Lake Mallalieu
Lake Management Plan

FEBRUARY 17, 2022

Prepared for:
Lake Mallalieu Association

Prepared by:
The Lake Mallalieu Association
and
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AES is excited to be part of RES

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Acknowledgements

This document was prepared by volunteers of the Lake Mallalieu Association, staff members of the St. Croix County Community Development Department, Wisconsin Department of Natural Resources personnel, Resource Environmental Solutions (RES), and other interested individuals who are working to preserve and enhance Lake Mallalieu's beauty and health for future generations. We appreciate the contributions from the following people and organizations:

Lake Mallalieu Association Members

- Susie Gilbert
- Jim Fahy
- Bill Fristad
- Paul Gavic
- John Gostovich
- Mike Laatsch
- Jeff Lavers
- Jim Loeffler
- Warren Schneider
- John Thomas

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USGS

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Executive Summary

Lake Mallalieu is a treasured waterbody, beloved by recreational boaters, fishermen, the many residents who call its shoreline home, the City of Hudson, the Village of North Hudson, and Hudson Township. It is steeped in the history of the region and its waters and shorelines provide habitat for a wide range of plants and animals. The Lake Mallalieu Association ("LMA" or "Association") values Lake Mallalieu and the Willow River watershed, particularly for recreation and the aesthetic qualities these wonderful water resources offer. Boating, kayaking, fishing, swimming, and simply enjoying the natural beauty of the Lake all contribute to a healthy, highly-valued, lifestyle.

Portions of the Willow River's mainstem and the North and South Forks of the Willow are Class II and Class III trout waters. Much like Lake Mallalieu, the lower River has supported a warm water sport fishery. Willow River State Park is located on lands along the Willow River mainstem in the lower watershed and includes the Willow River Gorge, Willow Falls, and Little Falls Lake.

Changes in Lake Mallalieu and the greater Willow River watershed have resulted in sedimentation, nutrient enrichment, reduced water clarity, and regular unsightly and potentially harmful algal blooms. These changes are symptoms of poor health – of the land and water from the watershed, contributing to impaired conditions of the Lake itself – which also have compromised their aesthetic and recreational values. Today, Lake Mallalieu is impaired due to total phosphorus levels predominantly from non-point source pollution, causing eutrophication and algal blooms, which have now become an annual problem in the Lake.

This Lake Management Plan recognizes that Lake Mallalieu and portions of the Willow River are federally designated as "high priority" under the U.S. Environmental Protection Agency (EPA) 303(d) Impaired Waters Program. In 1998, a portion of the Willow River was designated as impaired due to low dissolved oxygen levels, and in 2004, the EPA listed Lake Mallalieu as impaired due to excessive phosphorus and chlorophyll levels. EPA's designation directed the WDNR to develop a TMDL (Total Maximum Daily Load) assessment, which was completed in 2012 (MPCA et al 2012) and addressed nutrients entering Lake St. Croix (including flows from the Willow River and Lake Mallalieu). Development of the TMDL was followed by an Implementation Plan (MPCA et al 2013).

TMDLs have the authority to limit phosphorus discharges from point sources within the watershed (e.g., wastewater treatment plants); however, management of non-point sources of phosphorus are still voluntary. Specifics of the TMDL will guide nutrient reduction efforts for the Willow River/Lake Mallalieu watershed well into the future. The LMA has partnered with and engaged the WDNR, St. Croix County, the Interagency St. Croix Basin Team, farmers within the watershed, and other stakeholders in an effort to improve Lake Mallalieu's water quality and will continue to do so.

It is important to note that the 2013 Implementation Plan developed to address the TMDL study used land cover data from 1992. Significant changes have occurred in the Willow River/Lake Mallalieu watershed since the early 1990s, including changes in agricultural practices (e.g., introduction of confined animal feeding operations, changes in manure and fertilizer application rates and formulations,

crop residue management, etc.), which affect runoff and nutrient loading. Therefore, there is concern that actual nutrient loading levels are likely to be significantly higher than previously modeled.

This Lake Management Plan is focused on three overarching goals for Lake Mallalieu:

1. Improve water quality
2. Improve aquatic habitat
3. Address sediment that has been deposited in the Lake

Implementation of this Lake Management Plan will require a grassroots effort of local stakeholders to include citizens, municipalities, resource agencies, and the agricultural community. It will also require substantial funding. This Plan's recommended actions will protect and enhance what everyone values most for current and future generations of Lake Mallalieu users. An important purpose of this Plan is to educate and motivate all constituents (the Lake's residents and users, as well as farmers and other landowners in the upper watershed) to achieve improved water quality in the entire watershed, including within the Lake and, consequently, Lake St. Croix and downriver Lake Pepin.

These goals for management of the Lake will only be accomplished by improving watershed-wide water quality, and indicators of this accomplishment within the Lake would be exhibited by greater water clarity and reduced algae growth. To accomplish that, a two-scaled approach is essential: a) a watershed-wide approach to reduce nutrients entering the Willow River that then flow into the Lake, and b) a Lake-focused and scale effort on the surrounding lakeshore to reduce shoreline erosion and runoff from shoreland yards. In addition, sediment and organic materials deposited in the Lake by the Little Falls Dam demolition breach and the subsequent construction site breach (discussed in greater detail on page 7) must be removed or otherwise repositioned (perhaps creating protected island wildlife sanctuaries within the Lake). Lakeshore residents must protect and restore existing shoreland habitats and, together with Hudson, North Hudson, and Hudson Township, adopt best practices to prevent nutrient-laden surface water from entering the Lake. Also, aquatic invasive vegetation needs to be removed and controlled to facilitate re-establishment of native aquatic plants and desirable in-lake habitat.

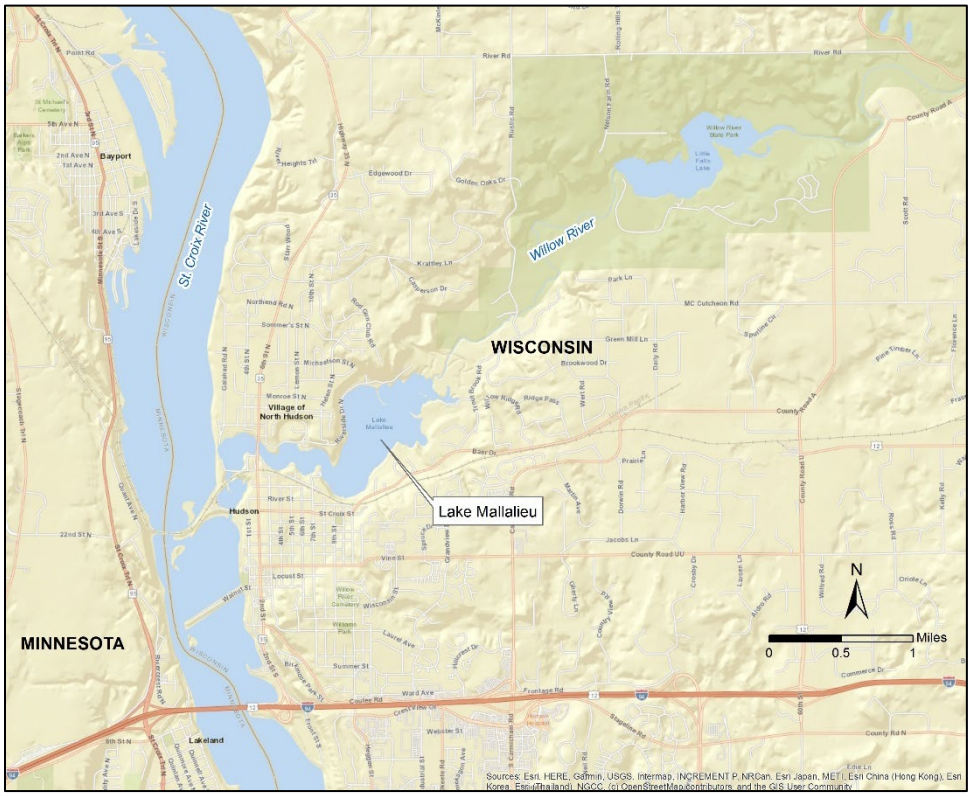
The resulting improved water quality and habitats will help restore the Lake's self-supporting, high quality, warm-water bass, panfish, and northern pike sport fishery, which past users of the Lake so enjoyed. Additionally, a healthy, sustainable aquatic plant community will be restored, and new infestations of non-native species prevented.

This Lake Management Plan maintains the Association's commitment to provide safe, multifaceted recreational opportunities for Lake users, whose numbers will multiply as the area's population continues to swell and development continues throughout St. Croix County (particularly as a result of the new St. Croix Crossing Bridge). Going forward, it will be more important than ever to provide clean water and safe recreational opportunities for all users while protecting critical habitats and downriver resources.

1. Baseline Data & Assessment

Lake Mallalieu is a 289-acre lake (an impoundment of the Willow River) located between Hudson and North Hudson, Wisconsin within the Lake St. Croix Basin (Figure 1).

Figure 1. Lake Mallalieu Location Map



The following chronology, much of which was compiled by the Lake Mallalieu Association, summarizes the history of Lake Mallalieu and its watershed. Appendix 1 summarizes much of this information in tabular form.

1.1 Historical Conditions

1848 – 1960

Lake Mallalieu was first impounded in 1848 with a dam where it empties into the St Croix River. The impoundment was initially referred to as Willow Pond, but in 1887 the Lake was renamed "Lake Mallalieu" by Dr. Irving Wiltrout, who built Hudson's first hospital. According to records, Dr. Wiltrout

stated, “I have named this lake in honor of Rev. William F. Mallalieu, DD., LLD, Bishop of the Methodist Church and a resident of New Orleans”. The 1850s brought rapid settlement to Hudson, and in 1854, a second dam was built on the river, a short distance above Willow Pond.

Through the years Hudson continued to grow and in 1871, the single most formative event in Hudson history took place – the railroad arrived. With the railroad came railyards, which concentrated on manufacturing and repairing both freight and passenger rail cars. The yards were Hudson’s principal engine of growth for many years, until production dwindled after WWII. The operations were closed by 1957.

Fishing activity on Lake Mallalieu became popular in the early years and by 1941, the Lake supported a commercial fishery. Around that time, a fisheries report noted that commercial fishermen netted 56,400 lbs. of carp out of the Lake. A 1951 fisheries report noted “abundant vegetation”, perhaps caused by removing carp which were present and fed on aquatic plants. Between 1941 and 1954 there were attempts to establish walleye by stocking. This was not effective however, and it was thought that Lake Mallalieu was best suited for northern pike, bass, and panfish.

The first recorded fish survey of the Lake was conducted in 1957 and was an inventory investigation to set management goals and objectives. Every survey management recommendation since 1957 promoted largemouth bass and bluegill and discouraged management of walleyes and northern pike. It was felt that walleye and northern pike would move into the much cooler Willow River. As a result, it would be difficult for the Lake to support healthy populations of walleye and pike.

The first recorded complaints of algae blooms in Lake Mallalieu arose in 1946. The first recorded complaints concerning excess aquatic plant growth followed in 1949. Letters were sent to the WDNR at that time requesting help in “destroying the weeds.”

During the 1950s, Lake Mallalieu started to be recognized as a prime residential location, and lakeshore development expanded.

1960-1980

Much residential construction occurred around the Lake in the 1960s as larger parcels were divided into smaller lots. Building has continued to the present, and for the most part, virtually all buildable sites around Lake Mallalieu are now occupied.

The first permit approved by the WDNR for chemical treatment of aquatic vegetation using arsenic compounds was issued in 1961, which led to a series of arsenic treatments totaling 7,240 pounds. Other chemicals applied to the Lake included Silvex, Endothall, Diquat, and 2, 4-D. Arsenic and Silvex were subsequently found to be harmful to the environment in general and are no longer permitted. Arsenic has been detected in the Lake’s bottom sediments (within the ranges seen in this part of the state in similar impoundments); however, those data are available from only a single core sample.

Over the years, three hydro-electric dams had been built on the Willow River upstream of the Lake. In 1967, the State of Wisconsin purchased these dams from Northern States Power and formed Willow River State Park.

By the 1970s, vegetation in the Lake was sparse, water conditions were bad, and carp populations were again large. In 1975, there was a partial drawdown of the Lake in an attempt to control the carp by disrupting their spawning period; however, this was determined to be largely ineffective.

1980-1990

In the early 1980s, the Association was formed. The group had three primary concerns:

- The dam would eventually need repairs, and it was unclear who would pay for those. Ultimately, in the fall of 1983 an agreement was reached, the Lake level was drawn down, and repairs were made.
- Concern over the potential development of a former fish hatchery. The property was believed to be unsuitable for building and eventually purchased by a private landowner, who has kept the property in its natural state.
- Proposed condominium on the southeast corner of the Lake. Objections to the development included concerns over wetlands, installation of utilities, and negative visual impacts. After much discussion and outcry, the proposed condominium project was abandoned.

In 1989, another very serious issue presented itself. Extremely high levels of fecal coliform were measured when some children became sick after swimming. "LAKE CLOSED" signs went up around the shore. Sampling confirmed that parts of Lake Mallalieu were dangerously polluted. Association members spent many hours taking weekly water samples from the Lake for analysis, with frequent newsletters giving the latest updates and speculating at the cause. Over time, local government inspections revealed sewage violations around the Lake. The problem sites were immediately capped, and the year ended without a conclusive resolution to the problem.

By the next year municipal engineers dominated the dialogue and local governments were persuaded to install full sewer and water services to all lakeshore homes.

1990-2000

Shortly after the installation of sewer and water around Lake Mallalieu in 1991, the LMA obtained a Lake Planning Grant from the WDNR, allowing the LMA to hire an engineering firm to conduct a lake study. The study's primary finding concluded that the Lake was receiving excessive nutrients. An aquatic plant study was conducted by Barr Engineering of Minneapolis in 1991 as part of the WDNR Lake Planning Grant. No actions were taken as a result of the findings and recommendations in the Barr report.

In Willow River State Park, the WDNR removed the middle (Willow Falls) and upper (Mounds Plant) dams in 1992 and 1997, respectively. Willow Falls and its gorge have reverted back to their beautiful, natural state.

In 1997 and 1998, the LMA obtained WDNR grants to support its reactivation, and it was charged with determining the source(s) of excessive nutrient loading to the Lake, in addition to developing a Lake Management Plan, which was published in January of 2001.

During the summer of 1997, invasive aquatic plants became abundant in Lake Mallalieu, especially in the shallow north basin, and in 1998 the WDNR completed a survey of the Lake's aquatic plants and determined that invasive Eurasian water milfoil had become the dominant species. The prescribed treatment was winter freezing by lowering the Lake level, so the residents endured a deep drainage (6 feet) for an extended period of time while the dam was being repaired. Freezing did control the milfoil, and the two succeeding summers (1999 and 2000) were virtually free of non-native aquatic plants. A limited program of selective use of approved chemicals was implemented with mixed success, and the LMA continued to support WDNR's Aquatic Invasive Species monitoring of the Lake.

In 1998 a portion of the Willow River was designated by the EPA as impaired due to low dissolved oxygen levels. Water samples taken from Lake Mallalieu during the summer of 1999 indicated phosphorous concentrations of 98 parts per billion (ppb), which is equivalent to 98 micrograms/liter. This phosphorous level is high for lakes in this eco-region (western Wisconsin prairie habitat) but is typical of impoundments fed by large watersheds.

Recognition of nutrient loading and associated low oxygen levels in the Willow River prompted annual monitoring of phosphorus loading upstream of Lake Mallalieu and of in-Lake conditions. Monitoring was conducted in the years 1991, 1999, 2003, and 2006. Upon completion, a land use model (Soil and Water Assessment Tool – SWAT) was used to evaluate the effect of land management changes on the quality of water entering Lake Mallalieu. The monitoring and modeling information gathered from SWAT has been used to develop water quality targets and loading reduction goals for the Lake St. Croix Nutrient TMDL (MPCA et al 2012). Ultimately, the TMDL report identified allocations and management actions that will help restore good water quality to the Lake.

Overall, Lake Mallalieu has been characterized by WDNR as having a low-quality aquatic plant community with very poor species diversity. Degraded plant communities can often tolerate poor water quality and disturbed conditions, but they do not provide quality habitat for many native species. Studies of aquatic plants in Lake Mallalieu were conducted in 1998, 1999, 2001, 2005 and 2018 (WDNR no date). These studies, conducted by WDNR Water Resources staff, were completed to assess the long-term impacts to the native plant community and to Eurasian water milfoil (*Myriophyllum spicatum*) of the three-foot drawdown (October 2004 to early May of 2005) and to assess impacts from the more significant six-foot winter drawdown in 1998-1999. Lower water conditions from Lake drawdowns appeared to successfully control Eurasian water milfoil by freezing the sediments which contained root structures. The drawdown did not appear to significantly affect fish communities. The WDNR concluded that there had been a significant positive change in the Lake's aquatic plant community during the years 1998-2005, resulting from the winter drawdowns.

2000 - 2010

Concern was expressed for the fish population during the extended drawdown (1998-1999). A comprehensive fisheries investigation was conducted on Lake Mallalieu from April 4, 2001, to September 11, 2001 by WDNR Fisheries Management Staff (Michalek and Engel 2002). A total of 39 species of fish were observed during the survey, rough fish being the most common. Of the sportfish present, Walleye populations were virtually nonexistent, Northern pike populations were low, Smallmouth bass were second most common and self-sustaining, and Largemouth bass were the most common, also self-sustaining. Muskellunge were present but had extremely low densities and Yellow perch were considered to be common. Black crappie and Bluegill were common and abundant in the Lake. The most common fish in the Lake included the White sucker, Gizzard shad, Carp, Silver redhorse, and Smallmouth buffalo. The 2001 survey concluded that "Lake Mallalieu provides an abundant and diverse sport fish community. Bass fishing is excellent with many trophy-size fish present. Northern Pike are found in low densities, but their average size is well above average. Panfish populations are good, but their growth rates are lower than expected for small, fertile flowages. The drawdowns conducted on Lake Mallalieu do not appear to have impacted fish populations."

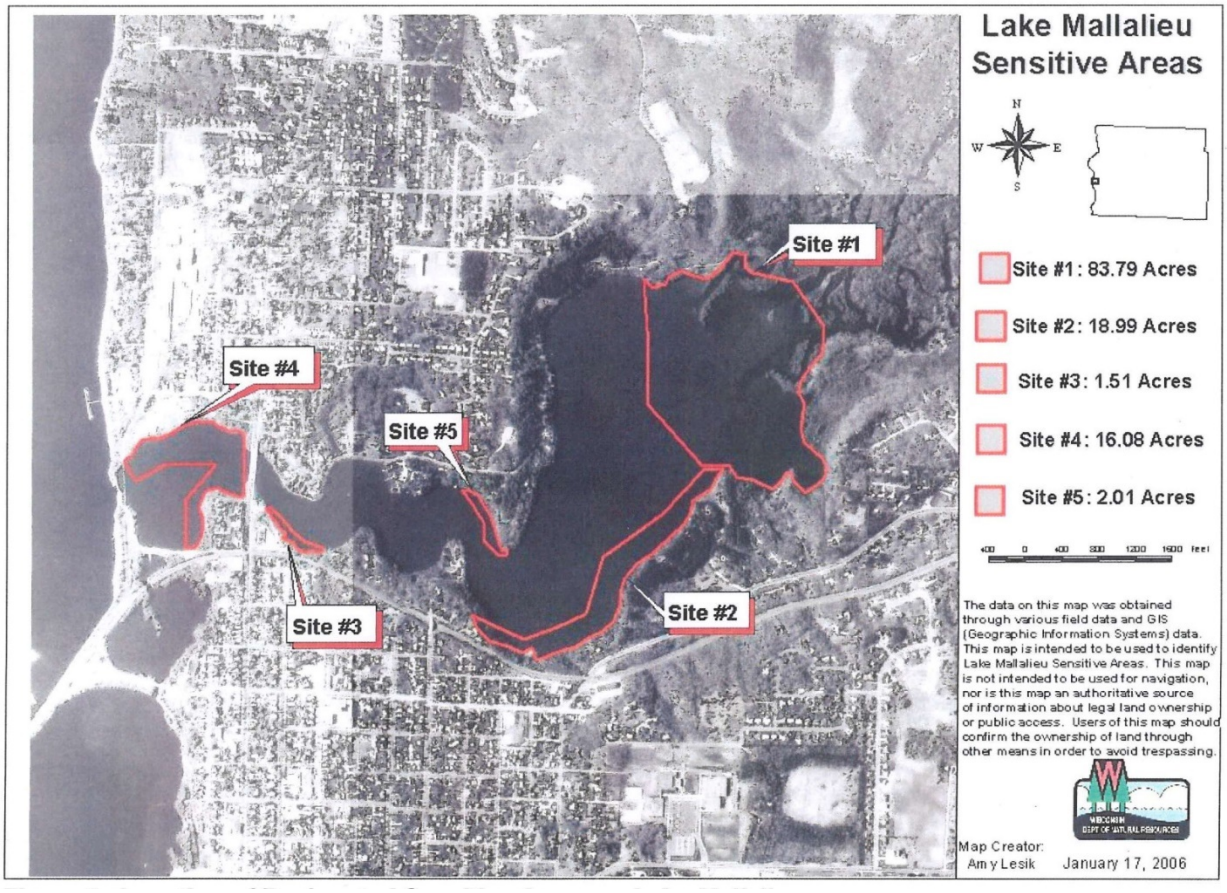
In 2004 Lake Mallalieu (Waterbody ID 2607100) was placed on the 303(d) impaired waters list for eutrophication and pH from total phosphorus (WDNR WADRS website). The most recent Lake Mallalieu water quality data available on the WDNR website is from 2006. WDNR summarizes those findings as follows:

> *Mid-Lake was sampled 9 different days during the 2006 season. Parameters sampled included:*
>
> - *total phosphorus*
> - *chlorophyll*
>
> *The average summer Chlorophyll was 52.2 µg/l (compared to a Southwest Georegion summer average of 50.4 µg/l). The summer Total Phosphorus average was 88.3 µg/l. Lakes that have more than 20 µg/l and impoundments that have more than 30 µg/l of total phosphorus may experience noticeable algae blooms. The overall Trophic State Index (based on chlorophyll) for Lake Mallalieu - Mid-Lake was 65. The TSI suggests that Lake Mallalieu - Mid-Lake was eutrophic. This TSI usually suggests blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible.*

WDNR-Designated "Sensitive Areas"

In 2006, the WDNR published an ecological assessment of Lake Mallalieu and identified five Sensitive Areas (Figure 2). Designation of sensitive areas within lakes provide for a comprehensive approach to ecosystem protection. Sites designated as sensitive are fragile areas that support wildlife and fish habitat and provide mechanisms for the protection of water quality. Protecting the terrestrial plant community on shore provides a buffer that absorbs nutrient runoff, prevents erosion, and helps to maintain water temperature. Protection of the littoral zone is critical for fish, wildlife, and the invertebrates that both feed upon.

