LAKE REDSTONE

SAUK COUNTY

2022-32 9-KEY ELEMENT WATERSHED AND LAKE MANAGEMENT PLAN

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Executive Summary

Lake stewardship is a challenging and complex task that can reap long term rewards for future generations when performed with long term goals in mind. Today's lakes face many obstacles that include nutrient loading, sedimentation, invasive species, shoreline erosion, loss of habitat, and climate change. While presenting distinct challenges to lake groups, these obstacles can provide opportunities for improvement, community engagement and education, collaboration between a wide array of stakeholders, and the ability to shape future generations of lake stewards.

To protect and restore Lake Redstone, this 9-Key Element Plan was developed to tackle these major obstacles. Primarily, this plan will focus on reducing sediment and nutrient loading to the lake, improving riparian habitat, promoting appropriate lake stewardship, and engaging multiple partners to be invested in the future of the lake. Three areas of concern are focused on in this plan: the watershed of Lake Redstone, the riparian area around Lake Redstone, and Lake Redstone itself. These areas are specifically targeted because of their indirect and direct relationship to the degradation of Lake Redstone through contributions of sediments and nutrients. This plan will focus on best management practices that will assist in reducing loads of sediment and nutrients from these surrounding areas through the lens of the following objectives:

Overarching Goal: Improve the water quality and overall ecosystem of Lake Redstone by working with various stakeholders to implement best management practices to improve the watershed, riparian area, and the lake itself.

Objective 1: Implement best management practices throughout the watershed to reduce sediment and phosphorus loading into Lake Redstone.

Objective 2: Improve the riparian area by implementing BMPs to increase quality habitat for wildlife and mitigate the effects of development on Lake Redstone

Objective 3: Use BMPs within Lake Redstone to reduce negative impacts from pollution, aquatic invasive species, and shoreline erosion.

Objective 4: Build and maintain partnerships with outside resource, state, university, county, lake groups, and other local entities to guide the implementation of BMPs.

The implementation of this plan will connect individual BMPs to the larger goals of the LRPD, including people and funding aligned with the objectives; individual riparian owners and agricultural practitioners throughout the watershed; monitoring and data information systems; and milestones designed to meet the expectations of stakeholders throughout the period of this plan.

Execution of this plan depends on the collaboration of multiple stakeholders, including the LRPD, Juneau and Sauk Counties, Producers of the Lake Redstone Watershed, USGS, WI-DNR, and others. Within the Appendices included with this document, tables are provided that list the current goals and objectives, specific milestones to be met throughout implementation, timelines and methods of implementation, and expected outcomes for each area of concern – watershed (Appendix F), riparian area (Appendix G), and Lake Redstone (Appendix H).

Appendix I combines all Plan Actions into one table and adds Years 1-3, 4-6, and 7-10 milestones, estimated costs, and expected Resource Agencies that will either be responsible for completing the action or will provide technical assistance with implementation.

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9-KEY ELEMENT WATERSHED AND LAKE MANAGEMENT PLAN

LAKE REDSTONE

PREPARED FOR THE LAKE REDSTONE PROTECTION DISTRICT

1.0 Introduction

Lake Redstone is a 635 acre, artificially impounded drainage lake in northwest Sauk County (Figure 1). Lake Redstone has a maximum depth of 36.5 feet and a mean depth of 14 feet (WI-DNR). Although there are other intermittent streams and springs that make up the 28.83 sq. mile watershed, the east and west branches of Big Creek are the two biggest contributors to Lake Redstone. Water from the lake is released from a top draw dam that creates a cascading waterfall at the southernmost end of the lake and eventually drains into the Baraboo River (Figure 2). The southern end of the lake has scenic red sandstone cliffs which steeply slope into deep water with very little littoral habitat, while the many bays and the remainder of the lake has a gradual drop off and more littoral habitat.

Lake Redstone was created in the mid 1960's when a 38 foot high earthen dike was installed across Big Creek in northwestern Sauk County with the intent of creating >1500 lots for development. It has 17½ miles of shoreline and it is 4½ miles long. Lake Redstone is located in the Crossman Creek and Little Baraboo River watershed which lies in northwestern Sauk County, southern Juneau County, northeastern Richland County, and the southeast corner of Vernon County. It is part of the Driftless, or unglaciated, region of Wisconsin. This region is geologically unique with land areas that were by-passed by the last glaciers leaving steep terrain susceptible to flash runoff events and erosion that can increase the amount of sediment and nutrients lost from agricultural land and carried be into streams, rivers, and lakes.

Figure 1: Lake Redstone shortly after filling. The two branches of Big Creek that flow into the lake are at the top of the picture. The dam is located at the lower right of the picture.

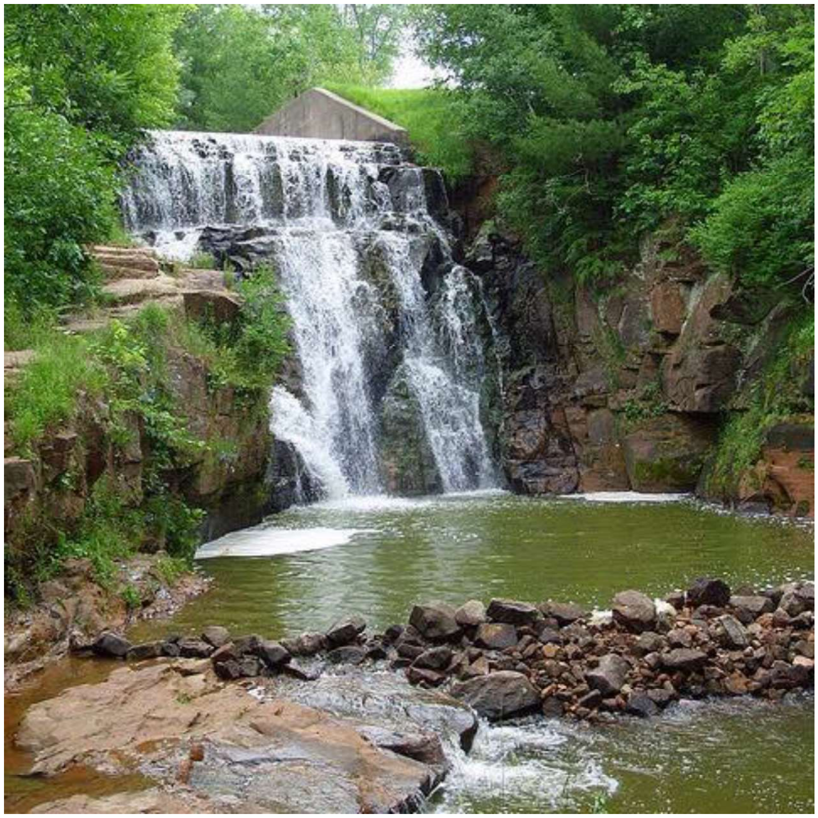


Figure 2: Cascading waterfall from the top draw spillway at the outlet of Lake Redstone (LRPD Facebook Page)

The topography of Lake Redstone includes many fjord-type bays around the lake. Each of these bays drains some portion of the watershed or riparian area of the lake. When discussing the lake and management actions, individual bays are often referred to by name. These names are generally determined by the road that travels around the bay or the name of the sub-division associated with it (Figure 3).

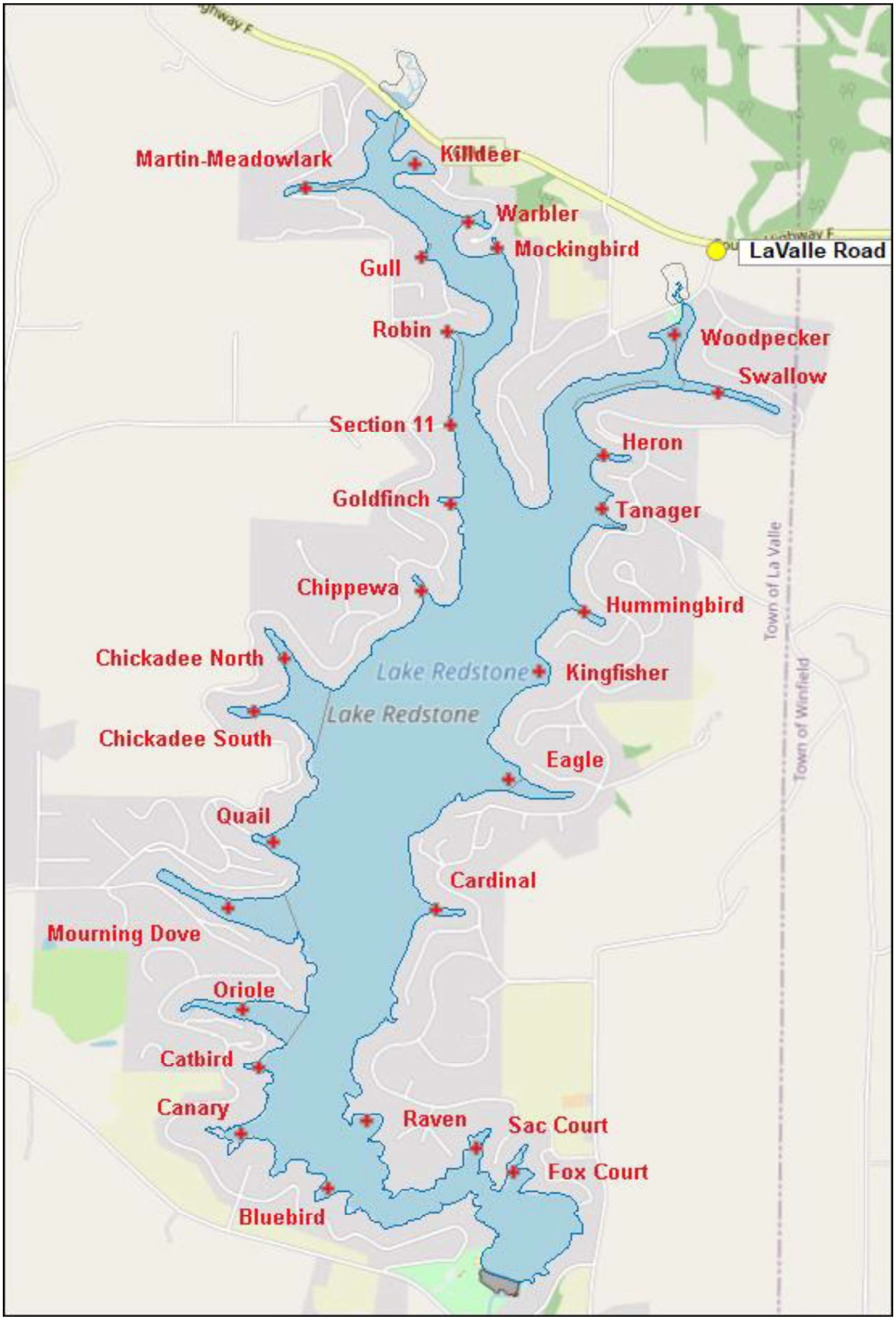


Figure 3: Individual bay names on Lake Redstone

1.1 Lake Redstone Protection District

Stewardship of Lake Redstone was first in the hands of the Lake Redstone Property Owners' Association (LRPOA), whose purpose when formed in 1969 featured "maintenance of the lake." In 1974, Wisconsin passed a set of laws that established local lake management districts to improve the quality of the lakes in the state. Under these guidelines, the Lake Redstone Management District was formed in 1976 and took over maintenance of the lake responsibilities. The LRPOA still remains but focuses more on social events and education. In 1987, the Lake Redstone Management District changed its name to the Lake Redstone Protection District (LRPD) to reflect an emphasis on protection and rehabilitation verses maintenance.

The LRPD is a government organization, funded through a small portion of taxes from property owners within the protection district. Other forms of support include grants from the Wisconsin Department of Natural Resources (WI-DNR), Sauk County, and other government entities. The LRPD is governed by a Board of Commissioners. Each commissioner is elected to a 3-yr term. Commissioners receive a small stipend for meetings and are reimbursed for expenses associated with LRPD work. Many volunteers contribute time during the year to support the actions of the LRPD.

The stated mission of the LRPD is to "protect and rehabilitate the water quality of Lake Redstone for its residences and the public." Powers granted to protection districts by the state are: to conduct studies for projects to improve and protect the lake, to adopt programs to improve water quality, and to control aquatic plants. The LRPD has the power to levy taxes and special assessments to improve water quality. Protection District powers are located in the Wisconsin Statutes, Chapter 33.

More information can be found on the LRPD webpage at: https://www.lakeredstonepd.org/.

1.2 Problem Statement and Purpose

The water quality of Lake Redstone has long been an issue – algal blooms, low oxygen, sedimentation, etc. – as a result of the land use in and topography of a watershed that contributes contaminants like nutrients and sediment. The lack of water clarity caused by the inflow of sediment and algal blooms (caused by the inflow of nutrients) limits the amount of aquatic plant growth by limiting the depth light can penetrate into the lake. However, the invasive aquatic plant, Eurasian watermilfoil (EWM), dominates the lake bed where native plant species cannot tolerate the degraded conditions. Additionally, at depths greater than 12-ft, oxygen is depleted beyond what is needed for fish and other biota to survive as a result of the decomposition of large amounts of organic material. These conditions placed Lake Redstone on the Wisconsin Impaired Waters List in 2014, where it remains to date.

The purpose of this project is to develop a lake and watershed management plan for Lake Redstone that will help reduce sediment and nutrient loading to the lake improving conditions consistent with the mission of the LRPD. Three areas of concern are focused on in this plan: the watershed of Lake Redstone, the riparian area around Lake Redstone, and Lake Redstone itself.

1.3 Impaired Waters Listing

Every two years, Sections 303(d) and 305(b) of the Federal Clean Water Act (CWA) require states to publish a list of all waters not meeting water quality standards and an overall report on the surface water quality status of all waters in the state. To assess surface water quality throughout the state, Wisconsin's Consolidated Assessment and Listing Methodology (WisCALM) is used. WisCALM uses available data to determine impairments based on two categories: natural (fish and aquatic life, FAL) and recreational (human/full body emersion activities, REC). A lake can exceed state standards in either or both of these categories, and designations are generally based on the concentration of total phosphorus (TP), the nutrient that supports aquatic life; and the concentration of chlorophyll-a (Chl-*a*), a measurement used to determine the biomass of algae in the water. Both are measured in micrograms per liter (µg/L). WisCALM provides guidance on the assessment of water quality data against surface water quality standards, and for required Clean Water Act reporting (WisCALM, 2021).

The Wisconsin acceptable standard for summer TP in the REC category for stratified reservoirs like Lake Redstone is a geometric mean concentration ≤30-µg/L (Figure 4). If the summer mean concentration of TP exceeds this level, the water is considered impaired. The Wisconsin assessment protocol for Chl-*a* is based on the number of days in a sampling season (July 15-September 15) that have moderate algal levels based on Chl-*a* concentrations that exceeds 20-µg/L. Once that level has been exceeded, the amount of algae in the surface water it represents discourages people from swimming (Figure 5). If the concentration of Chl-*a* exceeds 20-µg/L on more than 5% of the expected lake use days, then the water is considered impaired.

Figure 4: Wisconsin numeric water quality standards for phosphorus (WI-DNR, 2019)

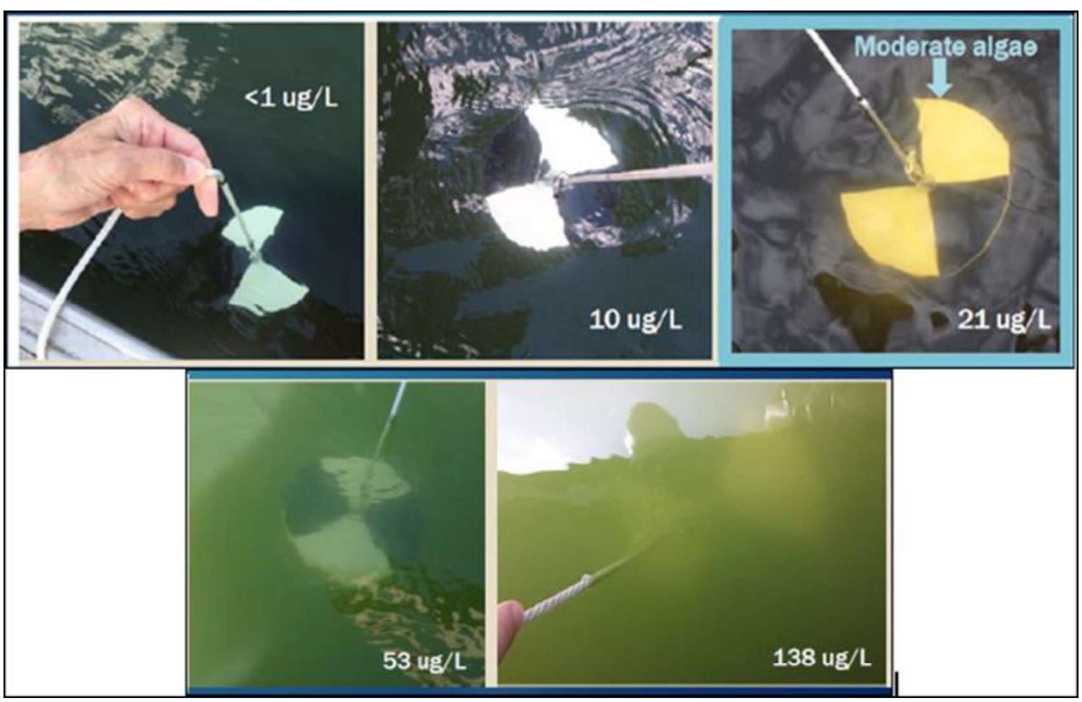


Figure 5: Chl-a concentrations and the corresponding water clarity as measured by a Secchi disk (WI-DNR, 2018)

Lake Redstone was first placed on the Impaired Waters List for TP in 2014, and for eutrophication with an unknown pollutant in 2016. In the most recent WisCALM assessment of Lake Redstone for the Impaired Waters List (for 2022), Chl-*a* values from 2016-2020 for REC indicated that the mean percent of lake use days where 20-µg/L of Chl-*a* was exceeded was 93% with a 78% to 98.5% high/low confidence interval, well above the 5% standard (Beranek, 2021). During the same assessment, the mean summer TP concentration was 57-µg/L, well above the 30-µg/L standard set for stratified reservoirs indicating that Lake Redstone will remain on the Impaired Waters List in 2022 (Beranek, 2021).

1.4 Total Maximum Daily Load (TMDL)

One of the underlying goals of the CWA is to restore all impaired waters so they meet applicable water quality standards. One of the key tools to meet this goal is the development of a TMDL. A TMDL establishes the amount of a pollutant (nutrients, sediment, manmade pollutants) a waterbody (lake, river, or stream) can receive and still meet stated water quality standards (WI-DNR, TMDL Overview).

Through a TMDL the current pollutant loads from point and nonpoint sources are quantified. Point source pollution is from easily identifiable locations including municipal, industrial, concentrated animal feed operations (CAFOs), and Municipal Separate Storm Sewer System (MS4) stormwater. Nonpoint source pollution comes from less definable locations like agricultural, residential, and urban landscapes and is often made worse by uncontrolled, natural storm events. Through the use of mathematical models, nonpoint source pollutant loads for specific waterbodies or collection of waterbodies are calculated with inputs related to weather, topography, soil types, and land use. With these and other data inputs, the model simulates physical processes associated with the flow of water, sediment movement, nutrient cycling, crop growth, etc. Models can also be used to predict impacts of changes in land use, climate, and management practices on water quality. Once targets are set for a given waterbody, the TMDL is established by allocating the allowable load between the point and nonpoint sources, with some amount of the total load set aside as a margin of safety (WI-DNR, TMDL Overview).

1.4.1 Wisconsin River Basin TMDL

The WI-DNR, together with many partners, is working to improve water quality in the Wisconsin River, its reservoirs, and tributaries through a TMDL (WI-DNR, Wisconsin River TMDL). The TMDL provides a strategic framework and prioritizes resources for water quality improvement in the Wisconsin River Basin (WRB). The WRB includes 9,156 square miles (15% of the state) spanning Wisconsin's central corridor from the headwaters of the river in Vilas County to Lake Wisconsin in Columbia County (Figure 6). Within this area, there are 110 stream/river segments and 38 lakes/reservoirs, including Lake Redstone, that are on the impaired waters list for phosphorus based on the 2016 303(d) Impaired Waters List.

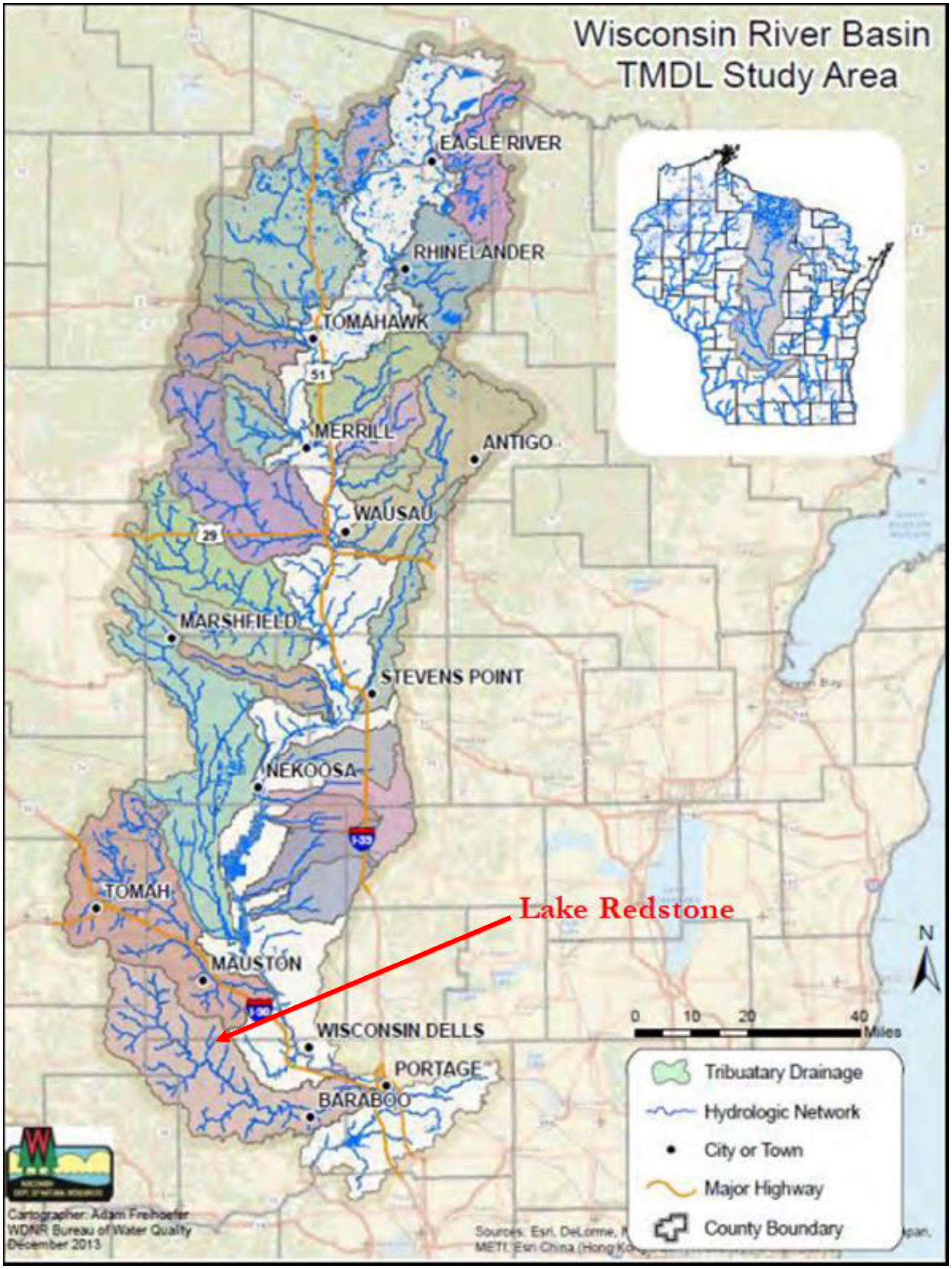


Figure 6: Wisconsin River Basin TMDL Study Area (WI-DNR, Wisconsin River TMDL)

For the purpose of assessing pollutant load generation and receiving water loading capacity, and for the development of load allocations in the WRB TMDL, the entire river basin was subdivided into 337 individual sub-basins. Each sub-basin represents a single "reach" which can be either a stream or an impoundment. The loads generated from each sub-basin are delivered to the reach and cumulate downstream through the drainage system. Lake Redstone and its watershed are delineated based on the lake itself and the east and west branches of Big Creek – sub-basins 13, 15, and 16 (Figure 7). These three sub-basins combined cover the entire Lake Redstone watershed.

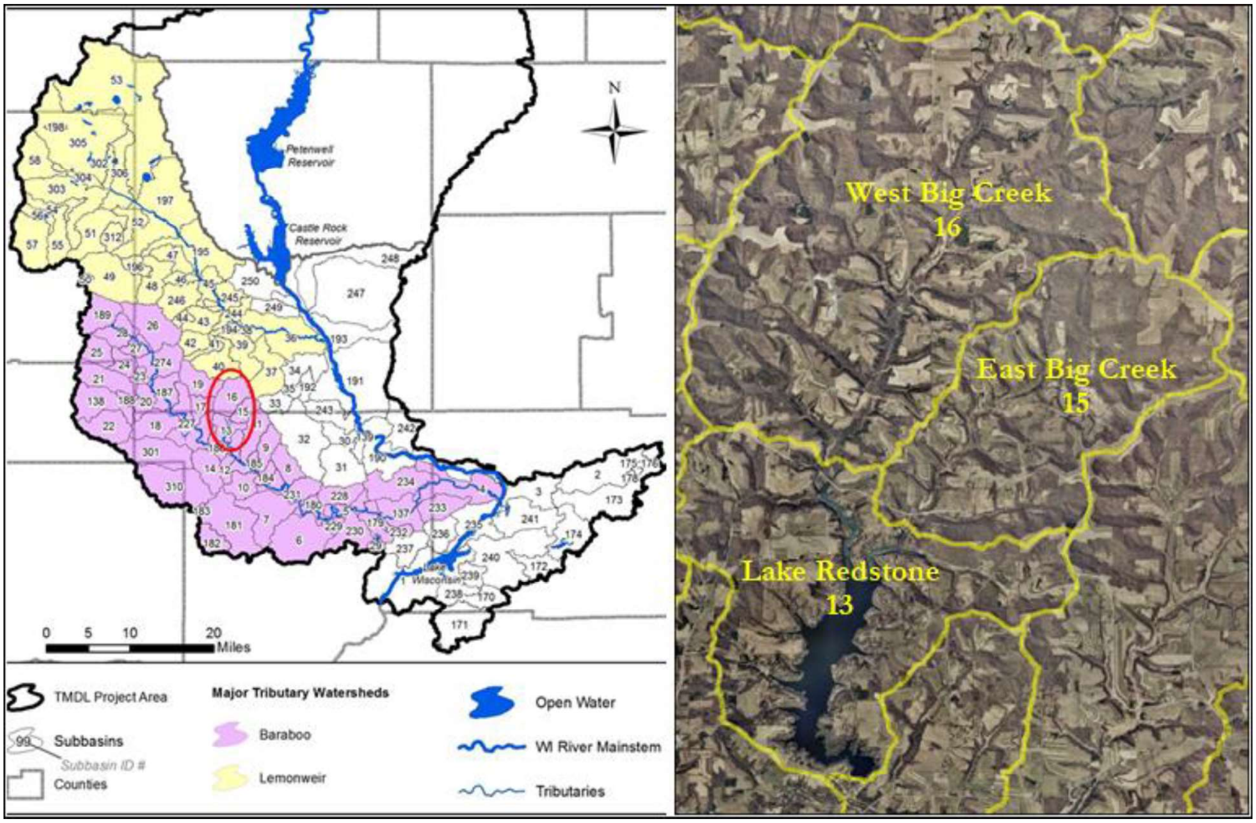


Figure 7: Wisconsin River TMDL sub-basins in the lower region. Lake Redstone and its watershed are circled in red, #'s13, 15&16 (left; WI-DNR, 2019) Sub-basins laid over Lake Redstone watershed (right).

The EPA approved the WRB TMDL on April 26, 2019. With that approval, allocations of point and nonpoint source load and margin of error were also approved based on both the statewide phosphorus criteria applicable at the time and newly approved site-specific criteria. These approved allocations are to be used for future point source permitting decisions and as the basis for locally-led nonpoint source reduction plans such as this Lake Redstone 9-Key Lake and Watershed Management Plan.

1.5 Watershed Planning and Implementation: 9-Key Elements Plan

In 2008, the EPA published a guide for developing and implementing watershed plans (EPA, 2008). The guide includes six steps to be included in a formal plan. Within the six steps are the nine key elements required by the EPA in order to make a watershed management plan and its implementation eligible for federal funds through the Clean Water Act, Section 319. The Clean Water Act Section 319 Grant Program awards grants to reduce and mitigate the effects of nonpoint source pollution – such as sediment, pesticides, and nutrients – to waters of the state.

The following 9-Key Elements are considered critical for achieving improvements in water quality following a watershed approach:

1) Identify causes and sources of pollution
2) Determine load reductions needed
3) Develop management actions to achieve goals
4) Identify technical and financial assistance needed to implement the plan
5) Develop an information/education component
6) Develop an implementation schedule
7) Develop the interim milestones to track implementation of management measures
8) Develop criteria to measure progress toward meeting watershed goals
9) Develop a monitoring component

More information about each of these steps is included in Appendix A.

2.0 Identification of Key Stakeholders

A stakeholder is any person, group, or organization that can place a claim on the organization's resources, attention, or output, or is affected by its output (Bryson, 1995). Over the past decade or more, the LRPD has worked at building partnerships with stakeholders who share a common goal of improving water quality in Lake Redstone. With that in mind, the LRPD identified the following key stakeholder groups that are important to management planning and implementation success:

2.1 Sauk County Land Resources and Environment Department

Even though the bulk of the Lake Redstone watershed is in Juneau County, the lake itself is in Sauk County. The Sauk County Land Resources and Environment (LRE) Department promotes many actions that protect Lake Redstone and others waters in the County. Their mission is to conserve natural, cultural, and community resources by promoting, planning, and implementing efficient and effective programs.

2.2 Juneau County Land and Water Resources Department

The largest portion of the Lake Redstone watershed lies in Juneau County. The mission of the Juneau County LWR Department is to aid the public in protecting, enhancing, and preserving natural resources through public information, education, and technical assistance within the guidelines of the Juneau County LWR Management Plan. Department staff has long been supporters of the LRPD and agricultural activities in the watershed to protect and improve the lake. Currently, they monitor the edge-of-field stations, lead stream monitoring activities in the two main branches of Big Creek entering Lake Redstone, and act as the main advisors to the PLRW.

2.3 Producers of the Lake Redstone Watershed (a Producer Led Cooperative)

The PLRW have the following vision statement – "The Producers of the Lake Redstone Watershed are working towards the goal of improving the water quality and soil health within the watershed," and their mission statement is as follows – "Our producer-led group is using on farm research and innovative practices to improve conservation in and out of the watershed." The group is collaborating with Juneau County and others to develop economically viable mechanisms to get cover crops seeded, develop a community manure application system, and use cover crops to provide nutrients late in the growing season. With additional funding from DATCP, the group continues to support farmer incentives to implement best management practices including cover crops, community manure sharing, establishing nutrient management plans, and for sponsoring community events, field days, and training.

2.4 Discovery Farms (a program of UW-Madison Division of Extension)

Discovery Farms, a program of UW-Madison Division of Extension, is a farmer-led research and outreach program focused on the relationship between agriculture and water quality. The program is unique in that it conducts research on privately-owned farms throughout Wisconsin, working with the USGS to gather credible and unbiased water quality information from monitored sites (UW-Extension Juneau County). In 2018, Discovery Farms established a partnership with the Juneau County Land and Water Resources Department and the Producers of the Lake Redstone Watershed. The partnership was established to understand what effects conservation practices in the area have on runoff and nutrient losses. Two edge-of-field monitoring stations were installed in the watershed to measure and collect runoff from monitoring basins.

2.5 Lake Redstone Property Owners' Association

The LRPOA focuses on the social side of the lake community and supports several clubs including the Garden Club, Nature Photography Club, In Stiches Sewing Club, and the Kayaking Club. Each of these clubs has an interest in maintaining or improving Lake Redstone for their own needs and in their own ways. Another organization, the Lake Redstone Fishing Club is concerned with promoting and protecting a healthy, abundant, and sustainable fishery.

2.6 Other Stakeholders

- Baraboo River Watershed Regional Conservation Partnership Program
- Natural Resource Conservation Service (NRCS) in Sauk and Juneau Counties
- United States Geological Survey (USGS)
- Town of LaValle
- Property owners on Lake Redstone
- General lake users
- Agricultural and animal operations in the watershed
- Dutch Hollow Lake Property Owners Association
- Wisconsin Department of Natural Resources
- UW-Stevens Point
- UW-Extension Services

Since 2014, the LRPD has organized an annual meeting of stakeholders known as the "Partners Meeting." Usually held in the fall at the Sauk County Building in Baraboo, WI, the meeting includes members of the LRPD board, member of the public interested in Lake Redstone, representatives from the WI-DNR, and from both Juneau and Sauk County Departments. In some years, farmers from the watershed have joined the meeting, and there have been representatives from other lake districts. In 2020, when the meeting was held virtually, representatives from the USGS participated. The topics on the agenda vary from year to year, but in the last two years, the major topic has been the preparation of the 9-Key Lake and Watershed Management Plan. Regardless of the topic, the meeting provides a chance for partners to exchange information, review activities from the previous year, and discuss plans for the coming year.

2.7 Public Outreach, Issues of Concern, and Preliminary Goals

In an effort to better understand issues of concern to property owners, the LRPD conducted several surveys of constituents seeking their input about the lake. In the first survey, completed in 1981, all 1270 property owners on Lake Redstone at that time were sent a survey, seeking their comment through a variety of questions. The survey had a 43% return rate and identified two important topics of concern to Lake Redstone residents: water quality perception and user conflict. Survey results indicated more people were concerned with user conflicts than water quality, and that more people were satisfied with water quality than were not. Most of those unsatisfied with water quality were occasional visitors to their lake property. Many responses from this survey had "no opinion" as it pertains to water quality, prompting researchers to suggest a greater emphasis on information and involvement efforts in the future to increase awareness.

In 2006, another survey, this time of approximately 1074 households in the LRPD boundaries was completed. The response rate to this survey was 32%. Based on the information from the survey and an internal LRPD board assessment, the following issues were determined to be of highest concern:

- How to better educate and communicate with users of Lake Redstone, both resident and day users;
- How to safely and effectively prevent and/or remove sediment build-up in Lake Redstone;
- How to better manage the number of exotic, invasive species found in and around Lake Redstone; and
- How to reduce the amount of nutrients entering Lake Redstone.

In response to this survey, the LRPD began strategic planning to guide future actions taken by the LRPD to improve the lake. Several broad goals were set to help focus planning and implementation efforts: 1) Identify, monitor, and address sediment erosion and nutrients entering the lake from the surrounding watershed; 2) Better manage/prevent the spread of exotic, invasive species in and around Lake Redstone; and 3) Make efforts to better involve and educate constituents of the LRPD (Erickson, 2006). Through this planning effort, potential actions that might lead to solutions to issues of concern were identified and in many cases, implemented.

In 2017, the LRPD created and distributed another constituent survey. Unlike the 1981 and 2006 surveys which were mailed out to over 1000 property owners, the 2017 survey was distributed online. There were 227 responses to the 2017 survey; the exact percentage of respondents is unknown.

The 2017 online survey presented a list of perceived issues on Lake Redstone and respondents were asked to rate them as serious, moderate, minor, or not a problem. The issues considered most serious in 2017 were:

- Water quality/water clarity;
- Accumulation of sediment;
- Farm runoff;
- Shoreline erosion;
- Excessive aquatic plants; and
- Excessive algae.

In the 2017 survey, a majority of respondents felt dredging was necessary to deal with the accumulation of sediment in the lake. Educating and informing lake users on a variety of topics from aquatic invasive species, boating rules and regulations, and lake and shoreland stewardship practices was not specifically addressed in the 2017 survey, but based on comments made, these issues were still important to many respondents.

In 2017, the LRPD completed a review of many of the studies related to Lake Redstone completed between 1981 and 2017. This 2017 review process culminated with a report summarizing the conclusions and recommended goals of each of these studies (Appendix B; (Blumer, 2017)). The report also identified apparent gaps in data collection and laid the groundwork for application and the subsequent award of WI-DNR surface water grant funding to develop this 9-Key Lake and Watershed Management Plan for Lake Redstone. The 2017 Report included the following, fairly specific recommendations:

- Complete a Shoreland Habitat Assessment of Lake Redstone;
- Complete a sediment pond feasibility study;
- Complete dredging of multiple bays;
- Evaluate methods for re-establishing native aquatic vegetation in the lake;
- Add nitrogen parameters to water quality monitoring; and
- Develop a Comprehensive Lake Management Plan.

Most of these recommendations have either been addressed, or are currently being addressed through this project.

3.0 Characterizing Lake Redstone and its Watershed

3.1 Lake Redstone

Depending on which source is used, Lake Redstone has a surface area of 612 to 635 acres. Based on a 2011 whole-lake, point-intercept survey, it has a maximum depth of 36.5-ft and a mean depth of 14.4-ft. Visitors have access to the lake from three public boat landings and a public beach. Fish include musky, panfish, largemouth bass, northern pike, and walleye. The lake's water clarity is low. Curly-leaf pondweed, Eurasian watermilfoil, purple loosestrife, and yellow iris are invasive plant species currently present in or along the shores of Lake Redstone; gizzard shad and common carp (an invasive fish species) are also present.

3.1.1 Water Quality

The quality of water in a lake is often assessed by collecting and comparing three measures or parameters – water clarity, total phosphorus, and chlorophyll-*a*.

