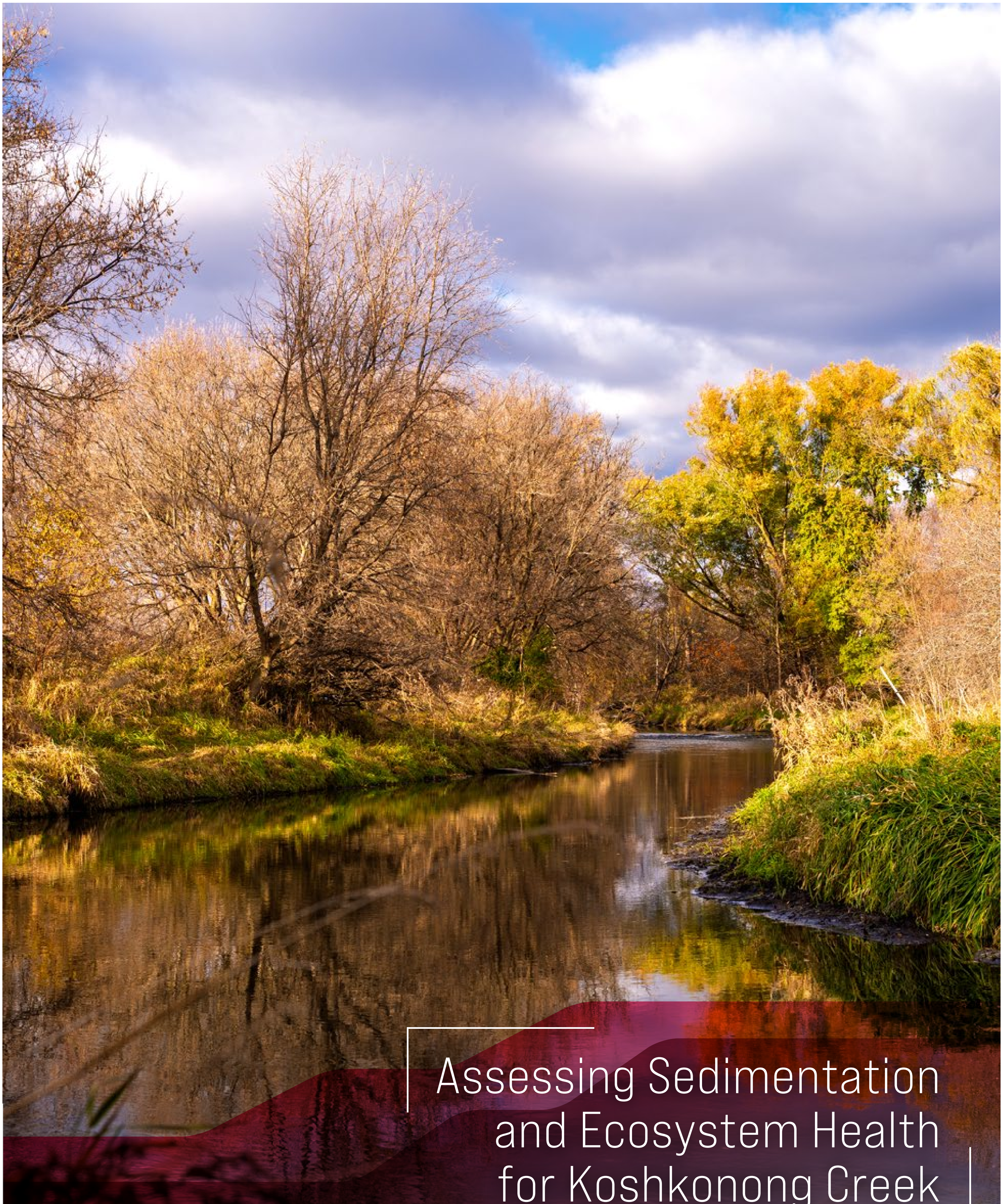


Assessing Sedimentation and Ecosystem Health for Koshkonong Creek

Nelson Institute for Environmental Studies
UNIVERSITY OF WISCONSIN–MADISON

2023 WATER RESOURCES MANAGEMENT PRACTICUM REPORT

PREFACE

Water resources management (WRM) is a master of science degree program housed within the Nelson Institute for Environmental Studies at the University of Wisconsin–Madison. WRM graduate students complete 45 credits of interdisciplinary coursework across categories such as the natural sciences, engineering, social sciences, planning, and water management.

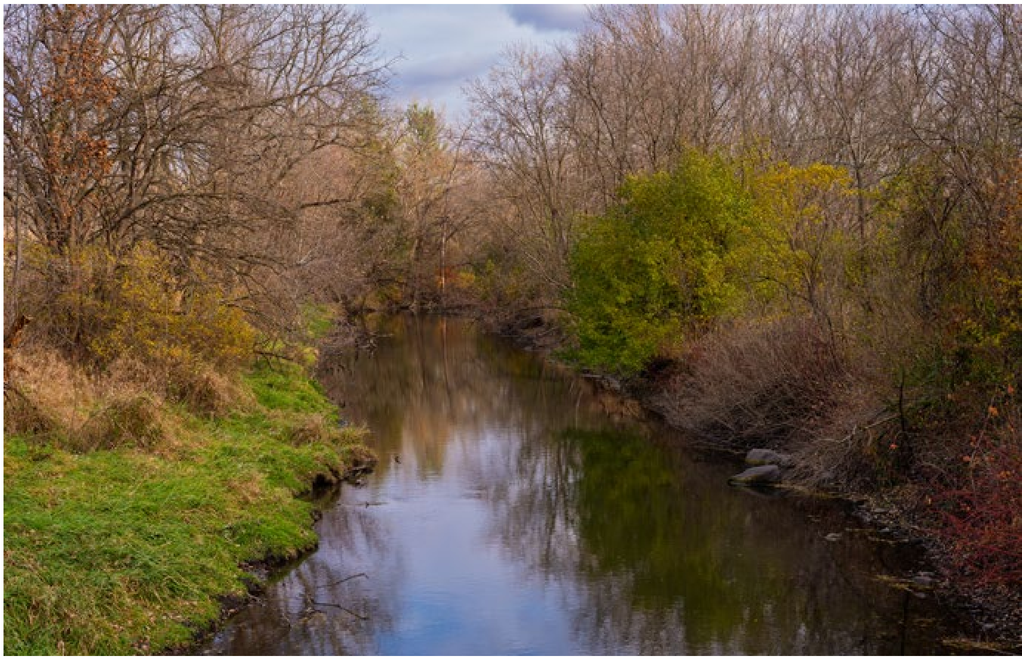
Instead of conducting individual research, students participate in a collaborative practicum that extends across their two years in the program. The WRM practicum concentrates on a relevant water management issue facing a local community, and students form partnerships with organizations and institutions to develop project objectives and ultimately deliver management recommendations.

The 2023–25 cohort focused our project on assessing sedimentation and ecosystem health in the Koshkonong Creek Watershed, addressing the flooding concerns in the creek, exploring innovative solutions, and reducing future risks.

ACKNOWLEDGEMENTS

The 2023 practicum experience benefitted and was made possible through the guidance, support, and collaboration of numerous individuals and organizations. We extend our deepest gratitude to all who contributed their time, expertise, and resources.

First, we would like to thank our faculty advisors and the Water Resources Management (WRM) program leadership. Dr. Ken Genskow, current chair of the WRM



Front cover and photos above by Kevin Berger

program, provided immense support throughout our practicum, offering critical editorial feedback, helping coordinate project logistics, and guiding our work with unwavering dedication. We also are grateful for Dr. Anita Thompson, former WRM chair, for her role in initiating this partnership and laying the foundation for our cohort's engagement with the Koshkonong Creek watershed. As our lead instructor throughout the practicum, Dr. Ed Boswell was instrumental in preparing us for fieldwork, participating in numerous site visits, and providing essential guidance on project presentations, proofreading, and technical edits. His hands-on mentorship was foundational to our fieldwork and analysis. We appreciate the many others at UW-Madison offered insights and advice throughout.

This project was conducted as part of the UniverCity Koshkonong Creek community partnership (2022-2024) between the UW-Madison UniverCity Alliance and the communities of the City of Sun Prairie, the Towns of Deerfield and Cottage Grove, and the nonprofit Friends of Koshkonong Creek, with support from Badger Farms. We are grateful for their collaboration and for the framework that connected our academic work with this community-identified need to study the creek and plan for its future. We owe particular thanks to our dedicated community partners, whose local knowledge and sustained advocacy inspired and informed this work. Special gratitude goes to David Muehl of the Friends of Koshkonong Creek and Badger Farms was instrumental in defining the project's focus and providing essential on-the-ground insights; Dave is a Koshkonong Creek champion. Steve Falter of Capitol Water Trails offered tremendous practical support, shared his extensive experience with waterway management, and actively collaborated on community engagement efforts.

We also thank the many other stakeholders, landowners, agency staff, and community members who generously shared their perspectives, granted us access to their properties, and participated in workshops and interviews. Your contributions were vital to shaping a report that is grounded in both scientific assessment and community priorities.

The Nelson Institute communications team has provided remarkable assistance in preparing this final report for publication.

Finally, we thank our families, friends, and the broader WRM community for their support and encouragement throughout this intensive two-year journey.

LAND ACKNOWLEDGMENT

This research was conducted along Koshkonong Creek in eastern Dane County and southwestern Jefferson County, Wisconsin, which occupies the ancestral lands of the Ho-Chunk, Potawatomi, Sauk, and Meskwaki nations, who have called this region home since time immemorial. Through treaties and forced cession, much of this land was taken from its original stewards, and the impacts of colonization have shaped the history and governance of this region. We acknowledge and respect the inherent sovereignty of these tribal nations and recognize the ongoing importance of waterways to their cultural, ecological, and spiritual practices

TABLE OF CONTENTS

Assessing Sedimentation and Ecosystem Health for Koshkonong Creek

2023 WATER RESOURCES MANAGEMENT PRACTICUM REPORT

Hannah Agner, Colleen Dickey, German Gonzalez, Alen John Idiculla,
Nicolas LaBracke, Heidi Putnam, Cailan Sederquist

SECTION 1: EXECUTIVE SUMMARY

Koshkonong Creek, located in eastern Dane County and southwestern Jefferson County, Wisconsin, faces historical and ongoing challenges with sedimentation, flooding, and debris blockages impacting ecosystems, farmland, and recreational potential. This two-year practicum project was conducted by students in the UW–Madison Water Resources Management (WRM) master's program in partnership with the UniverCity Alliance and local stakeholders coordinated through the Friends of Koshkonong Creek (FOKC). The project examined key physical, ecological, and management challenges within the Koshkonong Creek watershed with the aim to identify root causes of flooding, sedimentation, and habitat degradation and to provide actionable, science-informed recommendations to guide short-, intermediate-, and long-term management strategies through interdisciplinary fieldwork, community engagement, and scientific analysis. These recommendations are intended to improve creek function, reduce flood risk, enhance recreational opportunities, and support healthier riparian ecosystems across the watershed.

Our team employed an interdisciplinary and mixed-methods approach to understand the watershed and focus efforts on an 11-mile stretch of the creek where stakeholder concerns were the most acute. Field-based sediment analysis consisted of kayak-based surveys paired with Global Navigation Satellite System (GNSS) equipment to measure sediment depth and water surface elevation across 69 transects within the study area, estimating approximately 51,190 cubic yards of accumulated sediment, with 16 critical buildup zones identified. Sediment from six sites was analyzed for heavy metals and nutrients; heavy metal levels were low (not polluted), but nutrient concentrations, particularly phosphorus and nitrogen, were elevated, reflecting historical and ongoing nonpoint agricultural runoff. Hydraulic modeling using HEC-RAS indicated that removing two feet of sediment could reduce flood inundation area by up to 76.8 acres in a 10-year, 24-hour storm event, though benefits would be temporary without upstream controls. The modeling also highlighted the need for future 2D hydraulics and integration of sediment transport processes. Wetland conditions were assessed using Rapid Floristic Quality Assessments (RFQA) at five sites, revealing low floristic quality (weighted mean C-values 0.7–3.0) and dominance by invasive species such as reed canary grass. A GIS-based suitability analysis incorporating hydric soils, flood zones, slope, and land use identified priority areas for wetland restoration. Object-Based Image Analysis (OBIA) using drone-acquired multispectral imagery demonstrated a complementary remote sensing approach for vegetation classification and wetland health monitoring.

Governance and stakeholder analysis identified fragmentation across federal, state, county, and local entities, with no coordinated watershed-wide management body. Stakeholder engagement, including community workshops, cleanup events, and interviews with landowners, agencies, and organizations such as the WDNR, Rock River

Coalition, and Capitol Water Trails, underscored the need for improved collaboration and formalized coordination. Citizen science and digital tools were developed to support ongoing engagement and monitoring. An ArcGIS Hub site was created for data sharing and public outreach, and a mobile-friendly Survey123 form was designed for real-time obstruction reporting. Participation in existing volunteer monitoring programs, such as Water Action Volunteers (WAV), was encouraged, and the use of cloud-based platforms like Google Earth Engine and Colab was recommended to enhance analytical capacity.

Our key recommendations focus on governance, sediment management, flood mitigation, water quality, wetland restoration, and community engagement. It is recommended to formalize FOKC as a 501(c)(3) nonprofit and establish a watershed advisory group to improve collaboration, pursue funding, and align priorities across stakeholders. Sediment management should prioritize source control through sediment basins and vegetative filter strips on agricultural land. While hydraulic modeling showed dredging could temporarily reduce flood inundation, it is a costly and ecologically disruptive solution that should only be considered in combination with upstream best management practices and responsible disposal planning. For flood mitigation, a network of stream and precipitation gauges should be implemented to improve hydrologic modeling and flood forecasting, alongside evaluating wetland restoration and creation as nature-based strategies for flood attenuation.

To improve water quality, widespread adoption of riparian buffers should be promoted to stabilize banks, reduce nutrient and sediment loading, and address nonpoint source pollution, alongside encouraging nutrient management planning and reduced road salt application to mitigate chloride impacts. Wetland restoration should be supported through technical and financial assistance programs such as the NRCS Wetland Reserve Easements, with an emphasis on small, distributed restoration sites to cumulatively enhance flood storage and water quality. Finally, community and recreational engagement should be expanded through citizen science initiatives, maintaining digital tools for obstruction tracking, and improving safe public access points to increase recreational use and stewardship awareness.

Implementing these integrated recommendations is expected to reduce flood risk, improve water quality and habitat, enhance recreational opportunities, and foster a collaborative, resilient watershed community. This report provides a comprehensive assessment and an actionable pathway toward the long-term health and sustainability of Koshkonong Creek.

SECTION 2: INTRODUCTION

2.1 Background

Koshkonong Creek, located in eastern Dane County and southwestern Jefferson County, Wisconsin, embodies a complex interplay between natural systems and human influence. The headwaters are located in the City of Sun Prairie and run south through a number of communities such as Cottage Grove, Deerfield, and Cambridge, before flowing into Lake Koshkonong. A key and highly visible recreational asset within the upper reaches of the watershed is the Glacial Drumlin State Trail, a hiking and biking trail that runs east towards Milwaukee and crosses the Koshkonong Creek five times.

For years, landowners near the creek became concerned about numerous large blockages (e.g., fallen trees) impeding water flow and recreational navigability (Figure 2.1). In the early 2010s, two private landowners formed the "Friends of Koshkonong Creek" (FOKC) and started to remove these blockages, which required chainsaws and heavy equipment. However, they soon realized that they were going to need more help to address the larger set of issues at hand in the watershed. FOKC (along with the City of Sun Prairie and Towns of Deerfield and Cottage Grove) submitted a proposal to the UniverCity Alliance (UCA) at the University of Wisconsin–Madison to access additional resources through the UniverCity Year (UCY) program to study the issues and initiate a long-term management plan. The basis of the project request was their observations of increased creek obstructions and concerns about implications for reduced recreation opportunities, ecological issues within the riparian zone, increased flooding events, and sedimentation.

Figure 2.1. Picture of an obstruction while we paddled Koshkonong Creek in summer 2023.

Upon their selection as a UCY community, the UniverCity Koshkonong Creek commenced in 2021 (univercity.wisc.edu/koshkonong/). This project with the WRM practicum emerged as one of 12 within that effort. This report explores the concerns around Koshkonong Creek and makes recommendations in six areas to help focus priorities for short-, intermediate-, and long-term planning for the creek and watershed.

2.2 Project Objectives

The overall goal of this WRM practicum project was to provide management recommendations for a sub-watershed (HUC-12 scale) within the Koshkonong Creek watershed informed by models, stakeholder interest, and physical assessments. HUC is an abbreviation for 'hydrologic unit code' and is part of a hierarchical land area classification system created by the U.S. Geological Survey (USGS) which delineates water drainage divides at different scales. As an example, the Mississippi River Basin is a HUC-2. Our project study area is within the HUC-12 Mud Lake – Koshkonong Creek Subwatershed. Throughout the report, this geographic area is referred to as the project study area. The recommendations were developed to improve the aesthetic value, reduce flooding, and increase recreational opportunities along the creek. This goal was supported by these objectives and tasks:

Objective 1: Plan integration analysis/synthesis of existing information.

Task 1: Summarize the groups, agencies, municipalities, and others that are active in the watershed and document their current and past activities.

Task 2: Conduct research on any recent or upcoming changes that may impact the watershed, including:

a. Policy changes

b. New construction

c. Population growth

Task 3: Synthesize current UniverCity Year projects within the watershed.

Objective 2: Assess the potential for existing and potentially restorable wetlands within close proximity to Koshkonong Creek to provide flood control and/or lower water levels. Quantify the extent of flooding within the watershed.

Task 1: **Explore historic and current conditions of wetlands in the watershed and identify prior converted farmlands and other historic wetland areas that would be suitable for wetland restoration.**

a. Conduct a suitability analysis for restorable wetlands using ArcGIS Pro.

b. Complete a desktop wetlands review with aerial imagery and soils maps to complement and potentially confirm the GIS results.

Task 2: **Evaluate the quality of selected existing wetlands by completing floristic quality assessments in representative sample locations, as informed by task 1 and our advisory team.**

a. Identify landowners willing to allow site access to conduct floristic quality assessment (FQA) surveys.

b. Conduct FQA(s) and site analyses following standard methods.

Task 3: **Utilize modeling (e.g., HEC-RAS) to quantify the function of existing wetlands and proposed wetland restorations for flood abatement and storage purposes.**

a. Create inundation maps that can also be animated and contain multiple background layers (terrain, aerial photography).

Objective 3: Characterize creek obstructions and sediment loads in study area and model scenarios to inform improvement decisions.

Task 1: **Identify and quantify obstructions such as woody debris and vegetation that visibly impede flow throughout the HUC-12 (Mud Lake-Koshkonong Creek 070900020403).**

a. Conduct an inspection of the HUC-12 for obstructions.

b. Utilize Survey123 site to supplement visual inspection.

c. Determine which reach or reaches are appropriate for conducting cross-sectional measurements.

Task 2: **Estimate sediment volumes at specific points in the study area and model scenarios. Obtain appropriate input measurements for WinXSPRO.**

a. Follow field procedures as outlined in Hardy et. al (2005) for each of the predetermined stretches. Measure channel cross-section, water-surface slope, bed material sample, and discharge.

b. Model (e.g. WinXSPRO) scenarios pre- and post-sediment removal.

Task 3: **Obtain appropriate input measurements for use of the Hydrologic Engineering Centers River Analysis System (HEC-RAS).**

a. Follow field procedures as outlined in the user manual provided for the software for each cross-section/whole stretch of the river.

b. Input field measurements into HEC-RAS to perform sediment transport analysis, Water Quality Analysis.

c. Model subcritical, supercritical, and mixed flow regime water surface profiles using the steady flow component.

d. Determine the Manning Coefficient along parts of the stream.

Task 4: **Utilize the results of cross-sectional analysis to inform dredging decisions.**

Objective 4: Enhance community and recreational stakeholder collaboration within Koshkonong Creek to increase awareness, ecological function, and enjoyment of the creek.

Task 1: **Increase awareness and knowledge of the Koshkonong Creek Watershed.**

a. Collaborate with existing groups such as the FOKC, Mad City Paddlers, and individuals such as Steve Falter from the Cap City Water Trails team to improve and create digital tools and survey creation and distribution.

b. Create digital tools (e.g. ArcGIS Survey123, ArcGIS Hub site) to link related conservation group webpages in a central location and use it to track engagement using the website metrics.

c. Identify recreational use objectives of the Koshkonong Creek by coordinating with the above-mentioned area groups.

Task 2: Attend and help organize stakeholder events.

a. Attend the FOKC/Cap City Water Trails water trails workshop at Badger Farms on April 29, 2023, and other workdays in the fall.

b. Host a watershed visioning workshop on March 9, 2024, in Deerfield, open to members of the public, users of Koshkonong Creek, FOKC, and landowners in the area to guide the future visioning process for the waterway.

Task 3: Recommend and analyze methods to enhance aesthetic value along Koshkonong Creek for recreational users.

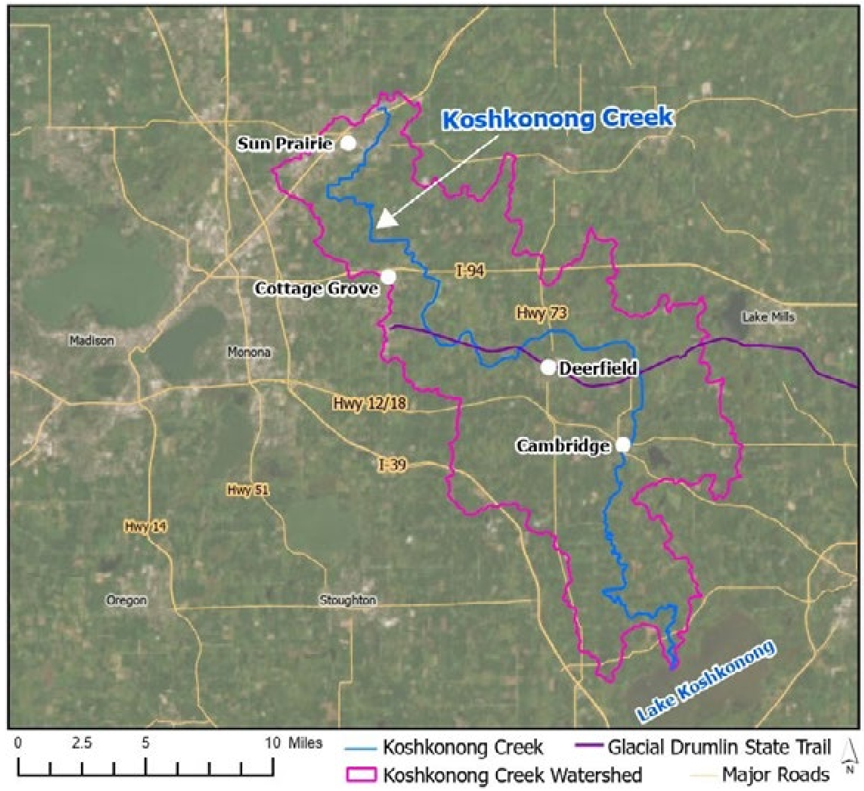


Figure 2.2. Full Watershed Map.

2.3 Watershed Description

The Koshkonong Creek Watershed (see Figure 2.2), located mostly in eastern Dane County and Western Jefferson County in southern Wisconsin, drains 169 square miles of land and runs 54 miles from Sun Prairie, a community of roughly 38,000 people in the north, down into the northwest side of Lake Koshkonong in Rock County. The creek flows primarily through agricultural lands, which comprise over 54 percent of the entire watershed (Amrhein and Sorge, 2018) and crosses through or near several small communities (under 9,000) in population including Cottage Grove, Deerfield, Cambridge, and Rockdale. The upper two-thirds of the watershed were channelized and ditched with tile drains installed primarily between 1901–61 for agriculture. Before that time, the watershed was a mix of sedge meadows, oak savannas, and mesic prairies supporting a diverse range of flora and fauna. The southern third of the creek is mostly unchanged from its original condition and meanders through a mix of forested wetlands and sedge meadows before emptying into Lake Koshkonong. Lake Koshkonong is a reservoir created by the construction of the Indianford Dam in 1932, which changed how this marshland functioned in terms of sediment transport downstream.

Expansion of communities throughout the watershed have changed the composition and quality of the creek. Four communities (Sun Prairie, Deerfield, Cambridge, and Rockdale) discharge wastewater effluent into the creek, and these volumes have increased with community growth. In times of high creek flow and when water level decisions at the Indianford Dam (Rock River) influence levels in Lake Koshkonong, those additional discharges add to the creek's low gradient and amplify already high water levels in the creek. Impervious surfaces from increased development in those areas also carry more road salt and stormwater into the creek. Diminishment of wetland areas adjacent to the creek also contribute to these issues due to lessened ecosystem services benefits. The combined factors further affect the overall ecological health of the watershed.

2.4 History of Land Management in the Watershed

The history and current state of the Koshkonong Creek watershed provides an informative case study on watershed management, erosion, sedimentation, and the efforts to balance human needs with environmental stewardship.

Historically, the watershed was a mosaic of sedge meadows, oak savannas, and mesic prairies, supporting a diverse range of flora and fauna. Indigenous peoples frequented the area for sources of food, shelter, and to set up communal living areas. Centuries later, European settlers came to the region with a desire to use the land for agriculture. The channelization of Koshkonong Creek in the early 20th century, aimed at enhancing drainage for agriculture, disrupted the creek's natural flow. This alteration marked the beginning of a significant human-induced shift of the watershed's hydrology and ecology, resulting in enduring negative impacts on the environmental health and stability of the region.

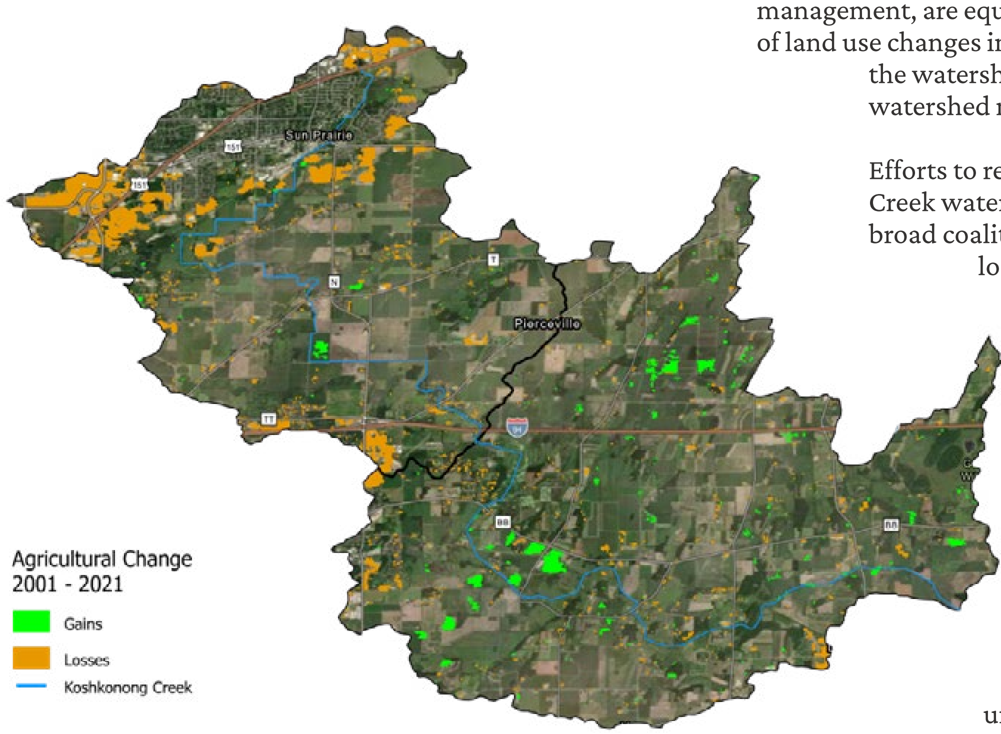


Figure 2.3. Agricultural Land Cover Change in Watershed.

Over the years, the expansion of agricultural lands (see Figure 2.3) and the growth of urban areas like Sun Prairie have increased sediment and nutrient runoff into waterways throughout the Koshkonong Creek watershed. The transition from diverse agricultural practices to a predominance of row cropping, alongside urban development, has increased soil erosion and sedimentation within the creek. In the early 1980s, research began on identifying sources of soil erosion and sedimentation within the creek and the impacts of these on water quality, but the recommendations from this research were not implemented widely.

The challenge of managing the Koshkonong Creek watershed lies in addressing the multifaceted issues of drainage efficiency, sedimentation, and water quality degradation while accommodating agricultural needs and urban development. This complex task requires a holistic approach to watershed management, incorporating both structural and non-structural measures. The recent UCY project by the students of Civil and Environmental Engineering 578 (available here: https://univercity.wisc.edu/koshkonong/) explored potential structural interventions. These students, through their capstone course, developed plans to reduce flooding severity and duration at Badger Farms using a weir, channel, embankment, and recreational lake system. Their work highlights the importance of innovative solutions in managing watershed challenges. Non-structural strategies, including land use planning, agricultural best management practices, and urban stormwater management, are equally critical in mitigating the impacts of land use changes in the watershed. Other entities within the watershed are addressing these facets of watershed management.

Efforts to restore and protect the Koshkonong Creek watershed are ongoing and involve a broad coalition of stakeholders, including local governments, environmental organizations, and a variety of residents such as landowners and agricultural producers. These efforts underscore the importance of collaboration and integrated management in addressing watershed-scale challenges. The history and current management efforts in the Koshkonong Creek watershed illustrate the complexity of watershed stewardship. As the watershed continues to evolve under the influence of human activity and natural processes, adaptive and collaborative management approaches will be essential in ensuring the sustainability of its water resources and the well-being of communities that depend on them. The story of the Koshkonong Creek watershed serves as a reminder of the delicate balance between human activity and environmental health, highlighting the need for sustainable practices that preserve water resources for future generations.

2.5 Ongoing Watershed Change

2.5.1 PROJECTED POPULATION INCREASE

Dane County has already experienced a 2.5 percent increase in population since 2020, which equates to roughly 30,000 additional people as of 2024 (Reid, 2024). Three of Wisconsin's top four fastest-growing municipalities since 2020 are located in Dane County, including Sun Prairie, which experienced a 6.73 percent increase in population between 2020 and 2023 (Groth, 2023). Increased urbanization is often a consequence of such an increase in population growth, which can lead to an increase in the number of impervious surfaces within the area subject to urbanization.

Hydrologically, there are significant consequences directly attributable to an increase in impervious surfaces within a watershed, including an increase in the volume of runoff from the land surface entering surface water bodies. In fluvial systems, this leads to higher peak flow rates, increased stream bank and bed erosion, and downstream flooding. Coupled with these effects is the potential for a more rapid delivery of nutrients, sediment, and contaminants into surface waterbodies within the watershed. Considering the position of Sun Prairie within the uppermost portion of the Koshkonong Creek HUC-10, it is prudent to be proactive in the development of strategies to mitigate these effects, especially considering these recent trends in population.

2.5.2 SUN PRAIRIE WASTEWATER TREATMENT PLANT (SPWWTP)

The SPWWTP is located near the head of Koshkonong Creek. Each day, an average of 4 million gallons of effluent is released into the creek contributing a significant portion of its daily flow. As Sun Prairie has experienced a rapid increase in population consistently over the past 40 years, the city's wastewater treatment capacity and capability have also increased during this time. The plant moved to its current location on Bailey Road in 1982. In 2005, it had outlived its expected lifetime and received a series of major upgrades. In 2022, the plant was expanded again at a cost of 19.9 million dollars to its current size. The new upgrades went online in June of 2022 with the goal of meeting the city's needs for the next 20 years. This increase in plant capability was necessitated by both Sun Prairie's rapid continued growth and stricter phosphorus effluent limits set by the Wisconsin Department of Natural Resources (WDNR). The SPWWTP projects an increase of daily outflow from approximately 3.5 million gallons per day today to approximately 6 million per day by 2040. To visualize flows today, let's consider rainfall over the 12.93 square miles of Sun Prairie. 3.5 million gallons is enough water to cover Sun Prairie to a depth of 0.016 inches. This amount also equates to a little over five Olympic-sized swimming pools. In combination with other flows from the watershed and water-level management of Lake Koshkonong, this increased outflow will likely increase flooding occurrences in the creek. Additionally, increased effluent from the SPWWTP will increase substances, such as nutrients and chloride, discharged into the creek. WWTPs are significant contributors of excess nutrients and other pollutants into Koshkonong Creek. These excess nutrients and pollutants can degrade the biological and aesthetic value of the creek. While it is still a point source of excess nutrients, SPWWTP has made substantial improvements and greatly lessened its nutrient and contaminant impacts on the watershed. However, the volume of water discharged into the creek daily by the SPWWTP still has an impact on the conditions of the creek today. While the amount discharged is assumed to increase, during rain events flooding can come from other sources. According to SPWWTP documents, rain events can cause an increase of 1-3 million gallons per day above average flow. While this flow is significant, consider that Koshkonong Creek is a basin and thus gathers a large amount of rain that falls over the general area. Runoff from roads, fields, and ditches are also a large portion of the experienced flooding. Nevertheless, the SPWWTP is undeniably an important consideration for successful long-term restoration of Koshkonong Creek.

2.5.3 CONSTRUCTION OF AMAZON WAREHOUSE

The construction of a 3.4 million square foot Amazon distribution center, dubbed "Project Silver Eagle," is occurring on a 150-acre site at the intersection of Highway N and TT in Cottage Grove; the project is expected to create 1,500 jobs. The project has sparked concerns about its environmental impact, and the significant increase in the stormwater and sediment expected from the construction led the residents

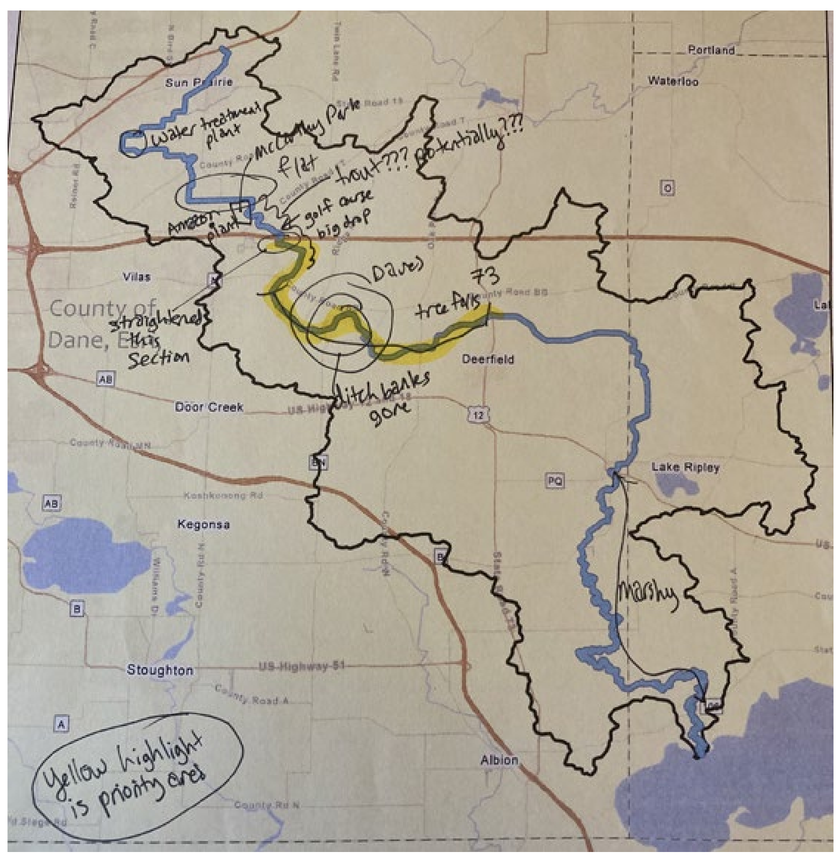


Figure 2.4. Highlighted map drawing done with Dave Muehl.

of Sun Prairie to request a review of the stormwater permits to ensure compliance with all applicable ordinances. The final stormwater management plan included stormwater ponds and an infiltration basin to ensure that the water discharge does not exceed standard regulations post-development (Yahr, 2022). The design also aims to reduce suspended solids and maintain water quality in nearby water bodies such as Koshkonong Creek.

