MANAGEMENT RECOMMENDATIONS AND PLAN IMPLEMENTATION 3

Credit: SEWRPC Staff

3.1 INTRODUCTION

Lake Comus is a valuable resource to lake residents and visitors, contributes to the local economy and quality of life, and is an important feature to the overall hydrology and ecology of the Turtle Creek watershed. Because of the Lake's value to the community, the Lake Comus Protection and Rehabilitation District (LCPRD) requested, and was subsequently awarded, a grant to inventory the Lake's resource base and conditions, study issues perceived to harm or threaten the Lake, and suggest solutions to help maintain or enhance the Lake's overall community value. Unmitigated human-induced change is generally detrimental to waterbody health. Therefore, management actions should be taken to counter negative effects of human activity. This chapter provides actionable suggestions that help maintain and enhance the health of the Lake and support its continued enjoyment.

Major Challenges and Goals

Lake Comus and its watershed possess many unique and valuable features including substantial lengths of undeveloped shoreline, extensive riparian wetlands, numerous opportunities for public access and recreation, large and growing areas of publicly owned land managed to support wildlife, and the presence of several rare and threatened species. Nevertheless, the Lake and the Creek face major challenges as revealed by its 2022 assignment to the Clean Water Act 303(d) impaired waters list. For example, as detailed in Chapter 2, the Lake receives heavy sediment and nutrient loads and is highly eutrophic (nutrient-rich). This causes the Lake to have very limited water clarity, large shoals of nutrient-rich sediment, a depauperate aquatic plant community, and experience occasional algae blooms. Such factors limit the Lake's ecological potential and its overall recreational use value. These conditions are exacerbated by abundant invasive common carp that hinder aquatic plant growth and agitate phosphorus-laden soft Lake-bottom sediment.

The Lake's eutrophic state is driven by excessive nutrient and sediment loads delivered to the Lake primarily from the upper Turtle Creek watershed. Extensive historical ditching and channelizing of Turtle Creek and its tributaries combined with intensive agricultural use have dramatically changed watershed hydrology and increased nutrient and sediment delivery to the Lake. Even with implementation of conservation practices that help reduce ongoing pollutant loading, legacy phosphorus and sediment are still delivered to the Lake via Turtle Creek and are deposited at the Lake's shallow northern end. Continuing efforts are required to decrease nonpoint pollutant loading within the watershed which, in turn, reduces the transport of excessive amounts of sediment and nutrients to the Lake. Similarly, the Lake's water supply must also be protected. Many of the management actions taken to manage nonpoint pollutant loading also benefit and protect the Lake's surface-water and groundwater supplies.

As stated in Chapter 1, this management plan strives to protect existing high-quality resources, prevent resource degradation, and enhance resource function by implementing tasks consistent with the following goals:

- Minimize further degradation of surface-water features and preserve, maintain, or enhance the quality of all waterbodies within the watershed.

- Identify opportunities to improve the quality of land and water (including groundwater) resources within the watershed by reducing both nonpoint agricultural and urban runoff.

- Manage and develop lands in a manner protecting natural resources features. This includes avoiding habitat fragmentation, encouraging preservation and enhancement of wetlands and wildlife corridors, providing and preserving connections with upland habitats, and encouraging thoughtful, sensitive landscaping practices.

- Enhance recreational opportunities on Lake Comus and Turtle Creek, particularly for fishing, hunting, paddle sports, and hiking on Lake shoreline trails.

- Promote active stewardship among residents, farmers, landowners, businesses, community associations, as well as governmental and non-governmental organizations.

Successful plan implementation depends upon strong community leadership and coordination, community outreach, and stakeholder collaboration. Examples of this include effective partnering arrangements amongst stakeholders, developing innovative watershed-based tactics that contribute to multiple strategic goals, developing institutional capacity to carry tactics through to completion, and actively monitoring progress and adjusting tactics as needed to reach strategic goals.

Management Recommendations

Management recommendations for Lake Comus are based upon the interests and priorities of lake users, analysis of available data, practicality, and the potential for successful implementation (Table 3.1). Select recommendation concepts, and the general areas of the watershed where these concepts are applicable, are shown in Map 3.1. Implementing these recommendations helps maintain and enhance the health of the Lake and its tributaries, helps the watershed better achieve its latent ecological potential, and improves the watershed's ability to provide short- and long-term sustainable benefits to the overall community.

The recommendations made in this chapter cover a wide range of programs and seek to address a broad array of factors and conditions that significantly influence the health, aesthetics, and recreational use of Lake Comus. Many initiatives share similar strategies and implementation tactics. Therefore, implementing certain tactics often benefits several goals. Since the plan addresses many issues, it is not be feasible to implement every recommendation immediately. To promote efficient plan implementation, the relative time sensitivity/significance of each recommendation is noted to help Lake managers prioritize plan elements. Nevertheless, all recommendations are important and should eventually be addressed, subject to possible revision based on analysis of yet-to-be collected data (e.g., future aquatic plant surveys and water quality monitoring results), project logistics, and/or changing/unforeseen conditions.

Several recommendations constitute major management actions that may provide multiple water quality, recreational use, and aquatic life benefits. However, major management actions may also require careful planning and permitting, community engagement, regulatory approval, and/or significant expense. Examples of such actions include water level manipulation, sediment dredging, and carp removal. Guidance regarding the effects, benefits, and considerations of these lake management actions are summarized in Table 3.2.

Table 3.1
Summary of Recommendation Grouped by Issues

Recommendation Number	Recommendation	Priority
	Hydrology/water quantity	
	Surface Water Monitoring and Management	
1.1	Continue to monitor Lake Comus' water surface elevation	High
1.2	Quantify surface water outflow	High
1.3	Monitor and quantify the volume of water delivered to the Lake from Turtle Creek	High
	Groundwater Monitoring and Protection	
1.4	Institute groundwater monitoring	Medium
1.5	Maintain of enhancing conditions slowing stormwater runoff	Low-High[a]
1.6	Curb growth of groundwater demand	Low-High[a]
1.7	Preserve or enhance water supplies to groundwater	Low-High[a]
1.8	Protect groundwater quality	High
	Lake Outlet Dam Operation and Configuration	
1.9	Dam design opportunities	High
1.10	Dam operation opportunities	High
	Water quality	
	Lake Monitoring	
2.1	Continue and enhance comprehensive water quality monitoring within Lake Comus	High
	Tributary Monitoring	
2.2	Continue to conduct level 1 Water Action Volunteer (WAV) monitoring in Turtle Creek and the CTH O Tributary	High
2.3	Consider expanding up to Level 2 WAV monitoring to install programmable water temperature logging devices in Turtle Creek and the CTH O tributary	Medium
2.4	Consider implementing a continuous turbidity monitoring program in Turtle Creek	Low
2.5	Supplemental water quality monitoring	Medium
	Phosphorus Management	
2.6	Reduce nonpoint source external phosphorus loads	High
2.7	Manage factors that stimulate in-Lake phosphorus recycling	High
	Cyanobacteria and Floating Algae	
2.8	Reduce Lake phosphorus concentrations	High
2.9	Monitor algal abundance and sample for algal toxins during suspected algal bloom conditions	High
2.10	Warn residents not to enter water in event of an algal bloom	High
2.11	Encourage healthy aquatic plant community to compete with algal growth	High
2.12	Reduce carp populations within Lake	High
	Pollutant and sediment sources and loads	
	Agricultural Best Management Practices	
3.1	Incentivize use of no-till and conservation tillage practices	High
3.2	Encourage increase in cover crop acres	High
3.3	Ensure that all lands are under nutrient management plans	High
3.4	Install additional grassed waterways	High
	Drain Tiles	
3.5	Reduce and retrofit drain tile systems	High
3.6	Implement saturated buffers and/or bioreactors to treat tile drainage	Medium
3.7	Manage fertilizer application to minimize losses via drain tile	High
	Animal Operations	
3.8	Ensure that animal operation performance standards are met	High
	Ditching and Channelizing	
3.9	Restore natural landscape elements to detain runoff	High
	Urban Best Management Practices	
3.10	Encourage pollution source reduction efforts through BMPs	Medium
3.11	Promote native plantings in and around existing and new stormwater detention basins	Medium
3.12	Retrofit existing and enhance planned stormwater management infrastructure	Medium

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Table 3.1 (Continued)

Recommendation Number	Recommendation	Priority
	Urban Best Management Practices (Continued)	
3.13	Combine riparian buffers with other structures and practices	Low
3.14	Stringently enforce construction site erosion control and stormwater management ordinances and creative employment of these practices	Low
3.15	Maintain stormwater detention basins	Low
3.16	Promote urban nonpoint source abatement	Low
3.17	Collect leaves in urbanized areas	Low
	Riparian Buffer Protection and Prioritization Strategies	
3.18	Increase coverage of riparian buffers	High
	Aquatic plants	
4.1	Protect native aquatic plants to the highest degree feasible through careful implementation of aquatic plant management and water quality recommendations	Medium
4.2	Avoid disrupting bottom sediment or leaving large areas of bottom sediment devoid of vegetation	Low
4.3	Reduce the Lake's carp population	High
4.4	Prevent the introduction of new invasive species	Low
4.5	Consider manipulating water levels to encourage native plant growth	Medium
	Fish and wildlife	
	Habitat Quality	
5.1	Preserve and expand wetland and terrestrial wildlife habitat, while making efforts to ensure connectivity between such areas	High
5.2	Preserve and enhance instream features that provide important fish spawning and rearing habitats	High
5.3	Restore natural meanders and improve floodplain connectivity to Turtle Creek and its tributaries	Medium/High[a]
5.4	Preserve natural areas of countywide and local significance, as those of critical species habitat	High
5.5	Incorporate upland conservation and restoration targets into management and policy decisions	Medium
5.6	Improve aquatic habitat in Lake Comus by maintaining and adding large woody debris and/or vegetative buffers along the Lake's edge	Low/Medium[a]
5.7	Mitigate water quality stress on aquatic life and maximize areas habitable to desirable fish	Medium/High[a]
5.8	Mitigate streambank erosion	Low
	Population Management	
5.9	Reduce and control the Lake's carp population	High
5.10	Improve wildlife populations by encouraging best management practice adoption	Medium
5.11	Continue to monitor fish and wildlife populations	Medium
	Eastern Massasauga Rattlesnake and Other Rare Reptiles	
5.12	Follow WDNR and US Fish and Wildlife guidance on land management BMPs in potential rare reptile habitat	High
5.13	Consider impacts to Eastern Massasauga rattlesnake and Blanding's turtle if conducting water level manipulation for lake management	High
	Recreational use and facilities	
6.1	Maintain and enhance fishing by protecting and improving aquatic habitat and water quality	High
6.2	Maintain public boat launch sites	Medium
6.3	Maintain natural shorelines in planned development	High
6.4	Incorporate the City of Delavan's planned recreational facilities	High
6.5	Enhance public access with walkway as part of dam replacement project	High
6.6	Develop and improve walkway and parkway along western shoreline	High
6.7	Collaborate with City of Delavan to develop planned lakeshore trail	Medium
6.8	Consider a designated portage route as part of outlet dam replacement	Medium/High
6.9	Enhance shoreline erosion protection, particularly along Paul Lange Arboretum	High
	Plan implementation	
7.1	Integrate lake users and residents in management efforts	High
7.2	Encourage key players to attend meetings, conferences, and/or training programs to build their lake management knowledge	Medium

Table continued on next page.

Table 3.1 (Continued)

Recommendation Number	Recommendation	Priority
	Plan implementation (Continued)	
7.3	Continue to ensure inclusivity and transparency with respect to all Lake management activities	High
7.4	Foster and monitor management efforts to communicate actions and achievements to future lake managers	Medium
7.5	Consider installing "This is Our Watershed" and "Adopt a Highway" signage throughout the watershed	Medium
7.6	Increase visibility of Lake Comus on City of Delavan website	Medium
7.7	Actively share this plan and work with municipalities to adopt it by maintaining and enhancing relationships with County, municipal zoning administrators, directors of public works/municipal engineers, and law enforcement officers	High
7.8	Keep abreast of activities within the watershed that can affect the Lake	Low/High
7.9	Educate watershed residents about relevant ordinances. Update ordinances as necessary to face evolving use problems and threats.	Medium
7.10	Encourage formation and growth of producer-led group within the watershed	High
7.11	Consider inter-governmental agreements with neighboring municipalities	Medium
7.12	Foster open relationships with potential project partners	High
7.13	Apply for grants when available to support implementing recommended programs	High

Note: This summary of recommendations is a compiled list of items the Lake Comus Protection and Rehabilitation District; the City of Delavan; the Towns of Delavan, Richmond, Sugar Creek; the residents of the Lake Comus watershed; and riparian owners, working together with volunteers and other nonprofit organizations, could implement to improve Lake Comus and its watershed.

[a] *The priority is based on the sub recommendations.*

Source: SEWRPC

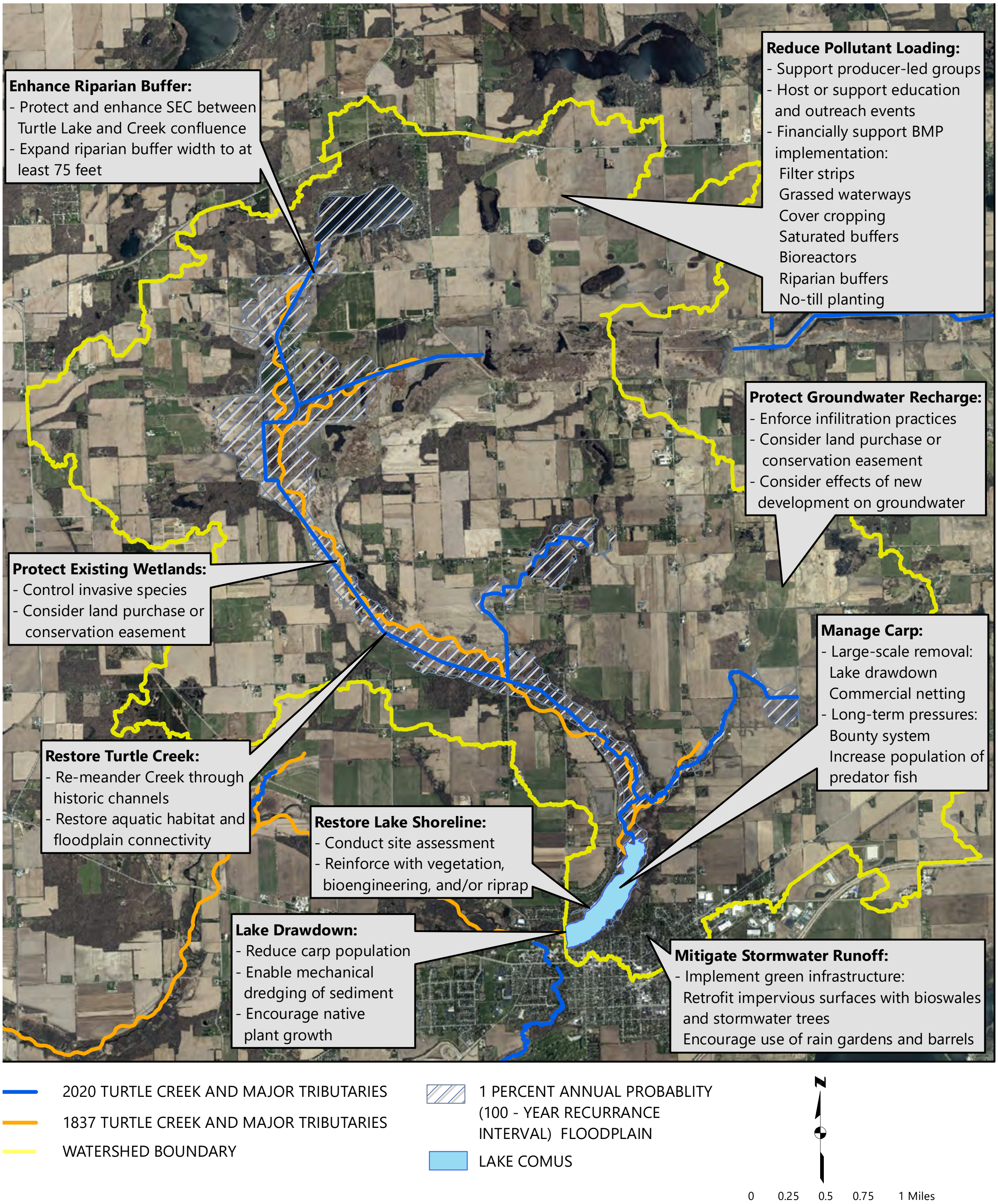
Those responsible for Lake planning and management should actively conceptualize, seek, and promote projects and partnerships that enable plan recommendations to be implemented. The measures presented in this chapter focus primarily on those that can be implemented through collaboration between local organizations, watershed property owners, and others who have a vested interest in the long-term health of Lake Comus, Turtle Creek, and the watershed. Examples include watershed property owners (riparian property owners in particular), the LCPRD, the City of Delavan, Walworth County, the Wisconsin Department of Natural Resources (WDNR), and the U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS). Collaborative partnerships formed among other potential stakeholders, such as agricultural producers, non-governmental organizations (e.g., Rock River Coalition, Kettle Moraine Land Trust, Friends of Turtle Creek, producer-led groups, the Michael Fields Agricultural Institute), developers, wastewater treatment plants (e.g., the Walworth County Metropolitan Sewerage District), and other watershed municipalities (i.e., Towns of Darien, Delavan, Richmond, and Sugar Creek), can help promote efficient, affordable, and sustainable actions promoting the long-term ecological health of Lake Comus.

As a planning document, this chapter provides concept-level descriptions of activities that may be undertaken to help protect and enhance Lake Comus and its watershed. It is important to note that plan recommendations provide stakeholders and implementing entities with guidance regarding the type and nature of projects to pursue to meet plan goals. These recommendations and project suggestions do not constitute detailed technical specifications. The full logistical and design details needed to implement many recommendations must be more fully developed in the future when individual recommendations are implemented. Grants are often available to develop concept plans into actionable design drawings and programs.

In summary, this chapter provides those implementing the plan the ability to:

- Better understand plan element context and what needs to be done
- Judge the relative importance of plan recommendations
- Better comprehend plan intent
- Envision the appearance of executed plan elements

Map 3.1
Select Recommendations for the Lake Comus Watershed



Source: SEWRPC

Table 3.2
Effects, Benefits, and Considerations of Major Lake Management Actions

Major Management Actions	Effects	Benefits	Considerations
		Lake Level Manipulation	
Water Quality	Little to no water in lake during drawdown. Drawdown compacts sediment and exposure to air decomposes sediment organic matter.	Reduced nutrient resuspension upon water level rise. Potential for increased clarity and reduced algal abundance.	Potential for lower dissolved oxygen and higher temperatures in remaining pool of water during drawdown.
Aquatic Plants	Fluctuations in water level encourage other native submerged and emergent plants to establish.	Increased coverage by plants. More habitat for aquatic organisms. Greater phosphorus uptake and reduced sediment resuspension.	Potential expansion of cattail marsh and/or other unwanted species into current open water.
Fisheries	Reduced water levels during drawdown would concentrate fish into small areas of Lake.	Facilitates invasive common carp removal operations.	Higher potential for lake-wide fish kill, including desired species.
Recreation and Aesthetics	Lake drawdowns leave sediment exposed for long periods of time. Frequent fluctuations may leave piers and docks stranded and/or underwater.	Long-term benefits via potential for reduced algal blooms, greater water clarity, and improved fishery.	Community may find exposed sediment to be unsightly and/or produce odors. Lake will be unusable during drawdown.
		Lake Sediment Dredging	
Water Quality	Dredging would remove phosphorus-laden sediment from lake bottom.	Reduced nutrient resuspension through wind and/or disturbance by carp. Potentially improved water clarity.	Increase in phosphorus resuspension during dredging operations, unless conducted during drawdown.
Aquatic Plants	Dredging removes rooted aquatic plants as well as plant turions and seeds in sediment.	Long-term benefits via enhanced aquatic plant growth and coverage if dredging improves water clarity.	Removal of much of the aquatic plant biomass within the lake, as it is concentrated in shallow northern area.
Fisheries	Dredging may remove some spawning habitat.	Minimal direct effects.	Minimal direct effects.
Recreation and Aesthetics	Dredging increases lake depth. Recreational use may be limited while dredging operations underway.	Greater water depth would facilitate boat passage in shallow northern area.	Community may find noise, smell, and/or sight of dredging to be undesirable.
		Carp Removal Program	
Water Quality	Carp disturb lake sediment, reducing water clarity and increasing algae and phosphorus abundance.	Improved water clarity and lower lake phosphorus concentrations.	Use of chemical treatments would affect short-term water quality.
Aquatic Plants	Carp consume and disturb aquatic plants. Decreased water clarity could affect colonization depth.	Greater aquatic plant coverage and at deeper depths in the Lake.	Plant coverage reduced if a lake drawdown is used to facilitate removal efforts.
Fisheries	Carp destroy aquatic plants that act as habitat and food sources for native fish. Native species sometimes consume carp eggs as food source.	More abundant habitat via increased plant coverage. Less competition for food sources.	Other native species may be affected by removal efforts. Native species may be reduced with loss of eggs as food source.
Recreation and Aesthetics	Recreational use may be limited while removal operations underway. Removal will affect lake fishery, potentially including sport and panfish populations.	Enhanced fishery for native species. Improved water clarity.	Lower carp population for bow-fishing. Community may oppose removal methods and/or find method to be unsightly.

Source: SEWRPC

Such concepts can be invaluable for building coalitions and partnerships, writing competitive and meaningful grant requests, and initiating project design work.

3.2 HYDROLOGY, WATER QUANTITY, AND WATER RESOURCE INFRASTRUCTURE

Management plans that call upon practices that preserve, enhance, or naturalize watershed runoff, consider natural resource features and limitations, and promote thoughtfully engineered water resource infrastructure can benefit waterbody and watershed health and resilience in many ways. Such plans help managers choose alternative courses of action that slow runoff, detain stormwater, promote stormwater infiltration, sustain groundwater supplies, protect and enhance habitat value, and benefit recreational pursuits A few examples of benefits accruing from such practices are listed below.

- Stormwater runoff intensity is reduced. This can reduce watercourse bed and bank erosion, lower sediment/nutrient loads, preserve topsoil integrity, foster soil water storage and groundwater recharge, protect infrastructure, and improve aquatic habitat value.

- Favorable soil moisture conditions are prolonged. This positively affects plant health and crop yields, especially during drier summers. Furthermore, less stormwater leaves the landscape as runoff, reducing downstream flooding and soil erosion.

- Groundwater recharge potential is maintained helping assure groundwater continues to flow at natural groundwater discharge points such as springs and seeps. Furthermore, maintaining groundwater recharge potential helps maintain aquifer water levels that assure reliable potable water supplies for human needs.

- Stream flow volumes are modulated and water quality is improved. Peak runoff volumes and flood elevations are reduced, dry-weather flows are increased, summer water temperatures are cooler, and winter water temperatures are sometimes slightly higher.

- Waterbody ecology is benefitted. Aquatic habitat health is promoted by the factors listed above allowing the waterbody to better reach its latent ecological potential.

- Recreational opportunities are maintained or increased. Healthy aquatic habitat supports more abundant, more diverse, and more desirable plants and animals.

Management strategies addressing the Lake's water supply and water elevation/storage volume should identify opportunities, quantify changes, and evolve over time. Data collected by systematic monitoring helps lake managers make decisions consistent with current conditions and trends. The following recommendations suggest practical strategies to protect and enhance the Lake's water supply and generate data needed to gage ongoing conditions.

➤ **Recommendation 1.1: Continue to monitor Lake Comus' water-surface elevation**

The Lake's water surface elevation is influenced by several factors including precipitation, evaporation, wind, and various other weather conditions; the elevation and condition of the outlet dam weir; obstructions in the outlet weir; and the volume of water entering the Lake from its watershed and groundwater. Variations in these factors cause Lake water levels fluctuate. Recording Lake-specific information relating these factors helps monitor human and environmental stressors on the Lake's water supply. Detailed knowledge of Lake elevation allows the Lake's hydrology to be better understood and changes noted. The availability of information collected consistently over long periods of time may be useful for future ordinance and technical guidance development, may help gage the impact of continued development and management activity, and can help with design and operation of water management infrastructure such as dam gates.

At a minimum, the LCPRD or the City of Delavan should continue to manually measure and record daily precipitation and Lake water levels whenever the monitoring point is not frozen. The measuring point elevation must be related to a known datum (e.g., NGVD 1929) to allow comparison to data collected in the past and the future as well as at other locations. This recommendation should be assigned a high priority.

Consideration should also be given to installing automated water level recording equipment to reduce labor demands and increase data collection frequency. Furthermore, automated water-level recording equipment could allow the LCPRD or the City to post Lake water surface elevation to a website in real time. Such information allows staff to react more quickly to rapid water elevation changes caused by blockage, heavy runoff, equipment failure, or other reasons. Electronic water level monitoring equipment is widely available with the hardware associated with simpler devices costing around $1,000. Monitoring additional weather conditions and noting lake appearance would also be beneficial (e.g., record wind speed, wind direction, water and air temperature, ice conditions, wave action). The measuring location used to monitor lake water elevation need not be directly at the dam outlet. Instead, it could be installed at any convenient location throughout the reservoir if the reference point and sensor remain static. Given the relatively low cost and great value of resultant data, automated sensor installation is also assigned a high priority.

➤ **Recommendation 1.2: Quantify Surface Water Outflow**

The amount of water leaving the Lake through the dam outlet works provides valuable information about Lake and watershed hydrology. Quantifying outlet flow over extended periods of time will help with future management decisions and may be valuable to future management actions such as aquatic plant management. The amount of water leaving through the dam outlet works can be easily estimated using water elevation data collected as part of Recommendation 1.1, noting the position of operable gates, and applying relatively simple published empirical relationships. Automated water level data collection would enrich this data set and could be used to post real-time outlet flow graphs. This recommendation should be considered a high priority.

➤ **Recommendation 1.3: Quantify the volume of water delivered to the Lake from Turtle Creek**

No stream gaging stations exist on Turtle Creek upstream of Lake Comus. Nearly all Creek discharge estimates are derived from models. Measuring Creek discharge would help validate modelled discharge projections and the Creek's contributions to the Lake's water budget estimated by the Commission using model values. At a minimum, stream flow should be occasionally measured when water quality samples are collected. Additional measurements should be made to help quantify flow during fair weather, periods of heavy runoff, and dry weather. Rough estimates of flow can be made by measuring water velocities at locations where stream cross sectional area is easily quantified (e.g., culverts, bridges). Velocity multiplied by cross sectional area yields a flow rate. The level of detail used to quantify flow and cross-sectional area improves estimate validity.[257] After sufficient data is collected, a rough rating curve for the particular site in question can be developed. A rating curve allows flow to be estimated from water depth or elevation alone, simplifying data collection. This recommendation is a high priority.

➤ **Recommendation 1.4: Institute groundwater monitoring**

Groundwater recharge within the Lake Comus watershed supplies water to the shallow aquifers, which, in turn, provides baseflow to the Lake, Turtle Creek, and their tributaries. Baseflow is essential to maintaining the hydrology, instream habitat, and overall health of the Creek, particularly during dry weather.[258] Groundwater discharge points, such as seeps and springs, are important sources of cool, unadulterated water to Lake Comus. Groundwater discharge points may help sustain coolwater fish species and bolsters the Lake's water quality. Therefore, maintaining or enhancing groundwater recharge is a crucial part of any plan that hopes to maintain or improve water quality and instream habitat conditions within the watershed. Methods to accomplish this are discussed in a subsequent subsection.

[257] *A summary of methods suggested by the Wisconsin Water Action Volunteers program to measure streamflow can by found at the following website: StreamFlowMethods_2015.pdf (wateractionvolunteers.org). Many alternate suitable methods exist.*

[258] *Atypically dry weather may occur more frequently as climate change occurs.*

Groundwater is not visible to casual observation and changes often go unnoticed until critical thresholds are reached (e.g., a well goes dry, a stream or pond dries up). Changes to groundwater flow systems are often subtle and may occur over decades. To ascertain subtle change, the LCPRD should consider initiating a groundwater monitoring program in the Lake's groundwatershed. Groundwater elevations can be monitored in appropriately selected water supply wells and/or in purpose-built shallow monitoring wells. Ideally, measurements would be collected at least once a month into perpetuity. Relatively inexpensive automated measuring devices are also commercially available. Groundwater elevation data should be permanently recorded and a brief annual "water year" summary should be made discussing thoughts regarding measured water levels.[259] This initiative should be assigned a medium priority.

➤ **Recommendation 1.5: Maintain or enhance conditions slowing stormwater runoff**

Human activity modifies drainage basin hydrology and profoundly affects the amount and timing of water reaching waterbodies. In general, human activity decreases a landscape's ability to detain and absorb precipitation, hastens runoff speed, increases peak and total runoff volume, and discourages water infiltration into soils. These changes increase surface runoff intensity and the overall volume of stormwater runoff reaching lakes and rivers during wet weather and decrease flow to waterbodies during dry weather. Increased wet-weather runoff intensity and volumes increase soil erosion, destabilize natural stream channels, increase downstream flood elevations, and increase sediment and nutrient loads to waterbodies. A few common examples of human activities promoting these consequences include creating impermeable or less permeable surfaces (e.g., roofs, parking lots, roadways, compacted soil areas), ditching natural streams, conveying stormwater over or through smooth impermeable surfaces or pipes, filling low areas, artificially draining closed depressions and wet areas, and eliminating native vegetative cover in favor of crops, lawns, and other manicured landscaping features.

Actions increasing runoff volume generally decrease the amount of water absorbed by soils, decrease water available to plants over dry portions of the growing season, and decrease the volume of water contributed to groundwater systems. Consequently, human activity often disrupts natural soil moisture regimens as well as groundwater flow directions and discharge patterns. Groundwater is the sole source of potable water in Walworth County. If most pumped groundwater is returned to groundwater after use (e.g., soil absorption fields associated with septic systems), overall impact to groundwater flow systems may be minimal. However, when water is either consumptively used (e.g., evaporated) or exported from the local groundwater flow system (e.g., carried by sanitary sewers to discharge points outside of the groundwatershed), groundwater elevations may fall and discharge to, and flow in, surface-water features can be reduced or eliminated. Protecting groundwater resources is discussed in more detail as part of recommendation 1.6.

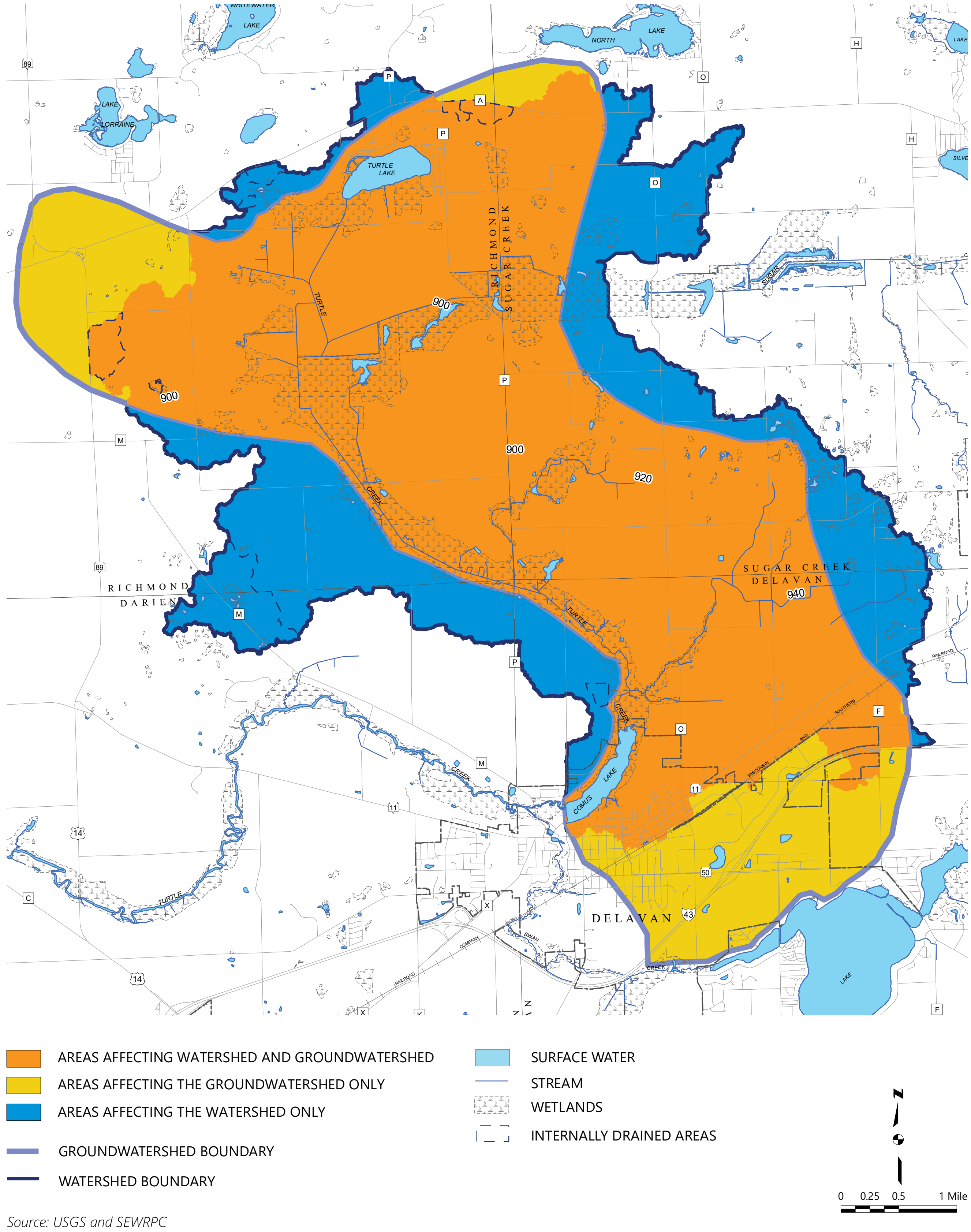
Strategies promoting the quantity, timing, and quality of water reaching surface water features are most efficiently applied to specific areas. The complex interplay of surface water and groundwater flow systems creates a situation where different geographic areas have differing potential to protect and enhance the Lake's water supply and water quality. These areas are described below and are illustrated in Map 3.2.