Water clarity is a measurement of how deep sunlight can penetrate into the waters of a lake. It can be measured in a number of ways, the most common being an 8" disk divided into four sections, two black and two white, lowered into the lake water from the surface by a rope marked in measurable increments (Figure 8). The water clarity reading is the point at which the "Secchi" disk when lowered into the water can no longer be seen from the surface of the lake. Water color (like dark water stained by tannins from nearby bogs and wetlands), particles suspended in the water column (like sediment or algae), and weather conditions (clouds, wind, or sunlight) can impact how far a Secchi disk can be seen down in the water. Some lakes have Secchi disk readings of water clarity of just a few inches, while other lakes have conditions that allow the Secchi disk to be seen for dozens of feet before it disappears from view.

Phosphorus is essential to plant growth as a vital nutrient for converting sunlight into usable energy during photosynthesis. Under natural conditions, phosphorus is typically scarce in water. In the late 1960s, scientists discovered phosphorus contributed by human activity to be a major cause of excessive algal growth and degraded lake water quality. Phosphorus can be attached to sediment particles like clay and silt, and can then build up in the sediments of a lake. When it remains in the sediment, it is generally not available for use by algae; however, various chemical and biological processes can allow sediment phosphorus to be released back into the lake water.

Chlorophyll-*a* is the pigment that makes plants including algae, green. Measuring chlorophyll-*a* in a water sample can be used to determine algal biomass in the lake.

All three parameters are commonly used to determine the state of water quality in a lake. Individual values of each, when measured over time, can show whether or not water quality in a lake is getting better, not changing, or getting worse. All three are related to one another in that excess phosphorus can grow algae (measured by chlorophyll-*a*), which can in turn, impact water clarity. All three are used to determine the productivity or trophic status of a lake, and can be represented in relation to each other on a Trophic State Index (TSI) scale (Carlson, 1977). The TSI is a numeric index of lake trophic status on a scale of 1 to 100, with higher numbers indicating greater nutrient enrichment (Table 1).

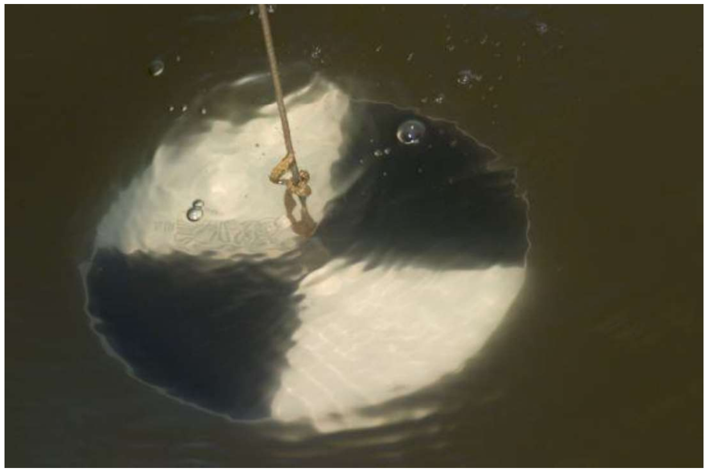


Figure 8: Secchi disk

Table 1: Carlson's Trophic State Index values

TSI values	TrophicStatus	Attributes
< 30	Oligotrophic	Clear water, oxygen throughout the year in the hypolimnion
30-40	Oligotrophic	A lake will still exhibit oligotrophy, but some shallower lakes will become anoxic during the summer
40- 50	Mesotrophic	Water moderately clear, but increasing probability of anoxia during the summer
50-60	Eutrophic	Lower boundary of classical eutrophy: Decreased transparency, warm-water fisheries only
60-70	Eutrophic	Dominance of blue-green algae, algal scum probable, extensive macrophyte problems
70-80	Eutrophic	Heavy algal blooms possible throughout the summer, often hypereutrophic
>80	Eutrophic	Algal scum, summer fish kills, few macrophytes

Based on long-term trend data for Secchi depth, TP, and Chl-*a* retrieved from the WI-DNR SWIMS database, Lake Redstone is classified as a eutrophic, or nutrient-rich, system with TSI values ranging from the low 50's to high 60's (WI-DNR, Surface Water Integrated Monitoring System (SWIMS) Database). Figures 9-12 reflect the summer (July & August) mean TSI values for Secchi, TP, and Chl-*a* through 2020 at four monitoring sites in Lake Redstone (WI-DNR, Citizen Lake Monitoring Network).

Of note at all four sites is that TSI values for Chl-*a* and Secchi depth are generally the same, while TSI values for TP are generally lower than both Chl-*a* and Secchi depth. This is one of several familiar patterns that often emerge when comparing these three values (Carlson & Havens, 2005). This pattern suggests that algae biomass in a lake is limited by phosphorus and that algae dominate light attenuation. Under these conditions, algal bloom frequency may respond more quickly to phosphorus load reduction (Carlson & Havens, 2005).

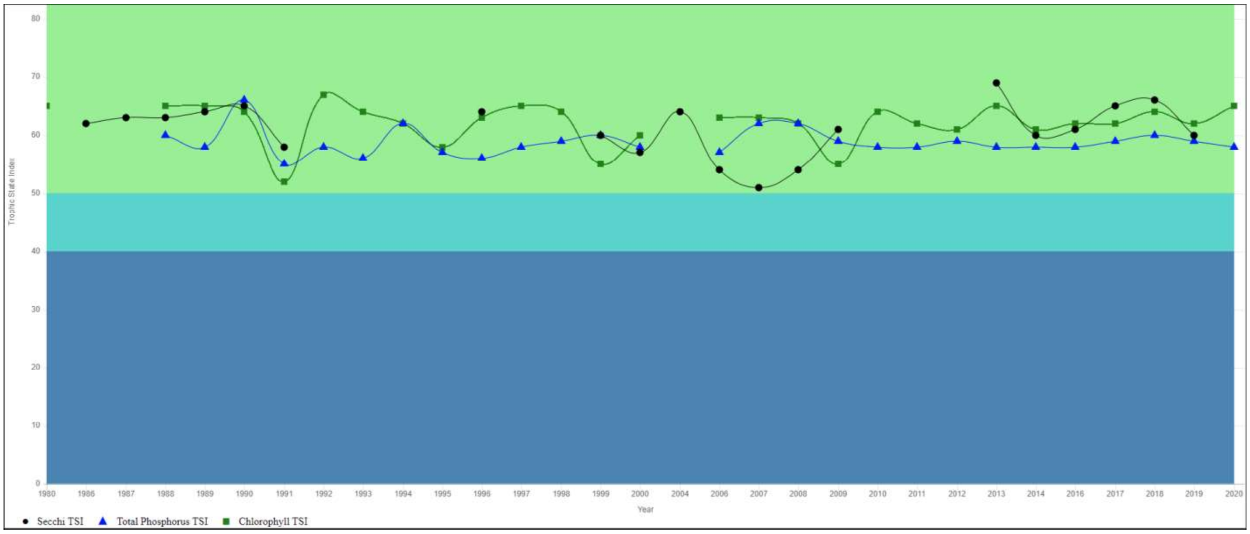


Figure 9: Deep Hole (SWIMS ID 573124) – Long Term Trend Monitoring

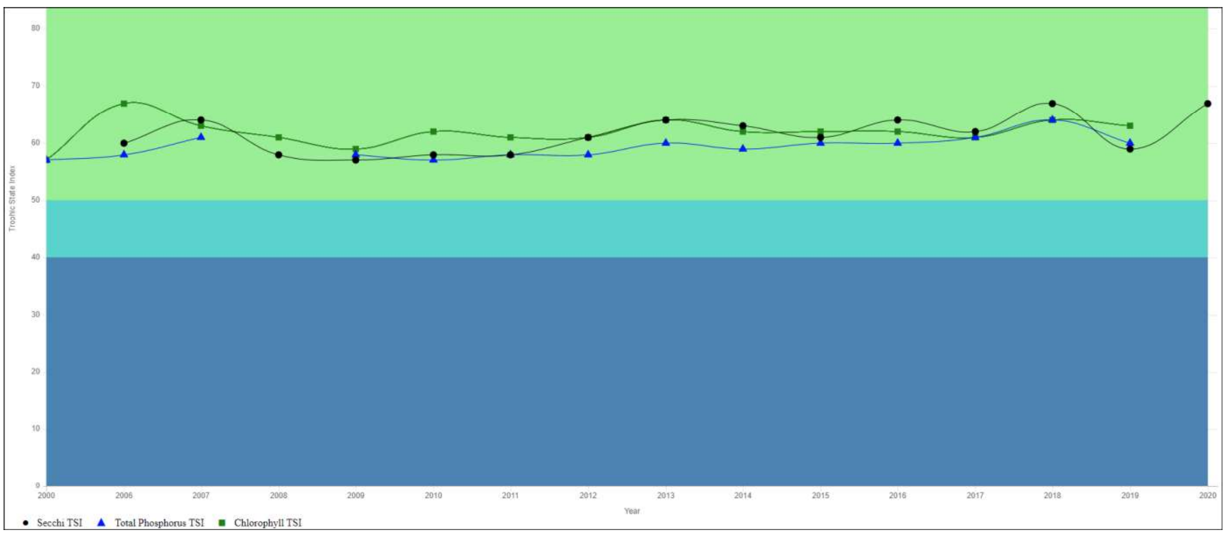


Figure 10: Lower Site (SWIMS ID 573129) – Navajo Court

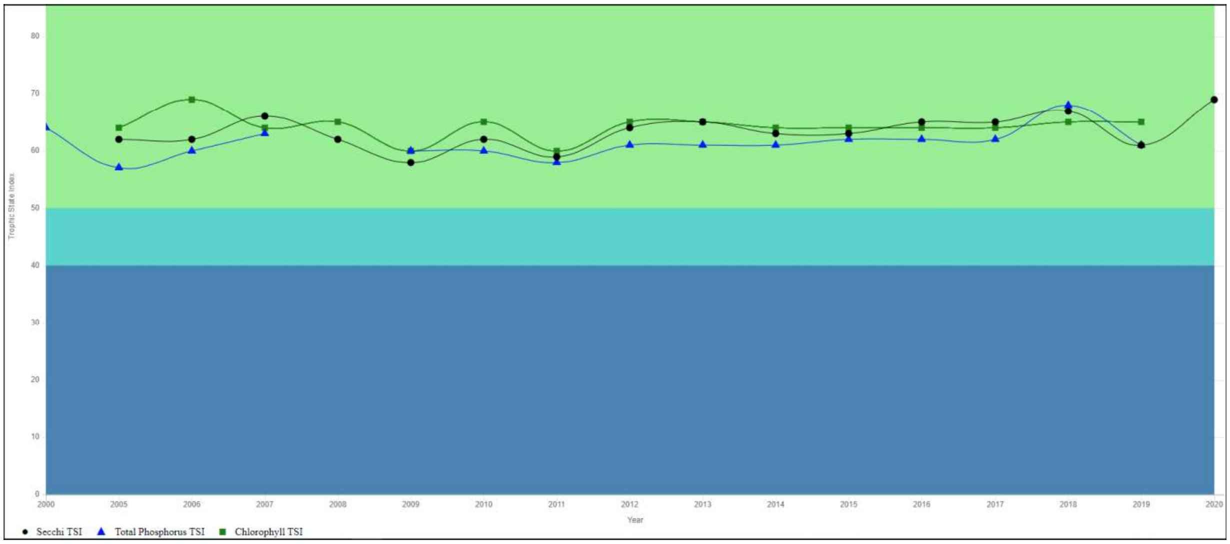


Figure 11: Middle Site (SWIMS ID 573131) – Mourning Dove

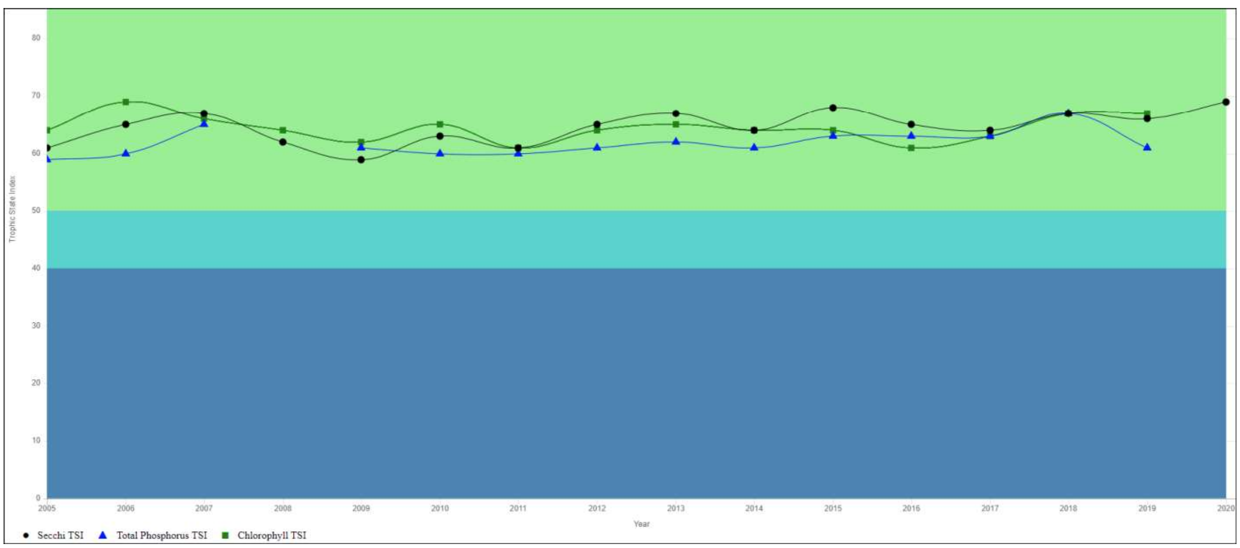


Figure 12: Upper Site (SWIMS ID 573205) – Winnebago Court

3.1.1.1 Statistical Analysis of Long-Term Water Quality Data from Lake Redstone (Oldenburg, 2021)

All four lake monitoring sites in the previous section have data sets supportive of long-term trend statistical analysis. Long-term trend analysis at the Deep Hole site, showed a significant increase in TP from 1988-2019. Given that the reservoir was initially built in 1966, this trend may be more indicative of reservoir ageing rather than an indication of increasing external TP loading. Looking at the data collected from 2006-2019, there was no significant trend in summer TP concentrations. Similarly, there was no significant trend in summer TP concentrations at the lower, middle, or upper sites.

When comparing each site to the other sites for TP, one-way analysis of variance (ANOVA) of TP data collected from 2006-2019 indicated that there was a significant difference between the four sites. Pairwise comparison of the sites indicated that the mean TP at the Deep Hole site was not significantly different than the mean TP at the Lower site, but was significantly different than mean TP at the Middle and Upper sites.

Pairwise comparison between mean TP at the Lower, Middle and Upper sites indicated that the means at these sites were not significantly different from one another (Table 2).

Based on these results, it may not be necessary to monitor all three supplementary sites in addition to the Deep Hole site to characterize the lake. When supplementary monitoring is conducted in the future, monitoring at the Deep Hole and Middle site should be sufficient to capture the longitudinal changes in TP that occur in the reservoir.

Table 2: Pairwise site comparisons of Lake Redstone TP data

Comparison	Absolute Difference in Mean log (TP)	Critical Range (α=0.05)	Critical Range Minus Absolute Difference	Result
Deep Hole-Lower	0.085	0.211	0.126	Not Different
Deep Hole-Middle	0.237	0.218	**-0.019**	Different
Deep Hole-Upper	0.291	0.216	**-0.075**	Different
Middle-Lower	0.152	0.211	0.059	Not Different
Upper-Lower	0.206	0.210	0.003	Not Different
Middle-Upper	0.054	0.216	0.162	Not Different

3.1.1.2 Lake Retention and Flushing Rate (Water Budget)

The average length of time that water spends in a lake (retention time) is the volume of the lake divided by the inflow of water from all sources. The flushing rate is the inverse of retention time, or the amount of time it takes to replace the volume of a lake (NALMS, 2017).

Lake response modeling was used in this plan to determine a retention time for Lake Redstone. Depending on which model is used, the retention time for water that comes into Lake Redstone is between 179 days (Bathtub Model) to 248 days (WiLMS)[1]. Thus, the total volume of water in Lake Redstone is replaced between 1.47 and 2.0 times per year (flushing rate). As a result, sediment and other pollutants entering the lake via surface water flow have plenty of time to settle and remain in the lake. Under normal conditions, a single flushing of Lake Redstone can take a long time, and the time required for multiple flushing events is even longer. But when things are not normal, like during large storm events like in 2018, the retention time may be only a few weeks, days, or hours and the flushing rate rapidly increases. Unfortunately, in these types of events, pollutant loading increases greatly as well.

3.1.1.3 WRB TMDL Lake Response Monitoring – Bathtub Modeling (Oldenburg, 2021)

As a part of the WRB TMDL, lake response modeling was done for Lake Redstone. The original modeling is described in Appendix I of the WRB TMDL report, and is included as Appendix C in this document. Steady-state modeling was conducted using Bathtub (Version 6.1, Walker 1996). Lake surface area and volume were based on values reported on WI-DNR lake survey maps (http://dnr.wi.gov/lakes/maps/). Mixed layer depth was based on model predictions. All model runs were based on long-term annual average loadings.

Long-term annual average water and nutrient loads to each lake were estimated using the SWAT model developed for the WRB TMDL (WI-DNR, 2019). Atmospheric loading rates were based on a precipitation rate of 0.8-m/yr. and a phosphorus load of 30-mg/m2/yr.

[1] For more information about water quality modeling tools and lake management tools go to https://dnr.wisconsin.gov/topic/SurfaceWater/Models.html or https://dnr.wi.gov/lakes/model/.

Epilimnetic (surface water) TP results for the modeling of Lake Redstone were acquired from the WI-DNR's comprehensive 2014 Lake Assessment data set developed for Wisconsin's 2014 Impaired Waters List. This data set encompassed the period from 2003 through 2012.

The Bathtub model and other lake response models are based on past research and studies. To assess whether modeling results make sense or not, the results are compared to these past studies, and the closest fit is used to make predictions. For Lake Redstone the Canfield-Bachman-Reservoirs TP sub-model was selected based on overall model fit. Model fit was adequate in all cases and no site-specific calibration was required.

To determine loading capacity for the lake, upstream tributary concentrations were sequentially lowered until modeled in-lake TP matched the goal for TP concentration in Lake Redstone of 30-µg/L (per NR 102.06 Wis. Admin. Code). Atmospheric TP loading rates were held constant as were hydraulic loading rates.

To provide some insight of potential lake response to reduced loadings, baseline TP loadings were reduced incrementally to evaluate resultant changes in in-lake TP concentrations (Figure 13). It is from this representation of the data that it is predicted that a 67% reduction in TP loading is necessary for the lake to meet state water quality standards. Note that these model outputs assume that the lake is in equilibrium with respect to any internal recycling (i.e. steady state condition). As watershed loads are reduced, there may be a lag in lake TP response as the system is adjusting to its new equilibrium. The length of this lag period is highly dependent on lake hydrology, morphometry, and sediment chemical characteristics. If substantial reduction in watershed loading is achieved and doesn't correspond to improvements in water quality; and if further investigation into the impact of and mechanisms controlling internal phosphorus recycling support them, then it may be appropriate at that time to implement practices like application of alum designed to control or minimize internal loading.

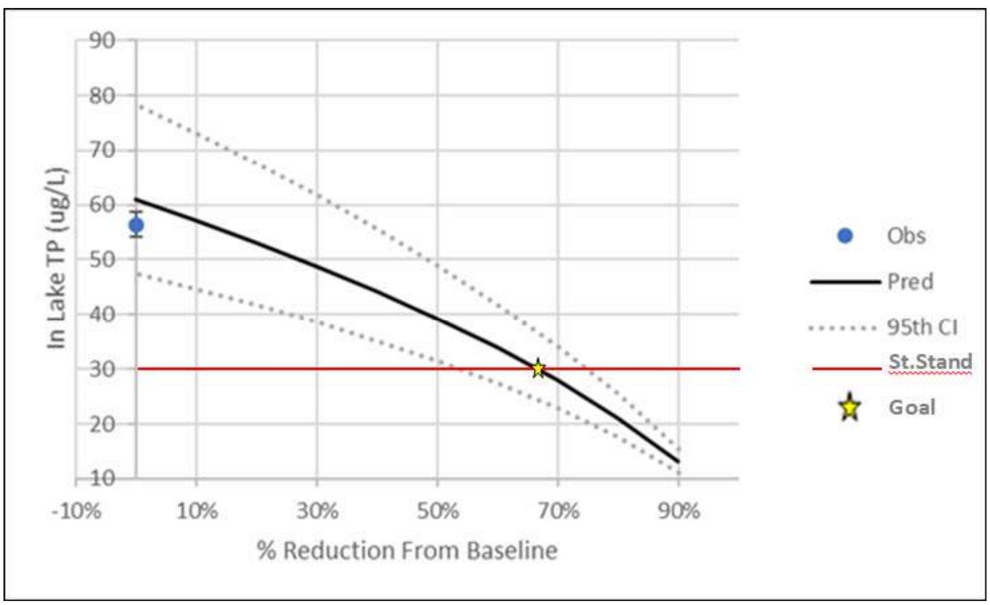


Figure 13: Bathtub predicted in-lake TP response to external TP load reductions. Error bars represent the 90th percentile confidence interval of observed values. The Star represents the goal for deep reservoirs like Lake Redstone set by the State of Wisconsin.

3.1.1.4 Chlorophyll as a Measure of Algae Biomass Response (Oldenburg, 2021)

While the TP criterion for Lake Redstone drove the TMDL goals, chlorophyll (algal) levels are a main driver impacting lake users and overall lake health. Bathtub modeling results were further evaluated to assess the impact of TP reductions on Chl-*a* levels. Several chlorophyll response models were evaluated in this process (Walker, 1984) (Hickman, 1980) (Jones & Bachman, 1976), with Jones & Bachman being selected based on best model fit. While the Jones & Bachman model was the best fit, based on measured Chl-*a* concentrations in the lake, it underestimates values. To account for this, and to provide a conservative estimate of the chlorophyll response, predictions from the model were adjusted upwards by 11%. Figure 14 reflects the expected change in Chl-*a* concentration with changes in TP concentration.

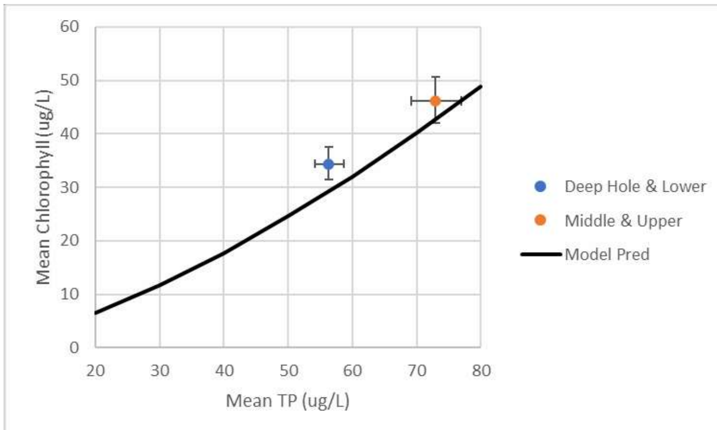


Figure 14: Jones & Bachman (1976) predicted mean Chl-*a* concentration. Error bars represent the 90th percentile confidence interval of observed values (Oldenburg, 2021).

Mean chlorophyll response is only a portion of the information that defines lake water quality. When measured in the water, Chl-*a* is used as a measure of the amount of algae in that water. Higher concentrations of Chl-*a* in the water are associated with more algae in the water. Increased levels of algae in the water are often associated with less enjoyment of that water. However, the amount of chlorophyll in the water does not always remain constant. Recreational lake users are oftentimes more impacted by periodic and often severe algal blooms (spikes in the concentration of chlorophyll) which can be much more intense than the seasonal averages that are predicted by Jones & Bachman model. How often an algae bloom is likely to occur in a body of water can be predicted through additional modeling. Once bloom frequencies are estimated they can be further related to the number of days an algae bloom of certain intensity may be expected between what is considered the period of heaviest lake use by the EPA and WisCALM between July 15 and September 15 (see Section 1.3).

How the intensity of an algae bloom impacts lake is perhaps best described through an analysis of a decade of Wisconsin user perception data from the Citizen Lake Monitoring Network (CLMN). This data indicates that at a chlorophyll concentration of 20-μg/L, half of Wisconsin lake users would consider their enjoyment of the lake somewhat impaired (WI-DNR, 2021). Other metrics include an analysis of user perception data from Lake Pepin by the Minnesota Pollution Control Agency. These data indicated a slightly higher tolerance by lake users for algal blooms with 40-μg/L considered a "nuisance" level (Walsey & Heiskary, 2009). The World Health Organization recommends a chlorophyll guideline of 50-μg/L to define a moderate health alert in recreational waters (World Health Organization, 2003).

Figure 15 estimates the frequency and intensity of algae blooms in Lake Redstone based on current summer conditions under all three of these metrics.

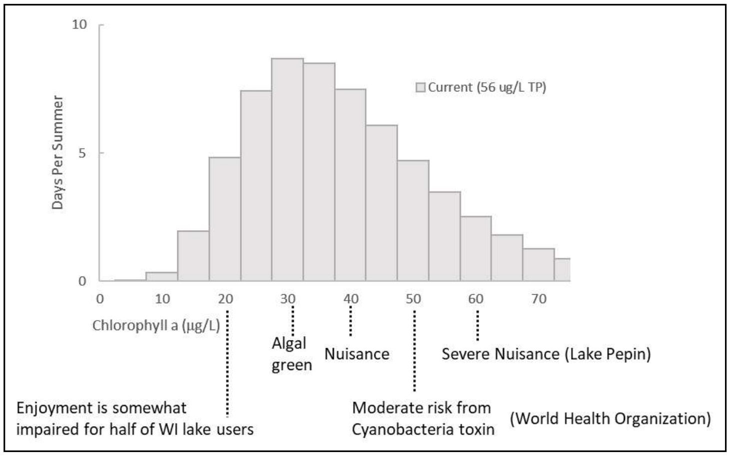


Figure 15: Estimated current distribution of chlorophyll bloom frequency for Lake Redstone in relation to user perception metrics (Oldenburg, 2021).

3.1.1.5 Internal Phosphorus Loading

Phosphorus entering the lake from external sources (watershed, riparian area, etc.) drives in-lake TP and productivity, and then that phosphorus is either exported out of the lake or deposited in its sediments (Robertson & Diebel, 2020). Not all phosphorus deposited in the sediments remains there, as some is released back into the water column, referred to as "internal phosphorus loading." From Robertson and Diebel 2020, internal phosphorus loading can be generically considered as all physical, chemical, and biological processes by which phosphorus is mobilized and translocated from the benthic (bottom of the lake) environment.

A study completed by the WI-DNR in 1997 determined that growing season TP loads to Lake Redstone came from the following sources: 66% from watershed runoff, 29% from internal phosphorus loading, and about 2% from groundwater (Leverance & Panuska, 1997). Although 29% of the phosphorus was predicted to be coming from internal loading of phosphorus, the study suggested that the 29% "may not be a significant part of the problem." The following factors led those who conducted the study to come to that conclusion. 1) Most of the phosphorus in the bottom water isn't available for algal use during the growing season but does become available in the fall when lake stratification is breaking down with cool weather. And 2) The frequency and duration of algal blooms during this period (fall) is low and not as noticeable as during the summer period. This latter observation was based on the flushing rate of Lake Redstone at the time that would exchange phosphorus laden water about two times per year suggesting that any phosphorus released from the sediment in early to mid-autumn would flow out of the lake by late autumn and winter (Panuska, 1997).

There is significant interest on the part of the LRPD to evaluate internal loading more completely in the first year or two of implementation.

3.1.1.6 Bottom Disturbances

Internal loading in shallow lakes can be exacerbated by the resuspension of bottom sediments. One study estimated that resuspension could enhance the phosphorus release rate by 20–30 times compared to undisturbed sediment (Sondergaard, Kristensen, & Jeppesen, 1992). About 90-95% of the phosphorus entering a lake is accumulated in the top layer of the sediment (Nedohin & Elefsiniotis, 1997). A significant portion of this is not readily available for uptake by algae, but the mixing of the sediment with the lake water above it releases a considerable amount of phosphorus which is then available for assimilation and utilization in the eutrophication process. Man-made mixing processes in a lake include swimming, motor boat activity, and other artificial mixing. These actions have greater impact on a lake when the lake has considerably high motor boat activity; it is considered shallow (<10 meters); and it has considerable resistance to wind and pressure changes (Nedohin & Elefsiniotis, 1997), all conditions that exist in Lake Redstone.

Re-suspended sediment can negatively impact water quality and aquatic plant growth. The current knowledge on effects of recreational boat traffic on the aquatic environment has been summarized in a number of reviews and government reports (Sagerman, Hansen, & Wickstrom, 2020). The resuspension of sediments can release sediment nutrients, stimulating phytoplankton growth that also results in shading of benthic vegetation The propellers of motorboats can directly cut or uproot the vegetation, and sensitive species can be damaged by wake and turbulence generated by propellers and boat movement. Water turbulence and wake also stir up sediment, resulting in shading of benthic vegetation due to increased water turbidity and in smothering when sediment settle on the shoots (Sagerman, Hansen, & Wickstrom, 2020). Figure 16 provides a simple illustration of the potential impacts of motorboat use.

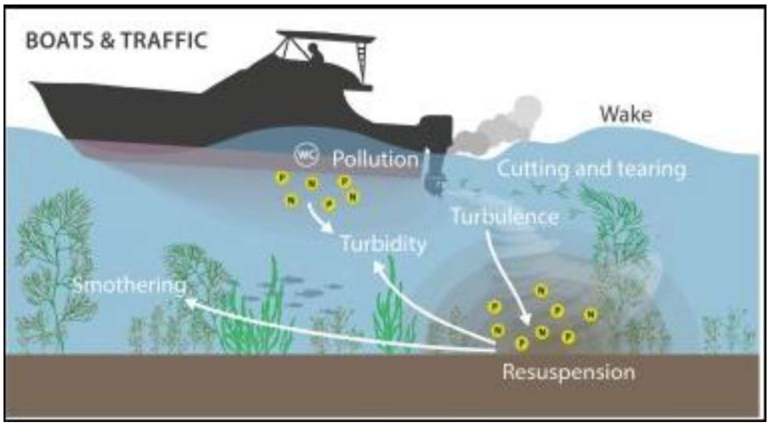


Figure 16: Illustration of mechanisms by which recreational boating activities affect submerged aquatic vegetation, separated into mechanisms generated by boats (Sagerman, Hansen, & Wickstrom, 2020)

3.1.2 Fisheries

Lake Redstone provides an excellent overall fishery, with a variety of quality fishing opportunities. Musky smallmouth bass, walleye, white crappie, and yellow perch are common. Yellow bullhead, channel catfish, bluegill, and largemouth bass are present. Because of the eutrophic nature of the lake, it has average to above average growth rates for all panfish and gamefish analyzed. According to the latest fisheries survey, management should focus on maintaining the current diverse fish community. Public access is good with three boat ramps maintained by the township and county (Rennicke, 2012).

Because depths over 12-ft have either low dissolved oxygen or are anoxic (no oxygen), the majority of the lake is not utilized by fish. For this reason, areas that are utilized by both fish and other organisms should be either enhanced or protected. Further remediation's to control, remove, and/or manage nutrients already in the lake and coming into the lake could potentially change the status of this area of the lake (Rennicke, 2012).

3.1.2.1 Fish Stocking (Rennicke, 2012)

With the exception of minimal stocking of walleye in 1967 and 1969, Lake Redstone did not receive stocked fish until 1982. Between 1969 and 1982 no stocking was done due to concerns related to annual and semi-annual die offs during both summer and winter months (Rennicke, 2012). Table 3 reflects stocking records since 1982 (WI-DNR, Fish Stocking Summary). Since 1982, walleye have been stocked almost annually. Since 1987, musky have been stocked in every other year. Northern pike were stocked once in 1982 and yellow perch once in 1983.

In 2018, the Lake Redstone Fishing Club (LRFC) began stocking larger walleye (6-8") in between the years when the WI-DNR stocked walleye fingerlings. In 2018 3,000 walleye were stocked by the LRFC, and in 2020, 5,500 were stocked (personal communication, Paul Burke 9/13/2021).

Channel catfish have been stocked twice, once in 1982 and once in 1993 (Rennicke, 2012). In 1997, the La Valle Hawg Hunters Club requested approval to stock smallmouth bass (which had previously not been present). The request was approved and for two years (1998 and 1999) smallmouth bass were stocked in the lake. There appears to be natural reproduction and the species is currently self-sustaining (Rennicke, 2012).

Currently the DNR quota requests for Lake Redstone are; walleyes at a rate of 18 small fingerlings per acre and musky at 1 large fingerling per acre each year. Walleye and musky will continue to be stocked to help maintain populations (Rennicke, 2012).

As of 2012, Lake Redstone follows the general inland fishing regulations with the exception of a 50 inch minimum for muskellunge (Rennicke, 2012).

3.1.2.2 Common Carp

Common carp were listed as "present" in Lake Redstone with WI-DNR survey results analyzed by Rennicke in 2012 documenting six carp ranging from 22.1-32.7 inches caught during the 2010 spring netting period. In the same year, spring electrofishing, where protocol is to observe and count carp, but not to measure them, found 29 carp per mile of shoreline surveyed. According to the current WI-DNR fisheries manager for Sauk County, this number is "not uncommon but not overly abundant either, relative to other area lakes" (personal communication Nathan Nye, October 7, 2021). Nye also stated that there is - not enough data on carp abundance, biomass, or population size structure to make any sort of educated statements about the carp population and how much it may be impacting Lake Redstone.

The effect of common carp domination on wetland and lake ecosystems is complex. Carp uproot aquatic macrophytes when spawning and feeding. These activities also suspend bottom sediments and nutrients, limiting light penetration needed for macrophyte growth. Carp also reduce zooplankton and macroinvertebrate populations by predation and by eliminating macrophytes that provide cover. Phytoplankton populations increase due to increased release of nutrients and reduced predation by zooplankton. Fish and wildlife are adversely affected by the loss of zooplankton and macroinvertebrate food sources, and loss of aquatic macrophytes that provide cover for larval and juvenile fish and substrate for eggs and invertebrates (Kahl, 1991).

Having a better understanding of the role of carp in nutrient cycling in the lake with an eye toward potential carp management activities is another important variable in determining just what is impacting the lake and how. According to Nye, it may be possible to "give carp some extra focus during the spring 2022 survey" and he sounds willing to do so (Personal communication Nathan Nye, 10/7/2021).

Regardless of not knowing for sure what role common carp play in internal nutrient loading in Lake Redstone, the Lake Redstone Fishing Club has sponsored carp "bow-fishing competitions" in years past. The last such event was held on June 20, 2020. It is a popular event on the lake and will likely continue at some level in the future.

Table 3: Fish stocking in Lake Redstone (WI-DNR, Fish Stocking Summary)

Year	StockedWaterbodyName	Location	Species	Age Class	NumberFishStocked	Avg FishLength (IN)
1983	LAKE REDSTONE	13N-3E-24	MINNOWS & CARPS UNSP.	ADULT	100,000	3
2018	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	612	12.3
2016	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	613	10.3
2015	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	609	11.8
2014	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	610	9.3
2013	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	612	11.35
2012	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	612	9.7
2011	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	612	10
2010	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	612	12.9
2008	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	1,224	10.7
2005	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	1,224	12.1
2003	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	1,224	11.4
2001	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	1,224	10.4
2000	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	612	12
2000	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	YEARLING	368	14.3
1999	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	337	11.8
1999	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	YEARLING	301	14.7
1998	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	275	11.9
1997	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	LARGE FINGERLING	560	10.4
1995	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	FINGERLING	1,200	8.8
1993	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	FINGERLING	1,200	10.5
1991	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	FINGERLING	850	11
1987	LAKE REDSTONE	13N-3E-24	MUSKELLUNGE	FINGERLING	1,200	3
1982	LAKE REDSTONE	13N-3E-24	NORTHERN PIKE	FRY	310,000	
2019	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	21,054	2.06
2017	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	21,159	1.7
2015	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	21,159	1.8
2013	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	14,813	1.7
2012	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	10,600	1.7
2011	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	10,579	1.47
2010	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	11,736	1.73
2009	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	11,016	1.6
2008	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	11,016	1.3
2006	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	34,345	2.05
2005	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	33,019	1.91
2004	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	30,550	2.1
2003	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	30,660	2.1
2002	LAKE REDSTONE	13N-3E-24	WALLEYE	LARGE FINGERLING	621	7.9
2002	LAKE REDSTONE	13N-3E-24	WALLEYE	LARGE FINGERLING	5,626	7.8
2001	LAKE REDSTONE	13N-3E-24	WALLEYE	FRY	1,100,000	0.5
2000	LAKE REDSTONE	13N-3E-24	WALLEYE	FRY	1,100,000	0.5
2000	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	61,969	1.5
1999	LAKE REDSTONE	13N-3E-24	WALLEYE	FRY	1,101,000	0.4
1999	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	61,200	1.5
1998	LAKE REDSTONE	13N-3E-24	WALLEYE	FRY	1,050,000	0.4
1997	LAKE REDSTONE	13N-3E-24	WALLEYE	SMALL FINGERLING	20,600	1.6
1995	LAKE REDSTONE	13N-3E-24	WALLEYE	YEARLING	6,854	5.1
1992	LAKE REDSTONE	13N-3E-24	WALLEYE	FINGERLING	18,837	3
1991	LAKE REDSTONE	13N-3E-24	WALLEYE	FINGERLING	13,992	3
1989	LAKE REDSTONE	13N-3E-24	WALLEYE	FINGERLING	15,136	2
1988	LAKE REDSTONE	13N-3E-24	WALLEYE	FINGERLING	2,100	8
1987	LAKE REDSTONE	13N-3E-24	WALLEYE	FINGERLING	12,000	4
1986	LAKE REDSTONE	13N-3E-24	WALLEYE	FINGERLING	9,135	3
1984	LAKE REDSTONE	13N-3E-24	WALLEYE	FINGERLING	6,540	5.25
1983	LAKE REDSTONE	13N-3E-24	WALLEYE	FINGERLING	1,500	5
1983	LAKE REDSTONE	13N-3E-24	WALLEYE	YEARLING	5	11
1983	LAKE REDSTONE	13N-3E-24	YELLOW PERCH	YEARLING	2,000	4

3.1.3 Critical Habitat Areas

Lake Redstone is considered an Area of Special Natural Resource Interest because portions of the lake contain critical habitat designated by the WI-DNR (Sefton & Graham, 2009). Every waterbody has critical habitat - those areas that are most important to the overall health of the aquatic plants and animals. Wisconsin law mandates special protections for these critical habitats assuming they have been identified in an official critical habitat designation. Areas are designated as Critical Habitat if they have Public Rights Features, Sensitive Areas, or both (WI-DNR, Critical Habitat Areas). The Critical Habitats (Public Rights Features) for Lake Redstone include:

- Fish and wildlife habitat, including specific sites necessary for breeding, nesting, nursery and feeding;
- Plant communities and physical features that help protect water quality; and
- Reaches of bank, shore or bed which are predominately natural in appearance or that screen man-made or artificial features.