2.6 Project Study Area

Given the large scale of the watershed and the limited timeframe available for fieldwork to complete the project, the study area for this project was reduced to an 11-mile reach of the creek. To select this area, the team analyzed online data resources showing land use, infrastructure locations, mapped wetlands, assessments and impairments from the WDNR amongst others to better understand how the creek and its surrounding upland areas changed across the larger watershed. Upon conclusion of this cursory review, the team chose initially to look at the upstream half of the creek as the area where greatest human influences were present on and near the waterbody. In February 2023, to further narrow down the study area to a more manageable size, the project team met with a local partner, Dave Muehl from the FOKC, who helped annotate a map of the watershed pointing out where his group felt the worst issues have been occurring.

The yellow highlighted area within Figure 2.4 is where the FOKC felt the highest concentration of issues have occurred. This area coincided with the majority of a single HUC-12 subwatershed within Koshkonong Creek (see Figure 2.5).

2.7 Orientation to the Report

To synthesize our work, this final report is divided into six sections: Governance and Community Engagement, Sediment Accumulation, Sediment Impacts on Flooding, Sediment Impacts on Water Quality, Adjacent Wetlands, and a final section comprising Summary Recommendations and Next Steps. Throughout these sections we delve into the governance, stakeholders and organizations involved in projects throughout the watershed and characterize physical metrics from our field work pertaining to sedimentation of the creek and adjacent wetlands that informed our recommendations for watershed-wide solutions.

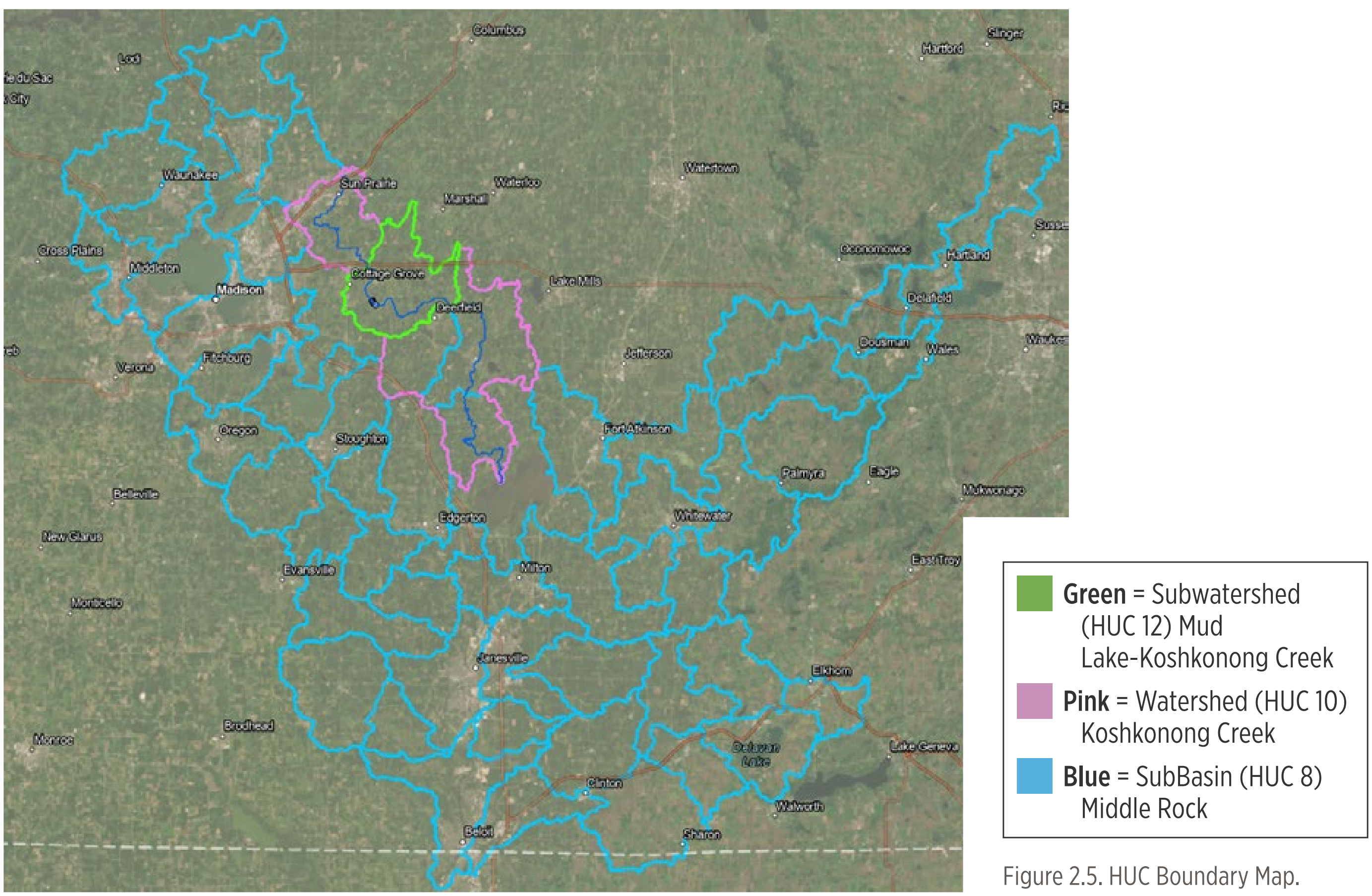


Figure 2.5. HUC Boundary Map.

SECTION 3: GOVERNANCE AND COMMUNITY ENGAGEMENT

3.1 Introduction

Effective governance and community engagement are critical components of ensuring sustainability when rehabilitating waterways such as Koshkonong Creek. Sustainable watershed management hinges on the integration of governance strategies and active community engagement and participation, driving initiatives that ensure the health of these important ecosystems for generations to come. The management of watersheds requires not only regulatory frameworks but also a deeply rooted sense of community ownership and engagement, underscoring the vital importance of inclusive decision-making processes and collaborative efforts. In the United States, watershed management relies on the coordination of multiple government entities and agencies, community members, landowners, farmers, and private businesses. There are national and state water quality standards that must be met, as well as other objectives and priorities in any given watershed. It is important for government entities and stakeholders to jointly set priorities for water resource management in each watershed. The main issues that are often considered are drinking water protection, wetlands and riparian area protection, point and nonpoint source pollution control, and water supply (Russo, 2008). The effective management of watersheds in both urban and rural contexts make a difference in the local, regional, and national water quality as well as the quality of life of those within the watershed (USDA, 2001).

Inclusive community engagement is necessary to achieve solutions to watershed management challenges. Without proper community engagement, projects often fail to meet their environmental goals because they fail to meet the community's needs, fail to attract participants, or they initiate changes that are not realistic or sustainable (Prokopy, 2011). Comprehensive and inclusive community engagement can only be achieved if information, opinions, and perspectives are collected from a representative pool of stakeholders. Giving community members the opportunity to develop their own solutions allows them to take ownership and responsibility for the health of the watershed, which in turn increases their buy-in of watershed management efforts (USDA, 2001). Enabling locally focused solutions not only increases participation in these solutions but also makes them more efficient and effective. Additionally, not engaging a variety of community members within the watershed leads to equity issues, which is too often the case with access to clean and safe water (Hansen, 2008). Community engagement in watersheds typically occurs through education and awareness, the participation in citizen science, the adoption of best management practices, volunteering in clean-up activities, support for conservation initiatives, more responsible recreation practices, and advocating for more sustainable government policies.

3.2 Governance in the Watershed

Governance refers to formal and informal processes for decision making that influences the watershed, and it plays an important role in terms of implementing changes within any given restoration and protection initiative. Without understanding the governance structure, it makes it incredibly difficult for groups to organize and facilitate positive changes for the watershed. The legal requirements around water quality decision making are outlined in the Clean Water Act (CWA) which governs water pollution and water quality standards across the United States and is the primary federal statute that affects watersheds in Wisconsin. The CWA requires the Environmental Protection Agency (EPA), along with states, tribes, and territories, to monitor the quality of U.S. (United States) lakes, rivers, streams, and other water bodies. Under the CWA, the EPA has implemented pollution control programs and also established national water quality criteria recommendations for surface waters (see Section 5 of this report).

The Public Trust Doctrine also plays a very important role in Wisconsin's water governance. The Public Trust Doctrine ensures that certain natural resources are held in trust by the state for all citizens, specifically applying to navigable waters in the state. This doctrine protects the people of Wisconsin's rights to transport and navigate on waterways, and also mandates protection of water quality and aquatic habitat as well as recreational activities including boating, fishing, hunting, trapping, and swimming in waterways. Navigable waters are defined as waterways that can accommodate small watercraft (such as a canoe or kayak) at some point during the year; this includes lakes, rivers, and streams, preventing private ownership from restricting access to these waterways (WDNR, n.d., Waterway Regulations and The Public Trust Doctrine).

Two of the major issues of concern for Koshkonong Creek are pervasive flooding that is becoming more common (plus sedimentation associated with that flooding) and creek blockages from treefall, sediments, and other debris. Governance structures that address these issues at a meaningful scale for watershed stakeholders are lacking. The question that many stakeholders continue to ask is: whose responsibility is it to manage these blockages? Some states (for example Minnesota, Iowa, Nebraska) have established Watershed Districts, which are special-purpose local units of government to manage watersheds (e.g., Minnesota Board of Water and Soil Resources n.d., Watershed Districts). Having these districts in place helps coordinate across governmental jurisdictions to make management at the watershed level more effective and straightforward. Establishing a governance structure like this in Wisconsin would require new statutory authority by the State Legislature to authorize the creation of watershed districts; there are no current plans to do so. Given this, community members and local organizations in the Koshkonong Creek Watershed may need to play a more active role in addressing gaps and supporting initiatives to coordinate across government entities to address flooding, sedimentation, blockage, and related issues. This underscores the importance of community-driven efforts in sustaining the health and vitality of watersheds like Koshkonong Creek. An inventory of those government entities in the watershed includes the following:

FEDERAL AGENCIES

United States Department of Agriculture Natural Resources Conservation Service

The United States Department of Agriculture Natural Resources Conservation Service (USDA NRCS) mainly operates through county offices in Dane and Jefferson Counties in relation to the Koshkonong Creek Watershed. It implements federal level and federally funded conservation programs that provide cost-sharing dollars, payments, and technical support to farmers who want to implement conservation management practices on their farms.

Environmental Protection Agency

The Environmental Protection Agency (EPA) is a federal agency whose mission is to protect human and environmental health. The EPA accomplishes this through developing and enforcing regulations, giving grants, studying environmental issues, sponsoring partnerships, educating the public about the environment, and publishing helpful information such as technical guidance and planning resources. In relation to watershed management, the EPA enforces the CWA, as well as overseeing several regulatory programs including the National Pollutant Discharge Elimination System (NPDES) and the Impaired Waters and Total Maximum Daily Loads (TMDLs).

U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers (USACE) is a branch of the United States Army that provides engineering services for both military and civil projects. The USACE administers and enforces section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act. In Wisconsin, the USACE's involvement with waterbodies, such as Koshkonong Creek, encompasses surveying, data collection, habitat restoration and provides essential information for water resource management. More specifically, USACE conducts hydrographic surveys, monitors water levels, issues permits for activities related to aquatic habitat restoration, and provides technical guidance such as the Wisconsin Stream assessment tools (USACE, n.d., Regulatory Frequently Asked Questions).

U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (USFWS) is a federal agency that oversees national wildlife refuges, protects endangered species, manages migratory birds, restores nationally significant fisheries, and enforces federal wildlife laws. In Wisconsin, the USFWS is responsible for administering the Endangered Species Act, identifying sources of environmental contamination, assessing impacts of contaminants to fish and wildlife resources, helping to restore contaminated habitats, and ensuring that fish and wildlife are considered during federal projects for roads, bridges, dams, and other infrastructure (USFWS, n.d., Minnesota-Wisconsin Ecological Services Field Office).

U.S. Geological Survey

The U.S. Geological Survey (USGS) is an agency of the United States Department of the Interior that researches earth systems. Its mission is to make scientific data available to help people understand earth, prepare for natural disasters, and manage natural resources. The data it provides also helps lawmakers and community leaders with decision making (National Geographic, 2023, United States Geological Survey).

The USGS provides current water data, some from Wisconsin, on their National Water Dashboard. USGS also provides real time, daily, peak-flow field measurements, and statistics related to stream levels, streamflow, lake levels, surface water quality, and rainfall in Wisconsin (USGS, n.d., Upper Midwest Water Science Center).

STATE AND COUNTY AGENCIES AND ORGANIZATIONS

Wisconsin Department of Natural Resources

The Wisconsin Department of Natural Resources (WDNR) is a government agency of the State of Wisconsin that is responsible for administering wildlife, fish, forests, endangered resources, air, water, waste, and other issues related to our natural resources. It is led by the Secretary who is appointed by the governor of the state. The WDNR develops regulations in accordance with the laws that are passed by the state legislature (WDNR, n.d., About the WDNR). The WDNR's surface water governing power includes "the ability to conduct water planning for natural areas and forests, implement regulations and secure designations to protect, maintain, or restore river resources." (WDNR, n.d., Water Quality Standards and Classifications).

Wisconsin Department of Agriculture, Trade, and Consumer Protection

The Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) has the Bureau of Land and Water Resource Management as well as the Wisconsin Land and Water Conservation Board within it. The Bureau of Land and Water Resource Management works with local, state, and federal government agencies, as well as landowners and farmers, to prevent agricultural runoff and to preserve farmland for future generations. The Land and Water Conservation Board reviews county land and water plans, allocating funds to counties for conservation.

Drainage Districts

Drainage districts also have jurisdiction given to them by the State of Wisconsin. They are regulated by Wisconsin DATCP and governed by county drainage boards. By definition, drainage districts are local government entities organized primarily to drain lands for agricultural use. The aggregation of the various drainage districts within each county in Wisconsin are managed by a county drainage board, which have extensive legal responsibilities (Dane County Drainage, n.d.).

Wisconsin Department of Health Services

The Wisconsin Department of Health Services (DHS) is a government agency responsible for maintaining public health in Wisconsin. In relation to water, the DHS mainly is involved with water quality (particularly groundwater) and its relation to public health. The DHS serves as a primary resource in the state for information about health risks from water contaminants and sometimes recommends groundwater and surface water standards related to water quality. (Wisconsin Department of Health Services, n.d.)

UW–Madison Division of Extension

The UW–Madison Division of Extension (Extension) is the outreach arm of the Universities of Wisconsin. Its mission is to provide statewide access to university resources and research for Wisconsin residents of all ages. Extension provides information and support to farmers, gardeners, and natural resource professionals including information on agriculture, horticulture, environmental conservation, and sustainable practices.

Dane County Land and Water Resources Department

The Dane County Land and Water Resources Department aims to preserve and enhance the natural, cultural, and historic resources of Dane County; provide the county's residents with a broad array of accessible, high-quality resource-based recreational services and facilities; and support residents, communities, local governments and other agencies and organizations in their resource management and protection efforts. The department is divided into four divisions: administration, land conservation, parks, and water resource engineering. Watershed management is one of the primary goals of the department. The department implements programs, initiatives, and projects on the land and in waterways to protect and improve these key resources (Dane County Land and Water Resources Department, n.d.)

Jefferson County Land and Water Resources Department

The Jefferson County Land and Water Resources Department administers State Statutes and County Ordinances pertaining to the conservation and protection of natural resources within the county. The department has various programs and activities to carry out their purpose (Jefferson County, n.d.)

WATERSHED MUNICIPALITIES

Municipalities in the watershed include the City of Sun Prairie); the Villages of Cambridge, Deerfield, Rockdale, and Cottage Grove ; and the unincorporated communities of Kroghville (Town of Lake Mills) and Busseyville (Town of Sumner). Multiple municipalities, particularly Sun Prairie, contribute discharge into the creek from their wastewater treatment plants, in addition to pollution from urban stormwater runoff.

3.3 Stakeholders and Community Members

Stakeholder and community engagement is a critical component of rehabilitating impaired waterways such as Koshkonong Creek. Engaged community members are the reason this research and report is being conducted, and ultimately, who this report is for. There are a variety of stakeholders with different interests and roles in the Koshkonong Creek Watershed. These include individual citizens, such as landowners and other community members, environmental and friends' groups, local businesses, other organizations, and the government agencies and entities noted above. Stakeholder engagement builds trust and support, fosters a sense of community, creates a shared responsibility for decisions and actions, and oftentimes, can enable more effective and efficient decision making. Of course, different stakeholders have varying interests, and when those interests do not align, this can pose challenges when recommendations and decisions need to be made. Building and maintaining relationships across different community groups in advance of difficult decisions is an important element of engagement.

For this project, contacting community members, and in particular, landowners, was not only critical for gaining access to land for field work, but also for learning more about the watershed and the community who live within it. Over 20 landowners that were contacted helped contribute to this report, as well as employees and volunteers from a variety of organizations and government entities. Governmental institutions that contributed in some way include the Wisconsin Department of Natural Resources, Dane County, Jefferson County, and the UW–Madison Division of Extension. Other organizations that were involved include Friends of Koshkonong Creek, Friends of Camrock Park, Rock River Coalition, and Capitol Water Trails.

3.3.1 SPECIFIC STAKEHOLDERS AND ORGANIZATIONS IN THE WATERSHED

Rock River Coalition

The Rock River Coalition (RRC) is a nonprofit organization that engages with stakeholders and supports conservation efforts across Wisconsin's Rock River Basin. The RRC conducts baseline monitoring along parts of Koshkonong Creek which includes measuring temperature, transparency, dissolved oxygen, stream flow, and biotic index. There are currently two volunteer monitoring sites on Koshkonong Creek. RRC has Chapters, which are non-incorporated groups of individuals working towards improving resources within a specific area or watershed in the larger Rock River Basin. These chapters receive administrative support, fiscal management, insurance, and other benefits (Rock River Coalition, n.d.).

Water Action Volunteers

Water Action Volunteers (WAV) is a group of citizen scientist volunteers that monitor as much of Wisconsin's streams and rivers as possible. Their goal is to preserve, protect, and restore Wisconsin's streams and rivers by collecting high-quality data that is useful for natural resource management and decision making. University of Wisconsin–Madison Division of Extension and the WDNR partner with WAV to help make this possible.

River Alliance of Wisconsin

The River Alliance of Wisconsin is an organization that works with local watershed groups, advocates for clean water protection laws, and promotes sustainable practices (River Alliance of Wisconsin, n.d.). Friends of CamRock park, which is active in the lower section of Koshkonong Creek, is one of the local groups that is a part of this alliance.

Friends of CamRock Park

CamRock park is a county park in Cambridge that Koshkonong Creek flows through. The creation of this park relied on 22 landowners who sold their land to Dane County. Business owners and others started buying land in the 1960s and then offered the land to Dane County, and the construction for the park began in 1974. This park allows for a variety of recreational activities such as paddling. Friends of CamRock Park has been monitoring water quality in the creek since 2000. They have been testing for phosphorus, studying the biotic index, and have filed hundreds of data sheets on water clarity, temperature, and creek levels (Janice Redford interview, 2023).

Friends of Koshkonong Creek

Friends of Koshkonong Creek (FOKC) was started by two farmers. Before the creation of the group, they had been independently removing blockages to help improve the water flow of the creek. Once FOKC was formed, they started cooperating with more landowners to remove more blockages. They then decided that a long-term plan needed to be developed for the entire watershed – which involves government entities, landowners, and all other interested parties. The group's main goal is to improve the creek for current and future generations to come.

Capitol Water Trails

Capitol Water Trails (CWT) was formed in 1998 and is an all-volunteer, nonprofit corporation dedicated to educating citizens in water stewardship, clearing waterways for recreational navigation, and improving waterways for fisheries and native habitat. CWT coordinates projects with multiple parties including habitat groups, paddlers, government agencies, and property owners (Capitol Water Trails, n.d.) This group has been working on Koshkonong Creek since 2021. In the summer of 2022, CWT, with the support of local municipalities and river alliances, logged over 35 work days clearing debris, trees, and general creek maintenance.

Mad City Paddlers

The Mad City Paddlers, a group of canoe and kayak enthusiasts based in Madison, gather every spring to prepare local creeks for recreational paddling. This club is dedicated to paddle sports and organizes various trips, including flat water paddling, kayaking, and whitewater paddling (Mad City Paddlers, n.d.).

The Nature Conservancy

The Nature Conservancy is a nonprofit organization dedicated to conserving and protecting the state's natural landscapes, habitats, and water resources. Their mission involves preserving ecologically significant areas, such as forests, wetlands, prairies, and lakeshores. Through land acquisition, restoration efforts, and community engagement, they work to ensure that future generations can enjoy the beauty and ecological diversity of Wisconsin. By collaborating with partners, advocating for sustainable practices, and raising awareness, the Nature Conservancy contributes to the long-term health of our environment.

Capital Area Regional Planning Commission

The Capital Area Regional Planning Commission (CARPC) is one of nine regional commissions in Wisconsin tasked with coordinating planning and development across municipalities. CARPC focuses on land use planning and areawide water quality management, working to protect and enhance the region's water resources, including Koshkonong Creek. In partnership with Capitol Water Trails, the Wisconsin State Trails Council, and the University of Wisconsin–Madison, CARPC developed an innovative web-based tool to identify and track obstructions in Wisconsin waterways, which is now available for use statewide.

3.3.2 COMMUNITY INPUT

Community events are one way to work with local organizations and community members in the watershed. Events help to increase awareness and education, allowing community members to learn more about the watershed and their community, and, most importantly, to identify the key concerns and hopes of the community, and how those can be addressed moving forward.

The first event during this project's involvement was hosted by CWT and FOKC on April 29, 2023 (see Figure 3.1). About 30 community members attended outside of our cohort. Steve Falter, the leader of CWT, gave a presentation about the creation and maintenance of water trials, and Dave Muehl, leader of FOKC, oversaw discussion about the future of the creek with other community members. Additionally, another group of students from UCA presented their governance report as well.

The next community event was a workday on November 4, 2023, where our cohort, as well as some community members, mainly from FOKC and CWT, cleared obstructions in the creek (see Figure 3.2). Afterwards, we gave a brief presentation about our Summer 2023 fieldwork.

Figure 3.1. Cohort members and stakeholders having a discussion at the April 29 event.

The last event was held on March 9, 2024, at Deerfield Coffeehouse. This event was a Community Visioning Workshop with the goal of identifying the community's top concerns and goals with regards to the future of Koshkonong Creek. Community members were split into small groups with each other and with at least one of our team members. We charted the community members' input, and after about an hour and a half of discussion, the larger group came together and compared each group's highlighted concerns and hopes/goals. We used what we learned from the community at this event to inform our vision plan and recommendations for the Koshkonong Creek Watershed. Figure 3.3 shows the top concerns and goals of the group at this event for the future of the watershed.

Figure 3.2. Cohort member German Gonzalez removing obstruction at November 4 cleanup event.

On December 13, 2023, our final project presentation was given, and around 30 individual stakeholders from the watershed, as well as UW faculty and students, WDNR employees, and other interested folks, attended both online and in person. This allowed for community members to provide feedback on our preliminary results of our research, and helped us to understand further what they would like to see in this final report.

3.4 Recommendations

Many stakeholders in our study area expressed their concerns over the lack of coordination across governmental entities, other groups, and individuals. To address this, we recommend that FOKC expands its membership and that groups within the watershed continue and further their collaborations. Moreover, increasing opportunities for volunteering, improving recreational access, hosting community events, and streamlining existing efforts will further bolster efforts towards sustainable watershed management.

In addition to FOKC increasing its membership, registering as a 501(c)3 nonprofit organization can help raise the group's profile with potential funders and other entities, including governments, other NGOs, and other community members. Additionally, FOKC could become a chapter of RRC. To do so, the group would need to approach RRC to request chapter status, and work with RRC to develop goals and a plan to accomplish them; the RRC Board would need to approve them as a chapter. The RRC expects that chapters will either complete their expected goals and dissolve or become their own incorporated nonprofit. Registering as a 501(c)3 nonprofit and potentially joining other groups such as RRC could help sustain FOKC as an organization focused on improving and restoring the

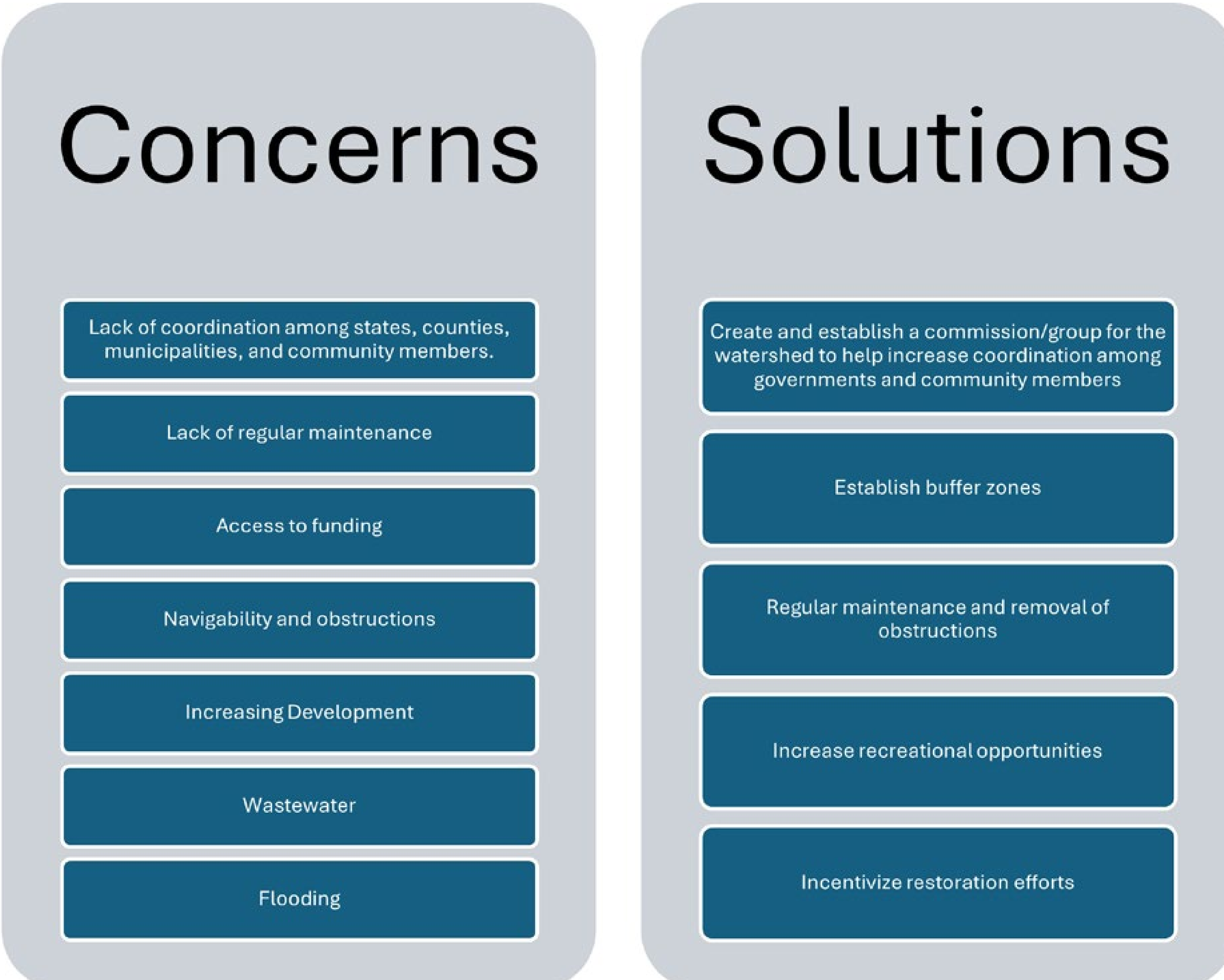


Figure 3.3. Most commonly mentioned concerns and solutions by stakeholders at the March 9 Community Visioning Workshop.

creek, improving creek access, and addressing the needs of watershed stakeholders.

Building common purpose and expanding trust among stakeholders involved can begin with informal conversations, and eventually can grow further through workshops, kayak trips, seminars, and other events. There are many potential directions for stakeholder events. In general, they should focus on educating the community about the importance of watershed health, the local ecosystem, and the impact of human activities on the creek. By inviting scholars from universities, environmental organizations, and local government agencies, these sessions can provide credible information and stimulate interest among community members. Interactive elements, such as water testing demonstrations, do-it-yourself conservation techniques, and watershed mapping activities, will make these events more engaging. Field trips are another effective way to educate and involve the community. Guided tours of the creek can highlight significant areas, showcasing both problem spots and pristine regions to illustrate the impact of pollution and the benefits of conservation efforts. Partnering with local schools to integrate watershed education into their curriculum and organizing school excursions will provide students with practical environmental science experience. Planning field trips around seasonal events, such as bird migrations or fish spawning, can further demonstrate the dynamic nature of the ecosystem. Having the foundation of an involved and well-connected community will help address other problems and recommendations mentioned throughout this report. Through concerted action and inclusive participation, stakeholders can set Koshkonong Creek on a sustainable path for generations to come.

SECTION 4: SEDIMENT ACCUMULATION

4.1. Introduction

Excess sediment in the creek is one of the primary concerns among stakeholders. Sediment is a pollutant that comprises soil particles that have been detached from land due to various factors. When soil erodes, sediments are washed into the streams and rivers. Sediment in the streams is usually higher in exposed areas such as where riverbanks are grazed by livestock or lack riparian vegetation. Sediment can come from soil erosion and runoff from agricultural lands, which can also include nutrients such as nitrogen, phosphorus and other pollutants that can also arise due to decomposition of plants and animals in the creek (Mid-America Regional Council, 2006). Near Koshkonong Creek, agricultural expansion and poor land management practices have resulted in a range of ecological challenges in the surrounding area. The runoff from neighboring farms could be the main source of elevated levels of phosphorus, primarily attributed to the extensive use of commercial fertilizers (Environmental Protection Agency, 2015). Additionally, the absence of riparian vegetation along the creek banks exacerbates sediment erosion, resulting in significant sediment accumulation within the creek. Increased soil erosion may also be influenced by the regulated flow from the Sun Prairie Wastewater Treatment Plant. These factors can contribute to flooding onto the land surrounding the creek, which has become an inevitable issue. Increased sedimentation raises water levels and reduces water flow, which compounds both flooding and nutrient overload within the creek. The high levels of phosphorus and nitrogen released into the creek due to runoff leads to excessive growth of aquatic vegetation which can completely cover the surface of the creek and affect the aquatic ecosystem by blocking sunlight and depleting oxygen levels (National Oceanic and Atmospheric Administration, 2024) (see Figure 4.1).

Figure 4.1. Blanket of duckweed and suspended sediments.

4.2 Sediment Analysis

To assess the sediment quantity and contaminants within the creek, our team conducted a series of sediment analyses within our project study area. Here we describe the methods used for sediment volume estimation and sediment quality analysis, along with the results and recommendations for considering sediment basins, vegetative strips, and dredging.

4.2.1 SEDIMENT VOLUME ESTIMATION

The analysis was focused on the section between County Road BB and Oak Park Road, employing two distinct methodologies (described below) to complete the comprehensive assessment (Figure 4.2). This approach involved the systematic collection of sediment depth data at various points along the creek to understand the overall sediment buildup in the study area. Excessive sedimentation can impede the hydraulic capacity of water flow, diminishing its efficiency in conveying water throughout the creek. Identifying areas with significant sediment accumulation is key to understanding where effective mitigation strategies are necessary.

4.2.1.1 GNSS Method

Global navigation satellite system (GNSS) is a general term describing any satellite constellation that provides positioning, navigation, and timing (PNT) services on a global or regional basis. GNSS methods work when a constellation of satellites provides signals from space to the GNSS receiver, which then provides the position coordinates and sediment depth in real time. To calculate the distance from the antenna to the satellite, the receiver multiplies the travel time, (the time taken by the signal to travel from the satellite to the receiver) by the speed of light. If the GNSS receiver is receiving messages from at least four satellites, it can then triangulate its location anywhere on the surface of the earth.

The GNSS equipped with Real-Time Kinematic (RTK) positioning connected to the Wisconsin Continuously

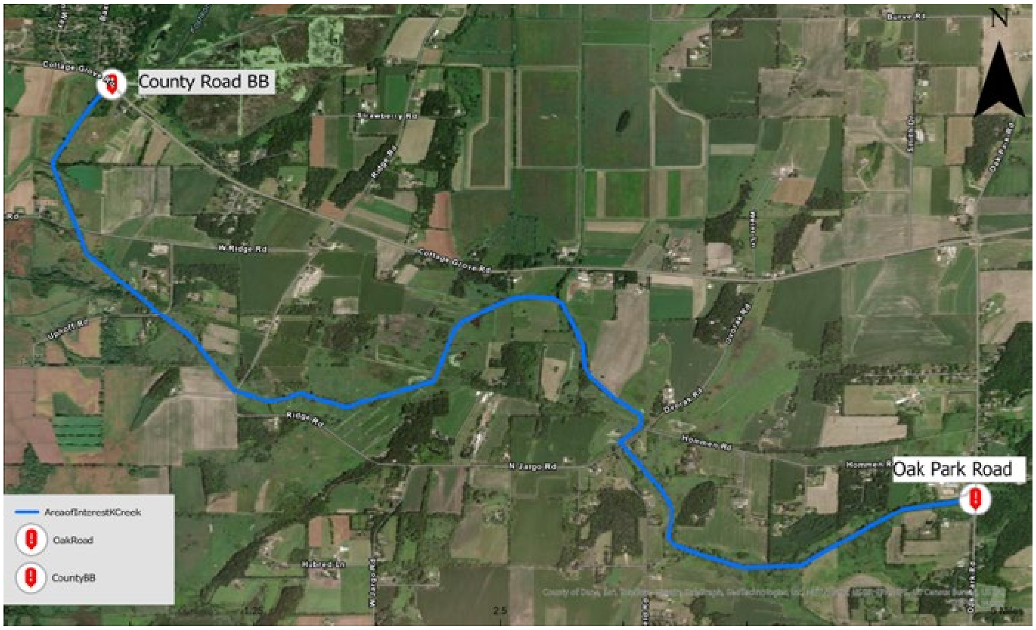


Figure 4.2. Map showing County BB Road and Oak Park Road (Scale 1:24,000).