Figure 2. WDNR-Identified Sensitive Areas of Lake Mallalieu (WDNR 2006)



Selection of each of the five sensitive areas around Lake Mallalieu was important. They were selected based on their natural buffering for terrestrial vegetation, which protects large portions of the Lake. In addition, each site serves to protect water quality, habitat, and offers buffering against the invasion of exotic species. A more detailed description of the WDNR's characterization and recommendations for the five Sensitive Areas is provided in Appendix 2.

The WDNR Sensitive Areas field assessment was conducted September 12, 2005. Since then, the Lake has experienced a substantial influx of sediment, particularly as a result of upstream dam demolition breach 2017-2018 and the 2019 construction site breach (discussed in the following section, "2010-2020"). Therefore, while potentially warranting an update, WDNR's Sensitive Area designations for Lake Mallalieu serve as guide for management decisions that impact the Lake's ecosystem.

2010-2020

As noted above, since 2004, Lake Mallalieu has been included on the EPA's 303(d) impaired waters list, as a "high priority" due to eutrophication (i.e., nutrient enrichment) from excess phosphorus as well as pH impairments. As a result of this designation, the Clean Water Act requires WDNR to prepare a nutrient TMDL (Total Maximum Daily Load) that addresses Lake Mallalieu and its upstream contributing

area. The Lake St. Croix Nutrient TMDL was completed in 2012 (MPCA et al 2012) and addressed nutrients entering Lake St. Croix (including flows from the Willow River and Lake Mallalieu). Development of the TMDL was followed by an Implementation Plan (MPCA et al 2013). The TMDL plan outlines a strategy to reduce nutrient loading of Lake St. Croix (including nutrients flowing into Lake Mallalieu), in addition to increasing public awareness of the upstream implementation efforts needed throughout the watershed. Specifics of the TMDL plan will guide nutrient reduction efforts for the Willow River/Lake Mallalieu watershed well into the future.

In the spring of 2011, on behalf of the St. Croix County Community Development Department and the LMA, the Environmental Resources Center of UW Madison designed and conducted a survey of owners of properties bordering Lake Mallalieu. Ninety-four of the 116 surveys sent were returned — an exceptional 81% return rate. UW Extension staff members Jake Blasczyk and Andrew Meyers compiled the results, which are attached as Appendix 3.

A WDNR Lake Survey Information Sheet (WDNR 2013) classified Lake Mallalieu as hypereutrophic with poor water quality due to high nutrient levels, high algal concentrations, and poor water clarity. Despite its water quality issues documented at that time, the Lake was still recognized as a high quality Largemouth and Smallmouth bass fishery. Aquatic invasive species documented in the lake included Rusty crayfish (*Orconectes rusticus*), Eurasian water milfoil (*Myriophyllum spicatum*), and curly-leaf pondweed (*Potamogeton crispus*).

The classification of "excess algal growth" was added to Lake Mallalieu's list of impairments in 2016 (WDNR WADRS website). Persistent algal blooms in the Lake hinder light penetration for aquatic plants and result in impaired recreational use and have the potential for algal toxicity. This condition has a negative effect on humans, pets, and wildlife. In 2018, Lake assessments showed continued excess algal growth, and chlorophyll-a sample data exceeded the 2018 WisCALM listing thresholds for Recreational Use.

In 2017, the Little Falls Dam in Willow River State Park was removed for replacement. The original project plan did not provide for preventing silt, which had accumulated behind the dam, from being transported downstream. The court-approved plan provided for a number of monitoring and prophylactic measures; however, these were not followed by the WDNR, resulting in a substantial volume of suspended organic matter being transported to Lake Mallalieu in 2017 and 2018. Then, on Sunday, March 24, 2019, the Willow River breached the construction site, sending an estimated 74 truckloads (740 cubic yards) of topsoil and glacial till down to Lake Mallalieu (Paul Gavic, personal communication). These sediments, together with much of the silt deposits that had accumulated in Little Falls Lake, were documented by the LMA as substantially shallowing the Willow River delta as it enters the Lake as well as other portions of the Lake. Appendix 4 presents data collected by the USDA/NRCS at the Willow River delta (i.e., where the River flows into the northeast portion of Lake Mallalieu). The cross-sections clearly depict the shallower Lake conditions following the dam breach, resulting from sediment deposition of over 3 feet in areas.

1.2 Current Conditions

1.2.1 Watershed Data

The 301 sq mi Willow River/Lake Mallalieu watershed consists of mostly flat-to-rolling terrain, dominated by silt loam and loam soils. Glacial deposits of gravel, sand, and mixed glacial till created the region's subsoil system. Soils with hydric inclusions are abundant in the upper watershed (Exhibit 1).

1.2.1.1 Land Use

In 2016, watershed land use was characterized as: 44% cultivated crops, 23% hay/pasture, 14% deciduous forest/woodland, 6% developed open space, 3% mixed forest, and remaining land cover classifications each occupied <2% of the watershed (Exhibit 2). WDNR data indicate 75 percent of the watershed is developed.

Cultivated crops (soybeans).

Hay/pasture (with livestock).

Deciduous woodland.

Developed open space (empty residential lot).

1.2.1.2 Wastewater Treatment Facilities

Five wastewater treatment facilities exist upstream of Lake Mallalieu: two larger ones (the cities of New Richmond and Clear Lake), two smaller dischargers (Deer Park and Lakeside Foods), and Emerald Sky

Dairy, a Concentrated Animal Feeding Operation (CAFO). Other CAFOs in the watershed include Arcand Poultry Inc., Jenni-O Turkey Store, and Minglewood Inc.

These wastewater treatment facilities are considered "point" sources or discharges, which contribute nutrients (e.g., phosphorus) to surface waters and fall under regulation by the Lake St. Croix TMDL and Wisconsin's statewide phosphorus rule. Of the two largest dischargers, New Richmond is practicing adaptive management to manage its facility discharges, and the Clear Lake plant is currently undergoing a significant facility upgrade.

Clear Lake wastewater treatment plant upgrade (under construction).

1.2.1.3 Willow River and Dams

The Willow River (which feeds and flows through Lake Mallalieu) is impaired for phosphorus. According to the *Implementation Plan for the Lake St. Croix Nutrient Total Maximum Daily Load* (MPCA et al 2013), 83% of the phosphorus loading to this waterway (and hence to Lake Mallalieu) originates from approximately 111,000 acres of agricultural fields and equates to 62,238 pounds of phosphorus per year.

The Little Falls Dam construction site breach on March 24, 2019, resulted in: 1) severe erosion upstream of the Little Falls Dam (flushing downstream the 100+ years of captured organic deposits), 2) deposits of heavier sediments (sand) in the delta of the Willow River where it flows into Lake Mallalieu, 3) transport of organic deposits far beyond the delta, where they settled throughout the Lake, and 4) a continuing increased presence of suspended nutrients released into the Lake from the organic deposits.

While the relationship between the 301-sq. mi. watershed and 289-acre Lake Mallalieu is recognized, few actions have been taken to reduce phosphorus, nitrogen, suspended solids, and other pollutants originating from non-point sources (largely agricultural fields) and point sources (including the five permitted sewage treatment or industrial discharge sources).

*Annual and daily load phosphorus statistics in the 2013 TMDL summary tables and Soil and Water Assessment Tool (SWAT) modeling for the Willow River/Lake Mallalieu watershed (*Almendinger and Murphy 2007*) appear to have used water quality data that predate significant agricultural changes that*

have occurred in the watershed. These changes in agricultural practices include: 1) approval and operations of concentrated animal feeding operations (CAFOs), 2) reductions in perennial cropping systems (e.g., alfalfa, grass-legume hay) and grazing lands, and 3) conversion to annual row cropping over a larger percentage of the watershed. RES's previous studies of phosphorus loading in Wisconsin suggest significant changes in farming have occurred statewide since ~2012 or later. The importance of updating land cover and related data sets and analyses used in SWAT and TMDL modeling cannot be stressed enough. *This concern suggests total and daily phosphorus loads are likely to be significantly underestimated*.

Concentrated animal feeding operation (CAFO).

Livestock in floodplain.

1.2.2 Watershed Observations

During a June 11, 2020 watershed inspection, three RES ecologists used the *ArcGIS Collector* application on digital tablets to review mapping of the watershed and digitally (and manually) document field conditions, including georeferenced photographs. Stops were made at 220 representative locations including crop fields, pastures, river channels (observed at bridge crossings), woodlots (visible from public ROW), concentrated animal feeding operations (CAFOs), wastewater treatment facilities, urban areas, and other land uses and habitats within the watershed (Exhibit 3). Observations included:

a. No till farming appeared to be used on perhaps 5-10% of the annually cropped land in the watershed.

No till field with 50% crop residue.

b. Soil surface disruptions from extensive corn stover harvesting was occurring widely.
c. Harvesting appeared to be removing 70-90% of the corn stover (possibly for farm animal bedding), and the remaining crop residue (estimated at 5-10% cover of remaining stover after harvesting at most farms, with an occasional farm having ~20-30% cover) is inadequate to control soil erosion.
d. Few farmers used cover crops in the watershed. As a result of large acreages with soil disruptions from conservation tillage (e.g., chisel plowing) and stover harvesting, we observed significant rill soil erosion in crop fields, including fields with stressed vegetation and sediment deposits at field margins and in road ROW.

Steep, erodible corn field.

e. Significant stream bed and bank erosion, sedimentation of fine substrates in the streams, high turbidity and suspended solid loads, very high levels of filamentous green algae (benthic growth attached to rocks and woody debris), and backwater areas had indications of excessive nutrient levels (e.g., blue-green algae (*Anabaena* sp.) and duckweed (*Lemma minor*)). These indications of nutrient enrichment are notable as they occurred already in late spring**.**

Streambank erosion.

f. Stream channels and the historical floodplain environment in upper reaches were largely dominated by native vegetation. However, most smaller tributaries and from perhaps the mid-portion of the Willow River/Lake Mallalieu watershed downstream, indicators of heavy nutrient enrichment were observed; some of these indicators were also seen in the upper watershed. Omnipresent dense monocultures of invasive, southeast Asian Reed Canary Grass (*Phalaris*

arundinacea) were observed instead of the native sedge meadows that historically occupied these floodplains. Vegetation that once dominated these floodplains (and supported local and regional wildlife) included Tussock Sedge (*Carex stricta*), Emory's Sedge (*C. emoryi*), Water Sedge (*C. aquatilis*), Lake Sedge (*C. lacustris*), and dozens of native grasses and wildflowers. RES's observations of karstic sink hole wetlands and glacial pothole wetlands dominated in many areas by invasive Reed Canary Grass and hybrid cattail (*Typha x glauca*), and water surfaces covered with filamentous green algae, blue-green algae, and duckweed, underscore the serious water quality change impacts underway in the Willow River/Lake Mallalieu watershed.

Dry Run Creek headwater stream.

High quality lake in headwaters.

g. Declining upland ecosystems included historical, semi-open oak savanna and forest systems that have been degraded by invasive European Buckthorn (*Rhamnus cathartica*), non-native honeysuckles (*Lonicera* spp), native (but aggressive) Boxelder (*Acer negundo*), and other non-native species. This condition now represents a large percentage of farm woodlots, but also is seen in semi-natural floodplain and riverbank environments. Where these dense non-native shrubs and Boxelder occur, dense shading results in the collapse of soil-stabilizing native grasses, sedges, and other wildflowers. This in turn contributes to the significant soil erosion observed in the watershed's riparian areas, similar to what we have documented elsewhere (e.g., see the book *Restoring Ecological Health to Your Land*, Apfelbaum and Haney 2012). This erosion contributes to degraded habitat quality and declining regional wildlife populations (e.g., native birds, insects).

Degraded, overgrown oak savanna.

1.2.2.1 Data and Modeling Discrepancies

Discrepancies exist within previous studies of the Willow River/Lake Mallalieu watershed with respect to the land use types, coverage percentages, and acreages. For example, the 2013 TMDL study used 1992 National Land Cover Dataset (NLCD) data, whereas RES used 2016 NLCD data in its analysis. Comparison of these two datasets indicates that from 1992 to 2016, cultivated cropland in the Willow River/Lake Mallalieu watershed would have decreased from 57% of the watershed to 44%, grassland (including hayfields and pastures) decreased from 26% to 23%, and urban land increased from 1.1% to 8.4%. It seems highly unlikely that the amount of cultivated cropland actually decreased by 13% in light of the introduction of CAFO operations at that time.

RES's review of the watershed suggests that annual crops such as corn and soybeans occupy more than the 75,000 acres used in the earlier SWAT analyses (Almendinger and Murphy 2007). We also believe the acreage of grassland, grazed lands, and "undeveloped land" appear to have declined significantly.

SWAT and TMDL modeling assumptions regarding crop residue were not clear. However, RES's conversations with Kyle Kulow (Land Use & Conservation Specialist for St. Croix County) during the field inspection suggest that the presence of a large CAFO (and perhaps other enlarged dairy operations) have resulted in significant corn stover harvesting, resulting in large acreages with greatly reduced crop residue. In addition, the observed estimates of the percentage of crop residue remaining after stover harvesting did not come close to the 30% coverage of the soil surface commonly referenced as the NRCS standard. This suggests greater clarity on crop residue management and water quality relationships is essential to improving the management of the agricultural lands in the Willow River/Lake Mallalieu watershed.

1.2.2.2 Impoundments

Many rivers (and lakes formed by damming rivers) in portions of Wisconsin that have significant deposits of glacial till, sand, and gravel also have moderate to high levels of phosphorus. Therefore, many of these surface waters were historically, naturally limited by available nitrogen within the water column. We are not aware if the previously-conducted SWAT and TMDL analyses considered nitrogen-related compounds, and we are also unsure if the significantly higher levels of nitrogen fertilizers being added now to achieve higher corn yields were considered in the latest SWAT and TMDL modeling. For example, to achieve 150-180 bushels/acre corn yields, the historical average Wisconsin addition of nitrogen fertilizer is 120 lbs of N/acre. However, with new high-density and high-yield corn varieties able to generate 280-300 bushels/acre, nitrogen fertilizer rates can be more than doubled. *This changing crop fertility dynamic needs to be understood in the Willow River/Lake Mallalieu watershed – for current conditions as well as projected into the future*.

1.2.2.3 Watershed Conclusions

Decades of watershed research indicate that agriculture is typically the largest contributor of phosphorus to surface waters. According to the Willow River Watershed Plan (WDNR 2010), approximately 75% of the phosphorus in the watershed is due to non-point agricultural sources.

However, during periods of low rainfall, municipal sources may exceed agricultural sources of pollution in the watershed. *Also, as smaller dairy farms have been replaced by operations with 1,000 animal units or more, the potential phosphorous danger has increased several fold*.

Although the Upper Willow River watershed was designated a "Priority Watershed" in the early 1980s, many of the pollution management measures installed by farmers were abandoned as the price of agricultural commodities increased. In addition, general population growth increases the pressure on the Willow and Lake Mallalieu.

If Lake Mallalieu continues to receive such large inflows of phosphorous, the ageing of the Lake will be accelerated dramatically. This means more organic deposits from decaying plants and algae, less oxygen for fish respiration, declining water clarity, and more rough fish.

1.2.3 Lake Mallalieu Data

The Willow River flows into Lake Mallalieu (actually the dammed up river) and then into the St. Croix River. Lake Mallalieu (Waterbody ID 2607100) is considered an Impounded Flowing Water under the state's Natural Community Determinations.

1.2.3.1 Lake Geometry and Sediments

The Lake has a very high watershed-to-lake area ratio of 667:1. The WDNR estimated the retention time of water in the Lake (i.e., the time it takes to flush through the lake) to be 3 to 7 days. This suggests the Lake will be both highly responsive to deleterious changes in the tributary watershed but then may also recover reasonably quickly after remedial actions have been implemented. Shallow lakes such as Lake Mallalieu are often susceptible to water quality issues due to warming of shallow water, resuspension of sediment, etc.; however, they can also recover relatively rapidly because they do not have a large acreage of deeper water that retains fine sediments with adsorbed phosphorus. Such deeper lakes experience anerobic conditions during the winter, which releases phosphorus into the water column, stimulating growth of algae and aquatic macrophytes every spring.

The 289-acre lake has 10.64 miles of shoreline, a mean depth of 5 feet, and a maximum depth of 17 feet. Approximately 60% of the lake's surface area is <5 feet deep. Due to its shallow nature, thermal stratification does not occur in the majority of the Lake.

Previous Lake Mallalieu Management Plans stated: "Maps of the lake made 30 years ago, as well as aerial photos dating back to the 1930s, suggested that there had been no large change in lake depth over the intervening period. Sediment did not appear to be entering the lake from the Willow River except during extreme rainfall events or major floods."

We now know that, as a result of the activity surrounding replacement of the Little Falls Dam, that is no longer the case. The resulting loss of significant depth in the upper portions of the Lake (based on depth measurements taken by LMA in May 2019) suggests that dredging is the only practical means of removing sediment to restore the former bathymetry of Lake Mallalieu.

Pursuit of a dredging project would require completion of a feasibility study, as contemplated by this Plan, followed by funding. The LMA recognizes that Legislative support might also be required. A WDNR

aquatic plant survey in 2018 did not produce a report with the results and implications of the findings or inform the potential for impacts of dredging and aquatic plant harvesting impacts to fish, aquatic wildlife, etc., or the potential release of contaminants from lake sediments.

Field observations from 2002 indicated that lake sediments typically grade from sand and gravel in the Lake's shallows to silts and organic deposits with increasing depth. Per the WDNR, "Were it not for the constant supply of fresh water from the Willow River, the decomposing plant matter at the Lake bottom would consume much of the Lake's oxygen and create a harmful environment for fish." (WDNR 2010).

Following the upstream dam breaches between 2017 and 2019, much of the Lake bottom now consists of silts and mucks. While organic deposits are formed naturally by the accumulation and slow decomposition of plant matter in a nutrient-rich environment, much of Lake Mallalieu's organic sediments appear to have originated from the upstream dam breaches.

Arsenic was detected in the Lake's sediment in 1979, albeit from limited sampling. Sediments in particular portions of the Lake could be a future concern if activities on or in Lake Mallalieu (e.g., dredging) resulted in disturbing the Lake bottom sediments. Therefore, it is recommended that prior to sediment-disturbing activities, sediment sampling be conducted to better define the extent and degree of arsenic contamination so that appropriate mitigation actions can be taken.

Algae and shallow, turbid water.

1.2.3.2 Lake Water Quality

Today, Lake Mallalieu is impaired due to total phosphorus levels from non-point source pollution, causing eutrophication and algal blooms, which have now become an annual problem in the lake. The lake classification system for Wisconsin lakes uses ranges in water clarity data to define categories of lake condition, or trophic status index (TSI). Lakes in this ecoregion are typically trophic and have summer total phosphorus concentrations of greater than 50 ug/L.

Water quality monitoring of Lake Mallalieu has been conducted by WDNR during summer months since the 1970s, and most consistently in this past decade (measuring total phosphorus, chlorophyll, and clarity). These data are used to calculate the TSI, which indicates the degree of nutrient enrichment in a lake. The TSI is a score from 0 to 110, with lakes that are less fertile having a low TSI. According to the WDNR's latest calculated TSI for the Lake (based on its total phosphorus concentration in 2006) is 63.

Table 1 below lists the characteristics of lakes with varying TSI scores. As indicated in the table, even back in 2006, Lake Mallalieu was identified as potentially experiencing extensive plant overgrowth, algal scums, and even harmful blue-green algae.

