COMMUNITY ASSISTANCE
PLANNING REPORT NO. 320

Preliminary Draft

JACKSON CREEK WATERSHED PROTECTION PLAN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

KENOSHA COUNTY

Adelene Greene, Secretary
Robert W. Pitts
Michael J. Skalitzky

RACINE COUNTY

Mike Dawson
David L. Eberle
Peggy L. Shumway

MILWAUKEE COUNTY

Marina Dimitrijevic
Brian R. Dranzik
William R. Drew, Treasurer

WALWORTH COUNTY

Charles L. Colman, Vice Chairman
Nancy Russell
Linda J. Seemeyer

OZAUKEE COUNTY

Thomas H. Buestrin
David W. Opitz
Gus W. Wirth, Jr.

WASHINGTON COUNTY

Daniel S. Schmidt
Daniel W. Stoffel
David L. Stroik, Chairman

WAUKESHA COUNTY

Michael A. Crowley
José M. Delgado
James T. Dwyer

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION STAFF

Kenneth R. Yunker, PE .... Executive Director
Michael G. Hahn, PE, PH ....Deputy Director
Elizabeth A. Larsen, SPHR .... Assistant Director–Administration
Stephen P. Adams ....Public Involvement and Outreach Manager
Nancy M. Anderson, AICP .... Chief Community Assistance Planner
Christopher T. Hiebert, PE. .... Chief Transportation Engineer
Laura L. Kletti, PE, CFM......................... Chief Environmental Engineer
John G. McDougall ....Geographic Information Systems Manager
David A. Schilling.............................. Chief Land Use Planner
Dr. Thomas M. Slawski ....Chief Biologist

Special acknowledgment is due to Mr. Aaron W. Owens, SEWRPC Planner, Ms. Megan A. Beauchaine, SEWRPC Research Analyst, and Maggie Zoeliner, Kettle Moraine Land Trust, for their contributions to the conduct of this study and the preparation of this report.

JACKSON CREEK WATERSHED PROTECTION PLAN WORKING GROUP

Peter Berrini, Town of Delavan, Consultant

Andrew Craig, Wisconsin Department of Natural Resources

Jim Deluca, Delavan Lake Sanitary District

Mike Gilbertson, Wisconsin Department of Natural Resources

Kate and Marc Grabow, Land Owner

Brad Huza, Walworth County Metropolitan Sewage District

Mary Knipper, Wisconsin Lakes

Lars Olson, NRCS Walworth County

John Olson, Town of Delavan

Dave Patzelt, Sho-Deen Corporation

Jerry Petersen, Kettle Moraine Land Trust

Mark Riedel, Wisconsin Department of Natural Resources

Rachel Sabre, Wisconsin Department of Natural Resources

Ryan Simons, Town of Delavan Chair

Brian Smetana, Walworth County Land Use and Resource Management

JACKSON CREEK WATERSHED PROTECTION PLAN TECHNICAL ASSISTANCE

Mark Steinfest, U.S. Department of Agriculture, National Resources Conservation Service

Nancy Sheehan, Rock River Coalition

Matt Komiskey, U.S. Geological Survey

Tim Lizotte, Wisconsin Department of Natural Resources

Brian Smetana, Walworth County LURM

Andy Yencha, University of Wisconsin Extension

Maggie Zoellner, Kettle Moraine Land Trust

The photographs on the front cover taken by Maggie Zoellner, Kettle Moraine Land Trust, Inc. include the field inspection by NRCS staff for residue management in June 2011 and WDNR fisheries backpack electrofishing survey in 2013. The rainbow darter fish photo was provided by John Lyons, WDNR. The aerial photo was taken by the Delavan Lake Sanitary District after a storm event on June 13, 2008, in the lower part of the Jackson Creek watershed.

Jackson Creek Watershed Protection Plan

Executive Summary

The Jackson Creek watershed is a subwatershed of the Rock River watershed located in Walworth County. Jackson Creek discharges into Delavan Lake, draining approximately 13,773 acres. Historically, the watershed basin was once dominated by oak savanna and significant amounts of wetland and prairie plant communities. Europeans began to settle in the area in the mid-1800s, primarily where the City of Elkhorn is now located. The settlers quickly began farming the high-quality soil, which resulted in the clearing of forests and natural areas and draining of wetlands. Over time, farming and associated stream channelization in the watershed has greatly impacted the water quality and wildlife in this ecosystem.

The Jackson Creek watershed has been identified as a significant contributor of sediment and phosphorus to the Rock River. And although Jackson Creek is not currently identified as impaired, it is a tributary to Turtle Creek, which has been listed as an impaired waterway by the U.S. Environmental Protection Agency (USEPA) and Wisconsin Department of Natural Resources (WDNR). Excessive sediment and nutrient loading to Delavan Lake have led to increased algal blooms, oxygen depletion, and water clarity issues that have been periodically documented since the WDNR's Turtle Creek Priority Watershed Plan in 1984. Excessive sediment and nutrient loading to the Rock River also has led to more algal blooms, oxygen depletion, and water clarity issues, and degraded habitat in the Rock River basin, prompting the need for action to be taken in that watershed. (Total maximum daily load, or TMDL, requirements for phosphorus and sediment were approved for the Rock River basin and its tributaries in 2011.)

In the 1990s, a significant amount of the nonpoint source loads of phosphorus and sediment to Delavan Lake were found to be coming from the Jackson Creek watershed. This prompted the need for local units of government and organizations to partner with State and Federal agencies to improve the water quality in the Lake and watershed. Although these efforts have been extensive, the water quality in Delavan Lake and Jackson Creek continue to be cause for concern. In response, the Kettle Moraine Land Trust engaged the Southeastern Wisconsin Regional Planning Commission (SEWRPC) to

The northern pike is a high-quality coolwater gamefish species. Jackson Creek provides miles of excellent potential spawning habitat and seasonally flooded/ submerged emergent stream side vegetation.

The challenge in this watershed is in developing more opportunities for conservation projects, installing more creative best management practices (BMPs), and ensuring the longevity and effectiveness of practices once BMPS are installed.

"The rainbow darter is an exquisitely beautiful inhabitant of clean gravelly streams… extremely sensitive to chemical pollution and silting." *- Scott and Crossman 1973*

Fish and wildlife that inhabit a watershed are a direct reflection of water quality and Jackson Creek hosts an excellent coolwater fish community!

Load reduction goals for the Jackson Creek watershed are to reduce phosphorus by 49% and suspended sediment by 25%.

develop the Jackson Creek Watershed Protection Plan in cooperation with the Delavan Lake Improvement Association, Delavan Lake Watershed Initiative Network, Delavan Lake Sanitary District, and the University of Wisconsin Extension.

Jackson Creek Watershed

Despite the agricultural land use impacts in the watershed, Jackson Creek continues to be able to sustain a fair- to high-quality macroinvertebrate (aquatic bugs) and fishery community, which is likely supported by a combination of groundwater discharge and its proximity/connection to Delavan Lake. In addition, where wetland has been preserved and/or restored (as in Kettle Moraine Land Trust's Jackson Creek Preserve), both aquatic and terrestrial species diversity and abundance have increased. This demonstrates the resiliency of this river system and indicates its capacity to improve, provided that it is protected to the extent possible.

The better this system is allowed to function, the better it will be at assimilating and reducing nutrient loads, protecting infrastructure from flooding, maintaining shallow aquifer water levels for drinking water supplies, and maintaining or improving water quality for recreation and the protection of property values. For example, re-meandering previously straightened/ditched sections of stream increases the total length of the stream channel, allowing for a greater capacity to assimilate nutrient loads and reducing the overall slope, thereby decreasing the potential for streambank erosion.

The Jackson Creek Watershed Protection Plan provides a framework for communities in the watershed area to work together on a common mission: to protect and improve the land and water resources of the Jackson Creek watershed and to meet the assigned TMDL requirements. The protection plan is designed to be a practical guide for the management of water quality within the Jackson Creek watershed and the management of land surfaces that drain directly and indirectly to the stream—and consequently to downstream reaches including Delavan Lake and Turtle Creek, and ultimately, the Rock River.