There were 20 areas designated as Critical Habitat for Lake Redstone (Figure 17). Fourteen of these were classified as Sensitive Areas for their aquatic vegetation and six were classified as Other Public Rights Features for containing reaches of shore that are predominately natural in appearance or that screen man-made or artificial features, and/or fish and wildlife habitat values.

Designation as Critical Habitat may affect the decision process on Waterway and Wetlands Permits under Ch. 30, Wis. Statutes. These include activities such as grading on the banks, dredging, placement of pea gravel beds or sand blankets, boat ramps, or shoreline erosion control (subject to appropriate site-specific wave energy calculations). This does not mean these activities will be prohibited, but that they will undergo more careful review to ensure that the activity does not adversely affect the critical habitat in the area.

Designation as Critical Habitat may also affect decisions on permitting of aquatic plant management under NR107 and NR109 of the Wis. Adm. Code. All aquatic plant management activities in Lake Redstone undergo careful review to ensure that the activity does not adversely affect the sensitive ecosystem in the area.

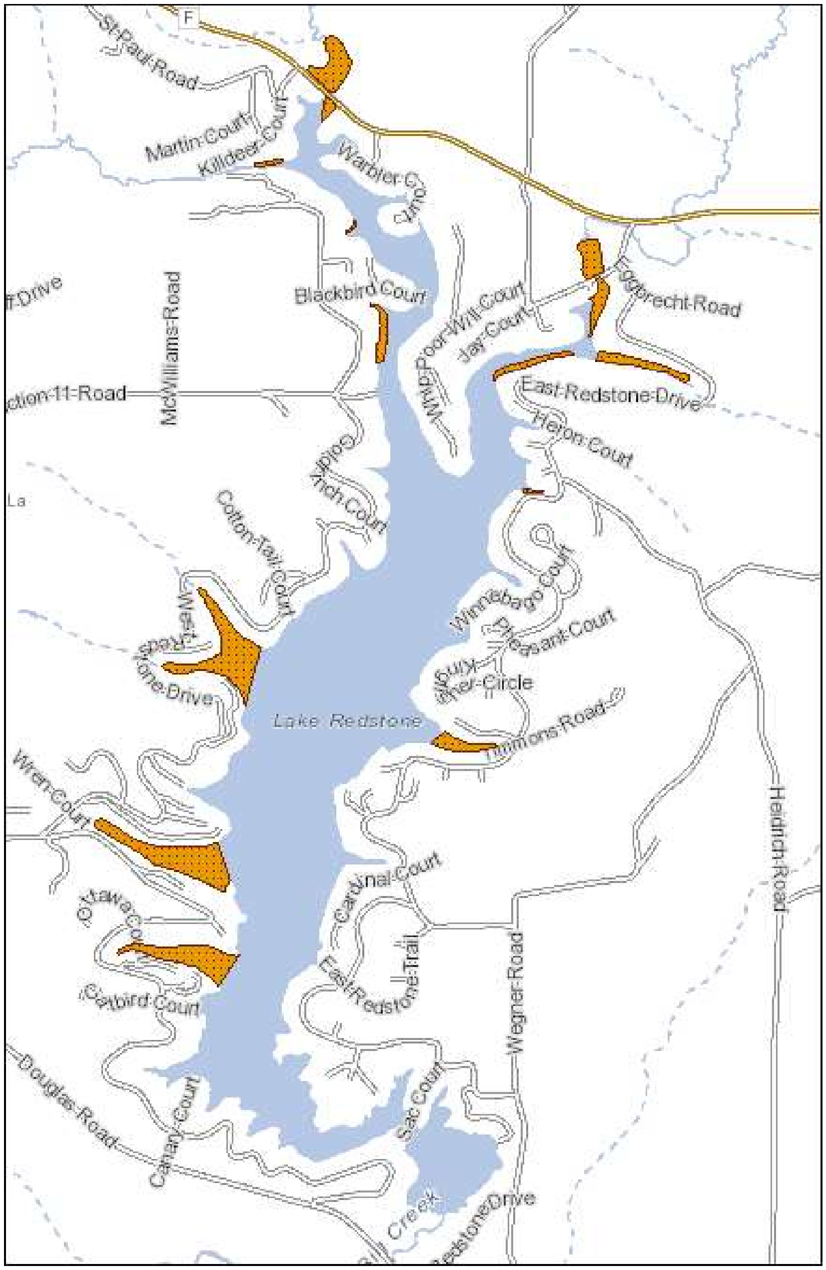


Figure 17: Critical habitat areas in Lake Redstone

3.1.4 Aquatic Plants

Aquatic plants form the foundation of healthy and flourishing lake ecosystems - both within lakes and rivers and on the shores around them. They not only protect water quality, but they also produce life-giving oxygen. Aquatic plants are a lake's own filtering system, helping to clarify the water by absorbing nutrients like phosphorus and nitrogen that could stimulate algal blooms. Plant beds stabilize soft lake and river bottoms and reduce shoreline erosion by reducing the effect of waves and current. Healthy native aquatic plant communities help prevent the establishment of invasive non-native plants like Eurasian watermilfoil, purple loosestrife or phragmites (WI-DNR, Aquatic Plants).

The best fishing spots are typically near aquatic plant beds. Aquatic plants provide important reproductive, food, and cover habitat for fish, invertebrates and wildlife. Aquatic plants fashion a nursery for all sorts of creatures ranging from birds to beaver to bass to bugs. In order to maintain healthy lakes and rivers, healthy native aquatic plant communities must be maintained (WI-DNR, Aquatic Plants).

Lake characteristics valued by so many are enhanced by the aquatic plant community. The visual appeal of a lakeshore often includes aquatic plants, which are a natural, critical part of a lake community. Plants such as water lilies, arrowhead, and pickerelweed have flowers or leaves that many people enjoy. Clear water is supported by the presence of aquatic plants. As a natural component of lakes, aquatic plants support the economic value of all lake activities.

3.1.4.1 Aquatic Plants in Lake Redstone

During the last whole-lake, point-intercept survey of the lake completed in July 2012, 85 out of 966 individual points surveyed had aquatic plants (Berg, 2012). Aquatic plants were patchy in distribution with just over 25% of the lake's available substrate being colonized. Species richness was low for such a large lake with only 11 species found in the lake. Including visuals and a boat survey, this number increased to 16 different plant species found growing in and immediately adjacent to the lake. Lake-wide, only 5 of the 85 points with vegetation had more than 3 native species present in the rake. The average number of plant species at points with vegetation was 1.4 when only counting native species and 1.74 when including exotic species. Plant density was low to moderate with a mean total rake fullness value at vegetative points of 1.54.

3.1.4.2 Measurements of Healthy Aquatic Plant Community

The Simpson's Diversity Index (SDI) allows the entire plant community at one location to be compared to the entire plant community at another location. It also allows the plant community at a single location to be compared over time thus allowing a measure of community degradation or restoration at that site. The SDI value represents the probability that two individuals (randomly selected) will be different species. The index values range from 0 -1 where 0 indicates that all the plants sampled are the same species to 1 where none of the plants sampled are the same species. The greater the index value, the higher the diversity in a given location. Although many natural variables like lake size, depth, dissolved minerals, water clarity, mean temperature, etc. can affect diversity, in general, a more diverse lake indicates a healthier ecosystem. Plant communities with high diversity also tend to be more resistant to invasion by exotic species (Berg, 2012). The SDI value for Lake Redstone in 2012 was 0.75 indicating low to moderate plant diversity (Berg, 2012).

The Floristic Quality Index (FQI) measures the impact of human development on an area's aquatic plants. The 124 species in the index are assigned a Coefficient of Conservatism (C) which ranges from 1-10. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and they often exploit these changes to the point where they may crowd out other species. The FQI is calculated by averaging the conservatism value for each native index species found in the lake during the point intercept survey, and multiplying it by the square root of the total number of plant species in the lake. Statistically speaking, the higher the index value, the healthier the lake's macrophyte community is assumed to be (Berg, 2012). (Nichols, 1999) identified four ecoregions in Wisconsin: Northern Lakes and Forests, Northern

Central Hardwood Forests, Driftless Area and Southeastern Wisconsin Till Plain. He recommended making comparisons of lakes within ecoregions to determine the target lake's relative diversity and health. Lake Redstone is in the Driftless Area Ecoregion.

During the 2012 survey, a total of 8 native index species were identified during rake sampling. They produced a mean Coefficient of Conservatism of 5.1 and a Floristic Quality Index of 14.5. Nichols reported an average mean C for the Driftless Area Ecoregion of 5.0 putting Lake Redstone slightly above average for this part of the state. The FQI was also slightly above the median FQI of 14.3 for the Driftless Area (Nichols 1999) (Berg, 2012).

Both the SDI and FQI indicate an aquatic plant community that is limited and that preserving what is currently present is important for the overall health of the lake.

3.1.4.3 Aquatic Plant Management

Aquatic plant management in Lake Redstone has been on-going since the early 1980's when the use of aquatic herbicides was first employed. In the years between the 1980s and 2002, EWM was chemically treated in small localized populations by LRPD volunteers who had obtained Category 5 commercial applicator certification. Large-scale algae treatments were completed in the 1980's. By 2002, the level of nuisance aquatic vegetation (EWM and certain native plants) in Lake Redstone reached a point where professional applicator services were required. From the early 2000s to the development of the last APM Plan in 2014, plant management permits applied for by the LRPD included 25-33 acres of possible treatment.

In 2009, the WI-DNR presented results from a critical habitat study (See Section 3.1.3) that was completed on Lake Redstone. This study identified areas of the lake sensitive to human development and use, and areas where the presence of valuable, native aquatic vegetation should have greater protection from nuisance aquatic plant management actions completed by the LRPD. The study raised a bit of controversy as it also impacted some of the regular aquatic plant management that had been occurring in the lake.

Lake Redstone property owners have many differing views related to the management of aquatic plants. Many did, and still do, express dissatisfaction with the aquatic plant management actions implemented by the LRPD. Many lake residents and users want improved water clarity in the lake and, at the same time, fewer plants, without realizing that these two statements are mutually exclusive. Aquatic plants in Lake Redstone are the basis of the ecosystem. Preserving them is critical to maintaining a healthy lake.

The main goal of the 2015 APM Plan was to seek a balance between management with the goal of protecting a healthy lake and management with the goal of protecting the rights of property owners to enjoy the lake. The 2015 APM Plan had the following ten aquatic plant management and lake protection goals. Each goal had several objectives to be met and identified management actions to help meet the objectives.

1) Protect, preserve and enhance native aquatic plant communities in Lake Redstone.
2) Complete annual monitoring and mapping of aquatic plants most affected by plant management actions.
3) Implement physical/manual removal actions to control aquatic invasive species and nuisance growth of native aquatic plants.
4) Implement herbicide application to control aquatic invasive species and nuisance growth of native aquatic plants.
5) Monitor and manage non-native, invasive plant species other than CLP and EWM identified in Lake Redstone.
6) Educate the lake populace so that they become well-acquainted with aquatic invasive species identification, prevention techniques, planning processes, and management actions.

7) Promote greater understanding in the lake populace of how their actions impact the aquatic plant and lake community.
8) Continue compilation and collection of lake related data to enhance and support current and future lake management planning and implementation.
9) Complete APM Plan implementation and maintenance for a period of five years following adaptive management practices.
10) Evaluate and summarize the results of the management actions implemented during the 5-year timeframe of this plan and repeat the whole-lake point-intercept aquatic plant survey implemented in 2012.

With the approval and implementation of the 2015 APM Plan, management of aquatic plants focused more on EWM in individual bays and less on native vegetation and EWM along the main shore of the lake – those areas not in a bay. It also included more increased aquatic plant surveying to determine the annual and long-term impacts of management. Chemical management of EWM has not been completed in any portion of Lake Redstone since 2018.

Repeating the 2012 whole-lake, point-intercept, aquatic plant survey work and updating of the 2015 APM Plan are short-term milestones in this plan.

3.1.4.4 Aquatic Invasive Species

Certain aquatic invasive species already in Lake Redstone can and likely are having an impact on water quality and overall health of the lake. These species include EWM, CLP, carp. Even native species such as coontail and gizzard shad, can rise to nuisance levels and impact the lake. There are several other aquatic invasive species that could be introduced into the lake and cause changes in water quality and lake health. Chief among these would be zebra mussels. Most existing and new AIS that could or are impacting the lake are discussed in the APM Plan. Guidelines are given in the APM Plan as to how to monitor and track AIS in the lake; how to prevent new introductions, and education and information resources to involve the constituency in protecting the lake from AIS.

3.2 Riparian Area

Riparian areas are the zones along all water bodies including lakes, ponds and some wetlands that serve as interfaces between terrestrial and aquatic ecosystems (Manci, 1989). Typical examples of riparian areas include floodplains, streambanks, and lakeshores. Riparian areas are important in mitigating or controlling nonpoint source pollution. Riparian vegetation can be effective in removing excess nutrients and sediment from surface runoff and shallow ground water and in shading waterbodies to optimize light and temperature conditions for aquatic plants and animals. Riparian vegetation, especially trees, is also effective in stabilizing streambanks and lakeshores and in slowing flood flows, resulting in reduced downstream flood peaks. Riparian areas are often important for their recreation and scenic values, such as hunting, fishing, boating, swimming, hiking, camping, picnicking and birdwatching (Montgomery, 1996).

Many riparian areas are heavily impacted by human activities, such as highway, bridge, and pipeline construction; water development; channel modifications for flood control; recreation; industrial and residential development; agriculture; irrigation; livestock grazing; logging; and mining (Manci, 1989).

3.2.1 Riparian Area of Lake Redstone

Two methods were combined to evaluate shoreland habitat and to determine the impact of development in the riparian area of the lake. The first was a Shoreland Habitat Assessment (SHA) following protocols found in the Lake Shoreland Habitat Monitoring Field Protocol developed by the WI-DNR in 2015 and updated in

November 2020.[2] This survey is intended to provide management recommendations to individual property owners based on the evaluation of their property. The protocol involves taking a photograph of each parcel/property from the lake and then assessing the land use in that parcel in an area from the high-water level back 35 feet. The information collected includes the amount of tree cover (canopy), ground cover (lawn, impervious surfaces, and native plants), human structures in the riparian area, and various other runoff concerns including steep slopes and the presence of erosion. Based on this information, each parcel is given an official "score" and a priority ranking. This assessment was completed in 2018.

The second part of this assessment involved mapping land use in a wider 300-ft strip of land around the lake. Aerial images of the lake and shoreland are digitized separating out impervious surfaces (rooftops, driveways, roads, and sidewalks), lawn, forest/undeveloped land, water, and wetlands. From these numbers, an estimate of the amount of nutrient loading from the riparian area can be made.

3.2.1.1 Shoreland Habitat Assessment

The priority rankings that accompany each parcel evaluation were developed by Lake Education and Planning Services (LEAPS) in order to determine the needs of each lake as it relates to projects that could realistically be completely on each parcel. The parameters used to determine the priority ranking were considered to be those that would have the biggest impact on rainwater runoff and habitat quality. This includes percentage of canopy cover, as well as the percentage of undisturbed vegetation and a summed percentage of ground covered by manicured lawn, impervious surfaces, and easily eroded surfaces such as exposed soil or shredded vegetation such as pine needles, loose leaves, small branches, etc. also known as duff. Additional consideration was given to the number of buildings present in the riparian area and the presence or absence of lawns that sloped directly to the lake. For each factor that was considered, there are value ranges assigned to each parameter which determine the color to be assigned (Table 4). Values that fall within the red range are worth 2 points, values in the yellow range are worth 1 point, and values in the white range are not given any points. The points are then summed and the properties prioritized based on the point range for the entire lake.

To establish priority rankings for the lake, it was important to consider the entire lake. The maximum possible score was 12 points, but the highest scoring parcel only scored 10 points. From here, four levels of concern were established: red, orange, yellow, and white. These colors correspond to properties that have the most potential to implement shoreland habitat and runoff reduction projects that will help improve the lake (Table 5, Figure 18).

[2] For more information about the Shoreland Habitat Assessment Protocol go to: https://www.google.com/search?q=2020+Shoreland+Habitat+Monitoring+Field+Protocol&rlz=1C1GGRV_enUS751US751&oq=2020+Shoreland+Habitat+Monitoring+Field+Protocol&aqs=chrome..69i57j33i160.20406j0j15&sourceid=chrome&ie=UTF-8

Table 4: Value ranges for color assignments of each SHA parameter of concern

Parameter	Red range (2 points)	Yellow Range (1 Point)	White (No points)
Percent canopy cover	0-33%	34-66%	>66%
Percent shrub and herbaceous (undisturbed)	0-33%	34-66%	>66%
Percent lawn, impervious, and other surfaces	>66%	34-66%	0-33%
Number of buildings and other human structures	>1	1	0
Presence/ Absence of lawn or soil sloping to lake	N/A	1 (Present)	0 (Absent)
Presence/Absence of bare soil	1 (Present)	N/A	0 (Absent)
Presence/Absence of sand deposits	N/A	1 (Present)	0 (Absent)

Table 5: Score ranges and priority rankings for the 784 parcels immediately adjacent to Lake Redstone

Color	Overall Score	Priority	Number of Parcels
Red	7-10 Points	High	214
Orange	4-6 Points	Moderate	209
Yellow	2-3 Points	Low	69
White	0-1 Points	No Concern	292

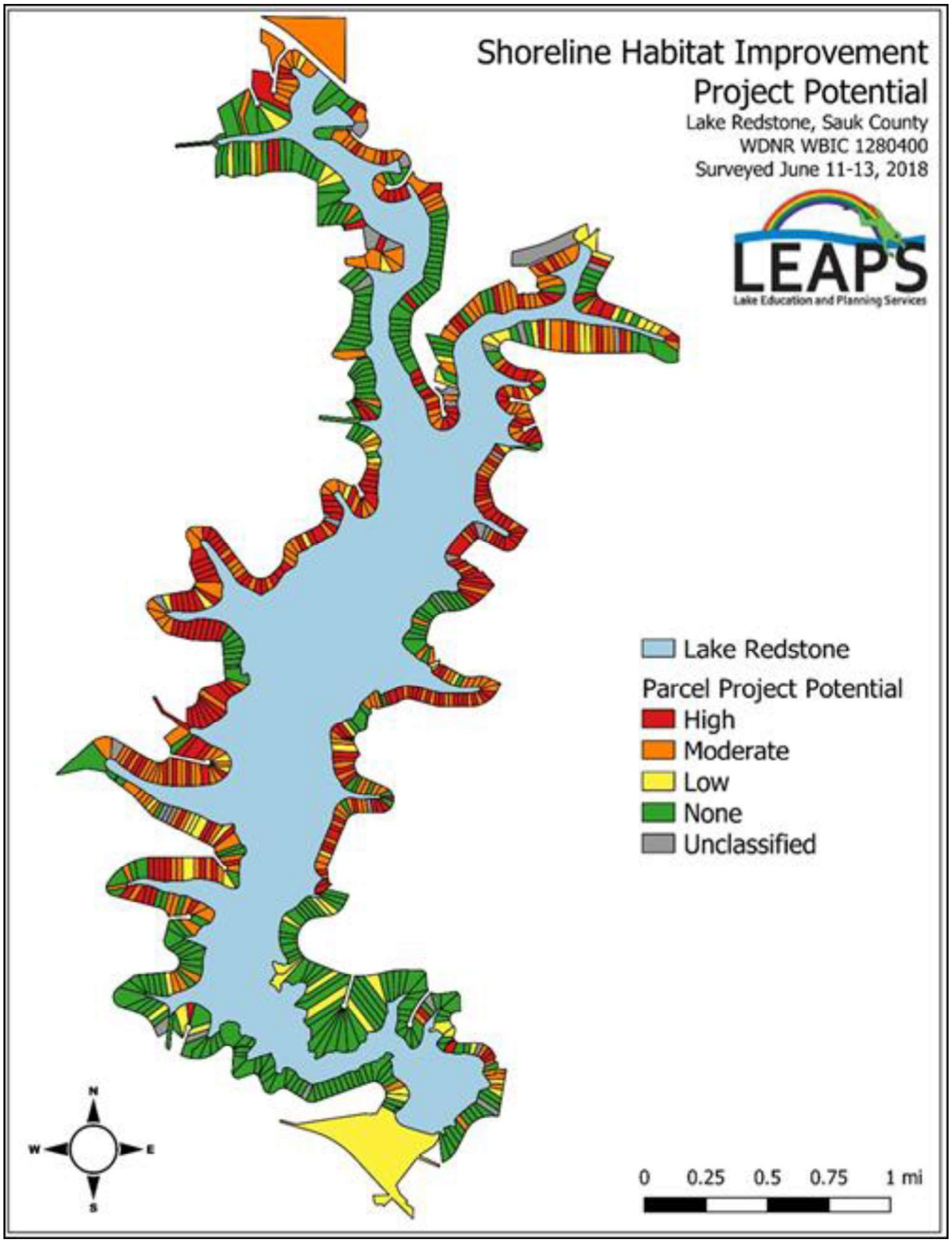


Figure 18: Lake-wide SHA results map

For each of the 784 parcels that were evaluated, an individual score and ranking was established based on the assessment. In addition to the assessment, surveyors took a photo of each parcel. Photos are intended to provide reference for individual property owners. It is important to note that when assessing each parcel, ONLY the 35-ft wide band along the shoreline was considered. The photos were not used to assess properties and can be misleading for certain parameters, particularly canopy cover. For example, some parcels appear mostly shaded, but only have 15% canopy cover. This is likely because the assessment only considered 35-ft back and the canopy cover started beyond that mark. Additionally, there are other considerations such as camera angle, time of day, etc. All evaluations were done in the field to prevent any misdirection that would have been caused by using photos to assess the properties. However, if it was determined that a photo of a given parcel was missing, aerial imagery was used instead of an actual photo.

3.2.1.2 Land Use Digitizing of the developed Area around the Lake

Land use digitizing in a 300-ft band around Lake Redstone was completed in 2019. The amount of impervious surface (rooftops, driveways, sidewalks, and roadway), lawn, natural/wooded, and wetland was determined by viewing aerial photos, and then creating geospatial files for each land use. In total approximately 600 acres in the developed area was digitized. This area includes both properties immediately adjacent to the lake and many of those "up on the bluff" or in some other way "off the lake". Table 6 shows how much of each land use was identified. Figure 19 shows the distribution of that land use.

Table 6: Riparian Area Land Use around Lake Redstone

Land Use	Acres	% of Total Land Use
Impervious Surface	95	15.8
Lawn	209	34.8
Forest/Natural	283	47.2
Wetland	13	2.2
	600	100

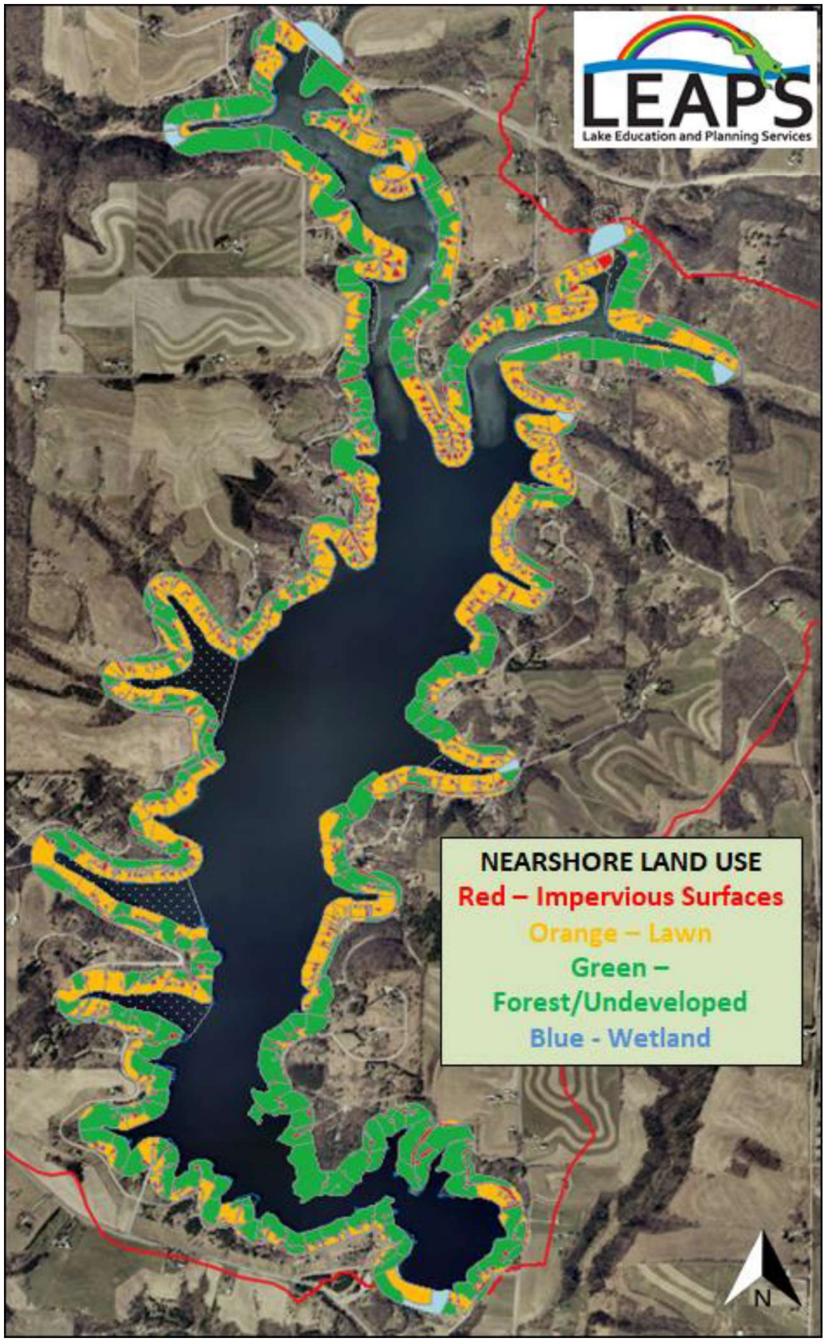


Figure 19: Land Use in a 300-ft band around Lake Redstone

More than 50% of the individual property parcels evaluated during the Shoreland Habitat Assessment were listed as having a moderate to high priority when considering the potential for implementing project that could improve habitat and reduce runoff. Similarly, results from the land use digitizing of the developed area around the lake showed more than 50% of the land in a 300-ft strip around the lake was either mowed grass or impervious surface (rooftops, driveways, roads, etc.).

Lake response modeling was used to estimate TP loading from the mowed lawn in the 300-ft riparian area around the lake and what would happen if the total acreage of mowed lawn increased or decreased (Table 7).

Table 7: Riparian land use TP loading (WiLMS)

Nearshore TP Loading (lbs/year)			
Condition	**Low**	**Likely**	**High**
50% less lawn	161.8	330.7	796.0
Current	161.8	331.6	802.5
20% more lawn	161.8	332.0	805.1

TP and sediment loading from the developed area of the riparian may be fairly insignificant when compared to loading from the larger watershed, but making improvements to this area is much easier and less expensive than what can be done across the entire watershed.

3.2.2 Gullies, Washes, and Streams

When Lake Redstone was first built, it flooded a large valley created by the two branches of Big Creek. Prior to the flooding, numerous gullies, washes, intermittent, and perennial smaller streams fed the two branches of the creek. Many of these same gullies, washes, intermittent and perennial streams now flow directly into Lake Redstone. There are 28 different bays around Lake Redstone proper, nearly all with some level of overland runoff via gullies, washes, or streams, particularly during storm events. After a large two-day rain event (August 27-28, 2018) that dropped 10 or more inches on Lake Redstone and its larger watershed, the LRPD solicited stories and photos of flooding and flood damage. Stories came in from around Lake Redstone, with Cardinal, Eagle, Mourning Dove, and Quail bays; and Sac Ct/Fox Ct having the most flood damage and soil erosion deposition (Figure 20).

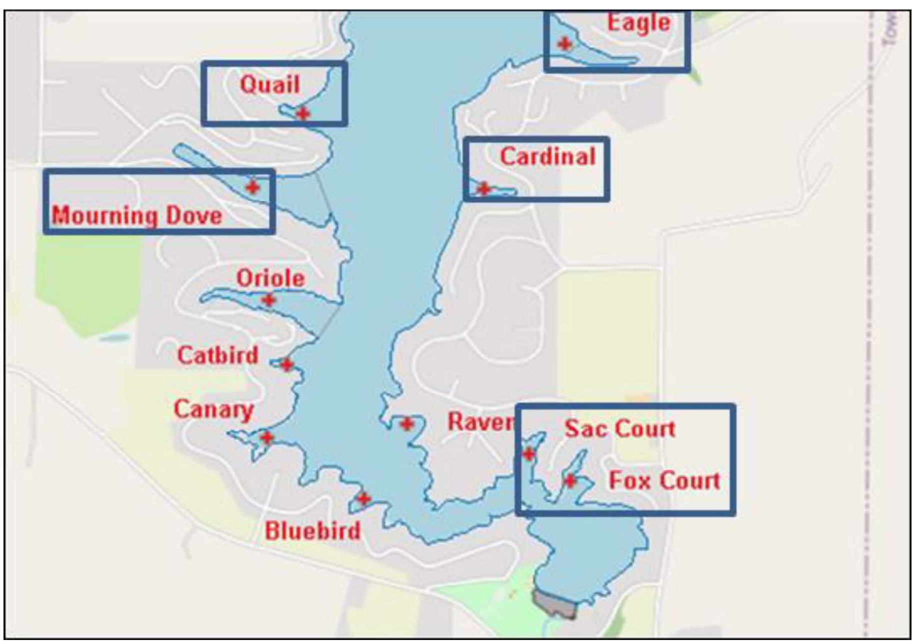


Figure 20: Locations of severe flooding during an August 2018 storm event

Several of the larger areas feeding certain intermittent and perennial streams have been delineated (See Section 3.2.2.1) and phosphorus loading estimated using models. However, none of the smaller gullies and washes has been delineated, nor has an attempt to determine sediment and phosphorus loading been made.

3.2.2.1 PRESTO Analysis of Phosphorous Loading from Intermittent or Perennial Streams in the Lower Lake Redstone Sub-basin

The Pollutant Load Ratio Estimation Tool (PRESTO) is a statewide GIS-based tool created by the WI-DNR that compares the average annual phosphorus loads originating from point and nonpoint sources within a watershed. PRESTO was designed to be easily modified, transparent to the end user, and to provide a consistent result based on readily available datasets. PRESTO performs three basic functions: watershed delineation, nonpoint source loading estimation, and point source loading aggregation. PRESTO outputs include a delineated watershed, watershed land cover composition, the estimated average annual nonpoint source and measured point source phosphorus loads (pounds per year), and the ratio of point to nonpoint phosphorus at a watershed outlet.

Chickadee North, Chickadee South, Martin-Meadowlark, Swallow, and Tanager (Heron) bays all have intermittent or perennial streams running into them and have all been delineated with PRESTO (Figure 21).

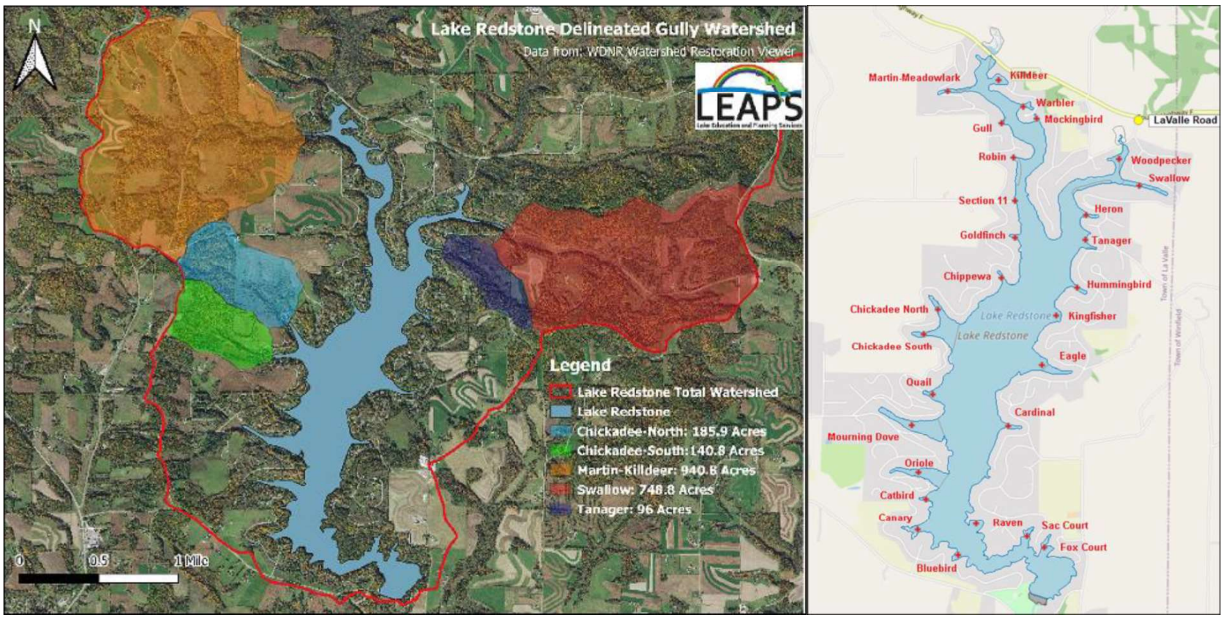


Figure 21: Land area delineation for intermittent and perennial streams flowing into Martin-Meadowlark (orange), Chickadee North (blue) and South (green), Swallow (red), and Heron (purple) bays

For each area delineated, a PRESTO report was generated to better define the contributing area to each bay (Figures 22-24). If the mean annual loading of phosphorus from each of these reaches is used and compared to the STEPL estimate of phosphorus loading from the entire Lower Lake Redstone sub-basin, they account for 26.8% of what is potentially entering Lake Redstone from this sub-basin.

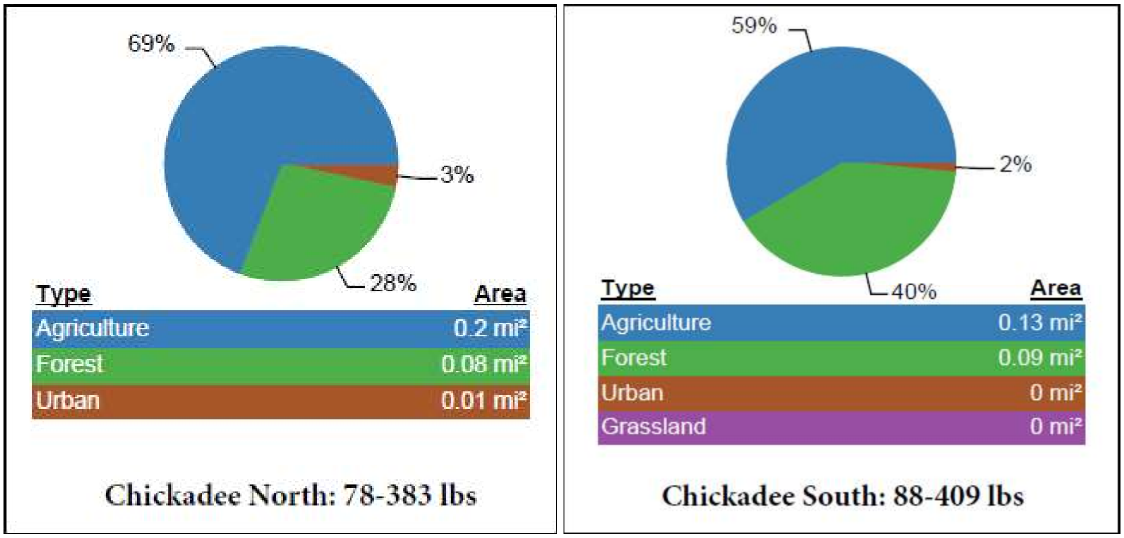


Figure 22: PRESTO outputs for land use and estimated annual phosphorus loading from Chickadee North and Chickadee South

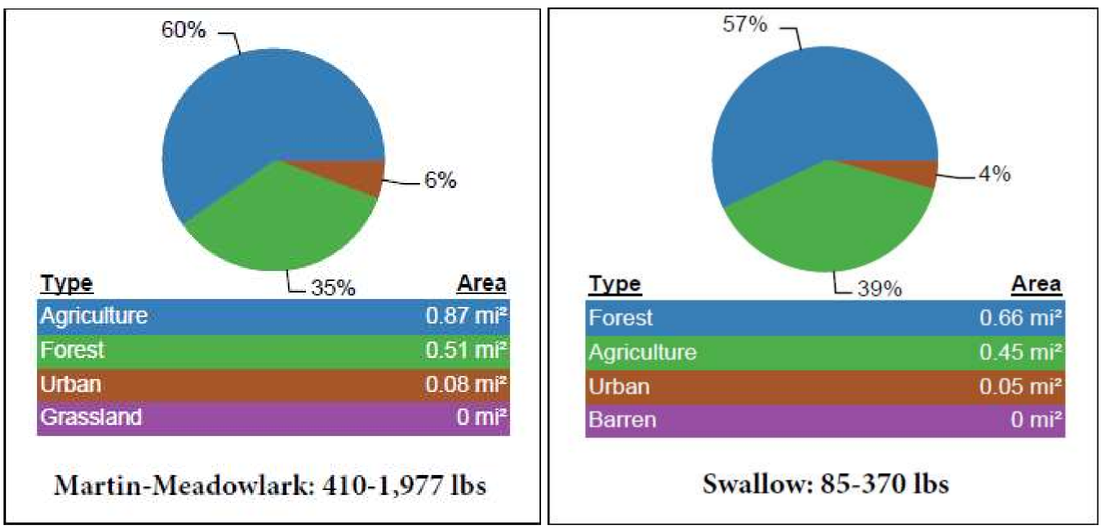


Figure 23: PRESTO outputs for land use and estimated annual phosphorus loading from Martin-Meadowlark and Swallow

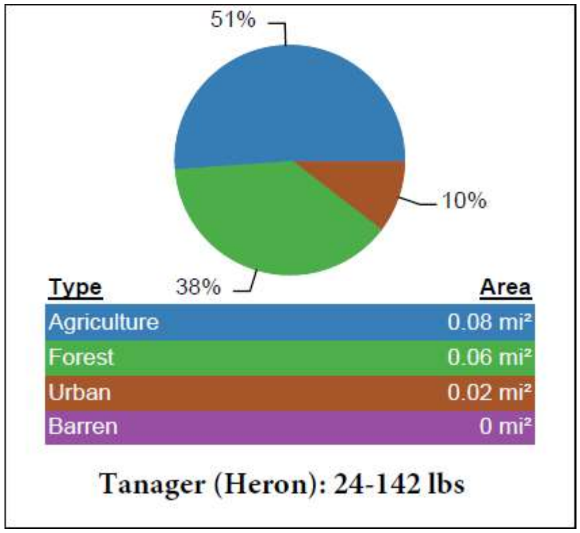


Figure 24: PRESTO outputs for land use and estimated annual phosphorus loading from Tanager

3.2.3 Private Onsite Wastewater Treatment (Septic) Systems

Private onsite wastewater treatment systems or POWTS, often referred to as septic systems, around Lake Redstone have not been inspected in any specific lakewide way since 2008. However, on record is a related program update that was given during a Sauk County Planning and Zoning meeting by Brian Cunningham.