- Areas within the Lake's surface-watershed, but outside of the area replenishing the shallow groundwater flow systems feeding Lake Comus, upper Turtle Creek, and their tributaries, are best suited to strategies that detain stormwater runoff and enhance runoff water quality. Projects in this area do not influence groundwater supplies feeding the Lake and its tributaries. Well-conceived projects within this area focusing on detaining stormwater runoff should be assigned a medium priority.

- Areas outside of the surface watershed, but within the recharge area of the shallow groundwater flow systems feeding Lake Comus, upper Turtle Creek, and their tributaries are best suited to strategies that aim to increase stormwater infiltration and control net groundwater demand. Surface-water detention projects in this area do not influence runoff reaching the Lake or its tributaries. Well-conceived projects within this area focusing on infiltration and control of net groundwater demand should be assigned a medium priority.

[259] *An example of a recent biannual groundwater report for the Village of Richfield in Washington County can be found at the following URL: wi-richfield2.civicplus.com/DocumentCenter/View/2539/Village-of-Richfield-Board-Presentation-2021.*

Map 3.2
Areas Affecting the Lake Comus Watershed and Groundwatershed



Source: USGS and SEWRPC

- Projects executed in the area within both the Lake's watershed and groundwatershed can benefit both the Lake's surface-water and groundwater supply. Projects completed within this area can use a combination of detention, infiltration, and net groundwater demand control to benefit the Lake. Because of the manifold benefit of projects completed in this area of overlap, all well-conceived projects in this area affiliated with runoff detention, groundwater recharge, and controlling net groundwater demand should be assigned a high priority.

Detaining Runoff and Enhancing Infiltration

Much of the Lake Comus watershed is intensively cropped or used for other agricultural purposes. Cropped areas are most often managed to quickly shed precipitation and snowmelt, a situation reducing the landscape's ability to temporarily detain runoff and recharge groundwater. Turtle Creek upstream of the Lake was extensively ditched and straightened, reducing the ability of floodwater to spread over the landscape and be temporarily detained in ponded areas. Reduced recharge and high human water demand stresses the watershed's surface water and groundwater resources, and the situation will likely intensify as the area continues to develop.

Human-induced change to watershed hydrology is most often detrimental to waterbody health and sustainability. Therefore, management actions in the area contributing water to Lake Comus should attempt to reduce the impact of human-induced change on waterbody hydrology. To maintain waterbody health and provide sustainable potable water sources, action should be taken to counteract human activity that compromise sustainable, high quality, water supplies. In general, management actions should aim to slow and detain runoff, maintain or increase groundwater recharge, and control the volume of groundwater extracted from systems feeding Lake Comus, Turtle Creek, and their tributaries. Examples of such approaches are described in the following paragraphs.

Detaining Runoff

Agricultural pursuits and urban development involve manipulating the natural landscape in ways that usually increase runoff volume and speed and decrease groundwater infiltration. Actions can be taken to detain and more slowly release surface runoff to better approximate natural rainfall/runoff patterns. When water is detained, runoff intensity and downstream flood elevations are reduced, natural streams are less likely to excessively erode their beds and banks, and physical and biological processes reduce pollutant and sediment loads. Examples of methods to protect or increase stormwater detention follow.

- Protect remaining landscape features that detain storm water. Many natural landscape features detain runoff. Examples of such features include wetlands, floodplains, and closed depressions. Efforts should focus on protecting and enhancing natural stormwater detention areas. Such features should be protected throughout the watershed. This activity should be assigned a high priority.

- In areas where human activity has diminished natural floodplain capacity (e.g., through ditching and berming natural streams), projects should be pursued to naturalize floodplain hydrology. A particularly good opportunity to restore floodplain function exists along ditched portions of Turtle Creek upstream of the Lake abutting public lands devoted to wildlife management. Remeandering the Creek and restoring hydraulic conductivity with the adjacent riparian wetlands would allow floodwaters to spread, be detained, be cleansed by natural processes, and benefit the ecology of the area and watershed. Restoring stream floodplain connectivity and naturalizing stream form is an excellent way to restore floodplain function. This recommendation should be pursued throughout the watershed and should be assigned a high priority.

- Retire marginally productive cropland and/or restore features that detain runoff. Historically, cropland was expanded into areas where soil moisture regimens were not naturally conducive to agricultural production. To facilitate agriculture, these areas were ditched, graded, and subsurface drainage tiles were installed. In many instances, the practices were successful with the drained cropland now providing additional productive and profitable agricultural land. In other instances, the newly drained land was not successfully converted to good cropland and was either abandoned or provides marginal crop yields and economic returns. These less-than-successful drainage projects should be scrutinized for restoration of natural hydrology and habitat. This can include disrupting drain tile networks, completing ditch plugs and fills, and enhancing landscape features that naturally hold runoff (e.g., closed depressions, wetlands). Because of the large acreage of public land already withdrawn from agricultural production available for restoration projects, this recommendation should be assigned a medium priority.

- Replace rural detention capacity lost on account of human activity with engineered infrastructure. If the capacity of existing and restored natural features remains insufficient to achieve desired goals, stormwater can be detained in purpose-built artificial structures (e.g., agricultural sedimentation basins, stormwater detention basins, ditch checks, swales). Given the amount of publicly and privately held land restoration opportunities available in the watershed, this recommendation should be assigned a low priority.

- Expand urban stormwater detention infrastructure. Artificial stormwater detention features should be installed to service new developments or retrofitted to infrastructure in developed areas. With careful and holistic planning, it can sometimes be feasible to build detention features as part of new development that also serve existing development. The recommendation should be assigned a medium priority as part of greenfield development or planned infrastructure replacement projects in legacy development. Homeowner-scale projects that help detain stormwater (e.g., downspout disconnection from storm sewers, rain gardens, promoting soil health in turfgrass areas) should also be assigned a low priority. In most instances, large stand-alone projects in existing high-value development areas should be assigned a low priority.

Enhancing Infiltration

Traditional urban development increases impervious surface area and decreases overall landscape permeability. Without deliberate engineering to promote infiltration of stormwater and meltwater runoff, development reduces the volume of water infiltrating into soils and feeding shallow aquifers. Reduced infiltration reduces groundwater supplies which in turn decreases stream baseflow. Decreased baseflow reduces dry weather flow that can lead to substantial loss in stream depth, increased water temperatures, loss of critical fish and other aquatic organism habitat, increased potential for summer fish kills caused by low dissolved oxygen concentrations, and loss or degradation of desirable fish species.

As inferred in the preceding paragraph, infiltration is component to both reducing stormwater runoff volume and recharging groundwater flow systems. Therefore, protecting and enhancing stormwater infiltration is integral to protecting both surface water and groundwater resources. Examples of concepts seeking to use stormwater infiltration to reduce runoff volume and intensity are provided below.

- Protect natural infiltration capacity. A basic way to promote stormwater infiltration is to protect natural infiltration in areas with conducive land use, soils, and topography. In rural and less urbanized areas, the best candidate sites are within moderate, high, and very high groundwater recharge potential areas (Map 2.7). Infiltration is promoted when areas exhibit naturally diffuse runoff paths, abundant vegetation, irregular topography with closed depressions, and features that detain or slow runoff promote infiltration (e.g., floodplains, wetlands). Protecting such areas by encouraging appropriate land use, land management, and enlightened land development, as well as adoption of thoughtful ordinances, should be given a high priority.

- Enhance landscape infiltration potential in areas modified by human activity. Historically, infiltration potential was commonly reduced when humans altered the landscape. Examples of such alterations include constructing impermeable surfaces (e.g., roadways, roofs), installing piped runoff conveyance features, grading and filling low areas to encourage rapid and complete drainage, reducing soil infiltration capacity through soil structure degradation, and reducing vegetative density. In such instances, many landscape practices can help increase stormwater infiltration and help naturalize hydrology. Some examples include restoring wetlands, reconnecting floodplains, disabling or modifying drainage tile networks, improving soil health, and restoring abundant perennial vegetation. Projects planned for areas with moderate, high, or very high groundwater recharge potential should be assigned a high priority. Projects in other areas should be assigned a medium priority.

- In some areas, land use has been extensively modified in a way that inexorably reduces landscape infiltration capacity. An example would be constructing a shopping mall upon a former meadow. In such instances, engineered stormwater infrastructure (e.g., detention ponds employing infiltration, vegetated swales) should be used to increase landscape infiltration potential. Larger-scale projects manage urban stormwater from entire developments. Considering that most of the Lake's watershed is rural in nature, engineered infiltration capacity restoration projects planned for areas with moderate, high, or very high groundwater recharge potential should be assigned a medium priority. Projects in other areas should be assigned a low priority.

- Smaller-scale practices installed across the watershed by many landowners can increase overall landscape infiltration capacity. This can help decrease runoff volume and intensity and improve runoff water quality. Examples of homeowner-scale practices include managing turf and other areas to decrease soil compaction and increase soil permeability, directing stormwater runoff to areas of permeable soil and favorable topography instead of piping water directly to storm sewers, minimizing, and if possible, reducing the extent of impermeable surfaces, and redirecting downspouts and other runoff away from storm sewers and into raingardens. Such initiatives can be promoted by active educational outreach, providing instructions and supplies to property owners, and/or through financial subsidies. Supporting efforts to attract landowners to such programs should be given a low priority.

- Given their relatively great importance of outreach programs associated with this recommendation, the LCPRD could consider providing financial incentives to owners of parcels that drain directly to the Lake, its major tributaries, and storm sewers leading directly to the Lake and its tributaries. Some practices and projects, especially those completed on publicly owned property, may also qualify for cost sharing through the WDNR's Healthy Lakes initiative. Again, these actions are particularly effective when applied to areas with moderate, high, or very high groundwater recharge potential (Map 2.7).

- Promote practices that bolster soil health. Since agricultural land uses dominate the Lake's watershed, actions increasing stormwater infiltration in cultivated areas are very important to Lake Comus' overall health. Research has shown that healthy soil has much higher infiltration capacities compared to soils subjected to conventional tillage. Higher infiltrations typically correlate with lower soil erosion rates. As former USDA soil health practitioner states, "we don't have a soil erosion problem, we have an infiltration problem." Recent government programs and a rapidly growing corps of agricultural producers are refining and successfully employing cropping systems that shift producer focus from "yield per acre" to "profit per acre."

- The LCPRD should promote soil health initiatives throughout the rural area contributing surface and/or groundwater to the Lake Comus. Healthy soils are more porous, are less prone to erosion, and, therefore, help reduce runoff volume and intensity and improve baseflow and water quality.[260] Actively promoting and financially supporting soil health initiatives across the entire watershed should be assigned a high priority. Although agricultural lands throughout the Lake's watershed are amenable to this approach, parcels abutting Lake Comus tributaries should be targeted first.

- Complement soil health initiatives. Other infiltration preservation and enhancement practices complementing soil health initiatives should be promoted throughout the entire rural portion of the watershed. For example, the landscape should not be further altered to cause water to rapidly leave the land surface, especially in dry upland cropland mapped to have moderate, high, or very high groundwater recharge potential. Therefore, intensive farmstead development, drainage ditches, tiling and other soil drainage schemes, runoff enhancing grading and filling, piped storm sewers, and soil compaction should be avoided, or the impact of such modifications should be carefully mitigated by restoring or enhancing natural detention features with good connection

[260] *More information regarding soil health can be obtained from many sources including the following website: www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health/*

to groundwater flow systems.[261] This recommendation should be assigned a high priority in high and very high groundwater recharge potential areas, a medium priority in moderate groundwater recharge potential areas, and a low priority in areas with low groundwater recharge potential.

- Promote stormwater infiltration throughout the Lake's surface-watershed. Although stormwater infiltration occurring outside of the Lake Comus groundwatershed does not support baseflow to the Lake or its tributary streams, it still benefits the Lake. Stormwater infiltration within the surface-watershed decreases stormwater runoff intensity and volume, decreasing the tributaries' ability to erode their beds and banks and carry sediment and nutrients to the Lake. Furthermore, groundwater recharge beyond the Lake's groundwatershed supports baseflow in neighboring lakes and streams, some of which are ecologically significant and may contribute to the Lake's fish and wildlife populations. For example, water infiltrating from natural sources and detention features in the western portion of the City of Delavan does not contribute flow to the Lake but does nourish groundwater systems discharging to Swan Creek.

Protecting Groundwater Supplies

The Lake and many of its tributaries receive significant amounts of groundwater, a situation benefiting waterbody health. For example, groundwater discharge sustains dry-weather stream flow, moderates stream temperatures in winter and summer, and maintains water levels in the Lake during dry weather. To help protect the quantity and quality of groundwater discharging to the Lake and its tributaries, management action must focus on the Lake's groundwatershed, an area lying mostly to the east of the Lake and Turtle Creek (Map 3.2). Appropriate management action in this area helps maintain groundwater recharge, avoids unsustainable groundwater extraction and export, and maintains high groundwater quality. Even if groundwater resources are carefully managed within the Lake's groundwatershed, large-scale groundwater extraction beyond the groundwatershed can also influence the amount of groundwater entering and/or leaving the Lake. Therefore, activities already occurring or planned to occur near the Lake's groundwatershed should also be scrutinized. Actions helping protect the Lake's groundwater supply include the following examples.

➤ **Recommendation 1.6: Curb growth of groundwater demand**

Groundwater supplies all residential, commercial, and industrial potable water demands in the City of Delavan, the Lake Comus watershed, and greater Walworth County. Additionally, much of the human population of the Lake Comus groundwatershed is served by public sanitary sewers which export wastewater to other watersheds. Therefore, some of the water pumped from local aquifers is exported from the local groundwatershed and no longer can supply baseflow to Lake Comus or its tributaries. This is a vexing problem that often increases over time and has few easy solutions. However, action can be taken to reduce current and future net demand placed on local aquifers. Examples of such concepts are provided below.

- Evaluate if any clean-water discharges now directed to sanitary sewers, or discharge points outside the watershed, can be redirected to discharge points within the area contributing surface water and groundwater to Lake Comus. An example would be redirecting clean non-contact cooling water drawn from wells located in the Lake's groundwatershed to surface water within the Lake's watershed. Since few opportunities likely exist in the Lake Comus watershed, this recommendation is assigned a low priority.

- Carefully vet the impact of new development, especially those using new high-capacity wells, on groundwater withdrawals in the Lake Comus groundwatershed. The Village of Richfield in Washington County requires a professional analysis of development's impact on local groundwater elevations as a caveat to granting construction permits.[262] This should be assigned a high priority for projects within the Lake's groundwatershed.

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[261] *Detention features can be built that encourage infiltration of stored water and contribute to groundwater recharge. Such systems are one of only a few artificial methods that meaningfully reduce overall runoff volume. They are best situated in areas of high and very high groundwater recharge potential.*

[262] *More information of the Village of Richfield's groundwater protection program may be found at the following URL: www.richfieldwi.gov/300/Groundwater-Protection.*

- Critically examine new commercial or industrial development proposals that use water consumptively or export water from the groundwatershed. Since most of the Lake's watershed is rural in nature and is anticipated to remain so in the next decades, this recommendation is assigned a low priority.

- Discourage new residential water supply systems in the groundwatershed that rely on private on-site water supply wells yet discharge wastewater to wastewater treatment plants outside of the Lake Comus watershed. This should be assigned a medium priority.

- Carefully evaluate activities within the Lake's groundwatershed that require long-term dewatering (e.g., quarry operations), especially if effluent water discharges to surface-water features draining to areas beyond the Lake's watershed. This should be assigned a high priority.

- Evaluate increased groundwater demands in nearby areas. Examples include new high-capacity wells or increased withdrawals from existing wells, clusters of small wells, or quarry dewatering. Such activities can influence groundwater flow directions and velocities and can change the amount of groundwater entering or leaving the Lake. This should be assigned a medium priority.

- Advocate actions that cause water providers to institute a potable water conservation campaign. This activity should focus on water now discharged to sanitary sewers in the City of Delavan. This should be assigned a low priority.

➤ Recommendation 1.7: Preserve or enhance water supplies to groundwater

Given the significant quantity of groundwater recharge lost through human landscape manipulation, maintaining, or more desirably increasing, stormwater infiltration is very important. This action not only protects surface-water features, encourages stable stream channels, reduces soil erosion, and promotes ecological health, it also helps safeguard groundwater supplying the needs of the area's human population and businesses. Several examples of tactics that help preserve or enhance groundwater recharge follow.

- As discussed earlier in this Section, the LCPRD should undertake actions promoting soil health. Healthy soils allow more stormwater to infiltrate and retain more nutrients and water benefitting crop growth. Healthy soils are characterized by greater aggregation, abundant soil macroinvertebrates like earthworms, higher root density, and higher concentrations of organic matter.[263] Promoting good soil health is most widely applicable to tilled agricultural lands within the watershed but the principles can also be applied to other lands such as parks and lawns. The LCPRD should encourage establishment of a producer-led watershed protection group covering the Lake Comus watershed. Grants are available to establish and maintain producer-led watershed protection groups.[264] The LCPRD should consider lending advice and, possibly, renting equipment and offering financial incentives to soil health practitioners. Although agricultural lands throughout the Lake's watershed are amenable to this approach, parcels abutting Lake Comus tributaries should be targeted first. Soil health promotion should be assigned a high priority.

- Preserve or enhance natural landscape features promoting groundwater recharge throughout the groundwatershed. Examples of such features include topographically closed depressions, natural areas, and well-vegetated open land. Such areas identified as having moderate, high, or very high groundwater recharge potential should be assigned high priority. The balance of such areas should be assigned a medium priority (Maps 2.7 and 3.2).

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[263] *See Wisconsin Natural Resource Conservation Service, Testing for Soil Health, October 2017 for more information on testing soil health: www.efotg.sc.egov.usda.gov/references/public/WI/NRCS-Soil_Testing-508.pdf.*

[264] *For more information on producer-led watershed protection grants, please consult the Wisconsin Department of Agriculture, Trade, and Consumer Protection. An example of information available can be found at the following URL: datcp.wi.gov/Pages/Programs_Services/ProducerLedProjects.aspx.*

- Discourage widespread use of artificial drainage enhancement infrastructure (e.g., field tiles, piped storm sewers, drainage ditches, straightened streams) in areas within the groundwatershed with moderate, high, or very high groundwater recharge potential. Encourage naturalizing hydrology in such areas where such infrastructure already exists (e.g., wetland restoration, stream remeandering, drainage swales substituted for buried pipes). Given the importance of agriculture in the area contributing groundwater to Lake Comus, this should be assigned a high priority.

- Promote careful control of new development in the watershed's best groundwater recharge potential areas (Map 2.7). This helps assure water supplying local and sometimes regional aquifers is protected. Control can include excluding certain types of development, maintaining recharge potential through thoughtful design, and minimizing impervious surface area. This should be assigned a high priority in areas with moderate, high, and very high groundwater recharge potential and a medium priority in low and moderate groundwater recharge potential areas.

- Promote policies that protect or enhance infiltration on public and protected lands. High priority should be given to areas identified as having high and very high groundwater recharge potential within the groundwatershed feeding Lake Comus. Medium priority should be given to low groundwater recharge potential areas.

- Encourage local regulators to require developers to infiltrate high quality stormwater as an integral part of new development proposals. Water containing high concentrations of road deicers or other contaminants should not be infiltrated. Such stormwater management infrastructure is best located on area of moderate, high, and very high recharge potential, where this recommendation should be assigned a high priority. Areas of low groundwater recharge potential should be assigned a medium priority.

- Encourage actions that retrofit existing stormwater conveyance systems in urbanized portions of the Lake's groundwatershed to promote high-quality stormwater infiltration. Good locations for retrofitted infiltration infrastructure are pockets of moderate, high and very high groundwater recharge potential within the City of Delavan (Map 2.7). Activities consistent with this recommendation would be modifying existing municipal infrastructure or promoting actions that enhance infrastructure on existing properties. Examples of the latter would be disconnecting rooftop drains from piped stormwater conveyance systems and allowing stormwater to discharge to well-vegetated soil areas.[265] This should be assigned a high priority.

- Advocate for ordinances discouraging excessively broad expanses of impermeable surfaces in any area contributing water to the Lake and/or that consider lost infiltration potential created by development and offset this loss with high-quality runoff infiltration infrastructure located on the site or elsewhere within the Lake Comus groundwatershed. This activity should be assigned a medium priority.

- Purchase land or conservation easements on natural, agricultural, and open lands within Lake Comus' watershed identified as having very high or high groundwater recharge potential and that are desirable for protection for other purposes. Given the potentially high expense of this initiative, it is assigned a low priority.

- Continue to protect wetlands and uplands with an emphasis on preserving groundwater recharge to the Lake by enforcing town, village, and city zoning ordinances (high priority).

[265] *Rain gardens are depressions that retain water, are vegetated with native plants, and help water infiltrate into the ground. Rain gardens can help reduce erosion and the volume of unfiltered pollution entering a waterbody and can also help augment baseflow to waterbodies. Visit the Healthy Lakes program website for more information on best practices: healthylakeswi.com/.*

➤ **Recommendation 1.8: Protect groundwater quality**

Groundwater quantity is only one aspect of sustaining water feeding waterbodies and supplying human needs in the Lake Comus area. Human activity commonly introduces substances that reduce the suitability of groundwater for various purposes. Therefore, the LCPRD should endeavor to promote actions that protect groundwater quality. For example, the LCPRD should promote guidelines, ordinances, and actions that help minimize use of sodium chloride-reliant roadway deicers and water softening agents as well as encourage action to expeditiously remediate identified groundwater contamination issues within the Lake's groundwatershed. This recommendation should be assigned a high priority.

Any unanticipated, long-term, or large future changes in the tributaries' flow or the Lake's water elevation would spur the need for re-evaluating these recommendations. Consequently, as mentioned earlier, tributary flow and Lake water elevation data should be collected, periodically examined, and the suitability of water quantity recommendations should be re-evaluated.

Lake Outlet Dam Configuration and Operation

Lake Comus is an artificial impoundment with water levels raised and controlled by human activity. The Lake would not exist without the dam. The way a dam is designed and operated can profoundly influence the resulting lake's overall health, its ecology, recreational opportunities, and the amount of labor and cost needed to operate and maintain the dam and its impoundment. For these reasons, dam management and operation considerations must be integral to a lake management plan addressing an impoundment. Although dam removal options are technically feasible, dam removal was not considered as part of this lake management plan given the goals of the LCPRD.

The original dam impounding Lake Comus was built almost two centuries ago to produce power for local industry. The current dam, constructed in 1931,[266] was designed to maintain the function of earlier dams, that is, provide power for ongoing milling operations. When milling operations ceased during the 1930s, the dam's residual purpose was maintaining water levels in Lake Comus to benefit aesthetics and recreation, a role for which the existing dam was not purposely designed. Mill dams are designed to store and release water at reliable and predictable rates while maximizing head drop, maximizing usable power production. In essentially all cases, mill dams were not designed to achieve broad goals such as maintaining or improving water quality, sustaining desirable fisheries, supporting recreation, promoting desirable waterfowl and wildlife, and fostering waterbody health and aesthetics. As discussed in Section 2.1, "Lake and Watershed Physiography," the existing dam reportedly has deteriorated to a point that it now has serious maintenance needs.[267,268] For this reason, significant repairs, modifications, or complete replacement are currently being considered for as early as 2024.

Dam design and construction are thoroughly regulated by government and influenced by many technical design standards and protocol. However, some dam design attributes and choices are not mandated by regulations or technical guidance and are instead tailored to meet dam owner and local needs and expectations. The contemplated Lake Comus dam refurbishment project presents an ideal opportunity to integrate Lake management goals into the dam design and engineering process. With knowledge, forethought, and sensitivity to present-day community desires and needs, the new or revised dam and its appurtenant structures can be designed and operated to better achieve community aspirations, address stakeholder concerns, and further many lake management plan strategies and tactics.

The LCPRD and City of Delavan requested that Commission staff develop examples of dam-related concepts and options that foster lake management goals. This subsection provides dam concepts and recommendations that should be considered during design and as part of operation of a new or revised dam.

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[266] *A maker's mark, stamped into concrete on the dam's upstream side, reads: "A.G. Bloland Mt. Horeb, Wis., 1931".*

[267] *Ayres Associates Inc Letter to Mark Wendorf,* Re: Dam Safety Inspection Report, Comus Lake Dam, WDNR Field File No. 64.02, Key Sequence No. 314, *June 2021.*

[268] *Ayres Associates Inc Letter to Mark Wendorf,* Re: Delavan Dam Feasibility Study, *August 2021.*

➤ Recommendation 1.9: Dam design opportunities

The dam impounding Lake Comus was recently inspected by the City of Delavan's consultant and was found to be in poor overall condition. For this reason, a feasibility study is underway that evaluates dam management alternatives. Given the dam's poor condition, complete replacement of the present dam with a new structure is a favored alternative. Dam replacement, or even an extensive retrofit, provides an opportunity for the LCPRD and City of Delavan to integrate dam design details that could help enhance the health and ecological potential of both the Lake and the Creek. Thoughtful design will maximize the value derived from dam revision/replacement and will increase the ultimate aesthetic appeal and the overall recreational value of the Lake and Creek.

Engineers must achieve certain technical and regulatory goals when designing a dam. A few examples are listed below:

- The dam structure must resist the pressure of impounded water so as not to overturn or otherwise fail during all flows, including water levels associated with rare large runoff events
- The dam outlet must have sufficient engineered spillway capacity to pass extreme runoff events without overtopping or endangering the dam
- The dam must not produce undo safety concerns to those operating the dam, to those near and downstream of the dam, and to those navigating the waterway
- In the case of Lake Comus, the current dam operation order stipulates that Lake water levels must remain between 886.74 and 888.23 feet NGVD 1929

Even though dam the dam design process is strictly regulated and has high technical standards, many design aspects are not explicitly specified and are instead left to the discretion of the dam owner and the owner's engineering team. To help illustrate the concept, these non-mandated elements could be thought as similar to "options" selected as part of an automotive purchase – features that are not mandatory for safe operation but instead help the owner achieve greater overall satisfaction with the final delivered product. Such features may increase the final cost but also increase the overall value perceived by the consumer. A few examples of dam design goals not necessarily mandated by regulations and technical design standards include the following.

- Ease of operation and reasonable operation and maintenance labor costs
- Structure aesthetics and longevity
- Ability to enhance aquatic life within the reservoir or downstream areas
- Elements that promote human enjoyment of the adjacent waterbodies and nearby upland areas

Given what is known about goals for the Lake itself, aspirations for the areas near and affiliated with the Lake, and Commission staff experience with other lake outlet dam projects, we recommend that the LCPRD and the City of Delavan consider dam design options that go beyond simple regulatory compliance and basic dam technical standards. These unmandated and optional design elements should be considered simultaneously with basic dam designs. Suggestions were relayed to the LCPRD and the City of Delavan earlier this year. Some of the broader suggestions are listed below. Consideration of all these recommendations, and other not-yet-identified ideas generated by other stakeholders, should be considered a <u>high priority</u> recommendation.

- Top-draw gates are often more capable of passing debris without fouling. Given the extensive marshy areas upstream of the dam, and the potential for mats of aquatic vegetation to float downstream, any gate design must strive to be self-cleaning to the degree practicable.

- Because of limited labor resources, many dam owners are better served by simpler top-draw gate designs. Such gates do not require frequent fine adjustment to contend with day-to-day stream flow variation. Instead, flow capacity significantly increases as reservoir water levels rise. For this reason, gates that draw from the reservoir surface are often better suited to small, shallow reservoirs as opposed to bottom-draw designs. From comments provided by the City, it does not appear that bottom-draw designs are being considered for the primary spillway, an approach with which the Commission agrees.

- Winter ice can make it difficult or impossible to modify operable gate position. This has proven problematic to some Southeastern Wisconsin communities who must operate dam gates during certain winter weather events. For example, a cold spell punctuated by rain on snow, a situation producing intense runoff and freezing temperatures. This produces need for additional spillway capacity, but the gates are frozen into the ice and are immobile, creating a serious problem. Care must be taken to produce designs that prevent ice from locking gates in a fixed position. This can be done in several ways including avoiding designs susceptible to ice locking or including ice disrupting bubblers, heat, or using active water flow or other means to avoid icing of sensitive and critical control components.

- Both the drop and labyrinth designs incorporate a sluice gate, assumedly for reservoir dewatering. In many designs, this gate is sized only to allow brief drawdown during low flow for dam inspection and simple maintenance. To allow for more reliable longer term reservoir water level control and/or dewatering, a situation potentially needed for various reservoir sediment and vegetation management practices, the sluice gate should strive to be sized to pass, at a minimum, the two-year flow event.

- Bottom-hinged crest gates have been used in some Wisconsin dams to retain the top draw configuration and reduce the problem with ice-locked vertical slide gates. An example is the hydraulically actuated Obermeyer gate on the Milwaukee River in Grafton, Wisconsin. For illustration, a schematic of a small pneumatic Obermeyer gate installed in Saint Cloud, Minnesota is included as Figure 3.1.

- The potential for seepage through the earthen embankment must be evaluated as part of dam rehabilitation. Brief inspection by Commission staff during late summer 2021 suggested that water may be seeping through the dam, particularly on its northern end. Seepage through earthen dams can contribute to embankment failure. Seepage can be arrested and/or captured through various remedies appropriate for use at the Lake Comus dam.

- Traditional dams are composed of a single vertical berm or structure that raises upstream water level to the desired level. Such single-structure systems are commonly barriers to fish migration, can be public safety hazards, and impede navigation. Alternatives to traditional dams exist. For example, a dam may be partially or wholly substituted by what amounts to an "engineered rapids." In such an instance, the single vertical water drop at the dam is supplanted by a stretch of high-gradient channel, a situation that is both navigable and passable to fish if engineered correctly. Many examples exist. A general concept sketch is included in Figure 3.2.[269] Ideally, the slope of the engineered rapids should be less than 2 percent although it can vary. Given that the Lake Comus dam has a hydraulic height of seven feet, an engineered rapids measuring 350 feet long would produce a 2 percent gradient. The engineered rapids could extend upstream and/or downstream of the current dam. Furthermore, dam substitution need not be a "all or nothing" alternative. A bypass channel supplementing spillway capacity could be incorporated into a traditional dam design, and to retain control over reservoir water levels, a gated outlet would need to be incorporated into the design.

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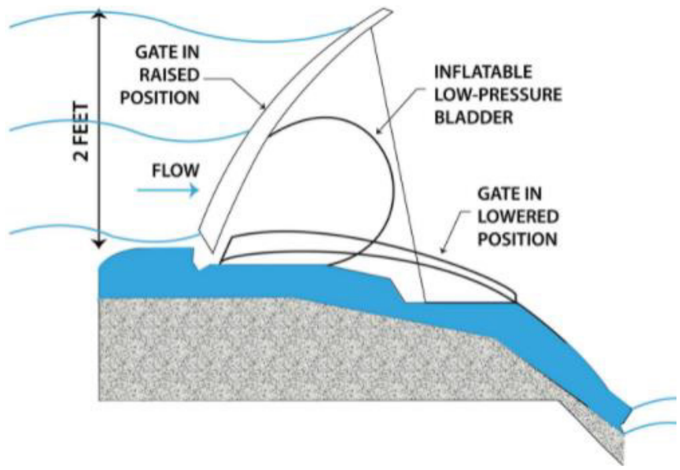
[269] *More information can be obtained from many state and federal agencies. Additional information regarding the illustrated concept can be found at the following website: files.dnr.state.mn.us/eco/streamhab/reconnecting_rivers_chap2.pdf.*

- The existing dam serves a supplemental purpose beyond impounding Lake Comus. The earthen berm is used as a road embankment traversed by North Terrace Street, connecting the City of Delavan with the City's Arboretum property and continuing north as Dam Road. A project proposing change to the dam presents an opportunity to improve roadway stability and capacity, pedestrian access, Lake access, portage routes, and a host of other factors that could influence the positioning, elevation, and configuration of the Dam embankments and outlet gates. For example, the bridge over the Lake's outlet could be widened to permit dedicated pedestrian and bicycle access to the Arboretum from the urbanized areas south of the Lake.