The watershed protection plan has the following goals:

- Minimize the further degradation of surface water and preserve, restore and maintain the high quality of all waterbodies within the watershed
- Identify opportunities to improve the quality of the land and water (including groundwater) resources within the watershed by reducing both nonpoint agricultural and urban runoff.
- Manage and develop lands in a manner that is consistent with the protection of living resources: avoid habitat fragmentation and encourage the preservation and enhancement of wetlands and wildlife corridors including connections with upland habitats and through sensitive landscaping practices
- Promote active stewardship among residents, farmers, businesses, community associations, as well as governmental and non-governmental organizations

Challenges and Sources in the Jackson Creek Watershed

As the dominant land use in the area, agriculture is responsible for over 85 percent of the sediment and phosphorus loading in the watershed. Prairie, woodland, and wetland have been cleared and drained over the past 100 years to increase agricultural production. Recent high land values and agricultural land rental rates due to competition with urban development and farm expansion in the watershed have significantly contributed to the amount of natural areas lost. Some standard farming practices are now known to contribute significant sediment loads to the watershed in certain circumstances.

Jackson Creek confluence with the Delavan Lake inlet at the Mound Road USGS gaging weir outlet during base-flow conditions. *July 23, 2012*

Although evolving farming practices elsewhere address soil erosion and soil health concerns with cover crops, residue management, and row crop rotation, in the Jackson Creek watershed (as in the majority of other watersheds in Wisconsin), these practices are not yet widely established. Limited funds to support the implementation of emerging farming practices further hinders movement toward these promising solutions to excessive nutrient loads in the watershed.

Delavan Lake Inlet (looking south on Mound Road) downstream of the Mound Road USGS gaging weir outlet. *July 23, 2012*

Instead, a focus on the maximum production of all available acreage, combined with the use of erosion-prone farming practices and limited funding to implement best management practices, has led to significant sediment and nutrient loss from agricultural land in the area. Increased drainage and flooding, particularly within channelized portions of the stream network, have also resulted in moderate to severe erosion of streambanks. It should be noted, however, that due to the high level of hydric soils being farmed, sediment and phosphorus loading from gullies (concentrated flow areas within agricultural fields) is contributing a greater portion of the total loads in this basin than streambank erosion.

The challenge in this watershed is not a lack of awareness. Many farmers are aware of the water quality issues and the need for conservation practices and sustainable land use management. In fact, the majority of the landowners in the watershed have worked with and are aware of County and Federal conservation programs and best management practices (BMPs), but significantly greater pollutant load reductions are needed to meet water quality criteria. To accomplish this, implementation of BMPs need to be expanded to address a greater proportion of the agricultural land area. The challenge in this watershed is threefold: to develop more opportunities for conservation projects, to install more BMPs, and to ensure the longevity and effectiveness of these projects and practices once they are implemented.

Agricultural Best Management Practices
Source: USDA, NRCS

Although urban development comprises only about 18 percent of the Jackson Creek watershed, development has been steadily increasing, with specific expansion emanating from the Cities of Elkhorn and Delavan. For example, the City of Elkhorn was recently required by WDNR to obtain a municipal separate storm sewer system (MS4) permit for stormwater management based upon meeting the 10,000-person population threshold. Although the urbanizing areas are not contributing a large proportion of the current total pollutant loads in the watershed, they are expected to continue to expand. In the absence of mitigation measures, continuing urbanization will fundamentally change the nature of pollutant loads and the hydrology in the watershed by increasing flashiness and the potential for more flooding. Green infrastructure projects (green roofs, porous pavement, rain gardens, and bioswales), the protection of floodplains from encroachment, the establishment of riparian buffers, the preservation of groundwater recharge areas, and stormwater infiltration practices are vital to mitigating negative impacts to water quality and wildlife in the watershed. These measures will need to be incorporated into the Jackson Creek watershed protection planning program as the watershed continues to become more urbanized.

Watershed Protection Plan Elements

A 10-year implementation plan was developed to meet water quality goals for the watershed. The plan recommends best management practices, information and education activities, and restoration practices, and lists the estimated costs, potential funding sources, agencies responsible for implementation, and measures to gauge its success.

Streambank erosion occurring in Jackson Creek.
June 4, 2013

Recommended Priority Management Practices

Agricultural BMPs Applied to Cropland
- No till
- Cover crops
- Nutrient management planning
- Grassed waterways
- Wetland buffers/restoration

Urban BMPs
- Stormwater runoff management
- Green infrastructure/Low Impact Development

Education and Information Recommendations

- Provide educational workshops and tours focusing on how to implement best management practices that include underutilized erosion control practices. Share emerging practices in the areas of cover crop management, no-till methods, and nutrient management planning.
- Engage landowners in planning and implementing conservation practices and provide them with information about technical tools and financial support.
- Promote engagement by the farming community in decision making and equip farmers with water quality monitoring tools and methods.
- Target action-oriented messages about water quality and conservation practices to riparian, resident, and non-resident agricultural landowners, and to elected officials and the general public.
- Produce and distribute newsletters, exhibits, fact sheets, and/or web content that includes watershed project updates and conservation-related information.

Conclusion

The Jackson Creek watershed embodies significant aesthetic and ecological values and has the potential to be a more diverse and resilient aquatic and terrestrial ecosystem in the future. The attributes that make Jackson Creek and its watershed unique are the same attributes that attract residents, businesses, and supporting infrastructure to the watershed and which are necessary for a healthy local economy. Therefore, meeting the goals of the Jackson Creek Watershed Protection Plan will lead to improved water quality and quantity for human needs and will help improve and preserve the hydrologic and ecological integrity of the water system. This, in turn, will also lead to a healthier and more resilient local economy.

Field erosion and concentrated flows discharging into Jackson Creek during a storm event.
April 19, 2011 (Maggie Zoellner photo)

Meeting the goals for the Jackson Creek watershed will be challenging. Watershed planning and implementation is primarily a voluntary effort, with limited enforcement for "non-compliant" sites. The effort will need to be supported with targeted technical and financial assistance. It will require a commitment of the ***entire community*** in the Jackson Creek, Delavan Lake, Turtle Creek, and Rock River areas to improve the water quality and condition of the watershed. The plan must be adaptable to the challenges, changes, and lessons learned by all.

SEWRPC Community Assistance Planning Report No. 320

JACKSON CREEK WATERSHED PROTECTION PLAN

Chapter I

WATERSHED SETTING AND CHARACTERISTICS

WATERSHED SETTING

Jackson Creek is a 21.5-square mile (13,773-acre) watershed situated entirely within Walworth County. Jackson Creek discharges directly into Delavan Lake, which is a 2,072-acre drainage lake, and then flows into Turtle Creek, which is a major subwatershed of the Rock River watershed. Jackson Creek is about six miles long and has several small (perennial and intermittent) tributaries that flow into it. Due to its proximity and connection with Delavan Lake, this watershed offers a variety of water-based recreational opportunities and has been a focus of the community surrounding the Lake. The southwestern portion of the watershed includes the inlet of Delavan Lake. The watershed includes portions of the Cities of Delavan and Elkhorn and the Towns of Delavan, Geneva, Lafayette, and Sugar Creek as shown on Map I-1. A small part of the Geneva National Golf Club also lies in the southern portion of the watershed.

PURPOSE OF THE PLAN

The Kettle Moraine Land Trust received Wisconsin Department of Natural Resources (WDNR) funding through the Chapter NR 195 River Planning and Management Grant Program to complete this Protection Plan for the Jackson Creek watershed. This planning effort was conducted cooperatively and involved the U.S. Environmental Protection Agency (USEPA), the Natural Resources Conservation Service (NRCS), WDNR, University of Wisconsin-Extension, Walworth County Land Use and Resource Management (LURM) Department, Delavan Lake Sanitary District, Delavan Lake Improvement Association, Walworth County Metropolitan (WalCoMet) Sewerage District, City of Elkhorn, the Town of Delavan, Kettle Moraine Land Trust, and the Southeastern Wisconsin Regional Planning Commission (SEWRPC).

This plan was also prepared in cooperation with representatives from the ad hoc Jackson Creek Watershed Protection Plan Advisory Group (see Appendix A). The Advisory Group was comprised of self-nominated individuals representing a range of stakeholders with interests in the Jackson Creek watershed who volunteered their time to meet and review portions of the plan. The Advisory Group represents a diversity of interests and perspectives both within and downstream of the watershed, including stream and lake residents, and County and local government staff as shown in Figure I-1. From 2012 through 2015, participants in the Advisory Group either attended one or more of the several meetings or provided electronic mail correspondence to define issues, develop goals, and establish recommendations for this plan. It is important to note that the plan goals, which were based upon the feedback provided by the Advisory Group, form the foundation for generating and evaluating the alternative and recommended plans, and for establishing a sound framework within which to implement the recommendations.