Figure 4.3. GNSS receiver was used to calculate location and sediment depth. Photo by Bryce Richter/UW–Madison

Operating Reference Stations (WISCORS) network was utilized to collect precise elevations of the creek bottom and the sediment surface along selected transects of Koshkonong Creek. This technology was also important in validating the terrain data that was utilized in the hydraulic model, which is described in Section 4. Water surface elevation (WSE) measurements were also taken at transects representing the boundaries subject to change within the hydraulic model, which provided validation for the hydraulic model representing existing conditions. This method was used to collect the sediment depth and the WSE at three different locations throughout the study area (see Figure 4.3). With the usage of the GNSS receiver, the coordinates of the mapped points were able to be plotted automatically.

A proper connection was established with the GNSS instrument by selecting strategic points along Koshkonong creek; measurements were carried out at the endpoints and at a possible central location of the selected stretch of the creek. Connection errors increased in the presence of a dense canopy, because when the signal from the satellite arrives at the surface of the earth, it can reflect off obstructions such as trees before making it to the antenna. The signal arrives at the antenna by "multiple paths," introducing a type of error called multipath error (Geospatial Trimble, 2022) (see Figure 4.4). Although some antennas are programmed to reduce the multipath interference to a minimum, it cannot be completely eliminated. Due to the possibility of error, the increased obstructions present in the creek, and to continue collecting sediment depth, our team moved on to the second method, the spot sediment collection method.

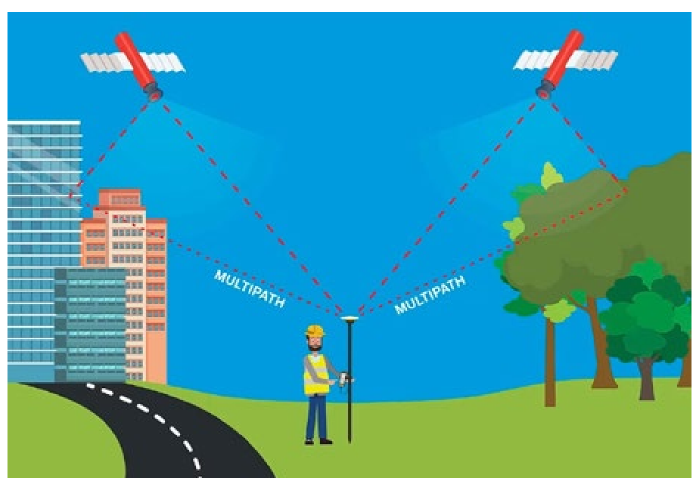


Figure 4.4. Multipath error.

4.2.1.2 Spot Sediment Collection Method

Spot sediment collection method is a manual method used to calculate sediment depth. In this method, our team used kayaks to paddle the creek through the entire study area. This method was primarily used due to comparable ease of accessing the sediment depth and compatibility with the maneuverability of the kayaks through narrow obstructions, allowing the team to efficiently collect accurate sediment data at the necessary transects. The team kayaked at different locations and manually collected sediment depths at various points in the study area, using a measuring stick and simultaneously collecting the GPS location of collection points (see Figure 4.5).

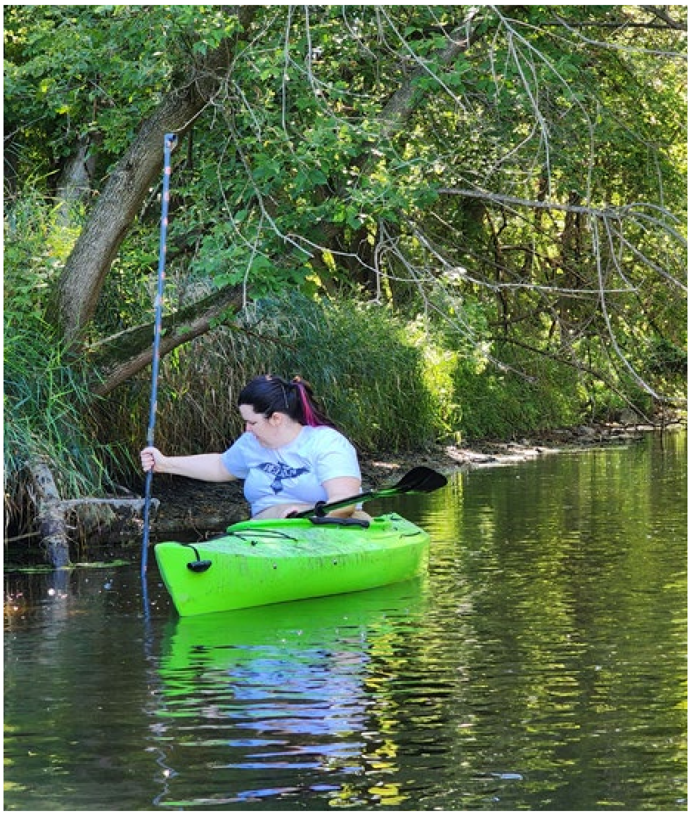


Figure 4.5. Collecting sediment depth using a measuring stick.

At each transect, three points were collected: the left bank, the center of the creek, and the right bank (see Figure 4.6a). The GPS points were plotted into a spreadsheet and then mapped in ArcGIS Pro. Subsequently, all the sediment depth values were written and calculated into a spreadsheet, which were then graphed onto a modelling software called SketchUp. This played an important role in quantifying the overall sediment load within the study area. Sediment depth for a total of 69 transects were collected by the team in the study area. Figure 4.6b shows the three points collected at a transect within the study area.

Figure 4.6a. Spot sediment collection method, 3 points are collected at each transect.

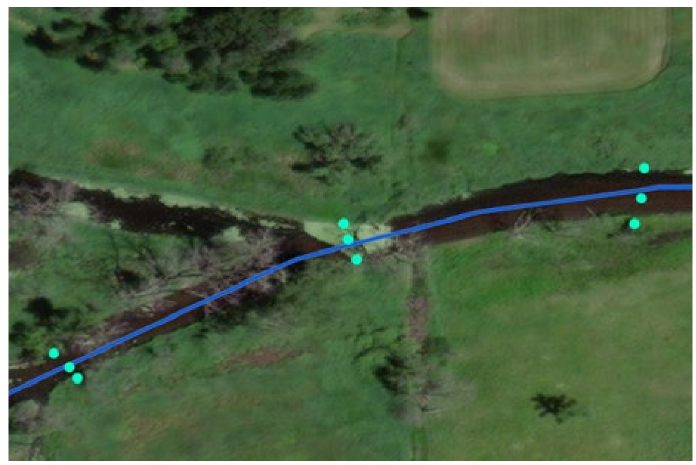


Figure 4.6b. Zoomed image showing the three points are collected at each transect [near Badger Farms].

4.2.2 SEDIMENT QUALITY ANALYSIS

Following the determination of the total sediment load in the study area, a sediment quality analysis was necessary to inform possible disposal methods as required by the WDNR and landfills. This analysis adhered to the protocol outlined in Wis. Admin. Code § 347.06 which provides guidelines for Sampling and Analysis.

In the event a landowner intends to remove sediment from the creek, necessary permits would need to be obtained as well as following proper county and WDNR procedures. In the case of dredging as a removal method, an individual would first need to consult WDNR staff in a pre-application process. As part of this pre-application, the applicant may be asked to provide an analysis of sediment samples from the site. WDNR staff would also specify the amount and locations to be sampled as well as the parameters to be analyzed.

Table 4.1. Recommended analytes to sample for in sediment quality analysis suggested by the WDNR Office of Great Waters staff.

Required Parameters for Testing		
Parameter	Suggested Analytical Method	Required Detection Limit (ug/g dry)
Inorganic Metals		
Arsenic	SW-846 3050B/6010B/C/D	1
Cadmium	SW-846 3050B/6010B/C/D	0.1
Chromium (total)	SW-846 3050B/6010B/C/D	0.5
Copper	SW-846 3050B/6010B/C/D	0.5
Lead	SW-846 3050B/6010B/C/D	1
Mercury	SW-846 7471/A/B	0.015
Nickel	SW-846 3050B/6010B/C/D	0.5
Zinc	SW-846 3050B/6010B/C/D	0.5
Inorganic Nurtients		
Total Phosphorus	Bray-1, USGS I-6600, EPA 365.1	9.9
Nitrate + Nitrite	Flow Injection (Lachat), EPA 300.0, EPA 350.1	0.25
Ammonia-Nitrogen	USGS I-6522, EPA 1690	0.16
Total K-Nitrogen	Total Nitrogen, SM 4500Norg B/C, EPA 351.2	
Particle Size Analysis	ASTM D-422 (%)	

To help inform sediment removal options in the creek, we consulted WDNR staff working in sediment contamination on what an applicant might be asked to sample for if a pre-application were submitted for this area. It was recommended that five sediment core samples should be taken from the project area approximately equidistant from each other. Each sample needed to be mixed to homogenize the core and a grab sample should be taken from the core resulting in five total samples to be submitted for analysis across the project area. The analytes that were suggested to test for are outlined in Table 4.1.

We adapted this methodology due to budget constraints, landowner interests, and academic purposes. We informally interviewed several landowners to learn about their observations in and around their property over time related to creek water levels, obstructions, and sediment depths. The area of primary concern was a stretch of the creek near Amber Lane (Figure 4.8). We sampled at this location in addition to five others that were chosen in order to obtain a representative sample of possible creek contaminants throughout the study area. The five remaining sites were selected because they allow easy access to the creek and are approximately evenly distributed among each other.

At each of the six sites, we collected three core samples that were distributed equidistant downstream from one another within a proposed project area. Samples were taken by wading into the creek and using a 3-inch piston core to collect the sediment. The core was vacuum sealed in the tube and released into a mixing bowl. Once all three samples were placed into the mixing bowl from an individual site, the sediment was well mixed. We took a final sample from the homogenized sediment, placed it into a 32-ounce jar and sent it to the Wisconsin State Lab of Hygiene (WSLH) to be analyzed (Figure 4.7). This was repeated at the six selected sites along the creek within the watershed (Figure 4.8) for purposes of capturing possible variations of metals and nutrients. We collected three of the six samples in August, and the other three were collected in October. All of the metals and nutrients that the WDNR recommended to be tested were analyzed, but particle size was not included in the lab analysis.

Figure 4.7. Mason jar filled to the brim with homogenized sediment mixture.

Figure 4.8. Six sediment analysis sites along Koshkonong Creek within the study area. From left to right: Baxter Road, County BB, Ridge Road, North Jargo Road, Amber Lane, Highway 73.

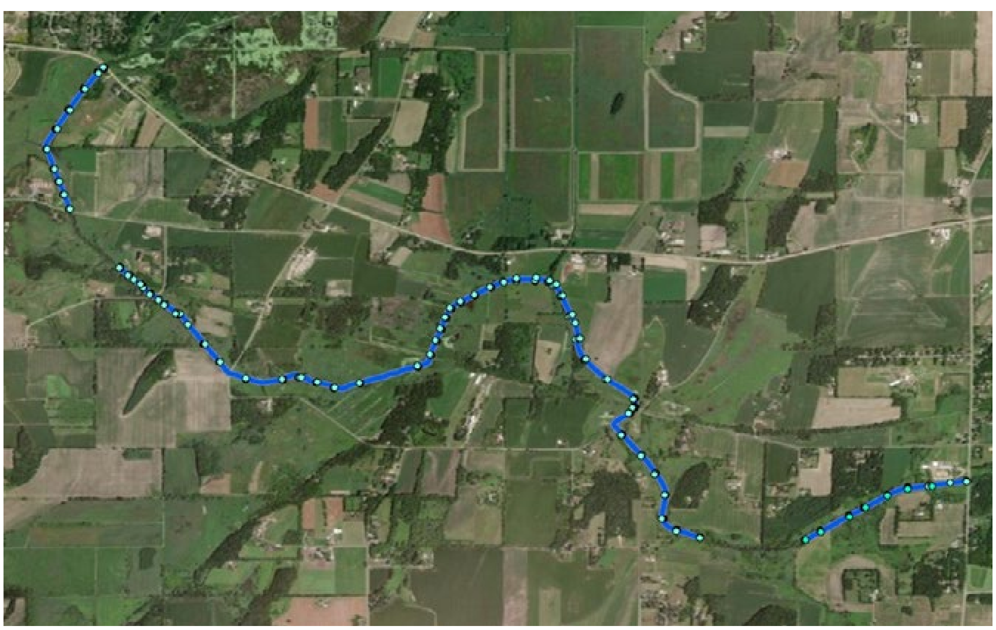


Figure 4.9. A total of 69 transects were collected in the study area.

4.2.3 RESULTS

The analysis of sediment volume within the study area provided a comprehensive understanding of the quantity and distribution of sediments, shedding light on the potential environmental impacts. Simultaneously, the examination of the sediment quality helped quantify metals and inorganic chemicals present in the creek and assess the ecological health and potential contaminant levels in the ecosystem.

4.2.3.1 Sediment Volume Analysis

In the sediment volume analysis, all the collected points from the fieldwork were put together in a spreadsheet and converted into visual points in SketchUp and also plotted onto the ArcGIS software. Figure 4.9 shows all the transects that were plotted along Koshkonong Creek, which starts from a point near BB road to a point flowing near Oak Park Road. The large visible gaps between transect points seen in the figure show the presence of log jams and obstructions in the creek that were inaccessible and difficult to kayak through, making it almost impossible to measure sediment depths in that area.

Subsequently, we modeled and computed the total sediment volume along the stretch, which amounted to 51,190 cubic yards. To provide context, if we consider the standard capacity of a dump truck at 15 cubic yards, the sediment volume within the study area would be equivalent to approximately 3,412 dump trucks.

Additionally, the sediment analysis has identified several critical areas where the sediment accumulation significantly obstructs the creek's flow. A sediment ratio (sediment thickness compared to the relative creek height at that transect) of 70 percent or more was assumed to signify critical sediment buildup at that transect of the Koshkonong Creek. Out of the total number of measured transects, 16 transects were identified as zones with critical sediment buildup. These high-occupancy sediment zones, highlighted on the GIS

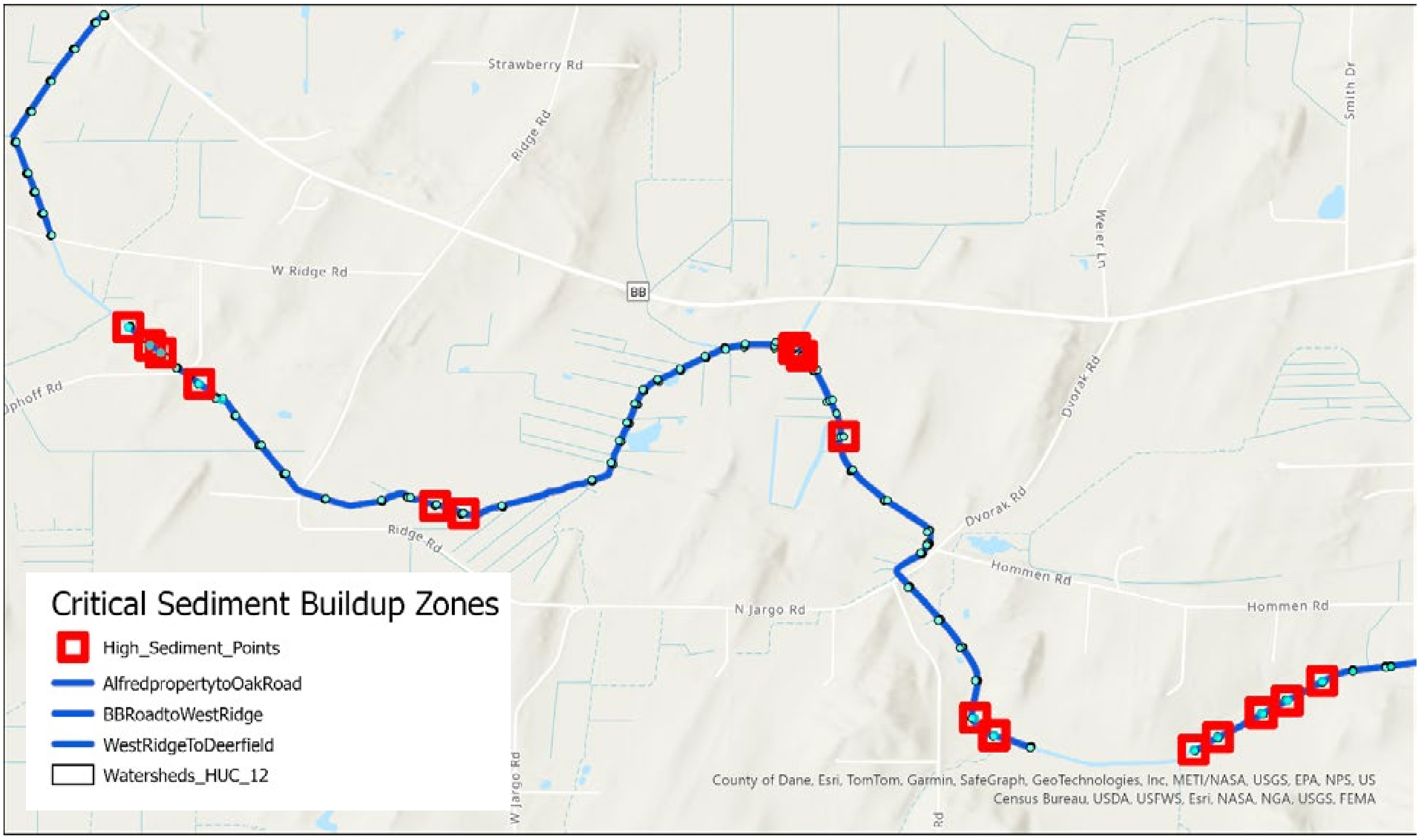


Figure 4.10. Critical sediment buildup zones were found at 16 transects along the selected study site.

map in Figure 4.10, represent areas where the creek capacity is substantially reduced, potentially increasing the flooding risks and impacting the aquatic habitats. Addressing these critical sediment buildup zones should improve the flow conditions and overall creek health.

Elevated levels of sediment can greatly impact aquatic life due to the increase of turbidity, disruption of natural flow, depletion of habitat, and decreased oxygen levels in the water. Along specific areas of the creek, we observed an obvious depletion of vegetation along the banks, primarily due to continuous grazing of livestock, which can increase erosion (Al-Kaisi et al., 2024). The absence of protective vegetation allows rainwater and runoff to directly erode the exposed soil, leading to higher sediment loads in the water. This sediment volume analysis provides a foundation for determining the necessary removal of sediment and prioritization of critical sediment buildup points to facilitate restoring the ecological balance of the creek and improve its aquatic habitat.

4.2.3.2 SEDIMENT QUALITY ANALYSIS

We compared the sediment quality results analyzed by the WSLH to the Consensus-Based Sediment Quality Guidelines (CBSQGs) developed by MacDonald et al. (2000), which are the standards that the WDNR has followed since 2003. These guidelines outline criteria for several metals, but do not include phosphorus and nitrogen, so different standards were used for the observed nutrient concentrations in the samples. The CBSQGs are separated into four tiers of levels of concern based on toxicity to benthic-dwelling organisms (Tables 4.2 and 4.3). Level 1 is less than or equal to a lower

Table 4.2. Pollution threshold definitions outlined in MacDonald et al. (2000).

Level of Concern	Threshold Effect Concentration (TEC)	Level of Concern	Midpoint Effect Concentration (MEC)	Level of Concern	Probable Effect Concentration (PEC)	Level of Concern
Level 1	From CBSQGs	Level 2	TEC + PEC/2 = MEC	Level 3	From CBSQGs	Level 4
≤TEC		>TEC ≤MEC		>MEC ≤PEC		>PEC

threshold effect concentration (TEC), Level 2 is greater than TEC but less than or equal to the midpoint effect concentration (MEC), Level 3 is greater than MEC but less than or equal to probable effect concentration (PEC), and Level 4 is greater than PEC. All metals tested at each of the sites fell within the Level 1 category indicating that these levels are not toxic to benthic-dwelling species (Table 4.4).

Since the CBSQGs does not include criteria for nutrients, we determined pollution levels for

Table 4.3. Recommended sediment quality guideline values for metals and associated levels of concern to be used in doing assessments of sediment quality.

Metal	mg/kg dry wt.++							
	Level 1 Concern ≤ TEC	**TEC**	**Level 2 Concern > TEC ≤ MEC**	**MEC**	**Level 3 Concern > MEC ≤ PEC**	**PEC**	**Level 4 Concern > PEC**	**Source of SQG Effect-Based Concentrations**
Antimony	◄	2	◄ ►	13.5	◄ ►	25	►	NOAA (1991)[1]
Arsenic	◁	9.8	◁ ▷	21.4	◁ ▷	33	▷	CBSQG (2000a)[2]
Cadmium	◁	0.99	◁ ▷	3.0	◁ ▷	5.0	▷	CBSOG (2000a)
Chromium	◁	43	◁ ▷	76.5	◁ ▷	110	▷	CBSQG (:200Qa)
Copper	◁	32	◁ ▷	91	◁ ▷	150	▷	CBSQG (2000a)
Iron	◁	20,000	◁ ▷	30,000	◁ ▷	40,000	▷	Onlario (1993)[3]
Lead	◁	36	◁ ▷	83	◁ ▷	130	▷	CBSOG (2000a)
Manganese	◄	460	◄ ►	780	◄ ►	1,100	►	Ontario (1993)
Mercury	◄	0.18	◄ ►	0.64	◄ ►	1.1	►	CBSQG (2000a)
Nickel	◄	23	◄ ►	36	◄ ►	49	►	CBSOG (2000a)
Silver	◁	1.6	◁ ▷	1.9	◁ ▷	2.2	▷	BC (1999)[4]
Zinc	◁	120	◁ ▷	290	◁ ▷	460	▷	CBSQG (2000a)

++ The CBSQGs for orgamc compounds are expressed on a dry weight concentration at 1 % TOC m sediments. However, unlike the organic compooods, the CBSQG and study site metals concentrations can be compared on a bulk chemistry basis and do not need to be adjusted to a 1 % TOC basis to do the comparison. TOC does not play the same role in determining metals availability as It does fn detennining organic compound availability (source, MacDonald et al., 2000).

Table 4.4. Concentration of heavy metals present in collected sediment samples.

Location	Analytes							
	Arsenic (ppm)	Cadmium (ppm)	Chromium (ppm)	Copper (ppm)	Lead (ppm)	Nickel (ppm)	Zinc (ppm)	Mercury (ppm)
BAXTER RD AT COTTAGE GROVE RD	5.68	ND (Not Detected)	18.4	23.1	17.0	18.2	111	0.0639
JARGO RD	7.58	ND	7.92	9.21	9.79	6.03	35.5	0.0248
HWY 73	5.57	ND	17.5	16.3	9.60	13.4	62.3	0.0425
BAXTER RD TWA SITE ROADSIDE		ND	10.0	10.9	8.54	9.13	57.2	0.0220
RIDGE RD,	6.07	ND	21.7	26.5	17.4	16.5	99.3	0.0821
AMBER LANE,	6.55	ND	20.1	19.6	13.1	14.8	83.5	0.0636
WDNR Maximum Contaminant Level (ppm) [Not Polluted]	≤9.8	≤0.99	≤43	≤32	≤36	≤23	≤120	≤0.18
WDNR Maximum Contaminant Levels (ppm) [Moderately Polluted]	9.9 – 25	1.0 – 4.0	44 – 109	33 – 149	37 – 129	24 – 48	121 – 460	0.19 – 1.1
WDNR Maximum Contaminant Levels (ppm) [Heavily Polluted]	>25	>5	>110	>150	>130	>49	>460	>1.1

ammonia, Total Kjeldahl Nitrogen (TKN), and phosphorus by comparing to the Guidelines for the Pollution Classification of Harbor Sediments developed by the US EPA Region V in 1977 (EPA, 1977). These guidelines were initially developed for Great Lakes harbor sediments and developed somewhat arbitrarily with a lack of scientifically-backed research (EPA, 1977). However, there are no alternative guidelines to follow for these parameters and these guidelines were recommended to use for dredged material disposal purposes by WDNR staff.

Table 4.5 summarizes the pollution criteria outlined in the 1977 guidelines. According to these criteria, all sites tested were considered heavily polluted for TKN except the Targeted Watershed Assessment (Amrhein and Sorge, 2018) site at Baxter Road, which was categorized as moderately polluted. The Baxter Road at Cottage Grove Road and Amber Lane sites are considered moderately polluted for ammonia whereas all other sites are in the not polluted category. The sites at Jargo Road and HWY 73 are moderately polluted for phosphorus and the rest of the sites are heavily polluted. Concentrations for each site are summarized in Table 4.6. In consultation with WDNR staff, given that the creek is located in a heavily agricultural watershed, these values are high, but are to be expected.

The detailed analysis of the heavy metals and the inorganic chemicals in the sediment samples provides a snapshot into the creek's environmental status. While the heavy metals align with the low pollution levels, the pollution level of ammonia in the highly polluted sites would require management strategies targeted at nitrogen reduction. The ele-

Table 4.5. Sediment criteria for ammonia, TKN, and phosphorus set by EPA Region 5 (1977).

1977 EPA Guidelines			
mg/kg			
Parameter mg/kg	Not Polluted	Moderately Polluted	Heavily Polluted
Ammonia	<75	75 – 200	>200
Total Kjeldahl Nitrogen	<1,000	1,000 – 2,000	>2,000
Phosphorus	<420	420 – 850	>850

Table 4.6. Concentration of inorganic chemicals present in collected sediment samples.

Location		Analyses		
	Total Kjeldahl Nitrogen (ppm)	Nitrate + Nitrite (as N) (ppm)	Ammonia (ppm)	Phosphorous (ppm)
BAXTER RD AT COTTAGE GROVE RD	2450	ND (Not Detected)	179	1530
JARGO RD	2160	ND	56.1	713
HWY 73	4400	ND	33.3	839
BAXTER RD TWA SITE ROADSIDE	1630	ND	30.0	882
RIDGE RD	5140	ND	42.2	1500
AMBER LANE	4670	10.4	110	1430
EPA Maximum Contaminant Level (ppm) [Not Polluted]	< 1000		<75	≤420
EPA Maximum Contaminant Levels (ppm) [Moderately Polluted]	1000 - 2000		75 – 200	420 – 850
EPA Maximum Contaminant Levels (ppm) [Heavily Polluted]	>2000		>200	>850

vated levels of nitrogen and phosphorus, though common for water bodies near agricultural farmlands, does raise the need for sustainable land management practices to prevent potential impacts on water quality and ecosystem health. Phosphorus and nitrogen management can help ensure the continued sustainability of the creek and its surrounding environment.

4.3 Recommendations

While the sediment volume presents challenges, heavy metal concentrations in the sediments all fall below state guidelines, suggesting minimal risks to water quality. However, inorganic forms of nitrogen and phosphorus present ongoing concerns that warrant attention. Though proper sediment disposal is feasible due to the absence of toxic pollutants, creek material must still be handled responsibly so as to mitigate potential environmental repercussions. We outline three options below as potential components of a sediment removal strategy.

4.3.1 SEDIMENT BASINS

Sediment basins are temporary ponds with appropriate control structures that are designed and constructed to handle the anticipated excess runoff and sediment from nearby agricultural farms (see Figure 4.11). According to the Minnesota Stormwater Manual, if properly designed, installed, and maintained, an 80 percent or greater sediment removal efficiency can be achieved, mostly depending on the soil particle size. Sediment basins function by intercepting and detaining the site runoff, which allows the sediment to settle before discharge. Sediments are periodically removed to sustain functionality of the basins. Proper placement of sediment basins is important and would require technical and design assistance.

Advantages:

- **Effectively captures and detain soil particles, preventing them from entering water bodies.**
- **Improves the overall water quality of the creek, reduces turbidity and suspended sediments (Minnesota Stormwater Manual, 2018).**
- **Preserves the health of aquatic organisms due to the reduction of suspended sediments in the creek.**
- **Possible protection of the soil structure from increased runoff from the farms and prevents excessive erosion (Minnesota Stormwater Manual, 2018).**

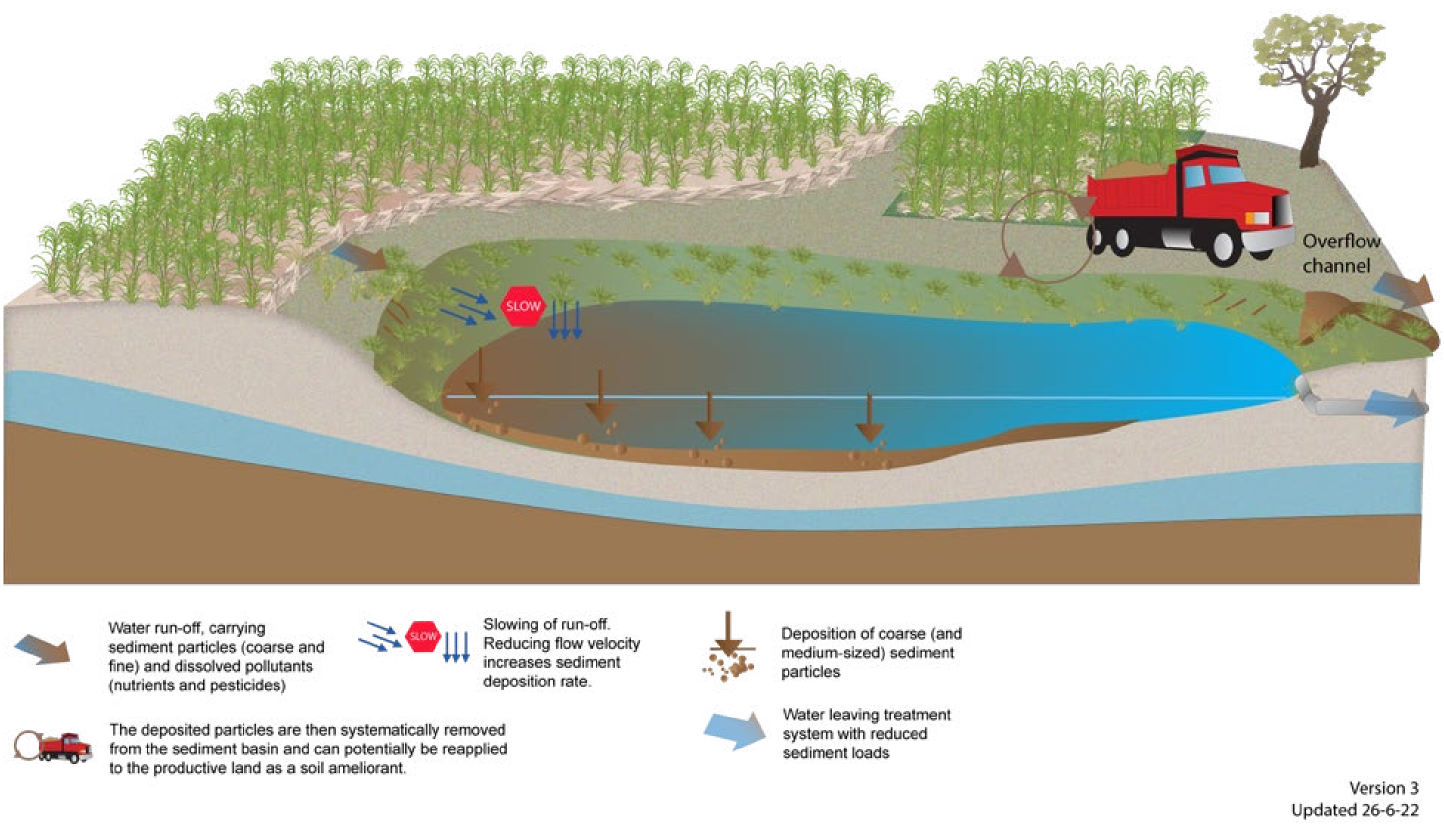


Figure 4.11. A typical sediment basin. Source: wetlandinfo.des.qld.gov.au/wetlands/management/treatment-systems/for-agriculture/treatment-sys-nav-page/sediment-basins

Disadvantages:

- **Regular maintenance of the sediment basins is required to ensure proper effectiveness, and the accumulated sediment must be removed periodically.**
- **During extreme weather conditions, if the basin has not been properly maintained or designed, it will lead to the possible resuspension of sediment particles and downstream sedimentation issues (Minnesota Stormwater Manual, 2018).**

4.3.2 VEGETATIVE STRIPS

A vegetative strip is an area of low growing dense plantings between agriculture and other disturbed areas (see Figure 4.12). They are used to protect water quality, and they are often referred to as strips of indigenous vegetation that are positioned between a potential pollutant source and a surface water body that receives runoff. Their primary functions include slowing stormwater velocities, filtering out sediment and other pollutants, some infiltration into the underlying soil, and reducing bank erosion (EPA, 2021).