Figure 3.1
Obermeyer Gate Configuration



Source: City of St. Cloud, Minnesota

The LCPRD and the City of Delavan should strive to collaboratively identify opportunities to use the dam construction dewatering process to benefit the Lake's morphology, vegetation, recreational potential, aquatic life, and fishery. For example, the Lake may likely be drawn down to facilitate dam replacement work. This drawdown could be timed and extended over a time period so as to help reduce and/or consolidate flocculent lake-bottom sediment, help reduce invasive aquatic plant populations, and help promote control of common carp. The actual techniques used to accomplish these goals are described in subsequent sections – Lake drawdown is integral to many alternatives.

Under natural conditions, water elevations in most waterbodies fluctuate in response to weather patterns and seasons. Changing water levels are important to the ecology of many desirable aquatic plants – several problematic and undesirable invasive aquatic plants favor static water elevations. Drawdowns must also consider hibernating herptiles and the needs of animals that use aquatic habitat or wetlands during critical portions of their life cycle. When considering construction drawdown, the LCPRD and the City should examine these relationships, should promote protocols fostering desirable native plants and animals while hindering populations of undesirable invasive species, and should manage water levels to help encourage sediment consolidation/consumption/erosion in portions of the Lake and Creek most favored for navigation.

➤ **Recommendation 1.10: Dam operation opportunities**

If the Lake Comus dam is replaced, new opportunities may become available in the future to enhance Lake management practices and recreational opportunities. This could be facilitated by increased ability to manipulate Lake Comus' water levels and the flow of Turtle Creek downstream of the dam. For example, the ability to change and control water levels can be useful for sediment compaction, facilitating dredging, shifting the Lake's aquatic plant community to a more desirable state, reducing populations of undesirable fish species, and creating habitat for rare species. Assuming that the proposed new dam is fitted with gates that allow well-regulated and sustained reservoir drawdown, the LCPRD and the City of Delavan could consider incorporating fluctuating Lake water elevations and variable flow rates in the downstream portion of Turtle Creek into long-term Lake management plans. This should be considered a high priority recommendation.

Although the goals of fluctuating water levels would be similar to those described in the preceding paragraphs regarding construction drawdown, recurrent Lake water level fluctuation would likely require a revised dam operating order. The extant dam operating order was set using water elevations chosen almost a century ago to facilitate waterpower production and agriculture with limited consideration

Figure 3.2
Engineered Rapids Diagram

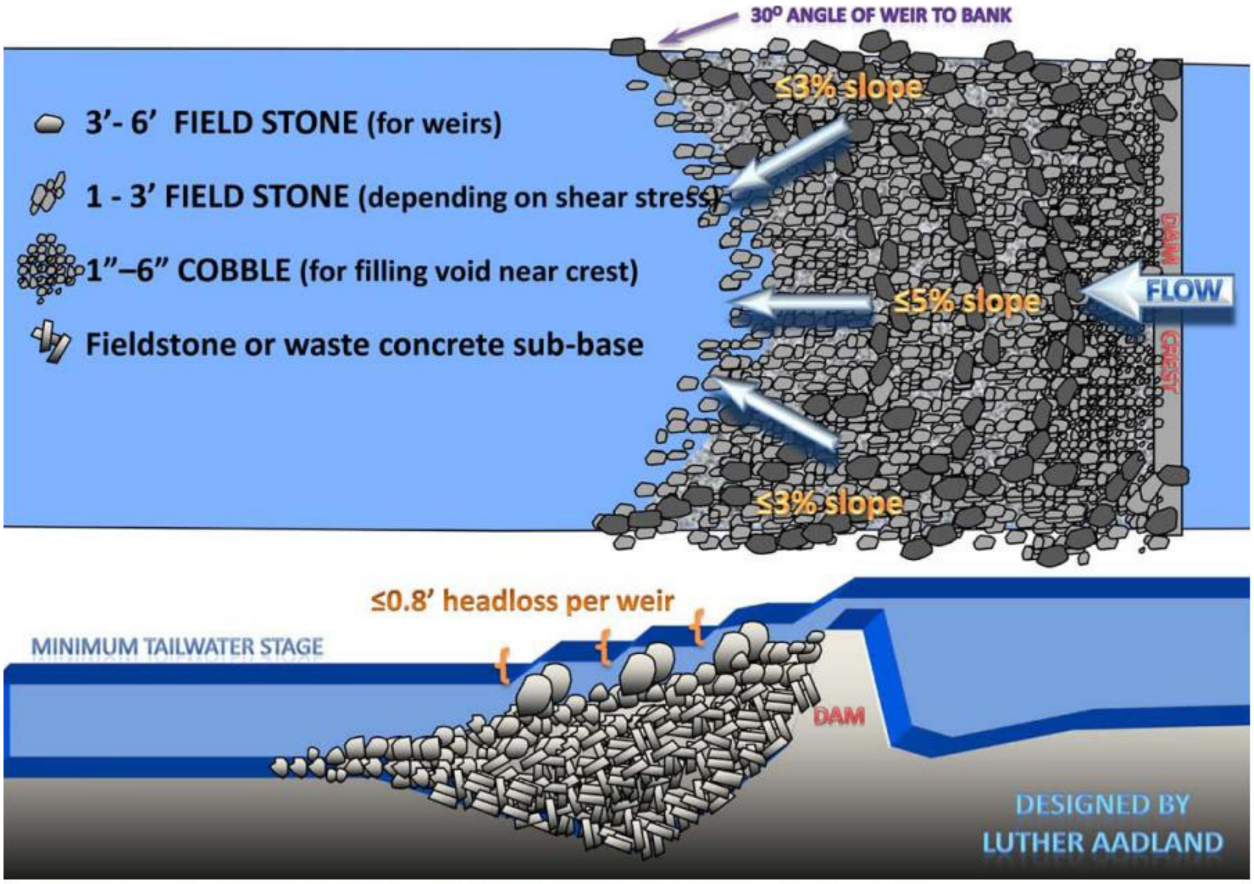


Figure 54. Generalized conceptual design of the Rock Arch Rapids developed by the author.

Note: Illustration drawn from the Minnesota Department of Natural Resource publication *Reconnecting Rivers: Natural Channel Design in Dam Removal and Fish Passage*

Source: Minnesota Department of Natural Resources

of Lake ecology and recreation. The water level operating range needed to make reservoir water level fluctuation an effective Lake management tool need to incorporate minimum elevations much lower than the minimum Lake level stipulated by the present-day dam operating order. Therefore, before such management actions are implemented, the dam owner would need to prepare and submit a petition to the WDNR to revise the water level operating order. The Commission has helped other communities with petition for revised lake level operating levels for various reasons and could provide advice and limited assistance. Although the present dam does not facilitate this initiative, it is important to set strategies and tactics related to water level manipulation now so that the dam design can support these future endeavors. This should be assigned a high priority to give the LCPRD and the City future operational flexibility to manage the Lake.

3.3 WATER QUALITY

Water quality is one of the key parameters used to determine the overall waterbody health. The importance of good water quality can hardly be overestimated. It affects or controls not only various recreational uses of a lake, but also nearly every facet of the natural balances and relationships between myriad abiotic and biotic processes. Because of the importance water quality plays in the functioning of a lake ecosystem, careful water quality monitoring represents a fundamental management tool. The fact that Lake residents are concerned with various water-quality-related issues (e.g., sources of pollution in the watershed, lack of aquatic plant growth, algal growth) suggests that water quality management is warranted on Lake Comus.

Lake Comus Water Quality Monitoring

Water quality monitoring is an important tool that helps quantify the Lake's current condition, understand long-term change, and provides insight into why changes occur. Prior to the onset of this management planning process, Lake Comus lacked consistent water quality monitoring necessary to assess Lake conditions and trends. Through the efforts of the LCPRD, WDNR, and others, a regular monitoring program has been established to measure Lake temperature, dissolved oxygen, and trophic state conditions. Recommendations to continue and enhancing these monitoring efforts are described below:

➤ **Recommendation 2.1: Continue and enhance comprehensive water quality monitoring within Lake Comus**

Water quality monitoring is an important tool that helps quantify the Lake's current condition, helps lake managers decipher longer term change, and allows the factors responsible for change to be identified. Monitoring is integral to management efforts aiming to maintain and improve Lake health. Therefore, monitoring water quality should be a high priority.

Through the efforts of the LCPRD in preparing this management plan, regular water quality monitoring has been initiated in the "deep hole" site in the middle of the Lake. To allow historical data to be contrasted to current conditions, and, thereby, allow trends to be identified, field measurements and water quality samples should continue to be collected at this "deep hole" site at least once during mid-summer and ideally at least monthly during the growing season. At a minimum, water quality should be analyzed for the following parameters:

- Field measurements
  - Water clarity (i.e., Secchi depth)
  - Temperature (profiled over the entire water depth range at the deepest portion of the Lake)
  - Dissolved oxygen (profiled over the entire water depth range at the deepest portion of the Lake)
  - Specific conductance (near-surface sample)
  - pH (near-surface sample)
- Laboratory samples
  - Total phosphorus (near-surface sample)
  - Total nitrogen (near-surface sample)
  - Chlorophyll-a (near-surface sample)
  - Total suspended solids (near-surface sample)
  - Chloride (near-surface sample)

Laboratory tests quantify the amount of a substance within a sample under a specific condition at a particular moment in time and provide valuable benchmarks and trend-defining values. Phosphorus, nitrogen, and chlorophyll-*a* analyses are the basic suite of parameters used to determine and track overall lake health and trophic state. These parameters are tested in many Southeastern Wisconsin lakes and are useful to contrast the Lake's health to other waterbodies of interest.

Field measurements are often reasonable surrogates for common laboratory tests. For example, water clarity decreases when total suspended solids and/or chlorophyll-*a* concentrations are high, samples with high concentrations of total suspended solids commonly contain more phosphorus, and water with higher specific conductance commonly contains more salt and, therefore, more chloride. Periodically sampling water and running a targeted array of laboratory and field tests not only provides data for individual points in time but can also allow laboratory results to be correlated with field test results. Once a relationship is established between laboratory and field values, field data can sometimes be used as an inexpensive means to estimate the concentrations of key water quality indicators normally quantified using laboratory data.

Supplemental temperature/oxygen profiles collected at other times of the year (e.g., other summer dates, nighttime summer, fall, winter) can be helpful. For example, temperature/oxygen profiles collected during midsummer nights, just before sunrise, help evaluate diurnal oxygen saturation swings.

Regular water quality monitoring helps Lake managers identify variations in the Lake's water quality, improves the ability to understand problems and propose solutions, and the capacity to track progress toward Lake water quality goals. The LCPRD should review the water quality monitoring regimen and recommendations regularly and implement revisions to address changing conditions or new threats.

Turtle Creek Monitoring

Since tributaries can play a significant role in determining a lake's water quality, it is recommended that water quality measurements continue to be taken on Turtle Creek upstream and downstream of the Lake. Recommendations for monitoring Turtle Creek are as follows:

➤ **Recommendation 2.2: Continue to conduct level 1 Water Action Volunteer (WAV) monitoring in Turtle Creek and the CTH O tributary**

UWEX maintains WAV, a stream monitoring program that is the analogue of Citizen Lake Monitoring Network for lakes. Volunteers in the Lake Comus watershed should continue to actively monitor Turtle Creek and the CTH O tributary through the WAV program. Monitoring water temperature, dissolved oxygen, as well as total phosphorus, transparency, conductivity, and pH should be included. Water chemistry monitoring in the tributaries should occur concurrently with stream flow estimation when possible. This recommendation is a high priority.

➤ **Recommendation 2.3: Consider expanding to Level 2 WAV monitoring to install programmable water temperature logging devices in Turtle Creek and the CTH O tributary**

The continuous monitoring provided by temperature logging devices provides substantially more information about stream conditions and suitability for fish species. However, participating in this program requires greater time commitment, including training, equipment calibration, and data entry. This recommendation is a medium priority.

➤ **Recommendation 2.4: Consider implementing continuous turbidity monitoring on Turtle Creek**

The LCPRD should consider installing a continuous reading turbidity monitoring device to estimate the amount of suspended sediment contributed to the Lake by Turtle Creek. Turbidity values may be able to be correlated with total suspended solids and phosphorus loads if appropriate calibration sampling is completed. Monitoring turbidity along the Creek's course should be considered by the LCPRD and assigned a low priority due to the higher training, equipment, and maintenance requirements.

➤ **Recommendation 2.5: Supplemental water quality monitoring**

Grab samples should be collected for to represent a cross section of flow events (i.e., low, medium, and high). The sampler should record the current and recent weather conditions, a qualitative description of flow and water quality (e.g., "creek is very high and muddy"), and the exact location, date, and time where the sample was collected. Sampling parameters should include the following:

- Stream flow
- Water clarity (transparency tubes)
- Total phosphorus
- Total nitrogen
- Temperature
- Dissolved oxygen

Flow rate information allows the actual mass load of phosphorus contributed from the tributaries and the areas they drain to be quantified and compared. Stream flow rates can be estimated using a variety of methods (see Recommendation 1.3). The total amount of water delivered from each tributary can also be estimated using empirical formulae (e.g., the Rational Method) and models (e.g., TR 55, SWMM, Presto-Lite). These flow estimates can be combined with water quality information collected in the tributary streams to estimate mass loadings from each stream. This information can then be used to target priority tributaries, seasons, and events for water quality analyses. This recommendation can prove very valuable to helping develop management solutions and tracking progress but requires significant volunteer commitment. Therefore, this recommendation is assigned a medium priority.

Parameters and sampling frequency may be adjusted as necessary to focus resources on the sub-basins identified to have the greatest impact to the Lake's water quality. Depending upon the sub-basin and sample results, action should be taken to help reduce pollutant loadings. For example, if phosphorus was detected in high concentrations in a tributary draining residential areas, efforts to communicate best practices to homeowners should be reinforced, stormwater management infrastructure inspected, actions to protect and expand wetlands and buffers increased, and other factors considered. Intensified and/or expanded monitoring may help pinpoint source areas for particular attention.

Phosphorus Management

As discussed in Section 2.3, "Water Quality and Pollutant Loading", Lake Comus' high total phosphorus concentrations drive high algal abundance and subsequently low water clarity. Consequently, managing phosphorus concentrations in the Lake as well as reducing phosphorus loading to the Lake are important for enhancing the Lake's water quality, aquatic life, and recreational use.

➤ **Recommendation 2.6: Reduce nonpoint source external phosphorus loads**

Lake Comus has a very large watershed in relation to the Lake's surface area, and, therefore, can receive significant sediment and pollutant loads from Turtle Creek and tributaries discharging directly to the Lake. The largest external mass load of phosphorus enters the Lake via Turtle Creek. Pollutant loading models indicate that nonpoint source loading from agricultural land uses is the predominant source of total phosphorus and sediment to surface waters. Nonpoint phosphorus loads should be reduced in accordance with the goals of the Rock River Total Maximum Daily Load (TMDL), and reduction strategies should be assigned high priority. This issue is discussed in more detail and with strategies to reduce loads in Section 3.4, "Pollutant and Sediment Sources and Loads."

➤ **Recommendation 2.7: Manage factors that stimulate in-Lake phosphorus recycling**

Available evidence suggests that phosphorus recycling and resuspension contributes substantial amounts of phosphorus to the Lake's water column. Several processes affect resuspension of phosphorus from lake sediment back into the water column including wind, common carp, boating, and the lack of aquatic vegetation on the lake-bottom sediment. Wind, boating, and common carp disturb bottom sediments while the lack of aquatic plants to act as sediment "groundcover" makes the sediment more susceptible to disturbance. Reducing in-lake phosphorus recycling through long-term watershed phosphorus load reduction measures and considering using in-lake measures should be considered a high priority.

While the most effective tool to reduce phosphorus recycling within the Lake over the long-term is reducing incoming phosphorus loads, several short-term management options may provide some temporary relief. However, these options are generally more expensive and will be rendered ineffective over time if ongoing phosphorus loading is not addressed.

- **Alum treatments** – Alum treatment involves dispersing a chemical (alum: hydrated potassium aluminum sulfate) throughout a lake. This chemical forms a flocculent solid that sinks, carrying solids to the lake bottom, allowing water to clear and rooted aquatic plants to grow at greater depth. Additional rooted aquatic plants uptake greater amounts of phosphorus and can help clear lake water in the longer term. Alum-bound phosphorus precipitated to the lake bottom does not become soluble under anoxic water conditions and can help form a cap to reduce internal phosphorus loading. These effects can help temporarily lower lake water phosphorus concentrations. Lake Comus' shallow depth and short residence time make effectiveness of alum application to maintain lower phosphorus levels very doubtful. Therefore, alum treatment is not a feasible option for long-term phosphorus reduction on Lake Comus.

- **Dredging** – Internal loading and resuspension of phosphorus depends on the availability phosphorus-rich lake bottom sediment. Dredging physically removes phosphorus-rich sediment from the waterbody and thus can reduce internal loading and recycling of phosphorus, particularly when the bottom sediment is continuously disturbed by common carp. Additionally, dredging could increase the lake volume and thus greater amounts of phosphorus would be required to attain the same concentrations as prior to dredging. However, dredging is very expensive, with estimated costs ranging from $5 to $25 per cubic yard. Dredging can also negatively affect lake ecology by removing aquatic vegetation and disrupting the habitat of aquatic organisms. If dredging is pursued as a lake management option, costs may be reduced through usage of the dredging spoil containment area already built and owned by the LCPRD. Additionally, the neighboring Town of Delavan occasionally sediment retention ponds along Jackson Creek north of Mound Road. The LCPRD could coordinate dredging at Lake Comus with the Town's Jackson Creek dredging in an attempt to lower project costs for both the LCPRD and the Town (see Section 3.8, "Plan Implementation").

- **Water Level Manipulation** – Drawing down water levels can affect phosphorus levels within a lake via several pathways. Most directly, drawdowns can cause the exposed lake bottom sediment to consolidate and enhance decomposition of organic matter, reducing the fertility of the sediment once the water level is raised again. Reduced water levels can also enhance carp winterkill and control methods. Carp stir up lake sediment and consume aquatic vegetation. Manipulating water levels to mimic natural fluctuations can also encourage the growth of native submerged aquatic plant species, such as naiads and muskgrass, and enhance the expansion of emergent plant species like cattails and bulrush (see Section 3.5, "Aquatic Plants"). Lake managers need to carefully plan and monitor the frequency, intensity, and timing of water level drawdowns to reap the greatest benefits while also minimizing unintended harm (see Recommendation 1.7). For Lake Comus in particular, any drawdown strategy should consider potential impacts protected reptile species (see Section 3.6, "Fish and Wildlife" for more information).

Cyanobacteria and Floating Algae

Algae are a naturally occurring and healthy component of all aquatic ecosystem. Algae are primary building blocks of aquatic food chains and produce oxygen in the same way as rooted plants. Many forms of algae exist, from filamentous algae to cyanobacteria to muskgrass. Most algae strains benefit waterbodies when present in moderate abundance. However, excessive algal growth or the presence of toxic algal strains should be considered an issue of concern. As with aquatic plants, algae generally grow in greater abundance in the presence of abundant dissolved phosphorus (particularly in stagnant areas). Consequently, when toxic algal strains or highly abundant algae begin to grow in a waterbody, it often indicates a problem with phosphorus enrichment or pollution. As discussed in Chapter 2, algal blooms appear to be a reoccurring problem on Lake Comus due to excessive nutrient pollution from its watershed. The following recommendations are provided to help reduce algal blooms as well as minimize illness to Lake users and their pets from algal toxin exposure.

Preventative Recommendations

To maintain desirable algal populations, this section recommends monitoring algal growth, helping Lake residents recognize and respond to excessive and/or toxic algae, and taking management actions that help prevent undesirable algal growth in the future.

➤ **Recommendation 2.8: Reduce Lake water phosphorus concentrations**

Algal growth in the Lake is limited by available phosphorus. Several techniques, discussed in Section 3.3, "Water Quality," can be used to help maintain or lower phosphorus concentrations in the Lake. Related issues are discussed in Section 3.4, "Pollutant and Sediment Sources and Loads", Section 3.5, "Aquatic Plants", and Section 3.6, "Fish and Wildlife". Lower phosphorus concentrations generally decrease potential for algal blooms. Implementing these recommendations is critical to maintaining healthy algal populations and thus is assigned a high priority.

- **Recommendation 2.9: Monitor algal abundance and sample for algae toxins during suspected algal bloom conditions**
  This effort should focus on monitoring chlorophyll-a, as was described in water quality monitoring recommendations. If large amounts of suspended or floating algae are observed (e.g., "pea soup" green water), algal samples should be collected to allow algal types, particularly toxic strains, to be identified and better inform healthy use of the Lake. Given that there have been several observations of algal blooms, including potential cyanobacterial blooms, on the Lake within the past few years, this recommendation should be assigned a high priority.

- **Recommendation 2.10: Warn residents not to enter the water in the event of an algal bloom**
  Methods to rapidly communicate unhealthful water conditions not conducive to body contact should be developed. The LCPRD could consider installing advisory signage at the boat launch to inform Lake users of the possibility of algal blooms.[270] Significant suspected blue-green algal blooms can be reported to the WDNR at DNRHABS@wisconsin.gov. This recommendation should be assigned a high priority.

- **Recommendation 2.11: Encourage a healthy aquatic plant community to compete with algal growth**
  Aquatic plants utilize phosphorus in the water column, limiting its availability for algae and subsequently limiting algal abundance. Thus, a healthy aquatic plant community is an essential component of improving water quality and reducing undesirable algae in the Lake. This can be promoted by implementing recommendations provided in Section 3.5, "Aquatic Plants." This recommendation should be assigned a high priority.

- **Recommendation 2.12: Reduce carp population within the Lake**
  Carp feeding habitats resuspend sediment and can change aquatic plant growth patterns, increasing phosphorus availability to lake algae. In-lake carp management options are more discussed in Sections 2.6, "Fisheries" and 3.6, "Fish and Wildlife." This recommendation should be assigned a high priority.

Implementing the above recommendations will help prevent excessive algal growth in Lake Comus and should not preclude or significantly inhibit Lake use. If future monitoring reveals excessive or greatly increased algal growth, or should toxic algae be identified, these recommendations should be reevaluated (high priority). Reevaluation should include rethinking all relevant Lake management efforts.

Potential Corrective Measures

In-lake measures and manual removal methods can also be implemented to correct algal populations in the Lake. Use of these methods should be considered; particularly as cyanobacterial algal blooms are a chronic problem and may threaten the health of Lake recreational users and their pets.

- **In-lake treatments** – Suspended and floating algae use dissolved or suspended nutrients to fuel growth. If water-column nutrient levels are reduced, the abundance of algae can be controlled. Water quality enhancement recommendations presented as feasible in Section 3.3, "Water Quality," should be the primary measures implemented to help control algal abundance. Supplemental activities not recommended for general water quality management, but which may provide short-term relief for severe algae problems are described below.

  - **Alum treatments** – As mentioned above in "Phosphorus Management," alum forms a flocculent solid that can carry algae to the lake bottom, providing increased light availability for aquatic plants that compete with algae for nutrients. Short term reductions in phosphorus concentrations from alum treatments also reduce the risk of algal blooms. However, the short residence time and shallow depth of Lake Comus limits the long-term effectiveness of alum treatments for algae control. Furthermore, permitting and logistical lead times to execute an alum treatment are lengthy. Therefore, alum treatment is not considered a feasible option for algae control on Lake Comus.

[270] *The WDNR blue-green algae webpage has example signage: www.dnr.wisconsin.gov/topic/lakes/bluegreenalgae.*

- ◦ **Hypolimnetic withdrawal** – Phosphorus released from the Lake's nutrient-rich bottom sediment is likely facilitating dense algal growth. Hypolimnetic withdrawal would switch the dam outlet withdrawal from the surface to a pipe drawing water from deep within the Lake. However, this technique is only significantly effective in lakes that thermally stratify in summer. Since Lake Comus remains fully mixed in summer, this option is not a feasible option and is therefore not recommended.

- ◦ **Aeration** – This process involves pumping air to the bottom of a lake to disrupt stratification and limit the extent of anoxic conditions forming in the deep portion of the Lake. This in turn reduces internal loading (i.e., the release of phosphorus from deep sediments) and may reduce the severity of algal blooms during mixing periods. This method has produced mixed results in various lakes throughout Wisconsin and appears to be most successful in smaller water bodies such as ponds. If not properly designed or operated, aeration can increase nutrient levels and intensify and/or prolong algal blooms. This technique is effective in lakes that thermally stratify in summer. Since Lake Comus remains fully mixed in summer, this option is not likely to be effective and is not recommended.

- **Manual removal** – Manual removal of algae using suction devices has recently been tested within the Region. This measure, though legal, is currently in the early stages of development and application. Additionally, algal "skimming" has been tried by lake managers with little success. Consequently, such measures should be further investigated and tested before investing significant time or funds into implementation.

All the above measures are commonly only implemented when algal blooms become so profuse that recreational use is impaired. This is often because each method is only temporarily effective, and repeated implementation of these measures can be cost prohibitive. The more permanent methods of algal control discussed above (i.e., pollution control, carp population management, and plant community maintenance) are considered most viable for Lake Comus.

3.4 POLLUTANT AND SEDIMENT SOURCES AND LOADS

Lake Comus' low water clarity, high nutrient concentrations, and significant amounts of nonpoint pollutant loading stem predominantly from rural land uses across its watershed. Turtle Creek is the main contributor of phosphorus and sediment to the Lake. As rural nonpoint runoff is the greatest source of pollutant loads, and potential load reductions, within the watershed, most of the targeted management measures are focused on cropland best management practices (BMPs). Specifically, targeted cropland BMPs recommended in this watershed include use of cover crops and no till practices, increased implementation of nutrient management plans, and expansion of potentially restorable wetlands and riparian buffers. The most effective approach for implementing BMPs across the watershed will likely require outreach about the need for, and benefits of, such practices, cost-sharing or financial incentives to reduce risk to agricultural producers, as well as meeting and exceeding existing agricultural performance standards. The examples recommendations presented below are intended to enhance ongoing efforts to reduce phosphorus and sediment loading at different scales: specific projects along the Lake's shoreline and its tributaries as well as programmatic approaches to reduce nonpoint source loading across the watershed. The overall strategy to reduce pollutant loading with the Lake Comus watershed follow.

- Utilize pollutant load reduction goals set by the Rock River Total Maximum Daily Load (TMDL)

- Prioritize implementing BMPs in areas with highest potential for pollutant loads to affect surface waters, as delineated in this plan

- Strive to implement the amount BMPs required to meet the TMDL goals, as provided in this plan

- Preserve and expand riparian wetlands adjacent to Turtle Creek to maintain and improve current phosphorus and sediment retention

- Remeander Turtle Creek and enhance its floodplain connectivity to mitigate and slow pollutant load transport downstream to Lake Comus

- Implement BMPs and restore the hydrology of Turtle Creek through a combination of outreach, cost-sharing and other financial incentives, and enforcement of existing agricultural performance standards

Table 3.3 provides a summary of the management recommendations most focused on nonpoint source pollutant load reduction, This summary includes performance indicators and quantities to implement these recommendations, their estimated costs and total phosphorus reductions, as well as the funding programs and entities responsible for their implementation.

Pollutant Load Reduction Goals from the Rock River Total Maximum Daily Load (TMDL)

Excessive sediment and nutrient loading to the Rock River has led to increased algal blooms, oxygen depletion, water clarity issues, and degraded habitat. Algal blooms can be toxic to humans and costly to the local economy. Annual economic losses associated with eutrophication in the United States have been estimated to be 2.2 billion dollars per year. The largest losses are related to losses in recreational expenditures (0.37 to 1.16 billion dollars per year) and loss of lakefront property value (0.3 to 2.8 billion dollars per year).[271] Other sources correlate a 15.6% decrease in property value with each 1.0-meter loss of secchi-depth based water clarity.[272] Additional economic costs relate directly to eutrophication beyond the examples listed previously. For example, over 44 million dollars are spent each year on plans alone to recover imperiled species, a situation related to habitat change and eutrophication. The need for potable water treatment is correlated with eutrophication. Billions are spent each year on potable water treatment, a common consequence of the need to remove sediment, tastes, and odors commonly related to eutrophication. Finally, nuisance aquatic plant growth often correlates to eutrophic conditions, a cost that some estimate to be over one billion dollars per year.[273]

Due to known waterbody impairments in the Rock River Basin, a TMDL study for phosphorus and sediment was developed for the Rock River basin and its tributaries. The TMDL study was approved in 2011 establishing phosphorus and sediment load reduction goals for the upper Turtle Creek watershed as a reach of the larger Rock River basin (see Map 3.3).[274] This watershed comprises all lands contributing to Turtle Creek upstream of State Hwy C, an area including the Delavan Lake and the Jackson Creek watersheds as well as Lake Comus and its watershed. Achieving the targeted instream concentrations in Turtle Creek will require annual total phosphorus reductions from baseline loads of 75 percent for wastewater treatment facilities (WWTFs) and 49 percent for non-point sources. It will also require baseline sediment loads reductions of 1 percent from WWTFs and 25 percent from non-point sources. Of these nonpoint source loads, non-permitted urban sources contributed 19 percent of the total phosphorus and 15 percent of the sediment.

This lake management plan envisions that restoration techniques be applied as a management action within the context of the Rock River TMDL pollutant load reduction goals as implemented through traditional regulatory actions (such as point source permits) and through voluntary programs (such as implementation of nonpoint source BMPs). Implementation of stream restoration techniques along with regulatory and voluntary actions would contribute to addressing the numeric or narrative water quality criteria and designated water use objectives for Lake Comus and Turtle Creek. In the context of the TMDL, stream restoration can also address nonattainment of a designated use or a narrative criterion that refers explicitly to habitat quality or biological diversity. The recommended management strategy would be to combine point and nonpoint source load reductions and instream ecological restoration techniques. It is important to note that stream restoration is an important and vital pollution reduction strategy to meet TMDL goals for phosphorus and sediment, but stream restoration should not be implemented for the sole purpose of nutrient or sediment reduction in this watershed.

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[271] *Dodds, Walter K, Wes W. Bouska, Jeffrey L. Eitzmann, Tyler J. Pilger, Kristen L. Pitts, Alyssa J. Riley, Joshua T. Schloesser, and Darren J. Thornbrugh, "Eutrophication of U.S. Freshwaters: Analysis of Potential Economic Damages,"* Environmental Science and Technology, *43(1): 12-19, 2009.*

[272] *C. Krysel.; E. M. Boyer, C. Parson, and P. Welle,* Lakeshore Property Values and Water Quality: Evidence from Property Sales in the Mississippi Headwaters Region*; Submitted to the Legislative Commission on Minnesota Resources: St. Paul, MN, 2003; p 59.*

[273] *Dodds, 2009,* op. cit.

[274] *USEPA and WDNR,* Total Maximum Daily Loads for Total Phosphorus and Total Suspended Solids in the Rock River Basin Columbia, Dane, Dodge, Fond du Lac, Green, Green Lake, Jefferson, Rock, Walworth, Washington, and Waukesha Counties, Wisconsin*, prepared by the CADMUS Group, July 2011.*

Table 3.3
Targeted Management Measures, Estimated Cost, and Estimated Phosphorus Reduction for the Lake Comus Watershed: 2021

Recommendations	Indicators	Quantity	Estimated Cost ($)[a]	Phosphorus Reduction[b]	Funding Programs[c]	Implementation
Agricultural BMPs						
Increase use of no-till and conservation tillage in watershed	Number of acres cropland with conservation practice applied	2,510 acres	49,267	3,665 pounds	EQIP, TRM, SWG	NRCS, Walworth County, WDNR, Local Partners
Increase use of cover crops	Number of acres cropland with conservation practice applied	2,510 acres	150,977	803 pounds	EQIP, TRM, SWG	NRCS, Walworth County, WDNR, Local Partners
Increase implementation of lands under nutrient management plans	Number of acres cropland with conservation practice applied	6,080 acres	243,200	7,236 pounds	EQIP, TRM, SWG	NRCS, Walworth County, WDNR, Local Partners
Install grassed waterways	Number of linear feet of grassed waterways installed	40,910 feet	204,550	2,624 pounds	EQIP, TRM, SWG	NRCS, Walworth County, WDNR, Local Partners
Riparian Buffers and Wetland Restoration						
Install minimum 75-foot wide riparian buffer strips	Number of acres of riparian buffer installed	179 acres	78,760	469 pounds	CREP/CRP, EQIP, TRM	NRCS, Walworth County, WDNR, Local Partners
Convert farmed Potentially Restorable Wetland into wetland	Number of acres of restored wetland	1,287 acres	5,148,000	2,214 pounds	CREP/CRP, EQIP, TRM	NRCS, Walworth County, WDNR, Local Partners
Turtle Creek Remeander						
Implement remeander projects, such as toe wood-sod mats	Number of linear feet with remeander projects installed	28,776 feet	2,877,600	N/A	TRM, SWG	NRCS, WDNR, Walworth County, Local Partners
Shoreline Protection						
Reinforce shoreline with vegetative buffer and low-lying structures	Number of linear feet with shoreline protections installed	2,200 feet	49,764	N/A	SWG	LCPRD, WDNR, Local Partners

Note: A combination of the listed practices will be applied to agricultural fields to get the desired reductions required by the Rock River TMDL. Not all practices listed will be applied to each field. The combinations of practices applied will vary by field. In most cases just applying one practice to a field will not get desired reductions and a combination of two to three practices will be necessary to get desired reductions.