The purpose of this plan is to provide a framework to enable communities in the area to work together with a common mission: *to protect and improve the land and water resources of the Jackson Creek watershed*. This watershed protection plan focuses on what can be done to continue to *protect* the existing high-quality resources from human impacts and *prevent* future water pollution or resource degradation from occurring by implementing the following general goals:

- Minimize the further degradation of surface water and preserve, restore, and maintain the high quality of all waterbodies within the watershed.
- Identify opportunities to improve the quality of the land and water (including groundwater) resources within the watershed by reducing both nonpoint agricultural and urban runoff.
- Manage and develop lands in a manner that is consistent with the protection of living resources: avoid habitat fragmentation and encourage the preservation and enhancement of wetlands and wildlife corridors including providing and preserving connections with upland habitats and through sensitive landscaping practices.
- Promote active stewardship among residents, farmers, landowners, businesses, community associations, as well as governmental and non-governmental organizations.

Excessive sediment and nutrient loading to Delavan Lake has led to increased algal blooms, oxygen depletion, and water clarity issues, which has been documented since the 1980s as part of the original Turtle Creek Priority Watershed Planning efforts by the WDNR. In the 1990s it was substantiated that a significant amount of the nonpoint source loads (i.e., phosphorus and sediment) to Delavan Lake were coming from the Jackson Creek watershed. This prompted the need for action to be taken by local units of government and organizations in partnership with State and Federal agencies to improve water quality in both Delavan Lake and in the Jackson Creek watershed. These efforts have been extensive, but community concerns regarding the state of Delavan Lake and Jackson Creek remain. As a result, the Jackson Creek Watershed Protection plan was developed.

More recently, 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 a local economy. Estimated annual economic losses due to eutrophication in the United States are as follows: recreation ($1 billion), waterfront property value ($0.3-2.8 million), recovery of threatened and endangered species ($44 million), and drinking water ($813 million).[1] Although Jackson Creek is not currently identified as impaired, both Jackson Creek and Delavan Lake were recently added to the *WDNR's proposed 2016 list of impaired waters*, due to total phosphorus pollutant loads. In addition, this stream is a tributary to Turtle Creek, which was listed as an impaired waterway by the USEPA and WDNR in 2012 (see Map I-2). Due to the impairments of the Rock River Basin, a TMDL (Total Maximum Daily Load) study for phosphorus and sediment was developed for the Rock River basin and its tributaries and was approved in 2011.[2] Under that study, the Jackson Creek subwatershed was identified as a significant contributor of sediment and phosphorus to the Rock River. Hence, this plan is designed with a 10-year timeframe and is intended to address phosphorus and sediment load reductions consistent with the TMDL load and wasteload allocations established for Turtle Creek and the Rock River. The Rock River TMDL requires that any tributaries to Turtle Creek meet a median summer total phosphorus limit of 0.075 mg/l or less and a median summer total suspended solids concentration of 26 mg/l or less. According to the Rock River TMDL, achieving those instream concentrations would require this 49 percent and 25 percent reductions in nonpoint source loads of phosphorus and total suspended solids, respectively, from lands tributary to the impaired reach of Turtle Creek, which includes the Jackson Creek subwatershed.

This watershed protection plan has been prepared to meet the USEPA nine minimum elements for a watershed based plan (see USEPA Watershed Plan Requirements sections below). This protection plan is also designed to serve as a practical guide for the management of water quality within the Jackson Creek watershed and for the management of the land surfaces that drain directly and indirectly to the stream, and downstream reaches including Delavan Lake, Turtle Creek, and, ultimately, the Rock River.

---

[1] *Dodds, W.K., W.W. Bouska, J.L. Eitzman, T.J. Pilger, K.L. Pitts, A.J. Riley, J.T. Schoesser, and D.J. Thornbrugh., Eutrophication of U. S. freshwaters: analysis of potential economic damages, Environmental Science and Technology 43: 12-19, 2009.*

[2] *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.*

USEPA Watershed Plan Requirements

In 1987, Congress enacted the Section 319 of the Clean Water Act which established a national program to control nonpoint sources of water pollution. Section 319 grant funding is available to states, tribes, and territories for the restoration of impaired waters and to protect unimpaired/high quality waters. Watershed plans funded by Clean Water Act section 319 funds must address nine key elements that the USEPA has identified as critical for achieving improvements in water quality.[3] In addition, projects implemented using Federal funds provided under Section 319 of the Clean Water Act must directly implement a watershed-based plan that USEPA has determined to be consistent with the nine elements. Thus, a finding of consistency with the nine elements is a significant benefit to implementation of the plan in that it would make projects recommended under the plan eligible for Federal funding. The nine elements from the USEPA Nonpoint Source Program and Grants Guidelines for States and Territories are as follows:

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

2. Estimates of the load reductions expected from management measures.

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

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

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

6. A reasonably expeditious schedule for implementing the nonpoint source management measures identified in this plan.

---

[3]*U.S. Environmental Protection Agency (USEPA),* Handbook for Developing Watershed Plans to Restore and Protect Our Waters*, USEPA 841-B-08-002, March 2008.*

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

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

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

PRIOR STUDIES, PROJECTS, AND EXISTING RESOURCE MANAGEMENT AND COMPREHENSIVE PLANS

Various studies have already been completed describing and analyzing conditions in the Jackson Creek watershed and nearby areas, and including management and comprehensive plans and monitoring programs. .

Priority Watershed Study

- *Turtle Creek Priority Watershed Plan, WDNR, March 1984;*
- *Turtle Creek Priority Watershed Plan Amendment-The Delavan Lake Restoration Project,* WDNR, August 1989*; and,*
- *Turtle Creek Priority Watershed Bioassessment Final Report,* WDNR Publication No. PUBL- WR-359 94, 1994.

These plans identified the original goals for nutrient reduction and set the stage for implementation of intense in-lake rehabilitation management measures within Delavan Lake and measures for the creation of the series of wetland detention basins in the lower portion of Jackson Creek.

Delavan Lake and Jackson Creek Wetland Studies

- *Delavan Lake: A Recovery and Management Study*, University of Wisconsin-Madison, Institute for Environmental Studies, September 1986;
- *Environmental Impact Statement on the Delavan Lake Rehabilitation Project*, Walworth County, Wisconsin, March 1989, WDNR;
- *Rehabilitation of Delavan Lake, Wisconsin,* Dale M. Robertson, Gerald L. Goddard, Daniel R. Helsel, and Kevin L. MacKinnon, Lake and Reservoir Management, Vol. 16, No. 3, pp. 155-176, 2000; and, *Phosphorus Dynamics in Delavan Lake Inlet, Southeastern Wisconsin,* U.S. Geological Survey Water-Resources Investigations Report No. 96-4160, 1994, 1996;

- *Retention of Sediments and Nutrients in Jackson Creek Wetland near Delavan Lake, Wisconsin, 1993-1995,* G.L. Goddard and J.F. Elder, U.S. Geological Survey Water-Resources Investigations Report No. 97-4014, 1997; and
- *Sediment and Nutrient Trapping Efficiency of a Constructed Wetland near Delavan Lake, Wisconsin, 1993-1995,* J.F. Elder and G.L. Goddard, U.S. Geological Survey Fact Sheet FS-232-96, 1996.

The major structural work undertaken as part of the Delavan Lake restoration and rehabilitation program (as set forth in the reports referenced above) that impacted Jackson Creek includes the construction of a wetland detention basin system situated upstream of the Lake Inlet on Jackson Creek and installation of monitoring gages. This project, which was completed in 1992, was designed to intercept and retain nonpoint source nutrient loads from Jackson Creek and two main unnamed tributaries and associated area tributary to the Lake. Since 1995, the Town of Delavan has undertaken additional programs to evaluate water quality conditions and identify specific refinements to the management measures designed to improve the water quality and recreational use potential of Delavan Lake. The Lake has been enrolled in the WDNR Self-Help Monitoring Program, and the USGS has monitored water quality in both Delavan Lake and Jackson Creek almost continually since the 1990s (see *Water Quality Monitoring* section in Chapter II of this report for more details).