"In the Fall of 2008, a total of 172 Lake Redstone homeowners were notified that they owned a steel tank or that they did not have a septic permit on file with Sauk County. Most of the required inspections as a result of notification were completed before the snow came. However, there is still a handful of owners who are in the process of completing the inspection form. I would like to thank all 172 home owners for their cooperation and response to this program.

Although the reports are still coming in, here are some of the preliminary results. So far only 8% of the steel septic tanks inspected have passed. As these tanks get replaced, many home owners are glad they replaced their tank when they see the condition of the tank. A much higher percentage, 64 % of the steel holding tanks have passed. It appears that a thicker gauge steel was used for holding tanks. Of the concrete tanks inspected 93% have passed.

Looking at the drain-fields, 26 % passed the inspection. The field inspections have revealed some interesting findings. For example, some drain-fields were actually installed below the lake level, causing direct discharge into our groundwater. Other drain-fields were found in or very near bedrock.

Homeowners who have a tank and/or a drain-field that did not pass inspection have until June 30, 2009 to have a completed septic permit application submitted to our office. They will then have two years from the issued date to install their septic system."

It is not known whether the "fixes" that were required as a result of this inspection were completed, but it has to be assumed that they were, given the time frame. It is also not known the current status of POWTS around Lake Redstone. Sauk County Ordinances, Chapter 25, Private Sewage System Ordinance currently guides building, management, and maintenance of POWTS around Lake Redstone and provides many resources on its webpage at https://www.co.sauk.wi.us/cpz/septic-systems.

The STEPL model used to estimate nutrient loading from the watershed has a portion of it directly related to septic system data from the watershed. Lake response modeling can be used to estimate nutrient loading from septic systems in the riparian area of the lake. However, to be more accurate, both of these septic system analyses require more current data that is not known at this time. As a result, only default data for watershed septic system loading was used in the STEPL model. For septic system loading from the riparian area of the lake, out-of-date data was used. This older data suggests that septic systems in the riparian area of the lake contributed between 2.73 and 73.02-lbs. of phosphorus per year. Further loading analysis could be done with more current conditions entered into STEPL and lake response models.

3.2.4 Beach Club Lots

There are a number of "beach club" lots around the lake. Beach club lots are parcels that have been put aside to provide access to the lake for out lots not directly on the lake. Figure 25 provides an example of these special parcels. Parcel 1115 on the lake is jointly owned by parcels 1979-1986 across W. Redstone Drive. Similarly, parcel 1098 on the lake is jointly owned by parcels 1120-1131 across W. Redstone Drive. These lots often have multiple docks on them, may be experiencing erosion, or be a place for invasive species to become established. There were at least 29 different beach club lots identified during the SHA for Lake Redstone. As these are jointly owned properties, if they present problems with erosion or other concerns, they will likely require extra effort to make changes, but could set great examples for other property owners. Furthermore, there are multiple lots owned by the LRPD or Town of LaValle and various easements that might also provide places to implement shoreland improvement projects.

Other than analysis associated with the Shoreland Habitat Assessment that was completed in 2018, no information has been collected regarding the state of Beach Club lots on Lake Redstone.

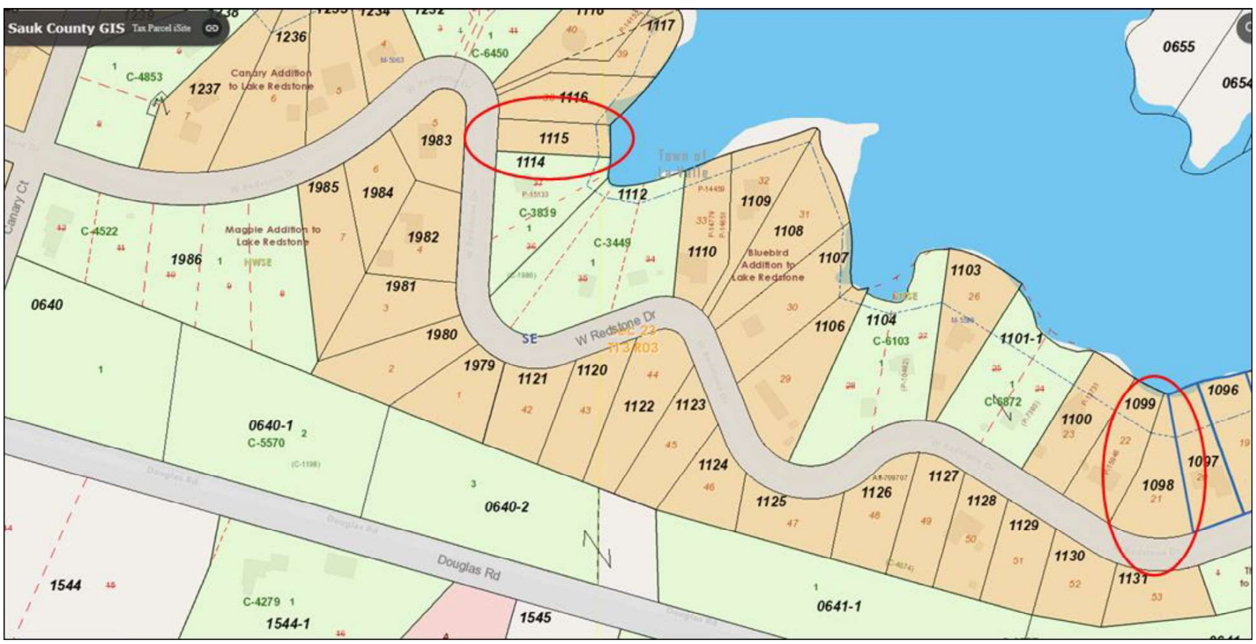


Figure 25: Example "beach club" parcels (1098 & 1115) and privately owned parcels (all others) on the south shore of Lake Redstone

3.3 Lake Redstone Watershed

The watershed of Lake Redstone covers approximately 18,500 acres, most of which is in Juneau County. The watershed consists mostly of forest (57.2%), with a combination of agricultural uses (cropland and pastureland) (35.4%) coming in second (Figure 26).

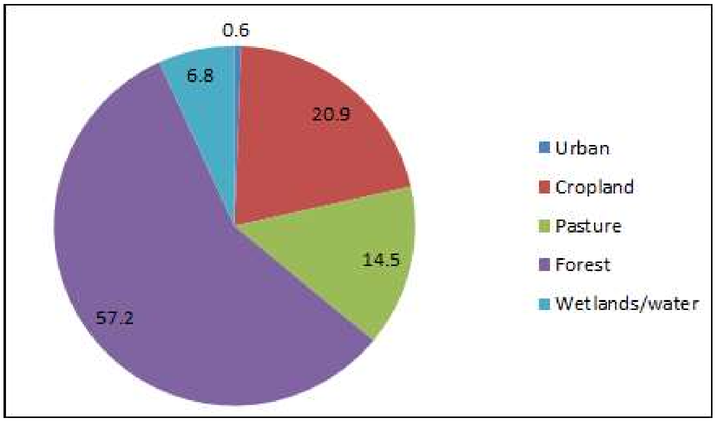


Figure 26: Percent of Land Use in the Lake Redstone Watershed

3.3.1 Lake Redstone Watershed Sub-Basins

In order to focus management planning efforts in this project, the watershed of Lake Redstone was further broken down from the reaches established by the WRB TMDL (see Section 1.4.1) to smaller reaches defined by stream order. Stream orders assign numerical designations to streams that indicate where in a watershed drainage system a certain stream segment lies. The smallest orders streams – first order – flow from upland, headwater areas like springs and seep sources that maintain defined stream beds throughout the year. Where two first-order streams combine, a second-order stream is designated; and two second-order streams join creating a third-order stream (Figure 27) (Strahler, 1957).

In the Lake Redstone watershed, both the east and west branches of Big Creek - sub-basins 15&16 in the WRB TMDL - are considered third-order streams. For this project, two areas of the Lake Redstone watershed are defined by third-order streams – Clark Road on the west branch of Big Creek, and LaValle Road on the east branch of Big Creek. The entire east branch of Big Creek is referred to as the LaValle Road sub-basin. The west branch of Big Creek is referred to as the Clark Road sub-basin. The west branch of Big Creek is further delineated into three additional sub-basins based on smaller tributaries feeding into it. These three sub-basins are referred to as the Daugs Road, Pfaff Road, and Lucht Road sub-basins. The final sub-basin, referred to as the Lower Lake Redstone sub-basin is made up of the part of the watershed that drains directly into Lake Redstone (Figure 28). This sub-basin contains all of the development in the riparian area of the lake and numerous gullies, washes, and intermittent or perennial streams.

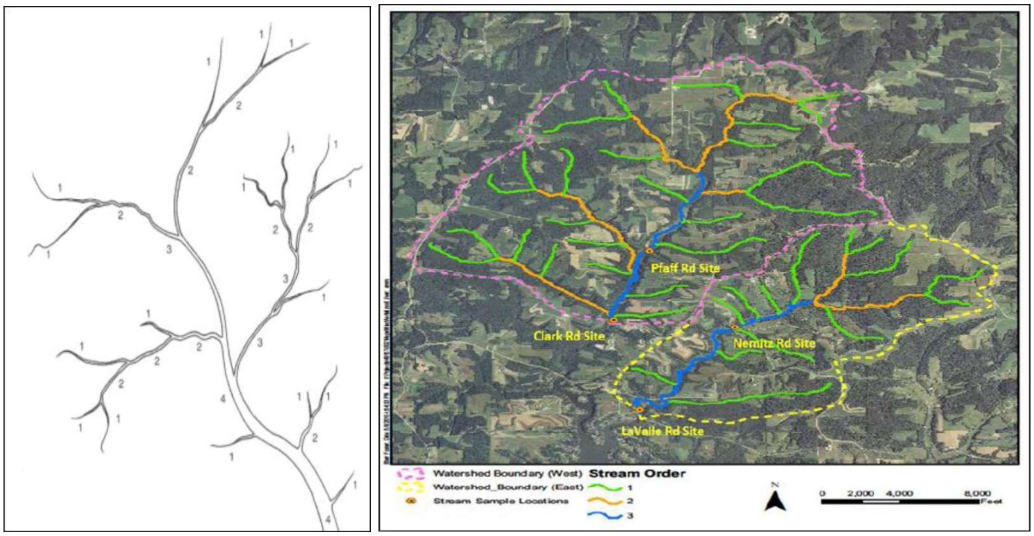


Figure 27: General stream order (left); Lake Redstone watershed stream order designations – blue streams represent the two branches of Big Creek (right)

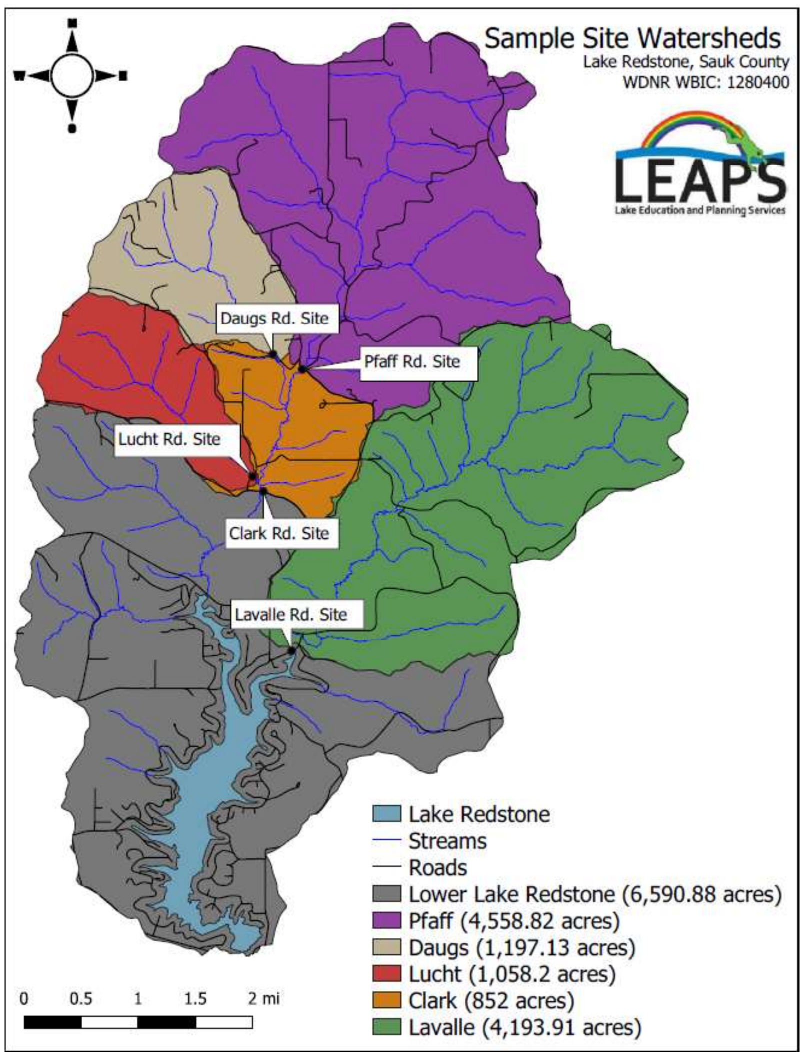


Figure 28: Lake Redstone watershed sub-basins (LEAPS, 2020)

3.3.1.1 Land Use in the Sub-basins

Land use in each of the sub-basins was determined by USGS 2016 National Land Cover Database (Table 8; USGS, 2016). It is these numbers that are used in calculating loads and load reductions across the watershed.

Table 8: Total acreage (land use) in each sub-basin of the Lake Redstone watershed

Land Use	W1-Pfaff	W2-LaValle	W3-LowRedstone	W4-Clark	W5-Lucht	W6-Daugs
Urban	0	0	113	0	0	0
Cropland	1076	909	1219	275	247	170
Pasture	434	583	1210	204	161	117
Forest	2713	2452	3623	321	574	810
Wetland	335	247	461	52	78	100
Feedlots	1.4	1.9	0.4	0.6	0	1
Total Acres	**4559**	**4193**	**6626**	**853**	**1060**	**1198**

3.3.2 Watershed Loading and Soil Erosion

Nutrient and sediment loading from a watershed into streams, rivers, and lakes is directly related to soil erosion. Dirt washed off a field, gravel along a road that is carried away, or material torn from a streambank has to go somewhere. Usually it goes with the water or wind that dislodged it to a place lower in the watershed. This process of erosion is natural and generally happens on long time scales, however, human activities like development and agriculture can greatly speed up these processes, resulting in unsustainable losses that natural mechanisms to replace the soil cannot keep up with. Soil erosion caused by water can be identified by small rills and channels on the soil surface, soil deposited at the base of slopes, sediment in streams, lakes, and reservoirs, and pedestals of soil supporting pebbles and plant material. Water-driven soil erosion can lead to sediment loading through the direct transport of sediment to a downstream location, like Lake Redstone. Wind erosion can be identified by dust clouds, soil accumulation along fence lines or snowbanks, and a drifted appearance of the soil surface (NRCS, 2012). Wind erosion can also contribute to sediment loading through atmospheric deposition when wind-blown particles get trapped in precipitation, like rain and snow, and then fall into the lake.

This loss of soil from where it belongs to places it doesn't belong has other consequences. Soil loss may also lead to nutrient loss. Phosphorus binds readily to soils, especially small particles like clay and silt that are easily eroded; thus, if an area has high soil loss from erosion, it may also be contributing large amounts of phosphorus that can be transported by wind and rain into water bodies where it can further degrade the quality of the water by contributing to algal blooms.

3.3.2.1 Soil Health

Soil erosion can be avoided by maintaining good soil health. Soil health, also referred to as soil quality, is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans (USDA). Healthy soils gives us clean air and water, bountiful crops and forests, productive grazing lands, diverse wildlife, and beautiful landscapes by performing five essential functions:

- Regulating water - Soil helps control where rain, snowmelt, and irrigation water goes. Water and dissolved solutes flow over the land or into and through the soil.
- Sustaining plant and animal life - The diversity and productivity of living things depends on soil.
- Filtering and buffering potential pollutants - The minerals and microbes in soil are responsible for filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials, including industrial and municipal by-products and atmospheric deposits.

- Cycling nutrients - Carbon, nitrogen, phosphorus, and many other nutrients are stored, transformed, and cycled in the soil.
- Physical stability and support - Soil structure provides a medium for plant roots. Soils also provide support for human structures and protection for archeological treasures (USDA).

When soil is disturbed by tillage, it becomes more vulnerable to erosion, waterlogging, and compaction. Because tillage also disturbs the habitat of soil organisms, their populations often decline and their positive effect on soil structure is reduced. No-till or minimal tilling practices usually promote the activity of soil engineering organisms and can improve the soil's physical characteristics (Earthfort, 2021). Additionally, practices such as adding manures or compost to soil, planting cover crops, and rotating crops are all aimed at rebuilding and maintaining soil organic matter, recycling and retaining nutrients, and potentially decreasing soil diseases. These practices are usually associated with increased microbial biomass and increased soil organism diversity – i.e. greater soil health (Earthfort, 2021).

3.3.2.2 Soils, Erodibility, Crop Rotations, and Practices in the Lake Redstone Watershed

The WI-DNR Bureau of Water Quality developed an Erosion Vulnerability Assessment for Agricultural Lands toolset (EVAAL) to assist watershed managers in establishing areas within a watershed that may be vulnerable to water erosion and increased nutrient export, which may contribute to downstream surface water quality problems. EVAAL evaluates the location of areas (fields) vulnerable to erosion using topography, soil, rainfall, and land cover data. The tool enables watershed managers to prioritize and focus field-scale data collection efforts, thus saving time and money while increasing the probability of locating fields with high sediment and nutrient export for implementation of best management practices.

EVAAL was used to prioritize areas or fields within the Lake Redstone watershed that may be vulnerable to soil erosion. A total of 140 fields in the Lake Redstone watershed were included in the EVAAL model run. From the 140 fields, the 20 fields with the highest vulnerability for erosion were documented. Following that, the remaining fields were evenly divided into 30 field groups in each ranking of low, mid-low, mid-high, and high vulnerability based on the average erosion vulnerability index (EVI) score of all the fields (Figure 29).

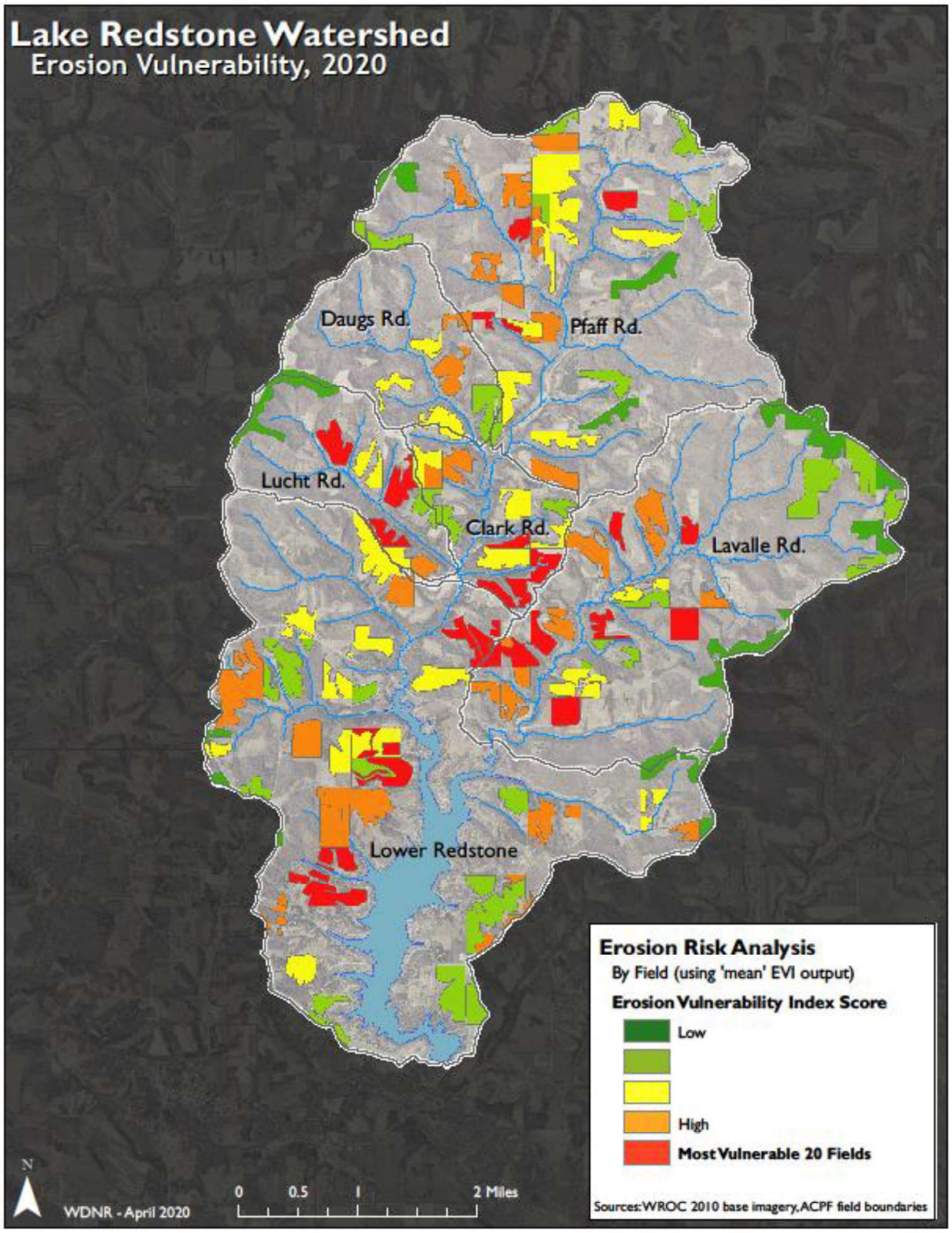


Figure 29: Erosion Risk Analysis for 140 fields in the Lake Redstone watershed (Beringer, 2021)

The number of field acres in each sub-basin that were either at high risk for erosion, or considered the most vulnerable fields for erosion are in Table 9. The Lower Lake Redstone sub-basin has the greatest amount of field acres considered at high risk for erosion, followed by the LaValle Road sub-basin. The Daugs Road sub-basin has the fewest number of acres considered at high risk for erosion (Figure 30).

Table 9: Individual sub-basin analysis of field acres highly vulnerable to soil erosion

Erosion Risk Analysis	Top20MVF (acres)	HighVF (acres)
W1-PfaffRoad	61.45	242.25
W2-LaValleRoad	188.39	201.55
W3-LowerRedstone	223.91	397.45
W4-ClarkRoad	82.89	50.26
W5-LuchtRoad	106.95	19.88
W6-DaugsRoad	0	39.97
Total	**663.59**	**951.36**

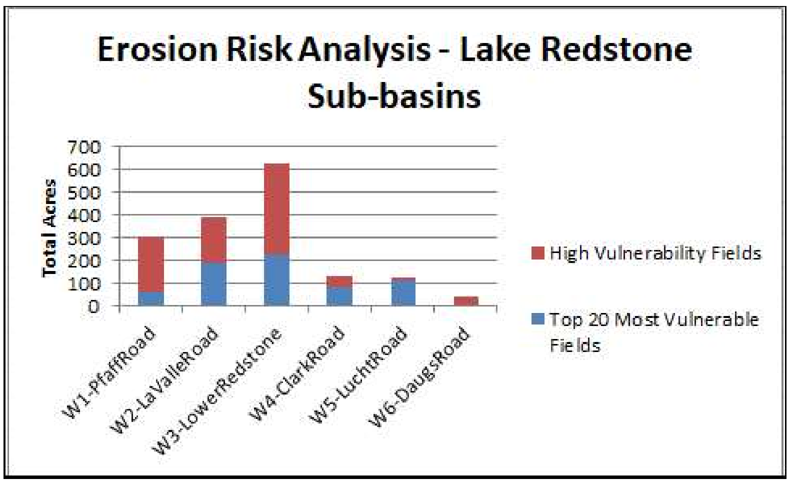


Figure 30: Individual sub-basin analysis of field acres highly vulnerable to soil erosion

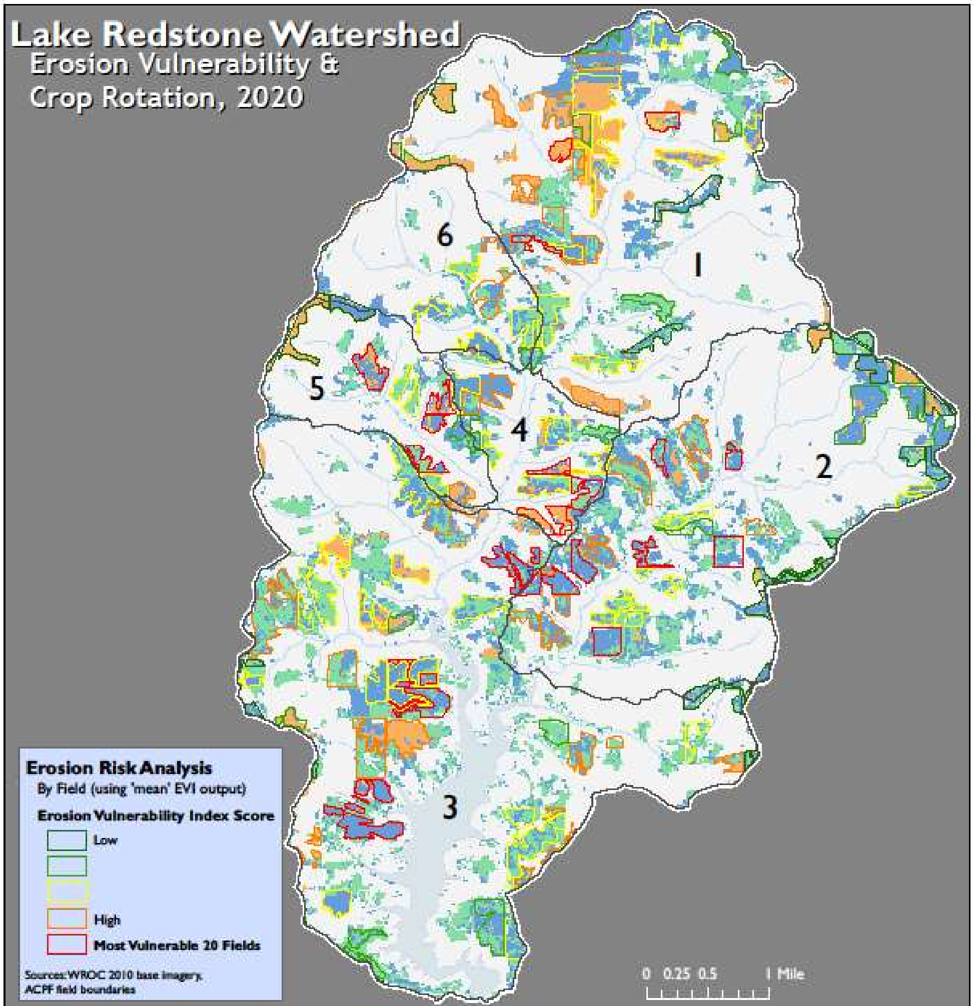
Using EVAAL, additional analyses were done to determine common crop rotations in the watershed over a five year period from 2015 to 2019 (Table 10). Other than no agriculture at all, dairy rotation (consisting of corn, corn silage, and then 3-yrs of alfalfa), pasture/hay/grassland, and cash grain are the most common crops. Continuous corn, corn planted in a dairy rotation, and cash grains generally would leave the most soil exposed during the planting, growing, and harvest season.

More than half of Lake Redstone's watershed agricultural land is in a continuous corn, cash grain, or dairy rotation (Figure 31). Many of the 20 most vulnerable fields and most of the fields with high vulnerability are either in a dairy rotation or cash grain.

Common cropping practices within the watershed over the last five years have been: contour farming with annual tillage during corn grain or corn silage years; average 30-59% crop residue levels maintained over crop rotation; grass pastures managed with 90% or greater vegetative cover (Juneau and Sauk County Land Conservation Departments, personal communication, 2020). These practices and their extent on agricultural cropland acres were incorporated into STEPL model inputs for the Lake Redstone watershed.

Table 10: Crop rotation within 6,451 agricultural acres of the nearly 18,500 acre watershed of Lake Redstone

Rotation Type	W1-Pfaff	W2-LaValle	W3-LowRedstone	W4-Clark	W5-Lucht	W6-Daugs	TOTAL (acres)
Potato/grain/vegie	8	5	5	5	1	2	**26**
Continuous corn	37	22	20	7	6	1	**93**
Cash grain	429	78	204	59	79	9	**858**
Pasture/hay/grassland	434	583	1210	105	106	117	**2555**
Dairy rotation	602	804	990	204	161	158	**2919**
Total Agriculture Acreage	1510	1492	2429	380	353	287	**6451**
No agriculture	3049	2701	4197	473	707	911	**12038**
TOTAL Sub-basin Acreage	**4559**	**4193**	**6626**	**853**	**1060**	**1198**	**18489**



Crop Rotation Acreage 2015 - 2019

	(1) Pfaff Rd.	(2) Lavalle Rd.	(3) Lower Redstone	(4) Clark Rd.	(5) Lucht Rd.	(6) Daugs Rd.
Potato/Grain/Veggie	8	5	5	5	1	2
Continuous Corn	37	22	20	7	6	1
Cash Grain	429	78	204	59	79	9
Pasture/Hay/Grassland	434	583	1,210	105	106	117
Dairy Rotation	602	804	953	204	161	158
No Agriculture	3,049	2,701	4,197	473	707	911
TOT. BASIN ACREAGE	4,559	4,193	6,626	853	1,060	1,198

Figure 31: Erosion Risk Analysis combined with Crop Rotation Acreage (Beringer, 2021)

3.3.2.3 Streambank Erosion (Iowa Department of Natural Resources, 2006)

Erosion of streams in agricultural areas normally occurs as a result of one of three factors: change in stream flow, water flowing over or through the streambank, and the discharge of concentrated runoff from other sources. Streams in the Midwest are subject to wide fluctuations in both flow depth and velocity over a period of years, due to normal seasonal changes in rainfall and large single-storm events. As flow depths and velocities increase, the force of the water flowing against the streambank removes soil particles from the banks, and in many cases erosion causes banks to slump and fall into the flowing water. Rain falling on streambanks or runoff from adjacent fields that enter a stream by flowing over the streambanks can also erode soil from streambanks, particularly if banks are inadequately protected. Water discharged into a stream from tributary drainage systems (such as waterways and tile lines) can also erode streambanks, particularly if the water is discharged in an area where the bank is unstable or highly erodible.

A document prepared by the Iowa Department of Natural Resource entitled "How to Control Streambank Erosion" provides many examples of actions that can be implemented to reduce streambank erosion.[3]

Another function of EVAAL is developing a Stream Power Index for the watershed in question. The Stream Power Index (SPI) is a measure of the erosive power of flowing water. SPI is calculated based upon slope and contributing area. Within a watershed, the SPI approximates locations where gullies might be more likely to form on the landscape. While this was done for the watershed of Lake Redstone, the results are not available. SPI will again be calculated for the watershed of Lake Redstone in the first year of implementation with results being used to identify potential problem areas within each sub-basin.

3.3.3 Watershed STEPL Modeling

The Spreadsheet Tool for Estimating Pollutant Load (STEPL) is a customized spreadsheet-based model in Microsoft Excel that is used to calculate nutrient and sediment loads in watershed surface runoff from different land uses and the load reductions that would result from the implementation of various BMPs (EPA, 2021).

STEPL can be used to evaluate watershed loading and load reductions at a variety of scales. The user defines the size and characteristics of each area being evaluated, based on the total acreage of each land use entered into STEPL. In the case of the Lake Redstone watershed, data from each of the six sub-basins was entered into the STEPL model. Annual nutrient loading from each sub-basin was calculated based on the runoff volume and the pollutant concentrations in the runoff water, as influenced by factors such as the land use distribution and management practices (Table 11)

Table 11: Designated land uses (acres) by sub-basin in the Lake Redstone watershed

Sub-basin	Urban	Cropland	Pasture land	Forest	Wetland, Open Water, Scrub	Feedlots	Total Sub-basin Acreage
W1 - Pfaff	0	1076	434	2713	335	1.4	4559
W2 - Lavalle	0	909	583	2403	247	1.9	4144
W3 - Lower Red	113	1219	1210	3693	461	0.4	6696
W4 - Clark	0	275	204	420	52	0.4	951
W5 - Lucht	0	247	161	629	78	0.0	1115
W6 - Daugs	0	170	117	810	100	1.0	1198
Total Land Use	113	3896	2709	10668	1273	5.1	

STEPL modeling is used to calculate an estimate of total loading and is based on the different land uses, dominant hydrologic soil group, annual rainfall, agricultural practices and BMPs. Table 12 shows the STEPL total nutrient loading for the entire watershed of Lake Redstone. Table 13 shows the STEPL nutrient loading from each sub-basin.

[3] To view the Iowa DNR document about how to reduce streambank erosion go to: https://www.iowadnr.gov/portals/idnr/uploads/water/stormwater/streambankmanual.pdf

Table 12: Nitrogen (N), phosphorus (P), and sediment loading from the entire Lake Redstone watershed

Land Use Sources	N Load (lb/yr)	P Load (lb/yr)	Sediment Load (t/yr)
Urban	427	72	11
Cropland	31245	13435	3982
Pastureland	15537	1771	257
Forest	3025	1765	252
Feedlots	9050	1810	0
Wetland, Open Water, Scrub	96	78	30
Septic	78	30	0
Total	59458	18961	4532

Table 13: Nitrogen (N), phosphorus (P), and sediment loading from each sub-basin included in the Lake Redstone watershed

Sub-basin	N Load (lb/year)	P Load (lb/year)	Sediment Load (t/year)
W1 - Pfaff	15466	5571	1381
W2 - Lavalle	14019	4194	919
W3 - Lower Red	18652	5550	1342
W4 - Clark	4237	1370	355
W5 - Lucht	3037	1088	308
W6 - Daugs	4047	1188	227
Total	59458	18961	4532

STEPL modeling suggests that the three highest contributing sub-basins to nutrient and sediment loading are Pfaff, Lower Redstone, and LaValle in that order. These three sub-basins also have 84% of the total agriculture in the entire watershed; 65% of the most vulnerable fields for erosion; and 83% of the fields considered to be highly vulnerable to erosion based on the mean erosion vulnerability index calculated using EVAAL.

In the first years of implementation of this plan, BMPs to improve soil health will primarily be focused on these three sub-basins.

3.3.4 Tributary Monitoring

Starting in 2018, Juneau and Sauk Counties partnered with the LRPD and their consultant to try and determine nutrient and sediment loading from the two major tributaries (east and west branches of Big Creek) flowing directly into the lake, and three tributaries flowing out of the Daugs, Lucht, and Pfaff sub-basins into the west branch of Big Creek (Figure 32). Basic stream flow and volume determination using pressure transducers, stream gauges, and volunteer data collection following guidelines in the Water Action Volunteer Stream Monitoring Program[4] along with collection of water samples to test for an array of water quality parameters (Table 14) were to be conducted manually by LRPD volunteers. Loading calculations were to be completed by Juneau and Sauk County personnel.

[4] For more information about the Water Action Volunteer program go to: https://wateractionvolunteers.org/

In the fall of 2018, the watershed was impacted by heavy rainfall and severe flooding. During this period, it was apparent that the available equipment to monitor stage and measure discharge (flow and volume) was inadequate, making it nearly impossible to compute loads as intended. As a result, changes were made to the tributary monitoring program in 2019 and 2020.

In 2019, the LRPD, their consultant, and the counties partnered with the USGS to explore a different method of collecting site discharge data – camera image stage-interpretation. This technology involved the installation of cameras to provide continuous monitoring of stream stage, while volunteers continued to collect monthly baseline water samples (Figure 33).

Monitoring results in 2019 were better, but still not completely representative of what was actually happening in the streams, particularly during storm events. Preliminary analysis of the data collected in both years revealed that the majority of the sediment and nutrients enters the lake during storm events, which are difficult to monitor with conventional means. USGS staff suggested that more detailed analysis of storm events would provide more reliable data regarding the total load of nutrients and sediment entering the lake during each year.

In 2020, in cooperation with the USGS automated sampling equipment was installed at the monitoring stations on the east branch (LaValle Road) and west branch (Clark Road) of Big Creek (Figure 33). The automated sampling equipment mechanically collects 6-8 water samples during a given storm event. Following the storm, LRPD volunteers collect the water samples from the sampling stations and ship them to USGS labs for analysis of TP and TSS. Based on the data provided by this analysis along with stream flow provided by the monitoring equipment, the total load of phosphorus and suspended solids entering the lake can be more accurately calculated by USGS staff. The automated sampling stations will remain in place as long as there is funding to support it.