Table 1. WDNR Description of Trophic Status Index Scores

TSI	TSI Description
< 30	Classical oligotrophy: clear water, many algal species, oxygen throughout the year in bottom water, cold water, oxygen-sensitive fish species in deep lakes. Excellent water quality.
30-40	Deeper lakes still oligotrophic, but bottom water of some shallower lakes will become oxygen-depleted during the summer.
40-50	Water moderately clear but increasing chance of low dissolved oxygen in deep water during the summer.
50-60	Lakes becoming eutrophic: decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident, warm-water fisheries (pike, perch, bass, etc.) only.
60-70	Blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible.
70-80	Becoming very eutrophic. Heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae block sunlight).
> 80	Algal scums, summer fish kills, few plants, rough fish dominant. Very poor water quality.

Wisconsin promulgated phosphorus standards for lakes in 2010. The standard for impoundments such as Lake Mallalieu is 75 ug/L (micrograms per liter). During the summer of 1999, phosphorous concentrations in the Lake were measured at 98 ug/L, and during recent years the Lake has become increasingly prone to excessive algae growth. Currently the Lake experiences algal blooms over 78% of the summer season (based on LMA observations). In addition, the TMDL Plan has set a "Percent of summer days with algal bloom condition" at a goal of 15 days. Based on LMA observations, this goal has not been achieved over the past several years.

Water quality is also regularly monitored through the Citizen Lake Monitoring Program. Volunteer and LMA member Bill Fristad conducts regular monitoring of Lake Mallalieu, including parameters such as water level, temperature, total phosphorus, dissolved oxygen, chlorophyll A, water color and appearance, Secchi depth (a measurement of water clarity), and general user perception of water quality (e.g., swimmable or not). Table 2 summarizes total phosphorus concentrations from recent sampling conducted in the deepest portion of Lake Mallalieu.

Table 2. Total Phosphorus Concentrations in Lake Mallalieu (2018-2020)

Sampling Date	Total Phosphorus (ug/L)
04/22/2018	141*
07/28/2018	137*
08/25/2018	63.8
04/09/2019	121*
06/17/2019	46.5
07/29/2019	50.4
08/25/2019	105*
07/27/2020	68.3
08/24/2020	44
09/21/2020	40.7

*Above the WDNR standard of 75 ug/L for impoundments like Lake Mallalieu.

As specified in WDNR code, pH standards for Wisconsin waters need to be maintained between 6.0 and 9.0 standard units to protect life. EPA has listed Lake Mallalieu as impaired due in part to frequent summer exceedances of this standard, with pH values over 9.0. High pH values are due to algal photosynthesis (removal of carbon dioxide from the water). A reduction in nutrient loading to Lake Mallalieu would reduce phosphorus levels in the Lake and cause a corresponding decrease in chlorophyll levels (indicative of the amount of algae in the water) and a reduction in maximum pH levels.

1.2.3.3 Lake Shoreline and Aquatic Communities

Healthy aquatic and shoreline plant communities provide food and shelter for fish, wildlife, and the invertebrates that serve as food for larger fish and other animals. Healthy aquatic and shoreline vegetation also protects shorelines from erosion, adds to the aesthetics of the Lake, and increases the Lake's recreation value. While there is a moderate amount and diversity of native vegetation along some of the Lake's shoreline, its aquatic plant community is quite poor. Invasive aquatic vegetation includes Eurasian water milfoil (*Myriophyllum spicatum*), Curly-leaf pondweed (*Potamogeton crispus*), and Purple loosestrife (*Lythrum salicaria*). Comparing the most recent vegetation sampling efforts (conducted in 2013 and 2018), the Lake's aquatic plant community appears to have decreased in cover (i.e., abundance), including reductions in both native and invasive plant species. This provides relatively poor habitat for most native fish and other native aquatic wildlife.

In Wisconsin, drawdowns of 3-7 feet have been found to be effective for aquatic plant control where the winter conditions are cold and exposed lake substrates and submerged root aquatic plants are frozen. Drawdowns have generally appeared to have had minimal effect on fish diversity, populations or other measures reported.

As mentioned above, the Lake supports a variety of warmwater fish, including game fish as well as rough fish (e.g., carp). The WDNR ranks the Lake's fish and aquatic life as poor, and the Lake's recreation is ranked as poor due to excess algal growth, which has grown conspicuously worse in recent years.

1.2.4 Lake Mallalieu Observations

Lake Mallalieu serves (as did former upstream impoundments) as a sediment trap, which slows water and traps fine sediments. These sediments consist of clay, silt, fine sand particles, organic substrates, and the nutrients adsorbed to these materials. Deeper portions of lakes such as Lake Mallalieu accumulate these sediments and nutrients over many years, providing a source of "internal loading" of nutrients that contribute to algal blooms.

From time-to-time, high flows through Lake Mallalieu will re-suspend some of the fine sediments and nutrients, flushing them into the St Croix River. These same high flows will deliver additional sediments and nutrients to Lake Mallalieu. As dams were removed from upstream, the pre-treatment benefits provided by these impoundments were eliminated and the previously-trapped sediment ended up in Lake Mallalieu. Most impoundments have a depositional delta where the river or stream enters the lake; Lake Mallalieu is no exception.

Review of existing data and discussions with members of LMA lead to the following conclusions:

1. Lake Mallalieu's delta at the "upper," east end of the Lake has grown shallower and increased in size. Cross sectional surveys conducted by the USDA/NRCS shortly before (pre-2018) and shortly after (June 7, 2019) the dam construction site breach indicate approximately 3 feet of relatively large particle (i.e., sand) sediment was deposited, with the smaller/lighter suspended fines and associated nutrients flowing into the deeper portions of the Lake.
2. The Lake's back bays and off-channel areas have experienced significant sediment deposition and have also shallowed. Now, some areas are not deep enough to allow residents to draft their pontoon boats and other watercraft. Following the site breach, a *Hudson Star-Observer* article featured the plight of one such lakeshore owner.
3. Islands in the enlarging delta that used to be accessible using pontoons and other motorized watercraft are now not approachable because of shallow water.
4. Turbidity and algal blooms have become commonplace; therefore, this Lake Management Plan is focused on reducing phosphorus levels such that algal blooms occur ≤ 15 days/year.
5. Aerial photographs (1938-2019) suggest that the sediment loads that have contributed to the decline of Lake Mallalieu have also filled in backwater emergent wetlands upstream of the Lake. Comparison of the 1938 and 2019 aerial photographs shows this ecological conversion, where now forested wetland cover occupies areas that were open water wetlands (apparently sedge meadow and perhaps some shrub-dominated wetlands) during the 1930s.

During a June 11, 2020 inspection of Lake Mallalieu by three RES ecologists, numerous issues were observed, and opportunities identified, at various locations:

a. Shallow conditions were confirmed in the deltaic system, in back bays, and along many of the Lake's WDNR-identified Sensitive Area shorelines.
b. Shallower areas tended to have fine sand sediments; deeper areas contained greater percentages of fine silts, clay, and organic deposits.
c. Nearly all the Sensitive Areas were observed to have adjacent declining oak savanna systems that have been invaded by Common buckthorn (*Rhamnus cathartica*), non-native invasive honeysuckles (*Lonicera* spp), and Boxelder (*Acer negundo*). These forest/woodlands are rapidly

closing in, causing increasingly dense shade. *Several locations were observed where the shoreline's stabilizing native vegetation is suffering from shade suppression, leading to bare and erodible soils.*

Historical oak savanna, currently overgrown.

d. The presence of invasive Eurasian Water Milfoil (*Myriophyllum spicatum*) and Curly-leaf Pondweed (*Potamogeton crispus*) was confirmed, but desirable native aquatic plants were also identified such as pondweeds (e.g., *Potamogeton praelongus, Potamogeton pectinatus*), White Waterlily (*Nymphaea odorata*), Yellow Waterlily (*Nuphar lutea*), etc.
e. A few sections of shoreline were observed to consist of native vegetation. These natural buffers provide habitat for soil-anchoring native plants and a variety of wildlife (e.g., birds and butterflies).

Stable, native shoreline.

Shorelines: rip rap (left) and natural/restored (right).

1.3 Institutional Assessment

The Willow River/Lake Mallalieu watershed lies almost entirely within St. Croix County, with a portion extending into southeast Polk County and a small portion extending into southwest Barron County. The Lake itself is bordered by the City of Hudson and the Village of North Hudson, with unincorporated, privately-owned land around much of the Lake's eastern shoreline in the Village of Hudson. Because the Lake discharges into the St. Croix River (a Wild and Scenic River managed by the National Park Service), Lake Mallalieu is part of the Lake St. Croix Basin.

1.3.1 Water Quality Protection

At the federal level, the Clean Water Act (CWA) is the strongest tool in protecting water resources. Within the state of Wisconsin, the authority to administer the provisions of the CWA has been delegated to the WDNR. Section 402 of the CWA establishes the National Pollution Discharge Elimination System (NPDES), while Section 319 Nonpoint Source Management Program was created in order to further support state and local nonpoint pollutant source efforts not addressed by NPDES permits. Section 319 permits states to receive grant money towards activities such as technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of nonpoint pollutant source implementation projects. Section 303 of the CWA requires states to catalogue impaired waters, prioritize them, and calculate Total Maximum Daily Loads (TMDLs) of pollutants a waterbody can receive and still safely meet the water quality standards. Wisconsin has also utilized Section 208 (the Priority Watershed Program) to develop a nonpoint pollutant source program. WDNR identified watersheds and lakes in most need of nonpoint pollution abatement and encouraged the use of nonpoint source controls to improve water quality. It is yet to be determined if the WDNR included Lake Mallalieu in the Priority Watershed Program and if it did not, why not.

The Safe Drinking Water Act also plays a role in protecting surface and groundwater resources.

1.3.2 Land Protection

The U.S. Fish and Wildlife Service (USFWS) and WDNR protect various dedicated natural areas and threatened and endangered species. The U.S. Army Corps of Engineers (USACE), with approval of WDNR, regulates wetlands through Sections 401 and 404 of the CWA. Land development affecting water resources (rivers, streams, lakes, wetlands, and floodplains) is regulated by the USACE when "Waters of the U.S." are involved. These types of waters include any wetland or stream/river that is hydrologically connected to navigable waters (which the Willow River is because it flows into the St Croix River). The USACE primarily regulates filling activities and requires buffers or wetland mitigation for developments that impact jurisdictional wetlands.

Land development in the watershed is regulated by county and municipal ordinances. St. Croix County is regulated under a Comprehensive Plan (2012) and a Land & Water Resource Management Plan (2018), while Polk County has a Comprehensive Plan (2009), Storm Water Management & Erosion Control Ordinance, and a number of environmental programs within their Land & Water Resources Department. Barron County has a Comprehensive Plan (2010), Land and Water Resource Management Plan (2019) managed by their Soil & Water Conservation Department, and a Farmland Preservation Plan (2015).

Beyond county-level regulations, each municipality has its own applicable regulations. Municipalities in the watershed may or may not provide additional watershed protection above and beyond existing local municipal codes. Most municipal codes provide ordinances covering business regulations, building regulations, zoning regulations, new subdivision regulations, stormwater management, streets, utilities, landscaping/restoration, tree removal, etc.

Other governments and private entities with watershed jurisdictional or technical advisory roles include the Federal Emergency Management Agency (FEMA) and the USDA's Natural Resources Conservation

Service (NRCS). County Boards are also important because they oversee decisions made by respective county governments and therefore have the power to override or alter policies and regulations.

1.3.3 Planning, Policy and Regulation

Planning, policy, and regulation are the foundation of watershed protection as the process sets the minimum standards for development that occurs or is proposed to occur in the vicinity of water resources. It is hoped that recommendations from this Plan will be referenced in future watershed and comprehensive plans and implemented in ordinances. In many cases, municipal codes also lay the foundation for the types of trees that can be removed from sites as well as what types of plant communities and species that can be replanted. County stormwater ordinances are the primary preventative measure that can be used to standardize for a county the requirements that proposed developments must meet. Monitoring compliance and enforcing implemented municipal codes and county regulations falls in the hands of local municipalities or county agencies. It is up to these enforcing bodies to communicate effectively and regularly, discussing the problems with how ordinance language is interpreted and providing amendments that may help clarify certain regulations.

Planning/zoning guidance provides another level of watershed and natural resource protection. Most planning and zoning guidance is in the form of local floodplain or zoning ordinances that regulate onsite land use practices to ensure adequate floodplain, wetland, stream, lake, pond, soil, and other natural resource protection. Zoning ordinances and overlay districts define what type of development is allowed and where it can be located relative to natural resources. Examples of how planning and zoning can provide resource protection include making recommendations or instituting requirements to establish and maintain riparian and wetland buffers, reduce impervious area, dedicate land to open space and greenways, establish conservation easements, and implement conservation and/or low-density development.

To improve the impact of planning/zoning guidance on water resource protection, there needs to be improved coordination and communication between state, county and local government. Watershed development regulations should be made very clear to local enforcement officers. Local planning officials and zoning boards should consider revisions to local ordinances that address watershed, lake, and/or site-specific natural resource issues. For example, communities with less current impervious development should revise their zoning ordinances sooner rather than later in order to adequately prevent the types of development that contribute to flooding, degrade wildlife habitat, and reduce water quality.

1.4 Social Assessment

Given the size of the Willow River/Lake Mallalieu watershed, there are many stakeholders and partners with various interests As indicated in Table 3, all stakeholders hold water quality improvement as a unified goal. This will require efforts throughout Willow River/Lake Mallalieu watershed as well as in and adjacent to Lake Mallalieu itself. Other goals are also shared by multiple stakeholders, and achievement of any goals will benefit the St. Croix River and all other downstream resources.

Table 3. Stakeholders and Management Goals

	Interests				
Stakeholders	**Reduce Erosion in Watershed**	**Improve Water Quality**	**Improve Aquatic Vegetation**	**Improve Fishery**	**Restore (Increase) Lake Depth**
U.S. EPA	x	x			
NRCS	x	x			
Wisconsin DNR	x	x	x	x	
St. Croix County	x	x	x	x	x
Polk County	x	x			
Barron County	x	x			
Interagency St. Croix Basin Team	x	x			
Agricultural Landowners (WI Farm Bureau)	x				
Willow River Rehabilitation District	x			x (trout)	
Lake Mallalieu Assoc. (lakeshore residents)	x	x	x	x	x
Boaters	x	x	x		x
Swimmers		x			
Anglers (e.g., Trout Unlimited, St. Croix County Sportsmen's Alliance)	x	x	x	x	x
City of Hudson & Village of North Hudson		x	x	x	x

Based on review of previous watershed and lake studies and plans, discussions with the LMA, and discussions with other stakeholders, the following goals were identified for the Willow River/Lake Mallalieu watershed, the Lake's local lakeshed and lakeshore, and in-lake goals.

1.4.1 Goals for the Larger Watershed

1. Promote watershed management practices to reduce nutrient and sediment delivery:
    a. Agricultural lands - Encourage conservation tillage, lowering soil test phosphorus, nutrient management to match fertilizer application to crop need, careful manure handling, and buffer strips on the margins of cropland and streambanks.
    b. Urban areas – Encourage best management practices to capture, filter, infiltrate, and clarify stormwater in each of the communities in the Upper and Lower Willow watershed.
    c. Point sources of phosphorus – Reduce discharges of phosphorus-laden water, especially from wastewater treatment plants such as Clear Lake and New Richmond.
2. Wetland protection and restoration, especially in subwatersheds identified as contributing disproportionate loading to Willow River and Lake Mallalieu.
3. Riparian protection and restoration, including healthy riparian buffers and stabilization of eroding streambanks.

1.4.2 Goals for the Local Lakeshed and Lakeshore

1. Promote resident education, communication, and partnerships on maintaining and restoring healthy lakesheds and lakeshores.

2. Encourage and incentivize better runoff management around the lake, including no-mow buffers, no fertilizer or pesticides, and opportunities to trap sediment from runoff before it reaches the lake.
3. Encourage a slow/no-wake zone in the upper lake.
4. Stabilize eroding shorelines; this may entail selective thinning of vegetation and bioengineering techniques.
5. Encourage and educate residents on measures to retain and improve habitat for birds, fish, and other wildlife consistent with St. Croix County's Shoreland Zoning Ordinance (St. Croix County Land Use Ordinance Chapter 17-17.30 Zoning; Subchapter III Shoreland). For example, retain snags (standing dead trees), cavity trees, and perch trees along the shoreline.
6. Advise and assist homeowners on the proper plants, trees, and buffers to establish in lakeshore areas (refer to USDA Natural Resource Conservation Service Technical Note: Shoreland Habitat Standard).
7. Encourage natural buffer zones, including plantings in existing rip rap.
8. Encourage emergent vegetation along lakeshore.
9. Eradicate purple loosestrife using biocontrol methods.
10. Conduct voluntary shoreline habitat assessments in cooperation with St. Croix County Resource Management staff.

1.4.3 Goals for In-Lake Actions at Lake Mallalieu

1. Restore self-supporting fishery, including healthy, sustainable aquatic plant community and habitat (e.g., large woody debris, cribs).
2. Maintain relatively stable water levels.
3. Prevent expansion of new infestations of non-native species.
4. Discourage chemical treatments of aquatic vegetation, and if done, use selective herbicides.
5. Require permit approval for pea gravel beds or sand blankets.
6. Work with St. Croix County's Resource Management Division to: (i) explore available grants and best management practices cost-sharing opportunities and (ii) provide seminars and workshops for the community. Workshops may cover rain garden design and installation, lakeshore restoration options, and other surface water runoff control measures.
7. Future drawdowns should be done by the end of September at the latest to reduce impact to turtles and amphibians.
8. Due to sedimentation from the dam demolition breach and the subsequent construction site breach, WDNR's 2005 "Sensitive Areas" mapping in the Lake (five areas were identified) needs to be updated.
9. Dredge the sediment plume resulting from the Little Falls Dam demolition breach and the subsequent construction site breach. Permitting would be required, and a feasibility study is likely warranted, especially if heavy metal suspension (e.g., arsenic) becomes a concern with any dredging or sediment disturbance.
10. Consider the use of Geotubes® to create new, protected island wildlife sanctuaries. Geotubes® are installed in strategic locations, filled with dredged lake sediments, designed to contain and

capture sediments, and can be planted with native wetland vegetation. As with sediment dredging above, a feasibility study is likely warranted.

1.4.4 General strategies to accomplish the above goals include:

1. Pursue feasibility study that addresses sediment dredging and/or use of Geotubes® or similar technique.
2. Work with WDNR to establish a plan for sediment dredging or relocation, shoreline restoration and enhancements, future Lake drawdowns, and invasive aquatic plant control.
3. Consult with WDNR specialists for their direction on wildlife enhancement projects.
4. Promote WDNR website as a source for information and education.
5. Work with WDNR staff, Interagency St. Croix Basin Team, and other partners in the watershed to implement the Lake St. Croix Nutrient TMDL, focusing on priorities and opportunities in the Willow River/Lake Mallalieu watershed.
6. Consult with UW Extension, the Interagency St. Croix Basin Team, and St. Croix County Resource Management staff to implement information and educational activities, including outreach to farmers and other landowners and stakeholders in the watershed. This includes building on a recent success: in 2021, the Dry Run Farmer-Led Council met with members of the Lake Mallalieu Association over two evenings to share perspectives on the challenges they face. On the first evening, they all met on-farm to talk about what the farmers are doing for conservation. The next night, they toured the lake by pontoon. These relationship-building events create an important opportunity for sharing information and ideas, finding common ground, building trust, and advancing watershed initiatives.
7. Conduct demonstrations and workshops showing proper installation of the following best management practices, such as rain gardens and shoreline restorations.

1.5 Statement of Need & Purpose

The Lake Mallalieu Association (LMA) and other users of the Lake value this important natural feature and the associated Willow River. These surface waters provide recreation opportunities such as boating, fishing, swimming, and simply enjoying the natural beauty of the Lake and river. All these factors contribute to a healthy lifestyle.

Lake Mallalieu and portions of the Willow River are federally-designated as “high priority” under the Environmental Protection Agency (EPA) 303(d) Impaired Waters Program. In 1998 a portion of the Willow River was designated as impaired due to low dissolved oxygen levels. In 2004, the EPA listed Lake Mallalieu as impaired due to excessive phosphorus and chlorophyll levels. EPA’s designation requires WDNR to prepare a nutrient TMDL (Total Maximum Daily Load) that addresses Lake Mallalieu and its upstream contributing area. The Lake St. Croix Nutrient TMDL was completed in 2012 (MPCA et al 2012) and addressed nutrients entering Lake St. Croix (including flows from the Willow River and Lake Mallalieu). Development of the TMDL was followed by an Implementation Plan (MPCA et al 2013). The TMDL plan outlines a strategy to reduce nutrient loading of Lake St. Croix (including nutrients flowing into Lake Mallalieu), in addition to increasing public awareness of the upstream implementation efforts

needed throughout the watershed. Specifics of the TMDL plan will guide nutrient reduction efforts for the Willow River/Lake Mallalieu watershed well into the future.

This Lake Management Plan continues the LMA's commitment of providing safe, multifaceted recreational opportunities for Lake users, whose numbers will continue to grow as area population continues to increase and development continues throughout St. Croix County (particularly as a result of the new St Croix Crossing Bridge). The LMA is also committed to a healthy environment, including protection of critical and sensitive habitats for native vegetation and wildlife. Implementing this Plan will help restore cleaner water for recreation as well as the Lake's high quality warm-water bass sport fishery. Good water quality will also restore healthy diverse aquatic vegetation and the bountiful numbers of panfish and northern pike which past users of the Lake so enjoyed.