Although the constructed wetland detention basins were found to be effective at capturing sediments—up to 74 percent of incoming loads in the growing season and 34 percent in the winter months—USGS also verified that they are not very effective in removing nutrient loads. For example, the constructed wetland detention basins only retained about 19 percent of total phosphorus and 11 percent of dissolved orthophosphate, the form of phosphorus most readily available for uptake by algae and aquatic plants. The detention basins retained even lower portions of the inflowing nitrogen compounds, with about eight percent of the combined ammonia and organic nitrogen and less than one percent of the dissolved nitrate plus nitrite nitrogen flowing into the wetland being retained over the course of the study. The wetland served as a net source of dissolved ammonia, with ammonia loads being about 22 percent higher in the outflow than in the inflow. In fact, net releases of nutrients were commonly observed for all nutrients and that these releases frequently occurred during the growing season. The increased mobilization of phosphorus during the spring and summer may be due to anaerobic conditions in the wetland detention basins caused by higher rates of microbial respiration during periods of warmer temperatures. These releases were accompanied by higher proportional releases of orthophosphate. Thus, relative to phosphorus, the principal function of the detention basins appear to be to modify the timing and the chemical form of the delivery of the phosphorus load to the Lake Inlet (see *Effects of the Mound Road Constructed Wetland Detention Basins* section in Chapter II of this report for more details). Therefore, community concerns regarding the state of Delavan Lake and long-term effectiveness of the wetland detention basins remain.

Delavan Lake Management Plans

- ***A Lake Management Plan for Delavan Lake, Walworth County**,* Wisconsin, Community Assistance Planning Report No. 253, 2002, SEWRPC.
- ***An Aquatic Plant Management Plan For Delavan Lake, Walworth County***, Wisconsin, Memorandum Report No. 190, 2011, SEWRPC.

The Lake has historically experienced various management problems, including excessive aquatic plant and algal growths, recreational user conflicts and water quality-related use limitations, and public concerns over the aesthetic degradation of the resource. In addition, concerns had been raised regarding deteriorating water quality conditions, the need to protect environmentally sensitive areas, and the prevention of the spread of exotic plant species within the Lake. The lake management plans incorporate and analyze the data and information developed under previous lake management-related studies, and other data and information acquired during the planning period that include: hydraulic improvements to the outflow channel, alum-dosing of the lake basin, and biocide-based aquatic plant and fisheries management programs that were completed between 1989 and 1992; data from aquatic plant surveys made in the Lake during 1992 through 1994, 1996 through 1998, and 2001 though 2010; and recreational boating-use surveys conducted during 1997 and 2008. In addition, the lake management plans present feasible, alternative in-lake measures for enhancing the water quality conditions, and for providing opportunities for safe and enjoyable use of the Lake. More specifically, the management plans describe the physical, chemical, and biological characteristics of the Lake and pertinent related characteristics of the tributary watershed (including Jackson Creek), as well as the feasibility of various watershed and in-lake management measures which may be applied to enhance the water quality conditions, biological communities, and recreational opportunities of the Lake.

Walworth County Comprehensive Plan and Land and Water Resource Management Plan

- ***A Multi-Jurisdictional Comprehensive Plan for Walworth County: 2035***, Community Assistance Planning Report No. 288, November 2009, SEWRPC; and ***Walworth County Land and Water Resource Management Plan Amendment, 2010*****,** Walworth County Land Conservation Committee

These plans serve a number of functions. Most importantly, they provide a basis for decision-making on land use-related matters by County and town officials and they guide the land and water quality programs, activities and priorities within Walworth County. In addition, the comprehensive plan serves to increase the awareness and understanding of County and town planning goals and objectives by landowners, developers, and other private interests. With the adopted comprehensive plan in place, private sector interests and residents can proceed with greater assurance that proposals developed in accordance with these plans should receive required approvals. These Plans include current and projected land use conditions of Walworth County as well as natural resource base inventories to prioritize resource issues and concerns and identify opportunities to achieve land and water resource management goals.

- **Rock River Basin TMDL Study**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

The TMDL study for the Rock River Basin was prepared by the Cadmus Group for the USEPA and WDNR and was approved in 2011. This plan established TMDLs for the Rock River and certain tributaries and estimated current pollutant loadings and loading reductions needed to meet the TMDL for subwatersheds in the Rock River Basin.

WATERSHED JURISDICTIONS, DEMOGRAPHICS, AND TRANSPORTATION NETWORK

Watershed Jurisdictions

The Jackson Creek watershed lies entirely within Walworth County and includes portions of six local governmental units (see Map I-1, and Figure I-2). The largest portion of the watershed is in the Town of Geneva with 47 percent. The City of the Elkhorn and Town of Delavan comprise 20 percent and 32 percent, respectively. The remaining three municipalities together (City of Delavan and Towns of Lafayette and Sugar Creek) comprise about 1 percent of the watershed.

Jurisdictional Roles and Responsibilities

Natural resources in the United States are protected to some extent under Federal, state, and local law. The Clean Water Act regulates surface water quality at the national level. In Wisconsin, the WDNR has the authority to administer the provisions of the Clean Water Act. The US EPA, U.S. Army Corps of Engineers, Natural Resources Conservation Service, and the U.S. Fish and Wildlife Service work with the WDNR to protect natural areas, wetlands, and threatened and endangered species. The Federal Safe Drinking Water Act also protects surface and groundwater resources.

Counties and other local governments in the watershed area have ordinances regulating land development and protecting surface waters. The comprehensive zoning ordinance represents one of the most important and significant tools available to local units of government in directing the proper use of lands within their jurisdictions. Local zoning regulations include general, or comprehensive, zoning regulations and special-purpose regulations governing floodplain and shoreland areas. General zoning and special-purpose zoning regulations may be adopted as a single ordinance or as separate ordinances; they may or may not be contained in the same document. Any analysis of locally proposed land uses must take into consideration the provisions of both general and special-purpose zoning. The ordinances administered by the units of government within the watershed are summarized in

Table I-1. In addition, since State laws governing County and local zoning regulations are often revised, the SEWRPC staff provides periodic summaries of the most up-to-date changes that can be read and downloaded at the following website location: http://www.sewrpc.org/SEWRPCFiles/CommunityAssistance/Smartgrowth/fact_sheet_implementation_of_comp_plans.pdf.

Other governmental entities with watershed jurisdictional or technical advisory roles include: the Wisconsin Department of Agriculture, Trade, and Consumer Protection; the University of Wisconsin-Extension; Walworth County Land Use and Resource Management (LURM); and SEWRPC.

Floodland Zoning

Section 87.30 of the *Wisconsin Statutes* requires that counties, with respect to their unincorporated areas; cities; and villages adopt floodplain zoning to preserve the floodwater conveyance and storage capacity of floodplain areas and to prevent the location of new flood-damage-prone development in flood hazard areas. The minimum standards that such ordinances must meet are set forth in Chapter NR 116, "Wisconsin's Floodplain Management Program," of the *Wisconsin Administrative Code*. The required regulations govern filling and development within a regulatory floodplain, which is defined as the area that has a 1 percent annual probability of being inundated. The one-percent-annual-probability (100-year recurrence interval) floodplains within the Jackson Creek watershed are shown on Map I-2A. Under Chapter NR 116, local floodland zoning regulations must prohibit nearly all forms of development within the floodway, which is that portion of the floodplain required to convey the one-percent-annual-probability peak flood flow. Local regulations must also restrict filling and development within the flood fringe, which is that portion of the floodplain located outside the floodway that would be covered by floodwater during the one-percent-annual-probability flood. Allowing the filling and development of the flood fringe area, however, reduces the floodwater storage capacity of the natural floodplain, and may, thereby, increase downstream flood flows and stages. Map I-2A shows floodplains designated as "Zone A" where the extent of the floodplain was based upon an approximate study that did not calculate specific flood stage elevations. The majority of these areas are associated with the small headwater tributary streams.

The Walworth County ordinances related to floodplain zoning recognize existing uses and structures and regulate them in accordance with sound floodplain management practices while protecting the overall water quality of stream systems. These ordinances are intended to: 1) regulate and diminish the proliferation of nonconforming structures and uses in floodplain areas; 2) regulate reconstruction, remodeling, conversion and repair of such nonconforming structures—with the overall intent of lessening the public responsibilities attendant to the continued and expanded development of land and structures inherently incompatible with natural floodplains; and 3) lessen the potential danger to life, safety, health, and welfare of persons whose lands are subject to the hazards of floods. Floodplain zoning is in place for all the towns in Walworth County (see Table I-1). The Cities of Delavan and Elkhorn have adopted their own floodplain ordinances.