Advantages:

- **Vegetative strips include dense planting of vegetation that reduce the risk of erosion within the waterway and also can withstand relatively high-velocity (EPA, 2021).**
- **Provides high pollutant removal: studies have shown average load reductions of 56 percent for total nitrogen, 66 percent for total phosphorus, and 86 percent for total solids (EPA, 2021).**
- **Enhance the soil structure and the water infiltration, reduce surface runoff and improve groundwater recharge (EPA, 2021).**

Disadvantages:

- **Proper design requires careful planning and execution. Regular maintenance of the vegetative filter is required to ensure proper effectiveness, including monitoring vegetation, regular mowing, trimming, fertilizing, and removal of accumulated sediment and debris (EPA, 2021).**
- **Could possibly serve as refuge for pests and damage nearby crops (Sanders 2023).**

4.3.3 DREDGING

Dredging is the removal of sediments from a waterway. Koshkonong Creek stakeholders expressed strong interest in dredging as a solution to mitigate flooding and sedimentation concerns. Dredging is commonly desired among landowners near shallow creeks, often to help improve water access to larger creeks or rivers (Center for Coastal Resources Management, 2010). Dredging has multiple uses, including enhancing water quality, improving water flow, and aiding

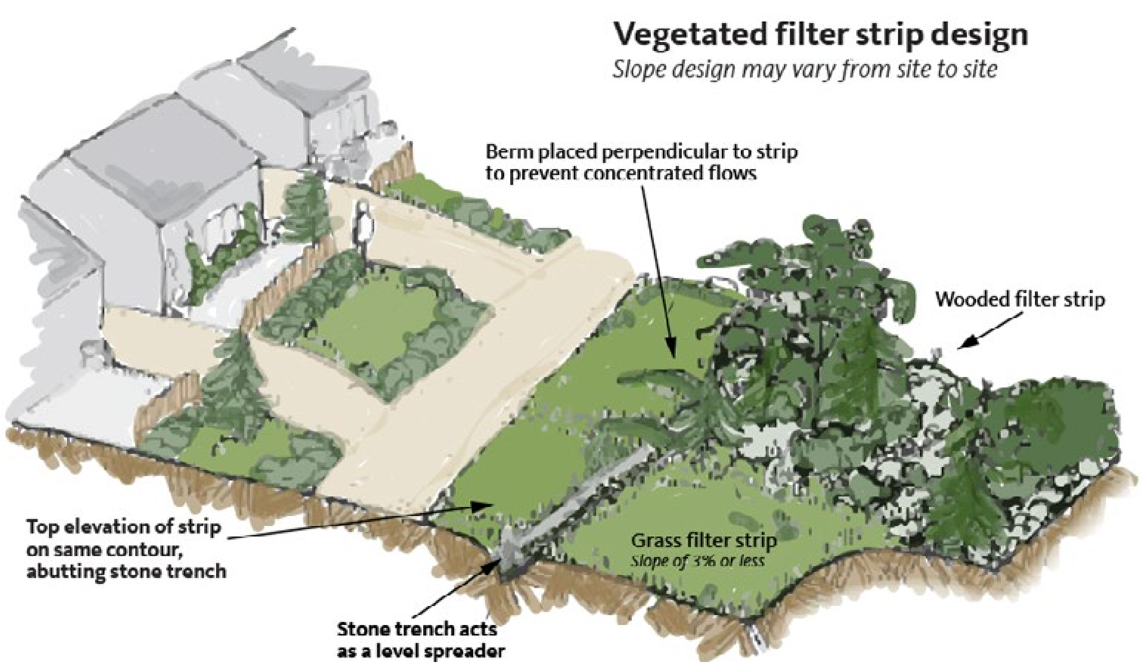


Figure 4.12. Types of vegetative strips. Source: edis.ifas.ufl.edu/publication/SS646

in navigation (Griffis et al., 1995; Nayar et al., 2004). It can enhance the creek's hydraulic efficiency by removing large amounts of sediment that contains potentially polluted material and may reduce the risk of flooding during heavy rainfall in the short term. Dredging a small creek, although a potential solution to mitigate flooding and sedimentation issues, poses several challenges. Possible negative ecological impacts as a result of dredging include increased turbidity, resuspension of sediments, soil contamination, and habitat disturbance (Pennekamp et al., 1996; Manap and Voulvoulis, 2014; Lu et al., 2019). Additionally, if not accompanied by improved erosion management, sediment will reenter the creek over time and require repeated dredging to maintain the benefits. Because of these factors, dredging projects in small creeks can become costly, involve resources of time and equipment, and require permits; the overall process is logistically challenging and arduous.

In Wisconsin, Wis. Stats. 30 outlines policies and procedures to be followed when developing a dredging project and additional conservation measures that can be taken to ensure the success of the project. Variables such as the location of the project, contaminants in the sediment, amount of sediment planned to be removed, and the disposal site of the dredged material will determine the permit necessary for the project. If the project is eligible for a general permit, the review can be done within 30 days and cost between $300 and $800, but if an individual permit is necessary, the process is much more intensive. This would require a public comment period and possibly a public hearing which could take up to 135 days to complete. Some projects may be exempt from permitting requirements if exemption requirements are met. All applicants must meet with a WDNR staff member as a part of the pre-application meeting requirement and this meeting will help determine which if any permit type is necessary.

Many factors are assessed when determining permitting options. Landowners in the watershed would most easily be exempt from permitting if it were done manually and met the requirements listed on the WDNR's Manual Dredging Checklist (Manual Dredging Checklist, n.d.). Erosion control and wetland filling need to be considered when deciding to manually dredge. This requires that exposed soil during construction needs to be stabilized through revegetation, rip rap, or other approved methods. Dredged material cannot be discarded in a wetland even if it is only temporary. Additionally, a manual dredging project would be exempt if no more than 100 square feet and 1 foot in depth of sediment were to be removed in a single calendar year according to the Manual Dredging Checklist. If these criteria among others listed in the Manual Dredging Checklist are not met, the applicant must apply for a general permit.

In the project study area for Koshkonong Creek, a large portion of the land is mapped as a wetland in the Wisconsin Wetland Inventory (WWI) which has implications for disposal methods. Even if a landowner were to be exempt from WDNR dredging permitting requirements, the dredged material cannot be discarded on private lands mapped as wetlands for any period of time. A landowner would need to verify on WDNR's Surface Water Data Viewer that the land in which they want to dispose of the creek sediments are not mapped as wetlands in the WWI. In the event a landowner cannot dispose of sediment on their own property due to wetland proximity, the only other option would be to transport the material to a landfill.

In Dane County, landfills that accept dredged material are Dane County Landfill and Madison Prairie Landfill. However, coordination with landfills can be costly and time consuming. The Dane County Landfill requires sediment analysis testing for any amount of material disposed of and requires retesting for every 500–1,000 cubic yards brought to the facility. The sediment would need to be tested for heavy metals, volatile organic compounds (VOCs), semi-VOCs, pesticides, herbicides, and polychlorinated biphenyls (PCBs). Each lab would have their own cost associated with these analyses. For context, the sediment analysis for this study included testing for heavy metals, TKN, ammonia, and phosphorus at each site. Combined costs for these analyses was $371 for each of the six sites that we sampled (total $2,226). Additionally, the disposal cost will be $56/ton with a $200 profile fee which involves an evaluation by landfill staff. The Madison Prairie Landfill charges $52/ton (4 ton minimum) and an additional $150 profile fee. There will also be a 14.5 percent wastewater management fee, a variable energy surcharge, plus taxes on total costs. The effort and resources required for this can become a barrier and this process may need to be repeated due to continued, unmanaged sedimentation.

Based on recollections from residents in the Koshkonong Creek Watershed, historic dredging has occurred in various locations along the Koshkonong Creek. A Koshkonong Creek Watershed Management Study published in 1982 (Water Resources Management Workshop, 1982) also mentions dredging and channel straightening of the creek. One resident, Randy Zakowski, described historic dredging that occurred along the creek on his land where sediment was disposed of on the creek banks. This can be seen in a DEM of the land where the banks are much higher than adjacent land due to sediment piles (Figure 4.13). Despite this, there is no documented evidence of historical dredging which one can speculate is due to a difference in permitting processes required at the time of dredging, the project was exempt from permitting, or was conducted without review and authorization. Today, many stretches of the creek remain high in sediment and the FOKC among other residents are interested in dredging out excess sediment for purposes of improving stream flow, navigability, and decreased flood risk.

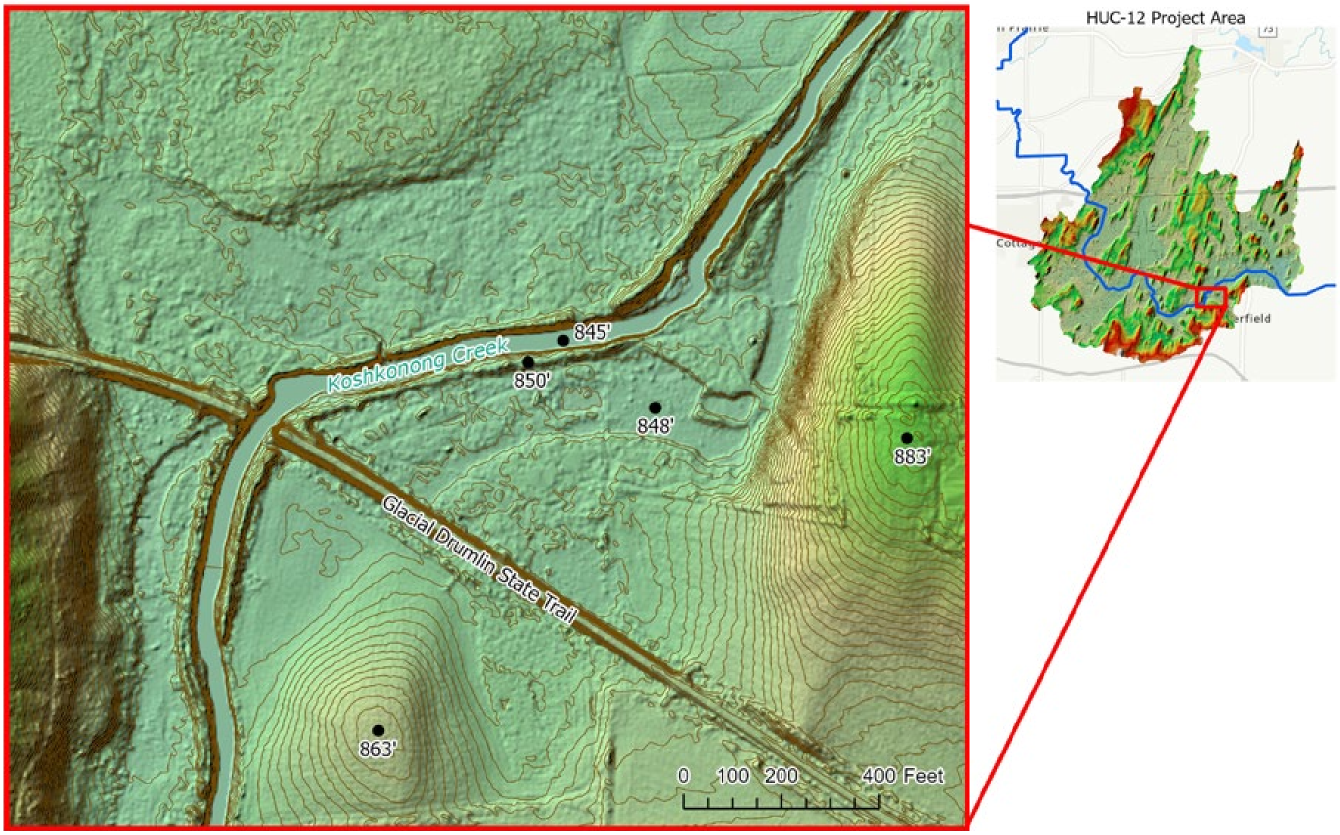


Figure 4.13. DEM near Koshkonong Creek with spot elevations depicting sediment piles along streambanks.

Advantages:

- **Reduces sediment and muck from the creek, which can in turn reduce the flooding on to neighboring farmlands (Minnich, 2017).**
- **Can possibly improve the navigation for kayaks and canoes within the creek, improving recreational activities.**
- **Can improve the waterflow of the creek (Minnich, 2017).**

Disadvantages:

- **Can disrupt the natural balance of ecosystems near the creek, leading to significant harm to the aquatic flora and fauna (Mulhollem, 2024).**
- **Improper disposal and management of sediments can lead to pollution near the downstream of the creek (Carter, 2023).**
- **Continuous dredging on the creek can lead to increased depth of the creek, which can reduce the access to available sunlight that the benthic habitats receive, thus preventing the photosynthesis of the aquatic plants (Mulhollem, 2024).**
- **When the creek is artificially deepened by dredging, it has more chances to frequently fill up with sediment and return to the "pre-dredged state," making dredging an unsustainable activity which must be repeated regularly (England and Burgess-Gamble, 2013).**

Although dredging is appealing to stakeholders as a short-term solution to existing sedimentation problems, we recommend that landowners first invest in practices to limit new sediment inflows such as sediment basins and vegetative strips. Each BMP brings its own set of unique advantages and combining these BMPs with other land management strategies can increase their efficiency. Unless other BMPs are used prior to dredging projects and regular management of the area is maintained after the project, the high costs, logistics, and negative ecological impacts associated with dredging this area could yield more negative outcomes than positive. BMPs and regular maintenance alongside dredging would enhance the positive impacts of dredging and reduce the need for extensive sediment removal in the future. Moving forward, the thoughtful implementation of sediment mitigation practices into proper land management strategies will play an important role in restoration and protection of the Koshkonong Creek.

SECTION 5: SEDIMENT IMPACTS ON FLOODING

5.1 Introduction

As expressed in Section 3, a primary focus for our research team was to evaluate the impact that sedimentation has on flooding within the study area. From the onset of this project, stakeholders who live in the study area raised concerns that sedimentation may exacerbate flood events. Historical hydraulic modifications within Koshkonong Creek, such as channelization, implementation of a tile drainage system, and subsequent wetland drainage, support these claims. Through these conversations, stakeholders have provided our team with several resolutions that they believed would prove effective for flood mitigation. As discussed in the previous section of this report, one potential mitigation strategy that was consistently mentioned was the idea of dredging portions of Koshkonong Creek within the project study area.

Over time, especially in fluvial systems characterized by low flow, sediment accumulation may impede streamflow. This process can be seen at several distinct locations within the study area. Utilizing local knowledge from stakeholders within the project area, our team pinpointed specific stretches where sediment accumulation could be observed to impact flow within the creek. Identifying these locations allowed us to develop a method to obtain an estimated volume of settled sediment within the study area, which is outlined in Section 3 of the "Sediment Accumulation" section of this report. In the following section, we outline the methods used to quantify sediment accumulation within Koshkonong Creek. This includes describing the data collection process, analysis techniques, and key findings regarding sediment volume and distribution.

5.2 Modeling Methodology

Obtaining the estimated volume of settled sediment described in Section 3 was a critical first step for the modeling effort, as it established a baseline estimate of average sediment depth within the study area. With this value established, the hydrologic and hydraulic (H&H) modeling efforts could begin in earnest. The Federal Emergency Management Agency (FEMA) conducted a flood insurance study (FIS) for Koshkonong Creek in November 2012 (FIS 55025CV004D), and the results of this study have been effective since February 2015 according to FEMA's National Flood Hazard Layer (NFHL) Viewer. A FIS comprises, "A compilation and presentation of flood risk data for specific watercourses, lakes, and coastal flood hazard areas within a community" (FEMA, 2020). These studies establish areas where flood risk is significant, which in turn determines which property owners within a given community are required to have flood insurance. The determinations garnered from FIS rely upon the results from H&H analyses for the flooding source under investigation.

Evaluation of the peak flow of a flooding source to a given amount of precipitation is the first step in this analysis and is referred to as the hydrologic analysis. Hydrologic Engineering Centers Hydrologic Modeling Software (HEC-HMS) was utilized to obtain peak flow values listed Volume 1 of the effective FIS for Koshkonong Creek. Modeling files associated with these analyses are sometimes available to the public via FEMA's Flood Risk Study Engineering Library, though we were not able to obtain hydrologic modeling files associated with FIS 55025CV004D through this resource. Therefore, values of peak flow listed in Table 2 of Volume 1 of FIS 55025CV004D were assumed to reflect current hydrologic conditions within the study area.

To conduct the hydraulic analysis, we utilized the Hydrologic Engineering Centers River Analysis System (HEC-RAS). HEC-RAS is an open-source software developed by the United States Army Corps of Engineers (USACE) and was chosen as the most appropriate model to simulate this sediment removal scenario based on its accessibility, and reputation amongst individuals working in the academic, private, public, engineering, and natural resource realms (U.S. Army Corps of Engineers, 2025). The HEC-RAS model files associated with FIS 55025CV004D and representing Koshkonong Creek were found via FEMA's Flood Risk Study Engineering Library. These model files were representative of the HUC-10 (0709000204, Koshkonong Creek), encompassing the study area.

To generate inundation maps from outputs generated in HEC-RAS for each return interval under investigation, it is important to have high-resolution terrain data. Terrain data was sourced from publicly available digital elevation models (DEMs) from the USGS 3D Elevation Program (3DEP). We downloaded a DEM with one-meter resolution and clipped it to the HUC-10 boundary, which encompasses the project area. The HUC-10 boundary was used to remain consistent with the HEC-RAS model geometry associated with FIS 55025CV004D. This initial geometric configuration provided us with a baseline representation of existing channel geometry and terrain within the study area (existing conditions geometry). To validate terrain data, we utilized a Global Navigation Satellite System (GNSS). GNSS instruments are widely used in the collection of survey data, and this particular instrument enabled fine-scale elevation measurements to be obtained. We obtained GNSS elevation measurements of both water surface elevation (WSE) and bank stations at the uppermost and lowermost boundaries of the model, to validate both terrain data and model geometry.

Using the estimation of sediment volume obtained for the stretch of creek encompassing our study area, outlined in Section 3, our group was able to make an informed estimate of an appropriate amount of sediment to remove, given baseline conditions obtained from the existing conditions model generated in HEC-RAS. From these initial estimates, we found that the average depth of sediment throughout the section of the creek encompassing the study area was approximately two feet. Given the shallow depth of the creek, this depth of sedimentation is considerable.
To simulate a situation in which the existing sediment within the stretch of creek encompassing the project area would be completely removed, we utilized this average depth when modeling this scenario in HEC-RAS. To model this scenario, we modified cross-sections within the existing conditions model in the boundaries of our study area. The points along a cross-section within the study area that represented the channel of the creek were lowered by two feet from the elevations in the existing conditions' geometry. This process was repeated for all 49 cross-sections within the study area. Once these modifications had been made, and using the same storm events as applied to the existing conditions model, we ran hydraulic modeling simulations with the modified geometry.

5.3 Hydraulic Modeling Results

We found that the greatest reduction in inundation as a result of this two-foot reduction in bottom elevation of the channel came from the simulation representing the 10-year, 24-hour storm event, which saw a 76.8-acre reduction in inundation area from baseline conditions (see Figure 5.1). Results from the remaining simulations are illustrated in Table 5.1 below.

The results from this hydraulic analysis support the assertion that the removal of two feet of sediment from the entire stretch of creek encompassing the project area would result in a reduction in inundation area during each flood event under investigation (see Figures 5.1 through 5.10). It is important to keep in mind that this simulation is representative of an instantaneous removal of two feet of sediment throughout this stretch. These results do not account for sediment delivery from upstream of this stretch, which would continue in spite of this simulated removal effort. Therefore, it should be noted that removal of sediment would only temporarily reduce inundation areas from the business as usual scenario, and is by no means a permanent solution to the flooding issues that stakeholders have been experiencing.

5.3.1 LIMITATIONS

Although HEC-RAS 1D is a helpful tool for floodplain managers, it is important to acknowledge the limitations of the program when evaluating model results. In HEC-RAS 1D, the version chosen for this hydraulic evaluation, flow is assumed to move primarily along the channel's centerline, which can oversimplify real-world scenarios where water spreads laterally or moves around structures and across varied terrain. In contrast, HEC-RAS 2D offers a more detailed representation of surface water dynamics by modeling flow in both downstream and lateral directions, allowing for a better depiction of overland flow, floodplain storage, and interactions with infrastructure. Incorporating subsurface features like agricultural tile drains presents challenges in both versions, but especially in HEC-RAS 1D. Additionally, HEC-RAS lacks built-in tools to represent tile drainage systems or simulate their interaction with surface hydrology, often requiring oversimplified assumptions or external modeling approaches. In future modeling efforts, conducting a comparison of the inundation boundaries generated by 1D and 2D models would be prudent to gain a more robust understanding of the hydraulic characteristics of the project area.

Table 5.1. The table above provides an illustration of the outputs resulting from both the business as usual (BAU) and 2-foot sediment removal simulations performed in HEC-RAS for flood events with recurrence intervals of 10, 25, 50, 100, and 500 years. These results indicate that the greatest reduction in inundation area in response to this 2-foot removal occurred in the 10-year, 24-hour event, whereas the smallest reduction in inundation area occurred in the 25 and 500-year events, respectively.

Flood Event	Business as Usual Inundation Area (Acres)	2-Foot Sediment Removal Inundation Area (Acres)	Inundation Reduction Area
10-Year	1804.8	1728	76.8
25-Year	2182.4	2131.2	51.2
50-Year	2316.8	2259.2	57.6
100-Year	2406.4	2348.8	57.6
500-Year	2681.6	2630.4	51.2

5.4 Recommendations for Next Steps

The findings from this analysis offer insight into the impact of sediment accumulation on flooding within the study area. While the hydraulic analysis demonstrates that sediment removal could provide temporary relief by reducing inundation areas, it is evident that the efficacy of long-term flood mitigation would benefit from a more comprehensive approach. It should also be noted that the model which these results are based on is limited in the sense that it is built upon a snapshot in time. While the model provides a general idea of what effects could occur, its precision and accuracy will deteriorate over time without additional measurements. The following recommendations outline actions that would enhance future modeling efforts and inform effective flood management strategies.

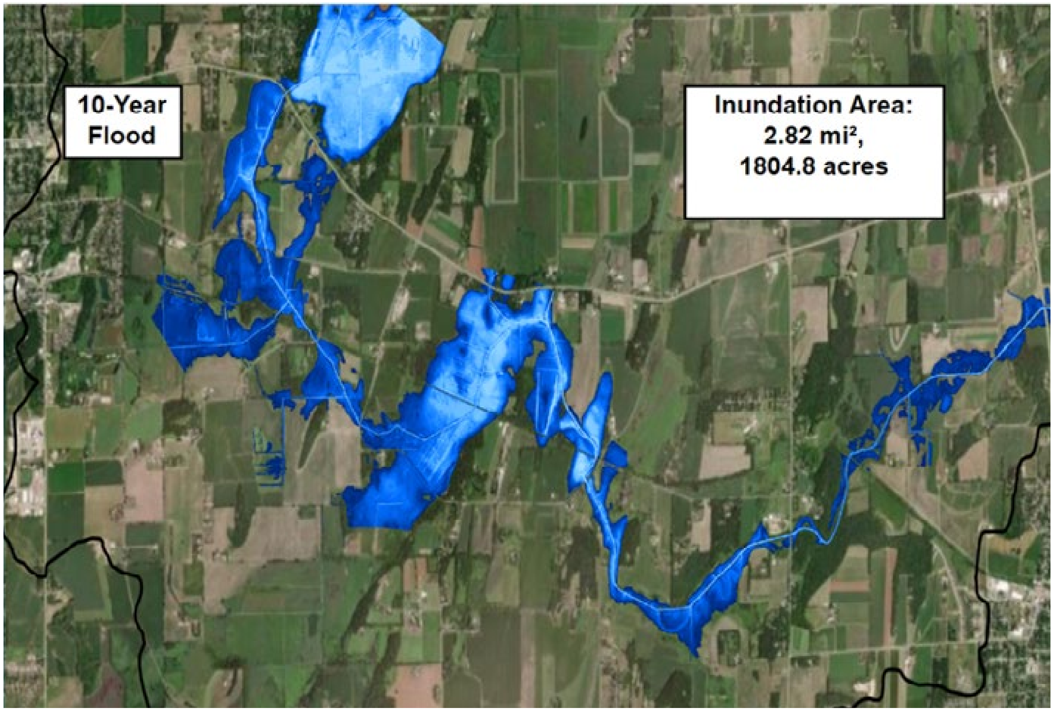


Figure 5.1. RAS-Mapper generated inundation area for the 10-year flood event under existing conditions.

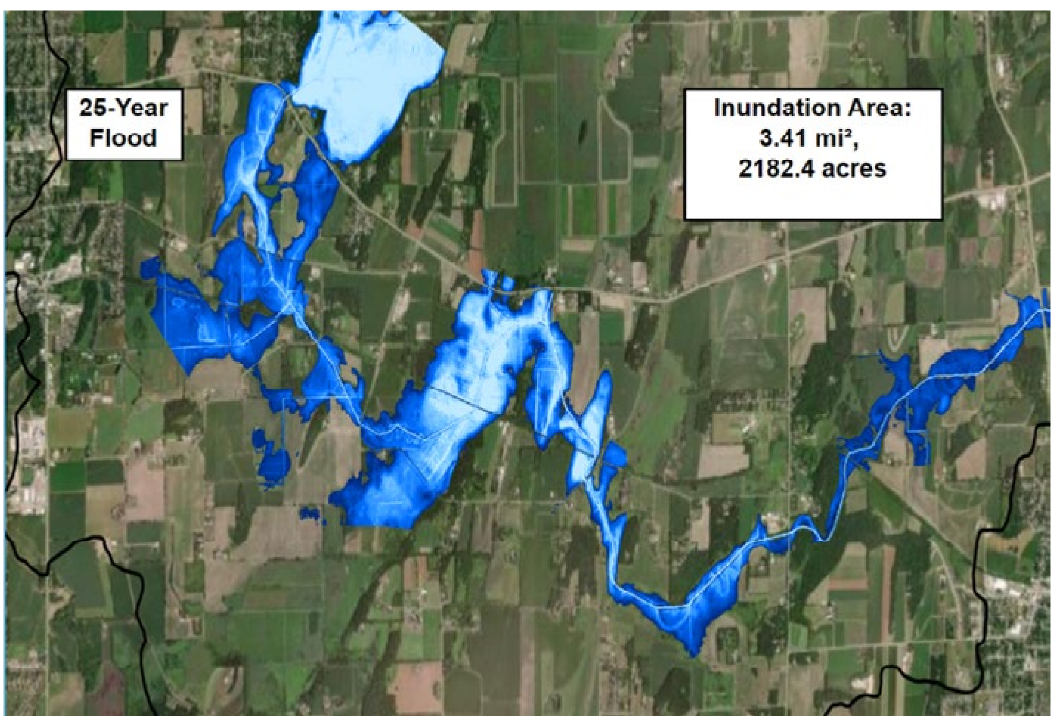


Figure 5.2. RAS-Mapper generated inundation area for the 25-year flood event under existing conditions.

5.4.1 ESTABLISHMENT OF A STREAM GAUGE ON KOSHKONONG CREEK

A dedicated stream gauge within the study area would provide real-time data on water levels and flow rates, allowing for improved calibration of hydraulic models. Continuous monitoring would enhance understanding of seasonal and event-driven variations in streamflow, supporting more accurate flood forecasting and sedimentation assessments.

5.4.2 IMPLEMENTATION OF A NETWORK OF PRECIPITATION GAUGES

Installing multiple precipitation gauges throughout the project area would enable more precise measurement of localized rainfall events. This data would improve hydrologic modeling by refining estimates of runoff generation and flood event magnitudes, ultimately leading to better predictions of inundation extents.

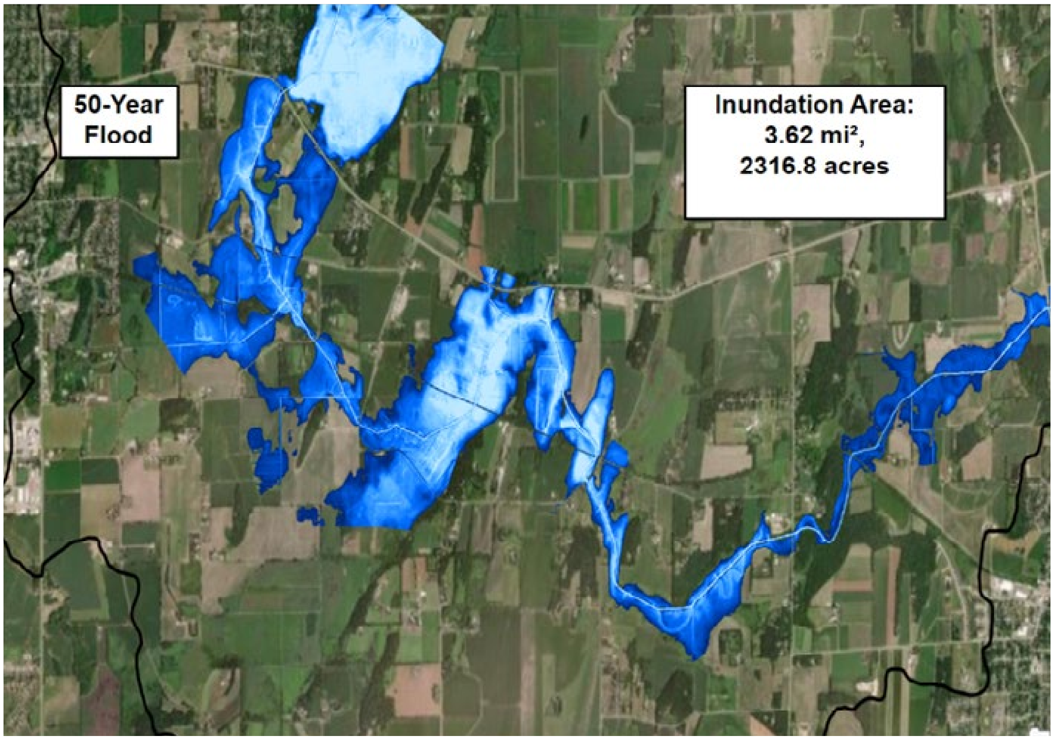


Figure 5.3. RAS-Mapper generated inundation area for the 50-year flood event under existing conditions.

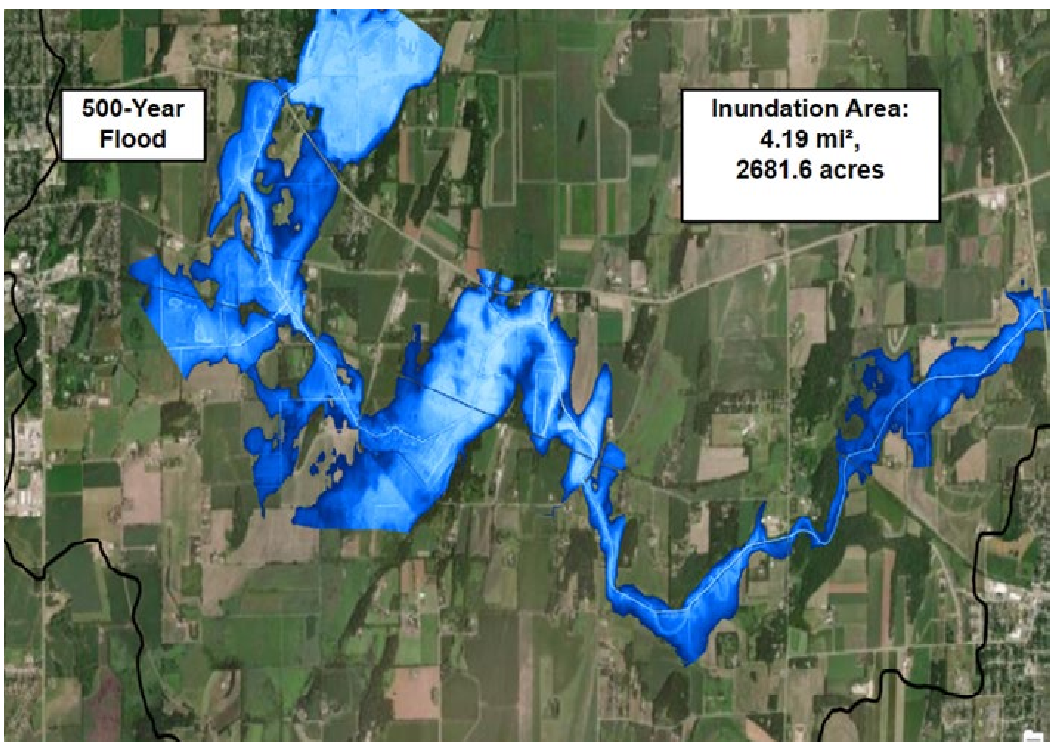


Figure 5.4. RAS-Mapper generated inundation area for the 100-year flood event under existing conditions.

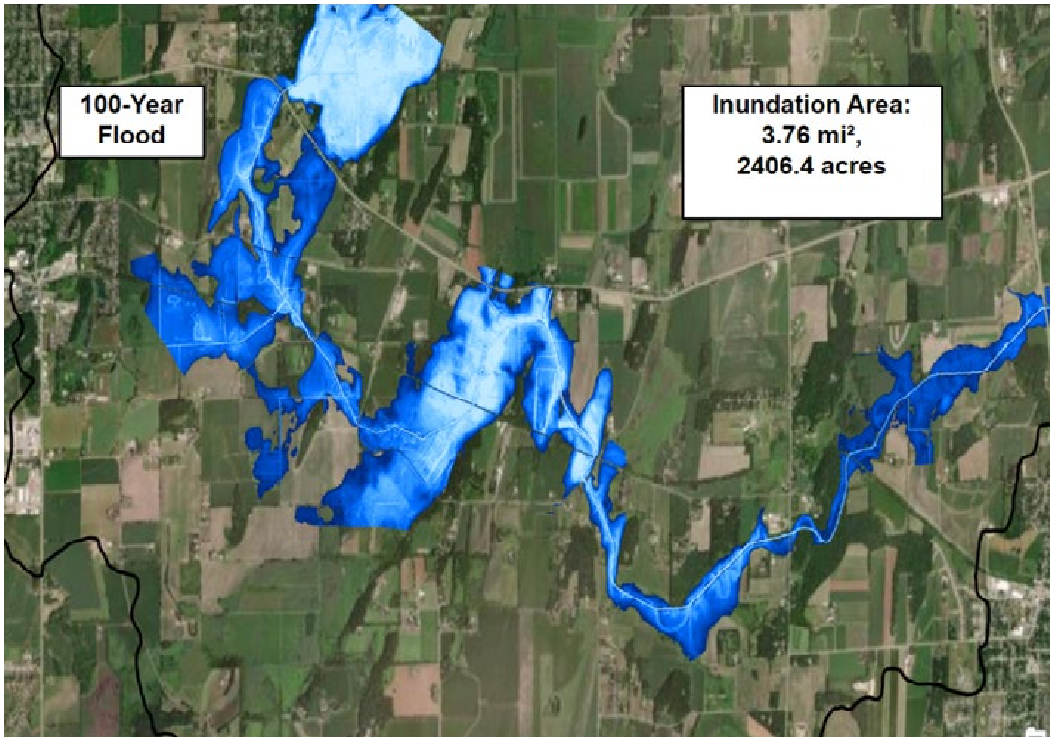


Figure 5.5. RAS-Mapper generated inundation area for the 50-year flood event under existing conditions.

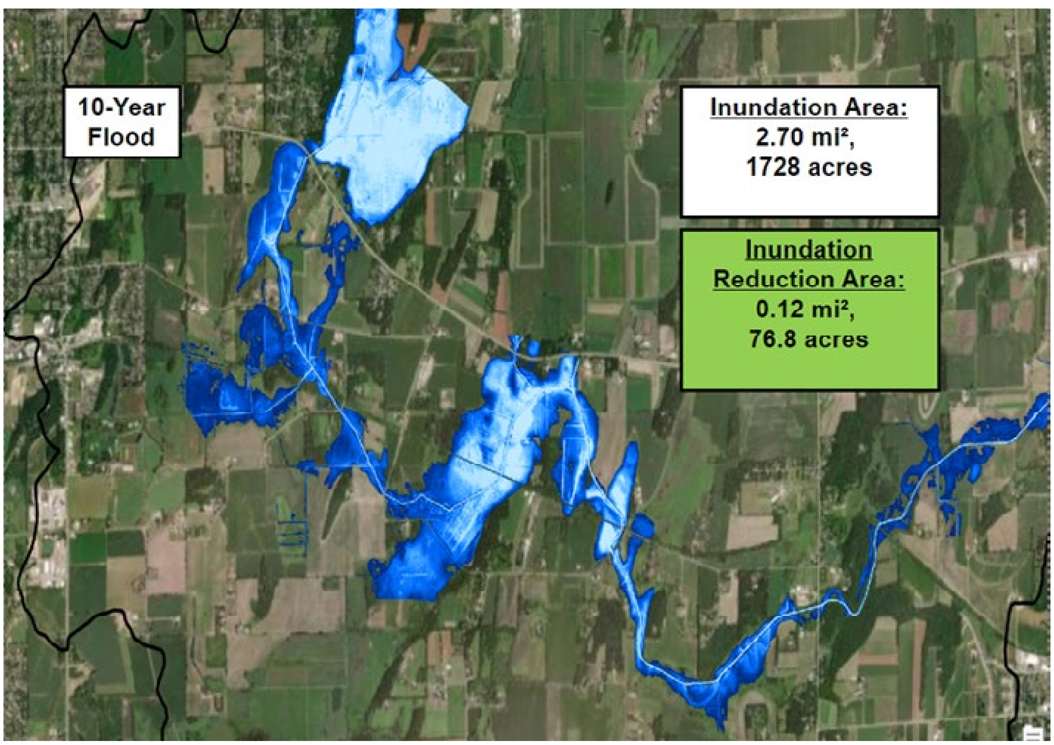


Figure 5.6. RAS-Mapper generated inundation area for the 10-year flood event under the proposed removal of two feet of sediment.