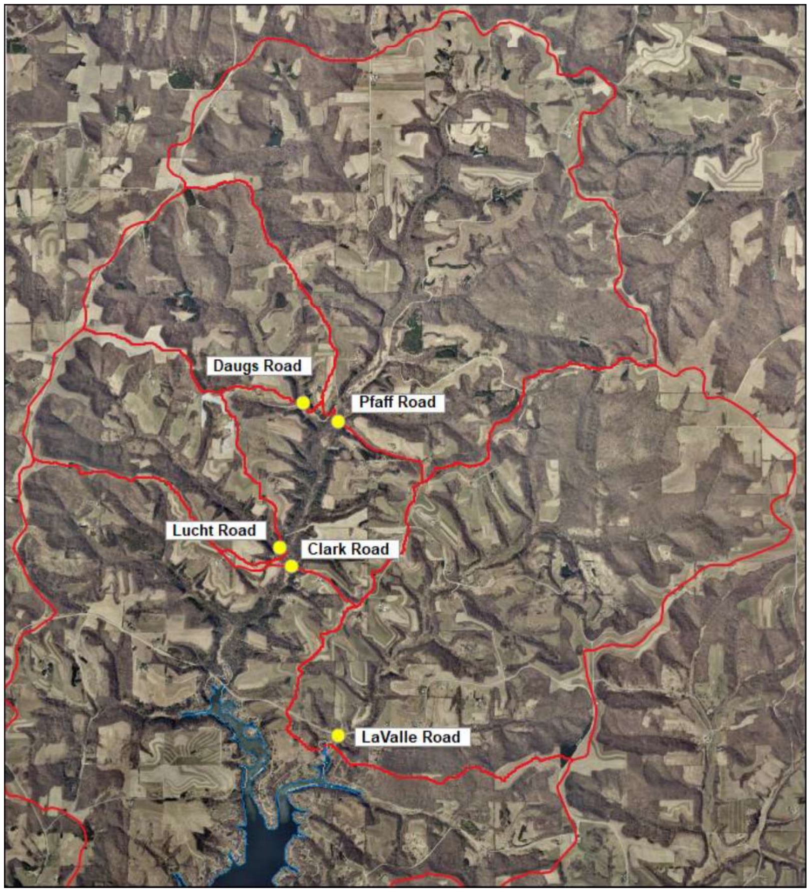


Figure 32: 2018-2020 Tributary Sampling Sites

Table 14: Tributary Monitoring Parameters 2018-2020

Nutrients and Suspended Solids (mg/L)		Flow (f/s) and Volume (cf/s)
Residue Total NFLT (Total Suspended Solids) (TSS)		WAV/floating orange
Phosphorus Total (TP)		Flow Meter
Phosphate Ortho Diss (Ortho)		Transducers and Staff Gage
Nitrogen NH3 - N Diss (NH3)		Video Camera
Nitrogen Kjeldahl Total (TKN)		USGS Monitoring Station
Nitrogen NO3+NO2 Diss (as N) (NO3-NO2)		

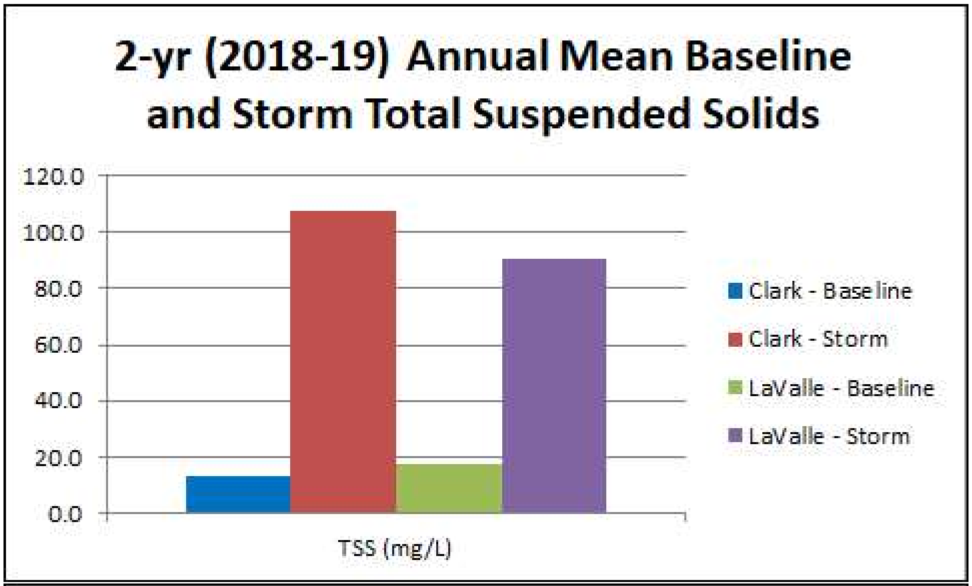
Figure 33: Camera installation for "camera image stage-interpretation" (left) (K. Keegstra, 2019); Typical USGS recording streamflow-gaging station with automatic water sampler for load determinations (middle & right) (K. Keegstra, 2021)

With the installation of the automated sampling equipment, sampling of the smaller streams coming from the Daugs, Lucht, and Pfaff sub-basins was suspended in 2020. However, two other sites were added where perennial streams enter Martin-Meadowlark and Swallow Bays. Monitoring of these two sites was added to begin to try and determine nutrient and sediment loading from smaller stream reaches within the watershed that form gullies that drain directly into Lake Redstone in the Lower Redstone sub-basin.

3.3.4.1 Tributary Monitoring Results

The Daugs, Lucht, and Pfaff road sub-basins drain into the west branch of Big Creek and make up some of what is measured at the Clark Road site. There currently is only one tributary monitoring site on the east branch of Big Creek at the LaValle Road site. Baseline water samples were collected by LRPD volunteers, once monthly between April and November in 2018 and 2019 at each of the sub-basin locations. Storm event samples were collected on four different dates at the same sites during the same time frame. Baseline and storm event loading from each individual sub-basin cannot be reliably calculated or compared due to incomplete or inaccurate flow and volume data, but comparisons of the nutrient and sediment concentrations in the samples from each sub-basin can be made giving a glimpse into those sub-basins that may be contributing more or less phosphorus and sediment into the two branches of Big Creek or into Lake Redstone.

Comparisons were made between water sampling results from the east branch (LaValle Road) and the west branch (Clark Road) of Big Creek. There is more sediment in the east branch during normal flow, but there is more sediment in the storm water from the west branch. There is more total phosphorus in both the normal flow and the storm water from the west branch (Figure 34). The east branch of Big Creek at the LaValle Road site drains 4,194 acres of the watershed. The west branch of Big Creek at the Clark Road site drains 7,666 acres of the watershed. Both have substantial agriculture.



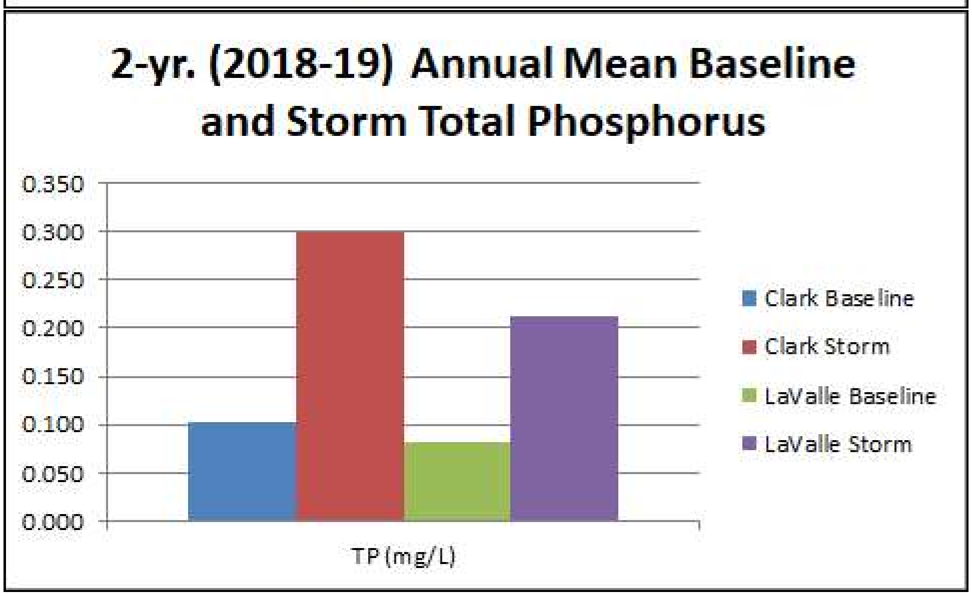


Figure 34: Comparisons of TSS (top) and TP (bottom) concentrations in water samples collected from Clark Road (west branch of Big Creek) and LaValle Road (east branch of Big Creek)

Tributaries from the Daugs, Pfaff, and Lucht road sub-basins drain into the west branch of Big Creek above the Clark Road monitoring site. Each covers a portion of the larger watershed draining through the Clark Road site: Daugs Road (1,197 acres), Pfaff Road (4,559 acres), and Lucht Road (1,058 acres). The remaining 852 acres are specific to the Clark Road sub-basin. Despite having the largest land area of the four sub-basins, water flowing from the Pfaff Road sub-basin had the lowest concentration of sediment and total phosphorus per sample in both its normal flow and storm water. Water from the Daugs Road sub-basin has the highest concentration of sediment and total phosphorus per sample in both its normal flow and storm water (Figure 35). A close second is the concentration of sediment and total phosphorus in samples from the Lucht Road sub-basin (Figure 35). These conclusions are drawn from preliminary observations made over two years. The patterns of sediment and phosphorus entry into the lake will be re-evaluated following the three years of more intensive analysis that will be performed during implementation of this plan (see Section 9.1.2.1 and items in Appendix I.) Section 3.3.4.2 discusses current and past conditions in the watershed in more detail.

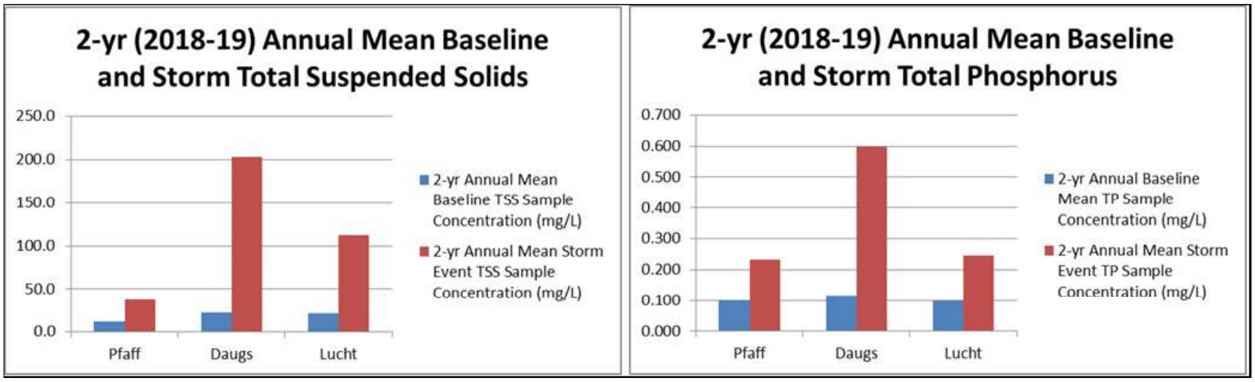


Figure 35: Comparisons of TSS and TP concentrations in water samples collected from Pfaff, Daugs, and Lucht sub-basins

3.3.4.2 Current versus Past Conditions in the Watershed of Lake Redstone

Two studies have been completed since the early 2000's that reflect conditions of erosion in the watershed at that time. In 2002, MSA completed a "field verification of sediment delivery" study as a follow-up to an earlier study of the watershed to determine the location of farming operations and land use (MSA, 1998; MSA, 2002). During the 2002 study it was determined that several of the farm tracts from the 1998 study that were expected to have excessive field soil loss were not experiencing that loss due to actions already taken by the property owner.

In 2007, MSA completed a watershed stream assessment project surveying nearly the entire waterway of both branches of Big Creek upstream of Lake Redstone (MSA, 2007). This survey found that the bulk of the main branches of Big Creek and its adjacent shoreland were "relatively untouched and in good condition"; and that they were "buffered by high quality wetlands with a high diversity of vegetation". They also noted that "minor tributaries in the headwaters of the watershed were in steeper valleys with forested slopes and more prone to sediment delivery to the streams"

Since 2007, there have been at least two major storm and flooding events, one in 2008, and again in 2018. It is quite possible that the "good conditions" surveyed by MSA in 2002 and 2007 may have changed. In the first years of implementation of this plan, the Daugs and Lucht sub-basins will be evaluated for gully/ravine erosion. Gully/ravine evaluations in the other sub-basins will occur in later years of implementation.

3.3.5 Silviculture (Forestry) and Mining

More than 57% of the land in the watershed of Lake Redstone is covered in forests, most of which is on the steep forested side slopes of the many intermittent and perennial stream, gullies, and washes that are characteristic of the Driftless Area. Several natural forest community types are represented including oak forests, mesic maple-basswood forests, floodplain forests, and hemlock and pine "relicts" (WI-DNR, 2015). Timber harvests and other forest related management actions are limited in the watershed, but do occur. There is no county-owned forest land in the watershed other than the Lake Redstone County Park at the lowest end of the watershed. As such, there are no forestry management practices occurring on public lands. Timber harvests on private land do occur. Silviculture is the art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society such as wildlife habitat, timber, water resources, restoration, and recreation on a sustainable basis[5].

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[5] For more information on silviculture go to: https://www.fs.fed.us/forestmanagement/vegetation-management/silviculture/index.shtml

3.3.5.1 Managed Forest Land

The Managed Forest Law (MFL), administered by the WI-DNR, is a landowner incentive program which encourages sustainable forestry on private woodlands in Wisconsin. Together with landowner objectives, the law incorporates timber harvesting, wildlife management, water quality and recreation to maintain a healthy and productive forest. Sustainable forest management benefits Wisconsin's economy, hunting, fishing, wildlife, recreation, soils, waterways, and air quality, and renews our beautiful forests for everyone to enjoy. In exchange for following sound forest management, the landowner pays reduced property taxes. MFL is the only forest tax law that is open to enrollment by private land owners. Land enrolled in the MFL program must be managed according to a plan agreed to by the landowner.

Over the next ten years, there are approximately 21 harvests scheduled totaling roughly 900 acres on MFL properties within the Lake Redstone watershed. These numbers may fluctuate as harvest schedules can be adjusted earlier or later if needed. All harvests on MFL properties are required to be completed sustainably and according to sound silvicultural practices. This includes following best management practices for water quality to limit the impact these activities will have on water resources (Personal communication Robert Anderson, WI-DNR Forester – Juneau County August 27, 2021).

On Non-MFL private lands within the watershed there has been a minimal level of harvest activity. The Wisconsin DNR Division of Forestry is currently emphasizing outreach to this demographic of landowners to try and encourage sustainable forest management so this level could increase in the future (Personal communication Robert Anderson, WI-DNR Forester – Juneau County August 27, 2021).

3.3.5.2 Non-metallic Mining

Non-metallic mining in Sauk County (and Juneau County) is regulated by the Planning and Zoning Department and, depending on activities, the Department of Natural Resources.

Non-metallic mining is defined as operations or activities at a nonmetallic mining site for the extraction from the earth of mineral aggregates or nonmetallic minerals (i.e. crushed or broken stone/gravel) for sale or use by the operator. Nonmetallic mining includes use of mining equipment or techniques to remove materials from the in-place nonmetallic mineral deposit, including drilling and blasting, as well as associated activities such as excavation, grading and dredging. Nonmetallic mining does not include the removal of materials such as commercial sod, agricultural crops, ornamental or garden plants, forest products, or plant nursery stock (Sauk County).

Nonmetallic mining also includes processes carried out at nonmetallic mining sites that are related to the preparation or processing of the mineral aggregates or nonmetallic minerals obtained from the site. These processes include, but are not limited to stockpiling of materials, blending mineral aggregates or nonmetallic minerals with other mineral aggregates or nonmetallic minerals, blasting, grading, crushing, screening, scalping and dewatering (Sauk County).

There is a low level of mining, primarily for aggregates (crushed or broken stone) currently going on in the watershed of Lake Redstone. There are many resources within the industry to do aggregate mining in a way that protects water resources. One such document is entitled Water Quality BMPs for the Aggregate Mining Industry[6].

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[6] Water Quality BMPs for the Aggregate Minong Industry. Atlanta, Georgia, USA. Highland Engineering, Inc. (2009, May 21). Retrieved from: https://epd.georgia.gov/sites/epd.georgia.gov/files/related_files/site_page/Aggregate%20Mining%20Industry%20Water%20Quality%20Best%20Management%20Practices%202009.pdf

4.0 Sources of Pollution and Load Reduction (Key Elements 1&2)

The emphasis of this planning project is to identify sources of pollutants, primarily excess phosphorus and sediment to Lake Redstone, and then determine what level of reduction in the loading of those pollutants needs to be achieved to help the lake meet state standards for recreation and fish and wildlife. The sources of pollutants are fairly clear, coming from the larger watershed, the riparian area of the lake, and from the lake itself.

4.1 Phosphorus in Lake Redstone

Based on 2018 in-lake, water column, total phosphorus sampling set up by a consultant and completed by LRPD volunteers, it was estimated that there was nearly 3,400-lbs of phosphorus in the lake water at any one time during the 2018 summer months (Table 15). Baseline water sampling data from the outlet of Lake Redstone during the summer of 2018 (collected by LRPD volunteers and analyzed by LEAPS) indicated a TP concentration of 0.17-mg/L. The amount of water leaving the lake through the outlet during that timeframe is estimated at 4,110-acft carrying an estimated 1,899-lbs of phosphorus. From Table 16, 3,527-lbs of phosphorus is entering the lake with 1,899-lbs leaving the lake during the same time frame, suggesting that 1,628-lbs or about 46% of the phosphorus entering the lake under normal flow conditions stays in the lake to be used up by plants and algae, or stored in the sediment.

Table 15: An estimate of the total phosphorus in the waters of Lake Redstone at any given time during the summer of 2018 based on water column sampling for total phosphorus (TP)

Depth (ft)	Volume (acft)	TP (mg/L)	Total TP (lbs)
0 to 6	2,544.47	0.08	576.15
6 to 15	3,924.10	0.10	1,088.02
15 to 24	1,760.07	0.21	1,004.72
24 to 35	499.74	0.53	725.41
TOTAL	**8,728.38**		**3,394.31**

The sources of phosphorus to Lake Redstone are fairly clear, consisting most prominently of the east and west branches of Big Creek; the immediate drainage area of the lake including the gullies and washes, developed area of the shoreland, and septic system contributions; some level of internal loading; and natural sources including ground water and atmospheric deposition. By combining data from various sources over the last 25 years some estimates can be made and a phosphorus budget for the lake created.

Under baseline conditions, not accounting for storm events, the east and west branches of Big Creek represented by the Clark and LaValle Road sub-basins contribute 34% of the TP load. The riparian area, gullies, and septic system represented by the Lower Redstone sub-basin, contribute an estimated 34% of the TP load to the lake. Internal loading is the next largest amount at 27%. Groundwater and atmospheric deposition contributes another 5% of the TP load (Table 16).

Table 16: Estimated lbs. of phosphorus contributed by each source and where the data used came from

Jun-Sept	Total TP (lbs)	% of Load	Source of Data
Clark - West Branch	693.68	20.00%	calculated
LaValle - East Branch	480.25	14.00%	calculated
Internal	984.35	27.00%	From 1996 Study
Groundwater	67.89	2.00%	From 1996 Study
Nearshore	165.80	5.00%	WiLMS
Measured Gullies	1014.75	28.00%	PRESTO
Septic	18.94	1.00%	WiLMS
Atmospheric	101.83	3.00%	From 1996 Study
	3527.49	**100.00%**	

In many TMDLs, internal phosphorus loading is assumed to be negligible or it is estimated based on sediment release rates and dissolved oxygen conditions in the lake (Robertson & Diebel, 2020). This was the case in 1997 when researchers concluded that internal phosphorus loading, in terms of how it likely impacted water quality in the lake, may not be a significant part of the problem (Leverance & Panuska, 1997). Robertson and Diebel 2020 further state that "Accurately quantifying net internal P loading and using this information in lake models are important in evaluating how large shallow lakes should respond to P reduction strategies, setting realistic expectations from watershed P reductions, and guiding TMDL efforts."

The LRPD has never been quite satisfied with the conclusion of the 1997 study and given the Robertson and Diebel statement, feel the impact of internal loading should be revisited. Once new data from an internal loading study, and other studies looking at tributary loading, septic systems, and gullies and washes has been gathered the phosphorus budget for Lake Redstone will be recalculated.

4.1.1 Phosphorus Reduction in Lake Redstone

The WRB TMDL set goals for nonpoint source phosphorus loading reductions across the entire Wisconsin River watershed. The goals vary for different parts of the larger watershed, but for Lake Redstone and the east and west branches of Big Creek (Sub-basins 13, 15, & 16, Figure 7) it was set at an 67% reduction. Taking out what is considered background or natural phosphorus loading, a total phosphorus reduction goal of 86% for urban and agricultural nonpoint sources (Table J-5 WRB TMDL) was determined to be necessary in order for Lake Redstone and its watershed to meet the WisCALM goal of 30-µg/L (see Figure 13 in Section 3.1.13). If the amount of phosphorus entering Lake Redstone is reduced by 67%, the WisCALM goal for chlorophyll-a (<5% of days in sampling season with algal levels >20µg/L) also gets closer.

4.1.2 Chlorophyll Reduction in Lake Redstone

Once the phosphorus level in Lake Redstone reaches the water quality criterion of 30-µg/L, the predicted mean chlorophyll would be 13-µg/L (Oldenburg, 2021). This indicates that the lake may have some difficulty completely meeting the WisCALM chlorophyll goal mentioned above. However, revisiting lake response modeling results in Section 3.1.1.4, a substantial reduction in bloom frequencies in Lake Redstone is predicted at the 30-µg/L criterion, including the effective elimination of algae blooms over 50-µg/L (Figure 36).

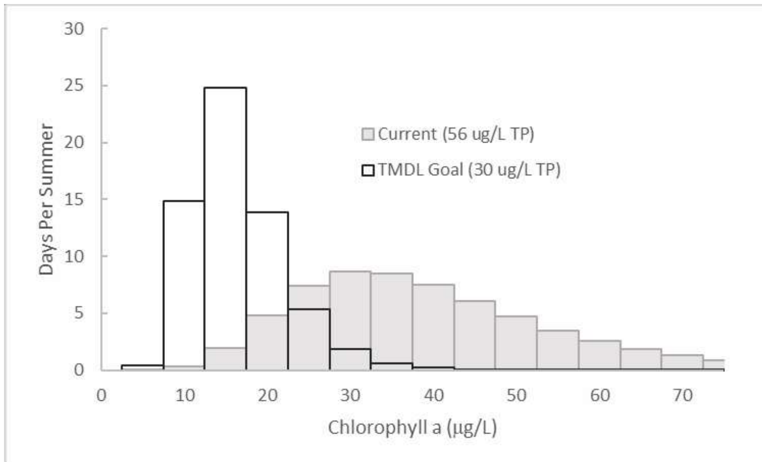

Figure 36: Estimated algae bloom frequency (days per summer) at current in-lake TP levels (grey bars), and bloom frequency if TP levels reach the TMDL goal of 30-µg/L (clear bars)

Given the uncertainty associated with predicting algal levels given major changes in lake nutrient levels, TP-Chl-*a* relationships and bloom frequencies through lake response modeling should be revaluated periodically during this plans ten year schedule and/or as lake improvements take place.

4.2 Sediment in Lake Redstone

Since the construction of Lake Redstone in the late 1960's, severe flooding events have been documented in 1978, 1992, 2008, and 2018. Each of these events included rainfall of 10 inches or more in as little as 24-48 hours. These events wreak havoc on the watershed, lake, and riparian area, and bring in untold amounts of sediment to be deposited on the bottom of the lake. Additionally, many smaller-scale flooding events have occurred, each contributing to the daily sediment load carried into the lake from the watershed.

Sediment carried into Lake Redstone from the two branches of Big Creek and from the many smaller gullies and washes has continually been an issue. Two large-scale dredging projects have been completed since the lake was constructed circa 1967. The first occurred in the late 1980's with 10 bays being dredged to improve boater access, deepen bays, and restore the lakebed closer to what it was in 1967. There is no easily attained record of how much sediment was removed at that time. The second, completed in 2019, removed an estimated 104,000 cubic yards of sediment combined from nearly all of the bays of the lake, enough to have been as tall as a six-story building if stacked on a football field (Mittelstadt, 2020). The 2019 dredging project carried a hefty price tag of $3.5 million.

Under baseline conditions, not accounting for extreme storm events, STEPL modeling referenced in Section 3.3.3 estimated the load of sediment into the two branches of Big Creek at more than 4,500 tons/year. The gullies, washes, streams, and developed area of the riparian zone were included in this modeling via estimates from the Lower Lake Redstone sub-basin.

In 2015, a sediment survey completed by Ayres Associates documented nearly 100,000 cubic yards of sediment averaging 3-ft deep in 29 different bays. Surveying after the August 2018 storm event concluded that another 67,000 cubic yards had been added on top of what was already there. Based on an estimate of the mass of lake/stream sediment (0.65-g/cm3) determined by a USGS study completed for Lake Linganore, Maryland in 2012 (Sekellick, Banks, & Myers, 2013), the mass of sediment in Lake Redstone before the 2019 dredging was nearly 94,000 tons. At 4,500 tons/year of baseline loading of sediment from the watershed, it would have taken about 21 years to put that much sediment into the lake.

The 2019 dredging project removed an estimated 56,972 tons of sediment from the lake, or 12.7 years of accumulation if baseline sediment loading was the only concern.

The additional sediment brought in between 2015 and 2018 has an estimated mass of 38,500 tons. Calculations after the August 2018 storm event estimated that 14,900 tons of sediment was brought into Lake Redstone just by the east and west branches of Big Creek. If 14,900 tons came in from the two branches of Big Creek in one event, and three years of base-level loading at 4,500 tons/year is added, it means about 10,200 tons of sediment came into Lake Redstone in between 2015 and 2018 from other sources - likely all of the gullies and washes that drain directly into the lake. With this calculation, the sediment removed by the 2019 dredging project would only equate to 4 years of baseline sediment loading and one year's (2018) worth of storm event loading.

The sediment surveys in 2015 and after the August 2018 storm event only included the bays, they did not take into account the sediment in the deeper portions of the main body of the lake, so the actual amount of sediment in Lake Redstone is likely far greater than is depicted here. These calculations, though likely not wholly indicative of the actual sediment load, provides some insights into how large storm events may be impacting Lake Redstone.

There has been some discussion related to documenting the amount of sediment in the main basins of the lake but how to do this has not been determined but is milestone in this project. It has also been discussed that keeping better records of changes in sediment deposition in the bays would be beneficial. To date, sediment deposition in the bays has only been documented two times, once in 2015 when developing the dredging plan for 2019, and again in 2018 after the large storm event in August of that year. Another milestone in this project is to document sediment deposition in multiple bays early in implementation and again in the last of 10-yrs of implementation.

4.2.1 Sediment Modeling

Between the first dredging and the 2019 dredging, dozens of projects were implemented in the watershed and riparian area of Lake Redstone to reduce sediment loading. Whether these actions can be tied directly to the extended time between dredging projects (from 20 to 30 years) is unknown, but it is hoped that continued management efforts will extend the period until the next large-scale dredging project is needed even longer. Over the next few years, it is expected that many more projects will be implemented to reduce sediment loading further. Given this, it would be useful to be able to model sediment loading from various sources to estimate the reductions that could be expected from projects implemented particularly in the riparian area of the lake.

Two models supported by the WI-DNR (and there may be others) potentially could be used, with modifications, to model sediment loading in the riparian area of the lake. WinSLAMM (Source Loading and Management Model for Windows) was developed to evaluate nonpoint source pollutant loadings in urban areas using small storm hydrology. The model determines the runoff from a series of normal rainfall events and calculates the pollutant loading created by these rainfall events. The user is also able to apply a series of control devices, such as infiltration/bio-filtration, street sweeping, wet detention ponds, grass swales, porous pavement or catch-basins to determine how effectively these devices remove pollutants (WI-DNR, SLAMM and P-8 Models). The P-8 (Program for Predicting Polluting Particle Passage through Pits, Puddles, and Ponds) Urban Catchment Model is a model for predicting the generation and transport of storm water runoff pollutants in urban watersheds. The model has been developed for use by engineers and planners in designing and evaluating runoff treatment schemes for existing or proposed urban developments. Predicted water quality components include suspended solids, total phosphorus, total Kjeldahl nitrogen, copper, lead, zinc, and total hydrocarbons (WI-DNR, SLAMM and P-8 Models).

The process of developing a sediment delivery and deposition model may benefit from collection of additional information related to the amount of sediment already in the lake and bays as discussed in Section 4.2.

4.2.2 Sediment Reductions

Unlike phosphorus and chlorophyll, there is no State standard for an appropriate amount of sediment loading to lakes, rivers, and streams. In the absence of a recognized and accepted goal to meet when considering sediment reductions in a lake, and until a separate goal is set based on modeling results proposed in Section 3.5.2.1, this plan defers to whatever reduction in sediment loading occurs in tandem with reductions in total phosphorus that occur with recommended management actions. More specifically, management actions implemented to help meet a 67% reduction in phosphorus loading to Lake Redstone will also create a reduction in sediment loading.

The STEPL model will be used to estimate sediment load reductions after adoption of various practices in the watershed. Once a new model has been created, STEPL model results will be used in tandem with other sediment reduction methods/calculations to determine baseline sediment loading into Lake Redstone.

4.3 Nitrogen

Nitrogen is second only to phosphorus as an important nutrient for plant and algae growth. Sources of nitrogen include: wastewater treatment plants, runoff from fertilized lawns and croplands, failing septic systems, runoff from animal manure and storage areas, and industrial discharges that contain corrosion inhibitors. There are three forms of nitrogen that are commonly measured in waterbodies: ammonia (NH_3), nitrates (NO_3^-), and nitrites (NO_2^-). Total kjeldahl nitrogen (TKN) is a combined measurement of ammonia, organic and reduced nitrogen. Total nitrogen is the combined sum of TKN and NO_3+NO_2 (EPA, 2013). Nitrites, nitrates, and ammonia – the dissolved forms of nitrogen – can be used by most plants and algae. Nitrate is usually the most prevalent form of nitrogen in lakes (UMass - Amherst, 2016).

An acceptable range of total nitrogen in lakes is 2-mg/L to 6-mg/L (EPA, 2013). The Deep Hole water quality monitoring site near the dam has the most existing nitrogen data for Lake Redstone, and has a combination of surface and bottom water samples collected between 1989 and 2019. During this time, total nitrogen values ranged from 0.436-mg/L to 5.64-mg/L with a mean of 1.22-mg/L. Total nitrogen data collected from the east and west branches of Big Creek between 2018 and 2020 show a concentration of nitrogen in the water carried into Lake Redstone between 1.09 and 2.47-mg/L. All Lake Redstone sampling data indicates that phosphorus, not nitrogen, is the limiting nutrient in Lake Redstone at this time. As phosphorus levels in the lake are reduced, this situation may change.

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4.3.1 Hypolimnetic Withdrawal

There is one scenario where the amount of nitrogen as pollution, in the form of ammonia (NH_3) has implications in Lake Redstone. The outlet of Lake Redstone is most recognizable as a small waterfall that is formed when surface water flows out of the lake through a spillway over the top of the dam. There is another outlet or gate near the bottom of the dam that can be opened to draw water out from the bottom of the lake. Because of this gate, hypolimnetic withdrawal is possible. Hypolimnetic withdrawal is simply removing water from the bottom of the lake instead of letting it flow out from the surface of the lake.

Hypolimnetic withdrawal was listed along with numerous other potential management alternatives for Lake Redstone in an earlier study (UW-Madison, 1981). In the 1990's, the LRPD proposed hypolimnetic withdrawal in an effort to reduce internal phosphorus source and complement ongoing efforts to reduce watershed nutrient loads.

In 2002, the WI-DNR in cooperation with the LRPD and Sauk County completed a hypolimnetic (bottom water) withdrawal study of the lake. The following is taken from the final report accompanying that study (Marshall, Jaeger, Panuska, Lathrop, Unmuth, & Decker, 2002).

Hypolimnetic withdrawal has been used to reduce internal phosphorus loading in European lakes since 1961 and North American lakes since 1983 (Cooke 1986, Nurnberg 1987). Both of these sources reported some successes when thermal stratification was maintained. Nurnberg (1987) reported that optimum effectiveness can occur when the withdrawal pipe is located near the bottom in the deepest location of a lake and high discharge rates are sustained without destratifying or lowering the lake levels. Other factors that will influence the success of a hypolimnetic withdrawal include the lake morphometry and balance of phosphorus inputs versus outputs (Cooke, 1986).

Numerous sources have identified the threats and impacts of anoxic hypolimnetic discharges to downstream fisheries and water quality, whether the release is designed to reduce sediment phosphorus pools or to maintain a desired temperature regime. Due to low dissolved oxygen levels in the hypolimnion of eutrophic lakes, special precautions are needed to protect downstream fisheries (Cooke, 1986). Nurnberg (1987) reported that wastewater treatment is required in some cases to prevent adverse effects downstream. Below several North American impoundments, including Twin Valley Lake in Wisconsin, hypolimnetic discharges significantly reduced macroinvertebrate (Young, et al. 1976, Hilsenhoff 1971, Lehmkulm 1972) and fish populations (Edwards 1978).

Tailwater discharges from reservoir hypolimnions often contain toxic levels of hydrogen sulfide and ammonia and can adversely affect downstream ecology, while epilimnetic discharges are generally less disruptive to tailwater biota (Walburg et al. 1981). Minute hydrogen sulfide concentrations can generate nuisance odors, of particular concern in populated areas. Efforts to reduce the "rotten egg" odors have included construction of baffles and fountains to dissipate hydrogen sulfide or enclosures to dilute hypolimnetic water with epilimnetic water (Nurnberg, 1987).

Hydrogen sulfide (H2S) is a toxic, colorless gas that can form in sediments when bacteria feed on organic debris in areas that are low or depleted of oxygen, giving off a rotten egg smell when the sediments are stirred up. When dissolved in water, H2S can undergo two chemical steps, which go back and forth depending on the pH. At pH less than 6, most of the hydrogen sulfide will be in the toxic H2S form, whereas at higher pH (8-12), most of the hydrogen sulfide will be in the less toxic HS- form (Sallenave, 2012).

Ammonia is a form of nitrogen found in organic materials and many fertilizers. It is the first form of nitrogen released when organic matter decays and is the main nitrogenous waste excreted by most fish and freshwater invertebrates. High concentrations of ammonia (greater than 0.02 ppm) are considered sub-lethal and fish exposed may experience reduced growth and increased susceptibility to disease (Sallenave, 2012).

The 2002 WI-DNR study concluded the following:

- Lake Redstone behaves as two contiguous lakes; the upper lake is mixed and lower lake is thermally stratified.
- Internal phosphorus loading is a significant water quality factor within the mixed upper lake and poor water quality resulted. Due to a combination of weak thermal stratification, close proximity to external phosphorus sources and the remote location from the dam, hypolimnetic withdrawal would not improve the water quality in this part of the lake.
- Pronounced thermal stratification in the smaller basin near the dam allows for sediment phosphorus reduction if outputs exceed inputs. However, this part of the lake displays the best water quality and indicates that internal phosphorus sources are not affecting surface water quality.
- Big Creek supports diverse fisheries and aquatic life. A hypolimnetic discharge could pose a serious threat to the stream based on high levels of ammonia and hydrogen sulfide and low dissolved oxygen.

- The two test releases showed that the existing valve could be manually set to accurately control the low flow rates needed for a bottom discharge, but the submerged dam makes the existing structure ineffective at removing high phosphorus concentrations from the lake. Some aeration occurred at the discharge valve and pipe. Downstream dissolved oxygen remained high in Big Creek during both tests. Elevated ammonia concentrations were found in Big Creek and to a lesser extent in the Baraboo River.
- Whether or not structural changes are made to avoid effects of the submerged dam, a Chapter 30 and/or WPDES permit will be required for any proposed hypolimnetic discharge in an effort to protect downstream fisheries, the public interest and water quality standards. As part of the permitting process, effluent calculations will limit hypolimnetic discharge rates based on a number of factors including stream classification, stream dilution and effluent quality. Maximum hypolimnetic discharge rates to Big Creek and directly to the Baraboo River are 0.123 and 3.1 cfs respectively.
- Strong hydrogen sulfide (rotten egg) odors would be produced during a hypolimnetic withdrawal and create nuisance conditions during heavy park use periods.
- Results of the Lake Planning Grant-Baraboo River Restoration and Research Study have largely confirmed the predictions and support recommendations of the 1997 Lake Redstone Water Quality Model Study that suggests controlling internal loading is less important than controlling significant external phosphorus sources.
- From a statewide perspective on water quality management, a thorough analysis of lake response and downstream impacts is recommended for all proposed hypolimnetic withdrawal projects, whether the goal is internal phosphorus loading reduction or sustaining a desired downstream temperature regime.

A more recent bottom withdrawal of water was implemented by Sauk County between 7/22/16 and 8/11/16 in response to the need for an emergency repair/examination of the dam. The release was started slowly so the anoxic water didn't have a profound and immediate effect on the aquatics within the stream that it was discharged into. Before increasing the release of water, as many fish as possible were removed from the stream between the dam and the Baraboo River with the help of a local WI-DNR fisheries biologist. After, the release of bottom water was subsequently increased, but at no time was the gate even opened halfway. There was no additional testing, other than Sauk County Park staff watching for any fish die off where the stream met the Baraboo River, and no die off was observed.

Because the bottom withdrawal was a directive from the DNR to drawdown the lake immediately, there was not a lot of time to prepare or plan for reducing the impacts the discharge could ultimately cause. Sauk County Park personnel were pleasantly surprised to see very little impact on the stream and no impact at the confluence of the Baraboo River (personal communication Matt Stieve, Sauk County, September 14, 2021).