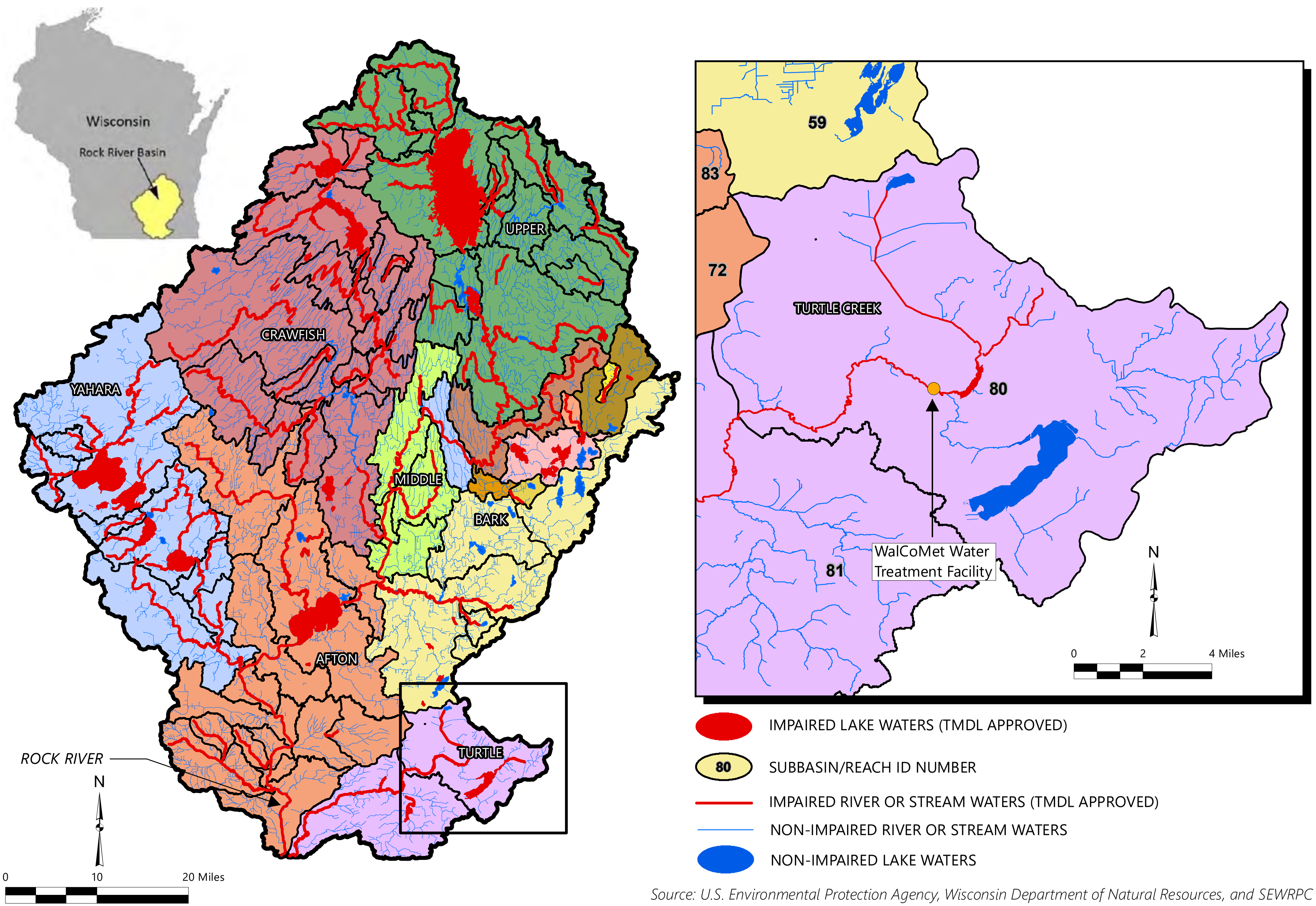
[a] Estimated per unit costs are as follows: 19.64 per acre for no-till, 60.15 per acre for cover crops, 40.00 per acre for nutrient management plans, 5.00 per linear foot for grassed waterways, 440 per acre for riparian buffer, 4,000 per acre for land conversion, 100 per linear foot for stream remeandering, and 22.62 per linear foot for shoreline protection.

[b] Estimated phosphorus reductions per acre were sourced from the STEPL pollutant loading model for each conservation practice individually applied to one acre of cultivated cropland.

[c] See "Funding Sources" in Section 3.8, "Plan Implementation" for a more detailed description of the Environmental Quality Incentives Program (EQIP), Total Runoff Management (TRM), Conservation Reserve Enhancement Program (CREP), Conservation Reserve Program (CRP), and the Surface Water Grants (SWG) programs.

Source: NRCS and SEWRPC

Map 3.3
Subbasins and Impaired Reaches of Wisconsin's Rock River Watershed: 2021



Source: U.S. Environmental Protection Agency, Wisconsin Department of Natural Resources, and SEWRPC

Choosing a management strategy is critical to meeting the water quality goals established by the TMDL. As an example, the City of Oconomowoc, also within the Rock River TMDL, has identified adaptive management as the preferred compliance alternative to meet its Wisconsin Pollutant Discharge Elimination System (WPDES) permit requirements.[275] This adaptive management plan spans three WPDES permit terms (15 years) with the understanding that progress can be demonstrated by the beginning of the third term. In order to achieve water quality goals, the City has developed the Oconomowoc Watershed Protection Program (OWPP) to build capacity and develop collaborative projects within the watershed. As of 2021, the OWPP has improved 157 acres through stormwater projects, 567 acres through long-term agricultural projects, 2029 acres through annual cover crop installation, and removed 356 pounds of phosphorus per year through wastewater treatment.[276] The OWPP has also increased water quality monitoring throughout the watershed to track compliance with the Rock River TMDL pollutant reduction goals. In addition to these efforts, the OWPP hosts informational meetings and events, such as the Nutrient Management Training workshops, and it produces and distributes the "Streamings" newsletter to provide updates on the program.[277] Through its support of the agricultural producer-led Farmers for Lake Country organization, the OWPP assists with agricultural producer education and conservation cost-share programs aimed to maximize crop profitability, improve soil health, and protect lake and stream water quality. Programs coordinated through Farmers for Lake Country include farmer education events, such as the Soil Health training day, the Water Friendly Farm Program, and an aerial cover crop seeding program.[278] Collaborating with local municipalities and WWTFs to create a similar program for the Turtle Creek watershed would greatly enhance the capacity for conservation education and implementation and help meet long-term water quality goals for Turtle Creek, Lake Comus, and other lakes in the watershed. Actions taken by the LCPRD and the City of Delavan to promote similar collaboration in the Lake Comus watershed should be assigned a high priority.

Prioritizing Parcels to Reduce Non-Point Source Pollutant Loads

Reducing nonpoint sources of phosphorus and sediment from agricultural land uses in the Lake Comus watershed is a major priority for the LCPRD, the City of Delavan, and other organizations committed to improving water quality in Lake Comus and Turtle Creek. Understanding where BMPs should be applied within a watershed is critical to ensure that land, financial, and time resources are effectively spent on projects with the greatest potential pollutant load reduction. To that end, Commission staff prioritized parcels for effectiveness of implemented conservation practices within the watershed using 2015 land use, soil, and floodplain information. Generally, the effectiveness of agricultural BMPs to improve water quality decreases with distance from a waterbody. Therefore, parcels adjacent to the Lake and its tributaries would receive high priority. Based upon this principle, a general parcel level agricultural priority map for BMP implementation was developed. Implementation priority for each parcel was assigned to one of the following three categories:

- **High priority** – Parcels with over 50 percent of land devoted to agriculture that abut or are intersected by waterways including Lake Comus, the mainstem of Turtle Creek, drainage ditches and tributaries, and/or floodways designated by the Federal Emergency Management Agency (FEMA)

- **Moderate priority** – Parcels with less than 50 percent of land devoted to agriculture that intersect waterways as well as parcels with any agricultural lands intersected by FEMA-designated floodplains

- **Low priority** – Agricultural lands that are not directly connected to a waterway and are outside of FEMA-designated floodplain

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[275] *As defined by the WDNR, "Adaptive management (AM) is a compliance option that allows owners of point and nonpoint sources of phosphorus to work together to improve water quality and to meet water quality standards. Adaptive management recognizes that excess phosphorus in lakes and rivers is the result of a variety of activities and sources; both point and nonpoint source reductions are often needed to achieve water quality standards". More information regarding AM can be found at the WDNR's website: www.dnr.wisconsin.gov/topic/Wastewater/AdaptiveManagement.html.*

[276] *For more information on OWPP projects, see oconomowocwatershed.com.*

[277] *Oconomowoc Watershed Protection Program,* Streamings*, 1(1), 2020.*

[278] *For more information on Farmers for Lake Country, see www.farmersforlakecountry.org.*

This scheme prioritizes sites where pollutant loads are most easily delivered to waterbodies and where pollutant loads can be most cost-effectively reduced. Based upon this analysis, approximately 5,622 acres of high priority, 2,000 acres of moderate priority, and 12,389 acres of low priority agricultural lands are found within the watershed (Map 3.4). Judiciously applying BMPs in higher priority parcels will help tangibly reduce pollutant loading to Lake Comus.

Recommended Non-Point Source Reduction Practices for the Lake Comus Watershed

Implementing BMPs that reduce non-point source pollutant loading throughout the watershed, educational programming, and broadening/deepening public support have the greatest potential for improving the health of Turtle Creek and Lake Comus. Reducing pollutant loads will take coordination at regional, County, municipality, and local scales. Strong partnerships that adopt programmatic approaches, such County land and water conservation plans, meaningfully contribute to long-lasting pollutant reduction. However, it is also essential to promote education and outreach programs regarding pollutant loading, particularly non-point source loading. The recommendations in this subsection are intended to improve soil health, enhance water quality, and support biological diversity.

Agricultural BMPs

Pollutant load modeling presented in this plan, the Turtle Creek Priority Watershed Plan, and the Rock River TMDL have identified rural nonpoint sources as the major contributors to total phosphorus and sediment pollution in Lake Comus and Turtle Creek.[279,280] Consequently, utilizing agricultural BMPs and regenerative agriculture techniques are the most effective measures to reduce nonpoint source pollutants and improve the water quality of the Lake and Creek. Walworth County Land Use & Resource Management staff supplied the estimated number of acres within the watershed where agricultural BMPs have already been applied.[281] Agricultural parcels where conservation practices and nutrient management plans have already been applied in the Lake Comus watershed are shown in Map 3.5.

The Commission's STEPL modeling effort indicates the number and amount of these practices required within the watershed to meet the pollutant load reduction goals set by the Rock River TMDL. A combination of enforcement to meet existing agricultural performance standards as well as outreach and financial incentives to implement additional BMPs that exceed these standards will be required to meet these goals.

Existing runoff management standards have been established by the State of Wisconsin and are administered by the WDNR and the Department of Agriculture, Trade, and Consumer Protection (DATCP). Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code* provides runoff management standards and prohibitions for agriculture, including the soil phosphorus index, manure storage and management, nutrient management, soil erosion, tillage setback, as well as implementation and enforcement procedures for the regulations. Chapter ATCP 50, "Soil and Water Resource Management Program," of the *Wisconsin Administrative Code* prescribes farm conservation practices that can be used to implement these standards.[282] *Wisconsin Statutes* 91.80 states that landowners claiming farmland preservation tax credits must comply with soil and water conservation standards while *Wisconsin Statutes* 91.82 provides the Counties with the responsibility and protocols for monitoring compliance with these standards.[283]

Since all cultivated land within the Lake Comus watershed is within a Farmland Preservation Zoning District, agricultural landowners may be eligible to receive a $7.50 per acre tax credit if they participate in the Farmland Preservation program and are certifiably complying with NR 151.[284,285] As per the aforementioned

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[279] *Rock County Department of Land Conservation,* Turtle Creek Priority Watershed Plan, *April 1984*.

[280] *USEPA and WDNR, 2011*, op. cit.

[281] *Personal communication between Brian Smetana, Senior Conservation Technician, Walworth County Land Use & Resource Management and Commission staff.*

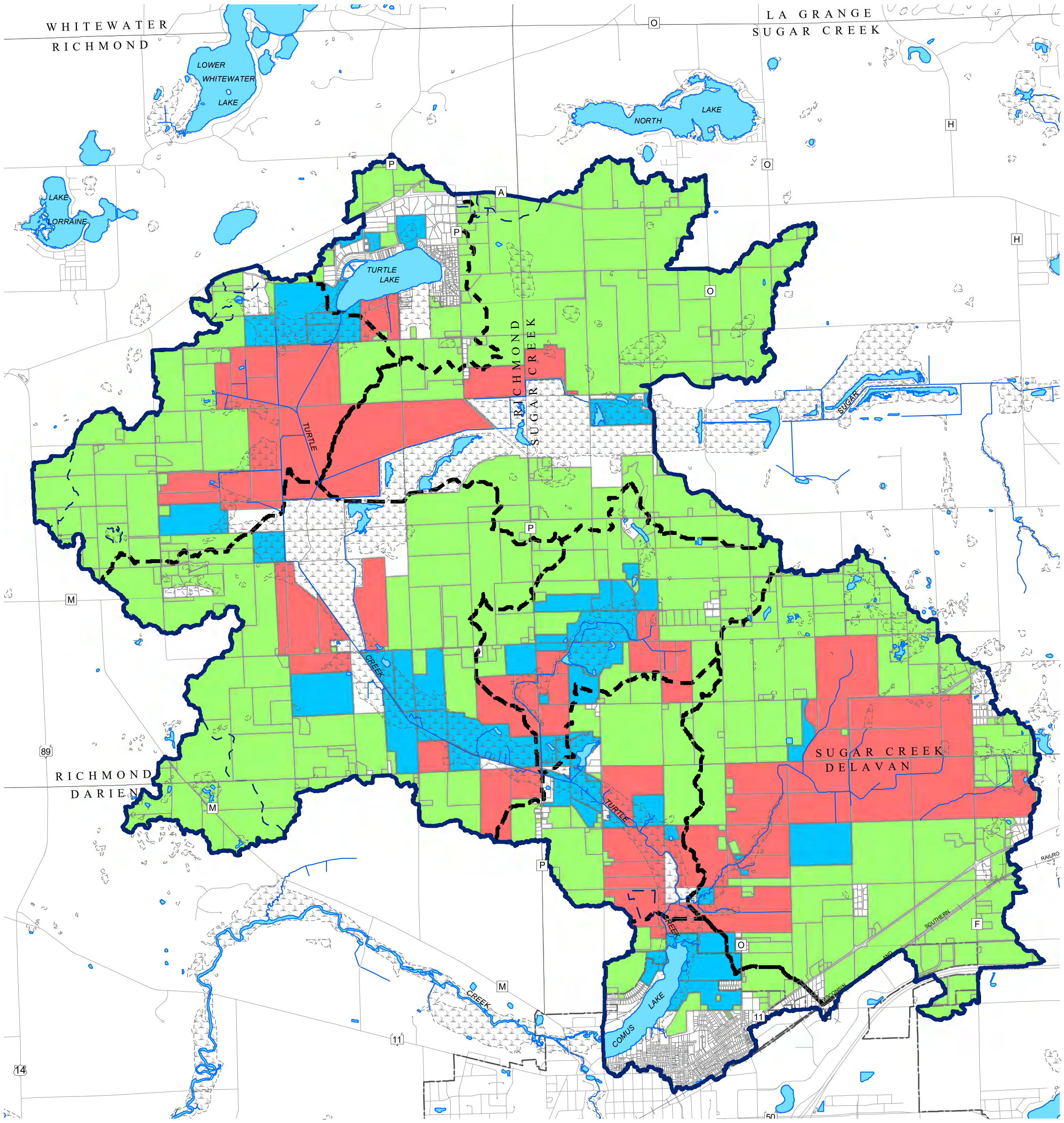
[282] *For a summary of the interaction between NR 151 and ATCP 50, see Wisconsin DATCP,* ATCP 50 Farm Conservation Standards, *ARM Pub 242, March 2014*. datcp.wi.gov/Pages/Programs_Services/NutrientManagement.aspx

[283] *For more information, see docs.legis.wisconsin.gov/statutes/statutes/91/v/80.*

[284] *To view a map of lands within Farmland Preservation Zoning Districts, see datcpgis.wi.gov/maps/?viewer=fpp.*

[285] *For more information on Farmland Preservation Zoning, see datcp.wi.gov/Pages/Programs_Services/FPZoning.aspx.*

Map 3.4
Prioritization Among Parcels for Implementation of Agricultural BMPs Within the Comus Lake Watershed



PRIORITY AGRICULTURAL BMP PARCELS

- HIGH
- MODERATE
- LOW
- TAX PARCEL
- WETLANDS

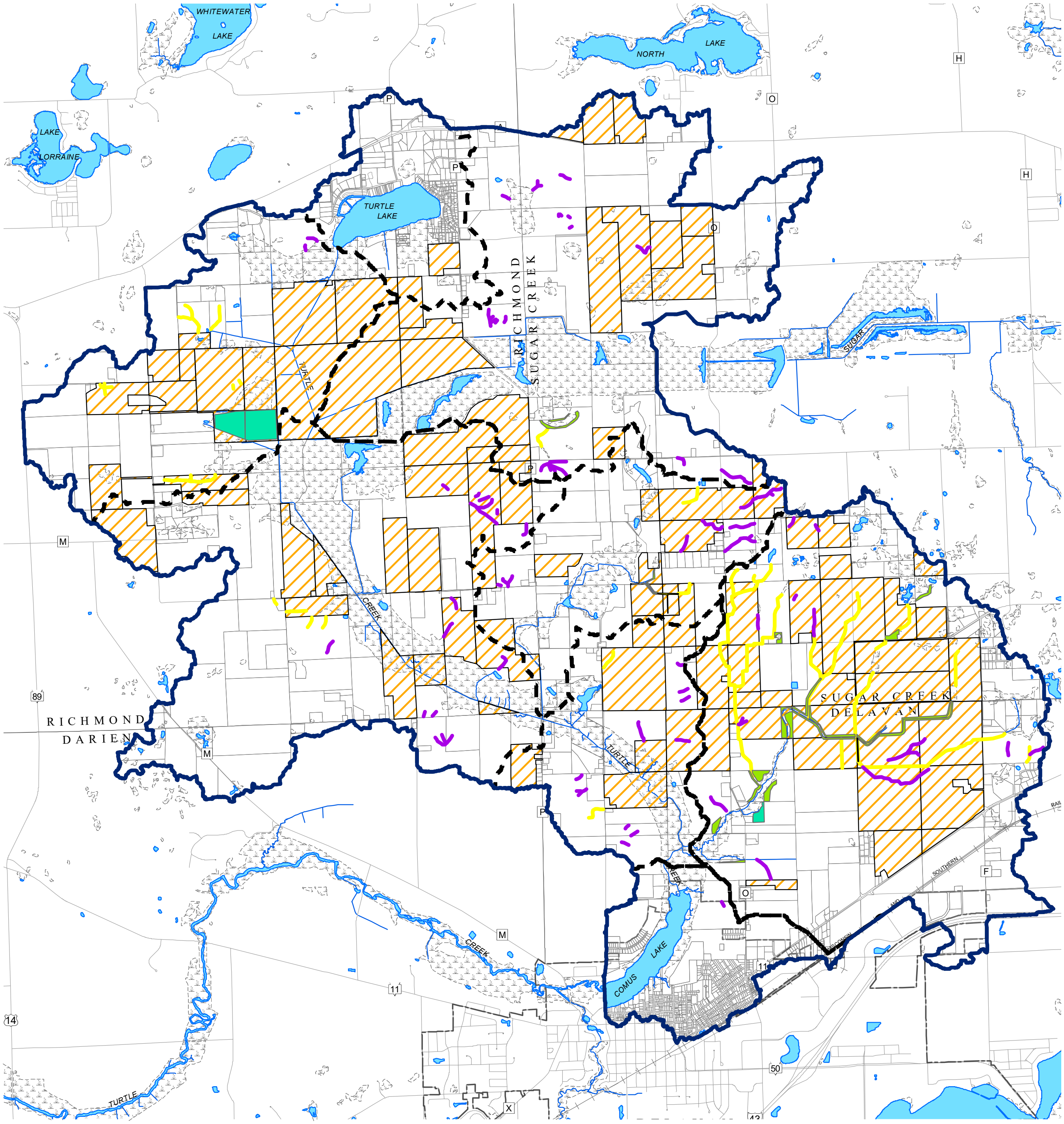
- SURFACE WATER
- STREAM
- WATERSHED BOUNDARY
- INTERNALLY DRAINED AREAS
- WATERSHED SUBBASINS

N

0 0.25 0.5 1 Mile

Source: SEWRPC

Map 3.5
Conservation Plans and Practices within the Lake Comus Watershed: 2021



CONSERVATION PLAN OR PRACTICE

- NUTRIENT MANAGEMENT PLAN (LURM)
- GRASSED WATERWAY (LURM)
- RIPARIAN BUFFER (LURM)
- RESTORED WETLAND (LURM)
- GRASSED WATERWAY (SEWRPC)
- POTENTIAL GRASSED WATERWAY (SEWRPC)
- WETLANDS
- SURFACE WATER
- STREAM
- WATERSHED BOUNDARY
- WATERSHED SUBBASINS

Source: Walworth County LURM and SEWRPC

Note: *Information regarding conservation practices in the left column were provided by Walworth County Land Use & Resource Management (LURM). The existing and potential grassed waterway lines were estimated by Commission staff using aerial imagery and topographical contours.*

statutes and Walworth County ordinances, agricultural landowners participating in the Farmland Preservation program not in compliance will be issued a notification of non-compliance detailing the violation, a deadline to cure the violation, the process to contest the violation, and that the landowner may not claim the aforementioned tax credit until the violation is corrected.[286] Experience in the State has indicated that a combination of regulation and informed local decision making by landowners/operators is needed to achieve water quality improvements consistent with the attainment of water quality standards and criteria.[287]

Although this plan recognizes the importance of continued funding and staff to ensure adherence to State, County, and local standards, it goes beyond reliance on regulation and enforcement. This plan's strategy is to rely on empowered local decision makers creating unique solutions that work for the Lake Comus watershed to ultimately exceed compliance standards. This strategy is designed to augment the work of Walworth County staff who work with landowners and operators to implement innovative and effective conservation practices continued through collaboration amongst the County, State, and Federal agencies.

Aside from the agricultural land that they own, the LCPRD, City of Delavan, Town of Delavan, and other municipalities have little capacity to directly implement agricultural BMPs. However, these entities can play a role in encouraging, educating, and incentivizing the adoption of these practices within the watershed. The Surface Water Restoration and Management Plan Implementation subprograms of the WDNR Surface Water Grant program are two avenues by which the LCPRD and others can help fund watershed BMPs that reduce nonpoint source loading (Table 3.3). As several of these practices may require specialized equipment and training as well as a major shift in how these farms have previously been operated, the local agricultural industry, including retailers, crop advisors, cooperatives and other local markets, should be prepared to assist farmers in changing practices. Due to the importance of reducing rural nonpoint source phosphorus and sediment pollution to the water quality and general ecosystem health of Lake Comus and Turtle Creek, the following recommendations should be considered a high priority.

- **Recommendation 3.1: Incentivize use of no-till and conservation tillage practices**

  Removing crop residue and disrupting soil through tillage often enables soil erosion. When soil is tilled, soil structure resisting erosion is weakened and more soil is exposed to erosive forces, leading to nutrient and sediment laden surface runoff. No-till farming is the practice where soil is undisturbed except for where the seed is placed in the soil. No-till planters disturb less than 15 percent of the row width. The combination of minimal ground disturbance and minimal removal of crop residue contribute to a more stable soil surface that is less susceptible to erosion and the accompanying runoff of nonpoint source pollutants.

  No-till benefits are recognized in several areas. By not turning soil over to prepare a seed bed, soil structure, including pores and channels formed throughout the soil surface layers, remains intact. Furthermore, soil does not become compacted, allowing precipitation to better infiltrate. These changes result in less surface runoff and enable agricultural producers to enter fields in wetter conditions. The residue left behind after crop harvest is left to breakdown naturally, increasing the amount of organic matter in the soil. Decaying residue cycles nutrients back into the soil, decreasing reliance on artificial fertilizer. Soil with higher organic matter and better structure generally has more capacity to absorb and hold water, releasing it to crops during the growing season. Some soils are better suited to no till than others. Soil warming and drying may be slower in the spring especially on poorly drained soils causing plants to germinate more slowly. Since the soil is not turned over, undesirable weeds may be harder to control and herbicide use could increase or alternative weed control practices used (e.g., cover crops coupled with mechanical termination). The benefits of no-till are not fully realized until the practice has been in place for several consecutive years.

  To be effective, no-till must be done as part of a system of crop rotation, nutrient management, and integrated pest management. Managing weeds and the residue resulting from no-till requires the farmer to be committed to changing additional seemingly interdependent farming practices as well

[286] *Walworth County Code of Ordinances Chapter 26 Article IV, "Conservation". library.municode.com/wi/walworth_county/codes/code_of_ordinances?nodeId=WACOCOOR_CH26EN_ARTIVCO_DIV2SOWACOSTFAPRPR*

[287] *The Minnesota Pollution Control, Wisconsin Department of Natural Resources, and The St. Croix Basin Water Resources Planning Team*, Implementation Plan for the Lake St. Croix Nutrient Total Maximum Daily Load*, prepared by LimnoTech, February 2013.*

as renting or purchasing new equipment or modifying existing equipment. These changes are not only a financial risk to farmers but also require that agricultural retailers, crop advisors, and local markets provide necessary training, equipment, and products to assist farmers transition to no-till.

As discussed in Chapter 2, Commission staff modeled pollutant load reduction scenarios using the Spreadsheet Tool for Estimating Pollutant Loads (STEPL) developed by the US Environmental Protection Agency. In order to achieve the nonpoint source total phosphorus reduction goal of 49 percent for the Turtle Creek Headwaters watershed established by the Rock River TMDL, the percent of acres on which no-till agriculture is currently practiced should be increased from an estimated 10 percent to at least 30 percent within the next ten years. This increase in no-till coverage, in combination with other agricultural BMPs described below, would be necessary to meet the goals set by the TMDL.

➤ Recommendation 3.2: Promote increased cover crop acreage

Establishing cover crops includes planting grasses, legumes, forbs or other herbaceous plants for seasonal cover and conservation purposes. Common cover crops used in Wisconsin include winter hardy plants such as barley, rye and wheat as well as less common crops like oats, spring wheat, hairy vetch, red clover, turnips, canola, radishes, and triticale.[288,289] Cover crops help reduce phosphorus and sediment loads to waterbodies by reducing erosion and improving infiltration, Cover crops grow during months when cultivated fields would otherwise be bare. This allows such fields to capture solar energy during fallow periods, a situation helping nourish soil biota, hold nutrients that otherwise be carried away in water, and hold soil protecting it from erosion. When used properly for erosion control, cover crops produce a near continuous vegetative ground cover protecting soil against raindrop impact as well as sheet and rill erosion. Continuous plant cover increases infiltration, reduces runoff speed, promotes diffuse flow and runoff across the soil surface, causes soils particles to aggregate promoting desirable soil structure, and binds soil particles to plant roots. Decreased soil loss and runoff translates to reduced transport from farmland of nutrients, pesticides, herbicides, and harmful pathogens associated with manure that degrade the quality of surface waters and could pose a threat to human health. Over time, a cover crop regimen increases soil organic matter leading to further improvements in soil structure, stability, increased moisture and nutrient holding capacity for plant growth, and greater soil carbon storage.

Recent findings of the USDA Sustainable Agriculture Research and Education program recommend that a variety of strategies be employed to encourage agricultural producers to plant cover crops. Education, sharing new research results, appropriate technical assistance, low-cost seed, and in some cases, financial incentives will be necessary to encourage more farmers to adopt cover crops.[290] To achieve targeted total phosphorus load reduction of 49 percent, the number of acres planted to cover crops in watershed area should increase from 5 to 25 percent in combination with other agricultural BMPs as per the Commission's STEPL modeling. The LCPRD should promote activities that encourage producers to experiment with and hopefully employ cover crops in the longer term. This could include sponsoring producer-led educational events that focus on cover crop application. Furthermore, the LCPRD could consider cooperating with Walworth County, the City of Delavan, and/or WalCoMet to make specialized equipment needed for cover crop application available to producers at low cost. Other counties have acquired such equipment and rent it producers at nominal cost.[291]

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[288] *USDA NRCS Wisconsin,* Cover Crops Factsheet, *2014*.

[289] *See UW-Extension website for more information at www.fyi.uwex.edu/covercrop*

[290] *Download USDA report at website www.sare.org/Learning-Center/From-the-Field/North-Central-SAREFrom-the-Field/2015-Cover-Crop-Survey-Analysis*

[291] *As an example, Ozaukee County and the Milwaukee River Clean Farm Families producer-led group offer a variety of incentives to encourage farmers to experiment with cover crops. Some of these programs are summarized at the following website: www.cleanfarmfamilies.com/cover-crop-program.*

➤ **Recommendation 3.3: Ensure all agricultural lands employ nutrient management plans**

The goal of a nutrient management plan is to avert excess nutrient applications to cropland and to thereby reduce nutrient runoff to lakes, streams, and groundwater.[292] Nutrient management plans consider the amounts, types, and timing of nutrient applications needed to obtain desired yields and minimize risk of surface water and groundwater contamination. In Wisconsin, nutrient management plans are based on the NRCS 590 standard.[293] Plans must be prepared by a qualified planner, which may be the farmer or a certified crop advisor. Soil testing is done on each field to help producers identify where nutrients are needed and where they are not and considers tillage, manure application, and residue management practices. Plans help farmers allocate nutrients economically (i.e., right source, rate, time, and place) while also helping to ensure they are not over-applying nutrients which could cause water quality impacts.[294] Ensuring that all agricultural fields in the watershed operate under a nutrient management plan would be a substantial step forward in achieving the 49 percent total phosphorus load reduction goal.

➤ **Recommendation 3.4: Install additional grassed waterways**

Grassed waterway carry runoff water off fields in a way that limits soil loss. Grassed waterways are constructed in natural drainage ways by grading a wide, shallow channel and planting the area to sod-forming grasses. When needed to help or keep vegetation established on sites having prolonged flows, high water tables or seepage problems, subsurface drains, underground outlets or other hard engineered components may be installed. Effective grassed waterways convey runoff water from fields and the sod helps capture entrained sediment and prevents runoff from eroding a channel and forming a gulley. The vegetation may also absorb some chemicals and nutrients in the runoff water and provide cover for small birds and animals. Grassed waterways fill with sediment over time and need to be rejuvenated by removing sediments, regrading, and replanting. Based on Commission staff estimates, the Lake Comus watershed already contains over 60,500 linear feet of grassed waterways, most of which are along ditches contributing water to the CTH O tributary (see Map 3.5). Installing additional grassed waterways, particularly within steeply sloped cultivated fields where gully erosion is already evident, can further reduce phosphorus and sediment loading to surface waters. Potential areas where grass waterways may be particularly useful due to steep slopes as well as signs of erosion and/or moisture identified via aerial imagery are illustrated on Map 3.5. Nearly 40,900 linear feet of potential new grassed waterways could be warranted in the Lake Comus watershed.

Drain Tiles

Extensive subsurface drain tile networks have been installed over large areas of agricultural land to help lower seasonally high-water tables, allowing these areas to be more amenable to profitable agricultural use. In some situations, drain tiles include surface inlets to drain closed depressions that fill with runoff (e.g., Hickenbottom inlets). Drain tiles often discharge directly into streams or into ditches that discharge into streams. Because they provide a direct drainage pathway from fields to surface waterbodies, drain tiles can allow water and pollutants to bypass agricultural BMPs and natural features that modulate flow and remove contaminants from runoff. Research conducted at the University of Wisconsin Discovery Farms illustrates this bypass effect.[295] Drain tiles can export a substantial portion of the total phosphorus lost from agricultural systems in a variety of phosphorus forms, although dissolved P tends to be more common than particulate forms.[296] In fields with intact drain tile, between 15 to 34 percent of the total phosphorus, 78 to 87 percent of the nitrogen, and about 25 percent of the sediment leaving the field moved through the drain tile system. In fields with damaged drain

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[292] *For more information on nutrient management and planning, see datcp.wi.gov/Pages/Programs_Services/NutrientManagement.aspx.*

[293] *Wisconsin Natural Resources Conservation Service,* Conservation Practice Standard: Nutrient Management Code 590, *CPS 590-1, 2015. datcp.wi.gov/Documents/NM590Standard2015.pdf*

[294] *As an example of tool to help farmers apply at the "right time", DATCP produced the Runoff Risk Advisory Forecast which uses soil moisture, temperature, landscape characteristic, and precipitation data to determine the risk of runoff in the present and near future. This tool can prevent inadvertent nutrient loss by warning producers of unsuitable nutrient application conditions. For more information, see www.manureadvisorysystem.wi.gov/runoffrisk/index.*

[295] *Eric Cooley,* Nutrients Discharging from Drain Tiles in Eastern Wisconsin*, Presentation at the Eighth Annual Clean Rivers, Clean Lake Conference, Milwaukee, Wisconsin, April 30, 2012.*

[296] *For a thorough literature review on phosphorus dynamics with drain tiles, see J. Moore,* Literature Review: Tile Drainage and Phosphorus Losses from Agricultural Land, *Lake Champlain Basin Program*, 2016.

tile (i.e., tile blow outs), about 65 percent of the total phosphorus and most of the sediment leaving the fields traveled through drain tile. These results show that drain tiles can constitute a major pathway through which sediment and nutrients travel from agricultural fields to surface waters.