5.4.3 DEVELOPMENT OF A SEDIMENT TRANSPORT MODEL

Incorporating sediment transport modeling into future analyses would allow for a more detailed evaluation of sediment movement within the watershed. This would help quantify the rate at which sediment accumulates in different sections of the creek and assess the long-term effectiveness of dredging or other sediment management strategies.

5.4.4 EVALUATION OF WETLANDS AS A FLOOD MITIGATION STRATEGY

Wetlands play a crucial role in attenuating floodwaters and trapping sediment before it reaches downstream areas. A detailed assessment of the potential for wetland restoration or creation within the watershed could provide a sustainable, nature-based solution to reduce flood impacts and sediment deposition over time.

By implementing these recommendations, stakeholders will gain access to more accurate data, allowing for better-informed decision-making regarding flood mitigation and watershed management. Additionally, these efforts will contribute to the long-term resilience of the Koshkonong Creek watershed by addressing both short-term sedimentation issues and broader hydrological dynamics.

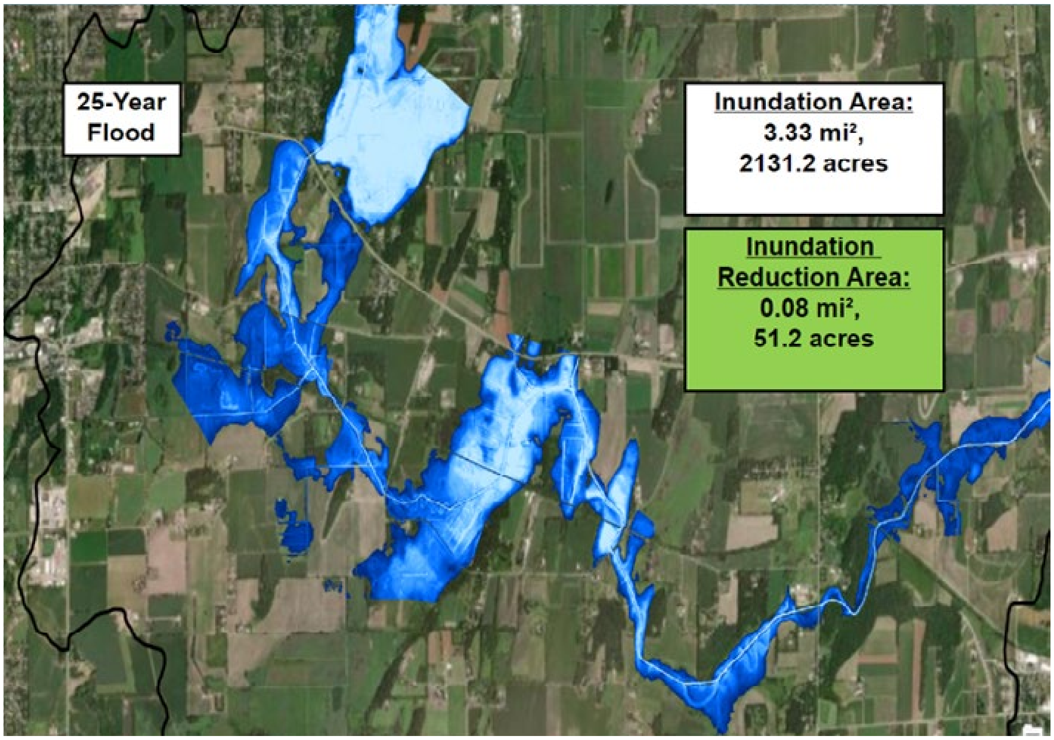


Figure 5.7. RAS-Mapper generated inundation area for the 25-year flood event under the proposed removal of two feet of sediment.

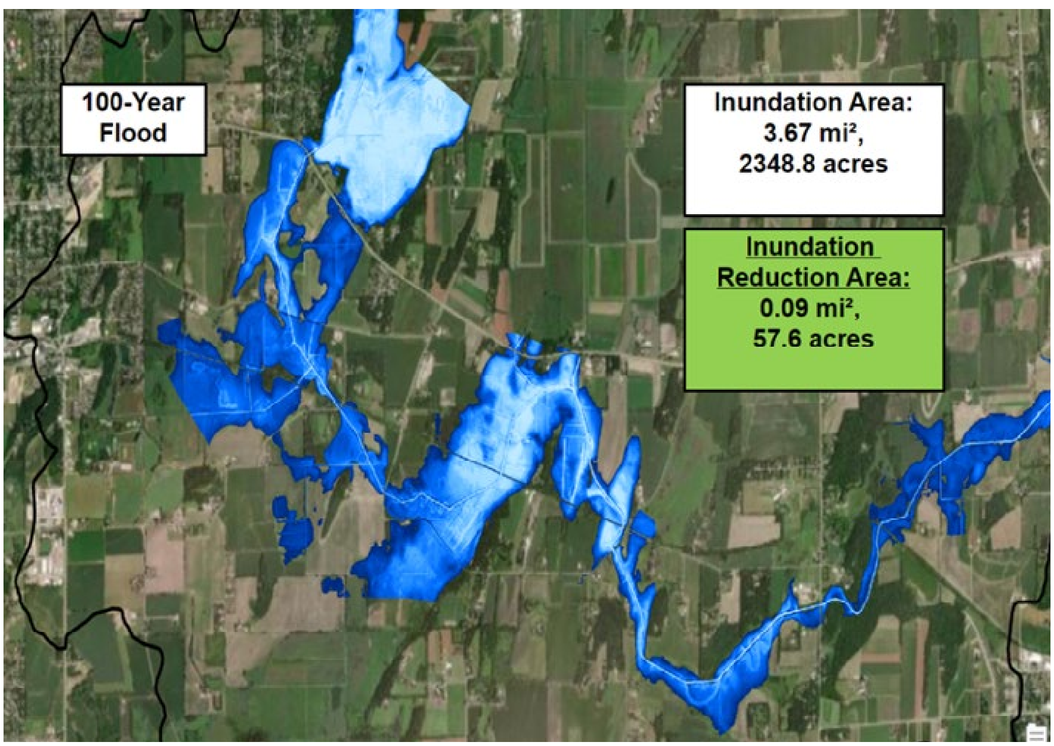


Figure 5.8. RAS-Mapper generated inundation area for the 50-year flood event under the proposed removal of two feet of sediment.

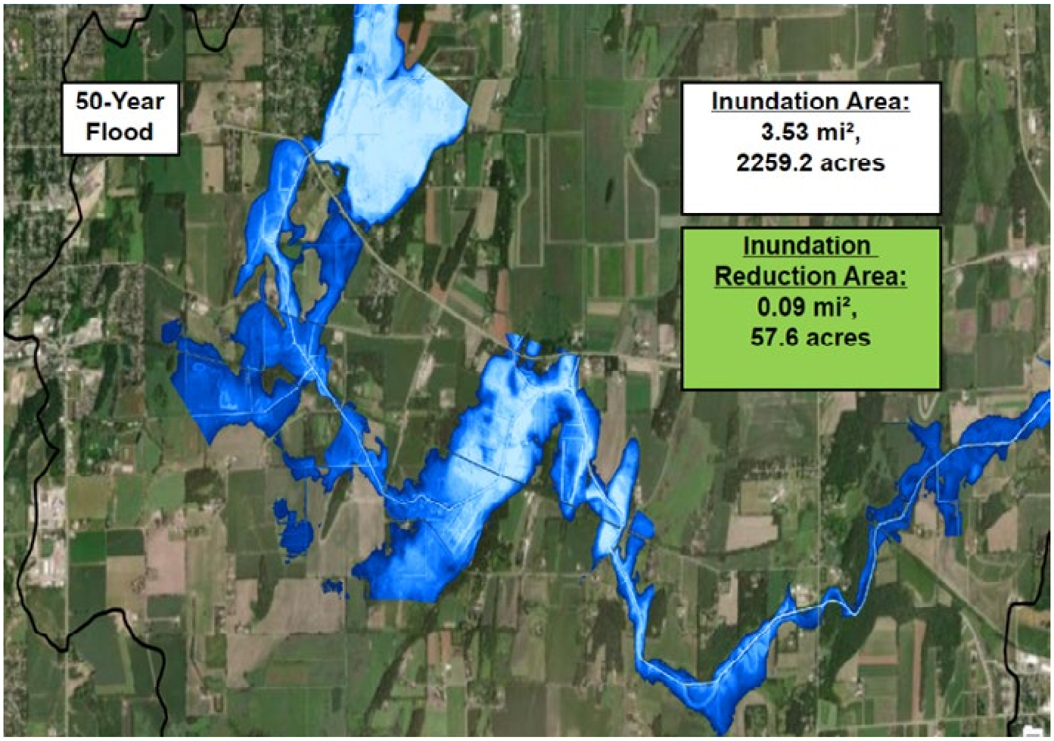


Figure 5.9. RAS-Mapper generated inundation area for the 100-year flood event under the proposed removal of two feet of sediment.

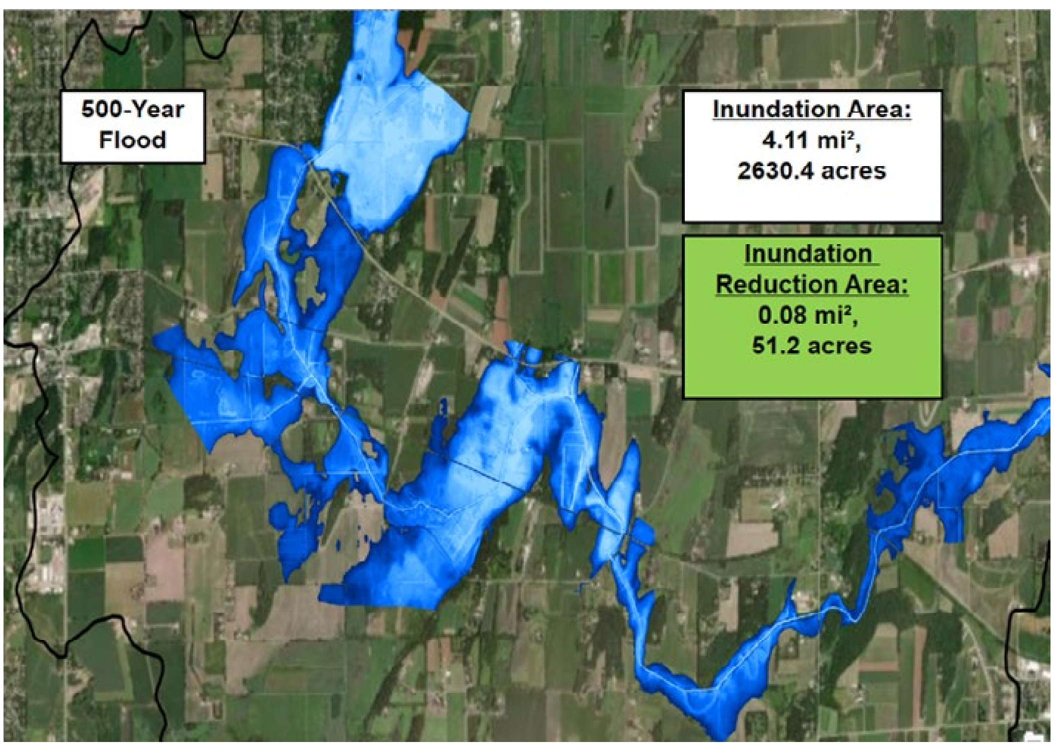


Figure 5.10. RAS-Mapper generated inundation area for the 500-year flood event under the proposed removal of two feet of sediment.

SECTION 6: WATER QUALITY

6.1 Introduction

To quote the WRM 1982 report, "Water quality in Koshkonong Creek is so poor that the creek can be called extremely polluted." This statement is as true today as it was over 40 years ago. Pollution from a variety of sources has remained largely unchecked for the better part of the past 100 years leading to the condition of the creek observed today. Poor water quality has led to a variety of persistent issues in the creek. These include rapid eutrophication (excessive nutrient loading leading to algal blooms and oxygen depletion), a compromised ecosystem, and a lowering of aesthetic value, among others. Other problems such as rising chloride levels are likely to appear in the near future. Immediate remediation efforts are needed to improve water quality for the enhancement of the creek today and in the future.

Water quality is paramount to a healthy stream ecosystem. Without it, feedback loops can worsen stream conditions over time. Streams with good water quality are characterized by low turbidity, balanced nutrient levels, high oxygen levels, and low sedimentation, leading to an ecosystem capable of supporting high amounts of biodiversity and great aesthetic value. Systems with poor water quality are characterized by high amounts of sedimentation, unbalanced nutrient levels, low biodiversity, and frequent algal blooms among other issues (Hamid, Bhat and Jehangir, 2019). Koshkonong Creek's current conditions fall within the latter. Because of decades of pollution, processes such as eutrophication have shaped Koshkonong creek into the unhealthy stream it is today (see Figure 6.1).

6.1.1 STATE LAWS

The WDNR sets regulations, criteria, and standards for substances that can be found in water bodies. These regulations are codified under the administrative code denoted as "NR." These include nutrients, minerals, and heavy metals. The exact criteria for surface water bodies can be found in NR § 102 and NR § 105. NR § 102 covers phosphorus, dissolved oxygen, pH, bacteria, and temperature while NR 105 covers toxic substances.

Koshkonong Creek is a unidirectional stream and thus falls under Wis. Admin. Code NR § 102.06 (3)(b). To protect the fish and aquatic life, the criterion for phosphorus is set at 0.075 mg/L. When converted, this equates to 0.075 parts per million (ppm). Anything above this number is considered impaired and will likely be added to the section 303(d) list as per NR § 102.07(2).

6.1.2 POLLUTION AND THE 303(D) LIST

Pollution is the main reason the stream is in the condition it is today. In the stream's location, pollution has come from a variety of sources over the past decades. These sources are divided into two categories: point source and nonpoint source. Point source pollution is pollution that comes from easily identifiable single sources such as wastewater treatment plants, industrial runoff, and drainage pipes. Nonpoint source pollution is harder to explicitly identify but is commonly runoff from cropland, city streets, lawns, feedlots, and suburban development (see Figure 6.2). At this time, and for reasons this section will describe, it's highly likely that the bulk of pollution entering Koshkonong Creek today is from nonpoint source pollution. Considering the characteristics of the area, it's likely that this comes primarily in the form of agricultural runoff entering the creek. Tackling this issue is necessary for improving the health of the creek.

In our study area of the Koshkonong Creek watershed, known point source pollution comes from the SPWWTP, the Oaks golf course, and local industrial buildings. Nonpoint sources for pollution are agricultural fields, residences bordering the creek, and runoff from roads. Though we were informed by stakeholders that their drain tiles have become ineffective, we know from the 1982 report (Water Resources Management Workshop, 1982) that 40 years ago, drain tiles contributed significant amounts of nutrients and sediment into the creek that likely persists today. It is unknown what effect, if any, the large network of drain tiles is currently having on the watershed. Another major source of pollution is urban runoff. The City of Sun Prairie has an extensive network of storm drains, ditches, and culverts, each of which lead either to the SPWWTP or to a tributary stream of Koshkonong Creek within Sun Prairie City limits. Water not intercepted by the treatment plant contains large amounts of urban runoff commonly from residential streets and lawns.

Pollution will continue to be a major concern in the watershed. Population is expected to increase and with that comes additional pollution. Pollution lowers the aesthetic value of the creek substantially, hampering recreation and putting the ecosystem at risk. It is also the primary driver in the deterioration of the stream's water quality, causing sedimentation and threatening the nutrient balance of the creek.

Because of concerns surrounding pollution in our surface waters, section 303(d) of the CWA requires that every two years states publish a list of all water bodies that do not meet water quality standards. Koshkonong Creek is included on the list because of "Degraded Biological Community, High Phosphorus Levels, [and] Organic Enrichment." According to the EPA, Organic Enrichment refers to excess nutrients that enter waterbodies due to human activities. Koshkonong Creek has been on this list for several years and will remain on it unless corrective action is taken. Taking measures to get Koshkonong Creek off the 303(d) list will be vital in securing a healthy future for the creek.

Figure 6.1. Koshkonong Creek (Photo credit: German Gonzalez)

6.1.3 STREAM CONDITIONS

Having knowledge of stream conditions of the past adds context when it comes to making decisions regarding remediation strategies. The presence of long-term data collection is necessary to identify trends within the watershed and to be able to attribute them to specific entities. The 1982 report, along with the WDNR and USGS, have provided over 60 years of data from which to draw conclusions regarding the condition of the creek. Interviews with landowners are another key piece in understanding its past and present conditions.

In a workshop our group hosted, landowners in the watershed expressed that current stream conditions in portions of the creek limit recreation, are visually unappealing, and exacerbate flooding on adjacent lands. This is unsurprising considering that the section of the creek from Baxter Rd. to HWY 73 averages two feet of mucky sediment that is heavily contaminated with nutrients, likely from agricultural runoff (see section 4). The ecosystem is also heavily polluted with both nutrient runoff and garbage. These conditions combine to obstruct the formation of a robust aquatic ecosystem. We know from reading the past report on this stream that 40 years ago the stream was in a similar state. Additionally, flow measurements taken at Oak Park Road indicate slowed flow rates that may be attributed to tree falls, wide banks, and shallow elevation. Areas with high flow (as those near the wastewater treatment plant) generally have better stream conditions. Areas where the flow is slowed either by snags, wider banks, or a shallower gradient have generally poorer stream conditions (Rolls, et al., 2012). This is supported by our observation that stretches of the creek with higher flow (>0.2 m/s) are not burdened with as many log jams and high sediment build up. Unfortunately, these conditions in the study area have persisted for at least the last 40 years. This ultimately stems from decades of inadequate management and unchecked nonpoint source pollution. The condition of the creek will deteriorate further as time progresses if management and mitigation strategies are not utilized.

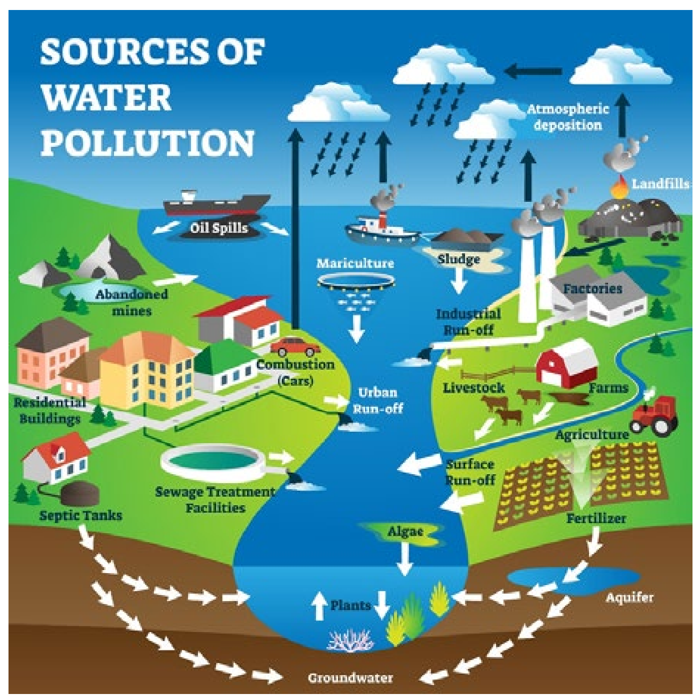


Figure 6.2. Anthropogenic sources of surface water pollution (threeriverswaterkeeper.org)

6.2 Nutrients and Chloride

6.2.1 BACKGROUND

The WDNR and other governing bodies regularly sample sites along Koshkonong Creek for analysis. Based on data pulled from USGS and the WDNR, it seems that Koshkonong Creek is sampled between three and five times per year. The technique that the WDNR uses to analyze water samples is colorimetry. Colorimetry relies on either titration to determine chemical concentrations or is a measure of a substance's absorption and reflectivity of color, which provides a measure of concentration. A handheld sensor can be used to perform colorimetry in the field, making it an accessible method of analysis to anyone interested in the creek's long-term health.

We performed interviews with stakeholders and experts to gain a better understanding of the stream's condition, challenges, and solutions. Conversations with landowners were extremely valuable in providing us with information about known and suspected pollution sources, places along the creek that were particularly problematic, and historical context. We also held an interview with Jeremy Cramer, the wastewater conveyance and treatment director from the SPWWTP (see Figure 6.3). Mr. Cramer provided us with highly detailed water quality information directly from the SPWWTP effluent. He also provided us with future projections of the plant, the rules under which they operated, and a description of the efforts they have made to lessen their impact on the creek.

6.2.2 EFFECTS OF EXCESS NUTRIENTS

Nitrogen and phosphorus are key ecological nutrients that every ecosystem relies on to thrive. When in excess, they can have devastating consequences on aquatic ecosystems (see Figure 6.4). These nutrients, often introduced through agricultural runoff, wastewater discharge, and urban stormwater, cause the rapid growth of primary producers, especially algae. The algae create dense mats on the water's surface which blocks sunlight from reaching submerged plants (see Figure 6.5). Postmortem, the organisms that decompose the algae consume dissolved oxygen, depleting it from the creek. This oxygen depletion, known as hypoxia, can suffocate fish and other aquatic organisms, leading to widespread die-offs and compromising the food web. In recent years, die-offs have become more devastating in freshwater systems, especially in the Great Lakes. Additionally, the decomposition of algae can release toxins and harmful byproducts into the water, further compromising water quality and posing risks to human health. The remains collect on the bottom of the stream and are a significant contributor to the sedimentation experienced by the creek. Controlling the levels of nitrogen and phosphorus entering the creek is critical not only in maintaining the aesthetic value of the creek, but also in promoting the health of the ecosystem.

Figure 6.3. The Sun Prairie Wastewater Treatment Plant under additional construction (Photo credit: City of Sun Prairie, October 2020)

6.2.3 NITROGEN

Data on nitrogen, in the form of nitrates and nitrites, was sparser than data on phosphorus in both location and frequency. The reason for this is that there are no surface water quality standards set for nitrates and as a result, WDNR measurements are taken more infrequently. There is a lot of concern about nitrates entering ground water, which is monitored frequently, but that was not one of the primary areas of focus of this project. Though nitrogen levels are an important

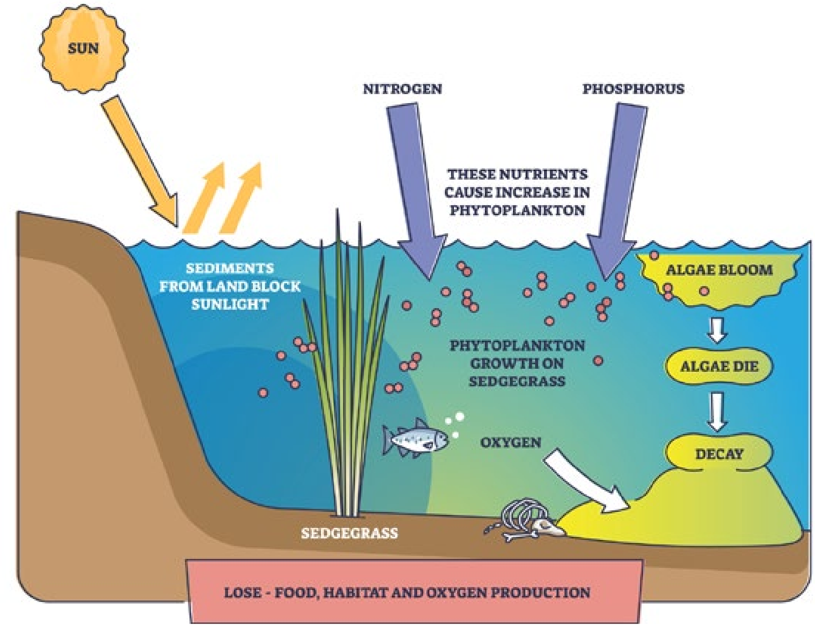


Figure 6.4. Eutrophication process.

Figure 6.5. Algal mats in Koshkonong Creek near County BB (Photo credit: Alen John Idiculla)

factor in stream ecology, the limited availability of information makes it difficult to draw concrete conclusions. Periodic USGS reports do contain usable nitrogen information. One USGS site was in our study area, at Bailey Road, with the other site south of Cambridge at Hoopen Road. This allowed for an upstream versus downstream comparison.

Based on our observations, phosphorus levels do not consistently differ between the upstream and downstream locations (see Figure 6.6). Though the differences are not substantial enough to conclude that one is particularly higher than the other, phosphorus levels do appear to be slightly higher downstream, which could be explained by the movement of nutrients along a stream. Both sections are consistently above the 0.075 PPM limit set by Wisconsin state law (Wis. Admin. Code NR § 102.06 (3)(b)).

In contrast to our observations regarding phosphorus, it's evident that nitrate levels vary considerably between upstream and downstream locations (see Figure 6.7). These differences in pollution are large and consistent, and may at least partially explain why the upstream portion of the creek is so impaired. Nitrogen is a key ecological nutrient, and when in excess, eutrophication can be expected to occur. While monitoring for nitrogen is typically conducted less frequently and in fewer locations, it is our recommendation that nitrogen levels be investigated and classified in this area. This includes Total Nitrogen (TN), which includes all forms of nitrogen (organic and inorganic), Total Kjeldahl Nitrogen (TKN), which focuses on organic nitrogen and ammonia (a useful indicator of biological nitrogen), Nitrate (NO_3^-), Nitrite (NO_2^-), and Ammonia (NH_3).

6.2.4 PHOSPHORUS

Historic levels of phosphorus being expelled into the stream by the SPWWTP are expectedly high. The lowest measurement of direct phosphorus effluent from the plant, depicted in Figure 6.8, is more than ten times the current limit of 0.075 PPM. The Bailey Road study site is located just a few hundred yards downstream of where the SPWWTP is located. There is some improvement evident across the six-year period, but the levels remain high. This is a prime example of point source pollution. The amount of phosphorus entering the creek during this time period was certainly a contributing factor of the state of the creek today.

As discussed previously, recent advances and upgrades in the SPWWTP have shown massive improvements in the concentration of phosphorus released into the stream. The SPWWTP has almost always expelled water that was above the 0.075 PPM total phosphorus concentration as set by the state, meaning that they were a contributing factor to Koshkonong Creek's addition to the 303(d) list. SPWWTP was authorized to do this as a part of their operations permit. However, the upgrades that went online in June of 2022 had an immediate effect in finally bringing their monthly outputs of phosphorus below the NR § 102.06 (3)(b) limit (see Figure 6.9). This had immediate effects downstream as well (see Figure 6.10). The Baxter Road study site, located just downstream of the Oaks golf course,

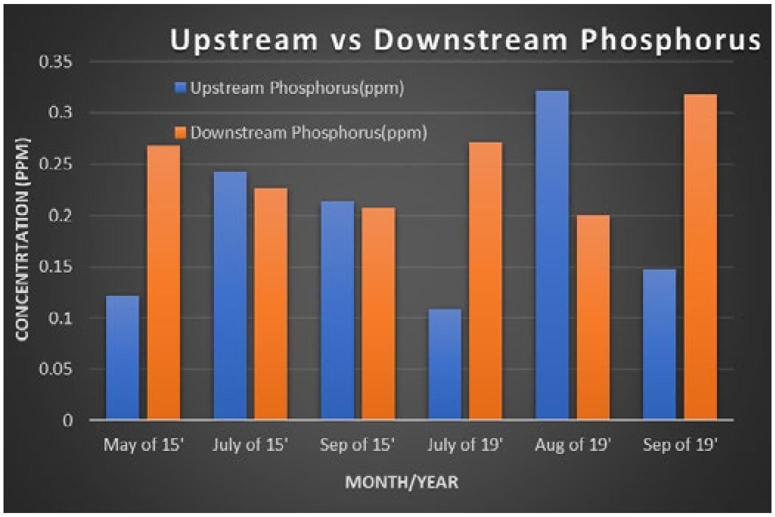


Figure 6.6. Periodic measurements of upstream (Bailey Road) and downstream (Hoopen Road) phosphorus levels from May 2015 to September 2019 in parts per million (PPM). Threshold for "impaired" is 0.075 PPM.

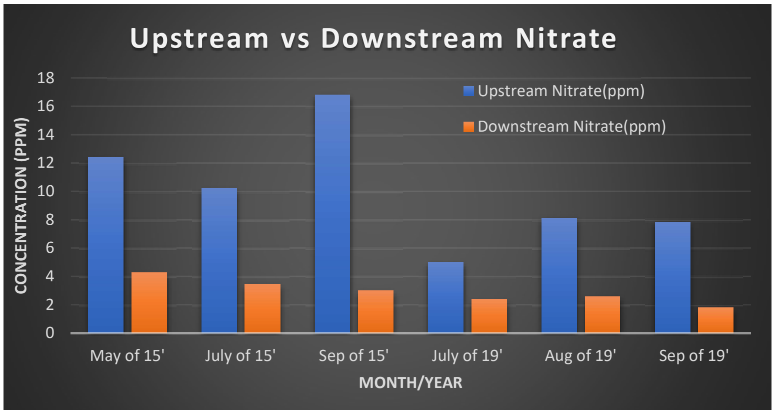


Figure 6.7. Periodic measurements of upstream (Bailey Road) and downstream (Hoopen Road) nitrate levels from May 2015 to September 2019 in parts per million (PPM).

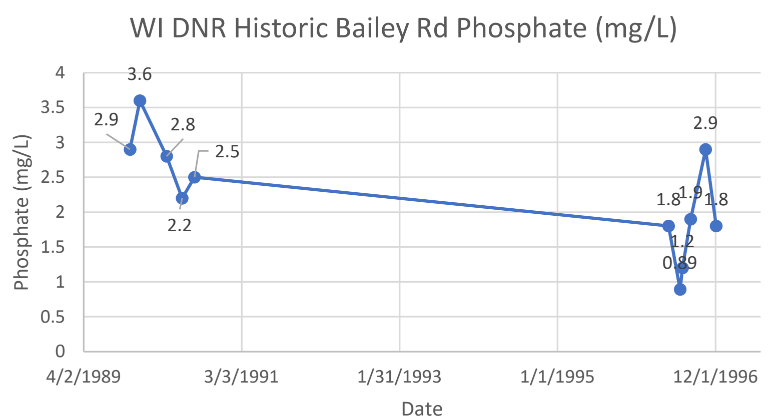


Figure 6.8. Phosphate levels at Bailey Road from 1989 to 1996 in mg/L. Current threshold for "impaired" is 0.075 mg/L.

has seen a remarkable decline in phosphorus in the same period. Many measurements are hovering at or below the 0.075 PPM limit. This is good news for the future of the stream and provides direct evidence of the benefits of lessening SPWWTP's role as a primary source of excess phosphorus.

Some of the post-June 2022 measurements are still above the limit, indicating that there is additional phosphorus pollution moving down the stream. This is evidence that nonpoint source pollution has likely become the primary source of excess nutrients in Koshkonong Creek. The phosphorus in excess of the amount expelled by the SPWWTP could come from any number of sources such as runoff from lawns, the golf course, or even sediment that has been disturbed (perhaps by precipitation or another high flow event) and liberated of its phosphorus. However, it is necessary to mention the most likely source for this excess is nonpoint sources. Considering the land use context surrounding the stream, agricultural runoff is by far the most likely culprit.

Putting both timelines together tells the whole story. As seen in Figure 6.11, there is a dramatic difference between the 1990s and today. For most of the creek's recorded history, it has been subjected to staggering levels of nutrient pollution from both point and nonpoint sources. The improvements made by SPWWTP to lessen their impact on the stream are clearly evident. While the effluent levels of the SPWWTP will increase in the future, the concentration of effluent nutrients will likely remain the same. Based on available information, the nutrient burden placed on the creek by the plant has decreased to acceptable levels. The next big step is to look for ways to reduce nonpoint source pollution.

6.2.5 CHLORIDE

Erosion, excess nutrients, eutrophication, pollution, and flooding are not the only future concerns for the creek. Our research revealed a concerning trend of increased chloride levels, which is likely to represent the next challenge that the creek will face. Increasing chloride concentrations is an emerging threat that is difficult to manage but will need to be addressed soon if the ecosystem of the creek is to maintain its integrity.

High levels of chloride are detrimental to aquatic and terrestrial plants that lack adaptations to cope with it (i.e. every species of flora besides halophytes). Since the period of antiquity humanity has known the consequences of spreading salt in the places where we conduct agriculture. In plants that are not tolerant, high chloride can block nutrient access leading to necrosis. The plant will wilt and act like it is experiencing drought by exhibiting drooping leaves with brown tips. Root rot, fragile leaves, and weakened cell walls are all symptoms of excess chloride (Geilfus, 2018). Near the creek this will weaken the plants holding the banks in place. It will also reduce the vitality of wetlands. Lastly, fields that border the creek may experience reduced yields.

Over the past 30 years, levels of chloride have steadily increased in Koshkonong Creek. Should this trend continue, there will be serious health concerns regarding aquatic, wetland, and agricultural plants in the vicinity of the creek. As seen in Figure 6.12, the area of greatest concern is the upstream portion of the creek, with concentrations of chloride three to four times higher at Bailey Road than Hoopen Road. The main anthropogenic sources of chloride are the application of road salt, water softeners, potash fertilizer, animal waste, and chlorinated drinking water (Dugan et al., 2017). Southeastern Wisconsin has the additional disadvantage of having bedrock with limestone inclusions near the surface, which leads to harder water and more intensive water softener use.

Figure 6.13 demonstrates the change in chloride levels over time as measured from the SPWWTP and from Bailey Road, located just a few hundred yards downstream. While the 1996 levels are concerning, the amount of chloride entering the stream today poses a higher threat to the creek's future. It's expected that the overall amount of chloride, especially in the upstream portions of the creek, will continue to rise.