TRANSPORTATION

The major roads that run through the Jackson Creek watershed include Interstate Highway (IH) 43 and State Trunk Highway (STH) 11 that both run from northeast-southwest in the western and central portion of the watershed (see Map I-1). U.S. Highway (USH) 12 runs northwest-southeast through the eastern portion of the watershed, STH 67 runs north-south through the center of the watershed, and STH 50 runs east-west across the southern boundary of the watershed. County Trunk Highways F, H, and NN are also located in the watershed. There is only one railroad line, which is part of the Wisconsin & Southern Railroad that passes through the western portion of the watershed and terminates in the City Elkhorn.

The White River State Trail is a 12 mile long trail used for biking and hiking as well as horseback riding in some sections that follows a former rail corridor as it travels between Elkhorn and Burlington (see Map I-2B). The trail is operated by Walworth County and is within five miles of Lake Geneva and Big Foot Beach State Park. The western end of the trail begins at County Highway H near Elkhorn. The eastern end of the trail is at Spring Valley Road near the Walworth-Racine county line, just west of Burlington.

POPULATION AND HOUSEHOLDS

Data on population and numbers of households in the Jackson Creek watershed from 1960 to 2010 is shown in Figure I-3. Over that time period, the resident population grew from about 3,000 to 6,200 individuals and the number of households grew from about 900 to more than 2,500. The greatest increase in both population and the number of households occurred between 2000 and 2010, however, there has been a steady growth in both population and households since 1990 as shown in Figure I-3. Based upon the adopted regional land use plan, the population and number of resident households in the Jackson Creek watershed are projected to continue to increase through the year 2035, which is consistent with the planned land use as shown in Table I-2.[4]

HISTORICAL URBAN GROWTH

Historical urban growth within the Jackson Creek watershed is summarized on Map I-3. Much of the early growth (pre-1900) in the watershed centered within the downtown area of the City of Elkhorn. Between 1900 and 1950, most of the growth continued to expand around the City of Elkhorn as well as the Delavan Lake shoreline. From

[4]*SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035, *June 2006.*

1950 to 2010 growth continued to emanate southward from the City of Elkhorn, but recent pockets of development have occurred in the center of the watershed directly adjacent to Jackson Creek. If population growth continues at the same rate of growth, urban runoff may have more of an impact in the watershed, and measures to mitigate that impact would need to be considered.

LAND USE

Existing year 2010 and planned year 2035 land use data for the watershed were developed by the SEWRPC staff.[5] [6]

Changes in Land Use Over Time

Historically, before European settlement in the mid-1800s, the landscape within the Jackson Creek watershed consisted largely of oak savanna (oak opening), a transitional habitat between forest and grassland containing prairie grasses and forbs beneath widely spaced trees, primarily Bur oaks. Other natural habitats included large expanses of wetland and prairie, with small pockets of oak forest along the southern edge of the watershed. The extent of these natural habitat types in the Jackson Creek watershed, derived from the original land survey records, is shown on Map I-4.

Following European settlement, large portions of the landscape were converted to agricultural use. Natural vegetation was cleared to make way for crops. Efforts were made to open up wetlands to cultivation through ditching and draining of wet soils. Steeply sloped lands that were spared the plow were often opened up to grazing by livestock. This land conversion had significant consequences on water quality, water quantity, and wildlife habitat. For example, water quality has been compromised through increases in erosion leading to siltation of surface waters, particularly in Delavan Lake. Natural waterways have been dredged and straightened to facilitate rapid runoff bypassing natural functions of adjacent wetlands including absorbing nutrients and storing flood waters.

Agricultural land use continues to dominant the landscape in the watershed, comprising about 82percent of the watershed area under 2010 land use conditions (Map I-5 and Table I-2). Cultivated crops consist of about 87 percent and pasture/hay accounts for 13 percent of the agricultural land use. Urban land uses accounted for about18 percent of the watershed area in 2010. The majority of the urban development is in the northern portion of the watershed,

---

[5]*Ibid.*

[6]*The existing land use data for this study area is based upon 12-inch pixel color year 2010 orthophotography and cadastral mapping. SEWRPC has over 60 land cover classifications and a spatial resolution scale of 1 inch equals 200 feet, which is equivalent to the National Map Accuracy Standards (NMAS) of 90 percent of the positions of well-defined points as determined from the orthophotographs to be within 6.6 feet of their correct position as determined by field measurement.*

within and adjacent to the City of Elkhorn. Wetlands comprise about 6 percent and forested land covers about 2 percent of the watershed, followed by surface water which covers 1.7 percent.

Under planned 2035 land use conditions (see Table I-2 and Map I-6), agricultural land is expected to be reduced by about 33 percent, or 3,250 acres. Urban development, primarily residential land use, is planned to increase by about 132 percent, comprising about 42 percent of the watershed by 2035 as shown in Table I-2. Map I-6 graphically depicts the agricultural land, open land, and woodland that would be expected to be converted to urban uses under planned year 2035 conditions. Although agricultural land will still be the largest land use overall in the watershed, it will not be the dominant land use among four of the six sub-basins (JC-2, JC-3, JC-4, and JC-6) as shown in Figure I-4. These four sub-basins are anticipated to shift to an urban dominated land use. Also, while they will remain in predominantly agricultural uses, the percent of agricultural land use in sub-basins JC-1 and JC-5will be reduced by about 6and 13 percent, respectively. Based upon this planned land use scenario urban runoff is anticipated to have more of an impact in the watershed in the future in the absence of mitigating measures (see the *Pollutant Loading Model* section in Chapter II of this report).

When urban development in a watershed increases, the amount of impervious surface area increases. Many researchers throughout the United States, including researchers at the WDNR, report that the amount of *connected* impervious surface is the best indicator of the level of urbanization in a watershed.[7] Directly connected impervious area is area that discharges directly to the stormwater drainage system, and, ultimately, to a stream without the potential for infiltration through discharge to pervious surfaces or facilities specifically designed to infiltrate runoff. Impervious surfaces :[8]

- Contribute to the hydrologic changes that degrade waterways;
- Are a major component of the intensive land uses that generate pollution;
- Prevent natural pollutant attenuation or removal in the soil by preventing infiltration; and
- Serve as an efficient conveyance system transporting pollutants into waterways.

[7]*L. Wang, J. Lyons, P. Kanehl, and R. Bannerman, "Impacts of Urbanization on Stream Habitat and Fish across Multiple Spatial Scales,"* Environmental Management*, Vol. 28, 2001, pp. 255-266.*

[8]*Dane County Regional Planning Commission,* Dane County Waterbody Classification Study-Phase I*, March 2007.*

Research over the last 20 years shows a strong relationship between the imperviousness of a drainage basin and the health of receiving streams.[9] Studies have found that relatively low levels of urbanization—8 to 12 percent connected impervious surface—can cause subtle changes in physical (increased temperature and turbidity) and chemical (reduced dissolved oxygen and increased pollutant levels) properties of a stream, leading to a decline in the biological integrity of the stream. For example, each 1 percent increase in watershed imperviousness can lead to an increase in water temperature of nearly 2.5°F.[10] While this temperature increase may appear to be small in magnitude, this small increase can have significant impacts on fish, such as trout and other biological communities that have a low tolerance to temperature fluctuations or require specific thermal ranges.

The Jackson Creek watershed overall had about 18 percent urban land use in 2010, which corresponds to about 5 percent directly connected imperviousness in the watershed (see Table I-3). That level of imperviousness is below the threshold level of 6 to 11 percent at which negative biological impacts can be expected to occur, which corresponds with the high quality cool water fishery observed within the mainstem of this system. However, the estimated levels of imperviousness by subwatershed for year 2010, as shown in Table I-3, indicates that the existing imperviousness of about 18 percent in sub-basin JC-4 already exceeds the 6 to11 percent range at which negative biological impacts could be expected to occur. In addition, based upon the planned 2035 development, sub-basins JC-2 and JC-6 could fall within the threshold range of 6 to 11 percent, and sub-basins JC-3 and JC-4 will achieve levels of development that have often been associated with significant degradation of aquatic resources in other streams within southeastern Wisconsin.[11] Hence, local stormwater management practices affecting runoff volume and quality such as promoting infiltration, green infrastructure projects, and preservation of riparian buffers will be key to mitigating the consequences of development (see recommendations in *Urban Surface Water Hydrology* section in Chapter III of this report).

