New York dairy watershed treated with multiple BMPs, Lewis and Makarewicz (2009) reported that the suspension of a ban on winter manure application 3 years into the monitoring study led to dramatic increases in stream nitrogen and phosphorus concentrations. First and foremost, knowledge of that suspension provided a reasonable explanation for the observed increase in nutrient levels. Secondly, the study was able to use data from the documented depreciation of land treatment to determine that the winter spreading ban had yielded 60–75 percent reductions in average stream nutrient concentrations.

The Walnut Creek, Iowa, Section 319 NNPSMP project promoted conversion of row crop land to native prairie to reduce stream NO_3-N levels and used simple linear regression to show association of two monitored variables: tracked conversion of row crop land to restored prairie vegetation and stream NO_3-N concentrations (Schilling and Spooner 2006). Because some of the restored prairie was plowed back into cropland during the project period—and because that change was documented—the project was able to show not only that converting crop land to prairie reduced stream NO_3-N concentrations but also that increasing row crop land led to increased NO_3-N levels (Figure 2).

[1] "Total maximum daily loads" as defined in §303(d) of the Clean Water Act.

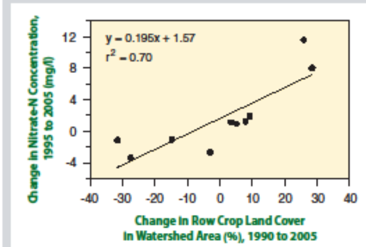


Figure 2. Relating Changes in Stream Nitrate Concentrations to Changes in Row Crop Land Cover in Walnut Creek, Iowa (Schilling and Spooner 2006)).

Modeling

When watershed management projects are guided or supported by modeling, knowledge of BMP depreciation should be part of model inputs and parameterization.

The magnitude of implementation (e.g., acres of treatment) and the spatial distribution of both annual and structural BMPs should be part of model input and should not be static parameters. Where BMPs are represented by pollutant reduction efficiencies, those percentages can be adjusted based on verification of land treatment performance levels in the watershed. Incorporating BMP depreciation factors into models might require setting up a tiered approach for BMP efficiencies (e.g., different efficiency values for BMPs determined to be in fair, good, or excellent condition) rather than the currently common practice of setting a single efficiency value for a practice assumed to exist. This approach could be particularly important for management practices such as agricultural nutrient management or street sweeping, in which degree of treatment is highly variable. For structural practices, a depreciation schedule could be incorporated into the project, similar to depreciating business assets. In the planning phase of a watershed project, multiple scenarios could be modeled to reflect the potential range of performance levels for BMPs already in place.

Recommendations

The importance of having accurate information on BMP depreciation varies across projects and during the timeline of a single project. During the project planning phase, when plans for the achievement of pollutant reduction targets rely heavily on existing BMPs, it is essential to obtain good information on the level of performance of the BMPs to ensure that plan development is properly informed. If existing BMPs are a trivial part of the overall watershed plan, knowledge of BMP depreciation might not be critical during planning. As projects move forward, however, the types of BMPs implemented, their relative costs and contributions to achievement of project pollutant reduction goals, and the likelihood that BMP depreciation will occur during the period of interest will largely determine the type and extent of BMP verification required over time. The following recommendations should be considered within this context:

- For improved characterization of overall baseline NPS loads, better identification of critical source areas, and more effective prioritization of new land treatment during project planning, collect accurate and complete information about:
  - Land use,

  - Land management, and
  - The implementation and operation of existing BMPs. This information should include:
    - Original BMP installation dates,
    - Design specifications of individual BMPs,
    - Data on BMP performance levels if available, and
    - The spatial distribution of BMPs across the watershed.
- Track the factors that influence BMP depreciation in the watershed, including:
  - Variations in weather that influence BMP performance levels,
  - Changes in land use, land ownership, and land management,
  - Inspection and enforcement activities on permitted practices, and
  - Operation, maintenance, and management of implemented practices.
- Develop and use observable indicators of BMP status/performance that:
  - Are tailored to the set of BMPs implemented in the watershed and practical within the scope of the watershed project's resources,
  - Can be quantified or scaled to document the extent and magnitude of treatment depreciation, and
  - Are able to be paired with water quality monitoring data.
- After the implementation phase of the NPS project, conduct verification activities to document the continued existence and function of implemented practices to assess the magnitude of depreciation and provide a basis for corrective action. The verification program should:
  - Identify and locate all BMPs of interest, including cost-shared, non-cost-shared, required, and voluntary practices;
  - Capture information on structural, annual, and management BMPs;
  - Obtain data on BMP operation and maintenance activities; and
  - Include assessment of data accuracy and confidence.
- To adjust for depreciation of land treatment, apply verification data to watershed project management and evaluation by:
  - Applying results directly to permit compliance programs,
  - Relating documented changes in land treatment performance levels to observed water quality,
  - Incorporating measures of depreciated BMP effectiveness into modeling efforts, and
  - Using knowledge of treatment depreciation to correct problems and target additional practices as necessary to meet project goals in an adaptive watershed management approach.

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