Within the Lake Comus watershed, the LCPRD, local volunteers, and Walworth County staff have noted locations where drain tiles discharge to Turtle Creek and its tributaries, particularly in the Turtle Valley Headwaters subbasin (Figure 3.3). As discussed in Section 2.3, "Water Quality and Pollutant Loading", some drain tiles in the watershed are contributing waters with high concentrations of total phosphorus to surface waters although the total phosphorus loading by these drain tiles could not be calculated due to lack of simultaneous flow measurements. Consequently, action should be taken to reduce phosphorus export from these drain tiles to help protect surface water quality. The following recommendations are intended to mitigate the impacts of drain tile on the surface water hydrology and quality:

➤ Recommendation 3.5: Repair, reduce, or retrofit drain tile systems

At a very minimum, damaged drain tile systems should be repaired to eliminate unintentional connections with surface water (e.g., blow outs, suck holes). As stated previously, these features dramatically increase the amount of soil and nutrients carried by drain tile networks to surface water. Natural surface hydrology should be restored by reducing, to the extent feasible, ineffective or unnecessary drain tile systems and/or retrofitting systems when needed. This recommendation should be considered a high priority. Specific measures that can be taken to accomplish this recommendation include:

- Encourage producers to identify and expeditiously repair drain tile network breaches. The most obvious locations are where water carried by drain tiles erupts to the surface or where surface runoff disappears into the Earth at unplanned locations.

- Discourage the use of surface inlets. Consider the profitability of closed depression areas drained by surface inlets and evaluate alternative water management or land use options.

- Investigate drainage patterns and available drain tile system maps to determine whether certain operational systems are no longer necessary. Remove or disconnect unneeded tile systems. If drain tile network maps are not available, drain tiles may often be identified using aerial imagery or unmanned aerial vehicles looking for lines of frost heave or reduced soil moisture in spring. Additionally, visual inspection along streams and ditches, especially in early spring when vegetation is low and runoff is generally greater, can reveal the drain tile outlets.

- Measure drain tile effluent total phosphorus concentrations and flow using a regular monitoring schedule (e.g., monthly or biweekly) to determine average total phosphorus loading and estimate proportion of total field phosphorus export. Whenever possible, measure tile discharge rates.

- Integrate in-line water level control devices into drain tile systems. Lower water levels would be used to encourage drainage during spring and other stretches of excessively wet weather. Conversely, higher water levels can benefit crop yields during dry weather through subirrigation. These control structures can reduce phosphorus and nitrogen loads by reducing tile flow volume as well as by promoting denitrification.[297] An example of an inline water level control device installed in a field tile network is illustrated in Figure 3.4.

➤ Recommendation 3.6: Implement saturated buffers and/or bioreactors to treat tile drainage

Saturated buffers, unlike ordinary riparian buffers, capture and treat water from tile drainage. A saturated buffer has a control structure that redirects flow from a main tile line through a lateral distribution line into the buffer. Once within the buffer soils, the water redirected from the tile percolates deeper into the soil or gets taken up by vegetation. In its study at Bear Creek in Iowa, the Leopold Center for Sustainable Agriculture at Iowa State University found that the use of a saturated buffer reduced annual nitrate loads by about 55 percent. However, the evidence for phosphorus removal through saturated buffers is not well established.[298]

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[297] Ibid.

[298] Ibid.

Bioreactors are another method for capturing and treating tile drainage water. Unlike saturated buffers, which redirect nutrients deeper into soil or into vegetation, bioreactors remove nitrates by promoting a process called denitrification, by which nitrate is predominantly converted to inert nitrogen gas. Bioreactors provide a carbon source, such as wood chips, for the bacteria to fuel this conversion. As with saturated buffers, there is less consensus that bioreactors are effective for reducing phosphorus loads.[299] Implementing saturated buffers and bioreactors to reduce nitrogen from tile drainage water should be considered a medium priority.

Figure 3.3
Drain Tiles in the Lake Comus Watershed

Source: Larry Meyer, LCPRD, and SEWRPC

➤ **Recommendation 3.7: Manage fertilizer application to minimize losses via drain tile**

Applying fertilizer and manure at the appropriate rates and timing has been shown to minimize phosphorus export from farm fields to drain tiles.[300] Over-application of fertilizer and manure results in excess nitrogen and phosphorus quantities in the soil that are not utilized by crops and subsequently can be exported via drain tiles. UW-Extension fertilizer application guidance suggests appropriate phosphorus and nitrogen application rates for crops and conducting soil tests for nitrogen and phosphorus to avoid over-application.[301] Avoiding application when soils are saturated can help to reduce transport of fertilizer and manure through the soil profile into the drain tile. Furthermore, since the excess nutrients are not needed by crops, excessive application diminishes producer profitability. The LCPRD, Walworth County, DATCP, and NRCS should continue to work with agricultural producers in the watershed to manage fertilizer applications and reduce nutrient loading into waterways. This recommendation should be considered a high priority.

Animal Operations

In Wisconsin, an animal feeding operation with 1,000 or more animal units is defined as a Concentrated Animal Feeding Operation (CAFO).[302] Under state and federal law, CAFOs must have a WDNR-issued Wisconsin Pollutant Discharge Elimination System (WPDES) permit to protect surface and ground waters from excessive runoff and animal waste. Consequently, CAFOs are more stringently monitored and regulated than smaller animal feeding operations. Among the requirements are that CAFOs have a nutrient management plan developed as part of the permit process; that response plans are developed for manure and non-manure spills; that manure spreading limits and setbacks are specified; and that additional inspection, monitoring,

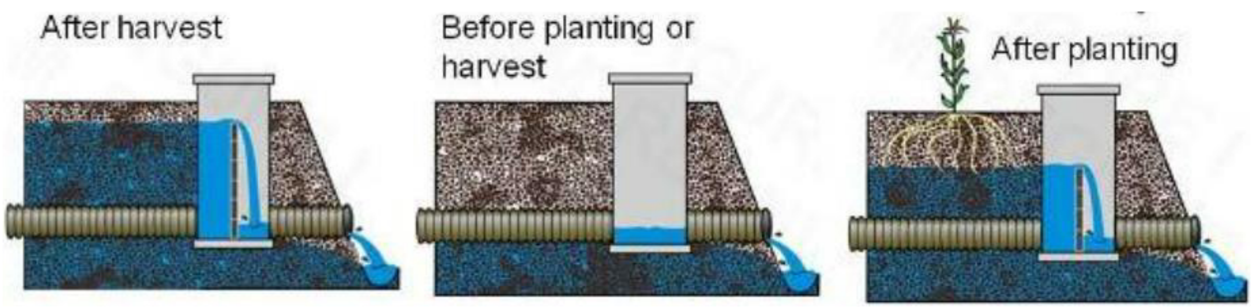
[299] Ibid.

[300] Ibid.

[301] *C.A.M. Laboski and J.B. Peters,* Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin*, University of Wisconsin Cooperative Extension A2809, 2018. walworth.extension.wisc.edu/files/2018/11/Nutrient-Application-Guidelines-for-Field-Vegetable-Fruit-Crops-in-WI-A2809.pdf*

[302] Wisconsin Administrative Code *NR 243* Animal Feeding Operations *relates an animal unit to the impact of one beef steer or cow. Therefore, 1000 beef cattle are equivalent to 1000 animal units. Other animals have differing ratios. For example, the following numbers of animals are equivalent to 1000 animal units: 500 horses, 715 dairy cattle, 5,000 calves, 5,500 turkeys, 10,000 sheep.*

Figure 3.4
Inline Water Control Diagram



Source: Purdue University

and reporting requirements are adhered to[303] No CAFOs are located within the Lake Comus watershed at the time of this writing; however, at least one dairy operation within the watershed has submitted a preliminary application to expand their operation into a CAFO.[304] Walworth County staff are working with local volunteers to conduct water quality monitoring near this operation and are aware of the requirements that would go into effect if the operation becomes a CAFO.[305] In addition to this operation, there are multiple other animal operations within the watershed that do not meet the number of animal units to be defined as a CAFO (Map 3.6). The LCPRD, Walworth County staff, and local residents should continue to work with the WDNR to address any concerns about water quality impacts from animal operations in the watershed.

➤ **Recommendation 3.8: Ensure that animal operation performance standards are met**
The provision for barnyard runoff control systems and six months of manure storage are recommended for all livestock operations in the watershed as well as maintaining exclusion of livestock from waterbodies and adjacent riparian areas. Animal waste storage, management, and utilization must comply with Walworth County ordinances.[306] To assist with enforcement, citizens and volunteers can report suspected violations to County or State authorities. Furthermore, it is recommended that WDNR and DATCP consider increasing levels of cost-share funding to enable a higher level of BMP implementation needed to meet the NR 151 performance standards. This recommendation should be considered a high priority.

Ditching and Channelizing

Ditching or channelizing streams can have important implications for acute and chronic sediment source and transport within a watershed. For example, ditching reaches through wetland organic soils and/or converting highly meandering stream channels into straight line ditches can create an almost limitless source of highly erodible sediments and associated nutrient loads with a great capacity to convey sediment and nutrient loads downstream. Most notably, ditching increases channel slope and confines floodwater to small channel areas. These factors work together to increase the ability of a stream to transport sediment. However, ditches are usually dug too deep and/or wide to provide reasonable flow velocities during fair and dry weather. Therefore, sediment accumulates along the ditch during lower flows and fill with soft sediment. These accumulated sediments are readily transported downstream during the next high flow event. Ditching usually disconnects the stream from its floodplain. This results in increased downstream flooding and bank erosion because high flows are not allowed to spill out over the floodplain. Lastly, ditching also causes significant damage to instream habitats and has many negative consequences on both water quality and associated fish and wildlife communities.

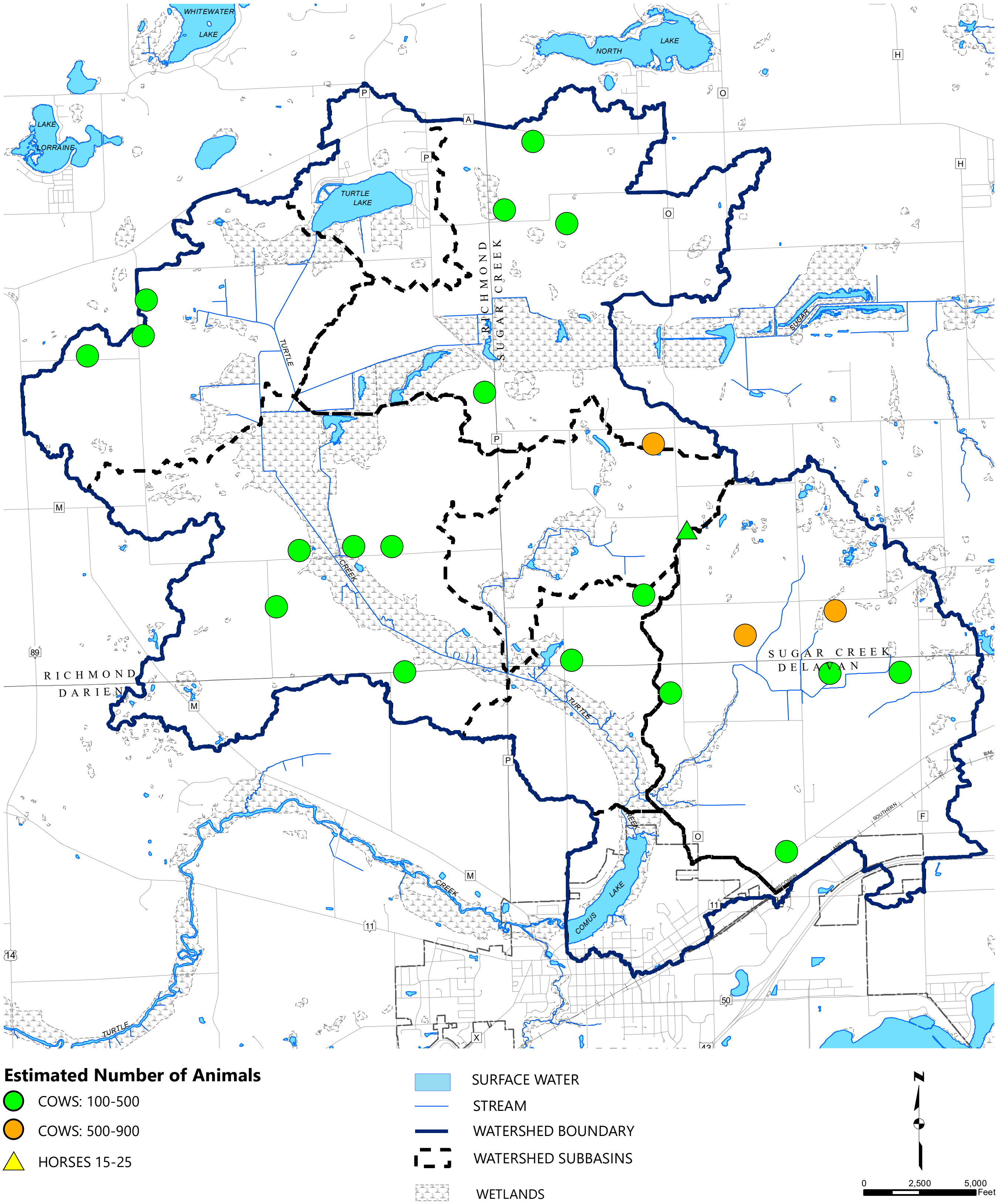
[303] *For more information, see dnr.wisconsin.gov/topic/CAFO/WPDESNR243.html.*

[304] *Letter to Marc Nelson from Anthony Salituro, WDNR,* CAFO WPDES Preliminary Permit Application- Acknowledgement of Receipt*, May 5th, 2021.*

[305] *Personal communication between Kevin Armstrong, LCPRD Chairman, and Commission staff, April 20th, 2021.*

[306] *Walworth County Code of Ordinances Chapter 6 Article IV, "Animal Waste Storage". library.municode.com/wi/walworth_county/codes/code_of_ordinances?nodeId=WACOCOOR_CH6AN_ARTIVANWAST*

Map 3.6
Animal Operations Within the Lake Comus Watershed



Source: SEWRPC

The extensive ditching and channelization of Turtle Creek and its tributaries upstream of the Lake has likely impaired desirable hydrologic and ecologic functions of Turtle Creek. A potential solution is to restore the Creek's mainstem back to its original path and profile to the extent practicable as shown in Figure 3.5, to decrease slope by remeandering, improving floodplain function, and mitigating streambank erosion. Figure 3.6 indicates areas for potential projects to restore hydrologic function in the Lake Comus watershed through the recommendations below. Further study beyond the scope of this plan would be required to determine appropriate exact reaches for installation of such features.[307]

➤ **Recommendation 3.9: Protect, enhance, or restore natural landscape elements to detain runoff**
Natural landscape elements should be restored to detain stormwater and reduce the speed that runoff leaves the landscape, contributes to stream flashiness, and its negative effects on aquatic habitat quality. This recommendation should be considered a high priority. Specific measures that can be taken to accomplish this recommendation include the following examples.

- Improve Turtle Creek's floodplain connectivity by adjusting stream morphology and channel profiles. This goal is integral with all stream realignment, remeandering, or restoration projects undertaken within the watershed. Stream morphology and profile can be adjusted to better resemble natural systems in many ways, including the following examples:
    - Relocate spoil piles that were deposited adjacent to ditched stream sections
    - Lessen stream slope by lengthening channel length as part of stream remeandering
    - Modify the stream bed or bed material to increase flood elevations (e.g., install riffles, ditch plugs, stream roughness enhancing features and/or vegetation)[308]
    - Less desirably, lower floodplain elevations in areas parallel to the creek
    - Implement sod toe restoration in straightened reaches of Turtle Creek to facilitate stream remeandering (also see Section 3.6, "Fish and Wildlife")[309]
- Divert intense runoff from impermeable surfaces away from direct discharge to surface water. Install check dams and ditch turnouts along roadside ditches to detain stormwater, encourage diffuse overland flow, encourage infiltration, and capture sediment and nutrients.
- When drained land no longer produces commodities at a profit, or when drained land is abandoned and left fallow, or when the landowner simply desires to introduce restoration practices, restore wetland hydrology and naturalize vegetation. These types of projects are particularly important in riparian areas. Implementing such projects commonly involves employing drain tile removal, ditch plugs, and ditch fills.[310]
- Consider installing saturated buffers and/or utilizing water control structures in tile-drained agricultural areas of the watershed. Alternatively, drain tiles outlets could be modified to discharge water into constructed wetlands rather than directly into surface waters.

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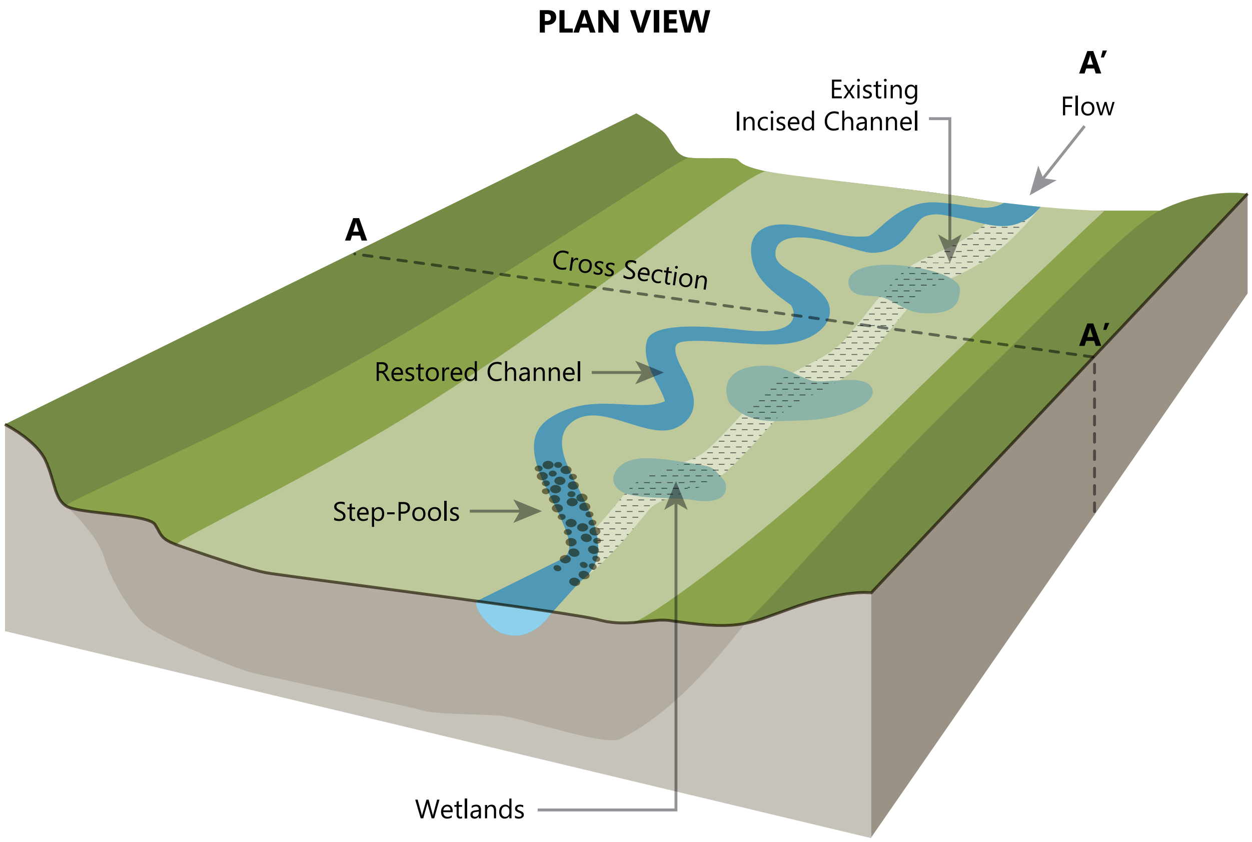
[307] *The Commission has completed plans focusing upon watershed protection. An example is Mason Creek, a tributary of North Lake in Waukesha County. This plan, entitled* Mason Creek Watershed Protection Plan*, is SEWRPC's Community Assistance Planning Report Number 321 and was published in 2018. A link to this report follows: www.sewrpc.org/SEWRPCFiles/Publications/CAPR/capr-321-mason-creek-protection-plan.pdf. The reader may find this report useful to envision future work benefiting the project.*

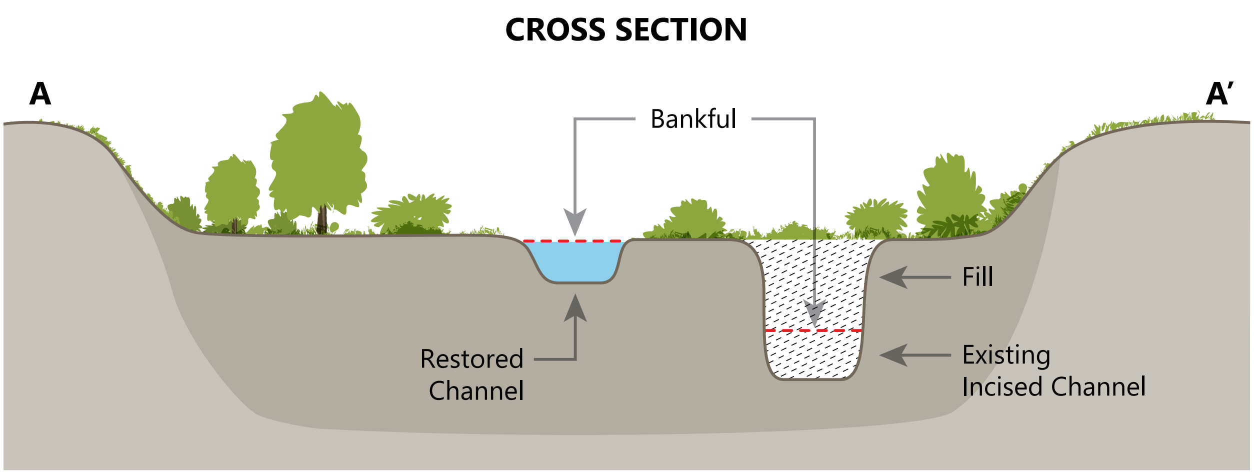
[308] *With careful planning, opportunities commonly exist to increase floodplain connectivity without expanding the extent of the modelled 100-year flood elevation.*

[309] *For more information on sod toe restoration, see Minnesota Department of Natural Resources,* Toe Wood-Sod Mat Factsheet*, 2010: www.files.dnr.state.mn.us/publications/waters/toe_woodsod_mat_dec2010.pdf.*

[310] *For more information on installing ditch plugs and ditch fills, see Chapter 4 of A.L. Thompson and C.S. Luthin,* Wetland Restoration Handbook for Wisconsin Landowners*, Wisconsin Department of Natural Resources Bureau of Science Services SS-989, 2004: www.dnr.wisconsin.gov/topic/Wetlands/handbook.html.*

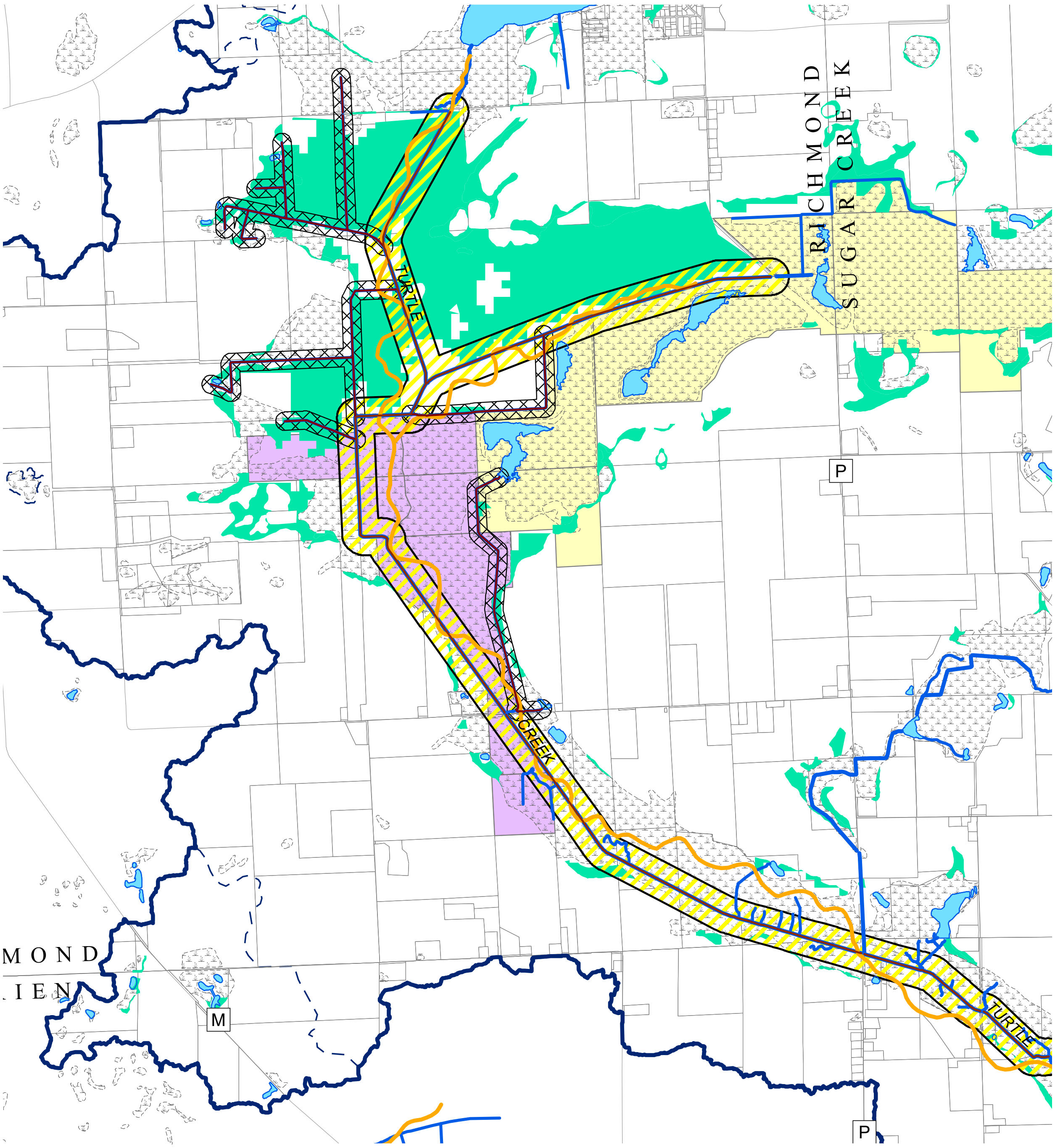
Figure 3.5
Potential Stream Restoration Design Example to Improve Stream Function





Source: Modified from W. Harman, R. Starr, M. Carter, et al., A Function-Based Framework for Stream Assessments and Restoration Projects, *US Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC, EPA 843-K-12-006, p. 36, 2012 and SEWRPC*

Figure 3.6
Potential Areas for Hydrologic Restoration Projects in the Lake Comus Watershed



AREAS TO CONSIDER PROJECTS THAT RE-ESTABLISH FLOODPLAIN CONNECTION, IMPLEMENT SATURATED BUFFERS, AND REALIGN STREAM TO HISTORIC CHANNEL

AREAS TO CONSIDER PROJECTS THAT RESTORE HYDROLOGIC FUNCTION SUCH AS DITCH PLUGS AND FILLS

POTENTIALLY RESTORABLE WETLANDS

WDOT-OWNED PARCELS

WDNR-OWNED PARCELS

2020 STREAMLINES

1837 STREAMLINES

SURFACE WATER

WATERSHED BOUNDARY

INTERNALLY DRAINED AREAS

Note: This figure indicates potential areas for hydrologic restoration. Further study would be required before designing and implementing any specific practice.

Source: SEWRPC

- Convert some of the watershed's potentially restorable wetlands (PRW) into wetlands (Map 2.17). The large PRW areas located south of Turtle Lake and near the intersection of Cobblestone Road and Goose Pond Road have been identified using the Wetlands by Design approach as particularly suitable for flood abatement.[311]

As many of these specific recommendations are intended to affect the Creek's hydrology, care should be taken to site these projects appropriately to avoid undesired effects on neighboring properties. The least controversial projects are likely to occur on publicly owned lands, such as the parcels owned by the Wisconsin Department of Transportation and WDNR in the Turtle Valley Wildlife Area (Figure 3.6). Owners of neighboring parcels should be informed of any potential restoration work and should ideally asked to collaborate on any proposed projects to expand the scope of restoration. Any wetland conservation or stream realignment work will likely require a permit from the WDNR and floodplain modeling.[312] Project that raise 100-year flood elevations require additional steps to execute. However, hydrologic restoration opportunities typically exist that do not raise 100-year flood elevations. For example, ditch-fill projects that fill a ditch crossing a broad floodplain oftentimes have negligible affect on 100-year flood elevations.

Urban BMPs

Historically, the approach to manage increases in rates and volumes of runoff within urbanized areas often involved constructing storm sewer and/or open channel systems to quickly convey stormwater to streams or lakes. In recent years, flooding, water quality impairment, and environmental degradation demonstrate the need for an alternative approach to urban stormwater management. Consequently, present-day stormwater management approaches seek to manage runoff using a variety of measures, including detention, retention, infiltration, and filtration, better mimicking the behavior and disposition of precipitation on a more natural landscape.

While urban nonpoint sources are not known to be and are not anticipated to be a major contributors of pollutants to the Lake, the proximity of urban development to the Lake may enable urban sources to have an outsized effect considering the low acreage of these sources within the watershed. The following recommendation address reducing urban nonpoint pollutant loads in the watershed:

➤ **Recommendation 3.10: Encourage urban pollution source reduction efforts through BMPs**
Reduce lawn fertilizer use, create rain gardens, and properly store and judiciously apply deicers and other chemicals to prevent them from washing into the Lake. Additional BMP examples are provided in the recommendations below. This recommendation should be considered a medium priority.

➤ **Recommendation 3.11: Promote native plantings in and around existing and new stormwater detention basins**
Planting native plants in these situations improves detention water filtration, reduces pollutant loading, and provides wildlife habitat. In addition, detention basin management practices should aim to reduce or eliminate fertilizing basin slopes and limit herbicide application and cutting to invasive species only. This should be considered a medium priority.

➤ **Recommendation 3.12: Retrofit existing and enhance planned stormwater management infrastructure to benefit water quality**
Water quality can benefit by extending detention times, spreading floodwater, and using features such as grassed swales to convey stormwater. Implementing such works requires close coordination with the municipalities within the Lake Comus watershed. This recommendation should be considered a medium priority.

[311] *Miller, N., J. Kline, T. Bernthal, J. Wagner, C. Smith, M. Axler, M. Matrise, M. Kille, M. Silveira, P. Moran, S. Gallagher Jarosz, and J. Brown,* Wetlands by Design: A Watershed Approach for Wisconsin*, Wisconsin Department of Natural Resources and The Nature Conservancy, 2017.*

[312] *More information on general and individual permits and required documents can be found at the following location: dnr.wisconsin.gov/permits/water.*

- **Recommendation 3.13: Combine riparian buffers with other structures and practices**
A much higher level of pollution removal can be achieved with "treatment trains" combining riparian buffers with better-managed detention basins or new practices such as floating island treatments (Figure 3.7), grassed swales, and infiltration facilities. This layering of overlapping practices and structures is a more effective way to mitigate the effects of urban stormwater runoff than such practices being used in isolation. This action should be assigned a low priority.

- **Recommendation 3.14: Stringently enforce construction site erosion control and stormwater management ordinances and creatively employ these practices**
Ordinances must be enforced by responsible regulatory entities in a manner consistent with current practices; however, local citizens can help by reporting potential violations to the appropriate authorities. This recommendation should be considered a low priority.

- **Recommendation 3.15: Maintain stormwater detention basins**
This should be considered a low priority due to the few basins located in the watershed. Maintaining stormwater basins includes managing aquatic plants, removing and disposing of flotsam or jetsam, ensuring adequate water depth to settle and store pollutants, inspecting and repairing outlet structures, and actively and aggressively managing excess sediment. Specifications associated with the design of stormwater detention basins and maintenance requirements ensure that basins are functioning properly.[313] It is important to remember that stormwater detention basins occasionally require dredging to maintain characteristics that protect the Lake. The frequency of dredging is highly variable and depends upon the design of the basin and the characteristics of the contributing watershed. Regulatory entities should complete basin inspection in a manner consistent with current practices; however, ensuring that the owners of these basins know the importance of meeting these requirements through educational outreach can help ensure continued proper functioning of the ponds. Coordinating with municipalities and neighborhood associations can play an important role.

- **Recommendation 3.16: Promote urban nonpoint source abatement**
In addition to local stormwater ordinances and stormwater management planning, another way to promote cost-effective nonpoint source pollution abatement is for Walworth County to work toward satisfying all conditions required by the Wisconsin Pollutant Discharge Elimination System municipal separate storm sewer system (MS4) discharge permitting process. This should be considered a low priority issue.