It is recommended that a study similar in scope for to the one completed in 2002 be completed to reevaluate the feasibility of hypolimnetic withdrawal.

5.0 Management Measures (Element 3)

Best management practices (BMPs) are methods or actions that have been determined to be the most effective and practical means of preventing or reducing non-point source pollution to help achieve water quality goals. They include both measures to prevent pollution via source control and measures to mitigate pollution via treatment/filtering methods. For the purpose of this plan, BMPs will be recommended in each of the three main areas of concern: watershed/agriculture, riparian area, and within the lake. Many of the management actions or measures to reduce sediment and phosphorus loading and improve water quality in Lake Redstone over the next 10 years or more are dependent on successful implementation of BMPs.

For more information on BMPs and examples of those that may be specific to one or more of these areas of concern see Appendix D.

5.1 Watershed/Agricultural BMPs

Agricultural BMPs focus on reducing non-point sources of pollution from cropland and farm animals Runoff from these areas may contain nutrients, sediment, animal wastes, salts, and pesticides. Many agricultural BMPs have already been implemented in the Lake Redstone watershed. Juneau and Sauk County land conservationists estimate that more than 3,000 acres of contour strip farming already exist in the watershed. More than 350 acres incorporate the use of cover crops. A few acres are included in nutrient management plans (Table 17). No-till farming has become a more common practice in the watershed in the last several years with about 20% of the cropland implementing it.

Table 17: Specific BMPs (cover crops, contour strip farming, no-till farming, and nutrient management planning) estimated acres within each sub-basin

Sub-basin	Conventional Farming	Contour Farming	No Till Farming	Estimated Total Crop Land	Pasture	Cover Crops	Nutrient Management Planning	% Conventional Farming	% Contour Farming*	% No Till Farming	% Cover Crops	% Nut Man Plan
W1-PfaffRoad	211	650	215	1076	434	55	0	19.6	60.4	20.0	5.1	0
W2-LaValleRoad	83	644	182	909	583	185	87	9.1	70.8	20.0	20.4	9.6
W3-LowerRedstone	330	645	244	1219	1210	50	200	27.1	52.9	20.0	4.1	16.4
W4-ClarkRoad	0	220	55	275	204	20	0	0.0	80.0	20.0	7.3	0
W5-LuchtRoad	0	198	49	247	161	45	0	0.0	80.2	19.8	18.2	0
W6-DaugsRoad	0	136	34	170	117	0	0	0.0	80.0	20.0	0.0	0
TOTALS	624	2493	779	3896	2709	355	287					
Mean % of Ag Land in practice								7.2	72.8	20.0	10.0	4.3
*updated with July 2021 Cropping Practices from Sauk and Juneau Counties 7/30/2021 DLB												

5.1.1 Loading Reductions In the Watershed

STEPL modeling results demonstrate one way to reach 67% reduction in nutrient and sediment loading from the watershed to the tributaries and Lake Redstone by implementing additional BMPs (Table 18). Nearly 19,000-lbs of phosphorus is estimated to be coming from the watershed annually. Not all of the phosphorus and sediment moving from the land in the watershed ends up in Lake Redstone. Much of it stays in the creeks and smaller tributaries, particularly under normal or baseline conditions. Table 16 in Section 4.1 estimated annual phosphorus loading to the lake itself at a little more than 3,500-lbs.

Table 18: Current pollutant loading: nitrogen (N), phosphorus (P), and sediment based on total land use in the six sub-basins

Sources	N Load (lb/yr)	P Load (lb/yr)	Sediment Load (t/yr)
Urban	427.13	71.84	10.59
Cropland	31244.51	13434.68	3982.12
Pastureland	15537.32	1771.00	256.65
Forest	3024.98	1764.68	252.19
Feedlots	9049.98	1810.00	0.00
User Defined	96.35	78.29	30.11
Septic	77.72	30.44	0.00
Gully	0.00	0.00	0.00
Streambank	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00
Total	59457.99	18960.93	4531.66

5.1.1.1 Feedlots

One of the most obvious changes in land use that has a direct impact on nutrient loading is reducing the number of acres in the watershed impacted by feedlots. In Table 18, feedlots contribute over 1,800 lbs of phosphorus. Table 8 in Section 3.3.1.1 identifies 5.3 acres across the six sub-basins with active feedlots. If 100% of the acres impacted by feedlots are addressed over the 10 yrs of this plan, just shy of 10% of loading can be eliminated.

5.1.1.2 Changing Land Use

Both Sauk and Juneau County conservationists feel a reasonable land use goal for the first five years is to reduce cropland by 779-acres, and replace it with pastureland while also transitioning 75% of remaining cropland acres in the watershed to soil health practices (no-tillage/conservation tillage and/or cover crop BMPs). With these changes, STEPL modeling results confirm 43% of the target goal of a 67% reduction in phosphorus can be achieved (Tables 19, 20, 21). At the same time, sediment loading is reduced by 53% and nitrogen loading by 25% (Table 21).

Table 19: Current land use in the six sub-basins of the Lake Redstone watershed (left); and land use after 20% of the crop land is converted to rotational grazing/pastureland (right)

Watershed	Cropland	Pastureland	Cropland	Pastureland
W1 - Pfaff	1076	434	860.8	649
W2 - Lavalle	909	583	727.2	765
W3 - Lower R	1219	1210	975.2	1454
W4 - Clark	275	204	220	259
W5 - Lucht	247	161	197.6	210
W6 - Daugs	170	117	136	151
Total Acres	**3896**	**2709**	**3116.8**	**3488**

Table 20: Pollutant loading after a 20% change in land use (cropland converted to rotational grazing/pastureland) and soil health practices on 75% of remaining cropland acres

Sources	N Load (lb/yr)	P Load (lb/yr)	Sediment Load (t/yr)
Urban	427.13	71.84	10.59
Cropland	13901.16	4990.69	1534.05
Pastureland	18193.99	2145.17	306.32
Forest	3024.98	1764.68	252.19
Feedlots	8851.23	1765.28	0.00
User Defined	96.35	78.29	30.11
Septic	46.63	18.26	0.00
Gully	0.00	0.00	0.00
Streambank	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00
Total	44541.47	10834.21	2133.26

Table 21: Changes in loading after a 20% change in land use and how they relate to the WRB TMDL goal of a 67% reduction

Sources	N Load (lb/yr)	P Load (lb/yr)	Sediment Load (t/yr)
Urban	0.00	0.00	0.00
Cropland	17343.35	8443.99	2448.06
Pastureland	-2656.66	-374.16	-49.67
Forest	0.00	0.00	0.00
Feedlots	198.74	44.72	0.00
User Defined	0.00	0.00	0.00
Septic	31.09	12.18	0.00
Gully	0.00	0.00	0.00
Streambank	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00
Total	**14916.52**	**8126.72**	**2398.40**
% Reduction	**25%**	**43%**	**53%**

Using the STEPL model, if the goal of the first five years is to convert 20% of cropland in the watershed to rotational grazing/pastureland, and adopt soil health practices on 75% of cropland acres and that gets 43% of the 67% reduction desired, changes in years six to ten can have an additional impact. By converting another 20% of cropland to rotational grazing/pastureland, retirement of 300 acres (10%) of existing cropland acres to prairie vegetation, and transitioning 85% of remaining cropland acres in the watershed to soil health practices (no-tillage/conservation tillage and/or cover crop BMPs) (Table 22), an additional reduction in phosphorus loading of 29% is predicted, totaling a 72% reduction, more than the goal of 67% (Table 23). These scenarios also reduce the amount of sediment entering the lake by another 26% and nitrogen by another 23% after ten years.

Table 22: Current land use in the six sub-basins of the Lake Redstone watershed (left); and land use after 40% of the crop land is converted to rotational grazing/pastureland (right)

Watershed	Cropland	Pastureland	Cropland	Pastureland
W1 - Pfaff	1076	434	645.6	865
W2 - Lavalle	909	583	545.4	947
W3 - Lower R	1219	1210	731.4	1698
W4 - Clark	275	204	165	314
W5 - Lucht	247	161	148.2	260
W6 - Daugs	170	117	102	185
Total Acres	**3896**	**2709**	**2337.6**	**4269**

Table 23: Changes in loading after a 40% change in land use and adopting soil health practices on 85% of remaining cropland acres (left) - and how they relate to the WRB TMDL 67% reduction goal (right)

Sources	N Load (lb/yr)	P Load (lb/yr)	Sediment Load (t/yr)
Urban	427.13	71.84	10.59
Cropland	6847.38	2172.44	650.07
Pastureland	20514.22	2233.17	245.52
Forest	2773.04	1559.98	173.46
Feedlots	1756.76	342.04	0.00
User Defined	81.87	66.52	25.59
Septic	38.86	15.22	0.00
Gully	0.00	0.00	0.00
Streambank	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00
Total	32439.27	6461.21	1105.22
AG NPS Total	29118.37	4747.65	895.58

Sources	N Load (lb/yr)	P Load (lb/yr)	Sediment Load (t/yr)
Urban	0.00	0.00	0.00
Cropland	24397.13	11262.24	3332.05
Pastureland	-4976.90	-462.17	11.14
Forest	251.94	204.70	78.73
Feedlots	7293.22	1467.96	0.00
User Definec	14.48	11.77	4.53
Septic	38.86	15.22	0.00
Gully	0.00	0.00	0.00
Streambank	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00
Total	**27018.73**	**12499.72**	**3426.44**
AG NPS Tota	**26713**	**12268**	**3343**
% Reduction	**48%**	**72%**	**79%**

5.1.2 Producer-Led Cooperative Predicted Reductions in Watershed Loading of Phosphorus and Sediment

On a more local level, the Producers of the Lake Redstone Watershed (PLRW) have been exploring the use of several BMPs and how they would reduce sediment and phosphorus leaving the fields and entering the waterways. They explored the use of cover crops, cover crops with the intent of incorporating them as "green manure", vertical tillage, no-till, and zero tillage (pasture/rotational grazing). Green manure is a term used to describe specific plant or crop varieties that are grown and turned into the soil to improve its overall quality. A green manure crop can be cut and then plowed into the soil or simply left in the ground for an extended period prior to and/or during planting. They also compared changes as a result of these practices on different sloping gradients; steeper gradients benefitted more from these practices than did less steep gradients.

In 2019-20, the DATCP worked closely with the PLRW members to identify prevalent crop rotations and the types/extent of existing agricultural BMP in the watershed and then modeled those conditions within SnapPlus model. DATCP found that if all 3000 acres of corn crops were planted using no-till methods instead of conventional tillage, an 8.9-lbs/ac/yr. (69%) reduction in phosphorus could be achieved. In another example, using a vertical tillage farming implement instead of a chisel plow to prep soil for planting could reduce phosphorus loss by 5.3-lbs/ac/yr. (40%). By adding a green manure cover crop and planting into living field cover, phosphorus loss could be reduced by an additional 4.7-lbs/ac/yr. (35%) for a total reduction of 75% in these areas. Finally, converting annual tilled cropland to rotational grazing for beef or dairy is another option for reducing phosphorus and sediment loading from cropland because it reduces nearly all sediment and particulate phosphorus loss from a field. A DATCP 2019 Producers of Lake Redstone Conservation Benefit report further explains these findings (Appendix J).

In 2021, 15 different farmers used cost-share incentives provided by PLRW to plant cover crops and implement other conservation practices. PLRW members farm over 3,000 acres in the watershed combined. When the different scenarios explored by the PLRW are modeled for the total acreage covered by these farmers, loading reductions are substantial and align with reductions predicted in the STEPL model. It is expected that member farmers of the PLRW will increase in the next five years, as will the total acreage covered by these producers, and will the number of BMPs put in place. Any amount of cropland where conventional farming practices are modified in favor of more friendly soil health and practices bodes well for water quality in Lake Redstone.

5.1.2.1 Financial Incentive Programs

Where appropriate and based on need, additional financial incentive programs will be developed that will increase the number of producers who can participate, beef up existing programs, and/or provide incentives where there currently aren't any.

5.1.2.2 Nutrient Management Planning

The number of acres in the watershed that are covered under nutrient management plans is limited, only 7%. Nutrient management planning accounts for all nutrient inputs to a field, ensuring that there are sufficient nutrients available for crop needs while preventing excessive nutrient loading (application of manure or fertilizer), which may result in leaching of the excess nutrients to the ground water, or contained in surface water runoff from the land into local lakes and waterways. Discussions with Juneau and Sauk County put increasing the number of acres covered by nutrient management plans as a low priority activity but one that is still worth doing. The Producers of Lake Redstone are the most logical to promote this activity in the watershed.

5.2 Riparian BMPs

Many BMPs exist for the improving the riparian area along a waterbody and minimizing the impact of development. Rain gardens, native plantings, different water runoff diversion techniques, and buffer strips along the lake are a few examples. There are many more pertaining to construction, homeowner access to the lake, patios and decks, use of fertilizers, pesticides and other chemicals, leaves and grass clippings, firepits, etc. The extent to which these and other BMPs are currently implemented or followed by property owners and others in the riparian area was not determined, but a continuous effort to remind property owners about them will help reduce pollution carried by runoff or added to the lake inadvertently.

5.2.1 Loading Reductions in the Riparian Area

The riparian area of Lake Redstone offers many opportunities to implement reduction projects that will benefit the lake. The results of individual projects may be difficult to measure, but the cumulative impact may be significant. For example, repairing damage caused by recent storm events to existing infrastructure in place to help control runoff; maintaining existing retention basins, berms, and other BMPs will reduce both phosphorus and sediment loading. Converting mowed lawns to more native vegetation; installing storm water diversions and infiltration trenches to reduce runoff into the lake from driveways, rooftops and other impervious surfaces; planting rain gardens to store more of the runoff allowing it to soak into the ground; repairing and preventing areas of active erosion, and eliminating unnecessary fertilization of lawns and gardens; will reduce phosphorus and sediment loading into the lake.

5.2.1.1 Shoreland Habitat Improvement Projects

Through the 2018 SHA (see Section 3.2.1.1), management recommendations were made for evaluated parcels based on Wisconsin's Healthy Lakes and Rivers Initiative. Recommended BMPs include the installation of raingardens, native plantings, runoff diversions, and runoff infiltration trenches. Most of these activities can be funded in part through WI-DNR grants.

A specific goal set by the LRPD regarding the SHA is to decrease the percentage of properties with a moderate to high priority ranking and increase the percentage of properties with a low or no priority ranking through the implementation of these small-scale BMPs (Brad Horner, personal communication).

5.2.1.2 Gullies, Washes, and Streams

Many of the bays around the lake have had runoff-reducing BMPs installed on them in the past including rock chutes, energy stilling basins, and retention basins (Figure 37). One example is a single dirt berm at the head of Mourning Dove Bay that was replaced in 2020 with three rows of gabion baskets filled with rock after having been washed out and repaired after flooding in 2008, and again in 2018 (Figure 38). Currently, the LRPD is seeking bids for another repair project at the head of Swallow Bay where a spillway was damaged during the 2018 flooding.

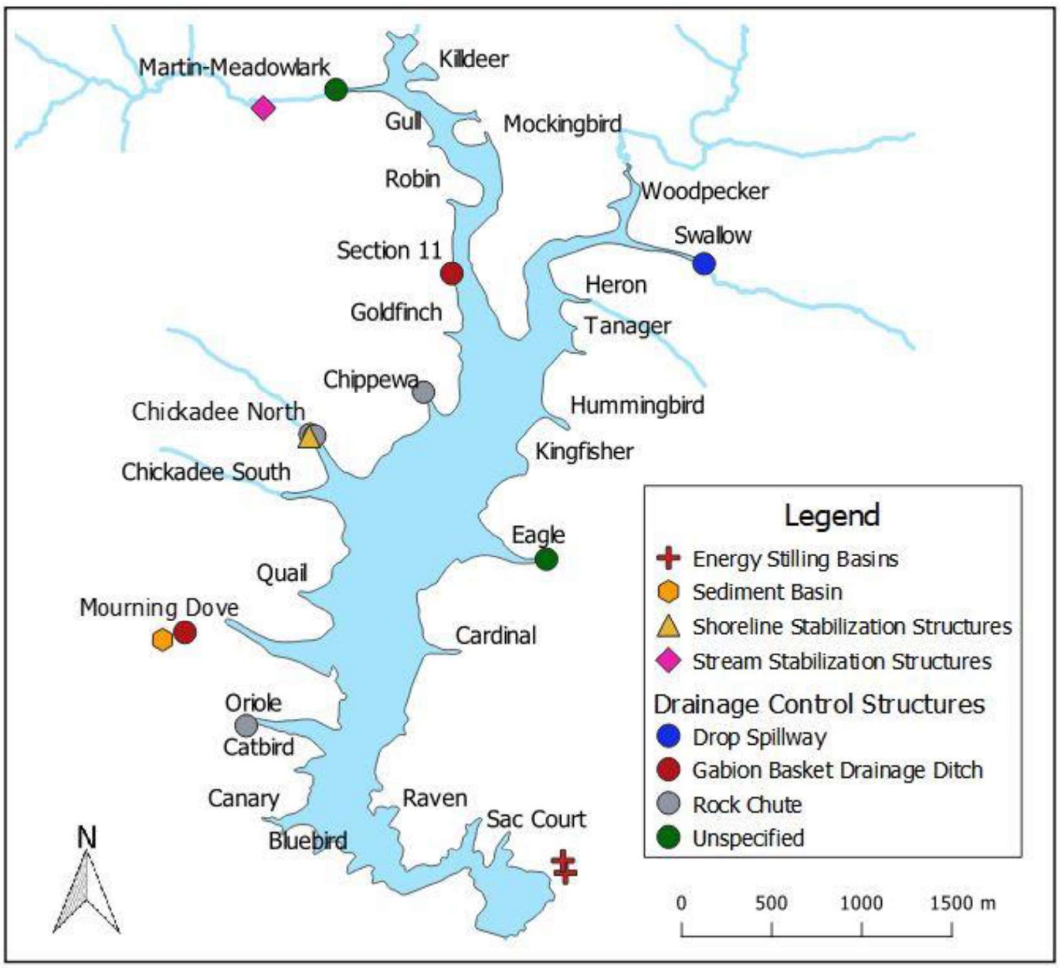

Figure 37: Existing sediment and runoff reduction BMPs in place around Lake Redstone (Al Baade, personal communication 9/29/2021, LEAPS)

Figure 38: Stone-filled gabion baskets placed at the head of Mourning Dove Bay (LRPD Website)

5.2.1.3 Beach Club Lots

Beach club lots around Lake Redstone provide a special challenge when it comes to implementing BMPs that will reduce runoff and improve habitat. Because they are collaboratively owned by multiple properties, it is not sufficient to convince a single property owner to implement a project. Individually owned parcels on Lake Redstone will receive initial priority for implementing BMPs, but once the number of individual parcels begins to lag, the LRPD will move to evaluating individual beach club lots and then meeting with the owners of each lot to prioritize issues and develop management plans.

5.2.1.4 POWTS

Private onsite wastewater treatment systems (septic systems) are used to treat and dispose of small volumes of wastewater onsite, usually from houses and businesses located in suburban and rural locations not served by a centralized public sewer system. Septic systems treat wastewater from household plumbing fixtures (toilet, shower, laundry, etc.) through both natural and technological processes (US EPA, 2020). There are several steps homeowners can take to prevent their home's septic system from impacting nearby water sources. Some are simple while others can be more involved and expensive[7].

To ensure that septic systems within the larger watershed of Lake Redstone and in the developed area (riparian zone) around the lake are functioning properly and not negatively impacting water quality, survey work will be completed to determine the number of septic systems, their age, and maintenance schedule for the last five years. Once completed, survey results will be used to: determine the potential extent of septic system failure (direct discharge into Lake Redstone or its receiving waters); prioritize POWTS for repair/maintenance; inform property owners; and share information with/connect them to the programs offered by the counties and supported by the State that are designed to reduce the number of faulty or failing systems.

5.3 BMPs in Lake Redstone

Like agriculture and riparian areas, in-lake BMPs also exist. Some focus on invasive species, others on protecting the littoral area of the lake, and still others on minimizing disturbances of the bottom sediment and keeping the water free of pollutants and garbage. The LRPD is responsible for aquatic plant management and in mindful of how those management actions impact the lake. No wake zones exist and are marked with

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[7] For more information about how homeowners can prevent their septic systems from impacting the lake and groundwater go to: https://www.epa.gov/septic/septic-system-improvements-protect-nearby-water-sources

buoys essentially wherever the distance from shore to shore is 400-ft or less (Figure 39). In addition, the Town of LaValle has an ordinance (Section 11.01.05 Controlled Areas), that establishes an Emergency Slow No-Wake designation for all of Lake Redstone during high water conditions. Aquatic invasive species education, planning, and prevention activities/BMPs including Clean Boats, Clean Waters and AIS monitoring are implemented on a regular basis by the LRPD and supported by the Town of LaValle and LRPOA.

How well users of Lake Redstone comply with fishing and boating regulations and other general lake stewardship activities has not been determined and no effort in this plan will be done to do so. However, the LRPD and its partners will continue to promote these activities to their constituency and other lake users.

Figure 39: Approximate location of buoys designating "no-wake" areas on Lake Redstone (Town of LaValle)

5.3.1 Mitigating Internal Loading

If additional study of the role of internal loading completed in the first year or two of implementing this plan determines that internal loading does play a significant role in the loading of phosphorus into Lake Redstone and reducing phosphorus loading from the watershed does not have a more immediate positive impact on the lake, additional actions including more dredging and/or the application of phosphorus binding agents could be evaluated. Internal loading can be exacerbated by the resuspension of bottom sediments caused by man-made disturbances like boating or by natural disturbances like wave action, particularly in areas where limited or no aquatic plants exist to buffer or attenuate wave energy.

If the levels of phosphorus entering the lake from the watershed can be controlled and if internal loading is found to be a significant factor in maintaining phosphorus levels in the lake, then the LRPD may examine other treatments, such as alum treatments to reduce the levels phosphorus in the water. But this is likely a long-term strategy that may happen after the 10 years covered by this plan.

5.3.1.1 Considering P Removal Technologies for Use at Smaller Scales

The LRPD is interested in evaluating the use of phosphorus removal technologies at smaller scales, i.e. at intermittently flowing inlets in the riparian area around the lake. One possibility is the use of absorptive filter media. From Bunce et al. (2018), P is removed by filter media through the process of sorption or by direct precipitation. Briefly, this involves the movement of inorganic P from the wastewater to the surface or body of reactive components (e.g., calcium or iron) contained in the media, where is accumulates. The P removal capacity is dependent on the mineral content of the media. Early work on P removal by sorptive media focused on the use of locally sourced sands and gravel. More recently, the development of a wide variety of natural or man-made materials has advanced the potential for the application of this technology at small-scale Bunce et al. (2018)

The applicability of this technology has not been fully developed with several obstacles still to be overcome. It is likely that a small-scale system like this would be remotely located without major civil infrastructure. As such, to sustain operational efficiency, it would be critical that any technology implemented in rural and remote locations requires minimal maintenance. This can only be made a reality if the system is rapid to stabilize and simple in terms of construction and operation. The use of absorptive filter media within the context of a constructed wetland or as a standalone system is a promising solution on these bases. However, significant capital outlay, space considerations, and long-term sustainability may limit these options Bunce et al. (2018).

Small-scale application of this P management technique is in its infancy, with only a few companies offering solutions. Further research is needed to determine the long-term effectiveness of such systems for smaller scale treatment applications and the performance of absorptive media under rapid fluctuations in flow and nutrient loadings.

5.3.2 Dredging to Remove Sediment and Phosphorus

Not listed as a BMP, but effective at reducing the amount of sediment and phosphorus in Lake Redstone regardless, is dredging. Based on analytics done on multiple core samples of sediment collected from the bottom of bays around Lake Redstone in 2015/16, the mean phosphorus content of the sediment was 232.8-ug/kg (Ayres Associates, 2015). The 2019 dredging project removed an estimated 51,684,129 kg of sediment – meaning approximately 12,032-kg or 26,526-lbs of phosphorus was removed from the lake with the sediment. At an estimated seasonal loading of phosphorus in the lake of 1,628-lbs, and assuming that all that phosphorus settled out into the sediment at the bottom of the lake (which it didn't), that would be a little more than 16 years' worth of phosphorus build-up.

These calculations are only for baseline loading conditions and do not represent what is brought into the lake during storm events or spring snowmelt. Improved monitoring techniques are already being implemented that will improve data associated with tributary loading during storm events.

6.0 Implementation Schedule (Key Element 6) and Milestones (Key Element 7)

The main goal of all of the efforts past, present, and future put forth by the LRPD and supporting entities is encompassed in its mission statement: "… to protect and rehabilitate the water quality of Lake Redstone for its residents and the public". For Lake Redstone, this means reducing loads of sediment and phosphorus from multiple sources in the larger watershed, the riparian area around the lake, and in the lake itself.

Sections 6.1 – 6.3 lay out actions to be implemented by the LRPD and its partners over the course of the next 10 years. The actions for each area of concern (watershed, riparian area, and lake) are listed under two categories - "Reducing Phosphorus and Sediment" and "Gathering Data". More detail about each action is included in the Implementation and Milestones Matrix for each area of concern presented in Appendices E, F, and G.

6.1 Watershed Objectives and Actions

Reducing sediment and phosphorus loading in the watershed is focused primarily on changing agricultural land use by implementing recognized BMPs. Additional focus is on addressing existing animal feedlots in the watershed, identifying and addressing issues where gully and ravine erosion exists (fields, streams, washes, etc.), and increasing the amount of agricultural land covered under nutrient management plans. Where appropriate, implementation is divided by each of the six sub-basins.

Actions to gather additional information to improve management include evaluating each individual sub-basin via the Stream Power Index, physical follow-up to confirm or document gully and ravine erosion, improving tributary monitoring to better document actual sediment and phosphorus loading in the two main branches of Big Creek.

6.1.1 Reducing Sediment and Phosphorus Loading - Watershed

- Convert 40% of existing cropland acres to grazing/pasture (1,558 acres)
- Apply a wide range of BMPs (no-till, cover crops, etc.) to 85% of all remaining cropland (1,988 acres)
- Increase the amount of acres covered by nutrient management plans by 10% (390 acres)
- Convert 10% of all remaining cropland to prairie through restoration (234 acres)
- Reduce the number of improperly managed animal feedlots by 100%
- Reduce verified field gully/ravine erosion areas
    - Implement grassed waterways, grade stabilization structures, contour farming, etc.
- Repair faulty or failing POWTS so they comply with current regulations
- Work with others to make sure appropriate forestry and mining BMPs are being utilized in the watershed

6.1.2 Gathering Additional Data - Watershed

- Complete streambank and lateral recession rate monitoring in at least two sub-basins
- Complete a Stream Power Index and gully/ravine inventory outside of the Lake Redstone sub-basin
- Monitor land use changes via satellite imagery and "cropland data layer" annually
- Complete cropland roadside transect surveys with in the entire watershed annually
- Complete an inventory of active POWTS outside of the Lake Redstone sub-basin
    - Prioritize POWTS for repair and maintenance

6.2 Riparian Area Objectives and Actions

Reducing sediment and phosphorus loading in the riparian area is focused primarily on encouraging property owners around the lake to modify their properties in ways that will improve and/or protect wildlife habitat and reduce surface water runoff across properties. Associated with this is identifying and addressing issues of gully, ravine, and wash erosion within the riparian area but not necessarily tied to individual parcels. Additional focus is on repairing and/or providing maintenance for existing runoff control structures in place to reduce direct drainage into Lake Redstone; and to identify new ones that could be put in place. Identifying and bringing faulty septic systems into compliance and reducing runoff from multi-owner parcels around the lake are also included.

Actions to gather additional information to improve management include repeating the Shoreland Habitat Assessment, documenting sediment loading in individual bays and developing a sediment model to be used to predict future loading, collecting time-at-the-lake people data for use in lake response modeling, determining potential loading from septic systems, and evaluating multi-owner parcels around the lake.

6.2.1 Reducing Sediment and Phosphorus Loading – Riparian Area

- Reduce the number of moderate and high priority property parcels by 20%
    - Annual Shoreland Improvement Workshops
    - Project assistance through application grant programs
- Reduce the number of beach club and other cooperatively owned parcels contributing to sediment and phosphorus loading
- Repair faulty or failing POWTS so they comply with current regulations
- Evaluate and repair existing sediment and stormwater control BMPs
- Reduce verified field gully/ravine and stream erosion areas
    - Implement grassed waterways, grade stabilization structures, contour farming, etc.

6.2.2 Gathering Additional Data – Riparian Area

- Repeat the SHA in five years
- Complete a Stream Power Index and gully/ravine inventory within the Lake Redstone sub-basin
- Complete an inventory of active POWTS outside of the Lake Redstone sub-basin
    - Prioritize POWTS for repair and maintenance
- Evaluate streams, gullies and washes entering directly into Lake Redstone for stormwater runoff and erosion issues
    - Prioritize for further documentation through monitoring and collection of water samples
- Document the level of sediment entering the individual bays of Lake Redstone during storm events
- Develop a sediment model

6.3 Lake Redstone Objectives and Actions

Reducing sediment and phosphorus loading within Lake Redstone is focused on actions that can reduce resuspension of sediment and availability of phosphorus to support plant and algae growth. Aquatic plant management, disturbance of bottom sediment by boats, waves, and carp are addressed either directly in this plan or in the Lake Redstone Aquatic Plant Management Plan. Actions are included that would remove sediment and phosphorus from the lake including hypolimnetic withdrawal, binding of phosphorus, and additional dredging. Of these three, adding agents that would bind phosphorus and dredging are low in priority and highly dependent on new data collected during the implementation of this plan.

Actions to gather additional information to improve management include updating the APM Plan, reevaluating the role of internal loading of phosphorus (and possible alum treatment), and the feasibility of hypolimnetic withdrawal. Efforts to better quantify the amount of sediment already in the lake and that which is added (or removed) over the next 10 years of implementation.

6.3.1 Reducing Sediment and Phosphorus Loading – Lake Redstone

- Aquatic plant management planning, survey, permitting and treatment
- Encourage carp removal by working with the Lake Redstone Fishing Club to continue the carp removal programs held in 2021 and earlier years.
- Use of alum or other phosphorus binding agents
    - After external phosphorus sources in watershed are substantially controlled and internal loading is determined to remain a significant factor in maintaining lake phosphorus levels
- Hypolimnetic withdrawal from the dam
    - If it is determined that such withdrawals can be performed without significant negative impacts downstream in the Baraboo River
- Adapt/adopt new boating ordinances that will help minimize bottom disturbances

6.3.2 Gathering Additional Data – Lake Redstone

- Update the Aquatic Plant Management Plan
- Update existing lake response modeling
- Complete an internal phosphorus loading study
- Reevaluate hypolimnetic withdrawal from the lake
- Review and evaluate existing boating ordinances
- Recalculate sediment and phosphorus loading to Lake Redstone from all sources based on new data
- Survey sediment in the main basin of Lake Redstone to quantify deposition

7.0 Education and Outreach (Key Element 5)

To be effective, an education and outreach plan must include increased and better communication with the many stakeholders across the three main areas of concern for Lake Redstone – the watershed, riparian area, and lake. The main goal for Education and Outreach for Lake Redstone is to create public awareness of water quality issues in the watershed, increase public involvement in watershed stewardship, and increase communication and coordination among stakeholders and partners.

7.1 Objectives

The following is a list of objectives related to the Education and Outreach goal.

- Develop targeted educational and information materials to appropriate audiences in the watershed and distribute through newsletters, brochures, website and Facebook posts, etc.
- Support, plan, and promote agriculturally-based field days, demonstrations, and project tours.
- Partner with other 9-Key Element Watershed Organizations to plan and present a Watershed Conference on a regular basis (how regular would be determined in the planning process)
- Promote goodwill and partnership between lake property owners and the agricultural community with tours of non-agricultural conservation practices put in place.
- Work with and support efforts by the Producers of the Lake Redstone watershed to successfully implement actions supported by DATCP grants
- Plan and promote at least two meetings a year to discuss implementation and evaluation of this plan with stakeholders and partners
- Host at least one annual meeting meant to update and involve the LRPD constituency in plan implementation

For more information about these objectives and the estimated cost to implement consult Appendix I.

7.2 Target Audience

Multiple audiences will be targeted through this education and outreach plan. Target audiences include but are not limited to property owners on and adjacent to Lake Redstone, agricultural operators and producers, local clubs and organizations, local businesses and schools, local government officials, and other watershed groups.

The following sections provide more information about specific education and outreach activities in each area of concern.

7.3 Watershed

The main stakeholders representing the larger watershed of Lake Redstone include the local agricultural producers, Sauk County, Juneau County, the United State Geological Survey (USGS), University of Wisconsin Discovery Farms, and the Producers of the Lake Redstone Watershed, a producer-led initiative.

7.3.1 Discovery Farms – Edge-of-Field Monitoring Stations

Two edge-of-field monitoring stations were installed in the watershed to measure and collect runoff from monitoring basins (Figure 40). Located in the Driftless area of the state, this region is geologically unique with land areas that were by-passed by the glaciers leaving steep terrain susceptible to flash runoff events and erosion that can increase the amount of sediment and nutrients lost from agricultural land and carried into streams, rivers, and lakes. Samples are collected with remote technical assistance from the USGS, and are analyzed for nitrogen, phosphorus and sediment. The Juneau County LWR Department performs sample collection and site maintenance at edge-of-field monitoring stations.

Results and data analysis from the monitoring stations are shared with interested partners during local field days and other events open to the public. It is during these events that the LRPD gets involved; bringing what is learned to its constituency. It is expected that these two monitoring stations and the partnerships will remain in place for several more years.

Figure 40: Example edge-of-field surface water monitoring station/system (left); actual Lake Redstone watershed edge-of-field monitoring station

7.3.2 Producers of the Lake Redstone Watershed

The purpose of a producer led watershed group is for participating farmers to reach out to other farmers to join the group and to help them adopt similar conservation practices. With additional funding from DATCP, the group will continue to support farmer incentives to implement best management practices including cover crops, community manure sharing, establishing nutrient management plans, and for sponsoring community events, field days, and training.

7.3.3 Juneau County

The following education and outreach components are part of the Juneau County LWR Management Plan and also are of benefit to Lake Redstone: planned on-farm visits to producers in selected watersheds to review resource concerns and potential ways to address them; summer/fall field events in each watershed to talk about practice implementations; winter meetings with watershed participants to review results and next steps; annual programs discussing soil health and innovative conservation strategies; tours on non-agricultural conservation practices like stream bank, shoreline, rain gardens, etc.; and as nutrient management plans are developed, meetings will be conducted with producers to expand and develop agricultural enterprise areas.

7.3.4 Sauk County

One of the goals of the Sauk County Land and Water Resource Management Plan is to deliver information and education programs focusing on agricultural and environmental issues affecting the county. Some of the current programs that can be associated with protecting and improving Lake Redstone include: classes and workshops – cover crop/soil health field days, small acreage landowner workshops, pasture walks, and nutrient management farmer education classes; publication of the Conservation Chronicle newsletter & news releases; maintaining a County website & Facebook page; sponsoring an Agricultural Plastics Recycling Program; sponsoring special events – Earth Day, lake fair, county fair, dairy breakfast;, supporting citizen water monitoring; and sponsoring partnership projects with environmental, sporting, and service groups.

In the past, Sauk County has been successful in obtaining funding to support the Baraboo River Watershed Regional Conservation Partnership Program (RCPP). Lake Redstone and its watershed are part of this partnership. RCPP promoted coordination between USDA, NRCS and its partners to deliver conservation technical and financial assistance to agricultural producers and forest landowners to help implement conservation practices that improve soil health, water quality, restore wildlife habitat, and improve agricultural productivity.

Both Sauk and Juneau County provide education and informational materials to the public via brochures, demonstrations, displays, notices, and other publications.

7.4 Riparian Area

The main stakeholders representing the riparian area of Lake Redstone include the LRPD, the LRPOA, group-owned beach club sites, individual property owners, and local businesses and real estate agencies. The riparian area of Lake Redstone is typical of most developed lakes in southern WI – far too much impervious surface and mowed lawn to the edge of the lake. Changing the public perception of what a healthy riparian area around Lake Redstone should be has long been a topic of discussion within the LRPD.

7.4.1 Riparian Ditch and Gully Erosion

Minimizing ditch and gully erosion during large storm events is a high priority for the LRPD. The LRPD Board recently created a Sediment Control Committee that will be focusing on ditches and gullies closer to the lake that periodically become streams following rain storms. This committee will try to identify problem areas and come up with ideas/plans to help reduce sediment carried into the lake from these areas. Included in this is analyzing culverts under the myriad of roads around Lake Redstone and documenting unimpeded runoff to the lake during storm events. Individual gullies draining directly to the lake will be prioritized based on the level of concern and potential for the implementation of "fixes". Existing BMPs in place to reduce runoff and sediment loading will be evaluated and maintenance planned and implemented if needed. Ideas for new or additional BMPs will be discussed, ultimately leading to plans and implementation. To do this, the LRPD will work closely with local and county resources, property owners around the lake, and owners of land upstream of any identified problem area.

7.4.2 Shoreland Improvement Project

In 2020, the LRPD began organizing a shoreland improvement education and implementation program based on the results of the 2018 SHA. The goal of the program is to help property owners understand how their property values benefit relative to better water quality through runoff reduction; healthier and more diverse habitat for fish and wildlife; and potentially improved natural aesthetics around the lake. This project has four phases to it. All four phases are expected to occur in each year of implementation.

The first phase of the project is to share with individual property owners the results of their evaluation during the 2018 SHA. Postings on the LRPD webpage and Facebook page, articles in LRPD newsletters, and one on one conversation with property owners, will encourage them to ask about their evaluation, review it with the LRPD, and ask questions about it.

During the second phase of the project, interested property owners will be invited to workshops to better understand their assessment results, learn more about possible improvement opportunities, and what resources exist to help them implement projects that will reduce runoff and improve habitat. These workshops would also include information on shoreline preservation methods (e.g. bio-logs, rip-rap, etc.) to prevent shoreland erosion.