---

[9]*Wang, L., J. Lyons, P. Kanehl, R. Bannerman, and E. Emmons. 2000. Watershed Urbanization and Changes in Fish Communities in Southeastern Wisconsin Streams. Journal of the American Water Resources Association 36(5):1173-1189; Wang, L., J. Lyons, P. Kanehl, and R. Gatti. 1997. Influences of Watershed Land Use on Habitat Quality and Biotic Integrity in Wisconsin Streams. Fisheries 22(6):6-12; Arnold, C., and C.J. Gibbons. 1996. Impervious Surface Coverage. The Emergence of a Key Environmental Indicator. Journal of the American Planning Association 62(2):243-258; Schueler, T. 1995. Site Planning for Urban Stream Protection. Center for Watershed Protection. Ellicot, MD; Masterson, J.P., and R.T. Bannerman. 1994. Impacts of Stormwater Runoff on Urban Streams in Milwaukee, Wisconsin. In National Symposium on Water Quality. 1994. American Water Resources Association. Middelburg, VA; and, Schueler, T. 1994. The Importance of Imperviousness. Watershed Protection Techniques 1:100-111.*

[10]*L. Wang, J. Lyons, and P. Kanehl, "Impacts of Urban Land Cover on Trout Streams in Wisconsin and Minnesota,* Transactions of the American Fisheries Society, *Vol. 132, 2003, pp. 825-839.*

[11]*SEWRPC Technical Report No. 39,* Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds*, November 2007.*

Description of the Farming Environment

Farming in the watershed is a significant economic factor with 90 percent of the farm operations in row crop/cash grain production, and 10 percent feedlots and pasture. Loss of dairy herds over past decades has nearly eliminated hay production from the watershed. Demand for corn and soybean production, while not at an all-time high, is still good, and petroleum prices (fertilizer and fuel) are lower than in past years. Farmers continue to look for ways to increase yields by removing fence rows to increase land in production and in some cases putting land enrolled in Federal set aside programs back into production. Agricultural lands located along Jackson Creek may be candidates for enrollment in Federal conservation programs.

While approximately 120 people own rural property in the watershed, roughly 60 of these landowner properties would fall into the category of farm operations. Many of these owners or their operators routinely employ conservation practices such as reduced tillage and grass waterways.

Field observations and review of data with the County conservationist identified approximately a dozen animal operations in the watershed (see Map B-1 in Appendix B - *STEPL Pollutant Loading Results for the Jackson Creek Watershed*). Pastured beef and other livestock feeding operations, rotational grazing, and horse stables contribute to a diversity of manure management approaches within the watershed. There are no CAFO's (Concentrated Animal Feeding Operations) in the watershed.

Natural Resource Elements

Many important interlocking and interacting relationships occur between living organisms and their environment. The destruction or deterioration of any one element may lead to a chain reaction of deterioration and destruction among the others. The drainage of wetlands, for example, may have far-reaching effects. Such drainage may destroy fish spawning grounds, wildlife habitat, groundwater recharge areas, and natural filtration and floodwater storage areas. The resulting deterioration of surface water quality may, in turn, lead to a deterioration of the quality of the groundwater. Groundwater serves as a source of domestic, municipal, and industrial water supply and provides low flows in rivers and streams. The destruction of woodland and other upland cover types, which may have taken a century or more to develop, may result in soil erosion and stream siltation and in more rapid runoff and increased flooding, as well as destruction of wildlife habitat. Although the effects of any one of these environmental changes in isolation may not be overwhelming, the combined effects may lead eventually to the deterioration of the underlying and supporting natural resource base, and of the overall quality of the environment for life. The need to protect and preserve the environmental corridors and their associated complexes of wetland, upland, and critical species habitats within the watershed thus becomes apparent.

Primary Environmental Corridors

Primary environmental corridors (PEC) include a wide variety of important resource and resource-related elements. By definition, they are at least 400 acres in size, two miles in length, and 200 feet in width.[12] The only PEC in the watershed under existing conditions is located along Jackson Creek and encompasses about 930 acres, or about 7 percent, of the Jackson Creek watershed. This PEC represents a composite of the best remaining elements of the natural resource base in the watershed, and contains almost all of the best remaining uplands, wetlands, and wildlife habitat areas (see *Natural Areas and Critical Species Habitat Sites* section below). It is also important to note that the lakes, streams and other surface waters and the associated shorelands, including the Delavan Lake Inlet, are shown as PEC on Map I-7. The Lake and Jackson Creek and its associated shorelands are part of the highest quality natural resources within the watershed. This is why management of those areas is vital to protecting and maintaining the quality and integrity of this resource (see Appendix C-*Managing the Water's Edge-Riparian Buffer Guide*).

Secondary Environmental Corridors

Secondary environmental corridors (SEC) are at least 100 acres in size and one mile long. In 2010, as shown on Map I-7, there was only one secondary environmental corridor which was located near the southern boundary of the watershed and encompassed about 120 acres, or just below 1 percent of the watershed. This secondary environmental corridor is a remnant resource that has been reduced in size compared to the larger PEC as described above, due to land development for intensive agriculture purposes. However, this SEC still contains a variety of resource functions that include facilitating surface water drainage, maintaining pockets of natural resource features, and providing corridors for the movement of wildlifeand for the movement and dispersal of seeds for a variety of plant species.

Isolated Natural Resource Areas

Smaller concentrations of natural resource features that have been separated physically from environmental corridors by intensive urban or agricultural land uses have also been identified. These natural resource areas, which are at least five acres in size, are referred to as isolated natural resource areas and are shown on Map I-7. Widely scattered throughout the watershed, isolated natural resource areas covered about 370 acres, or nearly 3 percent, of the total study area in 2010.

Natural Areas and Critical Species Habitat Sites

Natural areas, as defined by the Wisconsin Natural Areas Preservation Council, are tracts of land or water so little modified by human activity, or sufficiently recovered from the effects of such activity, that they contain intact native plant and animal communities believed to be representative of the pre-European settlement landscape (see Map I-

---

[12]*SEWRPC Planning Report No. 42,* A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin*, September 1997.*

4). Natural areas are generally comprised of wetland or upland vegetation communities and/or complex combinations of both these fundamental ecosystem units. In fact, some of the highest quality natural areas within the Southeastern Wisconsin Region are wetland complexes that have maintained adequate or undisturbed linkages (i.e., landscape connectivity) between the upland-wetland habitats, which is consistent with research findings in other areas of the Midwest as well as in the Jackson Creek watershed.[13] The extent and distribution of wetland and upland areas and their relationship to the designated natural areas and critical species habitats are shown on Map I-8.

Natural areas have been identified for the seven-county Southeastern Wisconsin Region in SEWRPC Planning Report No. 42, "*A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin*," published in September 1997, and amended in 2008 and 2010. This plan was developed to assist Federal, State, and local units and agencies of government, and nongovernmental organizations, in making environmentally sound land use decisions including acquisition of priority properties, management of public lands, and location of development in appropriate localities that will protect and preserve the natural resource base of the Region. Walworth County uses this document to guide land use decisions.

The identified natural areas were classified into the following three categories:

1. Natural area of statewide or greater significance (NA-1);
2. Natural area of countywide or regional significance (NA-2); or
3. Natural area of local significance (NA-3).

Classification of an area into one of these three categories was based upon consideration of several factors, including the diversity of plant and animal species and community types present; the structure and integrity of the native plant or animal community; the extent of disturbance by human activity, such as logging, grazing, water level changes, and pollution; the frequency of occurrence within the Region of the plant and animal communities present; the occurrence of unique natural features within the area; the size of the area; and the educational value.

[13]*O. Attum, Y.M. Lee, J.H. Roe, and B.A. Kingsbury, "Wetland complexes and upland-wetland linkages: landscape effects on the distribution of rare and common wetland reptiles,"* Journal of Zoology*, Vol. 275, 2008, pages 245-251.*

The Jackson Creek watershed contains two natural areas of local significance (NA-3) and one critical plant species habitat site as shown on Map I-8.[14] Site 39 is the Lake Lawn Wetland Complex that comprises nearly the entire Delavan Lake Inlet area of the Jackson Creek watershed. This is a large (292.9 acres) wetland complex that includes a variety of deep marsh, shallow marsh, and sedge meadow plant communities. Site 40 is the Jackson Creek Wetlands (known locally as the Jackson Creek Preserve) (21.9 acres) that are located along the mainstem of Jackson Creek just upstream of STH 67. This wetland complex owned by the Kettle Moraine Land Trust, Inc. includes prairie fen habitat, which is rare within this watershed. Finally, Site 89 is the Elkhorn Railroad Prairie Remnant critical species habitat site. These are the highest quality plant communities known to exist in the watershed, and they can serve as important seed sources for restoration in other areas (for more details see Appendix D-*Jackson Creek Potentially Restorable Wetland Evaluation*).