- **Recommendation 3.17: Collect leaves in urbanized areas**
Because of the modest amount of the Lake's watershed found in urban areas, this recommendation should be assigned a low priority. Leaves have been shown to be a very large contributor to total external phosphorus loading to lakes in urban settings. Stockpiling leaves in the street where they may be crushed and washed into the Lake or burning leaves in shoreline and ditch areas can create situations where a strong pulse of phosphorus is delivered to the Lake by late autumn rains. Residents should be encouraged to use leaf litter within their own yards as a nutrient source or much or should take advantage of the yard waste collection and leaf disposal programs in existence in those municipalities in the watershed that conduct such programs, such as the City of Delavan.

Communication, Education, and Outreach

Identifying, communicating with, and supporting willing partners in the watershed is necessary to implement the BMPs listed above. The following suggestions are provided to enhance communication, education, and outreach regarding nonpoint source BMPs. All are assigned a high priority.

- Host or sponsor educational workshops and tours, demonstration projects, and information exchange forums focusing on emerging BMPs. The LCPRD could potentially host such events on its parcels on Dam Road leased for farming.

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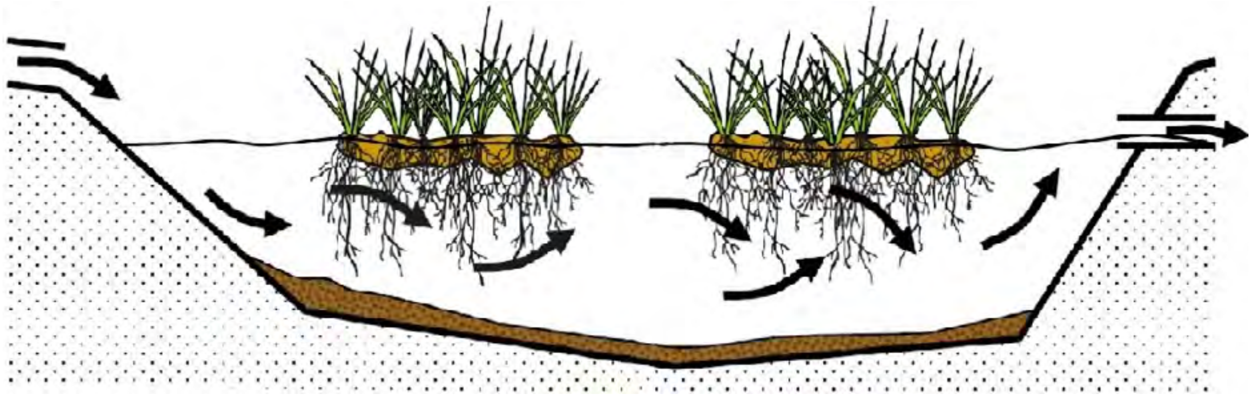
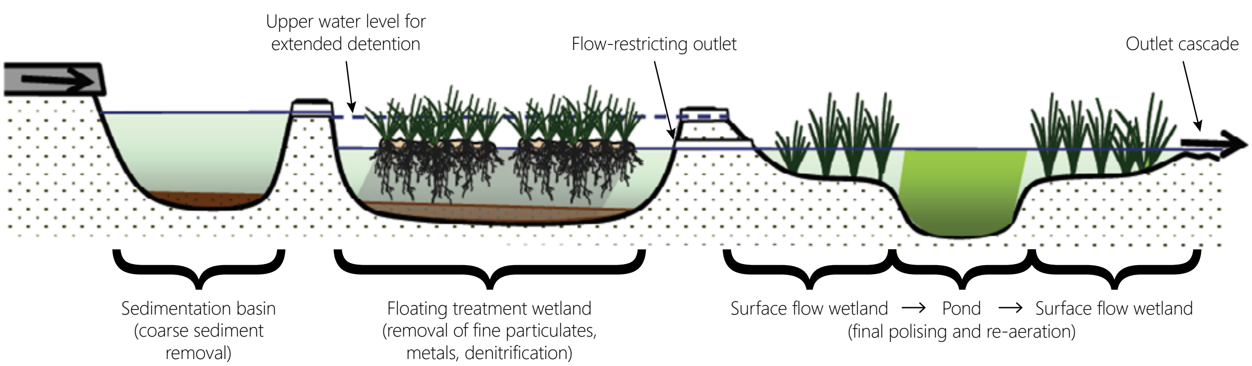
[313] *Technical standards for design and maintenance of wet detention basins and other stormwater management practices can be found at dnr.wi.gov/topic/stormwater/standards/postconst_standards.html.*

Figure 3.7
Schematic of Floating Treatment Wetland Design Applications

Emergent plants are grown within a floating artificially constructed material within a wet detention stormwater basin. The roots are directly in contact with the water column and can intercept suspended particles. The roots also provide a high surface area for microbiological activity that aid in adsorbing pollutants.



Conceptual longitudinal cross-section through a "newly designed" stormwater treatment system incorporating floating wetlands, ponds, and surface flow wetlands (not to scale).



Source: I. Dodkins, A. Mendzil, and L. O'Dea, Floating Treatment Wetlands (FTWs) in Water Treatment: Treatment Efficiency and Potential Benefits of Activated Carbon, *FROG Environmental LTD., March 2014; T.R. Headley and C.C. Tanner, "Constructed Wetlands With Floating Emergent Macrophytes: An Innovative Stormwater Treatment Technology,"* Critical Reviews in Environmental Science and Technology, *42: 2261-2310, 2012 and SEWRPC*

- Engage, and possibly subsidize, agricultural producers to implement practices that improve water quality. Provide information, technical support, tools and equipment, and financial support.
- Promote engagement by the farming community in decision-making and equip farmers with monitoring tools and methods.
- Target action-oriented messages about water quality and conservation practices to key groups.
- Produce and distribute newsletters, exhibits, fact sheets, and/or web content to improve communication around these issues.

Riparian Buffer Protection and Prioritization Strategies

Riparian buffers provide multiple benefits including mitigating pollutant runoff into surface waters, improving streambank stability, and providing habitat for wildlife and aquatic organisms (Figure 2.27). All riparian buffers provide some level of protection; however, wider buffers provide more benefits (infiltration, temperature moderation, and species diversity) than narrower buffers. Therefore, it is important that existing buffers be protected and expanded where possible. The riparian buffer network to the 75-foot, 400-foot, and 1,000-foot widths as summarized in Section 2.3, "Water Quality and Pollutant Loading" provides the framework upon which to protect and improve water quality and wildlife within the Lake Comus watershed. This framework can be achieved by combining strategies such as land acquisition, conservation easement acquisition, regulation, and best management practices, as discussed in the following subsection.

Regulatory and Other Opportunities

Chapter NR 115, "Wisconsin's Shoreland Protection Program," of the *Wisconsin Administrative Code* establishes a minimum 75-foot development setback from the ordinary high-water mark of navigable lakes, streams, and rivers. A minimum tillage setback standard of five feet from surface water channels is also called for under Section NR 151.03 of the *Wisconsin Administrative Code*. Insufficient buffer between a field and a waterway can contribute to significant sediment and phosphorus loading to the waterway and can significantly limit wildlife habitat. In addition, based upon the water quality and wildlife goals for this watershed, neither the 5-foot tillage setback nor the 75-foot buffer requirement are adequate to achieve pollutant load reduction goals and resource protection concerns.

Crop yield losses have been found to be greatest near drainage ditches that flood. Therefore, adding buffer to areas prone to flooding would not displace agriculture from prime production areas. Fields with high slopes (Map 2.2) and high soil erodibility, fields where the minimum riparian buffer width of 75 feet is not being met (Map 2.23) and/or crop land is located within the 1-percent-annual-probability floodplain, and fields containing potentially restorable wetlands within 1,000 feet of a waterway could be considered priority fields for riparian buffer installation. In addition, the 75 foot wide buffers adjacent to waterways are envisioned to be harvestable buffers, enabling periodic livestock fodder harvest or pasturing. Expanding riparian buffers to the 400- and 1,000-foot widths, or greater to the extent practicable, are not likely to be achievable until such time that the agricultural land is converted to urban uses. At that time, it may be possible to design portions of the development to accommodate such buffer widths. From a practicality standpoint, this may be the last chance to establish critical protective boundaries and/or open space and habitat connections around waterways.

Primary environmental corridors have a greater level of land use protections compared to secondary corridors, isolated natural resource areas, or designated natural areas outside of PEC. Therefore, the regulatory strategy to expand protection for vulnerable existing and potential riparian buffers would be to increase the extent of designated primary environmental corridor lands within the Lake Comus watershed. Expanding the narrow SEC connection between the PEC areas along Turtle Lake and the extensive PEC along Turtle Creek south to the Lake presents the greatest opportunity to expand primary environmental corridors in this watershed. Since these two areas already meet the minimum size requirements for designation as a PEC, any lands with sufficient natural resource features adjacent or connecting to this existing PEC could potentially be incorporated into this designation.

Wetlands located within PEC lands have been designated as Advanced Delineation and Identification wetlands under Section 404(b)(1) of the Federal Clean Water Act and are deemed generally unsuitable for the discharge of dredge and fill material. In addition, the nonagricultural performance standards specified in Section NR 151.125 of the *Wisconsin Statutes*, require a 75-foot impervious surface protective area adjacent to these higher-quality wetlands. This designated protective area boundary is measured horizontally from the delineated wetland boundary to the closest impervious surface.[314] Hence, these wetlands would have additional protections from filling and from being encroached upon by future development, enabling their riparian buffer functions to be retained.

Best Management Practices and Programs for Riparian Buffers

Most existing and potential future riparian buffers in the watershed are privately owned and are situated within wetland and agricultural areas. It is the private landowner's choice to maintain or establish buffers. In addition, although riparian buffers can effectively mitigate negative water quality effects attributed to urbanization and certain agricultural management practices, they cannot on their own address all the pollution problems associated with these land uses. Therefore, riparian buffers need to be combined with other management practices, such as infiltration facilities, wet detention basins, porous pavements,

[314] *Runoff from impervious surfaces located within the protective area must be adequately treated with stormwater BMPs.*

green roofs, and rain gardens to mitigate the effects of urban stormwater runoff. To mitigate the effects of agricultural runoff, riparian buffers need to be combined with other management practices, such as barnyard runoff controls, manure storage, filter strips, nutrient management planning, grassed waterways, cover crops, and reduced tillage. Therefore, BMPs to improve and protect water quality in both agricultural and urban areas are essential elements for protecting water quality, water quantity, and wildlife within the Lake Comus watershed.

Recent research has indicated that converting up to eight percent of cropland at the field edge from production to wildlife buffer habitat leads to increased yields in the remaining cropped areas of the fields, and that this positive effect becomes more pronounced with time.[315] As a consequence, despite the initial loss of cropland for habitat creation, overall yields for an entire field can be maintained, and even increased, for some crops compared to control areas. Although it took about four years for the beneficial effects on crop yield to manifest themselves in this research project, this yield increase was largely attributed to increased abundance and diversity of crop pollinators within the wildlife habitat areas. Such results suggest that at the end of a five-year crop rotation, there would be no adverse impact on overall yield in terms of monetary value or nutritional energy, and that in subsequent years, pre-buffer yields would be maintained or increased. Hence, establishing buffers or sacrificing marginal cropland edges to create wildlife buffer habitat or potential restorable wetland within the Lake Comus watershed may lead to increased crop yields, so this practice may be economically viable over the longer term. More importantly, these results also demonstrate that lower yielding field edges can be better used as non-crop habitats to provide services supporting enhanced crop production, benefits for farmland biodiversity, and protecting water and soil health.[316]

➤ **Recommendation 3.18: Increase extent of riparian buffers**

This recommendation should be considered a high priority, particularly for the 179 acres of unbuffered lands within 75 feet of a Lake tributary. Increasing the amount of riparian buffers coverage in the watershed helps enhance the water quality of Turtle Creek and Lake Comus as well as provide greater ecological connectivity between upland areas and the lowland wetland complex flanking Turtle Creek. Riparian buffer expansion priority (including primary and secondary environment corridors (PECs and SECs), isolated natural resource areas (INRAs), and natural areas (NAs)) should be based upon the following order of importance (from highest to lowest priority):

1. Existing riparian buffer (protect what already exists on the landscape)

2. Potential riparian buffer lands up to 75 feet wide (minimum level of protection for reducing pollutant loads reaching waterbodies)

3. Potentially restorable wetlands within 1,000 feet of Lake Comus or its tributaries (see Map 2.17) or the one-percent-annual-probability-floodplain (see Map 2.8), whichever provides greater coverage (priority for pollutant removal and wildlife habitat protection)

4. Potential riparian buffer lands up to 400 feet wide (minimum for wildlife protection)

5. Potential riparian buffer lands up to 1,000 feet wide (optimal for wildlife protection)

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[315] *R. Pywell, M.S. Heard, B.A. Woodcock, et al., "Wildlife-Friendly Farming Increases Crop Yield: Evidence for Ecological Intensification,"* Proceedings of the Royal Society B: Biological Sciences, *282(1816), 2015.*

[316] Ibid.

In addition, special consideration should be given to acquiring riparian buffers in locations designated as having high to very high groundwater recharge potential as shown on Map 2.9 and areas that help connect and expand critical linkages between habitat complexes to protect wildlife abundance and diversity. Furthermore, connecting SEC lands and multiple INRAs throughout the Lake Comus watershed to larger PEC areas, as well as building and expanding upon existing protected lands as shown in Map 2.15, represents a sound approach to enhance the corridor system and wildlife areas within the watershed. This approach mirrors the proposed open space preservation strategy outlined in the 2014 Walworth County Park and Open Space Plan.[317]

In Wisconsin, the USDA offers technical assistance and funding to support implementing riparian buffers and wetlands on agricultural lands. A 10- to 15-year contract must be entered into by the landowner or operator and the land is only eligible under certain conditions. Land enrolled in these programs normally must be currently or very recently used for agricultural production. Because the program requires a substantial commitment, it is often difficult to get farmers and/or landowners to commit to installing and maintaining riparian buffer strips. To overcome this, a custom program offering a shorter time commitment, potentially five years, with a yearly payment incentive greater than what the USDA program offers, has found favor in other counties in the State, and could potentially be developed for the Lake Comus watershed.

3.5 AQUATIC PLANTS

Lake Comus does not have populations of EWM and CLP dense enough to substantially interfere with recreation or navigation. Therefore, intensive aquatic plant management via chemical application, harvesting, and dredging is not recommended at this time. Instead, encouraging, enhancing, and maintaining a healthy aquatic plant community in the Lake will help achieve other desired water quality and fishery goals. A healthy aquatic plant community will help reach water quality and fishery goals by reducing Lake phosphorus concentrations during critical time periods, hindering sediment resuspension, enhancing water clarity, and providing food and habitat for aquatic organisms. As described in Section 2.4, "Aquatic Plants", the Lake currently exhibits characteristics of a algae-dominated state rather than a macrophyte-dominated state (Figure 2.37). Consequently, the following recommendations intend to promote healthy aquatic plant community establishment and growth within the Lake by encouraging a shift towards a macrophyte-dominated state.

➤ **Recommendation 4.1: Protect native aquatic plants to the highest degree feasible through careful implementation of aquatic plant management and water quality recommendations**
Lake Comus supports a limited number of aquatic plant species, and its community is dominated by invasive species. The few native species already present can provide food and habitat for wildlife and aquatic organisms. Seeding and/or planting fast-growing native species, such as bulrush (*Schoenoplectus* spp.), naiads (*Najas* spp.), and muskgrass (*Chara* spp.), may help to reduce sediment disturbance and provide better habitat for aquatic organisms, particularly following any large-scale actions like water level manipulations or dredging.[318] Protecting the Lake's native species and encouraging their growth should be a priority for fostering a healthier aquatic plant community. This recommendation should be considered a medium priority.

➤ **Recommendation 4.2: Avoid disrupting bottom sediment or leaving large areas of bottom sediment devoid of vegetation**
Disturbing the lake bottom can decrease water clarity and uproot submerged aquatic vegetation. Large areas of sediment devoid of vegetation are more prone to sediment resuspension into the water column and colonization by invasive species. Reducing sediment disturbance and enhancing lake-bottom coverage with aquatic plant species can improve water clarity. Rooted aquatic plants compete with algae for dissolved phosphorus, decreasing. More abundant rooted plants also reduce the propensity for lake-bottom agitation, lowering turbidity and phosphorus resuspension. This recommendation should be considered a low priority.

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[317] *SEWRPC Community Assistance Planning Report No. 135 (3rd Edition),* A Park and Open Space Plan for Walworth County, *March 2014.*

[318] *Introducing invasive and exotic species to the Lake and the Creek is strictly prohibited. Any plans to seed and/or plant native species will require a permit and should be thoroughly discussed with WDNR biologists.*

➤ Recommendation 4.3: Reduce the Lake's carp population

Common carp consume aquatic plants and agitate bottom sediment, reducing water clarity and making difficult for native plant species to establish and thrive in the Lake. Reducing the Lake's common carp population can reduce disturbance to native plant populations as well as increase water clarity, allowing greater and deeper vegetation coverage of the Lake. Refer to Sections 2.6, "Fisheries" and 3.6, "Fish and Wildlife" for guidance on reducing and controlling the carp population. This recommendation should be considered a high priority.

➤ Recommendation 4.4: Prevent the introduction of new invasive species

Introduction of new invasive species is a constant threat. Preventing introduction is crucial to maintaining healthy lakes. This is particularly true for Lake Comus with its large expanses of vegetation-devoid sediment that are susceptible to colonization by invasive species. To help decrease the chance of introducing new invasives the following recommendations are given a low priority:

- **Educate residents** as to how they can help prevent invasive species from entering the Lake.
- **Participate in the Clean Boats Clean Waters program** (a State program targeting invasive species prevention) to proactively encourage Lake users to clean boats and equipment before launching and using them in Lake Comus.[319]
- **Target the boat launch**. Since boat launches are likely entry points for alien species, the boat launch should be targeted for focused aquatic plant control.
- **Take immediate action to evaluate and eradicate newly identified invasive species.** If a new alien species infestation is found in the Lake, efforts to eradicate the new species should immediately be evaluated and, if possible, be employed to help prevent establishment. The WDNR has funding that can aid early eradication efforts, particularly as it pertains to aquatic plants (Table 3.4). Therefore, citizen monitoring for new invasive species is recommended. The Wisconsin Citizen Lake Monitoring Network provides training to help citizens participate in these efforts.

➤ Recommendation 4.5: Consider manipulating water levels to encourage native plant growth

As discussed in Section 2.4, "Aquatic Plants", water level manipulation can be an effective management tool for reducing populations of invasive aquatic plant species, particularly EWM and CLP, while encouraging the growth of certain desirable native species, such as naiads, muskgrass, and bulrush. While native species were not observed in Lake Comus as part of the Commission's aquatic plant study, there may be a seedbank present in the lake sediment that could be stimulated through a winter drawdown.[320] Additionally, the LCPRD can embark on a study to determine if transplanting native species in the Lake following a drawdown is feasible if no native species emerge once the Lake is refilled.

Water level manipulation can also be a useful tool for helping drive the shift from an algae-dominated state to a macrophyte-dominated state, resulting in improved water quality and clarity, greater aquatic plant growth, fewer carp, and a larger population of predatory sport fish. However, water level manipulation, particularly summer and early fall drawdowns, may facilitate expansion of the cattail marsh further into the Lake and can also reduce the population of water lilies, one of the native species observed in the Lake. Lake managers should carefully consider the goals of a lake drawdown to help ensure that the timing, frequency, and intensity of the water level manipulation will contribute to goals. This recommendation is a medium priority, however, as mentioned in Recommendation 1.7, high priority should be given to any retrofit of the outlet dam that helps reliably lower reservoir water levels over an extended period.

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[319] *More information about Clean Boats, Clean Waters can be found on the WDNR website at dnr.wi.gov/lakes/cbcw.*

[320] *Drawdowns on Tripp and Cravath lakes, two impounded lakes in northwestern Walworth County, from 2019 to 2021 stimulated the growth of several native aquatic plant species, including long-leaf pondweed* (Potamogeton nodosus)*, wild rice* (Zizania *spp.*)*, softstem bulrush* (Schoenoplectus tabernaemontani)*, water smartweed* (Persicaria amphibia)*, bullhead lilies* (Nuphar *spp.*)*, and cattails* (Typha *spp.*).

Table 3.4
Example WDNR Grant Programs Supporting Lake and River Management Activities

Program	Grant Program	Maximum Grant Award	Minimum Grantee Match (percent)	Application Due Date
Water				
Surface Water Grants	Aquatic Invasive Species (AIS) Prevention and Control	Clean Boats, Clean Waters: $24,000	25	November 1
		Established Population Control: $150,000	25	November 1
		Early Detection and Response: $25,000	25	Year-Round
		Research and Development annual funding limit: $500,000	25	November 1
	Surface Water Education	$5,000 per project $50,000 per waterbody	33	November 1
	Surface Water Plan	$10,000	33	November 1
	Comprehensive Management Plan	$25,000	33	November 1
	County Lake Grant	$50,000	33	November 1
	Ordinance Development	$50,000	25	November 1
	Management Plan Implementation	Lakes: $200,000 Rivers: $50,000	25	November 1
	Healthy Lakes & Rivers	$1,000 per practice $25,000 per waterbody	25	November 1
	Surface Water Restoration	Lakes: $50,000 Rivers: $25,000	25	November 1
	Land Acquisition and Easement	Lakes: $200,000 Rivers: $50,000	25	November 1
Citizen-Based Monitoring Partnership Program	--	$5,000	None	Spring
Targeted Runoff Management	--	Small-Scale: $225,000	30	May 15
		Large-Scale: $600,000	30	May 15
Urban Nonpoint Source and Stormwater Management	--	Planning: $85,000 Property Acquisition: $50,000 Construction: $150,000	50	May 15
Conservation and Wildlife				
Knowles-Nelson Stewardship Program	Habitat Areas	--	50	March 1
	Natural Areas	--	50	March 1
	Streambank Protection	--	50	March 1
	State Trails	--	50	March 1

Table continued on next page.

Table 3.4 (Continued)

Program	Grant Program	Maximum Grant Award	Minimum Grantee Match (percent)	Application Due Date
Boating				
Boat Enforcement Patrol	--	Up to 75% reimbursement	None	Various
Boating Infrastructure Grant	--	Up to $200,000 per state	50	June 1
Recreation				
Knowles-Nelson Stewardship Program	Acquisition and Development of Local Parks	--	50	May 1
	Acquisition of Development Rights	--	50	May 1
	Urban Green Space	--	50	May 1
	Urban Rivers	--	50	May 1
Sport Fish Restoration	Boat Access	Varies annually	25	February 1
	Fishing Pier	Varies annually	25	October 1

Note: This table incorporates information from NR 193, which was made effective on June 1st, 2020. More information regarding these example grant programs may be found online at the following address: dnr.wi.gov/aid/grants.html. Additional federal, state, and local grant opportunities are available. Eligibility varies for each grant program.

Source: Wisconsin Department of Natural Resources and SEWRPC

3.6 FISH AND WILDLIFE

Biological communities are a direct consequence of waterbody health—an indicator of the ability of a waterbody to support aquatic life. The Lake Comus fishery is locally popular and, supported by WDNR stocking efforts, maintains substantial panfish, largemouth bass, and northern pike populations. Fish and wildlife depend upon the health of the Lake, its tributaries, and the environmental corridors found throughout the watershed. Abundant and healthy fish and wildlife increases the Lake's recreational value, aesthetic appeal, overall enjoyment by humans, and the functionality of the Lake as an ecosystem.

Habitat Quality

Preserving and enhancing habitat quality is essential to promoting healthy fish and wildlife populations within the watershed. Recommendations to improve habitat quality follow.

➤ **Recommendation 5.1: Preserve and expand wetland and terrestrial wildlife habitat, while making efforts to ensure connectivity between such areas**

Most existing wetland adjacent to Turtle Creek and within the Turtle Valley Wildlife Area ranks very high for its capacity to support fish and aquatic life by The Nature Conservancy's Wetlands by Design GIS tool. This is particularly true for animals in the shallow marsh guild (e.g., American bittern, blue-winged teal, many aquatic invertebrates) and shrub swamp guild (e.g., American woodcock, flycatchers). Preserving these wetland through land or acquisition, conservation easements, and/or expansion of the Turtle Valley Wildlife Area would promote protection of this important wildlife habitat.

Habitat connectivity could be improved by implementing the buffer and wetland protection recommendations provided in Section 3.4, "Pollutant and Sediment Sources and Loads." Benefit could also be accrued by hydraulically reconnecting floodplains to ditched and straightened tributary streams. These reconnected floodplains detain floodwater diminish downstream flooding, retain sediment ad nutrients improving downstream water quality, promote groundwater recharge, and provide seasonally wet areas of great value for a wide range of birds, fish, amphibians, insects, and terrestrial animals. The Nature Conservancy's Wetland by Design tool identifies 759 acres of potentially restorable wetland between Turtle and the confluence of the Turtle Creek headwaters as particularly suitable for enhancing fish and aquatic habitat via conversion to wetland, Restoring natural or semi-natural condition in this area would also enhance habitat connectivity between Turtle Lake and the Creek.[321] This recommendation should be assigned a high priority.

➤ **Recommendation 5.2: Preserve and enhance instream features providing critical fish spawning and rearing habitats**

Stream flow is fundamental to stream health. Actions to mitigate the negative consequences of channelization and physical impediments to aquatic organism along tributaries and adjacent floodplains should be considered a high priority. While doing this natural stream features such as riffles, pools, riparian wetlands and vegetation, and stable instream stable wood that does not significantly obstruct flow should be preserved and, depending on the situation, enhanced, to provide valuable fish habitat, protection from predators, feeding areas, and refuges from summer and winter temperature extremes. Protecting instream habitat features should be a focus in the Creek tributaries with higher gradients and less channelization, such as the CTH O tributary, where these features are more likely to exist. Due to the extensive channelization and low gradient of the Creek itself, there is little existing instream habitat.

Like humans, aquatic organisms need a variety of habitat types to survive and prospers. Human often install infrastructure features and modify streams morphology ins ways that partially or completely block migration of aquatic organisms from life-cycle-critical habitat types. Features such as culverts, dams, levees, and ditched channels produce leaping obstacles, excessively shallow water, in-channel hazards and blockages, and velocity barriers. The LCPRD should consider completing an inventory of all mapped stream channels upstream of the Lake to locate and quantify potential aquatic organism

[321] *Miller et al., 2017*, op. cit.

passage impediments and barriers.[322] As part of the inventory, preliminary design standards and priorities can be generated.

The LCPRD should also monitor water-related infrastructure construction and repair in areas tributary to the Lake. When projects are proposed, the LCPRD should petition for use of modern, aquatic-organism friendly infrastructure design be used as part of project conceptualization and design. Many publications from a variety of agencies discuss such methods.[323]

- **Recommendation 5.3: Restore natural meanders and improve floodplain connectivity to Turtle Creek and its tributaries**

Most of Turtle Creek upstream of the Lake has been extensively channelized. Due to the channel's low gradient and attendant limited ability to move coarse-grained sediment, restoring stream channel function in a reasonable period requires physically reconstructing a new channel that emulates natural channel form. Reconstructing meanders or restoring more natural sinuosity, particularly in low gradient systems, is one of the most effective ways to restore instream habitat, hydrology, and the stream's ability to transport sediment and to function more like a healthy stream system. Pollutant loads from restored streams by allowing floodwater to spread onto floodplains and be temporarily detained. This can be done by reconnecting floodplains, restoring historical stream channel profiles, and reconstructing new channels and/or two-stage channel systems (Figures 3.5 and 3.8).

An ideal location to restore stream function is where pre-existing channel segments or stream traces remain visible (Figure 3.9). Even if historical stream channels have been obliterated or cannot be located, many opportunities are available to rehabilitate or increase stream sinuosities and associated habitat and stream function within channelized stream reaches. For example, spoil piles excavated during channel ditching often parallel ditched streams, a situation isolating the stream from its floodplain. Perforating the levee-like spoil pile can reactivate the streams floodplain located beyond the spoil pile.

Due to the high potential cost, remeandering streams and reconnecting floodplains should be considered a medium priority. Sod toe restoration could be used as a lower-cost alternative in the Creek to facilitate remeandering, narrow over-widened stream reaches, and create a low-flow channel alongside the current stream to reduce pollutant loading and enhance habitat.[324] As sod-toe restoration shares many of the benefits of stream remeandering at a significantly lower cost per lineal foot, implementing sod toe restoration projects should be considered a high priority. These projects could be particularly effective to restore conditions in areas where a historic stream channel is not apparent in aerial imagery or via field surveys.

- **Recommendation 5.4: Preserve natural areas of county-wide and local significance, particularly those with critical species habitat**

Critical species habitats are essential for protecting rare native species, including those on the state's endangered and threatened species list (Table 2.14 and Map 2.16). This recommendation is a high priority.

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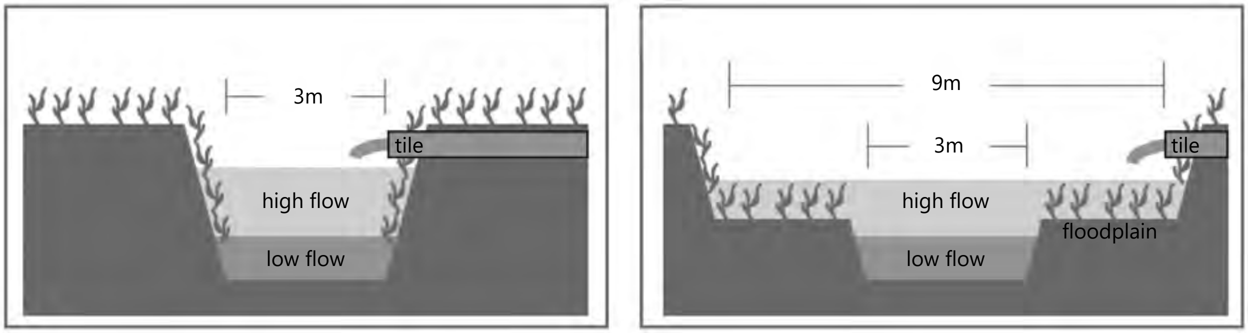
[322] *Many organizations have completed aquatic organism passage inventories in Southeastern Wisconsin, with most of these inventories completed in streams tributary to Lake Michigan. An example are projects completed in Ozaukee County, elements of which are described on the County's website: co.ozaukee.wi.us/619/Fish-Passage.*

[323] *For example, road/stream crossings are a common water-resource feature benefiting from aquatic organism friendly design. A few of the many agencies providing aquatic organism friendly design guidance include the United States Forest Service, the United States Fish and Wildlife Service, and the NRCS. A few websites discussing aquatic organism passage from these example agencies are found below: www.fs.usda.gov/restoration/Aquatic_Organism_Passage/index.shtml, www.fws.gov/service/fish-passage-technical-and-planning-assistance, www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_033247.pdf.*

[324] *Minnesota Department of Natural Resources, 2010,* op. cit. *www.files.dnr.state.mn.us/publications/waters/toe_woodsod_mat_dec2010.pdf.*

Figure 3.8
Schematic of a Two-Stage Design Channel

Ditched/Entrenched Channel   Two-Stage Restored Channel



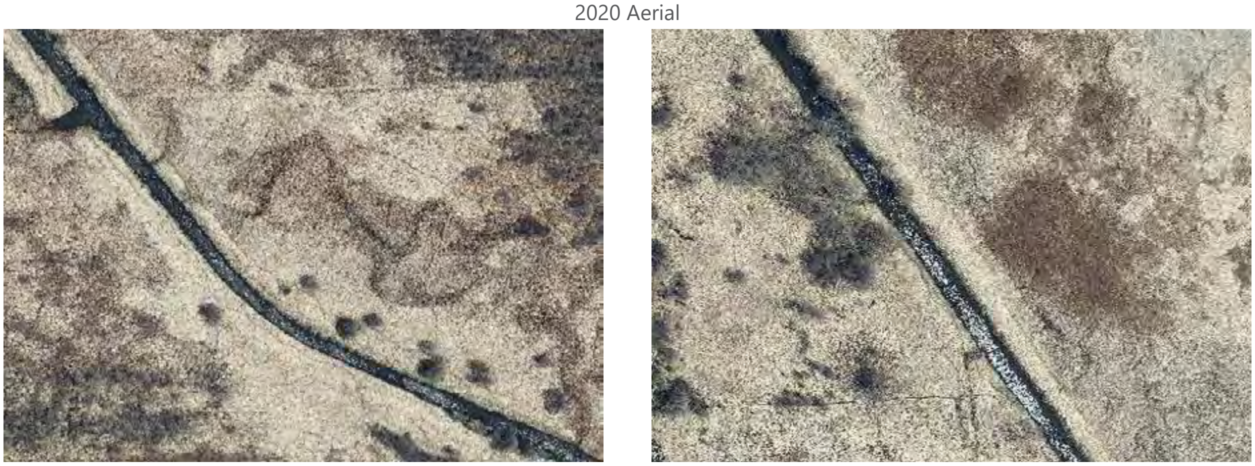
Note: The two-stage ditch design: a) Trapezoidal channel, with steep slopes, lack of floodplain connectivity, and drain tile, prior to floodplain restoration; b) restored two-stage ditch, with drain tiles cut back. The dark gray represents water levels during base flow and the light gray represents water levels during stormflow.