1.6 Additional Watershed & Lake Management Actions

Many watershed studies, lake monitoring efforts, impairment designations, and TMDL studies have been completed that help understand and address the ecological health of Lake Mallalieu. Many of these are referenced above, but some of the most significant recent studies and other efforts include:

- LMA engagement with the St. Croix Basin Water Resources Planning Team (2019 and ongoing)
- 2017 Lake St. Croix TMDL Progress Report (WDNR 2019)
- 2016 Lake St. Croix TMDL Progress Report (MPCA et al 2018)
- Lake Mallalieu – Lake Management Plan (Lake Mallalieu Association 2014)

2. Management

2.1 Watershed Management

2.1.1 Restoration Elements

2.1.1.1 Stressor Inventory

- **Agricultural land practices** – Agriculture represents the most extensive land use in the watershed and the most impactful to Lake Mallalieu's water quality. ***Recent changes include conversion to different crops, crop residue management changes, heavier fertilizer application rates, and establishment of CAFOs within the watershed***. Phosphorous originates from a variety of sources, most of which are related to human activities. Major sources include human and animal wastes, municipal wastewater treatment plants, soil erosion, septic systems, lawn fertilizer, and municipal runoff.

- **Urban and residential land use** – Urban and suburban areas in the watershed produce a disproportionate amount of runoff due to impervious surfaces and stormwater collection systems. Some of these more densely populated areas are serviced by wastewater treatment plants, which represent point discharges of nutrients and other pollutants.

- **Degradation of natural habitats** – While natural plant communities (e.g., forests, woodlands, wetlands) exist in the watershed, many of these have been degraded by invasive species, artificial drainage, and other alterations. These impacts lead to increased runoff, erosion, and decreased water quality.

2.1.1.2 Required Load Reductions

From the 2013 Implementation Plan for the Lake St. Croix Nutrient TMDL:

> *The TMDL allows for 84,000 lbs/yr of phosphorus to be loaded to the St. Croix River from St. Croix County [including the majority of the Willow River/Lake Mallalieu watershed]. This requires 49,000 lbs/yr of reduction from the estimated TMDL baseline load of 133,000 lbs/yr in the early 1990s. St. Croix County's required reduction ranks 2nd largest among the 19 counties in the basin. To achieve the St. Croix Basin Partners' goal of 20% Reduction by 2020, St. Croix County needs to reduce loadings by 36,000 lbs/yr by the year 2020. To attain this goal, activities must be implemented that achieve an average annual rate of phosphorus reduction of 1,200 lbs/yr over 30 yrs., or 3,600 lbs/yr over 10 yrs.*

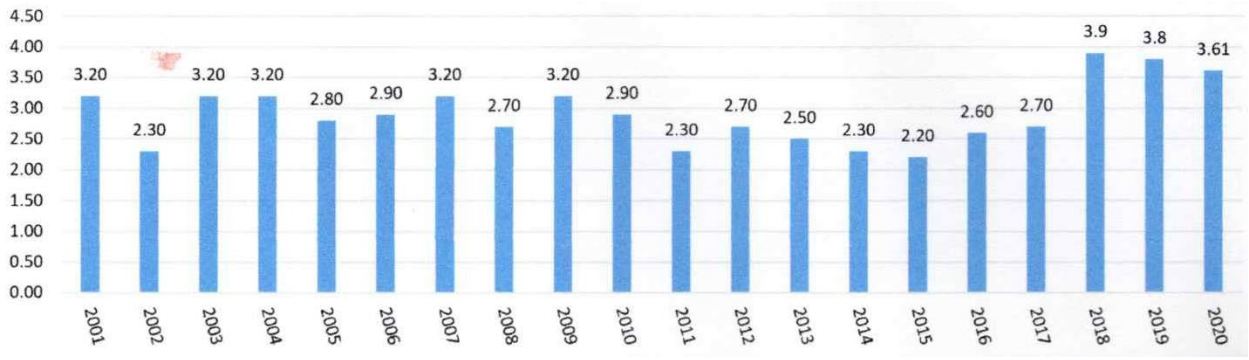
The WDNR is behind on their collection and analysis of surface water monitoring data; therefore, it is not known how effective efforts to date have been. However, the St. Croix County Land & Water Conservation Department's 2020 Annual Report's (St. Croix County 2020) documented achievements included the following.

- 1,074 lbs of phosphorus reduction
- 1,413 lbs of nitrogen reduction
- 1,479 tons of sediment reduction

- Numerous agricultural BMPs implemented and planned

Despite the County's progress and ongoing efforts, they also report 3.61 tons per acre of soil loss (Figure 3); this represents a three-year decreasing trend, but still a rate higher than it's been in the preceding two decades (St. Croix County 2020) It is submitted that these recent significant increases result from the changing land use practices identified in Section 2.1.1.1 above.

Figure 3. St. Croix County Soil Loss – Tons per Acre (St. Croix County 2020)



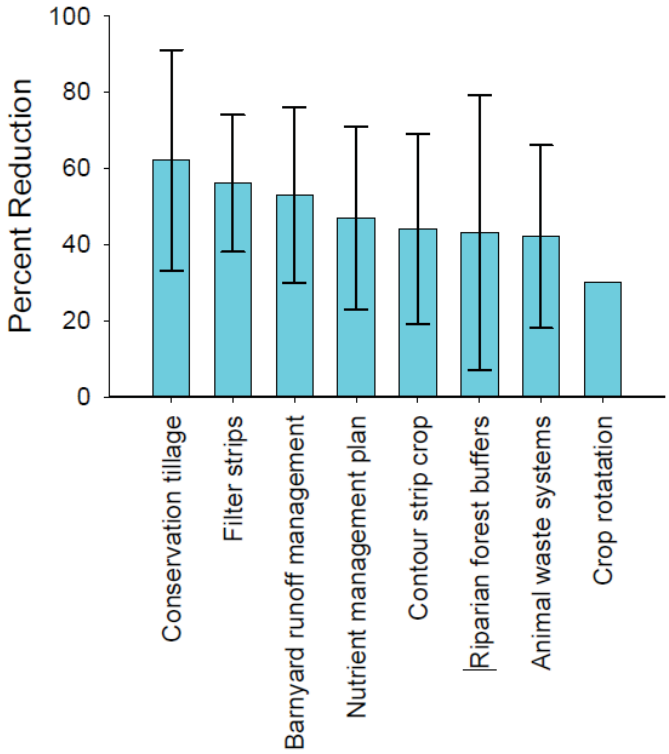
2.1.1.3 Restoration Recommendations

The following sections describe a variety of recommendations to improve Lake Mallalieu's water quality through improved land management in the watershed.

Agricultural Land BMPs

Per the WDNR, cropland runoff should be addressed to lower the export of nutrients and sediments. This will benefit all tributary streams, lakes, wetlands, the Willow River mainstem, Lake Mallalieu, and downstream waters such as the St. Croix River (Lake St. Croix). The existing Lake St. Croix Nutrient TMDL, as with all TMDLs, has the authority to limit phosphorus discharges from point sources within the watershed (e.g., wastewater treatment plants); however, management of non-point sources of phosphorus are still voluntary. Therefore, agricultural land practices within the watershed must be addressed through alternative strategies, such as voluntary and/or incentivized BMPs. Figure 4 presents several agricultural BMPs and the percent reduction in phosphorus they can achieve.

Figure 4. Phosphorus Reduction from Agricultural BMPs (Gitau et al 2015)



Based on RES's review of the Willow River/Lake Mallalieu watershed and its familiarity with Wisconsin agricultural practices, the following BMPs recommended, with their potential application shown on Exhibit 4.

1. All crop fields should use: a) cover crops, b) permanent vegetation strips, and e) ≥70% crop residue retainage. These BMPs apply to approximately 80,000 acres of the watershed (42% of the watershed and 72% of the agricultural acreage within the watershed).
2. In addition to item 1 above, all crop fields with > 6% slopes should use: a) grass waterways (along all intermittent drainageways) and b) continuous, one-pass, no-till farming. These BMPs apply to approximately 10,000 acres of the watershed (5% of the watershed and 9% of the agricultural acreage).
3. All crop fields with hydric soils should have: a) cover crops and b) permanent vegetation strips, as well as a wetland biofilter that cleanses runoff. These BMPs apply to approximately 1,400 acres of the watershed (<1% of the watershed and 1.3% of the agricultural acreage). Also consider non-growing season surcharging of tile or ditch systems in farmed floodplains and hydric soils to curtail oxidation of organic materials in soil.
4. Agricultural ditches with bare soil were not mapped during RES's 2020 watershed reconnaissance. Bare soil (i.e., erodible) ditch sections should be vegetated/stabilized with perennial native grasses, and extreme wet areas should be vegetated/stabilized with sandbar willow live stakes along with perennial native grasses.

5. Crop fields that receive manure also were not mapped during the reconnaissance, and it may be challenging to obtain such data. BMPs for these fields include: a) use composted manure, b) knife in the manure, and c) ensure containment and separation of manure from surface and ground waters.
6. All crop fields should use: a) just-in-time delivery of fertilizer, b) organic-bound, slow-release fertilizer or c) slow-release, osmocote fertilizer, and d) microbial soil health amendments. These BMPs apply to approximately 80,000 acres of the watershed (42% of the watershed and 72% of the agricultural acreage within the watershed).
7. Grazed pastures not already practicing conservation grazing were not mapped during the reconnaissance; however, this can be done in a later phase. Conventional grazing pastures should be converted to: a) Adaptive Multipaddock (AMP) grazing or b) fast rotation, long recovery, rotational grazing.
8. Runoff from CAFOs should be managed using stormwater BMPs to control this concentrated source of phosphorus and other contaminants.

Natural Habitat BMPs (potential application of these within the watershed are shown on Exhibit 5)

1. All forests, woodlands, and historical savannas and forested wetlands >5 acres should undergo restoration improvements to reduce invasive cover, allow ≥ 30% of ambient light penetration and promote native understory vegetation. These BMPs apply to approximately 26,800 acres (14%) of the watershed.
2. All pine plantations (not mapped during the reconnaissance but could be identified in a later phase) should have understory thinning of invasive shrubs to reduce shade suppression and consider planting heavy ground cover grasses just beyond the drip line of the outer-most pine rows.
3. All floodplain forests and wooded riparian wetlands and corridors (i.e., riparian management zones, or RMZs) should be managed within 100 feet of all channels. Vegetation should be managed to achieve light levels ≥30% of ambient and should entail: a) reduction of Boxelder (*Acer negundo*) and Silver maple (*Acer saccharinum*), and b) clearing of all non-native woody species (e.g., invasive buckthorn and honeysuckle). Prescribed burning should be considered as a long-term management practice, where appropriate. Road, skid trail, and livestock crossings over waterways should be properly planned, constructed, and maintained to minimize erosion. These BMPs apply to approximately 4,000 acres (2%) of the watershed.
4. Restore hydrology and native vegetation to drained wetlands (i.e., Potential Restorable Wetlands) to reduce organic soil decomposition and release of organically-bound nitrogen, phosphorus, and suspended solids. These BMPs apply to more than 7,300 acres (4%) of the watershed.
5. Establish native prairie grass buffers (minimum 50 feet) around all wetlands and drainageways. These BMPs apply to approximately 9,600 acres (5%) of the watershed. Prairie buffers around floodplains can be analyzed during a later phase.
6. Consider floodplain and larger hydric soil system buyouts or easements to allow these settings to be restored to wetland. These areas were not mapped during the reconnaissance, but this

could be done in a later phase. These areas can become the focus of conservation, land protection, and restoration.

7. Stabilize eroding streambanks (not mapped during the reconnaissance but this could be done in a later phase) using bioengineered solutions whenever feasible (e.g., soil lifts, live stakes). RES did identify and photo document examples of this issue in the watershed.
8. Existing rip rap on streambanks (not mapped during the reconnaissance but this could be done in a later phase) should be "joint-planted" with deep-rooted native vegetation (e.g., prairie cordgrass, sedges) to increase stability and habitat value.

Urban & Residential Area BMPs (potential application of these within the watershed are shown on Exhibit 6)

1. All wastewater treatment plants should monitor and report effluent phosphorus concentrations and loads to ensure they remain within their respective wasteload allocation per the TMDL and State of Wisconsin regulations. Variances should be immediately communicated to the WDNR and promptly corrected. In addition, trend analysis/modeling should be conducted to predict if the problem is likely to reoccur in the near future, in which case proactive actions should be taken to avoid or minimize such events.
2. Fully implement all elements of the City of Hudson's Municipal Separate Storm Sewer Systems program. This includes understanding existing conditions, determining required pollutant reductions, identifying and targeting BMPs, and demonstrating compliance. This includes end-of-street stormwater BMPs (e.g., rain gardens), which reduce and clean runoff.
3. Manage construction and industrial runoff using stormwater BMPs.
4. Ensure individual septic systems are not failing (i.e., releasing phosphorus and other contaminants to the environment).
5. Minimize connected (contiguous) impervious surfaces (which create and convey runoff), especially near surface waters.
6. Establish water quality buffers of perennial native vegetation around the Lake shoreline, Willow River banks, and around other drainages or waterways that flow into the Lake. These buffers prevent erosion through dense and deep root systems, promote infiltration of surface water into the ground, and filter out sediments and other pollutants before surface runoff reaches surface waters.
7. Establish native landscaping, which reduces inputs (e.g., fertilizer, pesticides, watering) and eliminates need for watering and fertilizing.
8. Install gutters, rain barrels, downspout re-direction to infiltration areas (e.g., flat lawn), and rain gardens to reduce, clean, and/or re-use runoff for watering of vegetation.
9. If fertilizer is applied, use slow-release osmocote fertilizer, which results in less nutrient runoff.
10. Manage pet waste and lawn debris (e.g., grass clippings and fall leaves) such that they do not leach phosphorus or wash into surface waters.

2.1.1.4 Capacity Recommendations

LMA has limited resources (people and finances) to address the magnitude of issues faced by Lake Mallalieu. Therefore, in order to address the Lake's water quality and related challenges (and achieve the goals of upstream and downstream stakeholders), LMA seeks to expand its partnerships with other stakeholder groups in order to secure the substantial technical and financial resources necessary to implement the recommendations in this Lake Management Plan. Only with such partnerships and support will the goals of the LMA and numerous other stakeholders be realized.

2.1.1.5 Examples of BMP Projects & Partnerships in the Watershed

The 2016 Lake St. Croix TMDL Progress Report (MPCA et al 2018) identified two projects within the Dry Creek Run tributary of the Willow River/Lake Mallalieu watershed. These are two recent, local examples of partnerships developed to implement BMP addressing water quality impairments.

- **National Fish and Wildlife Foundation "Dry Run Creek" Streambank Stabilization Demonstration site, Willow River Watershed**. In 2016, with aid from its National Fish and Wildlife Foundation partners, St. Croix County Resource Management completed approximately 500 feet of shoreline stabilization along Dry Run Creek, a tributary to the Willow River. The demonstration project consisted of reshaping 500 lineal feet of streambank for the purpose of remediating severe bank erosion. Upon completion of native seeding, erosion fabric was installed in an effort to armor the bank. In addition, a further focus of the project was to repair an existing gully that had formed at the outlet of an existing waterway. The waterway discharged to Dry Run creek at the midpoint of the demonstration project. The gully and associated waterway were regraded and stabilized to reduce nutrient and sediment loading to the Dry Run.
- **Introduction of Precision Agriculture methods within Dry Run Creek, focused on both profitability and conservation stewardship**: Also in 2016, Resource Management and NRCS staff introduced a precision Ag "tool" to Farmer-Led Council producers within Dry Run Creek. The "tool" utilizes data acquired by means of GPS, which in turn is used to analyze the profitability of a given crop field and or a specific portion of the field. Based on the results from the analysis, decisions can then be made as to which parts of a field are not profitable. Non profitable areas of production are thus good candidates for long-term conservation programs and sediment-reducing BMPs, which can be facilitated by programs and conservation practices such as the Conservation Reserve Enhancement Program (CREP), riparian buffers, and filter strips.

2.1.2 Protection Elements

2.1.2.1 Threat Inventory

Preceding section 2.1.1 "Restoration Elements" focuses on natural and other resources in the watershed that have been degraded; hence "restoration" is warranted. Threats to these resources (i.e., agricultural land practices, degradation of natural habitats, and urban and residential land use) are described in

subsection 2.2.1.1 below, "Stressor Inventory", the first subsection in section 2.2.1, "Restoration Elements". Additional threats to the protection of natural resources include:

- **Natural areas conversion to crop fields** (e.g., clearing prairie or natural pastures and planting row crops, or clearing native trees to create open pasture). Such conversions result in the loss of natural habitats and the many ecosystem services provided by those areas. Additionally, these conversions increase habitat fragmentation and degradation of remaining natural areas due to "edge effects". Natural area conversions in the Willow River/Lake Mallalieu Watershed include forest and woodland clearing and perennial grassland (e.g., semi-natural pasture) conversion to row crop production. Conversion of forests, woodlands, and perennial grasslands to crop fields results in increased runoff, erosion, and nutrient enrichment of surface waters.
- **Agricultural land conversion to urban land.** Urban and rural residential development continues in the watershed, often occupying former agricultural land (which previously consisted of natural areas). While conversion of crop fields to urban land may result in less annual soil disturbance and associated erosion and nutrient export, developed lands often promote more runoff and contribute additional contaminants to surface waters (e.g., fertilizer, pesticides and fecal coliform from pet waste).

2.1.2.2 Protection Recommendations

Natural areas can be protected from conversion, and agricultural lands can be managed to better conserve soil, reduce erosion, and minimize nutrient loss to surface waters. Practices and programs that can help protect natural areas and promote more sustainable/renewable agricultural practices, include, but are not limited to:

1. NRCS/USDA cost-share programs (e.g., Environmental Quality Incentives Program, EQIP: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/wi/programs/financial/eqip/?cid=nrcs142p2_020742)
2. USDA/FSA Conservation Reserve Program (CRP: https://www.fsa.usda.gov/Internet/FSA_File/crpfactsheet0213.pdf)
3. Farmland Preservation Program: (https://www.sccwi.gov/370/Farmland-Preservation-Program)
4. St. Croix County Land & Water Resource Management Plan (including cost-share opportunities: https://www.sccwi.gov/DocumentCenter/View/3536/St-Croix-County-Land--Water-Resource-Management-Plan-PDF?bidId=)
5. St. Croix County – Willow River Water Quality Project (cost-share program for agricultural and other restoration/stabilization projects on the Southfork of the Willow River and the Black Brook Creek): https://www.sccwi.gov/980/Willow-River-Water-Quality-Project

2.1.2.3 Capacity Recommendations

As stated above, the LMA has limited resources to address the magnitude of issues faced by Lake Mallalieu; therefore, it seeks to expand its partnerships with other stakeholder groups and secure the resources necessary to implement the recommendations in this Lake Management Plan. The *Implementation Plan for the Lake St. Croix Nutrient TMDL* (MPCA et al 2013) recommends a variety of job positions to help meet the phosphorus reduction needs of St. Croix County (which encompasses virtually all of the Willow River/Lake Mallalieu Watershed). Filling these positions will greatly enhance

the likelihood of meeting the goals of this Lake Management Plan.

2.2 Shoreland/Riparian Management

Shoreland/riparian management addresses land use and activities along the shore of Lake Mallalieu, including the upland areas (i.e., shoreline buffers) and shallow water areas (i.e., littoral zone) near the lake shoreline.

2.2.1 Restoration Elements

2.2.1.1 Stressor Inventory

- **Degradation of Natural Shoreline Buffers**. Shoreline buffers provide a variety of important water quality and ecological functions. These functions are typically best served by permanent, deep-rooted perennial native vegetation, which maintains stable soils, filters and infiltrates runoff, and provides diverse habitat for native wildlife. Shorelines are often altered or cleared on residential waterfront property and replaced with lawn, gardens, riprap, or beach sand. These conversions result in the loss of most if not all functions provided by natural shoreline buffers.
- **Degradation of Littoral Habitat**. Littoral (i.e., shallow, near-shore) areas are critically important habitats in lakes. These zones provide habitat for emergent wetland vegetation and often contain "structure" such as downed trees (i.e., woody debris); these combined living and dead vegetation features create habitat important for desirable wildlife, including game fish, birds, turtles, amphibians, and other native wildlife. Emergent vegetation also reduces the erosive effect of waves and boat wakes, helping to protect shorelines from erosion. Alteration or clearing emergent native vegetation and removing woody debris reduces plant and wildlife habitat and can increase shoreline erosion.

2.2.1.2 Restoration Recommendations

Lake Mallalieu Shoreline & In-Lake BMPs (potential application of these within the watershed are shown on Exhibit 7)

1. Enhance or re-establish naturalized Lake shorelines where they no longer exist. The buffer zone will preferably extend at least 30 feet inland from the water line and consist of permanent, native vegetation that maintains stable soils and provides diverse habitat for wildlife.
2. Educate Lake residents on measures to improve habitat for native animals, fish, insects, and birds, consistent with St. Croix County's Shoreland Zoning Ordinance (St. Croix County Land Use Ordinance Chapter 17-17.30 Zoning; Subchapter III Shoreland).
3. Advise and assist homeowners on the proper plants, trees, and buffers to establish in lakeshore areas (refer to USDA Natural Resource Conservation Service Technical Note: Shoreland Habitat Standard).
4. Enhance or re-establish native, emergent vegetation, woody debris (i.e., "structure" for fish habitat), and other littoral habitat. WDNR has agreed to work with the LMA and other stakeholders to promote the use of fish cribs as beneficial fish habitat. WDNR will lend expertise

to the beneficial types available to residents and help facilitate the necessary permit applications that are required as a condition of placing woody debris within the Lake.