Critical species are defined as those species of plants and animals that are designated by the State of Wisconsin to be endangered, threatened, or of special concern. There are 11 such plant species known to occur in the watershed and they are listed in Table I-4. Photos of each of these critical species and links to life history information are included in Figure I-5.

Exotic/Invasive Species

Invasive species can have a negative impact on ecosystems. They can out compete native species that provide optimal habitats for a variety of wildlife, which causes an overall reduction in available wildlife habitat and species diversity. Invasive species such as Purple Loosestrife and Phragmites tend to populate disturbed areas such as roadside ditches and then expand into other areas. There are many exotic species located in the watershed. These species consist of Eurasian water milfoil, reed canary grass, Purple Loosestrife, Cut Leaf Teasel, Phragmites, Garlic Mustard, Japanese Knotweed, buckthorn, and emerald ash borer to name a few. Invasive species are an important issue in this watershed and conservation practices that are implemented should be maintained to prevent establishment and spread of invasives, particularly when trying to restore native wetland habitat (see Appendix D- for more details).

CLIMATE

Based on the 30-year average temperature and precipitation data from 1981-2010 for Wisconsin from the NOAA National Weather Service Forecast Office Milwaukee/Sullivan, the average annual temperature and precipitation range from about 45-48 degrees Fahrenheit and 34-36 inches, respectively, within the vicinity of the Jackson Creek watershed.

---

[14]*Note: Site numbers correspond to those presented in the Regional Natural Areas Plan (SEWRPC Planning Report No. 42)*

However, it is also important to note that Wisconsin's climate and water resources are changing. Climate directly affects water resources and such resources can serve as indicators of climate change at various temporal and spatial scales. The Wisconsin Initiative on Climate Change Impacts (WICCI) has concluded that future climate projections may affect the quantity and quality of the State of Wisconsin's water resources. However, WICCI also found clear evidence from analysis of past trends and probable future climate projections that there will be different hydrologic responses to climate change in different geographic regions of the State (see Figure I-6). The differences reflect local variations in land use, soil type and surface deposits, groundwater characteristics, and runoff and seepage responses to precipitation, which illustrates the importance of considering the effects on hydrologic conditions of possible changes in those characteristics as part of a watershed protection plan strategy.

Climate change seems to be altering the availability of water (volume), the distribution of rainfall over time, and whether precipitation falls as rain or snow, each of which affects water's movement through a water cycle. As shown in Figure I-7, most of the water entering the landscape arrives as precipitation (rain and snowfall) that falls directly on waterbodies; or runs off the land surface and enters streams, rivers, wetlands, and lakes; or percolates through the soil, recharging groundwater that flows underground and re-emerges as springs discharging into lakes, wetlands, and streams. Even in the absence of climate change, when one part of the system is affected, all other parts are affected. For example, over drafting the shallow groundwater to irrigate crops or for providing a potable water supply, can lead to a reduction or complete loss in discharge of a local stream. More important, climate change exposes the vulnerabilities of water available within a given community, and this vulnerability is proportional to how much humans have altered how water moves through the water cycle (e.g., through reducing groundwater discharge potential during land development and/or through withdrawals from aquifers). This vulnerability becomes particularly evident during periods of prolonged drought conditions.

The WICCI Water Resources Working Group (WRWG) incorporated WICCI's 1980-2055 projections for temperature, precipitation (including occurrence of events), and changes in snowfall to guide their evaluation of potential impacts to hydrologic processes and resources.[15] This team of experts prioritized the highest potential climate change impacts on water resources and proposed adaptation strategies to address impacts across the State of Wisconsin as summarized below:

---

[15]*The Water Resources Working Group (WRWG) included 25 members representing the Federal government, State government, the University of Wisconsin System, the Great Lakes Indian Fish and Wildlife Commission, and the Wisconsin Wetlands Association. For more details on climate change, impacts, adaptation, and resources visit* http://www.wicci.wisc.edu/water-resources-working-group.php.

- **Minimize threats to public health and safety by anticipating and managing for extreme events through effective planning—floods and droughts.**

- **Increase resiliency of aquatic ecosystems to buffer the impacts of future climate changes by restoring or simulating natural processes, ensuring adequate habitat availability, and limiting human impacts on resources. Examples include limiting groundwater and surface water withdrawals, restoring or reconnecting floodplains and wetlands, and maintaining or providing migration corridors for fish and other aquatic organisms.**

- **Stabilize future variations in water quantity and availability by managing water as an integrated resource, keeping water "local" and supporting sustainable and efficient water use for humans and the environment.**

- **Maintain, improve, or restore water quality under a changing climate regime by promoting actions to reduce nutrient and sediment loading.**

Changing climatic conditions are drivers of water quality conditions within the Jackson Creek system and these adaption strategies are important considerations for the protection of surface water and groundwater quality as future development occurs in this watershed.

TOPOGRAPHY AND GEOLOGY

The Jackson Creek watershed lies in the Eastern Ridges and Lowlands geographical province of Wisconsin and was part of the glaciated portion of Wisconsin. Glaciers have greatly impacted the geology of the area. The Kankakee equivalent dolomite of the Silurian Group and the Maquoketa shale formation of the Ordovician Group are the major bedrock features within this watershed. The depth to bedrock generally ranges from 100 to 250 feet. The topography is generally smooth and gently sloping with some slopes steepened by post glacial stream erosion. The main glacial landforms are ground moraine, outwash, and lake plain. The highest point in the watershed area is 1,125 feet above National Geodetic Vertical Datum, 1929 adjustment (NGVD 29) and the lowest point in the watershed is 925 feet above NGVD 29. The central portion of this watershed is relatively flat while the remaining northern and southern edges contain some ridges and rolling slopes.

GROUNDWATER RESOURCES

Groundwater not only sustains lake levels and wetlands and provides the perennial base flow of streams, but it is also a major source of water supply. In general, there is an adequate supply of groundwater within the Region to support the growing population, agriculture, commerce, and viable and diverse industry. However, overproduction and water shortages may occur in areas of concentrated development and intensive water demand.[16] The amount, recharge, movement, and discharge of groundwater is controlled by several factors, including: precipitation; topography; drainage; land use; soil; and the lithology and water-bearing properties of rock units. All of the communities within the Jackson Creek watershed are dependent on groundwater for a potable water supply and for other commercial and industrial uses. Groundwater resources thus constitute an extremely valuable element of the natural resource base within the watershed. The continued growth of population and industry within the watershed necessitates the wise development and management of groundwater resources.[17]

Groundwater Recharge

Recharge to groundwater is derived almost entirely from precipitation. The amount of precipitation (and snowmelt) that infiltrates at any location depends mainly on the permeability of the overlying soils, bedrock or other surface materials, including human-made surfaces. As development occurs, stormwater management practices can be instituted that encourage infiltration of runoff. However, it is important to note that such practices have generally not been required to be installed prior to 1990 in the Jackson Creek watershed. So, much of the urban development was not constructed to promote such infiltration in this watershed. Ideally, practices that promote infiltration need to be located on soils with permeable subsoils and adequate groundwater separation to allow infiltration, but minimize the potential for groundwater contamination. Most of the precipitation that does infiltrate (either naturally or through a stormwater management practice) will generally only migrate within the shallow aquifer system and may discharge in a nearby wetland or stream system. This process helps support base flows, wetland vegetation, and wildlife habitat in these water resources. Therefore, as is the case for surface waters (lakes and streams), the quality of groundwater resources is clearly linked to the health and well-being of the biological communities (including humans) inhabiting those waters and their surrounding watersheds.[18]

Understanding recharge and its distribution is key to making informed land use decisions so that the groundwater needs of society and the environment can continue to be met. Fortunately, a groundwater recharge potential map derived from a soil-water balance recharge model was developed under the SEWRPC water supply planning program for the Southeastern Wisconsin Region. Groundwater recharge potential in the Jackson Creek watershed

---

[16]*SEWRPC Planning Report No. 52, A Regional Water Supply Plan For Southeastern Wisconsin, December 2010.*

[17]*Barlow, P.M., and Leake, S.A.,* Streamflow depletion by wells—Understanding and managing the effects of groundwater pumping on streamflow*, U.S. Geological Survey Circular 1376, 2012, see website at* http://pubs.usgs.gov/circ/1376/.