Recognizing that rising chloride levels were threatening the ecosystem of the Madison lakes, the city sought methods to reduce their salt usage. For the winter of 2023–24, the city removed 50 miles of roads from their salt routes. This resulted in a reduction of 270 tons of salt (City of Madison, 2023). The City of Sun Prairie has also taken measures to reduce salt usage. For example, beginning in 2008, the City of Sun Prairie switched to a salt brine and beet juice combination called GEOMELT which saw a road salt reduction of between 20 and 30 percent. This strategy not only reduced costs, but also lowered the amount of chloride entering the environment

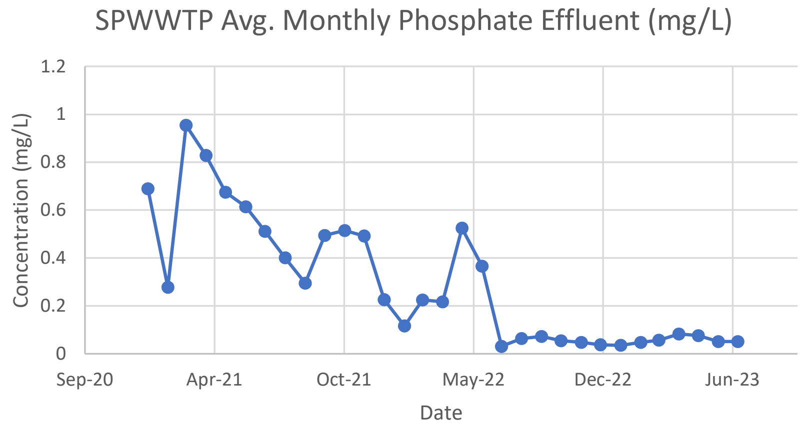


Figure 6.9. Current average monthly phosphate effluent from the SPWWTP in mg/L. Current threshold for "impaired" is 0.075 mg/L or 0.075 PPM.

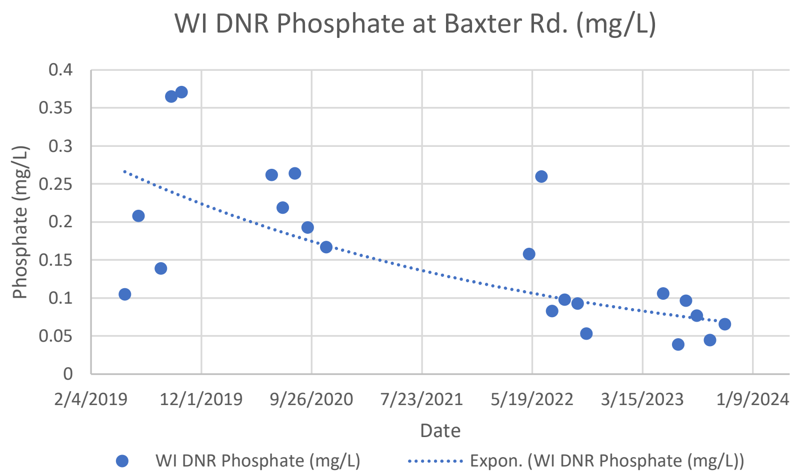


Figure 6.10. WDNR phosphate measurements taken at Baxter Road from 2019 – 2023 in mg/l. Note the decrease in concentration after the SPWWTP completed nutrient related upgrades.

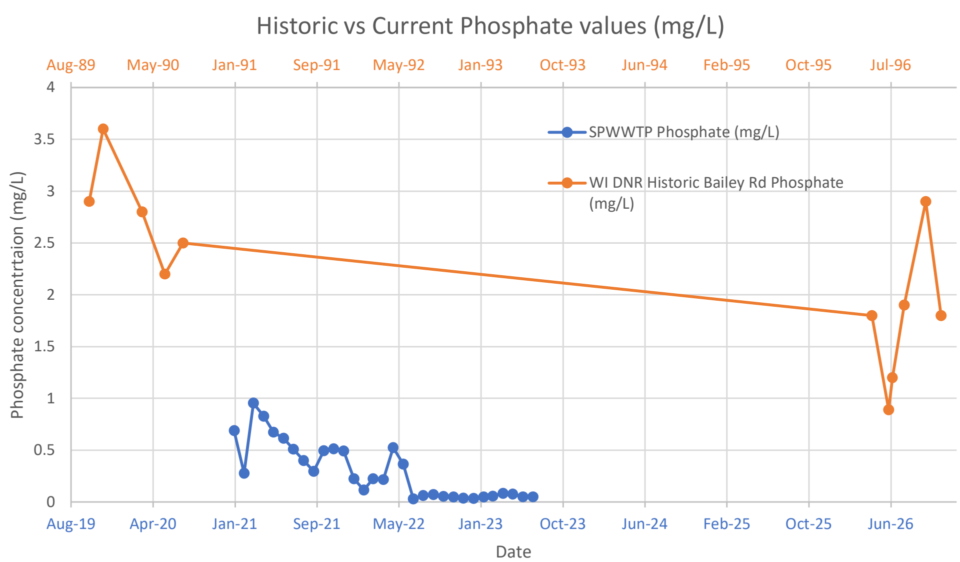


Figure 6.11. Historic and current phosphate effluent levels compared in mg/L. Current threshold for "impaired" is 0.075 mg/L or 0.075 PPM.

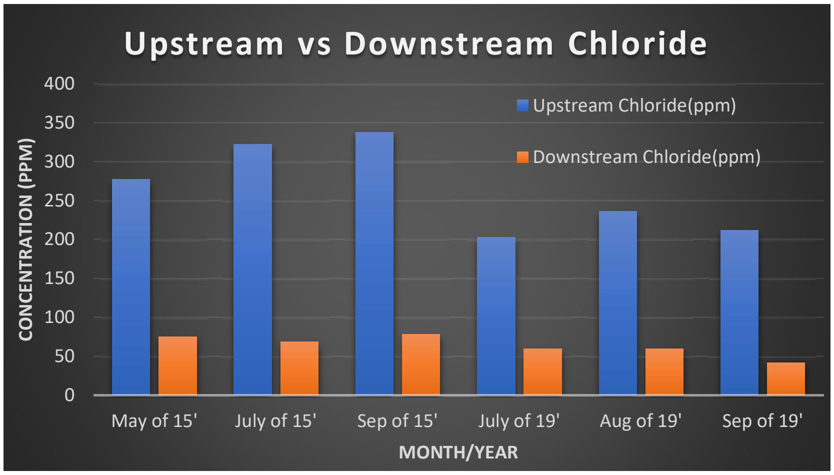


Figure 6.12. Upstream (Bailey Road, blue) and downstream (Hoopen Road, orange) chloride levels from May 2015 to September 2019 in parts per million (PPM).

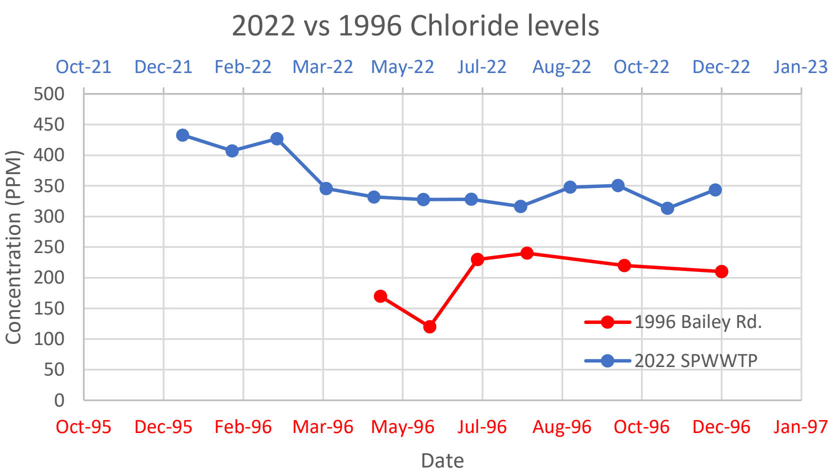


Figure 6.13. Historic (red) and current (blue) chloride levels displayed on the same Y-axis in parts per million (PPM).

(Olson, 2008). Although there is also the option to remove chloride from the effluent, this typically isn't done because the equipment capable of removing chloride is very expensive and requires a high amount of energy. The City of Madison estimates that adding chloride removal equipment to their wastewater treatment plant will cost more than 300 million dollars. Many municipalities do not have the financial resources to install and operate this equipment, even if they wanted to.

To protect against this future threat to the creek, action is needed to reduce salt usage in nearby areas. Should chloride levels continue to rise, the likelihood of negative effects will increase. It is necessary to take steps today to prevent excess chloride from jeopardizing the future health of the creek.

6.3 Excess Sediment Affecting Water Quality

Due to natural and human impact, soil erodes from the banks of the creek and flows into the water. Depending on the flow rate of the creek, the soil deposits to the bottom of the creek and forms a silt bed, with further erosion leading to an increase in sediment depth. Pollutants trapped in the silt bed have the potential to resuspend into the water column, resulting in an excess of nutrients that can fuel the formation of algal blooms. Excessive algal blooms release toxins which in turn leads to reduced quality of aquatic life (Xiao, 2018). Sediment buildup at the bottom of the creek can lead to a decrease in hydraulic capacity which can consequently reduce upstream spawning, disturbing the reproductive cycle of fishes (Wurtsbaugh et al., 2019). The presence of suspended sediment increases water turbidity, limiting light penetration and thereby affecting the ability of aquatic plants to photosynthesize. Additionally, sediment can obstruct the gills of aquatic organisms, potentially leading to mortality (Berry et al., 2003).

6.4 Recommendations

We recommend the following mitigation strategies to improve the water quality of Koshkonong Creek:

Establishing a riparian buffer zone: This would provide low-cost flood protection, nutrient uptake, runoff prevention, and erosion control, and is an essential element of getting Koshkonong Creek off of the 303(d) list.

Limiting nutrient use in the vicinity of the creek: Fewer excess nutrients would slow the rate of eutrophication making the ecosystem healthier, more productive, and safer for recreation.

Obstruction removal: This would prevent sediment buildup and promote stream flow.

Engaging in citizen science: This would assist state and federal agencies in decision making by providing information at a closer interval over more portions of the creek.
Limiting the amount of chloride entering the creek: This represents a future threat to the watershed that could damage the health of flora in and around the creek, including agricultural crops.

Improving water quality is crucial for increasing the recreational value of the stream. It is a well-kept secret that

Figure 6.14. Paddling Koshkonong Creek near Jargo Road. (Photo credit: Alen John Idiculla)

Figure 6.15. Paddling Koshkonong Creek near Ridge Road (Photo credit: Alen John Idiculla)

the downstream portion of Koshkonong Creek is a highly productive fishery. Improving water quality conditions will improve the habitat of sport fish, making the fishery more productive. Improving conditions in the upstream portions will bring valuable game species of fish back to the area. Not only will this improve the ecosystem by strengthening the food web, but it will also help to garner support and interest in the restoration and preservation of Koshkonong Creek.

Improving water quality is one of the keys to restoring Koshkonong Creek. External circumstances have created poor water quality and caused numerous problems, all of which lead back to poor water quality (see Figure 6.14).

To improve the creek, steps must be taken to defend and improve water quality, which will require both individual and cooperative action. Even small actions taken by stakeholders — like volunteering to remove snags, monitoring the creek as a citizen scientist, or establishing a riparian buffer zone on their property — will make colossal strides in improving the water quality. Improving water quality will reduce sedimentation, reduce erosion, improve the ecosystem, increase fish populations, and increase recreational interest in the creek (see Figure 6.15). It will be a time and effort intensive process, but the result will be spectacular.

SECTION 7: ADJACENT WETLANDS

7.1 Introduction

Flooding, sedimentation, and creek obstructions were some of the main issues brought to the research team by the landowners in the study area. Wetlands within the riparian zone can be a key component in addressing these issues. Three common features define a wetland: wetland hydrology, hydric soils, and wetland vegetation. Wetland hydrology is typically found when "an area is wet enough to result in soils that are anaerobic (depleted of oxygen) and support hydrophytic vegetation (plants adapted to anaerobic or waterlogged conditions)" (CARPC, 2008). Over the past 150 years, human alterations to the landscape, primarily due to urbanization and agricultural expansion, have altered hydrologic conditions to drain areas for development and farming (CARPC, 2008). With hydrology changed, soils and vegetation present in these regions will also change over time. However, if wetland hydrology can be established, wetland vegetation and hydric soil conditions can return over time (CARPC, 2008). The Dane County Wetland Resources Management Guide (2008) identifies ditching, draining, filling, dredging, and impoundment as the main causes of the most critical wetland impacts causing the direct loss of wetland acreage. This guide noted the degradation of water quality, water quantity, and wetland vegetation found in these regions, as the loss of water and increased pollutants from urban and agricultural runoff decrease the effectiveness of many wetland functions (CARPC, 2008).

Wetlands serve many functions in a healthy ecosystem. One of the main functional values of wetlands is providing natural flood protection in riparian areas like Koshkonong Creek. Restoring the wetland hydrology, vegetation, and soil in a region can increase an area's ability to manage flood events in addition to providing improved wildlife habitat, improving water quality, and restoring native plant species (WDNR n.d., Wetland Restoration). Landowner observations of flooding issues in the watershed prompted our investigation of long-term flood abatement strategies. When discussing wetland restoration or other constructed short term flood water storage holding facilities with landowners, most individuals were not keen on dedicated large land areas to this purpose. Fortunately, the WDNR has published that "while larger wetland[s] may have a greater individual impact upon flood storage, many small wetlands may cumulatively reduce peak flooding significantly." (Trochelell and Bernthal, 1998). In addition, small wetlands can have higher rates of evapotranspiration, making them more efficient for reducing runoff water volume than large wetlands (Millar, 1971).

When considering multiple options for flood control, wetland restoration can be an economical approach for a community. For example, in the 1980s, the City of Bellevue, Washington, found that "constructing stormwater facilities for flood control would be 130 percent more expensive than maintaining natural wetlands" (Trochelell and Bernthal 1998). Additional studies in the Midwest, according to Feierabend and Zelazny (1987), showed that basins containing wetlands experienced an 80 percent reduction in flood flows compared to those lacking wetlands. Additionally, wetlands are capable of retaining significant volumes of water, up to 326,000 gallons per wetland acre at a depth of one foot without harming the wetland ecosystem itself (Bedford and Zimmerman, 1974). Beyond being more economical in providing flood storage function, wetlands can improve water quality in the surrounding waterbody. In fact, wetlands that trap sediments can remove 80 to 90 percent of the phosphorus attached to sediments (Tchobanoglaus and Culp, 1980).

A large percentage of Wisconsin's wetlands, especially in agricultural areas, have been lost due to drainage system installation (Trochelell and Bernthal, 1998). This is evident within the Koshkonong Creek Watershed, especially the northern half of the system such as within the research team's HUC-12 study area. Restoring hydrology between historical wetlands in key locations along the creek may allow for increased natural flood storage capacity and reduce flooding in upland areas (CARPC, 2008).

In a floodplain management study conducted by the NRCS in cooperation with the Dane County Land Conservation Department in 2001, a wetland restoration site was modeled based on landowner observations of flooding concerns in the region. While the selected site did not create a significant decrease in downstream flooding, the discussion of the evaluation noted that restoring wetlands in multiple smaller drainage subareas with conditions similar to the chosen tributary could potentially have a greater impact on reducing floods (USDA NRCS and Dane County LCD, 2001). This study also provided increasing riparian vegetative buffers as another alternative to wetland restoration and one that could be done in conjunction with a larger stream restoration effort. For the purposes of this project, our team chose to consider riparian buffers as part of broader wetland restoration efforts.

The Floodplain Management Study identified the NRCS Wetland Restoration Program as a good funding mechanism for this region to restore wetlands on an individual or group landowner basis. This program allows permanent protection with 30-year easements or 10-year contracts, wherein the longer the duration, the more cost is covered by the program (USDA NRCS and Dane County LCD, 2001). The study also suggested that for riparian buffer installation, the NRCS Conservation Reserve Program would be the primary funding source available.

7.2 Historical Context

In order to select wetland areas to restore, understanding historical wetland coverage and qualities is key. However, delineating wetlands in the past was done with minimal training and varied methods of success as part of larger mapping efforts mostly to divide parcels for homesteading and identifying the best regions to farm. The original government land survey of Wisconsin was conducted from 1832 to 1866, in which surveyors mapped about five million acres of wetland (WDNR, n.d., Wetland Acreage Facts). In the early 1900s, additional surveys were conducted and comparisons of the varied methods illuminated inconsistencies in mapping methods, finding that wetlands were typically drawn smaller on the original survey maps in part due to the lack of education on wetland characteristics by the surveyors, while certain types of wetlands were not mapped at all (WDNR, n.d., Wetland Acreage Facts). With more modern information about soil types, more accurate estimations of wetland coverage can be made than with the original surveys. The soils maps, combined with aerial imagery starting in 1985, allowed the WDNR to prepare a more accurate Wisconsin Wetland Inventory map. This mapping effort surmised that about 47 percent of original wetland coverage had been lost. However, this analysis did not include wetlands less than two or five acres in size as these were the minimum mapping units which varied by county. These wetlands were denoted with a symbol rather than a polygon. While the legislature authorized the WDNR to update the Wisconsin Wetland Inventory every 10 years, due to funding and staffing issues it has been occurring closer to every 24 years. Therefore, the WDNR states "there is no reliable qualitative and quantitative data about current rates of wetland loss." (WDNR, n.d., Wetland Acreage Facts), though they do estimate that Wisconsin has lost about half of its wetland coverage in the last two centuries (WDNR, n.d., Tracking, Assessment and Monitoring Wetlands).

Some efforts have been made in the region to identify suitable wetlands for restoration across the Rock River Basin. The WDNR and the RRC have both prepared analyses with the RRC's being a sub-selection of the WDNR's based on property ownership of wetland areas to reduce barriers to restoration. In addition, the Wetlands by Design watershed approach prepared by the WDNR and The Nature Conservancy done in 2017 goes further into prioritizing wetland and watershed conservation.

Bedford and Zimmerman (1974) conducted a study on wetlands in Dane County which is the only systematic qualitative evaluation of wetlands available currently (CARPC, 2008). Their study found that more than 50 percent of Dane County's wetlands have been drained and removed from the natural ecosystem, with about 36,000 acres lost between 1901 and 1936 and another 22,678 wetland acres lost between 1939 and 1961 (CARPC, 2008). CARPC noted that recent estimates using GIS completed by the County "indicate a total loss of 66,728 acres, or 56 percent of the original wetland acreage" (CARPC, 2008). This loss and degradation has resulted in a decline of benefits that wetlands can provide such as fish and wildlife habitat, flood protection, water quality protection, shoreline protection, groundwater discharge and recharge, as well as providing recreational, educational, and scenic beauty and open space corridors (CARPC, 2008).

7.3 Wetland Management Strategies

Dane County has prepared a guide with wetland management strategies that can aid in increasing wetland acreage and protecting existing functioning wetland areas. The four main categories of management in their guide are: no action, protection, enhancement, and restoration (CARPC, 2008). Given the high level of pressure on wetlands in the study area by surrounding urban and agricultural land uses, protection, enhancement, and restoration would be the most appropriate management strategies. A few function-

Figure 7.1. Aerial composite of restored wetland.

ing wetlands could benefit from protection and enhancement. These strategies focus on methods such as shoreline buffer widths between agricultural and urban land uses and adjacent surface waters (which include streams, lakes, and wetlands). Research conducted by Johnson (1992) recommends different widths for buffers depending on the project's goals. Control of nutrients, water temperature, and stormwater control require less buffer distance than control of fecal coliform and sediment as well as protecting certain wildlife habitats.

Given the level of wetland loss found in this region, restoration may be the best form of management action in the study area (see Figure 7.1). The County outlines rehabilitation and reestablishment as the two main methods of restoration (CARPC, 2008). Rehabilitation occurs within an existing wetland while reestablishment occurs within a former wetland site (CARPC, 2008). Based on our field and remote sensing analysis of wetlands within the study area discussed later in this section (6.4 Analysis Methods), a combination of these two methods will be necessary to restore wetland functions at key points within the study area. Rehabilitation is best suited for currently existing wetlands that have been degraded. Based on wetland restorations, enhancements, and alterations within Wisconsin over the last 50 years, the most cost-effective and successful strategy for wetland restoration is to restore degraded/formerly drained wetlands by reversing the actions that originally damaged them (Thompson and Luthin, 2004). In the study area, this may mean altering agricultural drainage systems.

7.4 Analysis Methods

Our goal was to evaluate where wetland restoration would be best suited in the study area, given the complexities around accurately measuring wetland coverage and change over time. We analyzed site suitability based on presently mapped features in a GIS analysis to inform a field verification methodology (Rapid Floristic Quality Assessment) and then expand that search using a remote sensing method (Object Based Image Analysis for Rapid Floristic Quality Assessment). These analyses were used in combination to increase the accuracy of the wetland restoration feasibility for the watershed.

7.4.1 GIS SUITABILITY ANALYSIS FOR WETLAND RESTORATION

We identified suitable areas for wetland restoration informed primarily by a WDNR report emphasizing the importance of hydric soil classification in determining eligible areas for wetland restoration (Hatch and Bernthal, 2008). This report specified elevation gradient, flood zones, land use, and soil hydric classification as the four weighted parameters for analysis. Flood zones A, AE, and X in the FEMA classification were exported as the flood zones layer with A having the highest risk for flooding (and therefore most suitability for wetland restoration) and X having the least risk of flooding (and therefore least suitable for wetland restoration). For hydric soil classification, a Natural Breaks (Jenks) method of symbology classification was used to divide the percent hydric layer into five categories. Soils have multiple components within them and some of them may have hydric classification and some may not. Therefore, soils have a percent hydric attribute assigned to them. We divided the hydric soil percentages into the following categories:

- **0-2% hydric = 1 (least hydric, least desirable for wetland restoration)**
- **2.001-6% hydric = 2**
- **6.001-10% hydric = 3**
- **10.001-85% hydric = 4**
- **85.001% hydric = 5 (most hydric, most desirable for wetland restoration)**

We generated the "elevation gradient" layer using a hydro-conditioned digital elevation model of the entire Koshkonong Creek watershed. We used the slope tool to obtain the elevation gradient from the raster. The symbology of this new layer was then changed using the "Natural Breaks (Jenks)" option, where five natural breaks were chosen. We then used the "Reclassify" tool, using the same 1-5 scale as the "flood zones" and "hydric soils" layers, categorized as follows:

- **≤ 2.294083% = 5 (greatest gradient, most desirable for wetland restoration)**
- **≤ 5.571346% = 4**
- **≤ 10.814965% = 3**
- **≤ 19.335846% =2**
- **≤ 83.570183% = 1 (least gradient, least desirable for wetland restoration)**

We overlaid land use categories with these layers to assign values (1-5) to indicate how ideal a particular land use would be for wetland restoration. Land uses such as agriculture, open land, recreation, woodlands, vacant lands, and water were identified as more ideal than categories such as residential, transportation, communications/utilities, institutional, commercial, industrial, etc. Then, we completed a weighted overlay analysis with the following weights assigned to each parameter:

- **Flood risk = 25%**
- **Hydric soils = 35%**
- **Land use = 25 %**
- **Slope (elevation gradient) = 15%**

Areas with existing wetlands from the WDNR Wisconsin Wetland Inventory were removed from the weighted overlay analysis using the erase tool. The result was a full map of the watershed ranking areas 1-5 as least to most suitable for wetland restoration. This analysis informed the next field work steps as to where to concentrate test sites.

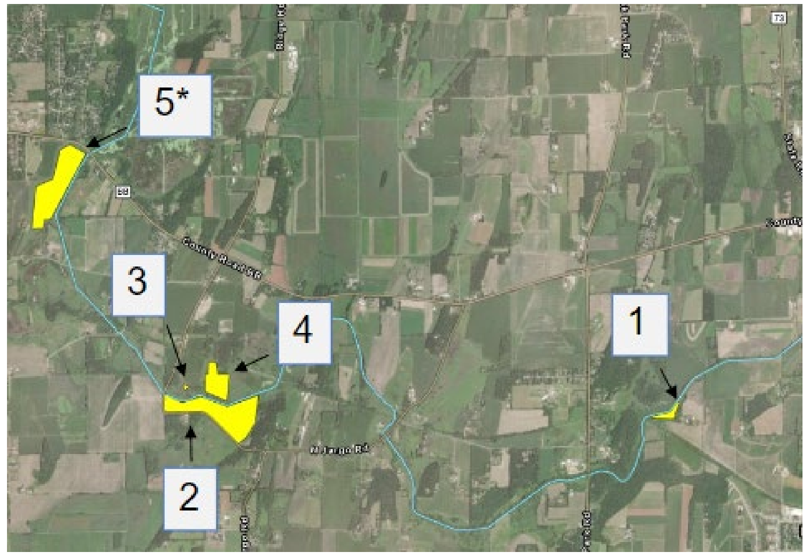


Figure 7.2. RFQA sites. Yellow areas are where surveys were conducted. *There was an active eagle nest and the drone was not flown.

7.4.2 RAPID FLORISTIC QUALITY ASSESSMENT RFQA

6.4.2.1 RFQA Methods

After the GIS suitability analysis was completed, we used field methods to evaluate existing wetland areas and degraded wetlands potentially suitable for restoration within the study area. The Wisconsin Rapid Floristic Quality Assessment (RFQA) was in development as of the summer of 2023 and has not been released for public use (Gibson et. Al., 2022). A draft of the user guide and methodology that was adapted to the needs of the project was approved for this study by the authors at the WDNR. This method was chosen for its quickness, efficiency, and accuracy. Depending on factors such as the size, heterogeneity of the wetland, and ease of meandering the assessment area, an RFQA should take no more than 15 minutes to complete. This 15-minute time frame is assuming the wetland is no more than 5 acres, but the methodology was adapted to survey larger wetland areas. Additionally, the type of survey is suitable for those with intermediate-levels of wetland vegetation knowledge because it allows for genus-level identification for many wetland plants and requires only documentation of dominant plants observed. Therefore, an expert botanist is not required for the completion of this survey in comparison to the full version. A regression analysis of the RFQA and the full FQA generated an R2 value of 0.91 (Gibson et. Al., 2022) where a R2 value of 1.0 indicates a perfect correlational match. With a value of 0.91, a user can be confident that the data gathered in an RFQA will yield similar results to a full FQA.

Prior to conducting the RFQA in the field, we selected the assessment area. We chose sites based on areas mapped as wetlands in the WWI in the WDNR database and areas in which landowner permission was granted. We further refined these areas by choosing areas within 1,000 feet of Koshkonong Creek for more direct hydrologic effects and enhanced aesthetic value. Within these criteria, we chose four areas due to their larger size and distribution along the creek. An assessment was also conducted on a fifth wetland because it was previously restored (see Figure 7.2). An assessment of this fifth area could provide insight into how successful a restoration in the study area could be and what it would look like. However, we discovered after this assessment that the majority of the fifth area has since been put back into agricultural production.

The RFQA is a random meander throughout the assessment area that documents all dominant plants, which are defined as vegetation estimated to make up at least 10 percent of the areal cover. Areal cover can be difficult to determine on the ground so the estimated 10 percent cover may vary between surveyors. The minimum number of plants required for the RFQA depends on wetland type (herbaceous, shrub, or forested) which is determined when first arriving at the assessment area. To determine areal cover of the vegetation more accurately, we flew a DJI Mavic 3M drone to collect high resolution imagery data before the survey which would result in a more accurate overall weighted mean C-value (wC). We flew the drone at four out of the five assessment areas because one of the surveyed wetlands was in close proximity to an active eagle nest. According to the U.S. Fish and Wildlife Service, drones should not be flown within 1,000 feet of an eagle's nest because the noise and disruptive presence can scare eagles away and cause them to abandon their eggs (Shaw, 2022). For sites where the drone was flown, we brought a high-resolution image of the assessment area to the field survey so that vegetation types and extent could be annotated on the image as it was seen in the field. Groups of two surveyors randomly meandered the area, noting dominant species of at least 10 percent areal cover of the assessment area, and estimating areal cover for each plant.

Once the RFQA was conducted, we used the dominant species present to calculate the wC, which is a value that indicates restoration potential. Each plant species has an associated C-value and these values are weighted by abundance and averaged for a total wC for each wetland (Table 7.1). Higher wC values are associated with higher floristic quality wetlands and lower values indicate restoration may be needed to maximize the ecological services that it can provide (Table 7.2).

Table 7.1. RFQA calculator for herbaceous wetlands (Gibson et al., 2022).

WISCONSIN RAPID FQA CALCULATOR: HERBACEOUS WETLANDS			**Rooted, herbaceous plants are the tallest life form with 30% min. cover; Trees and shrubs together comprise ≤30% cover.**						
Assessment Area Name:							**Date:**		
Assessment Area Notes:					**Location of Start of Meander Path:**		**Start Lat:**		
							Start Long:		
Name of Assessor(s):					**NHC Wetland Type (if known):**				
SURVEY RESULTS:									
RFQA Mean C:	#DIV/0!				**RFQA Weighted Mean C:**	**0.0**			
Dominant Species Count:	0				Total Cover of Dominants:	0			
INSTRUCTIONS: Select at minimum the top 3 most-dominant plant taxa including ALL taxa with 10% or greater areal cover.									
Species not appearing on list can be written in space provided at bottom. Stop meander when when no new dominant taxa are apparent. Estimate areal cover for marked taxa.									
Trees:									
Scientific Name	Common Name	C-Value	Dominant	Final % Cover	Scientific Name	Common Name	C-Value	Dominant	Final % Cover
Shrubs:									
Scientific Name	Common Name	C-Value	Dominant	Final % Cover	Scientific Name	Common Name	C-Value	Dominant	Final % Cover
Alnus incana	Tag alder	4			*Salix spp.* *ID to sp.-level if possible	Combined willows	2.9		
Cornus spp.	Dogwoods	3			….*Salix discolor*	….Pussy willow	2		
Frangula/Rhamnus spp.	Buckthorns (Non-native)	0			….*Salix interior*	….Sandbar willow	2		
Spiraea spp.	Meadowsweet; Hardhack	4.4			….*Salix petiolaris*	….Meadow willow	6		
Graminoids:									
Scientific Name	Common Name	C-Value	Dominant	Final % Cover	Scientific Name	Common Name	C-Value	Dominant	Final % Cover
Bolboschoenus fluviatilis	River bulrush	6			*Poa palustris*	Marsh bluegrass	5		
Calamagrostis canadensis	Blue-joint grass	5			*Sagittaria spp.*	Arrowheads	3.9		
Carex spp. (PEM)	Sedges	6.4			*Schoenoplectus spp.*	Bulrushes (Hardstem&Softstem)	5.4		
Juncus spp.	Rushes	4			*Scirpus spp.*	Wool-grasses	3.8		
Leersia oryzoides	Rice cut grass	3			*Sparganium spp.*	All bur-reeds	5.3		
Phalaris arundinacea	Reed canary grass	0			*Spartina pectinata*	Prairie cord grass	5		
Phragmites australis	Common reed grass	0			*Typha spp.*	All cattails	0.3		
Poa pratensis	Non-native bluegrass/ lawn grass	0			*Zizania spp.*	All wild rice	8		
Forbs:									
Scientific Name	Common Name	C-Value	Dominant	Final % Cover	Scientific Name	Common Name	C-Value	Dominant	Final % Cover
Eutrochium maculatum	Spotted Joe-Pye-weed	4			*Pilea, Boehmeria, Laportea spp.* (PEM)	Nettles Group *Not U. dioica	5.0		
Helianthus spp.	Sunflowers	2.2			*Solidago spp.* (PEM)	Goldenrods	1.5		
Impatiens capensis	Orange jewelweed	2			*Symphyotrichum/Doellingeria* (PEM)	Asters Group	5.6		
Lythrum salicaria	Purple loosestrife	0			*Thalictrum dasycarpum*	Purple meadow-rue	4		
Persicaria spp.	Smartweed	5.1			*Urtica dioica*	Stinging nettle	1		
Other Plant Groups (Aquatic plants, ferns, vines, etc):									
Scientific Name		C-Value	Dominant	Final % Cover	Scientific Name	Common Name	C-Value	Dominant	Final % Cover
Equisetum arvense	Field horsetail	1			*Lemna spp.*	Duckweeds	2.4		
Equisetum fluviatile	River horsetail	7			*Sphagnum spp.*	Sphagnum moss	7		
Ferns (PEM)	Ferns (Herbaceous Wetlands)	5.2			*Utricularia spp.*	All Bladderworts	8.3		
WRITE IN ADDITIONAL DOMINANT SPECIES HERE:									
Scientific Name		C-Value	Dominant	Final % Cover	Scientific Name	Common Name	C-Value	Dominant	Final % Cover
Comments:									

#PEM = Cowardin classification indicating that this is a grouped c-value only to be used on the herbaceous wetland RFQA forms.

Table 7.2. Floristic quality tiers based on RFQA wC results (Gibson et al., 2022).

RFQA wC	Floristic Quality Tier	Description	Restorability
7.1+	Exceptional	Unimpacted to mildly impacted, highly nutrient-poor and stable, flora almost exclusively specialists, minimal to zero non-natives.	None currently known
4.8-7.0	High	Unimpacted to mildly impacted, at least somewhat nutrient-poor, flora has significant coverage by habitat specialists, non-natives may be present in small amounts.	Unlikely but possible in certain circumstances
2.1-4.7	Medium	Moderately impacted, or mesotrophic to eutrophic; may have significant displacement of conservative species by non-natives or consist almost exclusively of native generalists.	Very possible, may require management
<2.1	Low	Highly impacted, eutrophic, at least 3/4 of wetland has been displaced by non-natives, or consists entirely of ruderal natives.	Likely, especially in surface water dominated wetlads in argricultural watersheds, or when restoration is incomplete

7.4.2.2 RFQA Results

Each RFQA generates a wC value that ranges from 0 to 10 (see Table 7.2). This value represents a wetland's Floristic Quality Tier, in which a wC <2.1 is classified as Low, 2.1 to 4.7 is Medium, 4.8 to 7.0 is High, and >7.1 is Exceptional (Gibson, 2023). These indicate restorability values where those in the low and medium categories would require restoration in order for that wetland area to provide maximum ecological impacts. The wC values for the five surveyed sites ranged from 1.2 to 3.0, indicating a need for restoration in all of the sites (see Table 7.3).

Site 1 was the furthest east within the watershed and totaled about 7 acres in size. This RFQA was conducted on August 16, 2023, and was the only forested wetland that we assessed. As defined by the RFQA, forested wetlands are those where mature trees are greater than six meters tall and that this life form makes up at least 30 percent of the areal cover (Gibson, 2022). For the forested category, a minimum of five dominant species must be recorded. The dominant species identified along with their respective C values and percentage of areal cover are summarized in (Table 7.4). The overall wC for Site 1 was 1.6.