5. Inventory existing rip rap shorelines to identify opportunities for shoreline plantings and restoration. Existing riprap shorelines can be naturalized and enhanced with joint-plantings (i.e., install live stakes of native shoreline shrubs and/or native herbaceous plants (e.g., grasses, sedges, wildflowers) between the rocks.
6. Inventory eroding shorelines to identify opportunities for stabilization. Revegetate these areas with deep-rooted native vegetation (e.g., prairie cordgrass, sedges) to increase stability and habitat value.
7. Establish and publicize demonstration projects of the above practices (e.g., native shoreline buffers, healthy littoral habitat, re-vegetated riprap, and stabilized shorelines).
8. Conduct voluntary shoreline habitat assessments, in cooperation with St. Croix County Resource Management staff. Identify opportunities for protection and restoration.
9. Work with St. Croix County's Resource Management Division to: 1) explore available grants, best management practices, and cost-sharing opportunities, and 2) provide seminars and workshops for the community. Workshops may cover rain garden design and installation, lakeshore restoration options, and other surface water runoff control measures.

2.2.2 Protection Elements

2.2.2.1 Threat Inventory

- **Loss of Natural Shoreline Buffers**. As described above, shorelines are often cleared on residential waterfront property and replaced with lawn, gardens, riprap, or beach sand. These conversions result in the loss of most if not all functions provided by natural shoreline buffers.
- **Loss of Littoral Habitat**. As described above, clearing emergent native vegetation and removal of woody debris reduces plant and wildlife habitat and can increase shoreline erosion.

2.2.2.2 Protection Recommendations

Protection Recommendations are similar to the Restoration Recommendations in Section 2.1.1.2 above:

1. Inventory and protect intact natural shoreline buffers of native perennial vegetation.
2. Inventory and protect existing areas of native emergent vegetation, woody debris, and other healthy littoral habitat.
3. Discourage the use of riprap except where hard-armoring is necessary to control erosion. Instead, use bioengineering techniques and littoral wetland restoration/enhancement to protect shorelines.
4. Educate Lake residents on ways to increase habitat diversity for native vegetation and wildlife, including waterfowl.
5. Explore the possibility of installing 'fish cribs" in deep water areas of the Lake for the purpose of enhancing deep habitat for fish.
6. Educate residents on state and municipal laws relating to lakeshore development or modification and educate residents on the roles played by state and municipal agencies.
7. Work with Lake residents to reduce impacts of storm water runoff from their properties by incentivizing clean water diversions and rain gardens.

8. Educate residents about eliminating fertilizer runoff from their properties and conduct periodic soil testing to evaluate soil test phosphorus and nitrogen levels.

2.3 Waterbody/In-Water Management

2.3.1 Restoration Elements

Lake Mallalieu is an artificial impoundment of the Willow River. However, despite its human construction, it formerly represented a healthy, albeit shallow, lake, offering habitat for native vegetation, fish and other wildlife and a variety of recreational opportunities. It's current condition (the result of the stressors listed above and below) presents an opportunity for restoring much of the Lake's former health and uses.

2.3.1.1 Stressor Inventory

- Naturally-occurring nutrient loading was greatly exacerbated by the removal of the Willow Falls Dam in 1992 and the Mounds Plant Dam in 1997.
- In late 2107 and throughout 2018, the equivalent of many decades of suspended nutrients, together with large amounts of silty muck, were released into Lake Mallalieu from Little Falls Lake as it was drained in anticipation of replacing its dam.
- Sediment accumulation is a common issue in lakes formed by damming rivers, such as Lake Mallalieu. While the Lake has been slowly collecting sediment washed down the Willow River, the 2017-2018 dam demolition breach and the 2019 construction site breach just upstream of the Lake represents an acute and substantial load of sediment. Regular lake users have experienced a noticeable increase in sediment and reduction in water depth, making dock access and boat usage challenging, if not impossible, in many portions of the Lake.
- While phosphorus is a naturally-occurring element, its high concentration in the Lake is the primary cause of algae blooms, and it also promotes aggressive growth of aquatic invasive plants. The Lake's shallow morphology and presence of sediment-disturbing carp lead to regular resuspension of Lake-bottom sediments and associated phosphorus, making it readily available in the water column for algae and aquatic invasive plant growth.
- Aquatic invasive plants are relatively abundant in Lake Mallalieu. The nutrient-rich water promotes their growth and spread, which displaces native aquatic plants, degrades aquatic habitats, and creates a nuisance for Lake boaters and swimmers.
- Populations of carp have been a concern in Lake Mallalieu for decades due to their "rooting" through lake sediments, which mobilizes nutrients, phosphorus included, leading to reduced water quality and clarity and greatly increased algae growth.
- Legacy applications of arsenic-containing herbicides (applied to the Lake starting in the 1960s) are believed to remain present in lake sediments. This heavy metal represents a potential health hazard, especially to aquatic wildlife, and, unless appropriate measures are taken, disturbance of sediments can mobilize this contaminant.

2.3.1.2 Restoration Recommendations

1. Consolidate Lake sediment using Geotubes®, creating shallows and habitat islands near the upper Lake's delta and select shallow bays. Potential use of Geotubes® would require additional investigation to establish feasibility, design, and permitting.
2. Remove Lake sediments using a hydraulic dredge. While this would remove the sediment

entirely from the Lake (as well as adhered nutrients and potentially other contaminants), this approach requires a dewatering facility and sediment disposal location. These requirements can add significantly to cost and permitting duration.

3. Alum treatments are common in lakes to remove phosphorus from the water column, transferring it to bottom sediments. However, the shallow morphology of the Lake would make such treatments less effective (due to wind and boat-caused re-suspension of lake-bottom sediments). Therefore, Lake Mallalieu does not appear to be a good candidate for alum treatment.
4. Aquatic plant control should be conducted only when the vegetation is at a level that interferes with usage of the Lake. Mechanical plant harvesting has been viewed as not viable by the LMA due to its relatively high cost; however, at times this control method may represent the best alternative for relief from this chronic Lake issue. Drawing down the Lake and allowing the substrate to freeze can provide some control of aquatic invasive vegetation; however, this technique requires permitting and impacts native aquatic vegetation and wildlife as well. Chemical control of invasive vegetation will only be permitted by the WDNR as a last resort. LMA could conduct continuing education through newsletters, meetings, guest speakers, distributing WDNR publications, and providing a lake homeowners guide to residents along and near the Lake to help reduce the introduction and spread of aquatic invasive species.
5. The WDNR conducts fish surveys of the Lake, ideally on a 12-year rotation. During these surveys (or sooner if possible), WDNR staff (or private contractor) should conduct near-shore electrofishing surveys for carp to estimate their population in the Lake. If determined to be problematic, control measures can be assessed and implemented, such as on-ice winter seining to remove carp from the Lake.
6. Lake users should understand the beneficial aspects of aquatic plants, woody debris, and wild shorelines for Lake Mallalieu's fish and wildlife. The LMA can help residents understand the interdependent relationship between aquatic plants, shoreline plants, fish and wildlife.
7. Regarding potential heavy metal contamination in the Lake, a systematic sampling of lake-bottom sediments should be conducted and analyzed for common heavy metals including arsenic. This is the first step to better understand the spatial distribution and concentration of heavy metals in the lake, which will inform next steps in a potential remediation plan.

2.3.2 Protection Elements

The above Section 2.3.1, "Restoration Elements," presents Stressors to the Lake and Restoration Recommendations. Many of those Stressors can be seen as Threats, and many Restoration Recommendations can be seen as Protection Recommendations. Some additional Threats and Recommendations regarding Lake protection follow.

2.3.2.1 Threat Inventory

- For decades, aquatic invasive species (AIS) have been a threat to the health of the Lake. Regrettably, they will continue to be a challenge for the foreseeable future.
- Removal of emergent and submergent vegetation growing in the Lake's shallows removes and/or degrades aquatic habitats and reduces protection of the lakeshore, leading to an increase in erosion. Removal of woody debris in the Lake's shallows reduces lakeshore protection and also represents a loss of healthy habitat for native fish and other wildlife.

2.3.2.2 Protection Recommendations

- Educational materials, signage, and cleaning facilities provided at the Lake's public landing will help prevent continued introduction of AIS into the Lake.
- Protect the density and quality of submergent and emergent plant beds and retain woody debris for the benefit of fish and other aquatic life.

3. Alternatives & Decision-Making

3.1 Alternatives Analysis

Management objectives that were considered but are not recommended included:

1. Aquatic herbicide applications in the Lake to control invasive aquatic vegetation. While such applications can be effective in the short-term, they address the symptom and not the cause of the problem. These applications are also costly, and they impact non-target native aquatic plants, which are beneficial to a healthy ecosystem. Therefore, the LMA has decided not to pursue such herbicide applications in the Lake.

3.2 Decision-Making Framework

Lake Mallalieu's greatest issues revolve around increased sediment and nutrient loadings from upstream; therefore, *the greatest needs for interventions and the greatest gains in improving the Lake's condition lie within the Willow River/Lake Mallalieu Watershed*. Watershed issues are often best addressed by agencies and groups that have widespread influence over the many landowners that manage these expansive areas, especially agricultural landowners, which occupy the vast majority of the watershed (67% !!). Based on RES's experience with lake planning, watershed management principles, and discussions with WDNR staff, St. Croix County staff, and the LMA, RES recommends that watershed issues be addressed by continuing to work with WDNR's Surface Water Quality program, St. Croix County's Resource Management Division, and the St. Croix Basin Water Resources Planning Team. The LMA is already actively engaged with these entities, and they will continue to support efforts to improve the ecological health of the Willow River/Lake Mallalieu watershed, Lake Mallalieu itself, and Lake St. Croix.

With watershed issues being addressed through LMA's continued partnerships with other organizations, the LMA can also focus on achieving its goals for the Lake by implementing actions around the shoreline (primarily to improve runoff water quality and riparian/littoral habitats) and addressing in-water projects (focused on sediment management). LMA's ability to demonstrate successes with management on the Lake shoreline and in the Lake will help compel others within the larger watershed to contribute to improvements at the watershed scale.

This Lake Management Plan takes a holistic approach to identifying stressors and threats that can be

addressed to restore and protect Lake Mallalieu. WDNR guidelines recommend Lake Management Plans address these issues from three spatial perspectives: 1) the watershed, 2) the shoreland/riparian zone, and 3) in the Lake itself. A similar approach was taken by RES during preparation of the Lake Mallalieu Restoration Plan – Phase 1 report (AES 2020).

Table 4 is based on the draft solutions matrix developed for that Phase 1 plan, and categorizes alternatives in a similar fashion:

- **Watershed**: see "Agricultural Land BMPs", "Natural Habitat BMPs", and the applicable "Urban & Residential Area BMPs"
- **Shoreland/riparian**: some "Urban & Residential Area BMPs" and the relevant "Lake Mallalieu Shoreline & In-Lake BMPs"
- **Waterbody/in-water**: applicable "Lake Mallalieu Shoreline & In-Lake BMPs"

The table outlines four categories of BMPs (Agricultural Land, Natural Habitat, Urban & Residential Area, and Shoreline & In-Lake) that have been proven to be effective at: 1) reducing runoff and associated sediment and nutrient loading to surface waters and 2) restoring historical lake depths. Table 4 column headings are defined as follows:

- **Issue** – Overarching issue to be addressed.
- **Solution** – Proven BMP.
- **Scale of Need** - Importance as reflected by both the acreage of the landscape generating excessive phosphorus and the per-acre discharge of phosphorus from each land use type (per TMDL modeling study).
- **Benefit** - Magnitude of the potential benefit that could be achieved.
- **Cost** - Relative cost of the effort.
- **Time to Accomplish** - How long it will take to engage with landowners/partners to accomplish the solution.
- **Preliminary Unweighted Opportunity Score** - Semi-quantitative method of prioritizing implementation of these BMPs; averages were used where multiple scores presented. The actual order in which each challenge can be addressed will depend on the good will and trusting relationships created, as well as new funding and cost-savings opportunities created for all parties.
- **Funding** - Potential opportunity (through existing or creative financing) to address the issue.

Table 4. Solutions Matrix from Lake Mallalieu Restoration Plan (modified from AES 2020)

Issue	Solution	Scale of Need (1=low, 2=med, 3=high)	Benefit (1=low, 2=med, 3=high)	Cost (3=low, 2=med, 1=high)	Time to Accomplish (1=slow, 2=med, 3=fast)	Preliminary Unweighted Opportunity Score (higher=better)	Funding (A=USDA funding available, B=other sources available, C=new sources needed)
A. Agricultural Land BMPs (opportunities shown on Exhibit 4)							
1. Farm field erosion & nutrient loss: *keep the ground covered with crop residue or living green plant tissue year-round*	a) Cover crops	3	3	3	1	10	A,B,C
	b) Permanent vegetation strips	3	3	3	1	10	A,B,C
	c) Grass waterways in all intermittent drainageways	3	3	2	2,3	10.5	A,B,C
	d) Continuous, one-pass, no-till	3	3	2,3	2,3	11	A,B,C
	e) ≥70% crop residue retainage	3	3	2	2	10	B
2. Manure management: *contain & disperse manure that is stable*	a) Compost it before application	3	3	1	1	8	B
	b) Knife in manure	3	2	3	3	11	C
	c) Containment and separation from surface and ground waters	3	3	1,2	3	10.5	A,B
3. Fertilizer formulation: *use of low volatility, low solubility, stable fertilizers*	a) Use just-in-time delivery of fertilizer, attuned to crop needs	3	3	1	1,2,3	9	A,C
	b) Use organic-bound, slow-release fertilizer	3	3	1	2,3	9.5	A,B,C
	c) Use slow-release, osmocote fertilizer	3	3	2	1,2,3	10	A,C,
	d) Improve microbial health	3	3	2	2,3	10.5	A,B,C
4. Grazing: *practice conservation grazing*	a) Conversion to Adaptive Multipaddock (AMP) grazing rather than continuous, hard, conventional grazing	3	3	2	2,3	10.5	A,B,C
	b) Conversion to fast rotation, long recovery, rotational	3	3	3	2,3	11.5	A,B,C

Issue	Solution	Scale of Need (1=low, 2=med, 3=high)	Benefit (1=low, 2=med, 3=high)	Cost (3=low, 2=med, 1=high)	Time to Accomplish (1=slow, 2=med, 3=fast)	Preliminary Unweighted Opportunity Score (higher=better)	Funding (A=USDA funding available, B=other sources available, C=new sources needed)
	grazing						
B. Natural Habitat BMPs (opportunities shown on Exhibit 5)							
5. Invasive vegetation management: *increase light, stabilize soils, and promote desirable native vegetation*	a) Upland forest, woodland and historical savanna restoration	2	2	1	3	8	A,B,C
	b) Pine plantation improvement	1	2	2	2	7	A,C
	c) Floodplain forest & wooded riparian corridor restoration	3	3	1	3	10	A
6. Restore hydrology & native vegetation: *increase acreage of wetlands & protect surface water resources*	a) Wetland restoration, including floodplain restoration and retirement from cropping	3	3	1	3	10	A,B,C
	b) Establish native prairie grass buffers around all wetlands, streams, floodplains and drainageways	3	3	2	3	11	A,B,C
7. Streambank stabilization: *reduce erosion*	a) Stabilize eroding stream/riverbanks, using bioengineered solutions whenever feasible	3	3	1	3	10	A,B,C
	b) Joint-plant existing rip rap along streams/rivers	1	1	3	3	8	A,C
C. Urban & Residential Area BMPs (opportunities shown on Exhibit 6)							
8. Reduce & clean runoff: *reduce nutrients & sediments leaving yards, parks, and ROW, especially when flow directly into storm sewers*	a) Establish native landscaping	2	2	2	2	8	B
	b) Install rain gardens, rain barrels and downspout re-direction	3	2	2	3	10	A,B
	c) Install end-of-street stormwater BMPs	3	3	2	3	11	A,B,C
	d) If fertilizer applied, use	3	3	1	3	10	A

Issue	Solution	Scale of Need (1=low, 2=med, 3=high)	Benefit (1=low, 2=med, 3=high)	Cost (3=low, 2=med, 1=high)	Time to Accomplish (1=slow, 2=med, 3=fast)	Preliminary Unweighted Opportunity Score (higher=better)	Funding (A=USDA funding available, B=other sources available, C=new sources needed)
	slow-release osmocote fertilizer						
D. Lake Mallalieu Shoreline & In-Lake BMPs (opportunities shown on Exhibit 7)							
9. Naturalize, stabilize & enhance lake: *establish & maintain native vegetation & habitat*	a) Establish naturalized lake shorelines	2	2	2	2	8	A,B,C
	b) Joint-plant existing rip rap shorelines	2	2	3	1,2	8.5	A,B,C
	c) Consolidate sediment using Geotubes®, creating shallows and islands or hydraulic dredging & disposal off site	3	3	1	2	9	A,B
	d) Draw-down lake & freeze for invasive vegetation management	1	2	3	2,3	8.5	A

4. Broader Impacts

4.1 Collaborative Process & Stakeholder Involvement – Watershed Scale

Any land or water quality improvement project ultimately requires the support of those who live in and nearby if it is to be successful over the long-term. In addition to the stakeholders identified above in Section 1.4 on page 22, local neighborhood associations, community groups, homeowner associations, and similar groups interested in protecting water resources, open space, shaping development, or protecting wildlife habitat and scenic vistas, make the best partners for specific projects. Those organizations ought to be involved in the context of specific individual projects.

The following general guidance is provided to help organize watershed-focused planning and actions.

4.1.1 Organize a governance and structuring process so everyone benefits.

- Farmers benefit from preventing loss of topsoil, improved revenues, reduced costs, and a deeper/wider, value-added base of consumers who can purchase farm-produced crops, goods, etc.
- Lake homeowners benefit from more attractive and predictable aesthetics, improved water quality, and healthy and safe lake recreational opportunities. These benefits can be achieved by reducing both internal and external nutrient loading, restoring lake depths, installing more diverse and stable shorelines and by using Geotubes® to better manage sediment and create wildlife habitat.
- Both farmers and lake homeowners need greater certainty on these outcomes.
- A governance structure encompassing most all of the watershed and striving to deliver greater certainty could have several fundamental goals:
    1. Convey the connection and opportunity of improved farming to reduce runoff (including reduced nutrients, sediments, and flood waters) and improve watershed and Lake water quality.
    2. Reward farmers for adopting improved farming practices proven to reduce runoff and erosion while improving water quality in the watershed.
    3. Promote to lake homeowners the benefit of durable relationships with farmers and the farming community.

4.1.2 Recognize the value of each funding source, but also their limitations.

- Farm programs alone will not solve the problem of excessive erosion and nutrient runoff from agricultural lands.
- Farm programs will not address degraded stream and river channels, disconnected floodplains, invasive species, and failing oak savannas.

- Changing market drivers have resulted in the reduction of Conservation Reserve Program (CRP) land, reduction in small dairy farms, and conversion to large-scale, intensive farming in order to achieve higher yields.
- Agriculture practices are changing simultaneously with storm intensification; therefore, meaningful and sustainable solutions will need to be strong and durable–just like the commitments of the participants.

4.1.3 Organize a participatory process.

- Only by working together can watershed-scale problems be addressed.
- Farmers are some of the most creative and innovative individuals on Earth; working together with this creative force is imperative to achieving LMA's goals.
- In many locations, farmers have been over-surveyed and over-engaged, and the participatory process has been burdensome.
- The farmer-led councils in St. Croix County have been some of the most advanced in Wisconsin, suggesting that there may be a constructive springboard opportunity for LMA and the farmer-led cooperatives to work together to create a participatory process that could be very practical and powerful.

4.1.4 Create trusting relationships between landowners in the watershed.

- Farmers and lake homeowners run on trust. Building trusting relationships will be essential to create a healthier watershed and Lake.
- RES has used some innovative strategies in facilitated meetings to quickly build trust, such as the "Places of the Heart" process. Another is "exchange" tours of the lake and demonstration farms, the first of which occurred in September, 2012. Other strategies include ways to socialize and get to know one another, helping all to recognize their similar goals and aspirations for the future. LMA could sponsor social events to help farmers get to know others in the watershed, build trust, and start a conversation about how they could work together to improve the Willow River/Lake Mallalieu watershed for farming, water quality, recreation, etc.
- One promising opportunity is collaborating with key landowners in the Willow River/Lake Mallalieu watershed, such as the primary farmer who grows/harvests all crops for Emerald Dairy (a large CAFO). This farmer lives right at the head of Dry Wash Creek and farms over 10,000 acres. The hope is this farmer would be amendable to using cover crops and other practices if funding were available to assist.

4.1.5 Link upstream and downstream watershed landowners.

- Neither farmers nor lake homeowners likely understand the watershed as a whole. Topsoil and nutrients are the life blood of the farm, so erosion and nutrient runoff is literally money down the drain for farmers.
- Stitch together the watershed by "creating strong bonds between people of place"—that is, farmers and lake homeowners, and other landowners and others (e.g., visitors) who use resources in the watershed.