Source: Modified from S.S. Roley, J.L. Tank, and M.A. Williams, "Hydrologic Connectivity Increases Denitrification in the Hyporheic Zone and Restored Floodplains of an Agricultural Stream," Journal of Geophysical Research, *117(G3), p. 2, 2012 and SEWRPC*

Figure 3.9
Turtle Creek Potential Remadering Locations: 1941 Aerial and 2020 Aerial

1941 Aerial

2020 Aerial



Source: SEWRPC

➤ **Recommendation 5.5: Incorporate upland conservation and restoration targets into management and policy decisions**

Upland areas provide a wide range of ecosystem services but are often among the first targeted for urban development (Map 2.11). While most of the upland areas within the watershed have already been developed through agricultural or urban land uses, small areas of grassland and woodland remain scattered throughout the watershed. Protecting these areas should be assigned a medium priority.

➤ **Recommendation 5.6: Improve in-Lake aquatic habitat by maintaining and adding large woody debris and/or vegetative buffers along the Lake's edge**

As the majority of the Lake's shoreline remains naturally vegetated, adding additional woody habitat should be considered a low priority while maintaining existing woody habitat should be considered a medium priority. WDNR grant money is available through the Healthy Lakes and Rivers program on a competitive basis for implementing additional "fish sticks" projects.

➤ **Recommendation 5.7: Mitigate water quality stress on aquatic life and maximize the extent of areas habitable to desirable fish**

The primary ongoing in-Lake issue affecting aquatic organisms are excessively turbid water, elevated summer water temperatures, and oxygen supersaturation. The most direct route to reduce water quality stress on fish and other aquatic life is to take action to reduce phosphorus inputs to the Lake and thereby decrease overly abundant algae. This can be done by implementing recommendations noted in Sections 3.3, "Water Quality" and 3.5 "Aquatic Plants." Since the groundwater springs on the Lake's eastern shoreline provide cool, clear waters that are likely beneficial to the Lake's fish population, these springs should be preserved in a natural state and the groundwater recharge potential of the areas feeding these springs should be maintained. The water quantity and quality recommendations discussed earlier in this chapter would help protect these areas. Implementation of those recommendations should be considered a high priority to reduce stressors on aquatic life. Other stressors may develop in the future (e.g., new invasive species) and conditions should be carefully monitored for their impact on aquatic life (medium priority).

➤ **Recommendation 5.8: Mitigate streambank erosion**

Streambank erosion destroys aquatic habitat, spawning, and feeding areas; contributes to downstream water quality degradation by releasing sediments to the water; and provides material for subsequent sedimentation downstream, which, in turn, covers valuable benthic habitats, impedes navigation, and fills wetlands. These effects may potentially be mitigated by sound land use planning combined with utilization of conservation-minded stormwater management practices. Such actions are considered a low priority as streambank erosion does not appear to be a major source of sediment pollution in the watershed.

Fish Population Management

Lake Comus is locally recognized and enjoyed for its fishing opportunities. However, the Lake's abundant common carp population is detrimental to water quality, the aquatic plant community, and potentially the overall fishery. The following recommendations can help maintain healthy populations of fish and wildlife.

➤ **Recommendation 5.9: Reduce and control the Lake's carp population**

As discussed in Sections 3.3 "Water Quality" and 3.5 "Aquatic Plants", the watershed's abundant carp are likely contributing to the Lake's poor water clarity, depauperate aquatic plant community, and subsequently are likely affecting desirable fish species vigor and abundance. Given the abundant habitat suitable for carp upstream of the Lake, a carp eradication program focusing on the Lake successfully reduce carp populations. Barriers are impractical, restrict movement of desirable native fish populations, and generally inadvisable. For these reasons, eradicating common carp from Lake Comus is not a practical alternative.

Since eradicating common carp from Lake Comus is impractical, management efforts should focus on reducing the carp population to a level at which harmful effects are minimized. A study on a shallow Minnesota lake suggested that a carp density of 90 pounds per acre or greater can be detrimental to water quality and aquatic vegetation.[325] An effective long-term management strategy may begin with a large-scale removal technique, such as seining during a lake drawdown, to sharply reduce the adult population (see Section 2.6, "Fisheries" for more detail regarding removal techniques). This reduction should be followed with persistent predation pressure by maintaining a healthy population of native piscivorous fish that prey upon young carp, particularly bluegill and northern pike, as well as carp harvest bounties and/or carp tournaments. Lake-wide chemical treatments, e.g., using Rotenone, require a WDNR permit and are not recommended due to their non-selective impact on native fish species. Given the widespread and manifold effect of the carp population on the Lake, this recommendation should be considered a high priority.

➤ **Recommendation 5.10: Improve wildlife populations by encouraging best management practice adoption**

This should be a medium priority, although this should increase to a high priority if wildlife populations decline. The acceptance and employment of BMPs can be fostered through voluntary, educational, or incentive-based programs for properties adjacent to the shoreline, and by directly implementing these practices on public and protected lands. Special interest non-governmental organizations ("NGOs", e.g., Pheasants Forever, Ducks Unlimited, etc.) exist to foster habitat improvement projects, some of which collaborate with landowners to install beneficial projects. When this recommendation is implemented, a complete list of BMPs and relevant NGOs should be compiled and provided to landowners.

➤ **Recommendation 5.11: Continue to monitor fish and wildlife populations**

In general, tracking the diversity and abundance of fish and wildlife helps future Lake managers detect change. Consequently, continued monitoring of fish populations and periodic recording of the types of animals found on and in the Lake and within its watershed is also a medium priority. Monitoring data can be collected from government agencies, non-governmental organizations (e.g., Audubon Society), and from volunteers around the Lake and throughout the watershed.

Eastern Massasauga Rattlesnake and Other Rare Reptiles

The eastern Massasauga rattlesnake (EMR) (*Sisturus catenatus*, a state Endangered and federally Threatened species), Blanding's Turtle (*Emydoidea blandingii*, a state Special Concern species), and Queensnake (*Regina septemvittata*, a state Endangered species) have been observed and reported within and near the Lake Comus watershed. Landowners in the watershed, particularly those with wetland and riparian habitat on their property, should be aware of the EMR, Blanding's Turtle, and Queensnake as well as best management practices for maintaining and enhancing habitat for these protected reptiles as well as reducing accidental habitat or population loss. The following recommendations are provided to assist and educate landowners on best management practices for these species.

➤ **Recommendation 5.12: Follow WDNR and US Fish and Wildlife Service guidance on land management BMPs in potential EMR, Blanding's Turtle, and Queensnake habitat**

The EMR requires early successional habitat but can also be susceptible to incidental mortality during the activities that preserve such habitat, like mowing and prescribed burning. Consequently, the WDNR and FWS published guidelines with best management practices to enhance EMR habitat and reduce incidental mortality during land management.[326,327] Using soil temperature information can help landowners conduct land management activities before EMR spring emergence and following fall dormancy to minimize incidental mortality. Following these guidelines should be considered a high priority.

Blanding's turtles require shallow water with abundant aquatic vegetation – a habitat that is plentiful within the Lake Comus watershed. However, they prefer sandy, disturbed sites for nesting, which can lead to incidental mortality along roadways. WDNR guidance for this species suggests that implementing turtle barriers, particularly when combined with turtle-friendly underpasses and/or culverts, could reduce

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[325] *P.G. Bajer, G. Sullivan, and P.W. Sorensen, "Effects of a Rapidly Increasing Population of Common Carp On Vegetative Cover and Waterfowl in a Recently Restored Midwestern Shallow Lake,"* Hydrobiologia 632(1): 235-245, 2009.

[326] *For more information regarding land management in Eastern Massasauga habitat, see dnr.wi.gov/topic/EndangeredResources/documents/LandManagementEasternMassasaugaHabitat.pdf.*

[327] *www.fws.gov/midwest/endangered/section7/bo/2018_Rangewide_EMRLandManagementByUSFWS06282018.pdf.*

road mortality and allow passage between habitats.[328] Burning and mowing in potential Blanding's turtle habitat areas should be conducted when the turtles are least likely to be using those areas (e.g., conduct work in nesting habitats during the non-nesting period).[329]

Queensnakes utilize riparian habitat alongside small to medium-sized, clear, spring-fed streams within Southeastern Wisconsin. Within the Lake Comus watershed, the most likely habitat for this species is along the small, spring-fed tributaries of Turtle Creek and Lake Comus in the eastern half of the watershed. As with the EMR and Blanding's Turtle, management activities like prescribed burning and mowing in potential Queensnake habitat should be conducted when the species is inactive. Riparian vegetation alongside these spring-fed streams should be preserved to the greatest extent possible.[330,331]

➤ **Recommendation 5.13: Consider impacts to EMR and Blanding's Turtle when considering water level manipulation for lake management**

Both the EMR and Blanding's turtles can be negatively affected by fluctuating water levels, particularly during late fall, winter, and early spring while EMR hibernate in cavities and Blanding's turtles remain under ice.[332,333] Prolonged flooding of cavities can cause loss of habitat with a subsequent decline in the EMR population. Winter drawdowns can reduce the amount ice-covered surface waters that Blanding's turtle utilize for overwinter habitat. In most instances, water levels should not be manipulated after early October or before April. If water level manipulation is utilized for other lake management activities, this manipulation should be appropriately timed to be of least impact to EMR and Blanding's turtle populations and habitat by following the WDNR and FWS guidelines referenced above. This recommendation should be considered a high priority.

3.7 RECREATIONAL USE AND FACILITIES

Lake Comus supports diverse recreational activities including birdwatching, fishing, hunting, and paddle sports. Maintaining the Lake's ability to provide safe, high-quality recreational pursuits is a priority issue. In support of this goal, the following recommendations are made.

➤ **Recommendation 6.1: Maintain and enhance fishing opportunities by protecting and improving aquatic habitat and water quality**

Fishing is one of the most popular activities for residents and visitors to Lake Comus. The Lake's fishery can be further enhanced by improving aquatic habitat, particularly the abundance of native aquatic vegetation, and water quality. This recommendation can be achieved by implementing the water quality recommendations provided in Section 3.3, "Water Quality" and the aquatic wildlife recommendations provided in Section 3.6, "Fish and Wildlife." This is a high priority issue.

➤ **Recommendation 6.2: Maintain public boat launch sites**

Launch site maintenance should be considered a medium priority. Maintenance should include incorporating management and maintenance activities that help reduce the chance of spreading invasive species. An example of one such activity would be deploying trained volunteers to inspect boats and distributing literature (Clean Boats, Clean Waters program) during high use periods. Such activities could help reduce the chance of spreading invasive species.

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[328] *For more information on WDNR guidance for Blanding's turtles, see Wisconsin Department of Natural Resources,* Wisconsin Blanding's Turtle Species Guidance, *Bureau of Natural Heritage Conservation, Wisconsin Department of Natural Resources, Madison, Wisconsin, PUB-ER-683, 2014*: www.dnr.wi.gov/files/PDF/pubs/er/ER0683.pdf*.*

[329] *In Wisconsin, Blanding's Turtles typically nest sometime between mid-May and mid-July.*

[330] *In Wisconsin, Queensnakes are commonly active between April and October.*

[331] *For more information on WDNR guidance for Queensnakes, see Wisconsin Department of Natural Resources,* Wisconsin Queensnake Species Guidance*, Bureau of Natural Heritage Conservation, Wisconsin Department of Natural Resources, Madison, Wisconsin, PUB-ER-673, 2012: www.dnr.wi.gov/files/PDF/pubs/er/ER0673.pdf.*

[332] Ibid.

[333] *WDNR, 2014,* op. cit.

➤ **Recommendation 6.3: Maintain natural shorelines in planned development**

One of the most treasured aspects of Lake Comus is its largely natural shoreline. The lack of intensive development along the Lake and infrequent powerboating activity makes it ideal for recreational activities such as paddle sports, fishing, and watching wildlife. Ensuring that planned development does not disrupt these activities by protecting the Lake's natural shorelines should be considered a high priority.

➤ **Recommendation 6.4: Incorporate the City of Delavan's planned recreational facilities**

The Downtown Delavan Strategic Plan envisions Lake Comus as a regional hub for water sports, such as kayaking and canoeing, as well as a greater connection between downtown Delavan and the lakefront.[334] As discussed in Chapter 2, this vision calls for developing recreational facilities in Veterans Memorial Park (across Terrace Street from the Lake) as well as the creating a walking trail and boardwalk along the western and southern shores of the Lake. Given that the Lake's shoreline is largely undeveloped wetland suitable for such activities and that Turtle Creek downstream of the Lake is already quite popular with paddlers, these facilities would further enhance the capacity of residents as well as regional visitors to recreate on the Lake and the Creek. Enhancing the water quality, fishery, and wildlife habitat in and around the Lake would further enhance recreational paddling. Implementing the strategic vision and actions recommended in the Downtown Delavan Strategic Plan should be considered a high priority.

➤ **Recommendation 6.5: Enhance public access with a walkway as part of the dam replacement project**

As discussed earlier in Section 3.2, "Hydrology, Water Quantity, and Water Resource Infrastructure", the City of Delavan plans to replace the Lake Comus outlet dam, providing opportunities to enhance recreation and public access integrated directly into the new dam design. The City of Delavan and LCPRD envision greater access to the Paul Lange Arboretum and the Lake Comus boat launch from downtown Delavan, as outlined in the Downtown Delavan Strategic Plan.[335] There is currently no walkway over the existing Lake Comus outlet dam, limiting pedestrian access across the dam to the trafficked portion of North Terrace Street. A dedicated pedestrian walkway should be installed during dam replacement to facilitate pedestrian access between downtown Delavan and the Lake Comus boat launch and Arboretum. This recommendation should be considered a high priority.

➤ **Recommendation 6.6: Develop and improve walkway and parkway along western shoreline**

Continuing the goal of enhancing pedestrian access between downtown Delavan and Arboretum, the walkway along the western shoreline of Lake Comus should be more fully developed to better facilitate pedestrian traffic.[336] While a sidewalk already exists on the western side of North Terrace Street, developing a walkway on the eastern side of the road would allow safer access to the Arboretum and boat launch using the dam walkway discussed in Recommendation 6.5. This recommendation should be considered a high priority.

➤ **Recommendation 6.7: Collaborate with the City of Delavan to develop planned lakeshore trail**

The Downtown Delavan Strategic Plan calls for developing a lakeshore trail extending along the southern and eastern shoreline of the Lake.[337] This lakeshore trail would pass through privately owned parcels by way of a trail easement. Collaborating with the City of Delavan on developing the lakeshore trail has been identified as a medium priority.

➤ **Recommendation 6.8: Create a designated portage route as part of outlet dam replacement**

To further encourage paddle sport recreation on Lake Comus, and to better connect with the already popular canoeing and kayaking route downstream of the Lake, a formalized portage route for canoes and kayaks could be created during outlet dam replacement. One potential option is to add a dock downstream of the dam, a cement staircase and/or ramp to connect to the sidewalk on the western side of North Terrace Street, a marked crosswalk to more easily cross North Terrace Street, and then connect

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[334] *City of Delavan and Vandewalle & Associates, Inc.*, Downtown Delavan Strategic Plan: City of Delavan, Wisconsin, *May 2013.*

[335] Ibid.

[336] Ibid.

[337] Ibid.

to the planned lakeshore trail on the eastern side of North Terrace Street (Figure 3.10). The LCPRD and City of Delavan should consider meeting with local paddling groups, such as the Friends of Turtle Creek, to get their insight and input on this recommendation and other potential improvements (e.g., portage route around the low-head dam downstream of the dam operated by the Walworth County Metropolitan Sewerage District) for paddle sport recreation on Turtle Creek downstream of the outlet dam.[338] Incorporating consideration of the formalized portage route into the dam design process should be given a high priority. Implementing this recommendation is a medium priority.

- **Recommendation 6.9: Enhance shoreline erosion protection, particularly along Paul Lange Arboretum**

  The LCPRD and City of Delavan have expressed concern regarding shoreline erosion along the Paul Lange Arboretum on the northwestern shore of the Lake. Comparing aerial imagery and field surveys determined that shoreline erosion was notable along the Paul Lange Arboretum and localized erosion has occurred in the southeastern corner of the Lake. A 2019 shoreline inventory identified approximately 2,200 linear feet of unprotected shoreline in these areas (Map 2.22). Due to low wave activity on Lake Comus, techniques that incorporate both riparian and aquatic vegetation and low-lying structural surfaces, such as edging and sills, may be sufficient to protect the Arboretum's shoreline from further deterioration (Appendix A).[339] However, this should be verified with further survey of the shoreline's condition. Furthermore, since the Arboretum property was once used for disposing of solid waste, the lakeshore should be inspected to assure that no waste is exposed or could be potentially exposed by future erosion. The LCPRD can apply for a shoreland protection project under the Surface Water Restoration subprogram of the WDNR Surface Water Grants program to help fund this effort (Table 3.4). This recommendation is a high priority.

3.8 PLAN IMPLEMENTATION

The methods to implement this plan vary with recommendation type, with efforts required, and can be achieved by education and outreach, ordinances and regulations, as well as partnership and collaboration. This section provides recommendations on how to successfully implement projects and recommendations provided in the management plan.

Awareness, Education, and Outreach

One of the most effective ways to promote plan implementation is educating lake residents, users, and governing bodies regarding the content of this plan. The following recommendations are intended to increase awareness of the management plan, engage interested parties, and encourage outreach that can lead to potential partnerships and collaboration.

- **Recommendation 7.1: Integrate lake users and residents into management efforts**

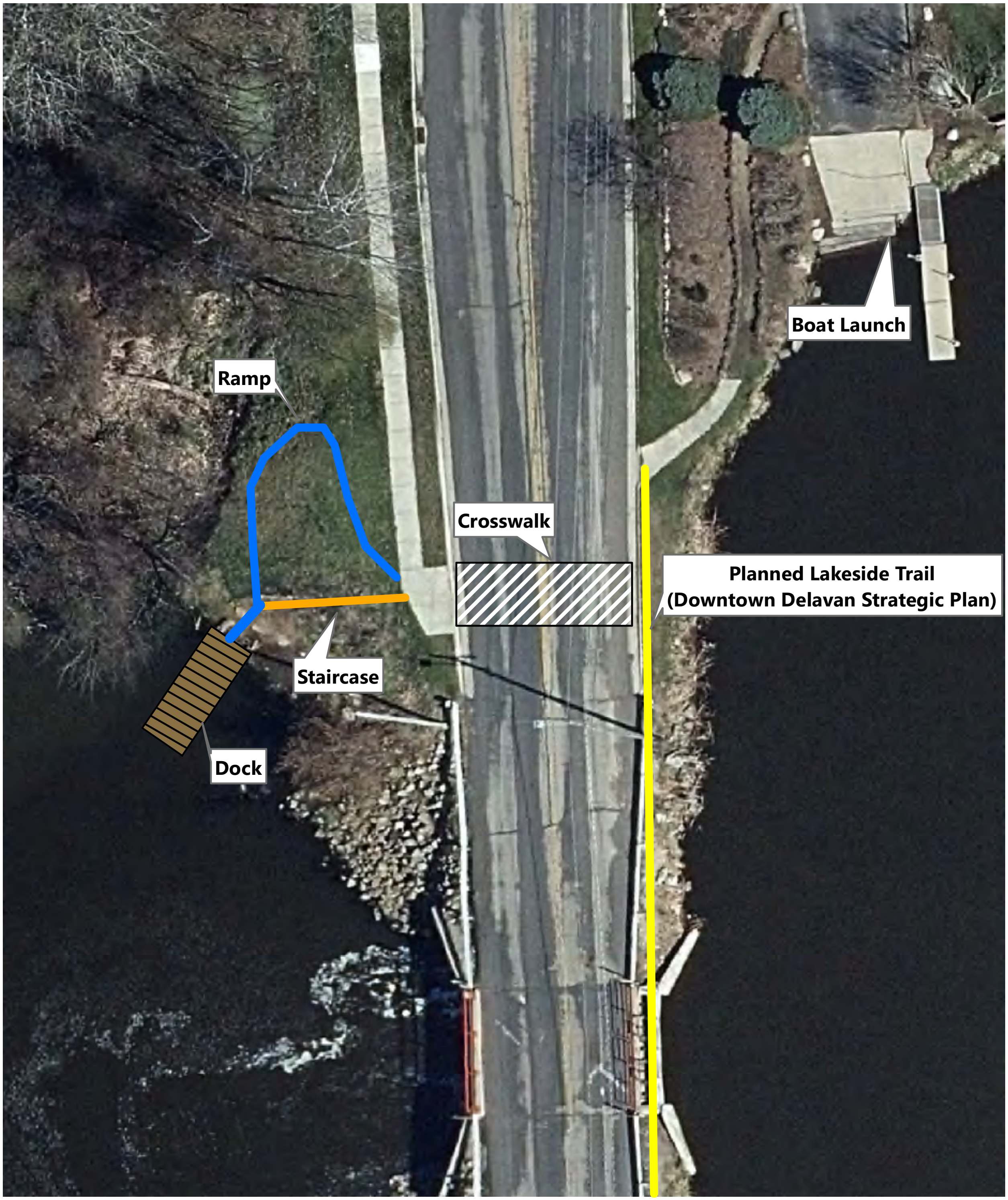
  This is recommended as a high priority. The aim of this effort is to add to the donor and volunteer base working toward improving the Lake, improving community buy-in, and receiving greater community input on lake planning and management decisions. Private donations and volunteer time can be used as cost match for some grants.

  As part of this effort, the LCPRD and the Commission will share this management plan for public comment and will strive to incorporate these comments as feasible into the plan. The LCPRD will be hosting a special meeting in spring 2023 to present the plan and expects to receive public comments at that time. Additionally, the Commission will host the plan on their website with an option to provide public comment; this option will remain open until the completion of the LCPRD's meeting. All public comments received either through the Commission's website or the LCPRD meeting process will be compiled in Appendix B of this plan.

[338] *For more information, see the Friends of Turtle Creek webpage: www.friendsofturtlecreek.com/*

[339] *See NRCS Technical Guide,* Streambank and Shoreline Protection Standard 580, *2018.*

Figure 3.10
Potential Canoe and Kayak Portage Route Around Lake Comus Outlet Dam



Note: This illustration is only provided as a general concept and should not be used for construction planning purposes.

Source: SEWRPC

- **Recommendation 7.2: Encourage key players to attend meetings, conferences, and/or training programs to build their lake management knowledge**

  These actions as recommended as a medium priority as they will enhance institutional capacity. Some examples of capacity-building events are Wisconsin Water Week (which targets local lake managers) and the "Lake Leaders" training program (which teaches the basics of lake management and provides ongoing resources to lake managers). Both are hosted by University of Wisconsin Stevens Point Extension Lakes.[340] Additionally, courses, workshops, on-line training, regional summits, and general meetings can also be used for this purpose. Another excellent local source of good information for pursuing soil health initiatives includes attending free meetings and field demonstrations sponsored by producer-led groups.[341] Attendance at these events should include follow-up documents and meetings so that the lessons learned by the attendee can be shared with the larger lake group.

- **Recommendation 7.3: Continue to ensure inclusivity and transparency with respect to all Lake management activities**

  If stakeholders do not fully understand the aims and goals of a project, or if they do not trust the process, excess energy can be devoted to conflict, a result that benefits no one. For this reason, this element is assigned high priority. These efforts should be implemented through public meetings and consensus building so that conflicts can be discussed, addressed, and mitigated before implementing projects.

- **Recommendation 7.4: Foster and monitor management efforts to communicate actions and achievements to future lake managers**

  Institutional knowledge is a powerful tool that should be preserved whenever possible. Actions associated with this are sometimes embedded in organization bylaws (e.g., minutes) and are therefore assigned medium priority. Open communication helps increase the capacity of lake management entities. This may take the form of annual meetings, websites, newsletters, emails, reports, and any number of other means that help compile and report action, plans, successes, and lessons learned. These records should be kept for future generations and made publicly accessible.

- **Recommendation 7.5: Consider installing "Turtle Creek," "This is Our Watershed," and "Adopt a Highway" signage throughout the watershed**

  Such signs should be placed where public roadways cross Turtle Creek and its major tributaries, along the Lake's watershed boundaries, and along major transportation routes. Such signs act help raise awareness for environmental concerns. Increased awareness usually leads to increased involvement as more of the public begins to see themselves as stakeholders in maintaining the quality of the natural resources around them. This is recommendation is assigned a medium priority.

- **Recommendation 7.6: Increase visibility of Lake Comus on City of Delavan website**

  Lake Comus is entirely within the City of Delavan boundaries and the City is interested in promoting recreational and tourism opportunities on the Lake. However, very little information regarding the Lake is found on the City's website to make residents and visitors aware of the Lake resources and its recreational opportunities. Adding a link to information regarding the lake and highlighting recreational opportunities on the web page banner could help increase the Lake's public visibility. This is recommended as a medium priority.

Ordinances and Regulations

Several important recommendations relate to enforcing current ordinances (e.g., shoreline setbacks, zoning, construction site erosion control, and boating). Public agencies often have limited resources available to monitor compliance and affect enforcement. Consequently, the following recommendations are aimed at local citizens and management groups and are made to enhance the ability of responsible entities to monitor compliance and enforce regulations.

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[340] *www.uwsp.edu/cnr-ap/UWEXLakes/Pages/default.aspx*

[341] *The closest producer-led group meetings are held by the Watershed Protection Committee of Racine County. A link to their website follows: www.wpcracinecounty.org/.*

- **Recommendation 7.7: Actively share this plan and work with municipalities to adopt it by maintaining and enhancing relationships with County, municipal zoning administrators, directors of public works/municipal engineers, and law enforcement officers**
  This helps build open relationships with responsible entities and facilitates efficient communication and collaboration whenever needed. This should be assigned a high priority.

- **Recommendation 7.8: Keep abreast of activities within the watershed that can affect the Lake**
  Certain activities (e.g., construction, filling, excessive erosion) could potentially affect the Lake. This initiative includes maintaining good records (e.g., notes, photographs) and judiciously notifying relevant regulatory entities of problems when deemed appropriate. Given the modest amount of such activity known in the watershed, this is currently assigned a low priority. If flagrant violation of existing ordinances becomes commonplace, this should be assigned a high priority.

- **Recommendation 7.9: Educate watershed residents about relevant ordinances. Update ordinances as necessary to face evolving use problems and threats**
  This helps assure that residents know why rules are important, that permits are required for almost all significant grading or construction, and that such permits offer opportunity to regulate activities that could harm the Lake. This should be considered a medium priority.

Partnership and Collaboration

Numerous opportunities exist for partnership and collaboration to improve water quality within the watershed. The following recommendations provide ideas and collaboration opportunities intended to inspire further action.

- **Recommendation 7.10: Encourage formation and growth of producer-led group covering the watershed**
  Producer-led watershed groups are a recent innovation that has greatly enhanced the ability to actively promote sustainable agriculture and allied conservation practices in Wisconsin. Producer-led groups sponsor programs that endeavor to improve soil health, water quality, and farm profitability by a variety of means, including the following examples.

  - Recruiting producers to apply for and install low-cost conservation BMPs to improve soil and water quality
  - Providing education and outreach (field days, workshops, tours) to area producers about the principles of soil health, soil improvement practices, equipment use, and water quality improvement conservation practices
  - Collectively leasing or buying novel equipment and sharing ideas for modifying existing equipment
  - Improving the image of agriculture by showcasing various local producer leaders, outreach activities, farms and/or fields through signage, and being active in the community promoting good farming practices

  The LCPRD and/or other interested organizations are highly encouraged to actively support the formation and growth of producer-led initiative covering the Turtle Creek watershed. The LCPRD should collaborate with Walworth County and their Producer-Led Group Coordinator, as well as others in nearby Rock River basin watersheds, to support creation of a producer-led group covering the Turtle Creek watershed. Some conservation-themed organizations, with goals like the LCPRD, actively support local producer-led groups by offering financial and logistical support to the initiative. Examples of financial support include stipends to offset tuition and fees associated with key educational events; hosting educational and outreach events; purchasing key equipment (which is often a barrier to initiating soil health practices) and leasing this equipment to producers; and offering subsidies to help offset the cost and financial risk of initiating conservation practices on farm fields. This is recommended as a high priority.

➤ **Recommendation 7.11: Consider inter-governmental agreements with neighboring municipalities**
The LCPRD has opportunities to create partnerships with other local government units through inter-government agreements. As previously discussed, the LCPRD is already working closely with the City of Delavan to enhance recreational opportunities in and along Lake Comus and to more closely tie the waterfront with downtown Delavan. Regarding dredging, the Town of Delavan is currently dredging the Mound Road ponds and will continue to periodically dredge them into the foreseeable future. The LCPRD could create an inter-governmental agreement to mobilize dredging equipment to Delavan and dispose of spoil material. Exploring options via inter-government agreements is recommended as a medium priority.

➤ **Recommendation 7.12: Foster open relationships with potential project partners**
Continue to partner with and maintain good relations with volunteer groups, municipalities, and governing bodies, which promotes effective solutions to issues shared. This is recommended as a high priority.

➤ **Recommendation 7.13: Apply for available grants to support implementing programs recommended as part of this plan**
The LCPRD, City of Delavan, Walworth County, and/or other local units of government may apply for grants from WDNR to control non-point source pollution and meet the TMDL load allocation as well as for other surface water related projects. The WDNR, DATPC, and the Federal government support nonpoint source pollution abatement by administering and providing cost-sharing grants to fund BMPs through various grant programs (Table 3.4 and "Funding Sources" subsection below). Sponsoring and applying for such grants is potentially the most important avenue for the LCPRD to implement recommended BMPs within the Lake Comus watershed. Having multiple collaborators providing external funding support, including equipment, volunteer hours, and cash, enhances the odds of a successful WDNR grant application. This is recommended as a high priority.

Funding Sources

The following subsection briefly describes potential State and Federal funding sources available to help fund BMPs and other plan recommendations in the watershed. This is not an exhaustive list. However, the list but does include some of the more common funding sources.

State

- **Surface Water Grant Program (SWG)** – A WDNR program that offers competitive grants for local governments, counties, lake districts, and other eligible organizations to address a range of surface-water issues.[342] Several subprograms could be useful for implementing plan recommendations and that the LCPRD, City of Delavan, and Walworth County could sponsor. These subprograms include:
    - **Surface Water Restoration** – Provides funds to implement shoreline, in-water, and wetland restoration projects that follow appropriate NRCS guidelines as well as funding to develop ordinances that protect surface water resources. Cost-share is up to 75 percent of eligible costs for up to $75,000 for lakes and $50,000 for rivers.
    - **Management Plan Implementation** – Provides funds to implement recommendations in a WDNR-approved surface water management plan. Eligible projects include nonpoint source pollution control, habitat restoration, water quality improvements, landowner incentives, and management staffing. Cost-share is up to 75 percent of eligible costs for up to $200,000 for lakes and $50,000 for rivers.
    - **Healthy Lakes and Rivers** – Provides funding to implement approved best practices for shoreland landowners following technical guidance. Practices include fish sticks, native plantings, water diversions, rain gardens, and rock infiltration. Cost-share is up to 75 percent of eligible costs for up to $25,000.

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[342] *For more information on the WDNR Surface Water Grant program, see dnr.wisconsin.gov/aid/SurfaceWater.html and Wisconsin Department of Natural Resources,* 2021 DNR Surface Water Grant Application Guide, *July 2021*: dnr.wi.gov/files/pdf/pubs/cf/CF0002.pdf.

- **Clean Boats, Clean Waters** – Provides funding to help prevent spread of aquatic invasive species through education and monitoring at boat launches. Eligible costs include supplies, training, and payment to any paid staff or in-kind donations from volunteers. Cost-share is up to 75 percent of eligible costs for up to $4,000 per boat launch.

- **Land Acquisition** – Provides funding to permanently acquire land to protect surface waters. Eligible costs including costs associated with appraisal, land survey fees, title costs, and any historical, cultural, or environmental assessments. Cost-share is up to 75 percent of eligible costs for up to $200,000 for lakes and $50,000 for rivers.

- **Targeted Runoff Management (TRM) Grant Program** – WDNR program that offers competitive grants for local governments for controlling nonpoint source pollution. Grants reimburse costs for agricultural or urban runoff management practices in critical areas with surface water or groundwater quality concerns. The cost-share rate for TRM projects is up to 70 percent of eligible costs.[343]

- **Soil and Water Resources Management Grant Program** - DATCP program that provides funds to Counties allowing them to enter cost-share contracts with landowners implementing eligible conservation practices. The cost-share rate depends on the conservation practice being implemented but can be up to 70 percent for practices associated with NR 151 performance standards and up to 90 percent if the landowner qualifies for economic hardship. Practices required as part of a CAFO or other WPDES permit are ineligible for cost-sharing.[344]

- **Farmland Preservation Program** – DATCP program that provides a tax credit per acre to eligible farmlands complying with NR 151 agricultural performance standards. Tax credits can vary from $5.00 to $10.00 per acre, depending on the zoning status of the farmland.[345] As discussed in Section 3.4, "Pollutant and Sediment Sources and Loads," cultivated lands within the Lake Comus watershed are zoned for farmland preservation and thus eligible farms can receive a $7.50 per acre tax credit if in compliance with NR 151.