Sites 2 through 5 were conducted on August 3, 2023, and were all classified as herbaceous wetlands, which are defined as wetlands where at least 30 percent of the areal cover are rooted, and emergent, herbaceous plants are the tallest life form (Gibson, 2022). The sizes of these sites were approximately 50, 0.5, 28, and 27 acres, respectively. The results for these sites are summarized in Tables 7.5, 7.6, 7.7 and 7.8 on page 50. Note that Site 2 percent areal coverage is 110 percent and site 5 is 105 percent. This is because there were trees present that were included in the identified vegetation. Areal cover can exceed 100 percent when tree canopy covers the understory, and both need to be included as dominant species. Site 5 has the lowest wC value surveyed of 0.7 and Site 3 had the highest wC of 3.0.

Site 3 was a previously restored wetland that has since mostly been brought back into agricultural production. Some of the plant species introduced during restoration still flourish, while much of the area has been taken over by reed canary grass and invasive cattails. Since the study area is predominantly agricultural, nutrient runoff is a likely driver of the large extent of invasive species such as reed canary grass and cattails since these species can outcompete native plants for these nutrients. However, high quality species such as sedges, Joe-Pye Weed, and Bulrush were observed in some of these areas.

Table 7.3. Weighted mean C (wC) for all assessed wetlands in watershed.

Site	C-Value
Site 1	1.6
Site 2	1.2
Site 3	3.0
Site 4	1.3
Site 5*	0.7

Table 7.4. Randy forested RFQA results (Site 1).

Species Scientific Name	Species Common Name	% Arial Cover	C-Value
Salix spp.	Combined Willows	20	2.9
Populus spp.	Aspen/Cottonwood	20	2.1
Phalaris arundinacea	Reed Canary Grass	20	0
Solidago spp. (PEM)	Goldenrod	15	2.6
Acer negundo	Box Elder	15	0
Acer spp. (Maplesonly)	Maples	10	2.3

7.4.3 OBJECT BASED IMAGE ANALYSIS FOR RAPID FLORISTIC QUALITY ASSESSMENTS

For this study, we utilized object-based image analysis (OBIA) as a novel approach for RFQAs in a restored wetland ecosystem. The primary objective was to develop a method that can either assist in these assessments or function independently as a rapid assessment tool. A critical focus of this analysis is the identification and classification of invasive reed canary grass (*Phalaris arundinacea*) (RCG), a species known for its negative impact on wetland habitats. Drawing inspiration from previous research, this study aims to harness the power of OBIA in QGIS, coupled with the Orfeo toolbox, to accurately classify this invasive species alongside other key vegetative classes such as duckweed, bulrush, trees, soy, and non-vegetative classes such as water.

QGIS (Quantum Geographic Information System) is an free, open-source geographic software program that enables users to create, edit, visualize, analyze, and publish mapping geospatial data. It is widely used in ecological and environmental studies for its flexibility and extensive range of tools. The Orfeo Toolbox, integrated with QGIS, is a library of image processing algorithms designed for remote sensing. It supports a variety of advanced image analysis techniques, making it an ideal tool for classifying

Table 7.5. Eilenfeldt RFQA Results (Site 2).

Species Scientific Name	Species Common Name	% Arial Cover	C-Value
Phalaris arundinacea	Reed Canary Grass	65	0
Phragmites australis	Common Reed Grass	15	0
Juncus spp.	Sedges	10	6.4
Eupatorium Maculatum	Joe-Pye Weed	10	4
Salix spp.	Combined Willows	10	2.9

Table 7.6. Restoration Area Hollenburger RFQA Results (Site 3).

Species Scientific Name	Species Common Name	% Arial Cover	C-Value
Schoenoplectus spp.	Bulrushes (Hardstem & Softstem)	45	5.4
Solidago spp. (PEM)	Goldenrods	15	1.5
Typha spp.	Cattails	15	0.3
Phalaris arundinacea	Reed Canary Grass	15	0
Salix spp.	Combined Willows	10	2.9

Table 7.7. Large Area Hollenburger RFQA Results (Site 4).

Species Scientific Name	Species Common Name	% Arial Cover	C-Value
Phalaris arundinacea	Reed Canary Grass	65	0
Salix spp.	Combined Willows	15	2.9
Carex spp. (PEM)	Sedges	10	6.4
Solidago spp. (PEM)	Goldenrods	5	1.5
Helianthus spp.	Sunflowers	5	2.2

Table 7.8. Ring RFQA Results (Site 5).

Species Scientific Name	Species Common Name	% Arial Cover	C-Value
Phalaris arundinacea	Reed Canary Grass	90	0
Persicaria amphibia	Water Smartweed	15	5

vegetation types in remote sensing data. The methodology, rooted in the principles of remote sensing and ecological management, seeks to offer a time-efficient, accurate, and cost-effective alternative to traditional floristic quality assessment methods. This approach is expected to provide valuable insights into the health and composition of the wetland, thereby informing conservation and management strategies.

7.4.3.1 Data and Methods

We used a DJI Mavic 3 Multispectral (Mavic 3M) drone to collect high-resolution imagery across wetland and riparian areas within the Koshkonong Creek study site (see Figure 7.3). The Mavic 3M is equipped with a dual-camera system that includes a 20 MP RGB camera and a multispectral sensor array composed of four bands: green (560 nm ±16 nm), red (650 nm ±20 nm), red edge (730 nm ±20 nm), and near-infrared (860 nm ±26 nm). This configuration enables the generation of vegetation indices such as NDVI and NDRE, which are critical for evaluating vegetative health and species composition in wetland ecosystems.

The multispectral sensor has a 5 MP resolution with a global shutter, and the RGB sensor has a mechanical shutter with 4/3 CMOS. At a flight altitude of 60 meters, the Mavic 3M achieves a ground sampling distance (GSD) of approximately 5.73 cm/pixel for multispectral imagery. The drone also includes an RTK module for real-time centimeter-level positioning accuracy, eliminating the need for ground control points and enhancing georeferencing precision. We processed data from the drone into orthomosaics and reflectance maps using Pix4D. We then used these outputs in an object-based image analysis (OBIA) workflow in QGIS with the Orfeo Toolbox to support rapid floristic quality assessments (RFQAs) and inform wetland health characterization (DJI, n.d.).

Data Preparation and Preprocessing in QGIS: The OBIA process begins with data preparation in QGIS, where we imported RGB (red, green, blue) imagery of the wetland. This stage is critical as it sets the foundation for the analysis. The image is first subjected to preprocessing, which includes noise reduction, normalization, and radiometric corrections to adjust for sensor anomalies

Figure 7.3. Aerial composite of restored wetland.

and atmospheric conditions. This step ensures that the data is reliable and suitable for accurate analysis. It's essential to carefully choose the pre-processing methods based on the characteristics of the image and the specific requirements of the wetland analysis.

Image Segmentation Using Orfeo Toolbox:
Segmentation is a key step in OBIA, performed using the Orfeo toolbox in QGIS. This process involves dividing the image into meaningful, homogenous regions or segments based on spectral and spatial characteristics (see Figure 7.3a). The segmentation parameters, such as scale, shape, and compactness, are meticulously chosen to ensure that each segment accurately represents a distinct part of the wetland ecosystem. For example, a large-scale parameter may be used to capture larger features like water bodies, while a small scale might be better for detailed features like individual plant species.

Feature Extraction for Classification:
Once segmentation is complete, the next step is feature extraction. This involves analyzing each segment to extract valuable information, such as mean spectral values, texture, and shape descriptors. These features are crucial for the classification algorithm to accurately categorize each segment into one of the predetermined classes (RCG, duckweed/bulrush/Water, trees, and soy). The choice of features to extract depends on the characteristics of each class and the overall goal of the study. For instance, texture features might be more relevant for differentiating types of vegetation, while shape descriptors could be useful for identifying water bodies.

Classification and Postprocessing:
The classification algorithm is then applied to assign each segment to a class based on the extracted features using the Train Vector Classifier tool in the Orfeo Toolbox. This step requires careful tuning of the algorithm parameters to achieve the highest accuracy. After classification, post-processing tools may be applied to refine the results. These steps help in reducing classification noise and improving the visual coherence of the classified image, which can be useful for subsequent analysis and reporting.

Accuracy Assessment and Result Exportation:
The final step is to assess the accuracy of the

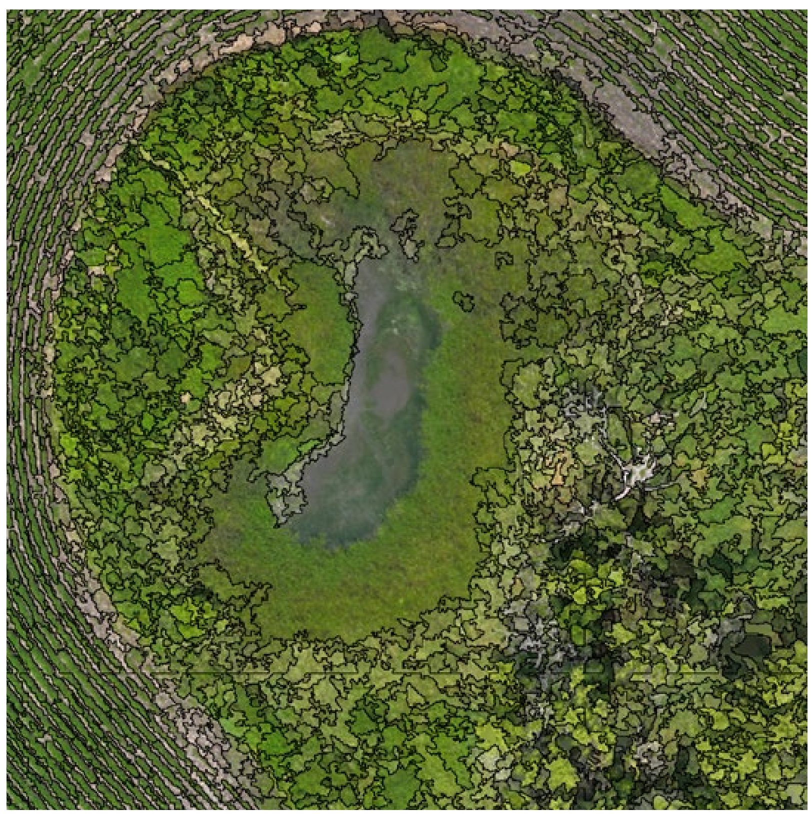


Figure 7.3a. Hollenberger restored wetland composite post segmentation, ready to begin OBIA.

classified image. This is typically done using ground truth data or other reference datasets, employing statistical measures like a confusion matrix or Kappa coefficient to provide a quantitative evaluation of the classification algorithm's performance. These measures provide a quantitative evaluation of how well the classification algorithm performed. Ground truth data is essential for validating the classification results by providing a reliable reference to compare against the classified image, and would ideally be collected in the field during an RFQA.

Finally, the classified image is exported for further analysis or visualization. QGIS offers robust tools for visual representation, allowing the creation of detailed maps and charts that effectively convey the classification results. These visual tools are crucial for interpreting the data and making informed decisions based on the classification, even in the absence of quantitative accuracy metrics.

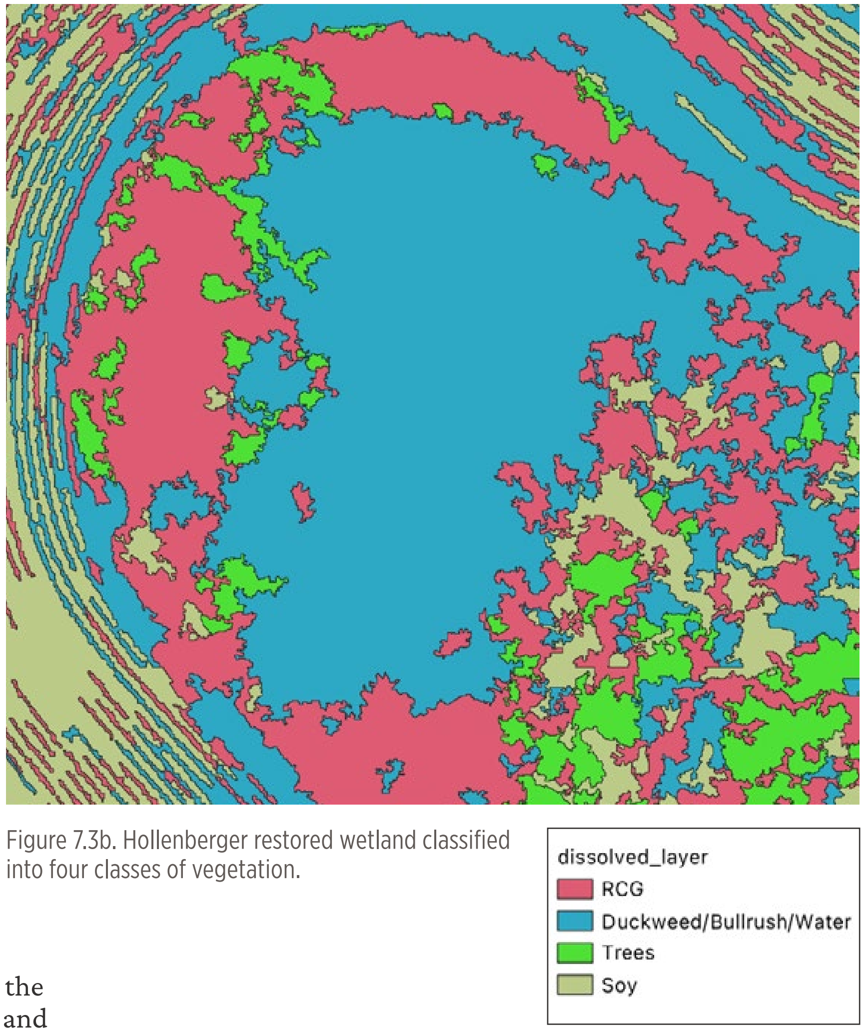


Figure 7.3b. Hollenberger restored wetland classified into four classes of vegetation.

7.4.3.2 Results

The results of this OBIA study demonstrate a noteworthy level of success in classifying the vegetative landscape of a restored wetland with limited training data. By utilizing only five points of training data for each class, the OBIA was able to differentiate between the invasive RCG, aquatic vegetation such as cattails and bulrush, trees, and soy with a high degree of accuracy (see Figure 7.3b). The classified image, with its distinct color-coded classes, illustrates the potential of OBIA as a rapid assessment tool in ecological studies, particularly when resources for extensive training data collection are scarce. The nuanced delineation of RCG from other vegetation types is especially valuable, as it highlights areas where invasive species management may be prioritized. The ability to perform such assessments rapidly opens the door for more frequent and up-to-date monitoring of wetland health, informing conservation efforts and ecological management decisions. Contextualizing our findings within the broader framework of existing literature is crucial, as it allows us to evaluate the implications for future research and practical applications in wetland management. This comparative evaluation will provide a comprehensive understanding of the study's contributions and highlight areas for further investigation.

7.4.3.3 Discussion and Conclusions

In this study, we were able to confirm the applicability and effectiveness of OBIA for RFQAs, even with minimal training data. It highlights the method's potential to serve as an independent assessment tool or as a complement to traditional fieldwork, especially in resource-limited scenarios. This study paves the way for future research focused on refining computational techniques to enhance detail without compromising speed or accuracy, ultimately benefiting wetland management and conservation efforts. It is recommended to undertake further studies with expanded datasets and varied ecosystems to reinforce the robustness of OBIA in environmental assessments.

The implementation of Object-Based Image Analysis (OBIA) for RFQAs in this study has provided a promising approach for wetland ecosystem monitoring. By utilizing QGIS with Orfeo Toolbox, this methodology not only demonstrated high accuracy in classifying vegetative and non-vegetative classes but also offered a cost-effective and time-efficient alternative to traditional assessment methods. This discussion will place our findings in the context of existing literature and explore the broader implications for wetland management.

Comparison with Existing Literature

Several studies have validated the efficacy of OBIA in environmental monitoring. For instance, Dronova et al. (2012) highlighted the utility of OBIA in classifying wetland plant functional types, emphasizing its ability to handle the spatial heterogeneity of wetland environments effectively. Similarly, Lourenço et al. (2021) successfully applied OBIA for mapping invasive plant species, which aligns with our focus on reed canary grass (*Phalaris arundinacea*). These studies support our findings that OBIA, when combined with advanced tools like the Orfeo Toolbox, can significantly enhance the accuracy and efficiency of vegetation classification in wetland ecosystems.

Oldeland et al. (2021) conducted a comparative study using drone-based and field-based assessments of plant species, demonstrating the advantages of OBIA in producing detailed and accurate species distribution maps. This aligns with our approach, which utilized drone imagery to enhance the classification process. The ability of OBIA to integrate various data sources and handle large datasets makes it a powerful tool for ecological monitoring and management.

Implications for Wetland Management

The success of OBIA in accurately classifying invasive species like reed canary grass has significant implications for wetland management. The detailed maps produced through this method (Figure 7.3b) can inform targeted management strategies, such as prioritizing areas for invasive species removal or restoration efforts. The ability to rapidly assess and monitor the health and composition of wetland vegetation can lead to more timely and effective conservation actions.

Moreover, the integration of OBIA with cloud computing platforms such as Google Earth Engine (GEE) and Google Colab presents exciting opportunities for future research and practical applications. These platforms offer substantial computational power and accessibility, enabling the processing of large datasets without the need for expensive hardware. GEE, in particular, provides access to extensive satellite imagery archives and a suite of geospatial analysis tools, which can significantly enhance the capabilities of OBIA in environmental monitoring. The use of Google Colab for collaborative research and algorithm development can further facilitate the adoption of advanced image analysis techniques in ecological studies.

Future Directions

To build on the findings of this study, future research could explore the integration of multi-temporal data to track changes in wetland vegetation over time. This would provide valuable insights into the dynamics of invasive species spread and the effectiveness of management interventions. Additionally, the application of deep learning techniques, as discussed by Arjasakusuma et al. (2021), could further enhance the accuracy of OBIA by leveraging advanced pattern recognition capabilities.

In conclusion, the application of OBIA for RFQAs in wetland ecosystems has shown great potential in improving the efficiency and accuracy of vegetation monitoring. By leveraging tools like QGIS, the Orfeo Toolbox, and cloud computing platforms, researchers and practitioners can develop robust and scalable solutions for environmental management. As the field continues to evolve, the integration of new technologies and methodologies will be crucial in addressing the complex challenges of wetland conservation and restoration.

7.5 Recommendations

- **Land in the riparian flood zone of the watershed or farm land that is unproductive because of flooding should be managed via restoration, enhancement, or protection based on the site's classification based on criteria for these methods following the guidance in the Dane County Wetlands Resource Management Guide.**
- **Landowners with property directly adjacent to the creek are encouraged to restore portions of their land to wetland to enhance aesthetic value and functional flood storage capacity.**
- **Those interested in wetland restoration efforts on their property should utilize technical and financial resources through the NRCS Wetland Restoration Program or the NRCS Conservation Reserve Program (if just installing riparian buffers), which come with grant funds and expert support.**
- **Future efforts to improve the efficiency and accuracy of Rapid Floristic Quality Assessments using Object-Based Image Analysis (OBIA) could benefit significantly from the integration of cloud computing platforms such as Google Earth Engine (GEE) and Google Colab. These platforms provide robust computational power and extensive data resources without the need for expensive local hardware. Utilizing GEE can streamline the processing of large datasets and facilitate advanced spatial analyses, while Google Colab can enhance collaborative research and the development of custom analysis scripts. This approach can democratize access to high-performance computing, making advanced environmental assessments more accessible and scalable.**

SECTION 8: SUMMARY AND NEXT STEPS

8.1 Introduction

Improving the health of Koshkonong Creek requires a multifaceted approach that integrates scientific research, community engagement, restoration initiatives, and long-term management strategies.

As part of the broader UniverCity Year project for Koshkonong Creek, various courses have conducted research and work aligned with these objectives. In total, 12 projects from eight different programs have contributed, as illustrated in Figure 8.1.

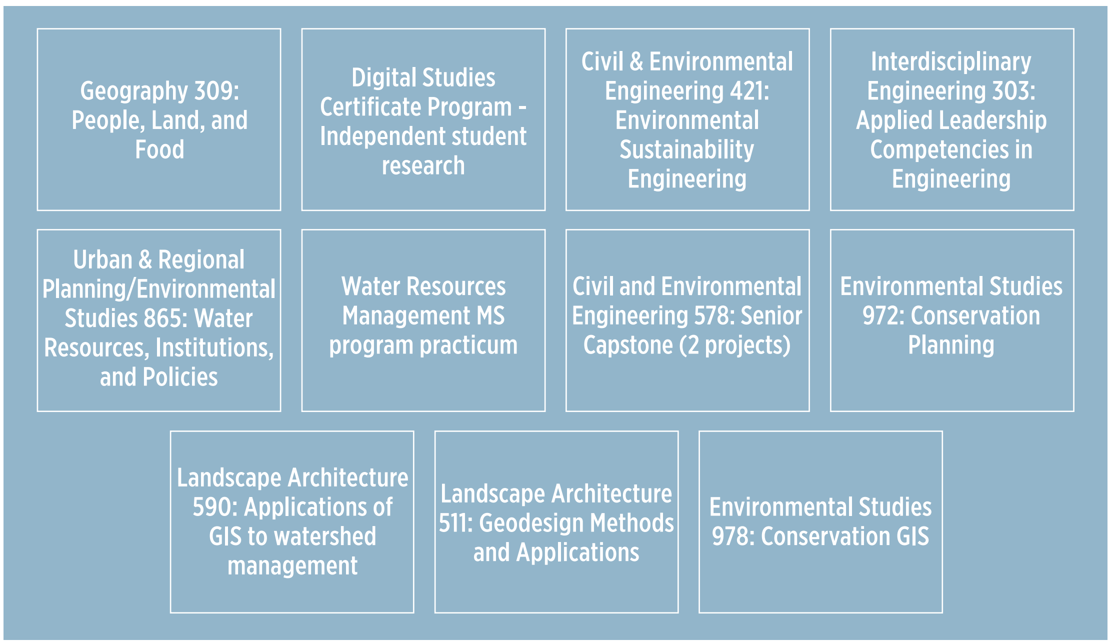


Figure 8.1. UW-Madison courses participating in UniverCity Year Koshkonong Creek.

This section outlines key recommendations for advancing Koshkonong Creek's restoration and resilience. These include fostering stakeholder collaboration, expanding citizen science initiatives, enhancing recreational opportunities, restoring wetlands, and mitigating sedimentation. Implementing these strategies will require a combination of technical expertise, funding opportunities, and policy support. By leveraging grants, community engagement, and science, the Koshkonong Creek community can develop solutions that support a healthier and more resilient watershed.

8.2 Citizen Science Opportunities

Citizen science refers to the active participation of community members in scientific research, often through data collection, environmental monitoring, and collaborative problem-solving. By involving local stakeholders — including residents, farmers, recreational users, and advocacy groups — citizen science strengthens watershed management by providing valuable real-time data on stream health, obstructions, and pollution sources. This information, which would otherwise be expensive and time-consuming to gather, enhances monitoring efforts and informed decision making. In the case of Koshkonong Creek, citizen science initiatives can help bridge gaps in monitoring efforts, increase public awareness, and foster a sense of shared responsibility for the watershed's health. This section explores opportunities for integrating citizen science into ongoing restoration efforts, including the use of GIS tools, obstruction reporting surveys, and water quality monitoring programs.

Involving the community not only aids in achieving stakeholder buy-in for government projects, but it also helps increase the range of data collection for scientific purposes, achieves community outreach requirements for a number of government grants, increases community member's watershed literacy and environmental knowledge, and in turn, allows community members to actively contribute to decision making processes. This makes solutions more efficient, equitable, and realistic. A pertinent example is the Chesapeake Monitoring Cooperative (CMC), which unites volunteers, local organizations, and government agencies to monitor water quality across the Chesapeake Bay watershed. This collaboration not only broadens data collection efforts but also enhances community engagement and environmental literacy. The data gathered by citizen scientists have been instrumental in informing policy decisions and guiding restoration projects, leading to more effective and equitable environmental management solutions (Chesapeake Monitoring Cooperative, 2025).

Figure 8.2 Students hand out information material during a UniverCity Alliance educational event. Photo by Bryce Richter/UW–Madison

8.2.1 GIS HUB AND OBSTRUCTIONS REPORTING SURVEY

In order to involve the community in watershed management, effective communication with community stakeholders is essential (Quinn, 2022). Digital tools are playing an increasingly important role in engaging community members by providing platforms for information and data sharing, collaboration, and participatory decision-making. ArcGIS Hub is a cloud-based platform that enables organizations to communicate more effectively with stakeholders and communities. We created a hub site for the watershed to increase the community's sense of ownership and responsibility, through furthering their active participation in the management process (Figures 8.2, 8.3). This hub site can provide visual representations of complex watershed data, helping more people understand the intricacies of watershed dynamics, while also increasing the availability of scientific data. Additionally, it can be a great way to combine citizen science efforts with other public engagement efforts within the watershed. The ESRI platform allows the creation of "initiatives" which can be hosted by government entities, community members, or jointly between different kinds of stakeholders. These initiatives can include Geographic Information System (GIS) maps and data, surveys, hub sites, and more. Surveys can be used to gather a variety of information and opinions, which can then inform decision-making. Online surveys can also be used as a method for community members to collect data, such as obstructions, water quality information, and anything else that is considered valuable for a watershed management project. Using online surveys such as Survey123 can allow for faster data results, less costs, and increased

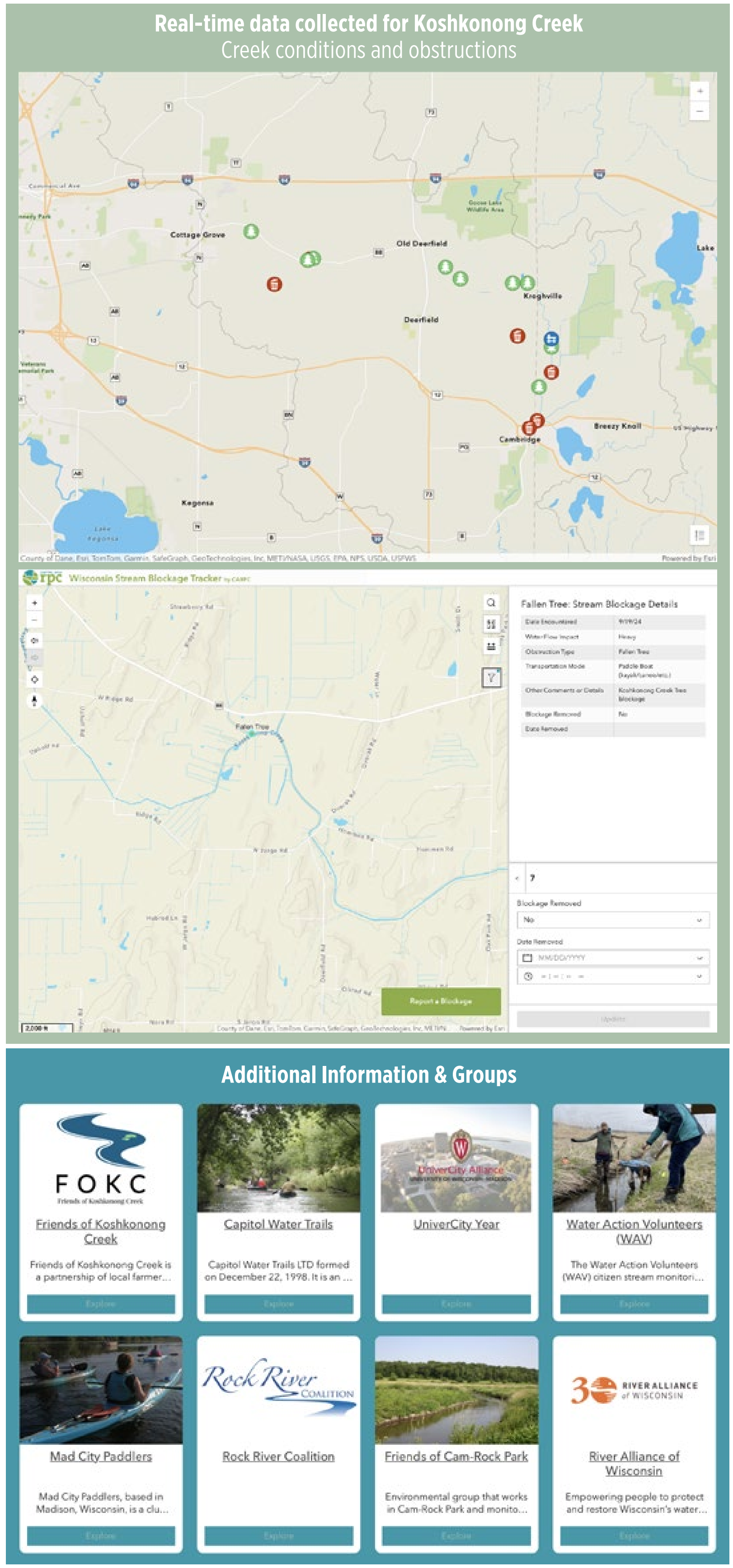


Figure 8.3. Koshkonong Creek hubsite.

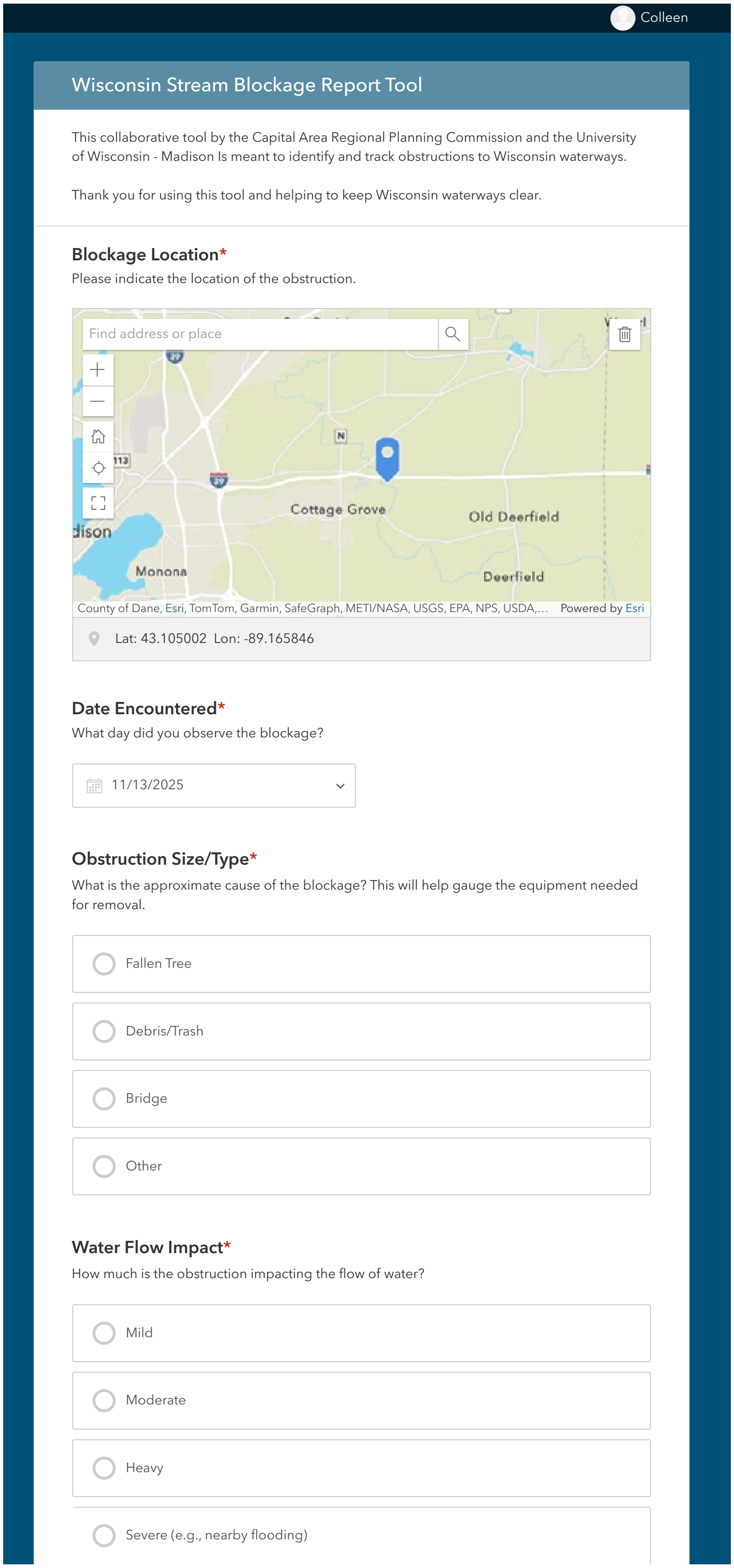


Figure 8.4. CARPC stream blockage report tool. CARPC [Stream Blockage Tracking Tool](experience.arcgis.com/experience/97db07e8c38c4d969ac8ea4cbe5703d8/) (experience.arcgis.com/experience/97db07e8c38c4d969ac8ea4cbe5703d8/).

responses. Community members can also sign up to receive alerts about an initiative to stay informed and they can choose their level of engagement.

We have used Survey123 to more efficiently track obstructions, particularly tree falls, which multiple stakeholders have been working to address independently (see Figure 8.4). The survey, accessible via mobile devices or desktops, allows participants to anonymously or non-anonymously map obstructions in real time or after the fact, include photos of the obstructions, and notify internal stakeholders — such as friends groups or government employees — when new obstructions are reported. The hub site currently hosts the Survey123 results, GIS data available for download, email subscription options for updates about the initiative, an event calendar, and links to stakeholder group web pages within the watershed. The goal of the hub site is to ensure this information is shared beyond the scope of our project and remains a useful resource for stakeholders. Additionally, this tool provides an excellent way to document local, traditional, and indigenous knowledge of the watershed. Inspired in part by the obstructions survey we developed, the Capital Area Regional Planning Commission (CARPC), in partnership with Capitol Water Trails, the Wisconsin State Trails Council, and the University of Wisconsin–Madison, launched an innovative web map to identify and track obstructions in Wisconsin waterways (CARPC, n.d.). This tool is not only applicable to Koshkonong Creek but can be used statewide to improve waterway management.

8.2.2 GOOGLE EARTH ENGINE AND GOOGLE COLAB

Another tool that could be leveraged by citizen scientists is Google Earth Engine (GEE). GEE is a powerful cloud-based platform designed for planetary-scale environmental data analysis. It provides an extensive catalog of satellite imagery and geospatial datasets along with tools for their analysis. By leveraging Google's infrastructure, GEE can process large datasets rapidly, which is particularly useful for tasks such as land cover classification, change detection, and environmental monitoring. GEE's platform is accessible via a web-based interface and JavaScript Application Programming Interface (API), allowing users to perform complex analyses without the need for significant local computational resources. Google Colab (Colab), on the other hand, is a cloud-based Jupyter notebook environment that facilitates Python programming and data analysis. It provides free access to computing resources, including GPUs and TPUs, making it an ideal tool for machine learning and deep learning applications. Colab supports collaboration, allowing multiple users to work on the same notebook simultaneously. This feature, combined with the ability to import and use popular Python libraries, makes Colab a versatile tool for developing and testing custom analysis workflows.