The third phase is sponsoring actual workshops. The content of each year's workshop could vary but would be focused on why the LRPD sponsored this SHA of properties around the lake; review/explanation of the parameters used to score properties during the SHA; a review/explanation of individual property management recommendations made during the SHA; an introduction to the WI-DNR Healthy Lakes and

Rivers Initiative and how it provides reimbursement for projects implemented to reduce runoff and improve shoreland habitat; options for reducing sediment runoff and habitat improvement that go beyond the management recommendations in the SHA; introduction to the Sauk County water quality improvement and lake protection program, eligible projects, and opportunities for reimbursement of expenditures for completed projects; and introduction of landscaper(s) and other businesses who could help assess properties for methods to reduce runoff and preserve shoreline and then possibly contract with property owners to perform the work.

The final phase of this activity is organizing property owners and projects and applying for grant funds on their behalf, and then providing support to complete identified projects.

It is expected that these activities will be carried out annually as long as there are still interested property owners. After five years, the SHA will be redone to determine the level of changes that have occurred.

7.4.3 Septic System Education

Sauk County has several information brochures related to septic systems, permitting, and erosion control that were prepared by the county with the intent to distribute to property owners, not just on Lake Redstone, but throughout the County. Gaining access to these existing publications and resending them to property owners around the lake is an activity that could be done and would be beneficial for making current and future improvements to the lake. Sauk County has a grant program – Wisconsin Fund-Private Sewage System Replacement or Rehabilitation – that exists to help property owner's deal with faulty or failing septic systems. More information about this grant is available through Sauk County.

7.4.4 Beach Clubs

Although the shorelines of some beach clubs are problematic, the complexity associated with working with multiple owners makes it difficult to make improvements on these shorelines. (Beach clubs on Lake Redstone can have fewer than 10 owners or more than 100 different owners.) Thus, initial efforts at shoreline improvement will focus on lots with a single owner. But in the latter years of this plan, it may become necessary to address the shoreline of some of the beach clubs.

7.4.5 Real Estate

When ownership of a property changes due to sale, foreclosure, or by some other means, this is a good opportunity to approach the new owners with information about what they can do to make their new property more lake friendly. Being part of a lake district, each new property owner automatically pays extra taxes to support a healthy lake. Providing information to these new property owners about what their extra taxes are being used for may increase support for what the LRPD does. Ultimately, taxes will be less and home/property values more when a lake is considered generally healthy with only minor issues. While mowed and manicured properties may sell better, a fact often noted by real estate agents, they are less healthy to the lake overall.

This plan recommends that the LRPD be actively engaged in property sales around the lake. When a property exchanges hands, representatives of the LRPD should be at the door immediately welcoming the new owner and passing on materials about how and what that property owner can do to maintain or improve the lake into the future.

7.5 Lake Redstone

Like the watershed and the riparian area, there are many things that are done that directly impact the water quality in the lake. The main stakeholders representing the lake are the property owners around the lake, users of the lake, fishing clubs and other community organizations, the LRPD, and the many resource agencies managing the lake.

7.5.1 LRPD

The LRPD will continue to work on identifying, obtaining, and/or developing their own publications on topics of concern for distribution to the watershed, riparian area, and lake stakeholders. Both the LRPD and the LRPOA have active web and Facebook pages to help keep stakeholders involved. The LRPD will continue to assist in planning and participate in watershed level activities and continue to promote riparian area workshops and training sessions. The LRPD will continue to hold annual "Partners" meetings whereby many stakeholders are brought together to discuss the status of Lake Redstone and share accomplishments and plans.

7.5.2 Property Owners

How property owners view and treat the lake, often called lake stewardship, is vital to maintaining the health of the lake. Lake stewardship can encompass many things including but not limited to how a property adjacent to the shore is managed, proper septic system maintenance, lighting along the shore, noise, being a good neighbor, responsible boat use, following fishing rules and regulations, and doing what is necessary to avoid spreading aquatic invasive species.

Lake stewardship will be promoted through lake organization meetings and publications. Many organizations create specific awards, brochures, or other materials promoting and/or recognizing good stewardship practices and the people who are practicing them.

People use lakes in different ways, and may have different goals for enjoyment of the lake. Discussing these goals in an open forum can help people understand each other's view points and vision for the lake. Additionally, gaining an understanding of general lake processes and ecology can help people understand what is happening in their lake. Determining the current condition of the lake can then provide a knowledge base that can be used to protect and restore the lake.

7.5.3 Lake Users

Lake users can be anybody with property on the lake or who comes to the lake for some purpose. Lake Redstone is a popular recreation lake for fishing, power boating, water skiing and tubing, and use of personal watercraft. Lake Redstone has several "no wake" areas where the lake is too narrow to accommodate fast moving boats safely. A continued effort toward providing education and information regarding safe and legal use of watercraft in Lake Redstone not only protects the people of the lake, but also helps protect the health of the lake. Fishing is another popular activity on Lake Redstone, practiced by both property owners and outside lake users. Like other good lake stewardship practices, following fishing rules and regulations related to size and bag limits, proper handling of catch and release fish, draining livewells, and proper disposal of live bait will also help protect the health of the lake.

7.5.4 Others

The various other clubs and organizations that focus on Lake Redstone and the surrounding area will continue to support and promote good lake stewardship through their members and the activities they support. Real estate agencies, local marinas and bait stores, businesses that do lake work (dock installers, landscapers, etc.), lake-related clubs and organizations, and local governments should also promote good lake stewardship and may need reminders every now and then from the LRPD to do so.

8.0 Authorities, Funding Sources, and Technical Assistance (Key Element 4)

Identifying practices that are expected to make improvements to the lake, riparian area, or watershed is only one step in developing and implementing a plan. It is necessary to know under what authority, what guidelines the practices are to be implemented. Then it is necessary to determine the cost of implementation and how that cost is going to be covered. Finally, knowing what expertise is needed to successfully implement a plan and where that expertise is coming from is imperative.

8.1 Authorities

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

Both Juneau and Sauk Counties have established zoning ordinances regulating land development and protecting surface waters. A majority of the Lake Redstone watershed is in Juneau County. The entirety of Lake Redstone is in Sauk County.

8.1.1 Juneau County

The following ordinances in both counties will help guide implementation of this plan.

8.1.1.1 Chapter 4, Article V – Animal Waste Management

The purpose of this article is to regulate the design, location, construction, installation, alteration and use of animal waste storage facilities and application of waste from these facilities; to prevent water pollution and thereby protect the health of county residents; to prevent the spread of disease; and to promote the health, prosperity and welfare of the residents of the county. It is also intended to provide for the administration and enforcement of this article and to provide penalties for its violation.

8.1.1.2 Chapter 16 – Floods

The purpose of this chapter is to regulate floodplain development to: 1) Protect life, health and property; 2) Minimize expenditures of public funds for flood control projects; 3) Minimize rescue and relief efforts undertaken at the expense of the taxpayers; 4) Minimize business interruptions and other economic disruptions; 5) Minimize damage to public facilities in the floodplain; 6) Minimize the occurrence of future flood blight areas in the floodplain; 7) Discourage the victimization of unwary land and homebuyers; 8) Prevent increases in flood heights that could increase flood damage and result in conflicts between property owners; and 9) Discourage development in a floodplain if there is any practicable alternative to locate the activity, use or structure outside of the floodplain.

8.1.1.3 Chapter 15 – Private Onsite Wastewater Treatment

The purpose of this chapter is to promote and protect public health and safety by assuring proper siting, design, installation, inspection and management of private sewage systems and non-plumbing sanitation systems.

8.1.1.4 Chapter 21 – Ag Waste and Performance Standards

The purpose of this chapter is to provide for proper and safe storage, handling, and land application of agricultural waste and to reduce the delivery of manure, other waste materials, fertilizers, and sediment to surface waters and groundwater through the use of conservation practices and implementation of state performance standards and prohibitions for agriculture. This chapter is also intended to provide for administration and enforcement, and to provide penalties for violation of the chapter.

8.1.1.5 Chapter 22, Article II – Non-metallic Mining Reclamation

The purpose of this article is to establish a local program to ensure the effective reclamation of non-metallic mining sites on which non-metallic mining takes place in the county.

8.1.1.6 Chapter 36 - Waterways and Boating, Appendix A: Shoreland-Wetland Zoning

For the purpose of promoting the public health, safety, convenience and welfare, this appendix has been established to:

1) Further the maintenance of safe and healthful conditions and prevent and control water pollution through:
    a) Limiting structures to those areas where soil and geological conditions will provide a safe foundation.
    b) Establishing minimum lot sizes to provide adequate area for private sewage disposal facilities.
    c) Controlling filling and grading to prevent serious soil erosion problems.
2) Protect spawning grounds, fish and aquatic life through:
    a) Preserving wetlands and other fish and aquatic habitat.
    b) Regulating pollution sources.
    c) Controlling shoreline alterations, dredging and lagooning.
3) Control building sites, placement of structures and land uses through:
    a) Separating conflicting land uses.
    b) Prohibiting certain uses detrimental to the shoreland area.
    c) Setting minimum lot sizes and widths.
    d) Regulating side yards and building setbacks from roadways and waterways.
4) Preserve shore cover and natural beauty through:
    a) Restricting the removal of natural shoreland cover.
    b) Preventing shoreline encroachment by structures.
    c) Controlling shoreland excavation and other earth moving activities.
    d) Regulating the use and placement of boathouses and other structures.
    e) Controlling the use and placement of signs.

8.1.2 Sauk County

8.1.2.1 Chapter 7, Subchapter III – Zoning Districts

The purpose of this subchapter is to outline the land management goals and general land uses allowed in each zoning district.

8.1.2.2 Chapter 8, Subchapter I – Shoreland Protection General Provisions

This Chapter/subchapter is nearly the same as Chapter 36 Appendix A in Juneau County ordinances.

8.1.2.3 Chapter 8, Subchapter IV - Shoreland-Wetland Zoning District

The purpose of the shoreland-wetland district is to maintain safe and healthy conditions, to prevent water pollution, to protect fish spawning grounds and wildlife habitat, to preserve shore cover and natural beauty, and to control building and development in wetlands whenever possible. When development is permitted in a wetland, the development should occur in a manner that minimizes adverse impacts on the wetland.

8.1.2.4 Chapter 9 – Floodplain Zoning

This Chapter is similar to Chapter 16 in Juneau County ordinances.

8.1.2.5 Chapter 24 – Non-metallic Mining Reclamation

This Chapter is similar to Chapter 22 in Juneau County ordinances.

8.1.2.6 Chapter 25 – Private Onsite Wastewater Treatment Systems

The underlying principles of this ordinance are to promote and protect the public health, safety, general welfare and natural resources and to:

1) Further the maintenance of safe and healthful conditions by regulating POWTS use, location, design installation, operation, management, inspection and repair.
2) Prevent and control surface water and groundwater pollution through:
   a) Requiring setbacks between POWTS components and water courses.
   b) Regulating the use of POWTS to protect the public health, safety, general welfare and natural resources.
   c) Requiring in-situ soils to be the preferred system.

8.1.2.7 Chapter 26 – Ag Performance and Manure Management

This Chapter is similar to Chapter 21 in Juneau County ordinances.

8.1.3 NR 151

In addition to using local ordinances and educating landowners in the watershed on programs and funding available to them to improve water quality and meet current state and local agricultural regulations, Juneau and Sauk County LCDs will collaborate with WI-DNR to verify and document NR151 compliance via the following actions:

1) Annually meet with WI-DNR Nonpoint Source and TMDL staff to review and discuss NR151 implementation efforts in the watershed, including:
   a) Review existing cropland acres and animal operations in the watershed
   b) Determine what number/percent of agricultural cropland acres and farms are complying with NR151 and how many are not.
   c) Confirm how many cropland acres or farms in watershed have been documented in compliance with NR151 Standards & Prohibitions via a letter.
   d) Review selected copies of NR151 compliance letters with WI-DNR staff.
   e) Do plan implementation efforts for agricultural cropland/operations reflect the following priorities?
      i) Priority 1: Achieving compliance with current NR151 performance standards on a majority (>70%) of agricultural acres/operations in the watershed
      ii) Priority 2: Promoting additional practices on agricultural acres/operations already in compliance with NR151 - to further reduce ag pollutant loads in the watershed.
   f) Incorporate NR 151 compliance information within selected 9-key element plan tracking reports.

8.1.4 WI Dept. of Safety and Professional Services (DSPS)

The DSPS – Private Onsite Wastewater Treatments Systems (POWTS) Program protects public health and the waters of the state by regulating onsite wastewater treatment and recycling systems. The program works with counties (including Juneau and Sauk) to promote the use of the best available technology to provide onsite sewage treatment system solutions for property owners. It provides required plan review for new system installations and/or replacements or additions to existing POWTS treatment, holding, or dispersal components. The program also provides oversight for the Wisconsin Fund (see 8.2.1).

8.1.5 Town of LaValle

The following Town of LaValle ordinances pertain directly or indirectly to Lake Redstone.

8.1.5.1 Chapter 4.02 – Boat Landing Entrance Fees

- Boat landing hours (4.02.04), piers and swimming (4.20.05), and signs (4.02.06)

8.1.5.2 Chapter 11.01 – Lake Redstone and Water Traffic

- 11.01.05 - Boat exclusion areas (public and marked swimming areas)
- 11.01.06 - Controlled areas (slow-no wake and emergency slow-no wake)
- 11.01.07 - Other water traffic rules (water skiing)
- 11.01.08 – Water exhibition

8.1.5.3 Chapter 11.03 – Aircraft landing

8.1.6 Lake Redstone Protection District

Lake districts can work cooperatively with other government bodies and private organizations to carry out authorized activities. Wisconsin local governments (including lake districts) have broad powers to undertake cooperative efforts with other government bodies and Indian tribes. For example, some lake districts work cooperatively with counties or other government bodies on boating law enforcement, erosion control, and other programs important to the lake or its watershed. Lake districts can also work cooperatively with nonprofit organizations on conservation projects beneficial to the lake and the district's mission.

8.1.6.1 Recreational Boating Regulations

All lake districts have the authority to establish water safety patrols and contract with certified law enforcement officers to enforce state boating laws and any local boating ordinances that affect the lake. Like on many lakes, the use of wake boats and other craft that create large wakes are a source of concern on Lake Redstone. At present, only state boating regulations and those in effect via the Town of LaValle ordinance related to high water are in place and can be enforced. At some point in the future, there may be some level of interest in creating additional ordinances to guide the use of wake boats or similar craft.

Wisconsin law generally gives towns, villages and cities the authority to enact local boating regulations. This power can be delegated to a lake district. For a lake district to enact a boating ordinance, it must be authorized by resolutions adopted by at least one-half of the cities, villages and towns having frontage on the lake, the approving units of government must include at least 60% of the lake's frontage, and the entire lake must be within the district's boundaries.

Whether a boating ordinance is adopted by a lake district, city, village or town, various statutory requirements must be met. The adopting local government (including a lake district) must take into account local conditions in developing boating ordinances, including the lake's size and shape, environmental features and the extent of congestion and conflict among boaters. There are also detailed procedural requirements, including published notices, public hearings, WI-DNR advisory review and other steps. The Legislature has expressly authorized boating regulations that restrict speed or establish time or location standards for different types of boating activities. Boating ordinances may not be inconsistent with state boating law, but may generally be more restrictive than state laws. If a lake district enacts boating ordinance provisions that conflict with town, village or city boating ordinances, the lake district provisions supersede the local conflicting provisions. Local boating ordinances may be enforced by citations, similar to "traffic tickets."

8.1.7 Producers of Lake Redstone

The Producers of Lake Redstone are required to follow guidelines established through DATCP, specifically those that apply to producer-led watershed protection grants – Wisconsin Statute 93.59 and Chapter ATCP 52. Permitted uses for grant funds include the following:

1) Development of work plan, mission development, goal setting, and learning days to have experts discuss related topics or development of incentive program.

2) Incentive payments for conservation practices such as soil testing and cover crop seed.
3) Field days, workshops and conferences including facility rentals, meals, and expenses directly related to hosting the event.
4) Personnel for coordinator role including expenses for salaries and wages, contract and consulting services, and mileage at allowable state rates. The maximum amount for any type of labor expense is $25 per hour.
5) Mailings, creation of marketing and outreach brochures, handouts, newsletters, or factsheets.
6) Materials and supplies directly associated with the project.
7) Incentive payments for equipment rentals of innovative technologies used or shared by all farmers within the producer led group, for example covering costs for renting a low-disturbance manure injector or no-till drill.
8) Rental costs for equipment directly associated with research projects, if pre-approved by project manager.
9) Cost-effective edge-of-field and water quality monitoring.
10) Farm assessments to identify and evaluate potential or existing resource concerns, nutrient management implementation and other water quality practices.
11) Other costs deemed by the department as consistent with the purpose of s. 93.59, Stats.

https://library.municode.com/wi/juneau_county/codes/code_of_ordinances
https://www.co.sauk.wi.us/general/county-ordinances
http://townoflavalle.us/towncodeofordinances.html
https://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/organizations/Lake%20Districts/Lake_Org_Guide2018.pdf
https://datcp.wi.gov/Pages/Programs_Services/ProducerLedProjects.aspx

8.2 Cost to Implement

Table 24 below and Appendix I attempt to estimate the cost to implement the actions in this plan. Table 24 provides a quick view of expenses, while Appendix I provides more detail about each item in Table 24.

Table 24: 10-year Implementation Cost Estimate

Plan Action	Total Cost Estimate - 10 years
Surface Water Monitoring	$263,784
Lake Monitoring	$14,040
Reduce Sediment and P loading – Watershed	$2,179,499
Reduce Sediment and P loading - Riparian	$534,000
Reduce Sediment and P loading - Lake Redstone	$81,000
Gathering Additional Data – Lake Redstone	$151,000
Gathering Additional Data - Riparian	$108,116
Gathering Additional Data - Lake Redstone	$11,500
Staff Costs	$790,000
Plan Implementation Tracking	$125,000
Education and Outreach	$207,500
TOTAL COST	**$4,465,439**

Cost estimates for WQ monitoring activities in Appendix I (described in sections 2, 3 and 9 of plan) were obtained from the LRPD, who previously provided the majority of funding for much of the existing WQ monitoring activities in the watershed. Other sources include the SLOH, USGS, WI-DNR, and County Land Conservation Departments/UW Discovery Farms (who has completed edge of field monitoring in the watershed.

Cost estimates for agricultural-based practices in Appendix I were obtained after consulting with Sauk and Juneau County Land Conservation Departments with additional information from the PLRW, who have been offering cost-share incentives to plant cover crops and implement other conservation practices in the watershed. Costs for interim milestones reflect plan content (modeling), information from existing 9-Key element plans, or professional judgment.

Cost estimates for shoreland improvements in the riparian area were based on the existing Sauk County Lakeshore Assistance Program and WI-DNR Healthy Lakes and Rivers Initiative (Section 8.2.7.2). These programs can be used to help implement BMPs for high priority shoreline parcels/properties identified in the plan. After implementation, cost estimates for redoing the SHA are based on the cost of past assessments.

Cost estimates for Education and Outreach efforts in the watershed were obtained from Land Conservation Departments, LRPD, and past educational efforts.

Cost estimates, or milestones for determining cost, to complete certain actions are missing from Appendix I. These are actions where either cost estimates are much harder to generate without additional data, or the action is included, but may not be implemented based on results of future data gathering. Individual lines in Appendix I marked with an asterisk indicates the cost estimate may change as new or additional cost information is determined during the 10-year plan implementation schedule. Individual lines marked with TBD (to be determined) indicate that the action is being considered, but actual implementation and the timing of that implementation will depend on future information.

8.2.1 Federal & State Funding Sources

Most of the federal funding is available for agricultural lands through the Natural Resource Conservation Service (NRCS) or the Farm Service Agency (FSA). State funding comes largely from the Surface Water grants program.

The Wisconsin Fund is a program that provides grants to homeowners and small commercial businesses to help offset a portion of the cost for the repair, rehabilitation, or replacement of existing failing Private Onsite Wastewater Treatment Systems (POWTS). Eligibility is based upon several criteria, including household income and age of the structure. In Wisconsin, 67 counties out of 72 counties, the City of Franklin, and the Oneida Tribe of Wisconsin participate in the program. County government officials assist interested individuals in determining eligibility and in preparation of grant applications.

8.2.2 EPA 319 Grant Programs for States and Territories

The 1987 amendments to the Clean Water Act (CWA) established the Section 319 Nonpoint Source Management Program. Section 319 addresses the need for greater federal leadership to help focus state and local nonpoint source efforts. Clean Water Act Section 319(h) funds are provided only to designated state and tribal agencies to implement their approved nonpoint source management programs. State and tribal nonpoint source programs include a variety of components, including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and regulatory programs. Each year, EPA awards Section 319(h) funds to states in accordance with a state-by-state allocation formula that EPA has developed in consultation with the states. Section 319(h) funding decisions are made by the states. States submit their proposed funding plans to EPA. If a state's funding plan is consistent with grant eligibility requirements and procedures, EPA then awards the funds to the state. In 2020, over $172 million dollars was awarded to the states for nonpoint source management.

8.2.3 Agriculture

The following are brief descriptions of current agricultural funding programs that may be applicable to the implementation of this plan, and their acronyms. In most cases these programs are supported by the WI-DNR or Natural Resource Conservation Service (NRCS). A majority of these programs would be administered by the Sauk and Juneau County Land Conservation Departments.

- **Targeted Runoff Management Grant Program (TRM) –** WI-DNR program offers competitive grants for local governments for controlling nonpoint source pollution. Grants reimburse costs for agriculture or urban runoff management practices in critical areas with surface or groundwater quality concerns. The cost-share rate for TRM projects is up to 70% of eligible costs.
- **Environmental Quality Incentives Program (EQIP) –** NRCS program provides financial and technical assistance to implement conservation practices that address resource concerns. Farmers receive flat rate payments for installing and implementing runoff management practices.
- **Conservation Partners Program (CPP) –** A collaborative effort between U.S. Department of Agriculture's Natural Resource's Conservation Service (NRCS) and the National Fish and Wildlife Foundation (NFWF) to provide grants on a competitive basis to increase technical assistance capacity to advance the implementation of NRCS/NFWF initiatives and Farm Bill conservation programs.
- **Conservation Reserve Program (CRP)** - A land conservation program administered by the Farm Service Agency. Farmers enrolled in the program receive a yearly rental payment for environmentally sensitive land that they agree to remove from production. Contracts are 10-15 years in length. Eligible practices include buffers for wildlife habitat, wetlands buffer, riparian buffer, wetland restoration, filter strips, grass waterways, shelter belts, living snow fences, contour grass strips, and shallow water areas for wildlife.
- **Conservation Reserve Enhancement Program (CREP) –** NRCS program provides funding for the installation, rental payments, and an installation incentive. A 15-year contract or perpetual contract conservation easement can be entered into. Eligible practices include filter strips, buffer strips, wetland restoration, tall grass prairie and oak savanna restoration, grassed waterway, and permanent native grasses.
- **Agricultural Conservation Easement Program (ACEP)** - New program that consolidates three former programs (Wetlands Reserve Program, Grassland Reserve Program, and Farm and Ranchlands Protection Program). Under this program, NRCS provides financial assistance to eligible partners for purchasing Agricultural Land Easements that protect the agriculture use and conservation values of eligible land.
- **Conservation Stewardship Program (CSP) –** NRCS program offers funding for participants that take additional steps to improve resource condition. Program provides two types of funding through 5-year contracts; annual payments for installing new practices and maintaining existing practices as well as supplemental payments for adopting a resource conserving crop rotation.
- **Farmable Wetlands Program (FWP) -** Program designed to restore previously farmed wetlands and wetland buffer to improve both vegetation and water flow. The Farm Service Agency runs the program through the Conservation Reserve Program with assistance from other government agencies and local conservation groups.

8.2.4 Preserving Land/Land Trusts

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

- Knowles-Nelson Stewardship Program

- Nature Conservancy

8.2.5 WI-DNR Surface Water Grants[8]

The surface water grant program provides 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.

- Education
- Planning
- Comprehensive Management Planning
- County Lake Grants
- Healthy Lakes and Rivers
- Surface Water Restoration
- Management Plan Implementation
- Clean Boats, Clean Waters
- AIS Supplemental Prevention
- AIS Early Detection and Response
- AIS Large- or small-scale Population Management
- AIS Research and Demonstration
- Land Acquisition
- Early Detection and Response Projects
- Established Population Control Projects
- Maintenance and Containment Projects
- Research and Demonstration Projects

8.2.6 Producer-Led Watershed Protection Grants

Funded through DATCP, these grants go to projects that address ways to prevent/reduce agricultural field runoff and to increase farmer participation in voluntary efforts to do so. This grant requires a minimum of at least 5 agricultural producers in the same watershed who, with a memorandum of understanding with at least one of a list of collaborators, want to assist agricultural producers in the watershed to conduct soil and water quality improvement efforts.

8.2.7 Sauk County Grants

8.2.7.1 Lake Management Grant Program

The Sauk County Land Resources and Environment (LRE) Department offers grants up to $50,000.00 to eligible applicants including lake districts, associations, or other organization that has been established for the protection of a lake that is located in Sauk County.

Funding can be used to offset costs associated with developing a lake management plan. Applicants are encouraged to integrate the US Environmental Protection Agency's 9 Key Element Plan into a Lake Management Plan, when appropriate. At a minimum, the lake management plan must be consistent with plan standards in ss. NR 191.45(20). Funding can be used to offset costs associated with updating an existing 9 Key Element plan or lake management plan previously approved by DNR. Funding can be used to offset costs associated with implementing lake protection and restoration projects identified in a DNR-approved

[8] For more information on WI-DNR Surface Water Grants go to: https://dnr.wisconsin.gov/aid/SurfaceWater.html

lake management plan that is less than 5 years old. Funding can be used to implement lake protection and restoration projects that reduce soil erosion, urban or agricultural runoff, or improve wildlife habitat within a lake or contributing watershed.

8.2.7.2 Lakeshore Assistance Program

The Sauk County LRE Department provides cost share assistance to lake shore owners to address erosion and runoff concerns on their property. Cost share funding is limited to 50% of the project cost up to $2,500 per applicant.

Eligible projects will be practices that reduce sediment loads that cause degradation of habitat and water quality of lakes in Sauk County. These projects may include but are not limited to: vegetated buffers, bioengineering with natural fiber products (e.g. natural fiber rolls and logs, blocks, and mats), wave-reducing natural timbers (e.g. log and root wad revetment, fish sticks and tree drops), and rock riprap with bioengineering techniques (e.g. Rock riprap with native plantings, geotextile bags, geogrid lifts, and synthetic engineered matting).

WI-DNR Healthy Lakes and Rivers grants also provide cost-share assistance to lake shore owners to address runoff and habitat improvement concerns on their property. Cost share funding is limited to 75% of the project costs up to $1,000 per project implemented. Eligible projects include native plantings, rain gardens, runoff diversions, infiltration trenches, and fishsticks fisheries habitat. Grants are sponsored by the lake organization on behalf of properties owners.

8.3 Technical Assistance

Technical expertise needed to successfully implement this plan includes the WI-DNR, Juneau and Sauk Counties, the USGS and NRCS, Producers of Lake Redstone, and consultants that specialize in relevant areas including aquatic plant management, water quality, shoreland planning and improvement. These entities have been discussed in previous sections.

It is expected that between Juneau and Sauk Counties, at least one full-time staff position will be needed to support implementation of this Plan. In addition, it is likely that the LRPD will have to hire outside private contractors to support plan implementation. In addition, there are several University of Wisconsin System Programs that could support actions recommended in this plan.

8.3.1 Center for Land Use Education

The Center for Land Use Education (CLUE) is a joint venture of the College of Natural Resources at the UW-Stevens Point and the UW-Madison Division of Extension. It is a focal point for land-use planning and management education. Through applied research, teaching and outreach, CLUE specialists and faculty support students, local government officials, communities and K-12 audiences on a variety of land and water topics including planning and zoning, land divisions, fragmentation, sustainability, bio- and renewable energy, food systems, shorelands and wetlands. By providing up-to-date and comprehensive training on planning and zoning tailored to address specific local needs, CLUE specialists are able to assist towns, villages, cities and counties in making sound land use decisions.

https://erc.cals.wisc.edu/programs/center-for-land-use-education/

8.3.2 Center for Watershed Science and Education

The Center for Watershed Science and Education (CWSE) at UW-Stevens Point supports watershed understanding and stewardship across and beyond the state of Wisconsin. The center includes specialists with expertise in groundwater, lakes, streams, water chemistry and analysis, and data science. The center helps individuals, organizations and private and public water resources professionals understand water quality and quantity in private wells, groundwater, lakes and rivers. Through their programming, center staff provides guidance on sampling and data collection, education on water quantity and quality, and interpretation and evaluation of monitoring results. The center also performs applied research and creates data visualization tools to improve watershed understanding.

Current research explores the movement of nitrate-nitrogen in soil and groundwater, the quantity and chemistry of groundwater, changes in lake water quality and the occurrence of pharmaceuticals and new pesticides in the water.

https://erc.cals.wisc.edu/programs/center-for-watershed-science-and-education/

8.3.3 Center for Limnological Research and Rehabilitation

The Center for Limnological Research and Rehabilitation (CLRR) at UW-STOUT focuses on eutrophication issues and management solutions for freshwater systems. They provide limnological research services to the surrounding community, including: diagnosing eutrophication-related problems in lakes and reservoirs; conducting comprehensive hydrologic and limnological monitoring programs; identifying and quantifying important phosphorus sources that drive cyanobacterial blooms; and developing and implementing management plans to sustainably rehabilitate degraded aquatic systems.

Their laboratory facilities provide an array of analytical capabilities for the examination of nutrients (primarily phosphorus species) and algae in water and sediment. They have a variety of field monitoring equipment for quantifying tributary flow and phosphorus loads discharging into lakes, boats and sampling equipment for monitoring lake chemistry and biology, and coring capabilities for the examination of aquatic sediment. In particular, they have unique expertise for determining important mobile phosphorus fractions in aquatic sediments and nutrient exchanges between sediments and the overlying water.

https://www.uwstout.edu/directory/center-limnological-research-and-rehabilitation

8.3.4 Natural Resources Education Program

NRE Water Programming - Leading and facilitating water quality projects across the state
Natural Resource Educators (NRE) are providing leadership on nutrient reduction and water quality projects across the state. Key efforts include outreach to increase local capacity to reduce nonpoint source pollution in the Lower Fox, Wisconsin, St. Croix, Red Cedar and Rock River watersheds and the Lower Fox River Demo Farm Network initiative. Projects are carried out in collaboration with federal, state and local partners as well as producer-led watershed initiatives. The Demo Farm initiative works with farmers and their advisers to conduct on-farm demonstrations that measure and share the effectiveness of conservation practices to reduce erosion and sediment runoff, control phosphorus runoff and address other nonpoint sources of pollution.

NRE Forestry Programming - Engaging private woodland owners to encourage sustainable forest management.
ERC-based Natural Resources Educators and key partners are leading classes (Learn About Your Land and Your Land, Your Legacy) and other efforts to engage landowners in the sustainable management of Wisconsin's privately-owned forests. NREs create content for landowners on a variety of topics in publication, video, and website formats.

https://erc.cals.wisc.edu/programs/regional-natural-resources-education-program/

8.3.5 Aquatic Invasive Species Outreach

Wisconsin's aquatic invasive species (AIS) program focuses on preventing the introduction of new invasive species to Wisconsin, containing the spread of invasives that are already in the state, and managing established populations when possible. In close cooperation with the Wisconsin Department of Natural

Resources and Extension Lakes program, UW– Madison Division of Extension education efforts focus on working with resource professionals and citizens statewide to teach boaters, anglers and other water users the steps they should take to prevent transporting aquatic invasives to new waters. Efforts also address other potential mechanisms of introduction, including aquarium pet release and water gardening.

https://erc.cals.wisc.edu/programs/aquatic-invasive-species-outreach/

8.3.6 UW-Extension Lakes Program

Based at UW-Stevens Point, the Extension Lakes Program seeks to preserve Wisconsin's legacy of lakes through education, communication and collaboration. The program works with over 800 local lake associations and lake districts in Wisconsin, assisting them through education and capacity building. Lakes also partners with the Wisconsin DNR to coordinate a number of programs and projects to assist those concerned with the future of our lakes, including the Citizen Lake Monitoring Network, the Clean Boats, Clean Waters program and the Lake Leaders Institute. The *Lake Tides* newsletter reaches thousands of readers throughout the region.

https://erc.cals.wisc.edu/programs/extension-lakes-program/

8.3.7 Ecological Restoration

There are many "Resource Professionals" that specialize in the restoration of native prairie, streambank, forest, wetland, and other natural areas in Wisconsin. The WI-DNR maintains of list of companies that do these types of work across the state.[9]

More on the project guiding authorities, individual cost estimates for actions in this plan, and the amount of technical assistance needed can be found in Appendix I.

[9] For more information about Resource Professionals specializing in various types of ecological restoration go to https://dnr.wi.gov/files/pdf/pubs/er/er0698.pdf. This list, put out by the WI-DNR, was last updated in January 2021.

9.0 Monitoring (Key Element 9)

Watershed restorations and adoption of agricultural best management practices for conservation purposes has become commonplace in recent decades (WI-DNR, 2020), and is the main avenue for attempting to make positive changes in Lake Redstone. However, for many projects like this, success in determining whether or not the practices actually have the desired effect has been mixed, partially due to inadequate monitoring and lack of appropriate experimental designs to evaluate the restorations. A typical watershed restoration project will include implementation of practices at multiple locations to reduce excess soil and nutrient runoff to a local or downstream waterbody, as in Lake Redstone. It is however, often difficult to document water quality improvements through standard monitoring procedures in only a 1-2 years within a HUC 12 size watershed. Monitoring three or more years in specific areas of the watershed where BMPs are adopted may be necessary to measure changes in stream water quality with confidence. Special thought should be given to a monitoring program to make sure it will help answer questions and to temper expectations of what monitoring can demonstrate.

The following defines the level of monitoring included in this plan. Monitoring recommendations are made for each area of concern – the watershed, the riparian area, and the lake itself. In addition a Monitoring Matrix is included as Appendix H.

9.1 Watershed and Riparian Area

For monitoring purposes, the watershed and riparian area are being combined as many monitoring recommendations made in this plan pertain to both.

9.1.1 Monitoring Land Use Changes

As human and natural forces modify the landscape, resource agencies find it increasingly important to monitor and assess these alterations. For the Lake Redstone project, changes in land use and land cover (LULC) in the watershed are most interesting as they have a direct impact on the water quality in local streams and the lake. This management plan focuses primarily on changing land uses through the implementation of BMPs designed to reduce surface water runoff. LULC changes are very dynamic in nature and have to be monitored at regular intervals for sustainable environment development.

There are several common methods for monitoring changes in LULC. On a nation-wide scale, the National Land Cover Database (NLCD) from the USGS is used to identify basic categories of land cover from agriculture to forests to urban. Initial land cover designations for the Lake Redstone watershed were derived from the 2016 NLCD. This database is satellite-based and updated every five years. Another tool that is updated annually is the USDA cropland data layer (https://nassgeodata.gmu.edu/CropScape/). This may be used to monitor changes in land use in the Lake Redstone watershed. The NLCD does not identify more specific LULC like no-till planting and residual cover, pasture verses forage crops, etc. in smaller, more local areas like the different sub-basins included in the Lake Redstone watershed.

Recently, remote sensing satellite imagery has been used as a tool for identifying changes in LULC. Small changes in the spectral response in these images related to tone, texture, shape, size, and pattern can be interpreted and associated with different land uses, and even down to the amount of crop residue that is present on a particular field (USGS).

Both Juneau and Sauk Counties have completed "boots-on-the-ground" surveys of points in the watershed with the intent to gather information on tillage and crop residue management systems. Referred to as "cropland roadside transect surveys", the purpose of these surveys is three-fold: (1) to provide information that can be used in establishing priorities for educational or other programs, (2) to evaluate progress achieved in reaching local, county, or statewide goals, and (3) to provide accurate data on the adoption of conservation tillage systems by crop for other national databases (Purdue Univesity, 2002).

While these surveys provide a high degree of confidence in the accuracy of the results, they are labor intensive and time consuming, often involving multiple staff and days to complete, so often are not implemented on an annual basis. Case in point, Juneau County has not completed a boots-on-the-ground transect survey in the last five years. Sauk County still completes an annual survey, but has limited points in the watershed of Lake Redstone (Figure 41). With this project, a survey route and points will be established within the entire watershed of Lake Redstone. County personnel will train LRPD volunteers how to complete the survey, which will then be done at least annually during the timeframe of this project. Alternatively, it may be possible to have the Producers of the Lake Redstone Watershed take the lead on completing these transects annually. This data, when combined with other land use data, can be used to track the BMPs put in place each year, to compare changes in implementation of BMPs, track overall changes in LULC, and be used as an indicator of the success of this management plan.

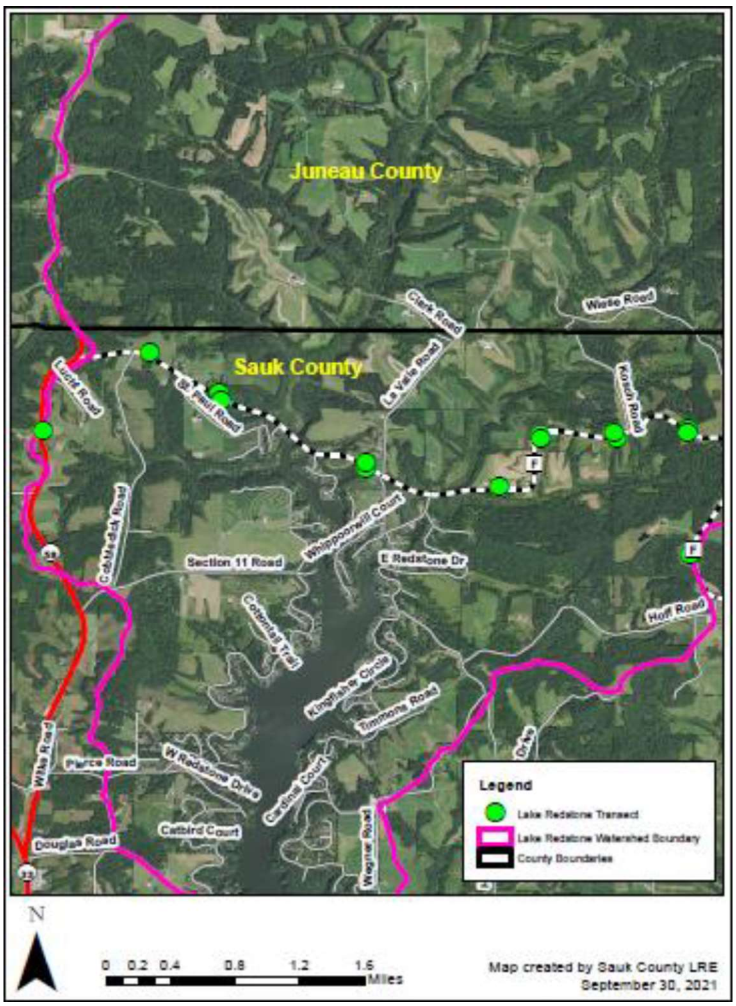

Figure 41: Lake Redstone Transect Survey Points – Sauk County

9.1.2 Monitoring Water Quality

The water quality parameters of most concern in the watershed and riparian area are sediment and total phosphorus. Of slightly less concern are nitrogen parameters including ammonia (NH_3), nitrates (NO_3^-), and nitrites (NO_2^-) and total kjeldahl nitrogen (TKN). The most commonly measured parameter for sediment is total suspended solids (TSS). TSS are particles larger than 2 microns found in the water, anything smaller than 2 microns (average filter size) is considered a dissolved solid (Figure 42). Most suspended solids are made up of inorganic materials, though bacteria and algae can also contribute to the total solids concentration. These solids include anything drifting or floating in the water, from sediment, silt, and sand to plankton and algae. Most of these parameters are measured in water samples analyzed by a lab.