- Explore opportunities for nutrient trading, such as between willing landowners (e.g., farmers) and nutrient sources, such as municipal wastewater treatment facilities in the Willow River/Lake Mallalieu Watershed.
- Regenerative agriculture practices (which would benefit the Willow River watershed and Lake Mallalieu) could be incentivized (or perhaps completely paid for) through the sale of carbon credits to entities outside the watershed.

4.2 Collaborative Process & Stakeholder Involvement – Shoreland/Riparian and Waterbody/In-Water Scale

The primary stakeholders at the Shoreland/Riparian and Waterbody/In-Water scales are residents around the perimeter of Lake Mallalieu and frequent recreational users of the Lake. Strategies to collaborate and engage with these stakeholders include the following:

- Promote increased membership in the LMA (currently 86% of lakeshore owners are members). Continue to encourage all lakeshore residents to attend Lake Association meetings and functions.
- Use the LMA website (www.lakemallalieu.org) and Facebook page (https://www.facebook.com/LakeMallalieu/) to share information on a regular basis to Lake owners and surrounding communities.
    - Water quality and aquatic plant updates (based on analytical sampling and anecdotal observations)
    - Lake-friendly landscaping (e.g., native lake buffer plantings) and lawn care practices (e.g., use non-phosphorus fertilizer if you *must* fertilize)
    - Runoff management techniques for improved water quality (e.g., rain gardens)
    - Legal methods for managing aquatic vegetation
    - Upcoming workshops and events related to the Lake
- Provide a printed semi-annual newsletter to LMA members. Distribute hundreds of copies of the printed newsletter to businesses and other organizations throughout Hudson and North Hudson to increase awareness of the Lake's value to the community and challenges faced by the Lake.
- Work with St. Croix County's Resource Management Division, WDNR and UW Extension to develop a "New Homeowner Packet" to be distributed to all Lakeshore residents. This packet would include information similar to that provided on the LMA website.
- Conduct an annual review of the current Lake Management Plan to evaluate progress and institute a path to achieve goals in a timely manner.

5. Implementation

5.1 Detailed Implementation Plan

Implementation of this Lake Management Plan will require the concerted effort of: the LMA, federal, state, and local agencies and municipalities, and a wide range of other partners and stakeholders (including the agricultural community) throughout the Willow River/Lake Mallalieu watershed. This Plan's primary management goals are listed below, followed by more specific tasks to help achieve each these goals.

1. **Improve water quality** in Lake Mallalieu.
    a. Increase public education & outreach (to LMA members and beyond) regarding water quality.
        i. Update and expand LMA's website to better reflect water quality issues and opportunities landowners have to improve water quality, including grant opportunities (Appendix 5).
        ii. Sponsor an annual open house and celebration on the lake, including educational handouts on lakeshore management for improved water quality.
        iii. Maintain a table / booth at civic events.
    b. Sustain and strengthen partnerships to work toward improved runoff management throughout the watershed.
        i. Continue to engage with and support the Interagency St. Croix Basin Team.
        ii. Engage with the City of Hudson, the Village of North Hudson, and Hudson Township to identify stormwater BMP opportunities and work to implement at least one BMP in each community.
2. **Improve aquatic habitat** for fish and wildlife, including removing aquatic invasive vegetation and enhancing the native aquatic plant community for improved fishery.
    a. See strategies listed above under "Improve water quality".
3. **Remediate in-lake sediment** resulting from the Little Falls Dam project.
    a. Retain a qualified professional firm to conduct a feasibility report for sediment removal or relocation within the Lake.
    b. Assuming the feasibility study supports proceeding, proceed with a qualified professional firm to design and permit the project.
    c. Retain a qualified professional firm to oversee implementation/construction the project by a qualified professional contractor.

Recommended implementation tasks are scheduled in Table 5.

Table 5. Implementation Tasks & Schedule

	2022				2023				2024				2025				2026			
Task	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1a. Public education & outreach																				
i. Update & expand LMA website to address water quality issues																				
ii. Sponsor community open house																				
1b. Sustain & strengthen watershed partnerships																				
i. Support Interagency St. Croix Basin Team																				
ii. Engage with Hudson & North Hudson to identify and implement BMPs																				
2a. Public education & outreach																				
i. Update & expand LMA website to address aquatic habitat issues																				
ii. Sponsor community open house																				
3a. Conduct sediment management feasibility study																				
3b. Proceed with design & permitting																				
3c. Proceed with implementation																				

5.2 Monitoring of Outcomes

Monitoring is a critical step in any management program, whereby information is collected and compared against goals to ensure progress is being achieved at an acceptable rate. Desired outcomes are representative of achieving goals; Table 4 above (Solutions Matrix) summarizes the goals of this Lake Management Plan and describes recommended monitoring strategies to evaluate progress and success. Monitoring should include an ongoing checklist of which of the identified solutions have been implemented (including who completed the effort and when) and which are left to be addressed. Updates should be performed at least annually so that adaptive management can be implemented if necessary.

Changes in agricultural management practice implementation, such as tillage conditions within the watershed, can be difficult to assess and track over time. Recently, analysis of satellite imagery has been used to track these changes in conservation practices at the watershed scale. Since tillage takes place at different times, a series of satellite images can be analyzed in spring and fall months to calculate a minimum Normalized Difference Tillage Index (NDTI) for the watershed. The NDTI estimates crop residue levels based on shortwave infrared wavelengths. This analysis of imagery can also be used to track implementation of cropping practices in a watershed as more years of imagery is collected, since satellites are always updating aerial imagery.

For more information, a webinar produced by Elliot Meyer and called "Satellite Imagery Used in Conservation" as well as a document on how to calculate vegetation indices using ArcMap and Earth Explorer can be found online at: http://wislandwatermedia.org/2018/05/02/webinar-satellite-imagery-used-in-conservation/

5.3 Plan Updates

To facilitate progress on goals and ensure best practices are being implemented, this Lake Management Plan shall be reviewed and updated as needed, but at a minimum, every 36 months.. Updates might include additional recommendations that were not identified during the planning process; new practices, methodologies, or programs that will improve implementation or lake or watershed outcomes; or the results or outcomes of any additional investigations or any similar findings.

6. References

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Exhibits

Exhibit 1. Soils Mapping of Willow River/Lake Mallalieu Watershed
Exhibit 2. Land Cover Mapping of Willow River/Lake Mallalieu Watershed
Exhibit 3. RES Field Data Collection Points (June 11, 2020)
Exhibit 4. Potential Locations for Agricultural BMPs
Exhibit 5. Potential Locations for Natural Habitat BMPs
Exhibit 6. Potential Locations for Urban & Residential Area BMPs
Exhibit 7. Potential Locations for Lake Mallalieu Shoreline & In-Lake BMPs

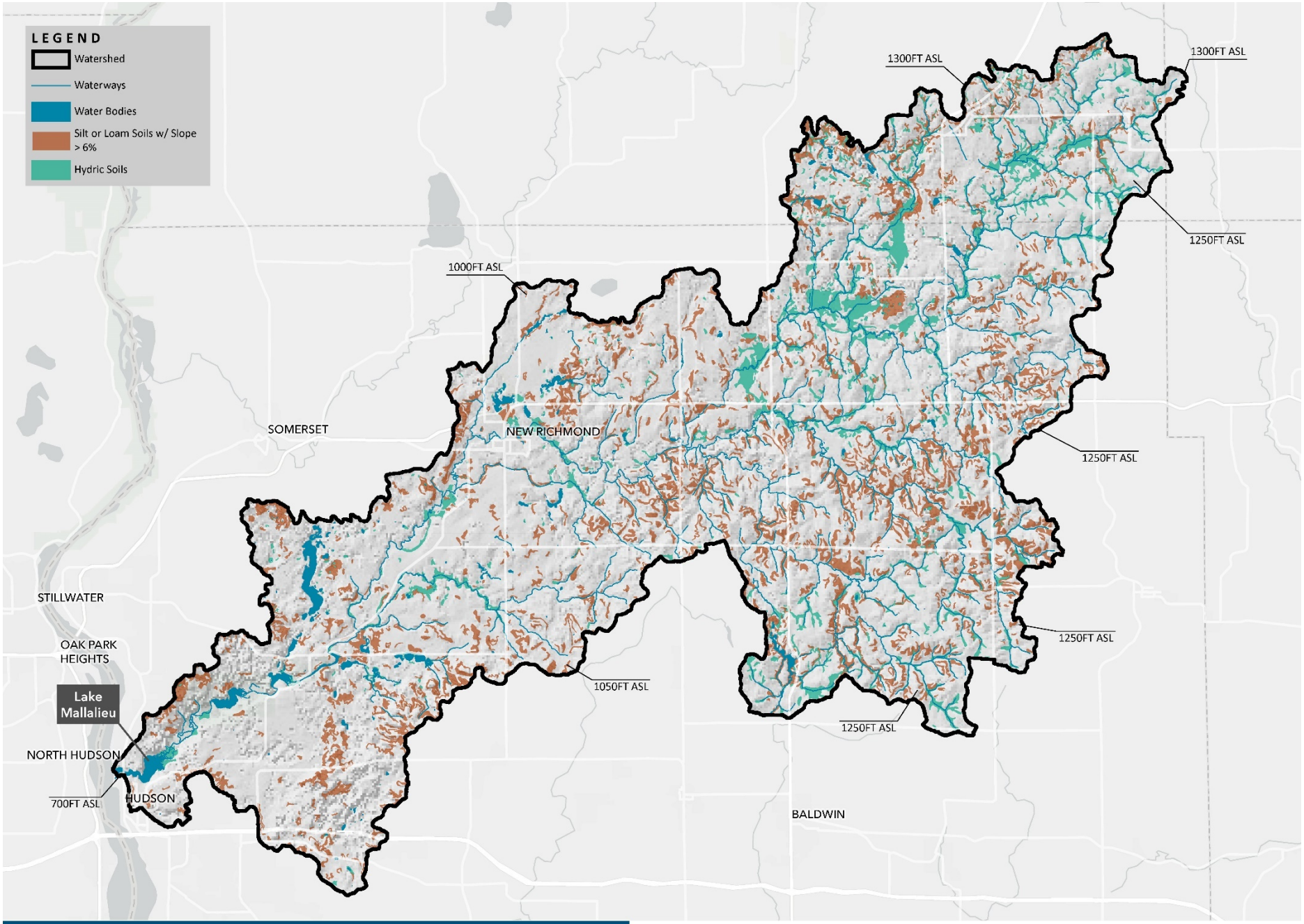

EXHIBIT 1: SOILS MAPPING OF WILLOW RIVER/LAKE MALLALIEU WATERSHED

N

0 0.5 1 2 3 4 Miles

NAD 1983 UTM Zone 15N

LAKE MALLALIEU LAKE MGMT PLAN

PRJ#: 104794 (TSCHWARTZ)

Map created on: 10/28/2021

res
PO Box 256 Brodhead, WI 53520

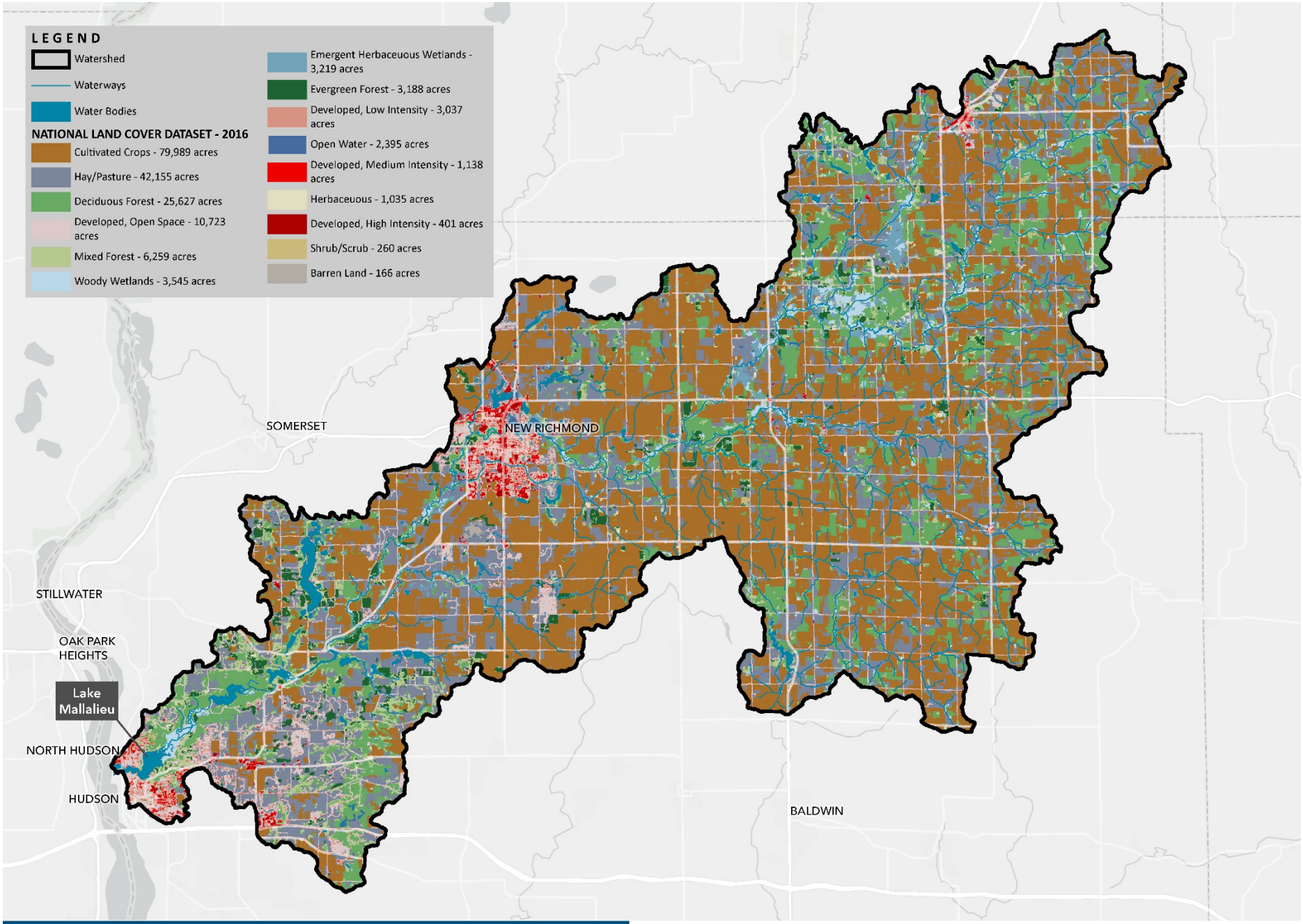

EXHIBIT 2: LAND COVER MAPPING OF WILLOW RIVER/LAKE MALLALIEU WATERSHED

N

0 0.5 1 2 3 4 Miles

NAD 1983 UTM Zone 15N

LAKE MALLALIEU LAKE MGMT PLAN

PRJ#: 104794 (TSCHWARTZ)

Map created on: 10/28/2021

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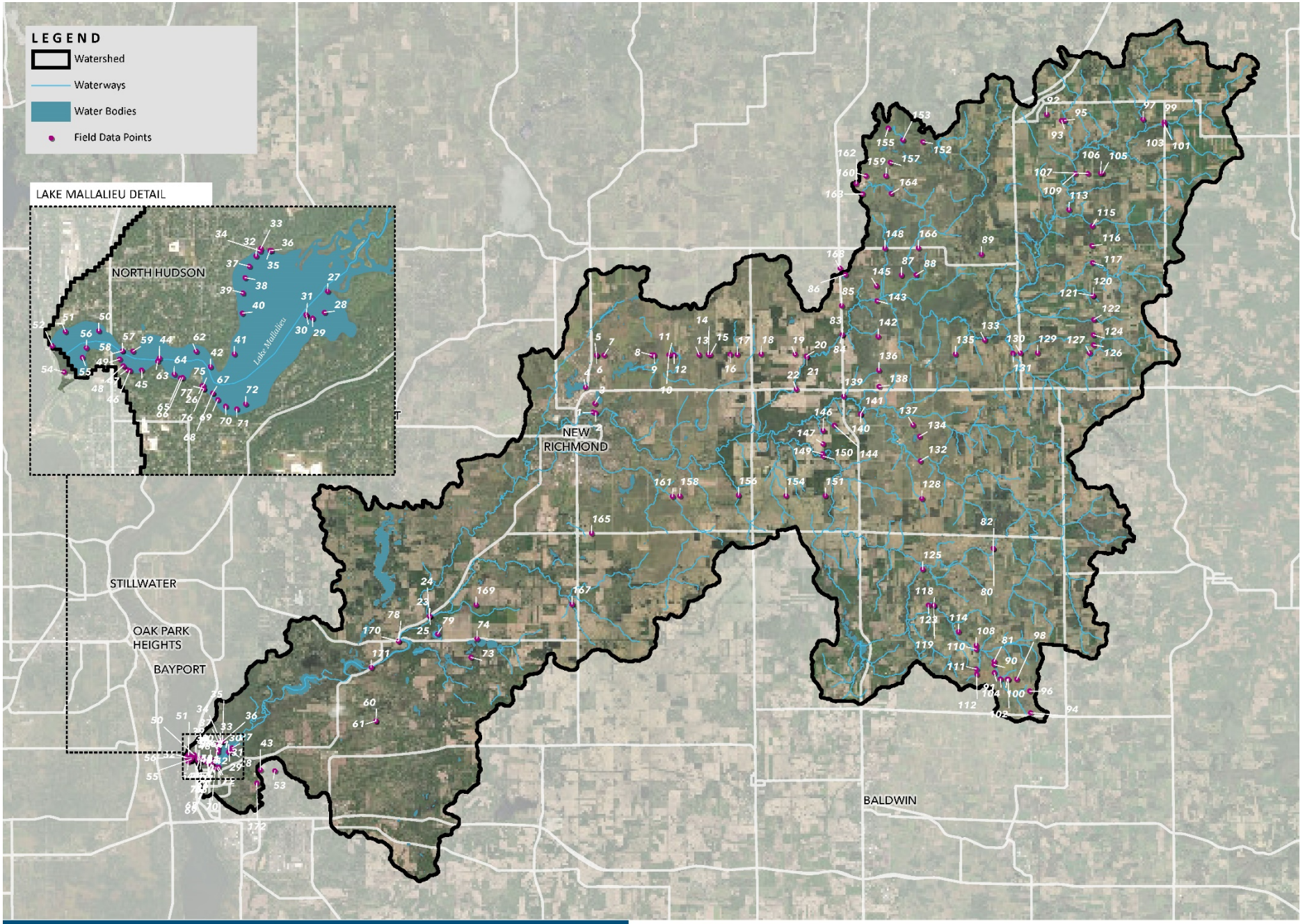

EXHIBIT 3: RES FIELD DATA COLLECTION POINTS
JUNE 11, 2020

N

0 0.5 1 2 3 4 Miles

NAD 1983 UTM Zone 15N

LAKE MALLALIEU LAKE MGMT PLAN
PRJ#: 104794 (TSCHWARTZ)
Map created on: 10/28/2021
Imagery Source: ESRI

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PO Box 256 Brodhead, WI 53520

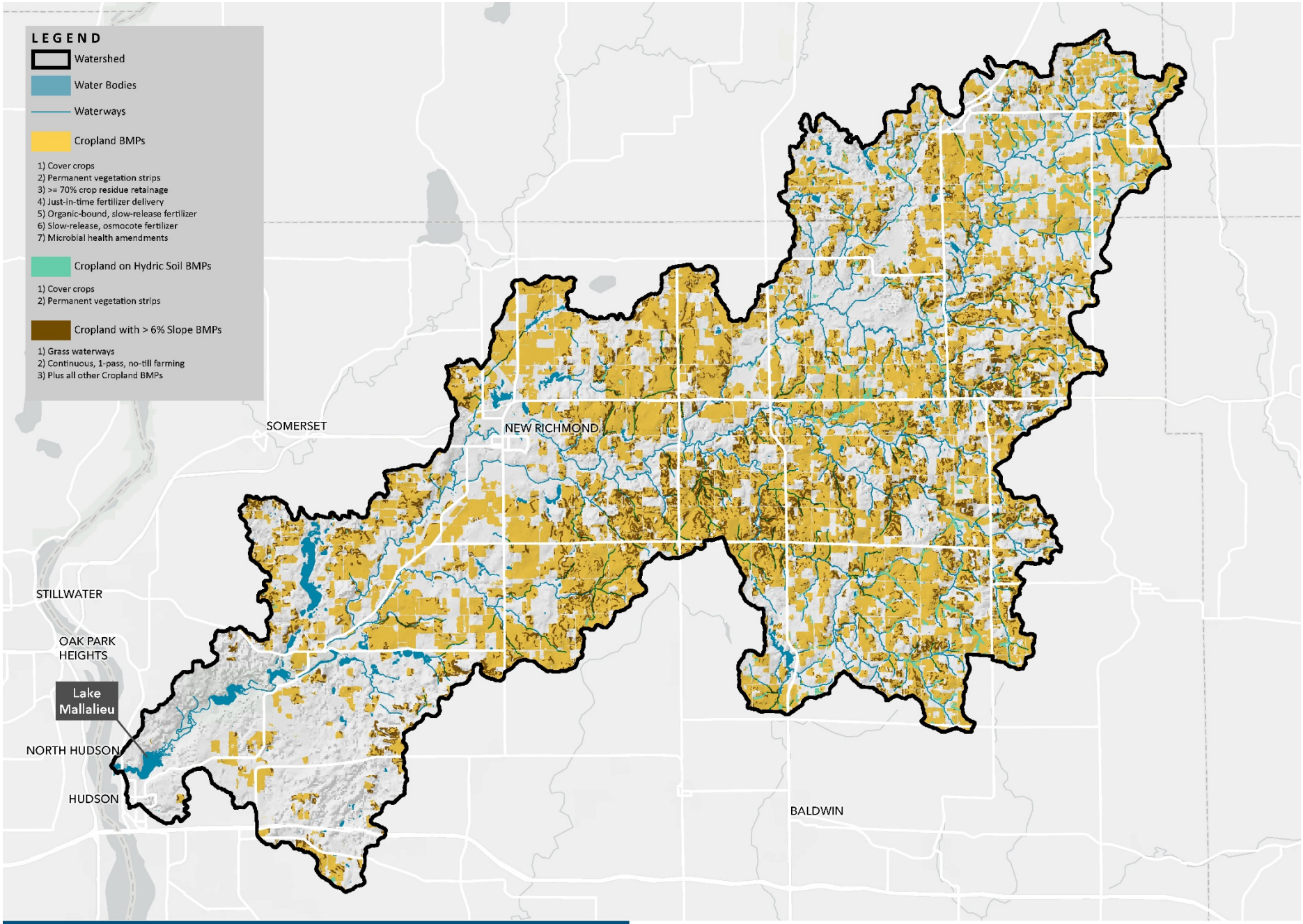

EXHIBIT 4: POTENTIAL LOCATIONS FOR AGRICULTURAL BMPs

N

0 0.5 1 2 3 4 Miles

NAD 1983 UTM Zone 15N

LAKE MALLALIEU LAKE MGMT PLAN

PRJ#: 104794 (TSCHWARTZ)