Integrating Google Earth Engine into Object-Based Image Analysis (OBIA) can significantly enhance the efficiency and scalability of floristic quality assessments. GEE's extensive data catalog includes high-resolution satellite imagery and environmental datasets that can be used to monitor vegetation changes over time. This real-time access to data, combined with GEE's powerful analytical capabilities, allows for the rapid processing of large volumes of imagery, which is essential for comprehensive vegetation assessments. One of the key benefits of using GEE is its ability to handle the computationally intensive tasks required for OBIA, such as image segmentation and classification. By offloading these tasks to GEE's cloud infrastructure, researchers can overcome the limitations of local hardware, enabling more detailed and extensive analyses. Additionally, GEE's collaborative environment allows multiple stakeholders to access and contribute to the analysis, fostering a more integrated approach to environmental management. Google Colab complements GEE by providing a flexible environment for developing and testing custom analysis scripts. Researchers can use Colab to write and run Python code that interacts with GEE's JavaScript API, enabling more sophisticated analyses and the integration of machine learning models. For instance, Colab can be used to develop and train models for classifying vegetation types based on spectral signatures, which can then be applied to large datasets in GEE.

The collaborative nature of Colab also facilitates teamwork, allowing researchers from different disciplines to work together on the same project. This can lead to more holistic and innovative approaches to floristic quality assessments. Furthermore, Colab's ability to integrate with other Google services, such as Google Drive, makes it easy to store and share datasets, results, and documentation. Implementing cloud computing tools like GEE and Colab in future OBIA efforts can streamline the workflow and improve the accuracy of floristic quality assessments. Researchers can start by leveraging GEE's data catalog to obtain up-to-date satellite imagery of the study area. Using GEE's analytical tools, they can perform initial image segmentation and classification to identify different vegetation types and assess their health. Next, researchers can use Google Colab to develop and test machine learning models that refine the initial classifications. These models can incorporate additional data sources, such as field observations (RFQIAs) and sensor data, to improve their accuracy. Once validated, the models can be deployed on GEE to analyze larger datasets and monitor vegetation changes over time. The integration of Google Earth Engine and Google Colab into OBIA workflows offers a powerful and cost-effective solution for enhancing floristic quality assessments. These cloud-based platforms provide the computational resources and collaborative tools needed to perform detailed and scalable environmental analyses. By leveraging these technologies, future research and monitoring efforts can achieve more accurate and comprehensive assessments, ultimately contributing to better-informed conservation and management decisions for the Koshkonong Creek watershed.

8.2.3 ACCESSIBILITY

It is important to note that there are accessibility and equity concerns with digital tools in citizen science. While these tools have greatly enhanced the accessibility of scientific data and citizen science, there are challenges such as equitable access to computers and the internet, digital literacy, and potential biases in data collection. These considerations need to be addressed to ensure the inclusion of all community members and interests in the watershed. Additionally, it can be difficult to get buy-in from some community members to use these digital tools. Making sure that community members from all backgrounds are aware of these tools and are able to use them is critical. For community members who cannot use digital tools, other community engagement strategies, such as events and workshops, will need to be leveraged. Digital tools are one solution of many in increasing community engagement in managing watersheds and environmental issues more broadly.

8.2.4 VOLUNTEER STREAM MONITORING AND WATER QUALITY TESTING

Landowners and those concerned with the health of the creek can do many things to help governing bodies study the creek. The Wisconsin Water Action Volunteers (WAV) is a program that is a collaboration between UW–Madison Division of Extension, the WDNR, and volunteers that aims to add much needed human power to stream monitoring efforts. Janice Redford, one of the many stakeholders and people we have interviewed is one such volunteer. WAV members help the WDNR with stream monitoring by measuring key indicators such as stream flow, dissolved oxygen, temperature, macroinvertebrates, turbidity, and habitat. They also assist in collecting samples for nutrient analysis. Volunteering as a part of this program would give governing bodies such as the WDNR much better information so that the decisions made about the future of the creek are of higher quality.

For example, with just a few basic tools — a tape measure, a velocimeter, and a marked pole — community members can easily measure stream dimensions and discharge, as well as conduct periodic water sampling. WAV provides detailed methodology on their website, ensuring that volunteers can collect accurate and valuable data to support watershed management efforts (wateractionvolunteers.org/resources/methods/).

8.3 Recreational Opportunities

Further developing recreational opportunities and infrastructure in the watershed will help build community awareness and support. Most recreational opportunities, such as paddling and fishing, are available further downstream from our study area. In our study area, issues like blockages, creek health, lack of safe access points, and community awareness make recreational opportunities harder to come by. Recreational activities can help to promote awareness of the creek, community involvement, local economies, physical and mental wellbeing, and the conservation of the creek through community involvement (Miller, 2020). When community members engage in recreational activities they can develop a deeper understanding and appreciation for them. This increased awareness can lead to stewardship, where more people are willing to take actions to protect and preserve the creek ecosystem. Community-led initiatives can include cleanup events, habitat restoration, and educational programs focused on the creek. Additional benefits from increased recreational activities include recreational tourism and outdoor recreation-related businesses. Activities such as paddling, fishing, and wildlife viewing can attract more visitors to the area, which can support local businesses such as restaurants, stores, cafes, and more. Creating Public Access Points (Figures 8.5 and 8.6) and expanding the Glacial Drumlin Trail (Figure 8.7) are some ways that recreational opportunities could be increased in the upper half of the watershed.

Obstructions create numerous issues, with one of the most prevalent being reduced streamflow. This reduced flow subsequently leads to an increase in sediment depth in the stretch of the creek behind these obstructions, further exacerbating sedimentation (Rolls et al., 2012). It also makes the creek difficult to navigate, lowering recreational interest. Continuing the work of removing obstructions will make great strides in the restoration of water quality and improving public interest in the creek. Groups like Cap City Water Trails, Rock River Coalition, and the Friends of Koshkonong Creek have done outstanding work in removing obstructions from the creek. Additionally, our group recommends the removal of these dead trees on one side of the streambank, while leaving trees on the opposite side of the streambank untouched. This would make it less likely for such trees to cause further obstructions, while still ensuring that shade and habitat can be provided for organisms utilizing this riparian corridor.

Paddling is the other major recreational avenue provided by the stream. During our sediment surveys, it took us a combined 20 hours to paddle a mere six miles one direction in the creek. The amount of time we spent weaving through snags or exiting our kayaks to portage around them was staggering. If anyone is to realistically enjoy a paddle down Koshkonong Creek, the snags and obstructions must be dealt with. It is defined as a navigable waterway but in the cohort's experience while conducting sediment measurements, there were several sections of the creek that required portaging or were impossible to pass through. The opportunity that Glacial Drumlin Trail provides for recreation is not to be ignored. If users could run/walk/bike the trail and then go for a paddle too, that would do wonders in generating support. Removing snags is only half of the solution. The

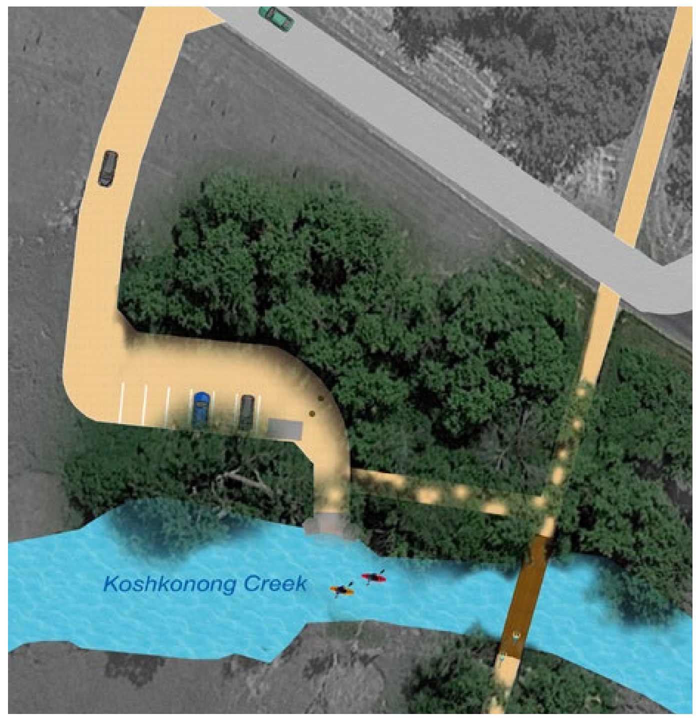


Figure 8.5. Depiction of a public access point for paddling from a UniverCity Alliance (UCA) class.

Figure 8.6. Picture of a public access point for paddling.

Figure 8.7. Rendering of what a Glacial Drumlin trail extension could look like from a UCA Class.

other is improving water quality. After a rain event, runoff containing increased levels of bacteria, nitrates, and other contaminants may pose health risks to potential paddlers of Koshkonong Creek. Excess nitrates, industrial pollution, algae blooms, and agricultural runoff are all human health hazards. Improving water quality would reduce these health risks and could bring more people in to enjoy the creek.

Exploring the recreational potential of Koshkonong Creek should be balanced with early engagement of adjacent landowners to address possible concerns about access, environmental impacts, and property rights. Building trust and maintaining open communication will be essential to ensure that any future initiatives reflect the interests of both the broader community and those most directly affected. Proactive collaboration can help identify mutually beneficial solutions and minimize potential conflicts.

8.4 Sediment Mitigation Strategies, Modeling, and Creek Health

Excess sediment in Koshkonong Creek negatively impacts water quality, aquatic habitats, and overall ecosystem health (Amrhein and Sorge, 2018). Sediment pollution, often driven by agricultural runoff, erosion, and stormwater discharge, can lead to increased turbidity, nutrient loading, and habitat degradation. Additionally, sediment buildup can reduce channel capacity, leading to increased flooding risks by slowing water flow and causing localized blockages. These issues are particularly concerning during heavy rainfall events when excess sediment and debris can exacerbate flood conditions.

8.4.1 HYDROLOGIC AND HYDRAULIC MODELING

The outputs generated by our hydraulic analysis are useful in quantifying the effect that instantaneous sediment removal would have within the study area. When reflecting upon the completion of this modeling effort, several recommendations for analogous future research endeavors became readily apparent.

Perhaps the most important recommendation to improve the validity of future modeling efforts is to establish a stream gauge at some point along the creek. Having tangible measurements for streamflow would allow for seamless calibration of future hydrologic, and subsequently, hydraulic models. Koshkonong Creek has not had an established stream gauge since 1967, evidently making it impossible to compare past and present flow regimes. The establishment of stream gauges at the outlet of each HUC-12 encompassing the greater Koshkonong Creek HUC-10 would be instrumental in developing a more robust understanding of the precipitation-runoff response of each subbasin. This understanding could be utilized to refine existing hydrologic and hydraulic models of the area, as the modeled outflow values could be readily compared to observed values from the stream gauge.

In a similar vein, it would be prudent for future modeling efforts to establish a more robust network of precipitation gauges within the watershed, so that the response of the creek from precipitation events of different magnitudes could be quantified more accurately. One resource that could be used to accomplish this objective is the Community Collaborative Rain Hail & Snow Network (CoCoRaHS). Established in 1998 with a few observers in Colorado, CoCoRaHS now boasts over 26,000 active observers throughout North America ("CoCoRaHS, Community Collaborative Rain, Hail & Snow Network"). Precipitation patterns can be quite variable even at small spatial scales. In part, the CoCoRaHS network covers gaps in areas where precipitation data may not have previously existed, and therefore leads to a more robust estimation of precipitation patterns within a relatively small area such as a HUC-10 or a HUC-12. Data from these gauges could then be used to refine the precipitation input within the HEC-HMS model, which currently uses empirical precipitation estimates from NOAA Atlas 14. By using observed precipitation data on a fine spatial scale, streamflow response from these precipitation events could be more accurately characterized, which in turn, would create a more robust hydrologic model.

Another point of refinement for the hydrologic model that our group would recommend investigating is to quantify a scenario in which wetlands are incorporated as a flood mitigation strategy. This could be accomplished in HEC-HMS by updating the curve number associated with each subbasin, which would be expected to decrease with a greater extent of established wetlands. The resulting outputs from this hydrologic model could then be run in HEC-RAS, in order to evaluate the effect of increasing wetland area on inundation areas. Additionally, the development of a sediment transport model, which could be seamlessly coupled with the existing HEC-RAS model, would provide a more realistic estimation of sediment fate within the watershed, allowing models simulating removal scenarios, such as the one developed for this research effort, to become more detailed.

8.4.2 SEDIMENT MITIGATION STRATEGIES

Effective sediment mitigation requires a combination of best management practices (BMPs) to reduce erosion and sediment accumulation. We recommend that landowners implement sediment basins and vegetative strips, as these strategies offer distinct benefits and can be enhanced when integrated with other land management approaches. While dredging may be necessary in some cases, its high costs, logistical challenges, and potential ecological harm make it a less desirable option unless preceded by other BMPs and followed by ongoing maintenance. When combined with BMPs, dredging can have more positive long-term impacts by reducing the need for future large-scale sediment removal. Moving forward, integrating sediment mitigation strategies into comprehensive land management practices will be essential for balancing agricultural needs, community interests, and the preservation of Koshkonong Creek.

8.4.2.1 Dredging

Although dredging can temporarily enhance water flow and reduce flood risk by removing accumulated sediment, it is not a sustainable long-term solution unless paired with effective sediment management practices. Without proper erosion control measures, sediment will continue to accumulate, necessitating repeated dredging and increasing financial and environmental burdens.

Given the complexities of the dredging permitting process in Wisconsin — including extensive regulatory requirements, potential wetland restrictions, and costly sediment disposal — landowners should first consider alternative sediment mitigation strategies. Best management practices (BMPs) such as sediment basins, vegetative buffer strips, and erosion control measures can significantly reduce sedimentation at the source, minimizing the need for large-scale dredging projects. Implementing these strategies can improve water quality, protect aquatic habitats, and reduce long-term maintenance costs.

For landowners who pursue dredging, careful planning is essential to ensure compliance with permitting regulations and to manage sediment disposal responsibly. Due to the prevalence of wetlands in the study area, special attention must be given to proper disposal sites, as dredged material cannot be placed on wetland-designated land. If on-site disposal is not an option, landowners must coordinate with designated landfills, which involves additional costs for sediment analysis, transportation, and disposal fees.

To achieve long-term sediment mitigation, we recommend that landowners prioritize preventative BMPs and ongoing land management practices. By addressing sedimentation at its source and integrating multiple mitigation strategies, landowners can reduce the need for repeated dredging, lower associated costs, and contribute to the long-term health and sustainability of Koshkonong Creek.

8.4.2.2 Sediment Basins

Sediment basins are temporary ponds with appropriate control structures, designed and constructed to handle the anticipated excess runoff and sediment from nearby agricultural farms. Sediment basins built and maintained according to the guidelines provided by the Minnesota Stormwater Manual are highly effective as a sediment mitigation practice.

Through the retaining of the sediment-filled runoff, the sediment basins are speculated to capture about 80 percent of the soil particles, which improves the water quality by reducing the turbidity and the suspended sediments, which in turn benefits the aquatic ecosystems and also preserves the soil structures by preventing erosion. The effectiveness of a sediment basin is dependent on the regular maintenance and proper removal of the accumulated sediment. Additionally, the proper placement of the sediment basin is a crucial factor to consider as areas with high velocity flow could disturb the sediment settling process. Properly managed sediment basins offer a balanced and efficient approach to controlling sediment runoff from agricultural lands.

8.4.2.3 Vegetative Strips

Vegetative strips are areas of permanent vegetation located within and between agricultural fields and the water courses to which the runoff drains. The purpose of the vegetative strips is to slow the incoming runoff, trap the sediment particles and other pollutants and in turn improve the water quality. The deeply rooted plant species planted along the bank stabilize the soil, significantly reducing erosion risks and enhancing water infiltration, which improves groundwater recharge. Research has shown that vegetative strips are most effective in reducing the concentrations of nitrogen, phosphorus and sediment in surface water runoff. Additionally, vegetative strips are speculated to have a sediment trapping efficiency ranging from 41 percent to 100 percent and an infiltration efficiency ranging from 9 to 100 percent (EPA, 2021). As mentioned above, these vegetative strips are expected to have a positive effect on soil health by the banks of the creek, and the perennial vegetation is believed to provide an excellent habitat for wildlife. Similarly to the sediment basin, proper maintenance is required for the effectiveness of vegetative strips, including weed control and managing the possible pests that can be introduced. Vegetative strips also offer a sustainable and efficient approach to mitigating sediment and improving overall environmental health.

In the context of riparian zones, vegetative strips can be considered an essential component of riparian buffer zones, which are areas of natural vegetation along the banks of streams and rivers. These riparian buffer zones serve as critical zones for protecting water quality, stabilizing shorelines, and enhancing biodiversity. By extending the vegetative strips into riparian buffer zones, the benefits to both water quality and ecosystem health are amplified, contributing to more resilient and sustainable waterways.

8.4.3 NUTRIENTPOLLUTION AND WATER QUALITY IMPROVEMENTS

To reduce the nutrient runoff into the creek, we recommend the establishment of a riparian buffer zone made up of native wetland plants. A riparian buffer is a low maintenance and inexpensive method of adding natural flood and runoff protection in fluvial ecosystems. Runoff remains one of the largest obstacles to good water quality. A buffer between fields, roads, and lawns made up of native wetland plants will act as an ecological "sponge" that prevents many potentially harmful compounds and nutrients from entering the creek. Establishing a buffer along a large portion of the creek will likely improve water quality. We recommend that every landowner install riparian buffers on their property adjacent to the creek. Riparian buffers can serve as a starting point to solve some of the major problems faced by landowners in the region. They can be used to stabilize streambanks, enhance the aesthetic value of the creek, and improve water quality. The majority of the study area is burdened with extensive creek obstructions that are primarily large fallen trees resulting from unstable banks. These unstable banks result in large amounts of erosion that leads to sediment build-up in the creek and this thick sediment anchors tree falls into place. Tree snags and sediment build-up make navigability in small watercraft impossible in many places, in addition to being visually unappealing.

For the purposes of improving water quality, riparian buffers are efficient at nutrient uptake through vegetation in the buffer. To remove Koshkonong Creek from the 303(d) Impaired Waters list, its phosphorus levels must be reduced. Agriculture in the watershed will remain, and if landowners want to see a healthier creek, they must take steps to reduce the amount of phosphorus entering the creek. Pesticides and fertilizers enter the creek after irrigation and storm events, and less of those contaminants can reach the creek if buffers were in place to trap those nutrients.

There is no perfect way to design a suitable riparian buffer, but we recommend that landowners reference a guide developed by Southeastern Wisconsin Regional Planning Commission (SEWRPC) to implement buffers on their land. Given the proximity of SEWPRC to the Koshkonong Creek Watershed, the guidance outlined in the Riparian Buffer Management Guide NO. 1: Managing the Water's Edge (2010) will be applicable to landowners in our study area. The overall goal of the buffers discussed in this document is the rule of 75. To maximize the integrity of the water resources, 75 percent of the entire stream should be naturally vegetated and the buffer zone itself should be a minimum of 75 feet wide (SEWRPC, 2007). Widths of varying sizes can have differing benefits. Though 75 feet is the minimum width to be effective, a buffer 200 feet wide may be necessary for optimal bank stability and as much as 300 feet wide to maximize nutrient removal (Southeastern Wisconsin Regional Planning Commission, 2010). Figure 8.8 illustrates overlapping connections with flood control.

Once the landowner identifies their primary goal of the buffer – whether that is aesthetic value, nutrient removal, bank stability, or otherwise – they will then need to determine the best types of vegetation to provide the benefits they desire. Buffers are typically divided into zones of varying vegetation. For understanding the types of vegetation necessary

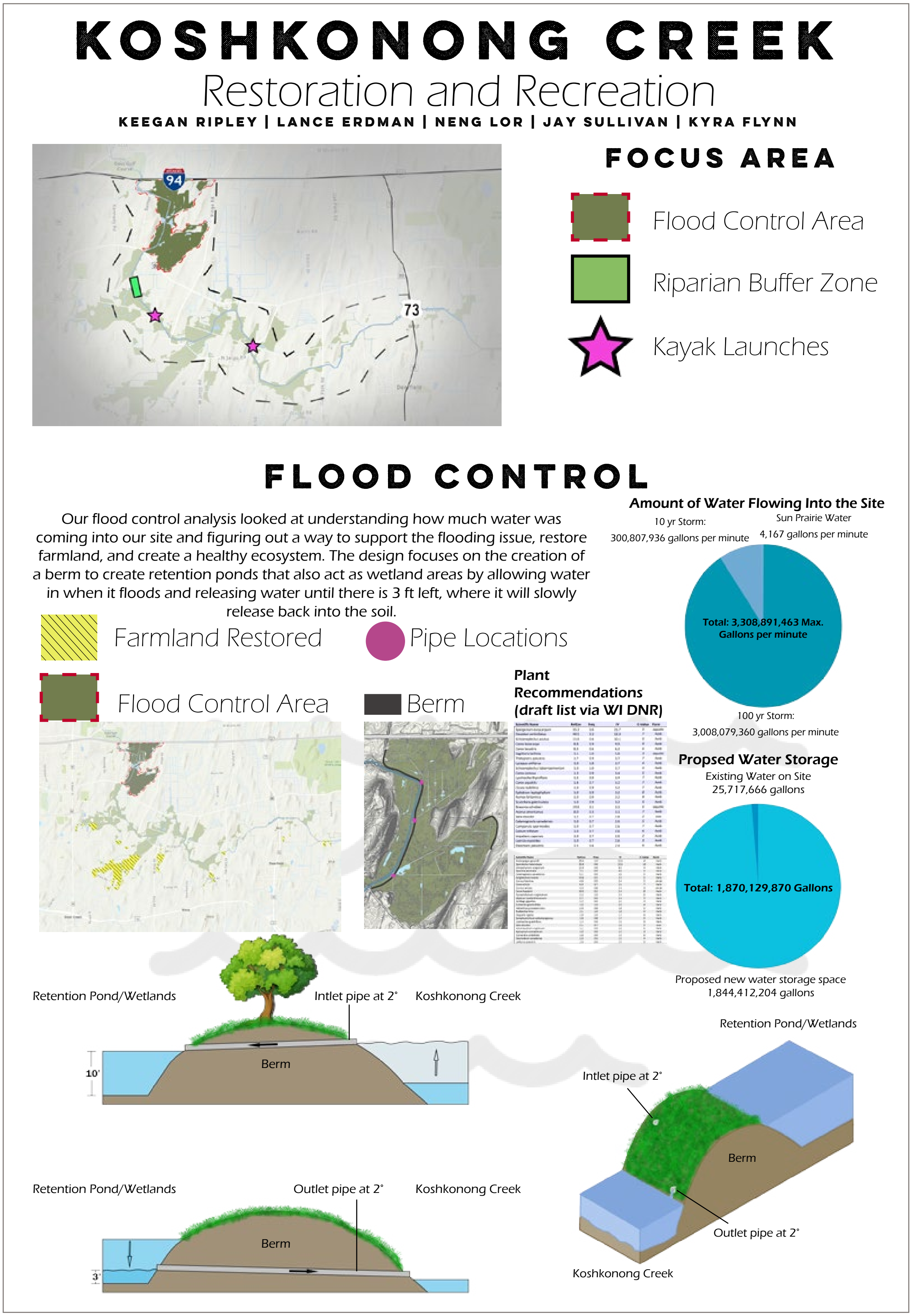


Figure 8.8. Illustrations of flood control options for Koshkonong Creek developed by UW–Madison students in Fall 2023 Land Arc 511 'Geodesign methods and applications' course.

for a landowner's buffer, we recommend referring to University of Wisconsin – Stevens Point's guide developed by Southeast Michigan Resource Conservation and Development Council that outlines categories of plants for each zone. Zones 1 and 2 should be filled with native woody vegetation that is strong enough to stabilize the banks. Specifically, Zone 1 should contain trees on one side of the creek to increase shade for recreation and wildlife, but only woody shrubs for the other side so as to reduce the amount of large tree falls entering the water. Zone 2 should also contain woody vegetation for erosion control and can be similar to the shrub side of the creek. Since different plants have different environmental benefits, it is recommended to diversify the plant species used in these areas. Finally, Zone 3 should be tall grasses that would be the first barrier for nutrient runoff (Southeast Michigan Resource Conservation and Development Council, n.d.).

Figure 8.9. seasonal organic matter in a stream. Photo by Kevin Berger

Working with farmers to utilize techniques such as cover cropping, precision agriculture, and implementing nutrient management plans will assist in lowering the amount of nutrients that flow toward the creek. Additionally, promoting sustainable land use practices such as conservation tillage and crop rotation will reduce nutrient needs. Combined with a riparian buffer, lowering initial nutrient usage will help remove Koshkonong Creek from the 303(d) list. Lastly, Nitrogen and Phosphorus levels in the soil should be monitored. This would help farmers make informed decisions when determining how much fertilizer to apply. Additionally, chloride is posing a threat to the quality of the creek and action is needed to reduce salt usage, especially in areas near the creek. Salt usage from water softeners will persist. There are salt free water softeners commercially available, and they should be utilized whenever possible, but expecting the entire watershed's population to switch to this alternative is unrealistic. The cheapest and simplest solution for the present is to reduce road salt usage during winter. For the longer term, the solution may be to lobby the state legislature into providing funds for municipalities to purchase and operate chloride removal equipment in wastewater treatment plants. The potential threat high chloride levels have on the creek's future warrants action sooner rather than later.

8.5 Wetland Restoration

Based on the research team's field observation of soils and vegetation within key sites, most locations observed have wetland soils present but predominantly invasive or non-native vegetation at these points due to disturbance from agriculture and increased pollutants. In contrast, reestablishment may be pertinent in areas where there are no existing wetlands suited for rehabilitation. A net gain in wetland area (and therefore flood storage capacity) occurs within areas of reestablishment but not rehabilitation.

As seen in the results of the RFQA, many of the remaining wetlands in the watershed are degraded, and historical wetland areas that were drained for agricultural production are returning due in part to increased flooding and ineffective drain tiles. One solution for farmers being negatively impacted by persistent flooding on their lands is restoring wetlands on their property. Much of the land surrounding the creek would be suitable for wetland restoration by standards of containing hydric soils. Some of the primary soil types in the watershed are Houghton muck, Colwood silt, and Adrian muck which are all considered hydric soils. In a flood management study in the Upper Koshkonong Creek Watershed requested by the Dane County Land Conservation Department in 2001, the NRCS concluded that multiple small-scale restorations would be more effective for overall watershed flooding than a single large-scale restoration (USDA NRCS and Dane County LCD, 2001). This is because flooding upstream from a restoration site wouldn't see any positive impacts.

Landowners interested in restoring wetlands on their land should refer to the USDA Web Soil Survey to determine the soil type on their land (USDA, Web Soil Survey). As a part of the NRCS Agricultural Conservation Easement Program (ACEP), landowners considering restoration can participate in the Wetland Reserve Easements component. The ACEP aims to provide technical and financial assistance specifically to individuals who own property with wetlands that were altered for agricultural production and are interested in removing land from production and returning the area to wetland. This option allows individuals to retain ownership of their land, remove unproductive farmland, and provide additional income, among other benefits. Currently, landowners can opt into Permanent Easements, 30-Year Easements, and Term Easements. Landowners can contact the Madison USDA Service Center to discuss their options in more detail.

Along with water storage, wetlands in the watershed can increase the area's aesthetic value. It is specifically recommended that landowners who own land directly adjacent to the creek consider wetland restoration. Not only can this provide flood relief from creek water overflow, but it also attracts both wildlife and recreation to the Koshkonong Creek. Increasing recreation can boost the local economy and raise awareness of the creek conditions. Widespread awareness about the creek and care for its health are more likely to attract community members to invest their time into local volunteer efforts to monitor water quality and remove creek obstructions. This may also spur financial investment from community members and increase advocacy to local officials to fund larger-scale restoration efforts.

8.6 Collaboration, Governance, Funding, and Implementation

The implementation of our recommendations requires the collaborative efforts of the Koshkonong Creek Watershed community. Engaging residents, conservation groups, and government agencies is essential to create a shared vision for the creek's health. Many stakeholders in our study area expressed their concerns over the lack of coordination across governmental entities, other groups, and individuals. Throughout our research, it became evident that while multiple stakeholders — including government agencies, nonprofit organizations, farmers, and community members — are working toward similar goals, their efforts are often uncoordinated. Strengthening collaboration among these groups is essential for effective watershed management. To address this, we recommend that FOKC expands its membership and that groups within the watershed continue and further their collaborations. We also recommend that FOKC registers as a 501(c)3 nonprofit organization to help raise the group's profile with potential funders and other entities, including governments, other NGOs, and other community members. Registering as a nonprofit and potentially joining other groups such as RRC could help strengthen FOKC to be a sustainable organization focused on improving and restoring the creek, improving creek access, and addressing the needs of watershed stakeholders. Additionally, we recommend the establishment of a watershed advisory group or partnership to help facilitate communication, align priorities, and oversee project implementation — this could be something FOKC takes over and becomes, or it could be a new group or coalition. This could involve establishing clearer roles and responsibilities, as well as creating new channels for communication and decision making. This group could help implement strategies such as citizen science to empower local communities to take an active role in data collection, monitoring, and stewardship of Koshkonong Creek. By integrating local knowledge and fostering a sense of ownership, citizen science initiatives can enhance monitoring efforts and provide critical, real-time data on water quality and biodiversity. Moreover, increasing opportunities for volunteering, improving recreational access, hosting community events, and streamlining existing efforts will further bolster efforts towards sustainable watershed management.

In addition to increasing collaboration among stakeholders and community members, getting funding from different government entities is an important mechanism for protecting the watershed for generations to come. One effective approach is to seek grants from federal, state, and county programs. By leveraging these diverse funding sources, the community can implement comprehensive strategies to enhance and preserve the Koshkonong Creek watershed. Table 8.1 (on page 65 and 66) shows the variety of programs available.

Fostering a sense of ownership and responsibility among community members is also essential for the sustained health of the watershed. Educational initiatives, volunteer programs, and public outreach efforts can help residents develop a deeper understanding of the issues facing Koshkonong Creek and the role they can play in its protection. Hands-on activities such as tree planting, streambank restoration projects, and water quality monitoring programs can further encourage public participation. Additionally, incentive-based programs, such as cost-share opportunities for implementing Best Management Practices (BMPs), can motivate landowners to adopt sustainable land management strategies. With proper planning and stakeholder buy-in, these strategies can collectively create a more resilient and sustainable Koshkonong Creek for future generations.

While there are opportunities for policy change, implementing them on a watershed scale in Wisconsin can be

Table 8.1. Public grants that could be used in the watershed broken down by federal, state, and county level. Continued on page 66.

FEDERAL LEVEL	
EPA Wetland Program Development Grants (WPDGs)	These grants are designed to support the development and enhancement of state, tribal, and local wetlands protection programs. They provide financial resources to improve the capacity of wetlands management, including monitoring, assessment, and restoration efforts. This program could be used to manage and restore wetlands in the watershed.
USDA Environmental Quality Incentives Program (EQIP)	EQIP offers financial and technical assistance to agricultural producers to address natural resource concerns and improve environmental quality. It promotes conservation practices that lead to cleaner water and air, healthier soil, and enhanced wildlife habitat.
NRCS Wetlands Reserve Program (WRP)	This program helps landowners restore, enhance, and protect wetlands on their property. It offers financial and technical assistance to improve wetland ecosystems, benefiting both the environment and the landowners. :andowners can opt into Permanent Easements, 30-Year Easements, and Term Easements
NRCS Agricultural Conservation Easement Program (ACEP)	CEP aims to provide technical and financial assistance specifically to individuals who own property with wetlands that were altered for agricultural production and are interested in removing land from production and returning the area to wetland
North American Wetlands Conservation Act (NAWCA)	NAWCA provides matching grants to support the conservation of North America's wetlands and associated habitats. The aim is to protect, restore, and enhance wetland ecosystems for the benefit of waterfowl and other wildlife

STATE LEVEL	
Environmental Improvement Fund (EIF)	The EIF provides funding for municipal drinking water, wastewater, and stormwater infrastructure projects. It aims to improve water quality and public health through loans and grants.
DOA Community Development Block Grant Public Facilities Program (CDBG-PF)	This program funds infrastructure improvements in low-to-moderate income communities. Eligible projects include water and sewer system upgrades, stormwater management, and public building rehabilitation.
WDNR Surface Water Grants	These grants support projects that protect or improve the quality of surface waters in Wisconsin. They fund activities such as lake and river management, aquatic invasive species control, and watershed planning.
WDNR Wetland Conservation Trust	This program focuses on the restoration, enhancement, and preservation of wetlands across Wisconsin. It provides grants for projects that compensate for wetland impacts from permitted activities.
WDNR Clean Water Fund Program (CWFP)	CWFP offers financial assistance for water pollution control projects. The program supports the construction and improvement of municipal wastewater treatment facilities and other water quality protection efforts.
WDATCP Producer Led Watershed Protection Grant Program	This program provides funding to groups of agricultural producers who work together to address soil and water quality issues within their watershed. It supports initiatives like cover

Table 8.1. Continued.

COUNTY LEVEL (DANE)	
Conservation Fund Grant Program	This program provides financial support for the acquisition of land or easements that protect natural resources. The goal is to conserve wildlife habitat, water quality, and open space in Dane County.
Friends of Dane County Parks Grant Program	This grant supports projects initiated by friends groups and other non-profit organizations that enhance county parks. Eligible activities include habitat restoration, trail development, and educational programs.
PARC & Ride Grants for Regional Bicycle Trails	This program funds the planning and development of regional bicycle trails and related facilities. It aims to improve recreational opportunities and promote sustainable transportation options.
Free Native Plants for School and Community Projects	This initiative provides native plants for educational and community-based projects. It promotes the use of native species in landscaping to enhance biodiversity and support local ecosystems.
Urban Water Quality Grant Program	This program offers grants to improve urban water quality through stormwater management projects. Eligible activities include the installation of green infrastructure, such as rain gardens, permeable pavement, and bioswales.

challenging due to fragmented governance and jurisdictional boundaries. However, local land-use policies and comprehensive watershed management plans can serve as effective tools for addressing these challenges. Local ordinances and zoning regulations should be updated to support erosion control measures, conservation easements, and riparian buffer restoration. By embedding these strategies into policy at the local level, communities can create stronger protections for Koshkonong Creek. Although achieving widespread policy change may require navigating complex political and administrative hurdles, these localized policy efforts can lay the foundation for broader regional or state-level action, contributing to the long-term resilience of the watershed.

By strengthening relationships among stakeholders, expanding FOKC's membership, and fostering new partnerships, the community can create a unified vision for the creek's future. Securing funding through various government programs, coupled with citizen science and volunteer-driven efforts, can provide the necessary resources and data to drive impactful action. While navigating policy changes on a watershed scale presents challenges, local land-use policies and comprehensive watershed management plans offer a critical pathway for long-term protection. With sustained community involvement and strategic partnerships, the Koshkonong Creek Watershed can become a model of resilience and sustainability for future generations.

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UNIVERSITY OF WISCONSIN–MADISON