Another measurement of sediment is settle-able solids or how much settles out of runoff once it enters a place where continuous flow no longer keeps it moving or suspended. Settle-able solids can be measured by collecting samples of runoff from gullies, ravines, streams, and washes entering a lake or other waterbody and then using Imhoff cones in a lab or home setting to quantify the amount (Figure 42). Measurements are un-complicated, only requiring a reading of how much material settles out after a set amount of time. The data collected might be indicative of the worst areas of runoff to focus on and help to determine a sediment budget for the lake.

Both total suspended solids and settle-able solids can impact a lake, so both measurements are recommended at least when monitoring the smaller, individual intermittent inlets to the lake.

In each of the following areas, one or more of the parameters just discussed will be monitored. Greater detail is also provided for when and where monitoring should take place.

Figure 42: Settled versus suspended solids in a lake (Fondriest Environmental, Inc, 2014); Imhoff cones for measuring settle-able solids (Wards Science, 2021)

9.1.2.1 Tributary Monitoring

The following plan for monitoring is based on guidelines in the WI-DNR document *Guidelines for Monitoring for Watershed Restoration Effectiveness* (WI-DNR, 2020). Because this project is expected to show restoration results over a long period of time, an observational, continuous monitoring plan will be incorporated in an attempt to detect subtle changes over time. In this kind of study, a smaller number of stream sites are monitored before, during, and after a period when BMPs are implemented. How many BMPs will be implemented, what BMPs will be implemented, and where they are implemented is likely unknown before the monitoring begins (WI-DNR, 2020).

The two main inlets to Lake Redstone, the east branch of Big Creek at LaValle Road and the west branch of Big Creek at Clark Road, were sampled in 2006-07, 2011, and 2018-2020. These locations are the last road crossings over the creeks before they entered Lake Redstone. The sampling sites correspond to the Clark Road and LaValle Road sub-basins. Due to issues with earlier attempts to sample discharge, automated sampling systems were set up in 2020 with support from the USGS, Juneau and Sauk Counties, and LRPD volunteers. These systems are designed to collect discharge data regardless of the size of a storm event, and to collect water samples that can be analyzed for TSS, TP, and other parameters. Automated sampling at these two sites is expected to continue for at least 2-3 more years, longer if funding can be obtained to keep the stations operating. These two sites will provide continuous monitoring for much of this project implementation. Companion outlet monitoring is also being completed and will continue until funding runs out.

Stream monitoring at the outlets of three sub-basins that drain into the west branch of Big Creek (Daugs Road, Lucht Road, and Pfaff Road sub-basins) was completed in 2018 and 2019 by a combination of LRPD volunteers and County staff. Multiple parameters were collected (see Section 2.3.2). Discharge was also collected but difficulties in sampling and short-comings in the equipment used may necessitate changes in how this data is collected in the future. These three sites will be sampled again for three years starting in 2023, then again for three years starting in 2028 collecting similar parameters. At least one additional site, Nemitz Road on the East Branch of Big Creek about midway from the outlet to its headwaters (sampled in 2011), could be added if it is determined that it would be relevant to BMPs implemented through this project.

Tributary sampling would follow WI-DNR WisCALM guidelines where samples are collected once a month from May to October. Parameters to be analyzed include but are not limited to TSS and TP.

9.1.2.2 Gullies, Ravines, and Washes

Once a new SPI study (Section 3.3.2.3) has been completed it is expected that a number of gullies/ravines/washes will be identified across the watershed, including in the Lower Lake Redstone sub-basin which also represents what is considered the riparian area of concern. While addressing ways to reduce runoff from these areas in the larger watershed is important, it is likely more important to address those that empty directly into Lake Redstone.

An unnamed tributary feeding into Martin-Meadowlark Bay was sampled in 2020 and a similar site upstream of Swallow Bay was sampled in 2006, 2007, and 2020. Data from these sampling events represent early attempts to monitor nutrient and sediment loading directly into Lake Redstone from gullies and washes. There are several other sites with intermittent gully flow into the lake including Chickadee North and South, Eagle, Heron, and Fox Court bays. Collecting water samples for analysis of sediment (suspended and settle-able) and phosphorus concentration, along with some attempt to quantify flow and discharge will help identify the severity of the problem in identified areas. Once that is done, and potential BMPs are identified and implemented, additional monitoring will be done at these sites to see if changes occur. That monitoring will involve similar parameters and procedures used in watershed tributary monitoring.

9.1.3 Streambank Erosion

In both the watershed and riparian area, once areas with potential erosion issues have been identified (based on the SPI and boots-on-the-ground surveys), the amount of physical erosion (lateral recession rate) can be tracked by using erosion pins. Erosion pins are metal rods that are inserted into the bank perpendicular to the flat surface of the streambed and either flush with the soil surface or with a measured section of the pin sticking out when installed. Figure 43 shows a follow up inspection that indicates 8” of soil has eroded from the bank since installing it flush. An initial survey of the streambank of selected sites should also be conducted to serve as benchmark. A minimum of 3 sites should be surveyed in each sub-watershed. Pins should be measured at least 3 times a year and after significant storm events to determine trends in erosion. There are several references for the proper installation and data interpretation when using erosion pins (Kearny, Fonte, Garcia, & Smukler, 2018) (Rathbun, 2009). Appropriate installation practices will be followed.

Long-term tracking of streambank erosion rates will help refine phosphorus and sediment loss estimates from streambank erosion and help to determine if source control practices implemented in the headwaters of the watershed are having an impact on streambank erosion rates downstream. Drone and aerial imagery may also be used as a tool to assess bank erosion rates over this plan’s 10-yr implementation period. A sustained decrease in observed lateral recession rate over a specified time period will demonstrate plan progress. If lateral recession rates are observed to be increasing or remaining the same after several years of implementation, it may indicate that the BMPs implemented in the watershed may need to be reevaluated for effectiveness. However, annual weather conditions will need to be taken into account as extreme storm events will likely impact the observations.

Figure 43: Erosion pin inserted into a streambank showing 8" of soil eroded after inspection in Kankapot Creek, Calumet County, Wisconsin.

9.2 Lake Redstone

There are currently two state-sponsored surface water monitoring programs going on in Lake Redstone. The first is through the Citizen Lake Monitoring Network (CLMN) sponsored by the WI-DNR and UW-Extension Lakes. As a part of this program, volunteers collect water quality data including Secchi disk readings of water clarity, total phosphorus, chlorophyll-*a*, and temperature and dissolved oxygen profiles. Regular Level volunteers collect Secchi data 2-3 times a month during the open water season and comment on other parameters including water color, lake level, ice-on and ice-out dates, and general perception of the lake for usability. Expanded Level volunteers add to this, collection of water samples to analyze total phosphorus and chlorophyll-*a*, collect temperature profiles, and in some cases collect dissolved oxygen profiles at least four times during the open water season.[10] Data presented in Section 3.3.1 is from Lake Redstone CLMN expanded monitoring at four different sites in the lake – Deep Hole, and the Lower, Middle and Upper Sites (Figure 44) since about the year 2000.

In addition, the Deep Hole site is part of the WI-DNR Long-Term Trend (LTT) lake monitoring program. In this program, water quality monitoring is conducted by the state every year on 62 lakes statewide to monitor trends over time. Water quality parameters collected on LTT lakes include total phosphorus and Secchi depth during spring overturn and collection of additional parameters 3 times during a summer index period (15 July - 15 September). These parameters include components of the Trophic Status Index or TSI (total phosphorus, Secchi disk, and chlorophyll-*a*), and field profiles for dissolved oxygen, temperature, and conductance. This should be done once every 2 to 3 weeks. Other water quality parameters collected once

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[10] For more information about the Citizen Lake Monitoring Network go to: https://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/programs/clmn/default.aspx or https://dnr.wisconsin.gov/topic/lakes/clmn

each summer include pH, conductivity, alkalinity, color, nitrate/nitrite, and total Kjeldahl-N. Calcium and magnesium are sampled once every 5 years.

Additional water quality data, beyond what is collected through the CLMN and LTT programs has been collected and paid for by the LRPD, mainly in an attempt to have as complete a water quality dataset as possible. That said analysis of available data completed by the WI-DNR (Oldenburg, 2021) determined that there were not significant differences in the data from each of the four sites as compared to all of the sites. It did show that data from two of the sites were different. As such, future in-lake monitoring is recommended at only two of the four sites. With only half the sites, it is possible for the LRPD to collect more data from the two sites at the same or less cost than it was to sample all four sites. Future monitoring will be completed at the Deep Hole and Middle sites, and should be sufficient to capture longitudinal changes in TP that occur in the reservoir due to management implementation.

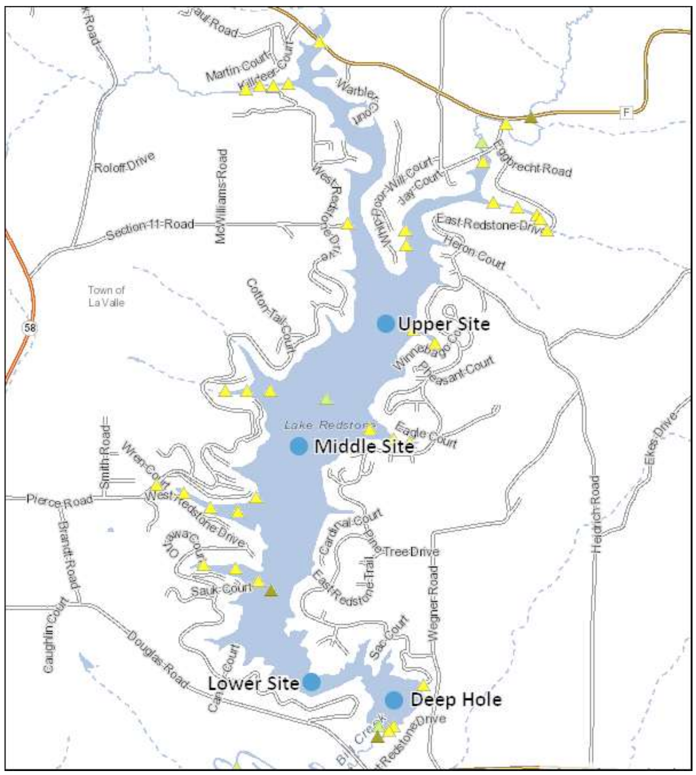

Figure 44: Citizen Lake Monitoring Network water quality monitoring sites

9.2.1 Surface Water Monitoring

The water quality parameters of most concern in Lake Redstone are sediment (both suspended and settle-able), TP, dissolved phosphorus, Chl-a, water clarity, temperature and dissolved oxygen. Of slightly less concern are nitrogen parameters including ammonia (NH_3), nitrates (NO_3^-), and nitrites (NO_2^-) and total kjeldahl nitrogen (TKN). Additional parameters of value are conductivity and pH.

TP, Chl-*a*, and water clarity as measured by the Secchi disk remain the most important parameters to monitor in Lake Redstone as they are the basis for all long-term trend analysis to date, and will be used to determine success or failure in the implementation of this plan.

More frequent collection/documentation of temperature and dissolved oxygen profiles in Lake Redstone will be important to understanding current and changing conditions in the lake. More frequent profiling will help determine when and for how long the lake stratifies with waters in the hypolimnion (bottom waters) becoming anoxic (devoid of oxygen). More frequent sampling for TP in the hypolimnion over several years will also help estimate the contribution of internal loading to the enrichment of the lake.

Specific conductance or conductivity is a commonly measured water quality parameter. In addition to being the basis of most salinity and total dissolved solids calculations, conductivity is an early indicator of change in a water system. Most bodies of water maintain a fairly constant conductivity that can be used as a baseline for comparison to future measurements. Significant change, whether it is due to natural flooding, evaporation, or man-made pollution can be very detrimental to water quality (Fondriest Environmental, Inc, 2014).

A measurement of how acidic or basic water is, is called pH. It ranges from 0 (acidic) to 14 (basic), with 7 being neutral. The pH of water determines the solubility (amount that can be dissolved in the water) and biological availability (amount that can be utilized by aquatic life) of chemical constituents such as nutrients (phosphorus, nitrogen, and carbon) and heavy metals (lead, copper, cadmium, etc.). It directly impacts how much and what form of phosphorus is most abundant in the water and determines whether or not aquatic life can use it.

Both conductivity and pH can be measured by field equipment or in water samples analyzed by a lab.

9.2.2 Recommended Lake Monitoring

Participation in the two existing surface water monitoring programs already active (CLMN and LTT) is highly recommended, however, it is likely only necessary at the Deep Hole and Middle sites in the lake. Secchi disk readings of water clarity should be collected at least two to three times per month but no more than once a week during the open water season from ice out to ice in, with particular focus put on the summer months between July and September. As a guide, Secchi disk readings could be taken approximately every 10 days following remote sensing satellite dates each year. TP sampling is completed approximately 2 weeks after ice out and then once a month June-August. Chlorophyll-*a* samples are collected once a month June – August.

Additional water sampling described below should be added in accordance with WisCALM guidelines. WisCALM guidelines for TP sampling frequency and seasonal range for stratified lakes include: one sample per month between May and mid-September with samples collected near the middle of the month and at least 15 days apart; with only surface samples taken from the top 2 meters of the lake. For chlorophyll-*a*, water samples should be collected once each in the months of July, August, and September with only surface samples taken from the top 2 meters of the lake. For Lake Redstone, this means adding both TP and chlorophyll-*a* sampling to the month of September, in addition to what is done via the CLMN program.

Long-Term Trend monitoring by the WI-DNR should continue at the Deep Hole site.

Because there is interest in learning more about how much internal loading contributes to the phosphorus load in Lake Redstone, it is recommended that water column sampling for TP (and perhaps orthophosphates) be completed up to two times per month from July through September or October for a period of at least 2 years, and maybe 3 at both the Deep Hole and Middle sites. Collecting temperature and dissolved oxygen profiles more frequently (at least once a week) during the same time period would better help quantify when the hypolimnion of the lake presents anoxic conditions and for how long. Coupled with a sediment release study at the same two sites, the role of internal loading could be much more clearly defined.

9.2.3 Aquatic Plant and Aquatic Invasive Species (AIS) Monitoring

Although aquatic plant and AIS monitoring will be covered in an update of the existing Aquatic Plant Management Plan for Lake Redstone, a brief description of both is included here. Under an active plant management scenario, documentation of changes in the aquatic plant community is usually accomplished through whole-lake, point-intercept (PI), aquatic plant survey work to be completed every five years. In between, aquatic plant monitoring will likely include pre- and post-treatment PI survey work possibly on an annual basis, and some level of late season AIS reconnaissance or bed-mapping survey work. AIS monitoring will also be completed during the entire open water season following CLMN AIS Monitoring Guidelines.[11]

For more information on the monitoring components of this plan and the estimated costs associated, refer to Appendix I.

[11] For more information about the CLMN AIS Monitoring Program go to: https://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/programs/clmn/AIS.aspx

10.0 Tracking, Assessment, and Depreciation (Key Element 8)

Tracking and assessment is a critical component to meeting interim and long term goals of this plan. Plan progress and success will be assessed by tracking the implementation of conservation practices, information and education activities, and water quality monitoring. Beyond implementation, ensuring that the expected value of implementation is reached and/or maintained will be accomplished by following recommendations made by the EPA to identify causes of and then minimize depreciation of the BMPs implemented.

For more information on these actions and the estimated costs associated, refer to Appendix I.

10.1 Tracking Conservation Best Management Practices

Annual updates related to the implementation of conservation practices and their corresponding pollutant load reductions in the three areas of concern will be completed and may include but are not limited to the following:

- Number or extent of conservation practices implemented
- Modeled or measured pollutant load reductions from completed BMPs
    - STEPL, In-lake Modeling (WiLMS, Bathtub), Producer Led Reports, Sediment modeling (as developed), etc.
- Number of NR 151 implementation compliance checks and plan reviews performed.
- Costs associated with implementation of conservation practices.
    - Cost share funding under contract and spent;
    - Expenditures by landowners and/or partners;
    - Staff time (salary + fringe) and expenses allocated to project within the watershed;
    - Estimate of future expense needs.

10.1.1 BMP Depreciation

The causes and sources of water resource impairment have been assessed in this watershed plan. Existing and new BMPs to address the identified problems, the best locations for these BMPs, and the pollutant load reductions likely to be achieved by implementing these BMPs have been determined. Whether or not these BMPs will actually do what they are supposed to for the expected amount of time depends on accurate information on their performance levels.

All too often, watershed managers and agency staff have assumed that, once certified as installed or adopted according to specifications, a BMP continues to perform its pollutant reduction function at the same efficiency (percent pollutant reduction) throughout its design or contract life, sometimes longer. An important corollary to this assumption is that BMPs already in place during project planning are performing as originally intended. Experience in NPS watershed projects across the nation, however, shows that, without diligent operation and maintenance, BMPs and their effects probably will depreciate over time, resulting in less efficient pollution reduction – BMP Depreciation. Recognition of this fact is important at the project planning phase, for both existing and planned BMPs.

BMPs credited during the planning and implementation phases of a watershed project will be expected to achieve specific load reductions or other water quality benefits as part of the overall plan to protect or restore a water body. Verification that BMPs are still performing their functions at anticipated levels is essential to keeping a project on track through implementation to achieve its overall goals.

Once verified, through adaptive management, verification results can be used to inform decisions about needs for additional BMPs or maintenance or repair of existing BMPs. In a watershed project that includes short-term (3–5 years) monitoring, subtle changes in BMP performance level might not be detectable or critical, but planning must account for catastrophic failures, BMP removal or discontinuation, and major maintenance shortcomings. Over the longer term, however, gradual changes in BMP performance level can be significant in terms of BMP-specific pollutant control or the role of single BMPs within a BMP system or train.

The methods outlined in the US EPA technical memo (Meals & Dressing, 2015), "Adjusting for Depreciation of Land Treatment When Planning Watershed Projects" will be used when evaluating BMP effectiveness and identifying factors that may affect BMP performance levels and implementation.[12]

10.2 Tracking Information and Education Efforts

Annual updates related to efforts made related to education and outreach may include but are not limited to the following:

- Number of one-on-one contacts made with operators, landowners, and riparian property owners in the watershed.
- Number of information pieces create and updated annually.
- Number of communication pieces distributed, including handouts, mailing, emails sent, and social media metrics.
- Number of educational events held or advertised, including number of attendees.
- Assessment of current education program and future educational needs.

10.3 Future Conservation Practices and Technologies

As part of the annual update process, progress towards finding and implementing new or changing solutions to issues across the three areas of concern will be reported as follows:

- Proposed and ongoing research projects and grant opportunities.
- Final reports of data gathering efforts in each of the areas of concern.
- Review of innovative practices and improvements in pollutant load reductions advancing in other watersheds.
- Updating the Lake Redstone 9-Key Plan to incorporate emerging practices into the implementation strategy and model pollutant load reductions.

10.4 Water Quality Improvements in Lake Redstone

The purpose of this entire document is to make improvements in water quality in Lake Redstone. Several monitoring components are built into this plan to track changes or the lack of changes in water quality. Assessments of this data will occur annually and be presented in summary reports shared with all involved stakeholders.

Consultation with the WI-DNR Biologists will be critical when evaluating water quality monitoring results. Water quality changes may not occur immediately following implementation of BMPs. Several factors may contribute to shortfalls in meeting water quality goals, and should be evaluated along with water quality monitoring to determine reasons for shortfalls. Remodeling is already included in this plan in order to incorporate additional factors and new information. Some factors that perhaps are not entirely within the control of anyone involved in the implementation of this plan include but are not limited to:

- Changes in operator and/or management resulting in a reversal of phosphorus loading reductions that were gained.

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[12] For more information go to:
https://www.epa.gov/sites/default/files/2015-10/documents/tech_memo_1_oct15.pdf

- Changes in growing season, soil conditions and water quality resulting from changes in climate, weather patterns, and precipitation events.
- Frequency and timing of monitoring.
- Legacy phosphorus in sediment (i.e. cropland, shoreland buffers, wetlands and benthic).
- Modeling estimates that exceed realistic reductions.

In general, measuring the success of actions implemented in this plan will require:

- Patience and a long-term outlook (make incremental progress over time).
- Focusing existing resources where it is determined they are needed most.
- Increased adoption/compliance with existing standards and programs.
- Coordination between agricultural producers, riparian owners, lake users, and county, state and local stakeholders for a long period of time.
- Setting interim reduction goals with realistic times frames.
- Keeping up with the changes that occur to accurately represent their impacts.

10.5 Grants and Other Funding Sources

Throughout the implementation of this 10-yr Plan various state grant and other funds will be utilized. One important measure of the success of this project will be how well the LRPD and its partners meet the requirements for these funding sources, complete funded projects, and receive reimbursements. The progress reports, study reports, and other documents generated during the implementation of this plan will also support funding mechanisms.

WORKS CITED

(n.d.).

Allen, M., Brandenburg, B., Cruse, J., Gonzalez, V., & Turk, K. (2019). *Environmental Impacts of Wake Boats on Deep Creek Lake wiht Consideration of Recreational and Social Benefits.* University of Maryland University College.

Apslund, T. R. (2000). *The Effects of Motorized Watercraft on Aquatic Ecosystems.* Madison: Wisconsin Department of Natural Resources.

(2020). *Ashwaubenon and Dutchman Creeks Nonpoint Source Watershed Implementation Plan.* Appleton: Outagamie County Land Conservation Department.

Associated Press. (2016, June 13). *The Daily Reporter.* Retrieved March 20, 2021, from https://dailyreporter.com/2016/06/13/man-made-lake-redstone-an-engineering-marvel/#APRights

Ayres Associates. (2016). *Lake Redstone Sediment Sampling.* Eau Claire: Ayres Associates.

Bedford County Conservation District. (2021, April 11). Retrieved April 11, 2021, from Stream Order and the River Continuum Concept: https://www.bedfordcountyconservation.com/Watersheds/watersheds_page2_stream%20order.htm

Benard, J., Binger, R., Dabney, S., Langendoen, E., Lemunyon, J., Merkel, W., et al. (2010). *Ephemeral Gully Erosion - A Natural Resource Concern.* Oxford: Laboratory Publication Report No. 69.

Beranek, A. (2021, March 19). Personal Communication.

Berg, M. S. (2012). *July Warm Water Point Intercept Aquatic Macrophyte Survey Lake Redstone (WBIC: 1280400) Sauk County, Wisconsin.* St. Croix Falls: Endangered Resource Services, LLC.

Beringer, L. (2021, April 14). Personal communication. WI DNR.

Blumer, D. (2017). *Strategic Lake Management Planning Review - Lake Redstone.* Cameron: Lake Education and Plannning Services.

Blumer, D. (2017). *Strategic Lake Management Planning Review - Lake Redstone Sauk County, WI.* Chetek: Lake Education and Planning Services, LLC.

Bryson, J. M. (1995). *Strategic Planning for Public and Nonprofit Organizations.* San Francisco: Jossey-Bass Publishers.

Bunce, J., Ndam, E., Ofiteru, I., Moore, A., & and Graham, D. (2018, February 22). A Review of Phosphorus Removal Technologies and Their Applicability to Small-scale Domestic Wastewater Treatment Systems. *Frontiers in Environmental Science*, pp. 1-15.

Carlson, R. (1977). A trophic state index for lakes. *Limnology and Oceanography*, 361-369.

Carlson, R. E., & Havens, K. E. (2005). Simple Graphical Methods for the Interpretation of Relationships Between Trophic State Variable. *Lake and Reservoir Management 21:1*, 107-118.

DATCP. (2021). Retrieved August 9, 2021, from https://datcp.wi.gov/Documents/PLWPGBrochure2021.pdf

Earthfort. (2021). Retrieved July 27, 2021, from Transforming Agriculture with a Life Focused Approach: https://earthfort.com/

EPA. (2008). *Handbook for Developing Watershed Plans to Restore and Protect Our Waters.* Washington, DC: Office of Water Nonpoint Source Control Branch.

EPA. (2013). *A Quick Guide to Developing Watershed Plans to Restore and Protect Our Waters.* Washington DC: Office of Wetlands, Oceans, and Watersheds - Nonpoint Source Control Branch.

EPA. (2013, June 4). Total Nitrogen.

EPA. (2019, September 12). *EPA.* Retrieved May 22, 2021, from Nitrogen and Phosporus in Streams in Agricultural Watersheds: https://cfpub.epa.gov/roe/indicator.cfm?i=31

EPA. (2021, February 11). *United States Environmental Protection Agency.* Retrieved April 13, 2021, from Polluted Runoff: Nonpoint Source (NPS) Pollution: https://www.epa.gov/nps/spreadsheet-tool-estimating-pollutant-loads-stepl

Erickson, J. (2006). *Lake Redstone Protection District Lake Planning Process.* Baraboo, WI: Sauk County UW-Extension.

Fondriest Environmental. (n.d.). *Temperature Profiling in Lakes*. Retrieved July 25, 2021, from Fondriest Environmental Inc.: https://www.fondriest.com/pdf/fondriest_temperature_guide.pdf

Fondriest Environmental, Inc. (2014 , June 13). *Turbidity, Total Suspended Solids and Water Clarity*. Retrieved July 19, 2021, from Fundamentals of Environmental Measurements: https://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/

Fondriest Environmental, Inc. (2014, March 3). *Conductivity, Salinity and Total Dissolved Solids"*. Retrieved July 19, 2021, from Fundamentals of Environmental Measurements: https://www.fondriest.com/environmental-measurements/parameters/water-quality/conductivity-salinity-tds/>

Hickman, N. (1980). Phosphorus, Chlorophyll, and Eutrophic Lakes. *Hydrobiology*, 137-145.

Highland Engineering, Inc. (2009, May 21). Water Quality BMPs for the Aggregate Minong Industry. Atlanta, Georgia, USA. Retrieved from https://epd.georgia.gov/sites/epd.georgia.gov/files/related_files/site_page/Aggregate%20Mining%20Industry%20Water%20Quality%20Best%20Management%20Practices%202009.pdf

Iowa Department of Natural Resources. (2006). How to Control Streambank Erosion. Iowa, USA.

Jones, J., & Bachman, R. (1976). Prediction of phosphorus and cholorophyll levels in lakes. *Water Pollution Control Federation 48*, 2176-2182.

Kahl, R. (1991). *Restoration of canvaseback migrational staging habitat in Wisconsin: a research planwith implications for shallow lake management*. Madison: Wisconsin Department of Natural Resources.

Kearny, S., Fonte, S., Garcia, E., & Smukler, S. (2018). Improving the utility of erosion pins: absolute value of pin height change as an indicator of relative erosion. *Catena 163*, pp. 427-432.

Larson, T. (2003). *Stocking Success of Smallmouth Bass*. Madison, WI : Wisconsin Department of Natural Resources.

Larson, T. (2003). *Stocking Success of Smallmouth Bass*. Madison: Wisconsin Department of Natural Resources.

Leverance, J., & Panuska, J. (1997). *Water Quality Model Study for Lake Redstone, Sauk County*. Madison: WI-DNR.

Manci, K. (1989). *Riparian ecosystem creation and restoration: a literature summary*. Washington DC: U.S. Fish and Wildlife Service.

Marshall, D., Jaeger, S., Panuska, J., Lathrop, R., Unmuth, J., & Decker, E. (2002). *Feasibility of Releasing Hypolimnetic Water to Reduce Internal Phosphorus Loading in Lake Redstone*. Madison, WI: WDNR.

McGinley, P. (2014). *UW Extension*. Retrieved April 28, 2021, from https://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/programs/lakeleaders/crew10/McGinley-Modeling.pdf

Meals, D., & Dressing, S. (2015, October). EPA Technical Memorandum #1: Adjusting for Depreciation of Land Treatment When Planning Watershed Project. Fairfax, VA, USA. Retrieved from https://www.epa.gov/polluted-runoff-nonpoint-source-pollution/watershed- approach-technical-resources.

Mittelstadt, M. (2020). 2019 Dredging Year in Review. *Lake Redstone Protection Connection*. La Valle, WI, USA: Lake Redstone Protection District.

Montgomery, G. L. (1996). *Riparian Areas - Reservoirs of Diversity*. Lincoln: Natural Resource Conservation Service.

MSA. (1998). *Lake Redstone Watershed Agricultural Inventory*. Madison: MSA Professional Services, LLC.

MSA. (2002). *Field Verification of Sediment Delivery Study*. Madison: MSA Professional Services, LLC.

MSA. (2007). *Lake Redstone Watershed Stream Assessment*. Madison: MSA Professional Services, LLC.

NALMS. (2017, August 29). *Understanding Detention Time and Flushing Rate*. Retrieved May 20, 2021, from New England Chapter of the North American Lake Management Society: https://nec-nalms.org/index.php/2017/08/29/understanding-detention-time-and-flushing-rate/

Nedohin, D. N., & Elefsiniotis, P. (1997). The Effects of Motor Boats on Water Quality in Shallow Lakes. *Toxicological and Environmental Chemistry*, 127-133.

Nichols, S. A. (1999). Floristic Quality Assessement of Wisconsin Lake Plant Communities with Example Applications. *Lake and Reservoir Management*, 133-141.

NRCS. (2012, March). Retrieved May 1, 2021, from https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1187268.pdf
Oldenburg, P. (2021, April 20). Correspondence/Memorandum - Update Lake Redstone Modeling. Eau Claire, WI, United States of America: State of Wisconsin.
Panuska, J. L. (1997). *Water Quality Model Study for Lake Redstone, Sauk County*. Madison, WI: Wisconsin Department of Natural Resources.
Purdue Univesity. (2002). Revised and Simplified Cropland Roadside Transect Survey. West Lafayette, IN, USA: Conservation Technology Information Center.
Rathbun, J. (2009). *Standard Operation Procedure - Monitoring Streambank Erosion with Erosion Pins - Black River Watershed Management Plan*. Michigan Department of Environmental Quality - Water Division.
Rennicke, M. (2012). *Lake Redstone Comprehensive Fisheries Survey Report Sauk County, Wisconsin 2010*. Poynette: Wisconsin Department of Natural Resources.
Robertson, D. M., & Diebel, M. W. (2020). Impartance of accurately quantifying internal loading in developing reduction strategies for a chain of shallow lakes. *Lake and Resevoir Management Vol 36, No. 4*, 391-411.
Sagerman, J., Hansen, J., & Wickstrom, S. (2020). Effects of boat traffic and mooring infrastructure on aquatic vegetation: A systematic review and meta-analysis. *Ambio*, 517-530.
Sallenave, R. (2012). *Understanding Water Quality Parameters to Better Manage Your Pond*. Las Cruces, New Mexico: New Mexico State University Guide W-104.
Sauk County. (n.d.). *Mineral Extraction*. Retrieved August 11, 2021, from https://www.co.sauk.wi.us/planningandzoning/mineral-extraction
Sefton, D., & Graham, S. (2009). *Designation of Critical Habitat Lake Redstone, Sauk County, Wisconsin*. Fitchburg, WI: Wisconsin Department of Natural Resources.
Sekellick, A., Banks, W., & Myers, M. (2013). *Water volume and sediment volume and density in Lake Linganore between Boyers Mill Road Bridge and Bens Branch, Frederick County Maryland*. Reston: US Geological Survey.
Sondergaard, M., Kristensen, P., & Jeppesen, E. (1992). Phosphorus release from resuspended sediment in the shallow and wind-exposed Lake Arreso, Denmark. *Hydrobiologia 228 (1)*, 91-99.
Strahler, A. (1957). Quantitative analysis of watershed geomorphology. *Eos, Transactions American Geophysical Union 38(6)*, 913-920.
UMass - Amherst. (2016). Retrieved May 22, 2021, from Massachusetts Water Watch Partnership: https://www.umass.edu/mwwp/resources/factsheets.html#:~:text=Nitrate%20is%20usually%20the%20most,to%20support%20summer%20algae%20blooms.
UofM Extension Service. (n.d.). Understanding Shoreland BMps - Shoreland Best Management Practices Series. St. Paul, MN, USA.
US EPA. (2020, November 24). Retrieved October 3, 2021, from Septic Systems Overview: https://www.epa.gov/septic/septic-systems-overview
USDA. (n.d.). *Natural Resources Conservation Services*. Retrieved 07 27, 2021, from Soils: https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/
USGS. (2016). *National Land Cover Database*. Retrieved 07 27, 2021, from https://www.usgs.gov/centers/eros/science/national-land-cover-database?qt-science_center_objects=0#qt-science_center_objects
USGS. (n.d.). *Land Cover Trends*. Retrieved June 16, 2021, from USGS Western Geographic Science Center: https://www.usgs.gov/centers/wgsc/science/land-cover-trends?qt-science_center_objects=0#qt-science_center_objects
USGS. (n.d.). *Water Science School*. Retrieved July 19, 2021, from Water Quality Topics - pH and Water: https://www.usgs.gov/special-topic/water-science-school/science/ph-and-water?qt-science_center_objects=0#qt-science_center_objects
UW-Extension Juneau County. (n.d.). *Crops and Soils*. Retrieved August 8, 2021, from https://juneau.extension.wisc.edu/agriculture/crops-and-soils/
UW-Madison. (1981). *Lake Redstone: A Water Quality and Management Study*. Madison, WI: UW-Madison.
Walker, W. (1984). Empirical prediction of Chlorophyll in Reservoirs. *Lake and Reservoir Management*.

Walsey, D., & Heiskary, S. (2009). Site Specific Eutrophication Criteria for Lake Pepin. *TMDL 2009 Conference, Water Environment Federation*, (pp. 186-211). Minneapolis.
Wards Science. (2021). Retrieved August 10, 2021, from https://www.wardsci.com/store/product/8877520/imhoff-settling-cone
WDNR. (2003). Wisconsin Lake Modeling Suite. *Program Documentation and Users Manaual Version 3.3 for Windows*.
WDNR. (2018). 2020 WisCALM Public Comment Period: Update Supplemental Information. Madison: Wisconsin Department of Natural Resources.
WI-DNR. (n.d.). Retrieved August 8, 2021, from TMDL Overview: https://dnr.wisconsin.gov/topic/TMDLs/Overview.html
WI-DNR. (n.d.). Retrieved August 8, 2021, from Critical Habitat Areas: https://dnr.wisconsin.gov/topic/lakes/criticalhabitat
WI-DNR. (n.d.). Retrieved August 8, 2021, from Surface Water Integrated Monitoring System (SWIMS) Database: https://dnr.wisconsin.gov/topic/SurfaceWater/SWIMS
WI-DNR. (n.d.). Retrieved August 8, 2021, from Citizen Lake Monitoring Network: https://dnr.wisconsin.gov/topic/lakes/clmn
WI-DNR. (n.d.). Retrieved August 8, 2021, from Fish Stocking Summary: https://cida.usgs.gov/wdnr/apex/f?p=220:1:::NO::P1_COUNTY_NAME:SAUK&cs=1883BFC6E6C6FB9D10EA529E43F409B60
WI-DNR. (n.d.). Retrieved August 8, 2021, from Aquatic Plants: https://dnr.wisconsin.gov/topic/lakes/plants
WI-DNR. (n.d.). Retrieved August 8, 2021, from SLAMM and P-8 Models: https://dnr.wisconsin.gov/topic/Stormwater/standards/slamm.html
WI-DNR. (2015). *Wisconsin Wildlife Action Plan*. Retrieved August 11, 2021, from Significant Ecological Features of WI: https://dnr.wi.gov/topic/endangeredresources/documents/significantEcoFeatures.pdf
WI-DNR. (2019). *Total Maximum Daily Loads for Total Phosphorus in the Wisconsin River Basin.* Madison: Wisconsin Department of Natural Resouces.
WI-DNR. (2020). Guidelines for Monitoring for Watershed Restoration Effectiveness. *EGAD#3200-2020-26*. Madison, WI, USA: Wisconsin Department of Natural Resources Bureau of Water Quality.
WI-DNR. (2021). *Wisconsin 2022 Consolidated Assessment and Listing Methodology (WisCALM) for CWA Section 3030(d) and 305(b) Intergrated Reporting.* Madison: Bureau of Water Quality Program Guidance.
WI-DNR. (2021). *Wisconsin Department of Natural Resources*. Retrieved April 7, 2021, from Wisconsin's Consilidated Assessment and Listing Methodology: https://dnr.wisconsin.gov/topic/SurfaceWater/WisCALM.html
WI-DNR. (2021a). *Wisconsin Department of Natural Resources*. Retrieved May 22, 2021, from SLAMM and P8 Models: https://dnr.wisconsin.gov/topic/Stormwater/standards/slamm.html
WI-DNR. (n.d.). *Lakes Page*. Retrieved August 10, 2021, from Lakes Page: https://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=1280400&page=facts
WI-DNR. (n.d.). *Wisconsin River TMDL*. Retrieved August 8, 2021, from https://dnr.wisconsin.gov/topic/TMDLs/WisconsinRiver/index.html
World Health Organization. (2003). *Guidelines for Safe Recreational Water Environments, Volume 2*. Geneva: World Health Organization.