Map created on: 10/28/2021

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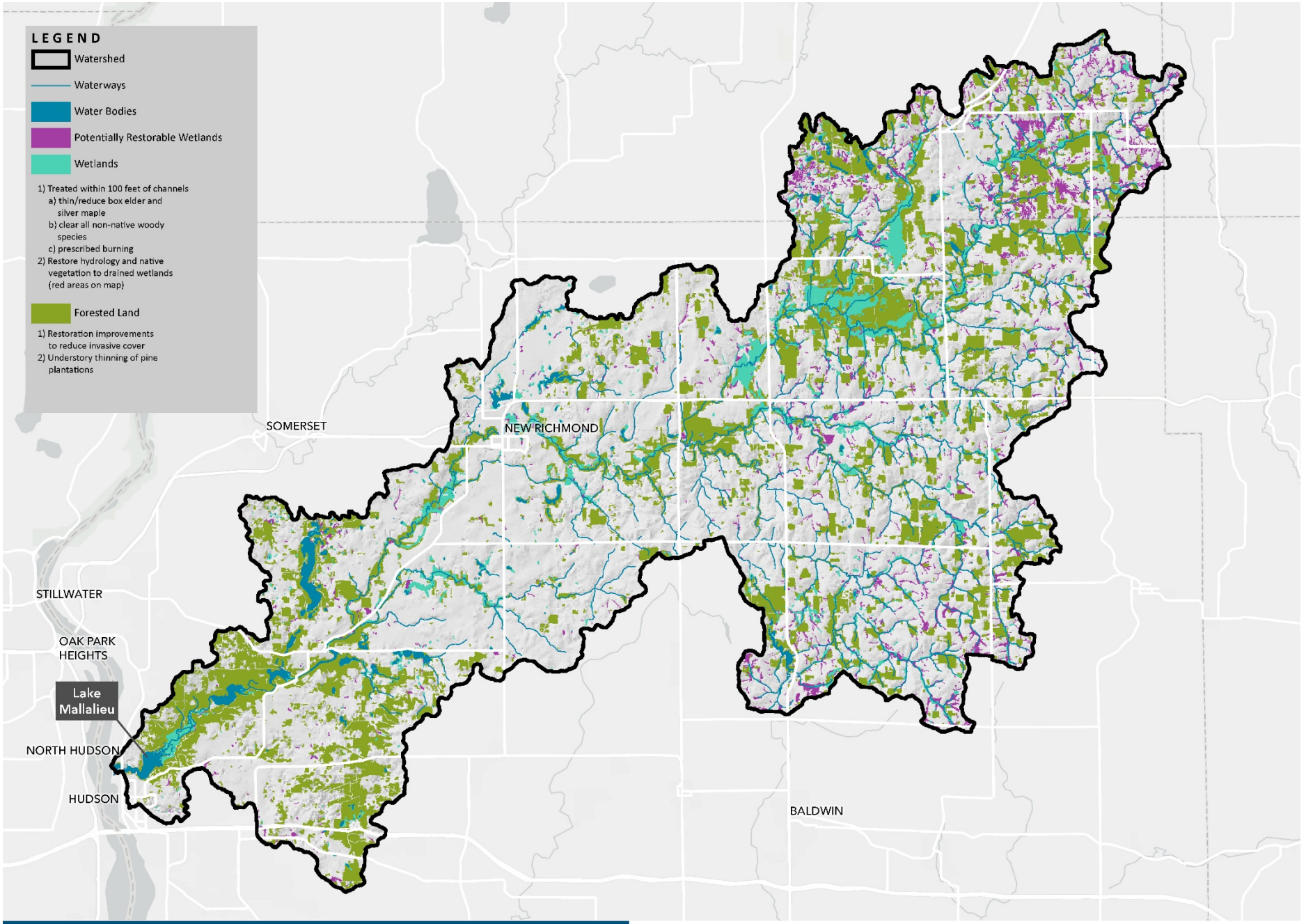

EXHIBIT 5: POTENTIAL LOCATIONS FOR NATURAL HABITAT BMPs

N

0 0.5 1 2 3 4 Miles

NAD 1983 UTM Zone 15N

LAKE MALLALIEU LAKE MGMT PLAN

PRJ#: 104794 (TSCHWARTZ)

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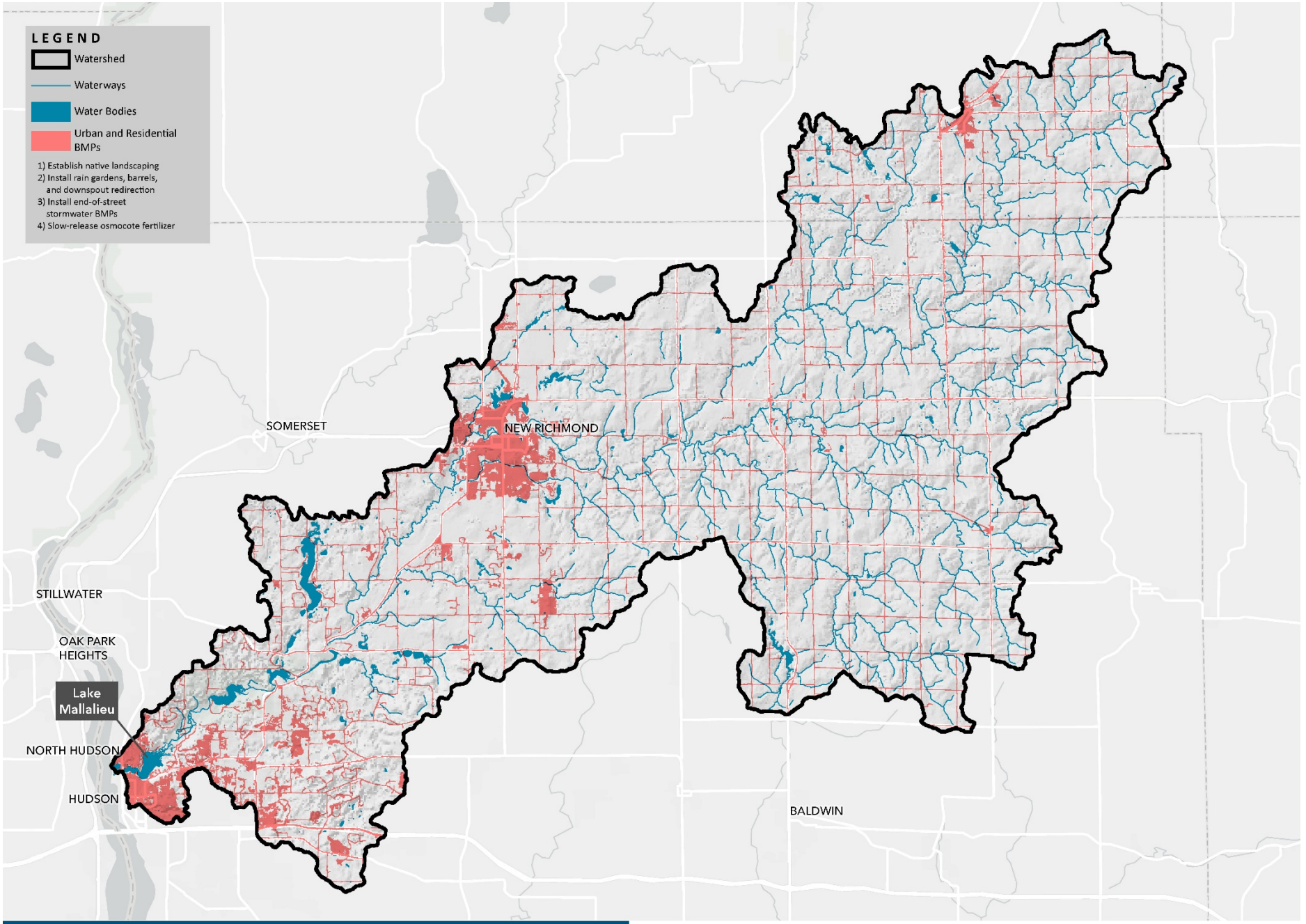

EXHIBIT 6: URBAN AND RESIDENTIAL AREA BMPs

N

0 0.5 1 2 3 4 Miles

NAD 1983 UTM Zone 15N

LAKE MALLALIEU LAKE MGMT PLAN

PRJ#: 104794 (TSCHWARTZ)

Map created on: 10/28/2021

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PO Box 256 Brodhead, WI 53520

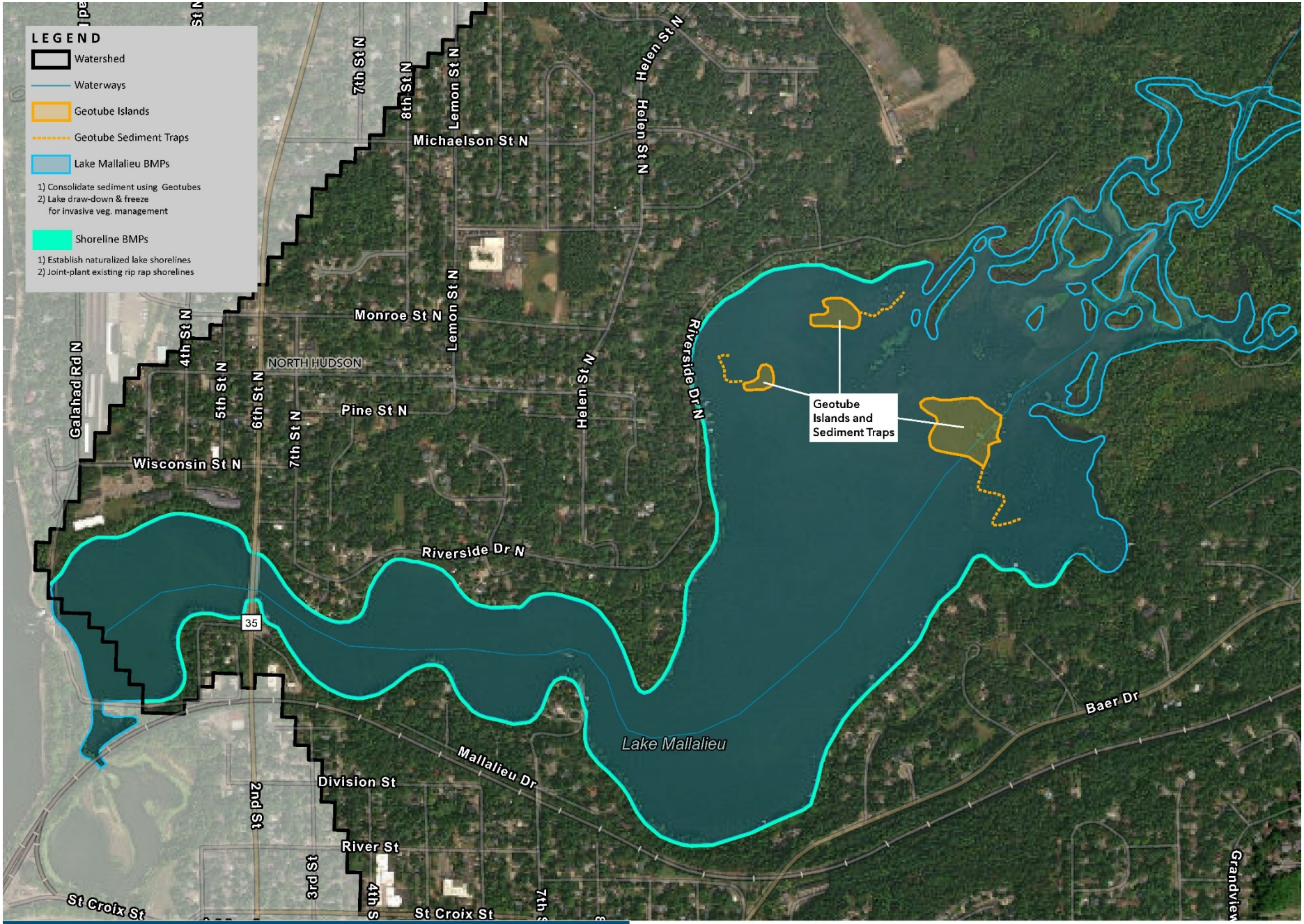


EXHIBIT 7: POTENTIAL LOCATIONS FOR LAKE MALLALIEU SHORELINE AND IN-LAKE BMPs

N

0 250 500 1,000 US Feet

NAD 1983 UTM Zone 15N

LAKE MALLALIEU LAKE MGMT PLAN
PRJ#: 104794 (TSCHWARTZ)
Map created on: 10/28/2021
Imagery Source: ESRI

res
PO Box 256 Brodhead, WI 53520

Appendices

Appendix 1. Summary of Previous Studies and Existing Data for Lake Mallalieu and Willow River Watershed

Appendix 2. WDNR Assessment of Sensitive Areas (WDNR 2006)

Appendix 3. Results of the 2011 Lake Residents Survey (Blasczyk and Meyers 2011)

Appendix 4. Lake Depths at Willow River Delta into Lake Mallalieu (USDA/NRCS 2019)

Appendix 5. Grant Opportunities

Appendix 1. Summary of Previous Studies and Existing Data for Lake Mallalieu and Willow River Watershed

The following table summarizes key criteria that are important to understand the lake and watershed, historical and current conditions, issues and concerns, and opportunities for improvement.

Criteria	Willow River Watershed	Lake Mallalieu
Size	• ~300 sq mi; ~183,000 acres • Ratio of watershed basin area to lake area ~1,000:1	• 289 acres
Landforms	• Elev. range: 1,316 ft (eastern headwaters) to 677 ft (near St. Croix River) • 2010 watershed plan – "The Willow watersheds are located along the boundary between two ecoregions (c.f., Omernik and Gallant, 1988): the Western Corn Belt Plains to the south, and the North Central Hardwood Forest to the north. The watersheds are characterized by nearly level to rolling glacial till plains and significant agricultural land use."	• Max depth 17ft; mean depth 5ft; mostly gentle slopes (except W of Hwy 35 bridge) • ~60% <5ft deep • 2020 plan – "Previous Lake Mallalieu Management Plans stated: "Maps of the lake made 30 years ago, as well as aerial photos dating back to the 1930s, suggested that there had been no large change in lake depth over the intervening period. Sediment did not appear to be entering the lake from the Willow River except during extreme rainfall events or major floods."; no longer the case after the Little Falls Dam breaches • No GIS bathy data; old map exists
Soils/sediment	• Dominant watershed soils are silt loams followed by loams. • 2010 watershed plan – "Sandstone underlies a mosaic of soils. Silty loams that can be shallow and stony cover most of the area. Alluvial sands and peats are found in stream valleys."	• Dominant sed is sand; profile: sand & gravel 0-1.5ft depth; sand dominant 1.5-5ft; silt & sand 1.5-10ft; silt dominant 5-17ft (2020 plan indicates organic "muck") • Swanson report – "The bottom consists of 75% sand, 10% gravel, 5% rock, and 10% muck." • 1979 – arsenic detected in sediment • Post-dam breaches survey data by USDA/NRCS indicates ~3ft of sediment in much of lake inlet delta
Hydrology	• Local precipitation, Willow River stream stats	• Retention time of <2 weeks
Land use/cover/vegetation	• 2010 watershed plan – "Historic vegetation was comprised of dry to mesic prairie grasses in the rolling areas and wet prairies in the broad depressions. Open oak savannas and barrens were found on the hilly	• 1946 - first complaints re. algae blooms • 1949 – first complaints re. excess veg • 1970s – aquatic veg sparge (carp abundant)

Criteria	Willow River Watershed	Lake Mallalieu
	topography, with small inclusions of sugar maple-basswood forest in small steep sites. Prairie pothole type wetlands were mainly found in St. Croix and Polk counties. Barrens were found along the river terraces of the St. Croix River. Almost half of the current vegetation is agricultural crops and almost a third of the area is grasslands, with smaller areas of open water, open wetlands, and urban areas. The major forest types are maple-basswood and oak-hickory, with smaller amounts of lowland hardwoods and lowland conifer." • 5 waste treatment facilities upstream of Lake Mallalieu • 2016 NLCD: 44% cultivated crops, 23% hay/pasture, 14% deciduous forest, 6% developed open space, 3.4% mixed forest, rest <2% each	• Aquatic macrophyte studies: 1991 (Barr), 1998, 1999, 2001, 2005, 2013, 2018 (data, no report) • 1991-2005 – 29 veg spp (15 in 2005) (dominants: coontail (pre-drawdown), water stargrass, white water lily, elodea, sago pondweed; 3 invasives: purple loosestrife, Eurasian water milfoil (EWM, frequency 17%-6%), curly-leaf pondweed • 1997 – abundant aquatic veg, especially in shallow N basin (mostly EWM); 1998-1999 6ft drawdown virtually eliminated EWM for 2 yrs. • 1998 – purple loosestrife treatment (Rodeo, 50 oz.) • 2003 – EWM spread in E end of lake • 2005 (post-drawdown) - EWM decreased 67-76%; curly-leaf pondweed decreased 80-95%; EM veg has doubled in occurrence); veg spp richness decreased; cover decreased, filamentous algae increased, FQI decreased • 1998-2005 – filamentous algae: 11% • 1998-2005 - natural shoreline decreased from 66% to 63%; 2005 – ¼ of shoreline was lawn; aquatic macro community index – lowest quartile in region • Since 1999 – rip rap increased • Circa 2005 – Aquatic veg colonized 49% of littoral zone, mostly E basin, to 8ft rooting depth • After 2004-2005 drawdown - northern water-nymph dominant, followed by sago pondweed • 2013-2018 - .ppt shows reduction in littoral zone and aquatic veg
Water quality (P, N, TSS, bacteria)	• 1998 – portion of Willow R listed as impaired for low DO; 2015 TMDL begun but not approved • 2013-2016 – Willow R/Little Falls Dam outflow (TP, DP, SS); 2016 saw significant increase in TP & SS "According to the Upper and Lower Willow River Water Quality Management Plan (WDNR 2010), approximately	• Lake appears to be N-limited (not P) • 1989 – high fecal coliform (sewage violations; capped) • 1999 – P 98ug/l • Hard water (2001: 144 mg CaCO3/l)

Criteria	Willow River Watershed	Lake Mallalieu
	75% of the phosphorus in the watershed is due to non-point agricultural sources. However, during periods of low rainfall, municipal sources may exceed agricultural sources of pollution in the watershed. Also, as smaller dairy farms have been replaced by operations with 1,000 animal units or more, the potential phosphorous danger has increased." AND "TMDL and Implementation Plan are under development at the time of this plan was written. Preliminary projections call for a 40% reduction of phosphorus overall to lower the in-lake phosphorus concentration from 65.5 ug/L (2006 measured level) to 45 ug/L. This represents a drop from 24.3 tons per year entering Lake Mallalieu to 12.3 tons/year…" AND, "In the Willow, the main dischargers are the two larger municipalities, Clear Lake and New Richmond. Significant reductions will be needed by contributors of non-point source runoff as well." • 2013 St. Croix River TMDL indicates Willow River discharged 75,729 lbs of P per yr (82% from agr. land) • TMDL goal to reduce P loading from agr lands to 26,400 lbs	• 2003 - classified as eutrophic & poor water qual (20.7ug/l chlorophyll, 4.3ft Secchi, so est. max rooting depth 10.9ft) • 2004 – listed as impaired due to excessive P and chlorophyll levels • 2010 (Upper and Lower Willow River Water Quality Management Plan) – "Lake Mallalieu is impaired due to total phosphorus levels from non-point source pollution, causing eutrophication and algal blooms." • 2013-2016 – VWC data for P spp suggests hypereutrophic (high nutrient levels, high algal concentrations, poor water clarity) • 2018 – WDNR classified as eutrophic (but summer TP average was 100.4 µg/l; WDNR scale lacks hypereutrophic); Trophic Status Index 67 (based on chlorophyll) • Recent – ~3ft Secchi; mean TP 94 ug/l (but 2020 plan states standard of 75 ug/l rarely if ever exceeded?); avg of mean annual TSI is just over 60; frequent summer exceedance of WDNR's pH limit of 9.0 (due to algal activity); lake experiences algal blooms over 78% of summer season
Fisheries & other aq. biota	• Portions of Willow R and tributaries are Class II & III trout waters; lower river is warm water fishery	• 1941 – lake supported commercial fishery (carp) • 1941-1954 – failed attempts at walleye stocking; N pike, bass & panfish present • 1957 – first recorded fish survey; since then, promote largemouth bass & bluegill, discouraged walleye & N pike • 1970s – carp abundant & aquatic vegetation sparse • 2001 - WDNR fish survey: 39 spp – largemouth bass most abundant, followed by smallmouth bass and bluegill; yellow perch and black crappie common; N pike and musky populations low, and walleye virtually absent; rough fish: white sucker, gizzard shad, carp, silver