- **Notice of Intent/Discharge Grant Program** – Joint WDNR and DATCP program that provides funds to local governmental units working with livestock operation owners and/or operators that have received a Notice of Discharge or Notice of Intent to Issue a Notice of Discharge from WDNR. Eligible BMPs include those designed to improve water quality affected by livestock pollutant discharge. The cost-share rate for these projects is up to 70 percent of eligible costs.[346]

Federal

- **Environmental Quality Incentives Program (EQIP)** – USDA NRCS program that provides financial and technical assistance to implement conservation practices addressing natural resource concerns.[347] Farmers receive flat rate payments for installing and implementing runoff management practices. The following agricultural practices are eligible for cost sharing:
  - Cover crop
  - Critical Area Planting
  - Diversion
  - Fence
  - Field Border
  - Filter Strip
  - Forage and Biomass Planting
  - Grade Stabilization Structure

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[343] *For more information on TRM, see dnr.wisconsin.gov/aid/TargetedRunoff.html.*

[344] *For more information, see www.datcp.wi.gov/Pages/Programs_Services/SWRMGrantResources.aspx.*

[345] *For more information, see www.datcp.wi.gov/Pages/Programs_Services/FarmlandPreservation.aspx.*

[346] *For more information, see dnr.wisconsin.gov/aid/NOD.html.*

[347] *For more information on EQIP, see www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip.*

- Grassed Waterway
- Heavy Use Area Protection
- Lined Waterway or Outlet
- Livestock Pipeline
- Mulching
- Obstruction Removal
- Prescribed Grazing
- Streambank and Shoreline Protection
- Strip Cropping
- Surface for Water Control
- Subsurface Drain
- Terrace
- Trails and Walkways
- Tree/Shrub Establishment
- Tree/Shrub Site Preparation
- Underground Outlet
- Vegetated Treatment Area
- Water and Sediment Control Basin
- Water Well
- Watering Facility
- Wetland Restoration

- **Conservation Reserve Program (CRP)** – A land conservation program administered by the USDA Farm Service Agency. Farmers enrolled in the program receive a yearly rental payment for environmentally sensitive land that they agree to remove from production. Contracts are 10 to 15 years in length. Eligible practices include buffers for wildlife habitat, wetland buffers, riparian buffers, wetland restoration, filter strips, grass waterways, shelter belts, living snow fences, contour grass strips, woodland establishment, and shallow water areas for wildlife.[348]

- **Conservation Reserve Enhancement Program (CREP)** – Joint effort between County, State, and the Federal government providing funds for practice installation, rental payments, and an installation incentive. Administered by the Farm Service Agency. Interested parties can enter a 15-year contract or perpetual contract conservation easement. Eligible practices include filter strips, buffer strips, wetland restoration, tall grass prairie and oak savanna restoration, grassed waterway, and permanent native grasses.[349]

- **Agricultural Conservation Easement Program (ACEP)** – USDA NRCS program that consolidates three former programs (Wetlands Reserve Program, Grassland Reserve Program, and Farm and Ranchlands Protection Program). Under this program, NRCS provides financial assistance to eligible partners for purchasing Agricultural Land Easements that protect the agricultural use and conservation values of eligible land.[350]

- **Conservation Stewardship Program (CSP)** – USDA NRCS program that offers funding for participants that take additional steps to improve resource condition. Program provides two types of funding through five-year contracts: 1) annual payments for installing new practices and maintaining existing practices and 2) supplemental payments for adopting a resource-conserving crop rotation.[351]

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[348] *For more information on CRP, see www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program.*

[349] *For more information on CREP, see www.datcp.wi.gov/Pages/Programs_Services/CREPLandowners.aspx.*

[350] *For more information on ACEP, see www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/acep.*

[351] *For more information on CSP, see www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp.*

- **Farmable Wetlands Program (FWP)** – USDA Farm Service Agency program designed to restore previously farmed wetlands and wetland buffer to improve both vegetation and water flow. The Farm Service Agency runs the program through the Conservation Reserve Program with assistance from other government agencies and local conservation groups.[352]

- **Aquatic Ecosystem Restoration Program (AERP)** – United States Army Corps of Engineers (USACE) program to plan, design, and implement aquatic ecosystem restoration projects located in the public interest and that have a non-federal public agency sponsor willing to maintain and rehabilitate the project site.[353]

- **Partners for Fish and Wildlife Program** – United Stated Fish & Wildlife Service program providing technical assistance and cost-share funding to incentivize fish and wildlife habitat restoration on privately owned lands.[354]

Non-Governmental Organizations

- **Kettle Moraine Land Trust** – Non-profit land trust based in East Troy, Wisconsin that works to preserve high-quality natural habitats through land acquisition, conservation easements, and partnerships with Walworth County and WDNR.

- **Wisconsin Waterfowl Association** – Non-profit organization focused on conserving and restoring wetland and waterfowl habitat in Wisconsin. Among other activities, the Wisconsin Waterfowl Association provides technical expertise on project design and grant funding opportunities as well as a potential funding match to other funding sources.[355]

Plan Implementation Timeline

Watershed restoration, particularly with heavily modified ecosystems, is a long-term process that requires sustained effort and engagement from all stakeholders. The LCPRD, Walworth County, WDNR, and other partners have already been active in recognizing the challenges facing the watershed and implementing many plan recommendations. Improvements in the condition of natural resource features may not be immediately apparent due to legacy effects from nearly two centuries of hydrologic modification, pollutant loading, habitat loss, invasive species introductions, and changes in climate. Consequently, continued monitoring of more rapidly responding conditions, such as water quality, macroinvertebrates, and aquatic plants, paired with semi- to annual meetings with stakeholders regarding plan progress is highly recommended.

Tracking progress on recommendation implementation, particularly those focused on non-point source pollutant loading outlined in Table 3.3 and Section 3.4, "Pollutant and Sediment Sources and Loads," should be a major focus of stakeholder meetings. As lake management plans are considered active for ten years after WDNR approval, annual target for acreages and linear feet of recommended BMPs in Table 3.3 can be easily calculated by dividing the recommended total quantity by ten (e.g., 2,510 acres of no-till over ten years would require 251 acres per year). However, these improvements are unlikely to occur in such a linear fashion due to challenges in acquiring the necessary funding, ability to identify willing partners, and the time required to design and construct some recommended BMPs. Progress is more likely to occur in a staggered or steplike fashion as grants are secured, watershed collaborators identified, and as management activities are permitted. The LCPRD and other stakeholders need to remain fully engaged in the process of identifying willing partners and managing available funds with the goal of implementing improvements in higher priority areas (e.g., as identified on Map 3.4).

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[352] *For more information on FWP, see www.fsa.usda.gov/programs-and-services/conservation-programs/farmable-wetlands/index.*

[353] *For more information on AERP, see www.sas.usace.army.mil/Missions/CAP/Section-206-Aquatic-Ecosystem-Restoration/.*

[354] *For more information on the Partners for Fish and Wildlife Program, see www.fws.gov/midwest/partners/getinvolved.html#a.*

[355] *For more information on the Wisconsin Waterfowl Association, see https://www.wisducks.org/.*

3.9 SUMMARY

The future will bring change to Lake Comus and its watershed. It is critical that proactive measures be pursued to lay the groundwork for effectively dealing with and benefiting from future change. Working relationships with appropriate local, County, and State entities need to be nurtured now and, in the future, to help protect critical natural areas in the watershed during development, to initiate actions, and to instill attitudes among current and future residents fostering cooperation and coordination of effort on many levels.

To help implement plan recommendations, Table 3.1 summarizes all recommendations and their suggested priority level. The maps referenced in this chapter indicate where recommendations should be implemented. These guides will provide current and future Lake Comus managers with a visual overview of where to target management efforts.

As stated in the introduction, this chapter is intended to stimulate ideas and action. Therefore, these recommendations should provide a starting point for addressing the issues identified in Lake Comus and its watershed. Successfully implementing this plan requires vigilance, cooperation, and enthusiasm, not only from local management groups, but also from State and regional agencies, Walworth County, municipalities, and Lake residents, Lake users, and the public. Implementation of the recommended measures will provide the water quality and habitat protection necessary to maintain or establish conditions in the watershed that are suitable for maintaining and improving the natural beauty and ambiance of Lake Comus and its ecosystem. This, in turn, benefits the Region today and in the future.

APPENDICES

NATURAL AND STRUCTURAL MEASURES FOR SHORELINE STABILIZATION

APPENDIX A

Natural and Structural Measures for Shoreline Stabilization

Living Shorelines

Innovative approaches are necessary as our coastal communities and shorelines are facing escalating risks from more powerful storms, accelerated sea-level rise, and changing precipitation patterns that can result in dramatic economic losses. While the threats of these events may be inevitable, understanding how to adapt to the impact is important as we explore how solutions will ensure the resilience of our coastal communities and shorelines.

This brochure presents a continuum of green to gray shoreline stabilization techniques, highlighting Living Shorelines, that help reduce coastal risks and improve resiliency though an integrated approach that draws from the full array of coastal risk reduction measures.

Coastal Risk Reduction and Living Shorelines

Coastal Risk Reduction

Coastal systems typically include both natural habitats and man-made structural features. The relationships and interactions among these features are important variables in determining coastal vulnerability, reliability, risk and resilience.

Coastal risk reduction can be achieved through several approaches, which may be used in combination with each other. Options for coastal risk reduction include:

- Natural or nature-based measures: Natural features are created through the action of physical, biological, geologic, and chemical processes operating in nature, and include marshes, dunes and oyster reefs. Nature-based features are created by human design, engineering, and construction to mimic nature. A living shoreline is an example of a nature-based feature.
- Structural measures: Structural measures include sea walls, groins and breakwaters. These features reduce coastal risks by decreasing shoreline erosion, wave damage, and flooding.
- Non-structural measures: Includes modifications in public policy, management practices, regulatory policy and pricing policy (e.g., structure acquisitions or relocations, flood proofing of structures, implementing flood warning systems, flood preparedness planning, establishment of land use regulations, emergency response plans).

The types of risk reduction measures employed depend upon the geophysical setting, the desired level of risk reduction, objectives, cost, reliability, and other factors.

SAGE – Systems Approach to Geomorphic Engineering

USACE and NOAA recognize the value of an integrated approach to risk reduction through the incorporation of natural and nature-based features in addition to non-structural and structural measures to improve social, economic, and ecosystem resilience. To promote this approach, USACE and NOAA have engaged partners and stakeholders in a community of practice called SAGE, or a Systems Approach to Geomorphic Engineering. This community of practice provides a forum to discuss science and policy that can support and advance a systems approach to implementing risk reduction measures that both sustain a healthy environment and create a resilient shoreline.

SAGE promotes a hybrid engineering approach that integrates soft or ‘green’ natural and nature-based measures, with hard or ‘gray’ structural ones at the landscape scale. These stabilization solutions include “living shoreline” approaches which integrate living components, such as plantings, with structural techniques, such as seawalls or breakwaters.

Living Shorelines achieve multiple goals, such as:

- Stabilizing the shoreline and reducing current rates of shoreline erosion and storm damage;
- Providing ecosystem services (such as habitat for fish and other aquatic species) and increasing flood storage capacity; and
- Maintaining connections between land and water ecosystems to enhance resilience.

In order to determine the most appropriate shoreline protection technique, several site-specific conditions must be assessed. The following coastal conditions, along with other factors, are used to determine the combinations of green and gray solutions for a particular shoreline.

REACH: A longshore segment of a shoreline where influences and impacts, such as wind direction, wave energy, littoral transport, etc. mutually interact.

RESILIENCE: The ability to avoid, minimize, withstand, and recover from the effects of adversity, whether natural or man made, under all circumstances of use. This definition also applies to engineering (i), ecological (ii), and community resilience (iii).

FETCH: A cross shore distance along open water over which wind blows to generate waves. For any given shore, there may be several fetch distances depending on predominant wind direction.

PHYSICAL CONDITIONS: The slope of the foreshore or beach face, a geologic condition or bathymetry offshore.

TIDAL RANGE: The vertical difference between high tide and low tide.

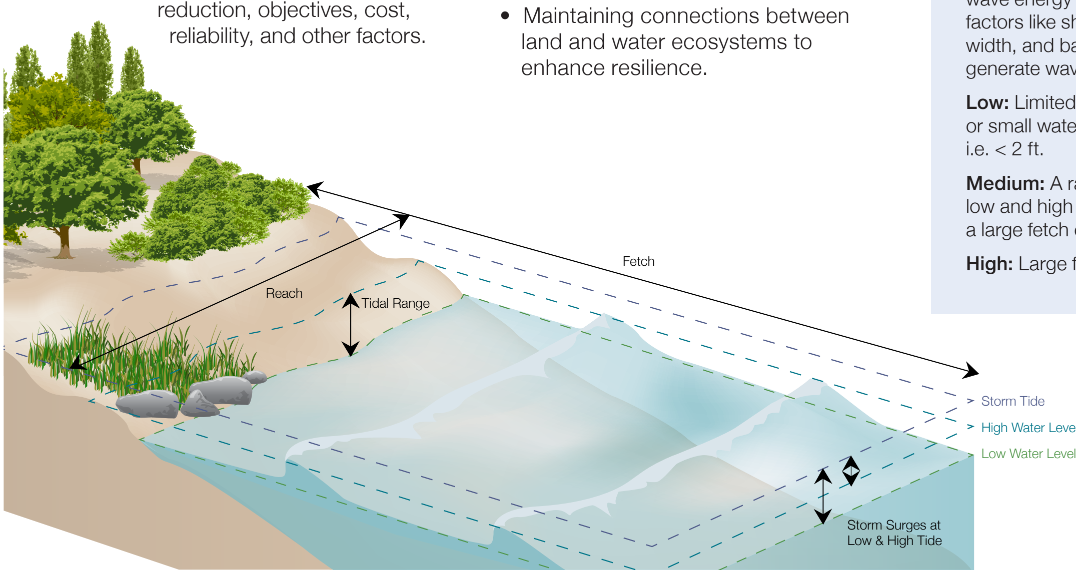
STORM SURGE: The resulting temporary rise in sea level due to the action of wind stress on the water surface and low atmospheric pressure created during storms which can cause coastal flooding. Surge is the difference from expected tide level. Storm tide is the total water level.

WAVE ENERGY: Wave energy is related to wave height and describes the force a wave is likely to have on a shoreline. Different environments will have lower or higher wave energy depending on environmental factors like shore orientation, wind, channel width, and bathymetry. Boat wakes can also generate waves.

Low: Limited fetch in a sheltered, shallow or small water body (estuary, river, bay) i.e. < 2 ft.

Medium: A range that combines elements of low and high energy (e.g., shallow water with a large fetch or partially sheltered) i.e. 2 - 5 ft.

High: Large fetch, deep water (open ocean).



HOW GREEN OR GRAY SHOULD YOUR SHORELINE SOLUTION BE?

GREEN - SOFTER TECHNIQUES
Small Waves | Small Fetch | Gentle Slope | Sheltered Coast

LIVING SHORELINE

VEGETATION ONLY

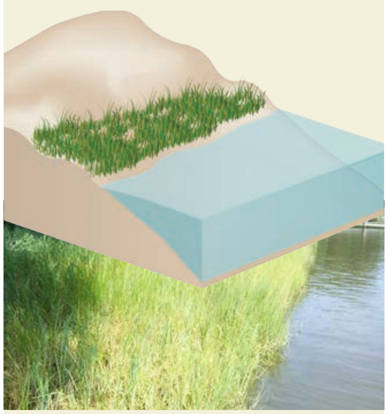


Photo Credit: Maryland Department of Natural Resources - Shoreline Conservation Service

Roots hold soil in place to reduce erosion. Provides a buffer to upland areas and breaks small waves.

Suitable For

Low wave energy environments.

Material Options

- Native plants*

Benefits

- Dissipates wave energy
- Slows inland water transfer
- Increases natural storm water infiltration
- Provides habitat and ecosystem services
- Minimal impact to natural community and ecosystem processes
- Maintains aquatic/terrestrial interface and connectivity
- Flood water storage

Disadvantages

- No storm surge reduction ability
- No high water protection
- Appropriate in limited situations
- Uncertainty of successful vegetation growth and competition with invasive

Initial Construction: ●
Operations & Maintenance: ●

EDGING

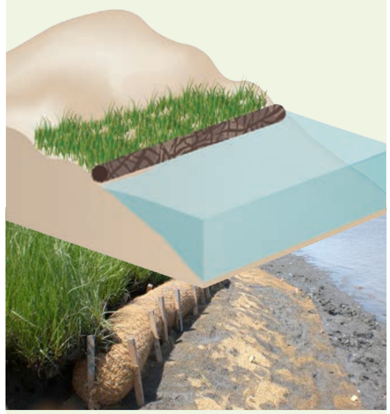


Photo Credit: Partnership for Delaware Estuary

Structure to hold the toe of existing or vegetated slope in place. Protects against shoreline erosion.

Suitable For

Most areas except high wave energy environments.

Vegetation* Base with Material Options

(low wave only, temporary)
- "Snow" fencing
- Erosion control blankets
- Geotextile tubes
- Living reef (oyster/mussel)
- Rock gabion baskets

Benefits

- Dissipates wave energy
- Slows inland water transfer
- Provides habitat and ecosystem services
- Increases natural storm water infiltration
- Toe protection helps prevent wetland edge loss

Disadvantages

- No high water protection
- Uncertainty of successful vegetation growth and competition with invasive

Initial Construction: ●●
Operations & Maintenance: ●

SILLS

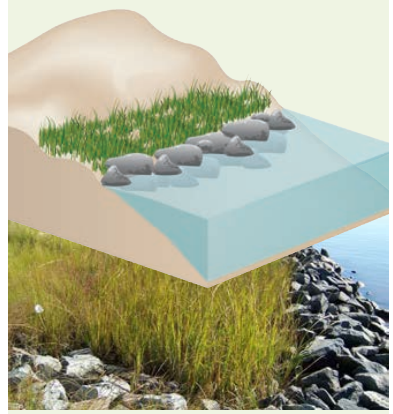


Photo Credit: Maryland Department of Natural Resources - Shoreline Conservation Service

Parallel to existing or vegetated shoreline, reduces wave energy and prevents erosion. A gapped approach would allow habitat connectivity, greater tidal exchange, and better waterfront access.

Suitable For

Most areas except high wave energy environments.

Vegetation* Base with Material Options

- Stone
- Sand breakwaters
- Living reef (oyster/mussel)
- Rock gabion baskets

Benefits

- Provides habitat and ecosystem services
- Dissipates wave energy
- Slows inland water transfer
- Provides habitat and ecosystem services
- Increases natural storm water infiltration
- Toe protection helps prevent wetland edge loss

Disadvantages

- Require more land area
- No high water protection
- Uncertainty of successful vegetation growth and competition with invasive

Initial Construction: ●●
Operations & Maintenance: ●

CONTINUED ON NEXT PAGE

* Native plants and materials must be appropriate for current salinity and site conditions.

Initial Construction: ● = up to $1000 per linear foot, ●● = $1001 - $2000 per linear foot, ●●● = $2001 - $5000 per linear foot, ●●●● = $5001 - $10,000 per linear foot
Operations and Maintenance (yearly for a 50 year project life): ● = up to $100 per linear foot, ●● = $101 - $500 per linear foot, ●●● = over $500 per linear foot

HOW GREEN OR GRAY SHOULD YOUR SHORELINE SOLUTION BE?

GREEN - SOFTER TECHNIQUES

Small Waves | Small Fetch | Gentle Slope | Sheltered Coast

LIVING SHORELINE

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BEACH NOURISHMENT ONLY

Photo Credit: USACE New York District Public Affairs

Large volume of sand added from outside source to an eroding beach. Widens the beach and moves the shoreline seaward.

Suitable For

Low-lying oceanfront areas with existing sources of sand and sediment.

Material Options

- Sand

Benefits

- Expands usable beach area
- Lower environmental impact than hard structures
- Flexible strategy
- Redesigned with relative ease
- Provides habitat and ecosystem services

Disadvantages

- Requires continual sand resources for renourishment
- No high water protection
- Appropriate in limited situations
- Possible impacts to regional sediment transport

Initial Construction: ●●●
Operations & Maintenance: ●●

BEACH NOURISHMENT & VEGETATION ON DUNE

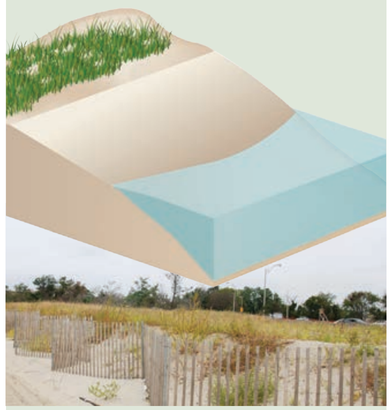

Photo Credit: USACE New York District Public Affairs

Helps anchor sand and provide a buffer to protect inland area from waves, flooding and erosion.

Suitable For

Low-lying oceanfront areas with existing sources of sand and sediment.

Material Options

Sand with vegetation
Can also strengthen dunes with:

- Geotextile tubes
- Rocky core

Benefits

- Expands usable beach area
- Lower environmental impact
- Flexible strategy
- Redesigned with relative ease
- Vegetation strengthens dunes and increases their resilience to storm events
- Provides habitat and ecosystem services

Disadvantages

- Requires continual sand resources for renourishment
- No high water protection
- Appropriate in limited situations
- Possible impacts to regional sediment transport

Initial Construction: ●●●
Operations & Maintenance: ●●

Initial Construction: ● = up to $1000 per linear foot, ●● = $1001 - $2000 per linear foot, ●●● = $2001 - $5000 per linear foot, ●●●● = $5001 - $10,000 per linear foot
Operations and Maintenance (yearly for a 50 year project life): ● = up to $100 per linear foot, ●● = $101 - $500 per linear foot, ●●● = over $500 per linear foot

4

HOW GREEN OR GRAY SHOULD YOUR SHORELINE SOLUTION BE?

GRAY - HARDER TECHNIQUES

Large Waves | Large Fetch | Steep Slope | Open Coast

COASTAL STRUCTURE

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BREAKWATER

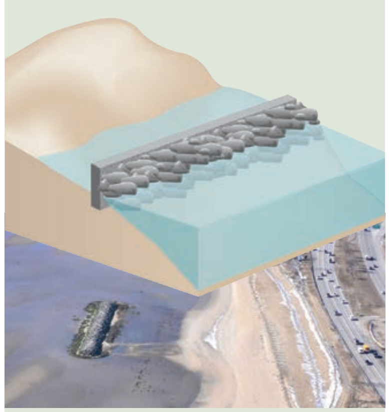

Photo Credit: USACE New York District Public Affairs

Offshore structures intended to break waves, reducing the force of wave action and encourages sediment accretion. Can be floating or fixed to the ocean floor, attached to shore or not, and continuous or segmented. A gapped approach would allow habitat connectivity, greater tidal exchange, and better waterfront access.

Suitable For

Most areas except high wave energy environments often in conjunction with marinas.

Material Options

- Grout-filled fabric bags
- Armorstone
- Pre-cast concrete blocks
- Living reef (oyster/mussel) if low wave environment
- Wood
- Rock‡

Benefits

- Reduces wave force and height
- Stabilizes wetland
- Can function like reef
- Economical in shallow areas
- Limited storm surge flood level reduction

Disadvantages

- Expensive in deep water
- Can reduce water circulation (minimized if floating breakwater is applied)
- Can create navigational hazard
- Require more land area
- Uncertainty of successful vegetation growth and competition with invasive
- No high water protection
- Can reduce water circulation
- Can create navigation hazard

GROIN

Photo Credit: USACE New York District Public Affairs

Perpendicular, projecting from shoreline. Intercept water flow and sand moving parallel to the shoreline to prevent beach erosion and break waves. Retain sand placed on beach.

Suitable For

Coordination with beach nourishment.

Material Options

- Concrete/stone rubble‡
- Timber
- Metal sheet piles

Benefits

- Protection from wave forces
- Methods and materials are adaptable
- Can be combined with beach nourishment projects to extend their life

Disadvantages

- Erosion of adjacent sites
- Can be detrimental to shoreline ecosystem (e.g. replaces native substrate with rock and reduces natural habitat availability)
- No high water protection

‡ Rock/stone needs to be appropriately sized for site specific wave energy.

GRAY CAN BE GREENER: e.g., 'Living Breakwater' using oysters to colonize rocks or 'Greenwall/Biowall' using vegetation, alternative forms and materials

Breakwater — Initial Construction: ●●●● Operations & Maintenance: ●●●

Groin — Initial Construction: ●●● Operations & Maintenance: ●●

Initial Construction: ● = up to $1000 per linear foot, ●● = $1001 - $2000 per linear foot, ●●● = $2001 - $5000 per linear foot, ●●●● = $5001 - $10,000 per linear foot
Operations and Maintenance (yearly for a 50 year project life): ● = up to $100 per linear foot, ●● = $101 - $500 per linear foot, ●●● = over $500 per linear foot

HOW GREEN OR GRAY SHOULD YOUR SHORELINE SOLUTION BE?

GRAY - HARDER TECHNIQUES

Large Waves | Large Fetch | Steep Slope | Open Coast

COASTAL STRUCTURE

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REVETMENT

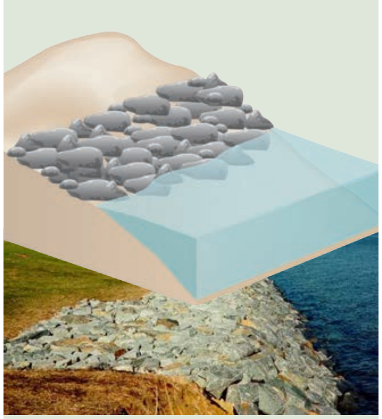

Photo Credit: Maryland Department of Natural Resources - Shoreline Conservation Service

Lays over the slope of a shoreline. Protects slope from erosion and waves.

Suitable For

Sites with pre-existing hardened shoreline structures.

Material Options

- Stone rubble†
- Concrete blocks
- Cast concrete slabs
- Sand/concrete filled bags
- Rock-filled gabion basket

Benefits

- Mitigates wave action
- Little maintenance
- Indefinite lifespan
- Minimizes adjacent site impact

Disadvantages

- No major flood protection
- Require more land area
- Loss of intertidal habitat
- Erosion of adjacent unreinforced sites
- Require more land area
- No high water protection
- Prevents upland from being a sediment source to the system

† Rock/stone needs to be appropriately sized for site specific wave energy.

Initial Construction: ●●●●
Operations & Maintenance: ●●

BULKHEAD

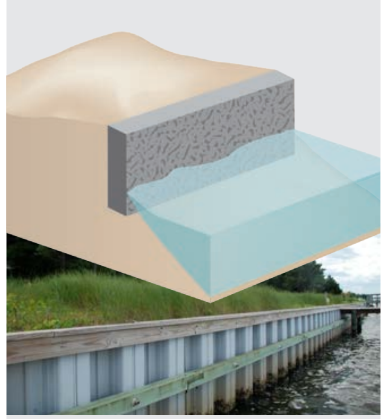

Photo Credit: North Carolina Department of Environment and Natural Resources

Parallel to the shoreline, vertical retaining wall. Intended to hold soil in place and allow for a stable shoreline.

Suitable For

High energy settings and sites with pre-existing hardened shoreline structures. Accommodates working water fronts (eg: docking for ships and ferries).

Material Options

- Steel sheet piles
- Timber
- Concrete
- Composite carbon fibers
- Gabions

Benefits

- Moderates wave action
- Manages tide level fluctuation
- Long lifespan
- Simple repair

Disadvantages

- No major flood protection
- Erosion of seaward seabed
- Erosion of adjacent unreinforced sites
- Loss of intertidal habitat
- May be damaged from overtopping oceanfront storm waves
- Prevents upland from being a sediment source to the system
- Induces wave reflection

Initial Construction: ●●●
Operations & Maintenance: ●●

SEAWALL

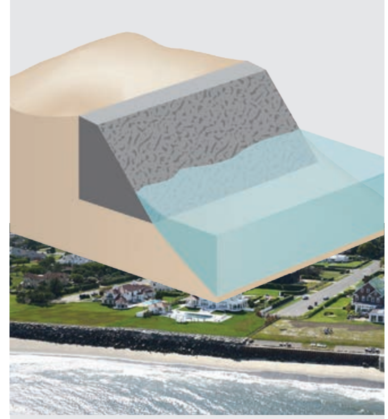

Photo Credit: USACE New York District Public Affairs

Parallel to shoreline, vertical or sloped wall. Soil on one side of wall is the same elevation as water on the other. Absorbs and limits impacts of large waves and directs flow away from land.

Suitable For

Areas highly vulnerable to storm surge and wave forces.

Material Options

- Stone
- Rock
- Concrete
- Steel/vinyl sheets
- Steel sheet piles

Benefits

- Prevents storm surge flooding
- Resists strong wave forces
- Shoreline stabilization behind structure
- Low maintenance costs
- Less space intensive horizontally than other techniques (e.g. vegetation only)

Disadvantages

- Erosion of seaward seabed
- Disrupt sediment transport leading to beach erosion
- Higher up-front costs
- Visually obstructive
- Loss of intertidal zone
- Prevents upland from being a sediment source to the system
- May be damaged from overtopping oceanfront storm waves

Initial Construction: ●●●●
Operations & Maintenance: ●●●

GRAY CAN BE GREENER: e.g., 'Living Breakwater' using oysters to colonize rocks or 'Greenwall/Biowall' using vegetation, alternative forms and materials

Initial Construction: ● = up to $1000 per linear foot, ●● = $1001 - $2000 per linear foot, ●●● = $2001 - $5000 per linear foot, ●●●● = $5001 - $10,000 per linear foot 6
Operations and Maintenance (yearly for a 50 year project life): ● = up to $100 per linear foot, ●● = $101 - $500 per linear foot, ●●● = over $500 per linear foot

Is a Living Shoreline a Good Fit for What I Need?

Living Shorelines achieve multiple goals such as:

- Stabilizing the shoreline and reducing current rates of shoreline erosion and storm damage
- Providing ecosystem services, such as habitat for fish and other aquatic species and increasing flood storage capacity
- Maintaining connections between land and water ecosystems to enhance resilience

Site-specific conditions will influence your choice of shoreline protection technique (ex: wave energy level, fetch lengths, rate and pattern of erosion, etc). Here are some additional factors to keep in mind as you consider Living Shorelines.

WHAT ARE THE BENEFITS?

- Erosion control and shore stabilization.
- Restored and enhanced habitat which supports fish and wildlife populations.
- Increased property values.
- Enhanced community enjoyment.
- Opportunities for education.
- Improved public access to waterfront through recreational activities such as fishing, boating and birding. Can be used to satisfy zoning and permitting requirement for waterfront development projects.
- Complemented natural shoreline dynamics & movement; increased resilience and absorption of wave energy, storm surge and floodwaters; and an adaptive tool for preparation of sea level rise.
- Improved water quality from settling or trapping sediment (e.g. once established, a marsh can filter surface water runoff or oysters can provide coastal water filtration).

WHAT ARE SOME CHALLENGES?

- Uncertainty in risk because of lack of experience of techniques.
- Public funds are often tied to government permit compliance.
- Permitting processes can be lengthy and challenging. The existing regulatory process is centered on traditional "gray" or "hard" techniques. Regulators and project sponsors alike are learning how to design living shorelines projects. Talk with someone about your state's permitting process or to hear about their experiences.
- It takes time to develop and test new shoreline protection methods.
- There may be land ownership constraints. Consider where federal and state jurisdiction for the water body starts and ends.
- In urban environments, there is limited land (bulkheads may seem like the only option), a variety of upland uses (industrial past use may have left legacy contaminants) and high velocity waters.
- The overall sediment system needs to be taken into account to protect neighboring properties from experiencing starved down drift shorelines or other consequences as a result of a project.
- Lack of public awareness of performance and benefits of living shorelines.
- Not all techniques have the same level of performance or success monitoring. Less practiced techniques may require more monitoring.

WHAT INFLUENCES COST?

- The materials chosen for the project influence cost.
- Including green techniques can be cheaper than traditional gray techniques.
- Sometimes it's possible to install the project yourself, other times you will need help from a professional.
- Long term maintenance is required as any landscape project (e.g. replanting may be needed after a storm).

HOW TO FIND OUT MORE

If you have a Living Shorelines permitting question, contact your state's office of Environmental Protection, Conservation or Natural Resources, your coastal zone manager such as your state's Department of State, as well as your local U.S. Army Corps of Engineers (USACE) district office.

If you would like science or engineering advice, or to talk to people who have experience studying or constructing living shorelines, reach out to some of the following: your local universities, your City's Department of Planning and Department of Parks, Sea Grant Chapter, Littoral Society, The Nature Conservancy, The Trust for Public Land, The Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), USACE, engineering firms and other organizations that focus on your local waterfront.

These and other websites are good references to learn more about Living Shorelines:

SAGE
www.SAGEcoast.org

NOAA Restoration
www.habitat.noaa.gov/livingshorelines

USACE Engineer Research Development Center, Engineering with Nature
el.erdc.usace.army.mil/ewn

USACE North Atlantic Division, National Planning Center of Expertise for Coastal Storm Damage Reduction
www.nad.usace.army.mil/About/NationalCentersofExpertise/CoastalStormDamageReduction(Planning).aspx

Virginia Institute of Marine Science (VIMS) Center for Coastal Resources Management
ccrm.vims.edu/livingshorelines/index.html

Coasts, Oceans, Ports & Rivers Institute (COPRI)
www.mycopri.org/livingshorelines

The Nature Conservancy
www.nature.org/ourinitiatives/habitats/oceanscoasts/howwework/helping-oceans-adapt-to-climate-change.xml

NOAA

US Army Corps of Engineers®

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PUBLIC COMMENTS
APPENDIX B

[To be written following Public Comments]