Criteria	Willow River Watershed	Lake Mallalieu
		redhorse, smallmouth buffalo; lake drawdowns do not appear to have impacted fish populations • 2020 plan – "Were it not for the constant supply of fresh water from the Willow River, the decomposing plant matter at the Lake bottom would consume much of the Lake's oxygen and create a harmful environment for fish (WDNR 2010)."
Known Issues & Events	• 1992 – WDNR removed middle dam • 1997 – WDNR removed upper dam • 2015 – Little Falls Lake drawdown (summer); re-filled late 2019? • 2017 – Little Falls Dam removed for replacement, washing sediment into Lake • 2019 (3/24) – dam construction site breached sending 740cy soil into Lake	• 1848 – first dam to create lake (sawmill) • 1961-2000 – treatments of arsenic (7,240 lbs), Endothall, Diquat, 2,4-D, Silvex • 1974 – complaints re. lack of veg • 1975 – partial drawdown to control carp; ineffective? • 1983 – 7ft drawdown (dam repair) • 1991 – utilities installed around lake • 1998-1999 – 6ft winter drawdown • 2001 – lake mgmt. plan • 2004-2005 – 3ft winter drawdown • 2011 – lakeshore owner survey • 2020 – planned fall 5ft drawdown to flush (dam-released) nutrients from lake and control invasive aquatic vegetation

Appendix 2. WDNR Assessment of Sensitive Areas (WDNR 2006)

Area #1 was the shallow water inlet to Lake Mallalieu. This was selected for its high quality of fish and wildlife habitat and diverse aquatic vegetation. The following observations and management recommendations were made for site #1:

1. *Snag and cavity trees along the shore.*
2. *The eradication of Purple loosestrife through biological means.*
3. *Emergent vegetation.*
4. *Slow no-wake in upper Lake.*
5. *Removal of any shoreline vegetation.*

Area #2 was defined as the south shore. This site was selected for the diverse aquatic vegetation and the natural terrestrial vegetation found. This area comprises about 3,400 feet of shoreline, out to a maximum rooting depth of 4 feet. The following observations and management recommendations were given:

1. *Current wildlife habitat.*
2. *Snag and perch trees on shore.*
3. *Natural shorelines when possible.*
4. *Fish cover via cribs and tree crops*
5. *Not remove fallen trees*
6. *Dredging or lakebed removal.*

Area #3 is the rock cliff that encompasses approximately 600 feet along the southern shore, just east of the boat landing. The shoreline at this site is composed mostly of a steep rock wall with wooded cover on top. This area provides habitat for fish cover and wildlife resting areas. The following observations and management recommendations were given:

1. *Minimize removal of shoreline.*
2. *Minimize, if not eliminate, lawn fertilizers.*
3. *Control the amount of sediment from street runoff coming into this important area of the Lake.*
4. *Maintain current natural vegetation buffer.*
5. *Maintain aquatic vegetation in an undisturbed condition.*

Area #4 is the West Basin which encompasses about 15 acres, near the Highway 35 bridge. This site includes shoreline habitat and shallow water habitat. Large woody debris from fallen trees provides valuable habitat for fish and wildlife. The following observations and management recommendations were given:

1. *Current habitat.*
2. *Emergent vegetation.*
3. *Natural shoreline in areas that have more than 30 ft. of cleared access.*
4. *Fallen trees in water.*
5. *Dredging or lakebed removal.*
6. *Permit approval for pea gravel beds or sand blankets.*

Area #5 is the North Point that includes approximately 1500 feet of shoreline on the north point and its west side. This area has been identified as being important for near-shore terrestrial habitat, and shoreline habitat. Large woody debris in this area provides valuable habitat and cover for fish and wildlife. The following observations and management recommendations were given:

1. *Current habitat.*
2. *Reduce, if not eliminate, lawn fertilizer applications.*
3. *Property owners work with County Resource Division and DNR staff in efforts to re-establish native vegetation on and along eroded shorelines.*
4. *Bank grading.*
5. *Dredging or removal of lakebed.*

Appendix 3. Results of the 2011 Lake Residents Survey (Blasczyk & Meyers 2011)

On behalf of the St. Croix County Community Development Department and the Lake Mallalieu Association, the Environmental Resources Center of UW Madison designed and conducted a survey of owners of properties bordering Lake Mallalieu.

In the spring of 2011, the University of Wisconsin Extension's Environmental Resources Center completed a survey of Lake residents. Ninety-four surveys were returned of the one hundred and sixteen sent—an exceptional 81% return rate. UW Extension staff members Jake Blasczyk and Andrew Meyers compiled the results (Blasczyk & Meyers 2011).

The most significant responses are listed below (percentages are of total respondents). These responses helped determine the major issues addressed in this Lake Management Plan.

1. What types of activities do you "often" do on or around the lake? Wildlife viewing (83%), Relaxing with family and friends (76%), Pleasure boating (57%), Swimming (30%), kayaking/canoeing (17%) and open water fishing (19%).

2. What moved you to purchase Lake Property? Scenic Beauty (73%), boating/watersport activities (34%), place for family and friends (33%), and investment potential (14%).

3. What potential pollution sources do you believe to be contributing to the lake (high to very high likelihood)? Ag fertilizers (59%), storm water runoff (52%), manure from farm animals (50%), fertilizing of lawns along lake (48%), Use of pesticides by lake property owners (41%), and soil from agricultural fields (39%).

4. How has the lake changed since owning your property? The amount of algae has increased (54%), amount of aquatic plants has increased (54%), shoreline erosion on your lot has stayed the same (44%), water clarity has decreased (44%), and the quality of fishing has stayed about the same (33%).

5. Do you have a strong willingness to change and support several strategies on your property to improve water quality? I am willing to change some things (41%), I favor improved government regulations as a means to better water quality (14%), efforts to improve water quality must be strictly voluntary (12%), I would financially support a group that worked to improve water quality (12%), I would favor forming a lake district that could levy taxes (7%).

   The survey report concludes with a final section discussing the following twelve conclusions about respondents and their attitudes and opinions regarding aspects of Lake Mallalieu.

   1. Almost all are long term permanent residents who value Lake Mallalieu, with many belonging to the Lake Association, but are uninvolved.

   2. Many respondents have water frontage under 200 ft. and with a buffer.

   3. Many value a well-kept lawn but not necessarily the well-manicured suburban type.

4. Many had some awareness of Wisconsin's fertilizer law which was reflected in opinions and behaviors regarding fertilizing.

5. Most respondents mow their lawns, and some hire a service to apply fertilizer or weed killers. Few had soil tests taken.

6. Some respondents were indecisive about buffers while noting their potential benefits.

7. Many noted changes to the lake since owning their property.

8. A majority viewed agricultural sources as being major contributors to pollution of Lake Mallalieu, but also recognized that to a certain extent, lake residents also contribute.

9. Large majorities utilized some form of conservation practice on their property, with few numbers installing rain gardens or rain barrels.

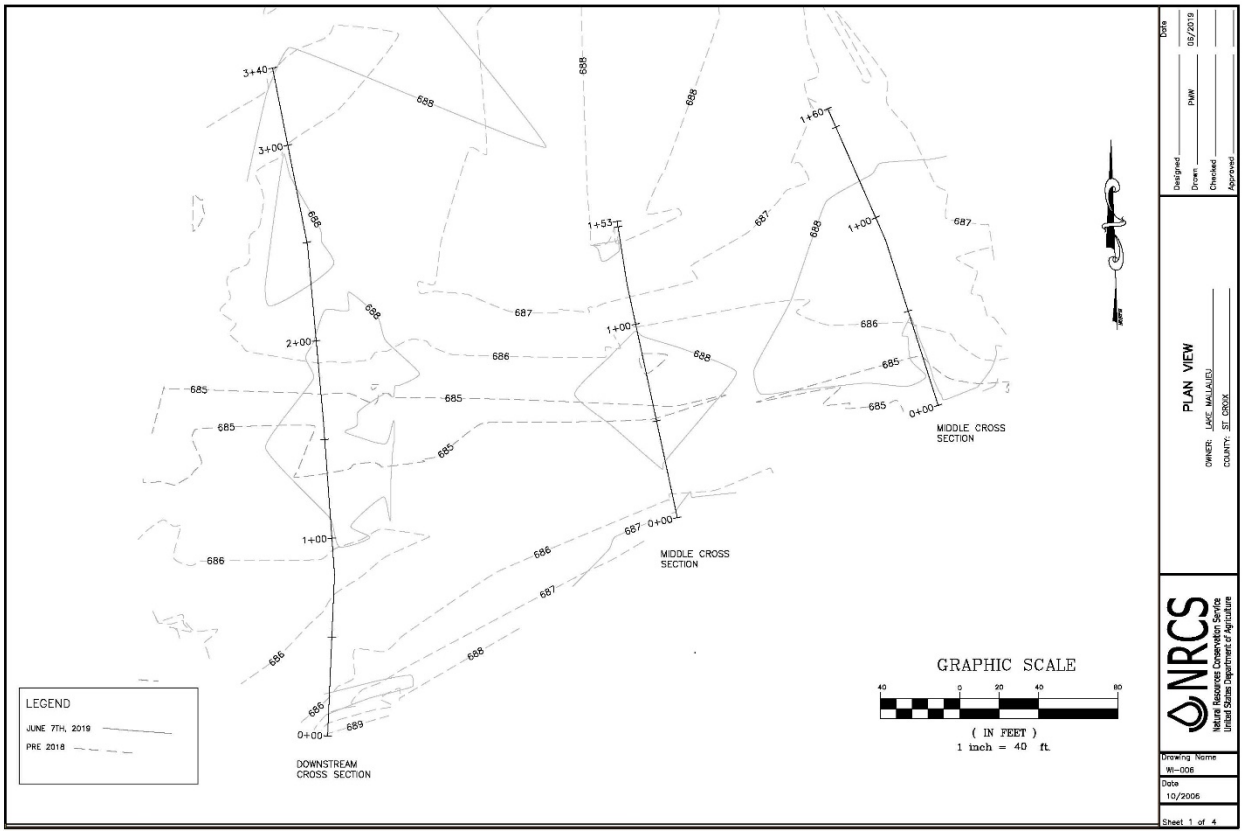
10. A majority are not in favor of becoming a taxing lake district, but respondents do support broad strategies to improve local water quality.

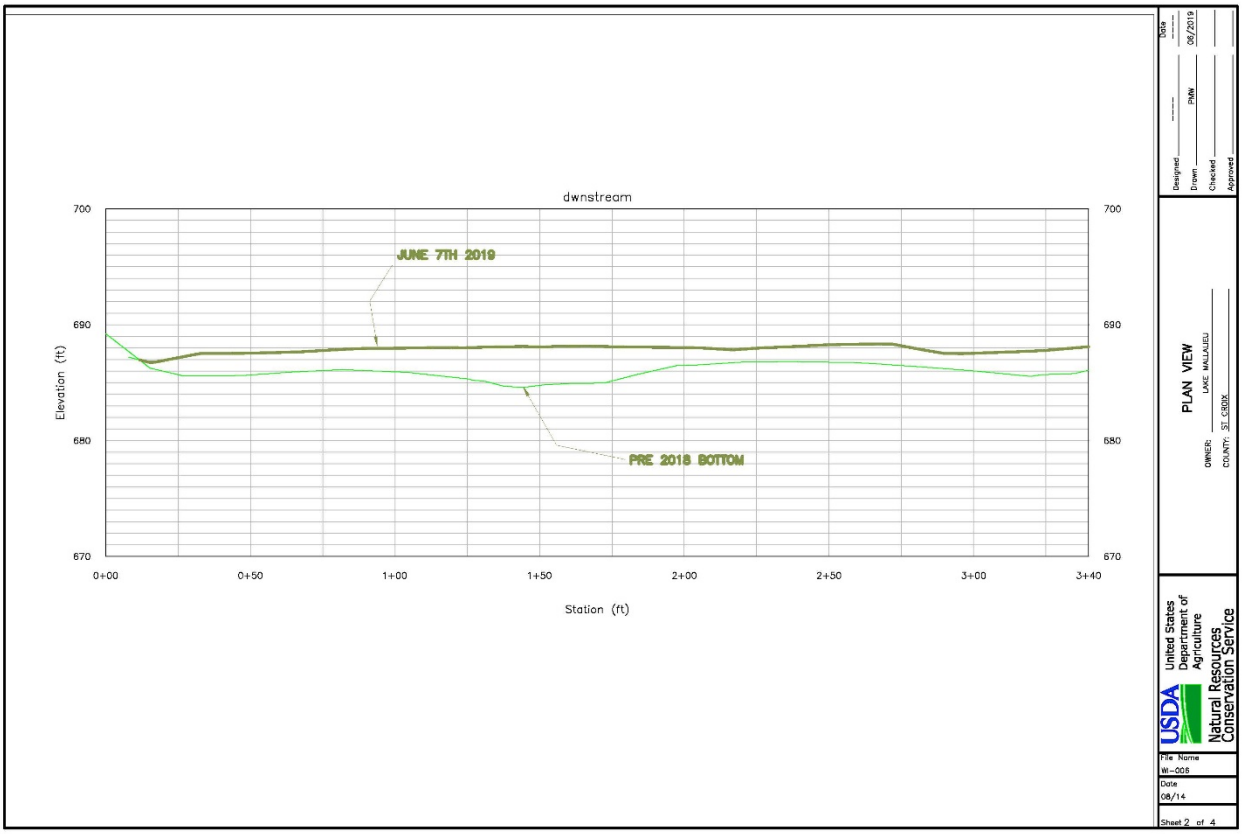
11. Many respondents agreed they are willing to change how they manage their property to improve local water quality.

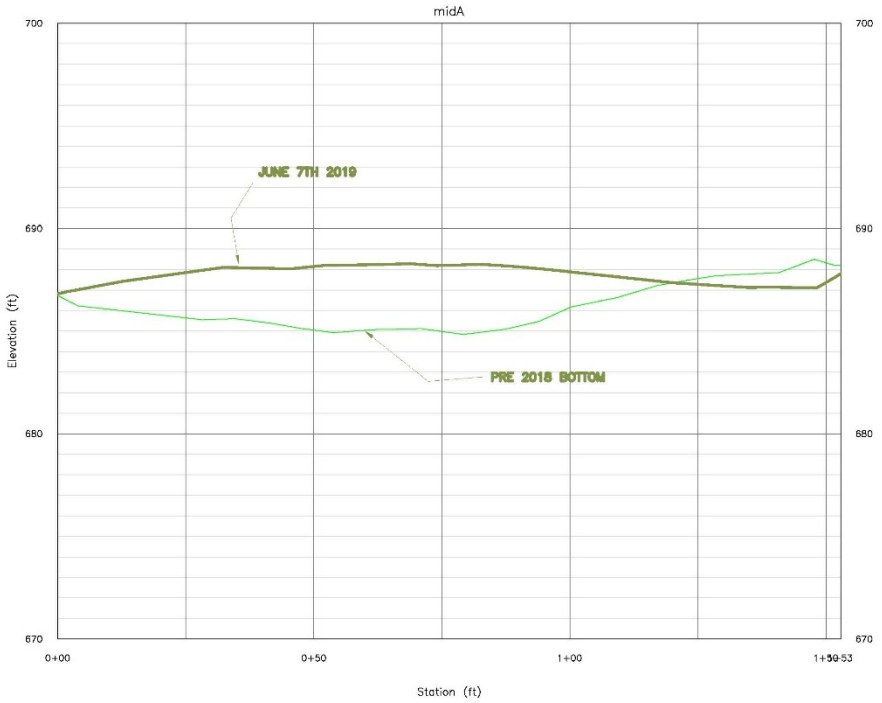
12. A minority burned yard waste or leaves, and a minority would volunteer for fall and spring boulevard leaf pickup.

You can view the complete 2011 Lake Mallalieu survey on the LMA's website (Blasczyk & Meyers 2011).

Appendix 4. Lake Depths at Willow River Delta into Lake Mallalieu (USDA/NRCS 2019)







Data
Designed
Drawn PMW 05/2019
Checked
Approved

PLAN VIEW
OWNER: LAKE MALALEU
COUNTY: ST CROIX

United States Department of Agriculture
Natural Resources Conservation Service

File Name
WI-008
Date
08/14
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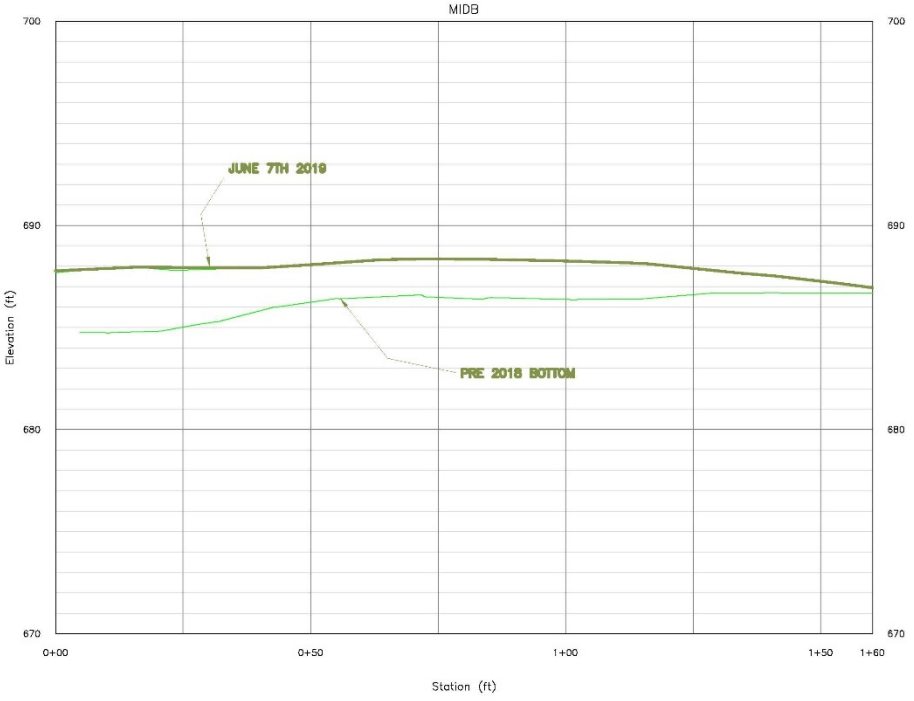

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Sheet 4 of 4

Appendix 5. Grant Opportunities

Wisconsin Surface Water Grants

http://dnr.wi.gov/Aid/SurfaceWater.html

Overview: The surface water grant program provides a wide variety of cost-sharing grants for surface water protection and restoration. Funding is available for education, ecological assessments, planning, implementation, and aquatic invasive species prevention and control. With many different projects eligible for grant funding, you can support surface water management at any stage: from organization capacity development to project implementation.

Funder: State of Wisconsin, Department of Natural Resources
Frequency: Annual
Eligible: All levels of government, various districts, non-profits
Geographic Area: State of Wisconsin
Deadline: September 2 (pre-application) and November 1 (final application)
Award Announcement: February 15 (approximately)
Funds: vary, depending on project type; see Application Guide (link below)
Match: vary, depending on project type; see Application Guide (link below)
Application Guide: https://dnr.wi.gov/files/pdf/pubs/cf/CF0002.pdf

Five Star and Urban Waters Restoration

Overview: The program focuses on the stewardship and restoration of coastal, wetland and riparian ecosystems across the country. Its goal is to meet the conservation needs of important species and habitats, providing measurable and meaningful conservation and educational outcomes. The program requires the establishment and/or enhancement of diverse partnerships and an education/outreach component that will help shape and sustain behavior to achieve conservation goals.

Funder: National Fish and Wildlife Foundation (NFWF)
Frequency: Annual
Eligible: State and local governments, educational institutions, tribes, non-profits (501-c-3).
The program requires the establishment and/or enhancement of diverse partnerships and an education/outreach component that will help shape and sustain behavior to achieve conservation goals.
Geographic Area: Geographic focus depends on funding available from the funding partners. Area may vary by year.
Deadline: Proposals due in January (but this may vary year to year)
Award Announcement: August of same year (but this may vary year to year)
Funds: $20,000 to $50,000; average of $40,000
Match: 1:1 required; federal dollars not eligible for match
More Information: https://www.nfwf.org/programs/five-star-and-urban-waters-restoration-grant-program