[18]*David Hambright, "Golden Algae & The Health of Oklahoma Lakes," LAKELINE, Volume 32(3), Fall 2012.*

is shown on Map I-8A. That map can be used for identifying and protecting recharge areas that contribute most to baseflow of the lakes, streams, springs, and wetlands in the Jackson Creek watershed.[19]

Groundwater recharge potential was divided into four main categories defined as: low, moderate, high, and very high. Any areas that were not defined were placed into a fifth category as undefined. These undefined areas are most often associated with groundwater discharge, which is why they tend to be located adjacent to streams as shown on Map I-8A. Much of the Jackson Creek watershed can be considered to have moderate groundwater recharge potential (about 9,518 acres, or about 69 percent of the entire watershed area), as shown on Map I-8A. About six percent of the watershed was undefined and about 14 percent of the watershed was identified as having low recharge potential. The remaining nearly 11 percent of the watershed contains high and very high recharge potential, but less than one-half of one percent of the watershed was comprised of very high recharge potential. Hence, protecting recharge areas, particularly those located on agricultural and other open lands that have not yet been developed, is important to the goals of sustainable groundwater use and a healthy natural environment in this watershed.

SOIL CHARACTERISTICS

Soil data for the watershed was obtained from the NRCS (SSURGO) database. Soil type and characteristics are important for planning management practices in a watershed. Factors such as erodibility, hydrologic soil group, slope, and hydric classification are important in estimating erosion and runoff in a watershed.

The dominant soil types in the Jackson Creek watershed are Miami silt loam (27.6 percent), Pella silt loam (26.3 percent), Plano silt loam (21.0 percent), Griswold silt loam (5.9 percent), Elburn silt loam (5.2 percent), Miami loam (4.6 percent), and Conover silt loam (3.1 percent).

Hydrologic Soil Group

Soils are classified into hydrologic soil groups based on soil infiltration and transmission rate (permeability). Hydrologic soil group along with land use, management practices, and hydrologic condition determine a soil's runoff curve number as established by NRCS. Runoff curve numbers are used to estimate direct runoff from rainfall. There are four hydrologic soil groups: A, B, C, and D. Descriptions of Runoff Potential, Infiltration Rate, and Transmission Rate of each group are shown in Table I-5. Some soils fall into a dual hydrologic soil group (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and water table depth when drained. The first letter applies to the drained condition and the second letter applies to the undrained condition. Table I-6 summarizes the percent of each group present in the watershed and Map I-9 shows the location of each hydrologic soil group. The

[19] *SEWRPC Technical Report No. 47,* Groundwater Recharge in Southeastern Wisconsin Estimated by a GIS-Based Water-Balance Model*, July 2008.*

dominant hydrologic soil groups in the watershed are Group B (64.7 percent) and Group B/D (26.3 percent). The majority of the soils in the Jackson Creek watershed are Group B soils that have a moderately low runoff potential. However, up to 35 percent of the soils in the watershed may have moderately high to high runoff potential, which includes Group C soils and Group B/D soils in the undrained condition.

Soil Erodibility

The susceptibility of a soil to wind and water erosion depends on soil type and slope. Course textured soils such as sand are more susceptible to erosion than fine textured soils such as clay. Highly erodible and potentially highly erodible soils were mapped based on soil type and slope. Soils with a 2 to 6 percent slope were considered potentially highly erodible soils and soils with a 6 percent or higher slope were considered highly erodible.[20] About 50 percent of the soils for which slopes and erosion potential have been classified in the Jackson Creek watershed are considered potentially highly erodible to highly erodible (see Map I-10). There are 4,113 acres or 44 percent considered potentially highly erodible and 609 acres or about 6 percent are considered highly erodible.

[20] *Outagamie County Land Conservation Department,* Nonpoint Source Implementation Plan for the Plum and Kankapot Creek Watersheds*, 2014, 141 pages.*

SEWRPC Community Assistance Planning Report No. 320

JACKSON CREEK WATERSHED PROTECTION PLAN

Chapter I

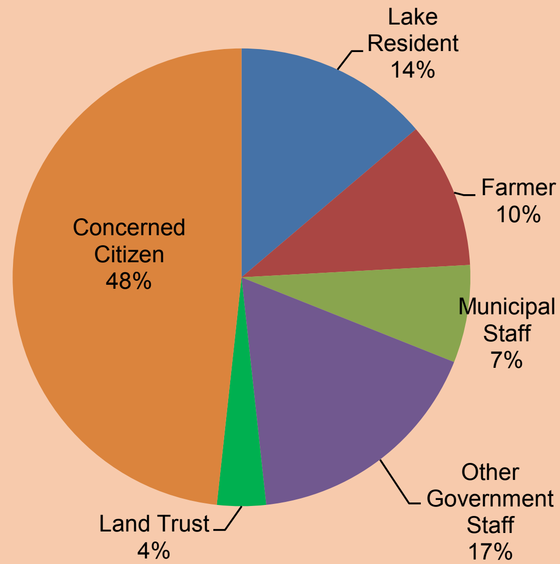
WATERSHED SETTING AND CHARACTERISTICS

FIGURES

This Page Left Blank Intentionally

Figure I-1

BREAKDOWN OF ADVISORY GROUP MEMBERS CONTRIBUTING TO THE FORMULATION OF THE JACKSON CREEK WATERSHED PROTECTION PLAN: 2012 THROUGH 2015

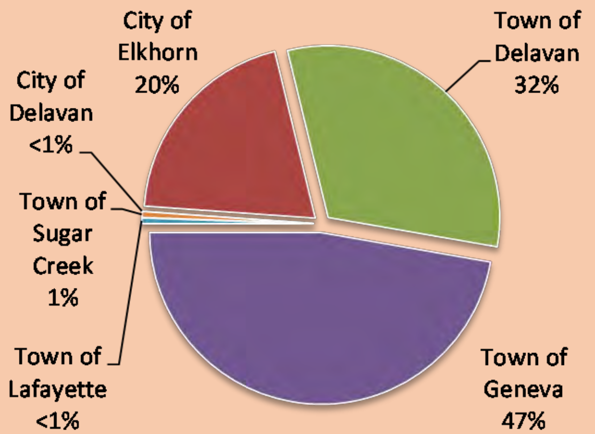


The composition of the work group demonstrates that the **greatest assets** to protect and improve Jackson Creek **have been and continue to be the dedicated people** (individuals, organizations, and agency staff) **that live and/or work within the watershed**.

Source: SEWRPC.

Figure I-2

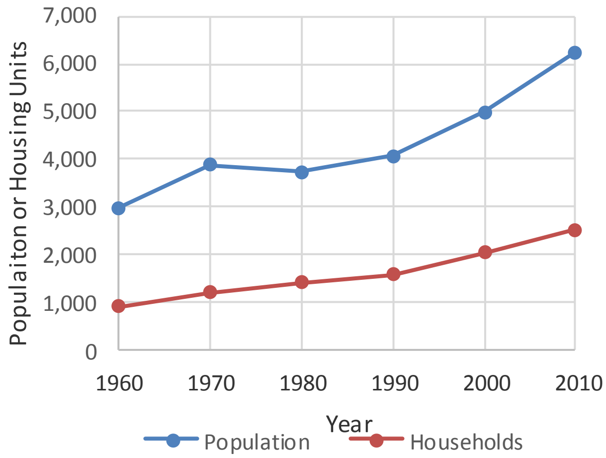
PROPORTION OF CITIES AND TOWNS WITHIN THE JACKSON CREEK WATERSHED: 2010



Source: SEWRPC.

Figure I-3

POPULATIONS AND HOUSHOLDS WITHIN THE JACKSON CREEK WATERSHED: 1960-2010



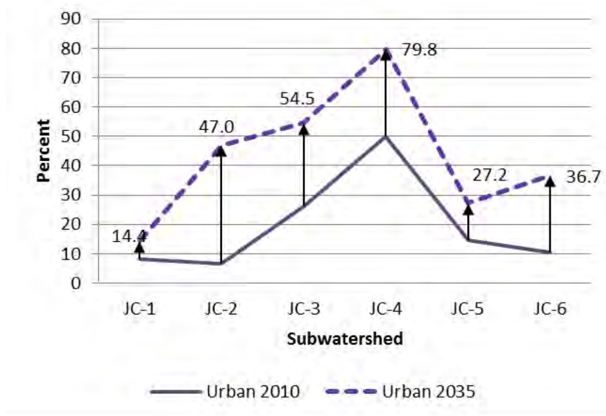
NOTE: Watershed area approximated by whole U.S. Public Land Survey quarter sections.

Source: U.S. Bureau of the Census and SEWRPC.

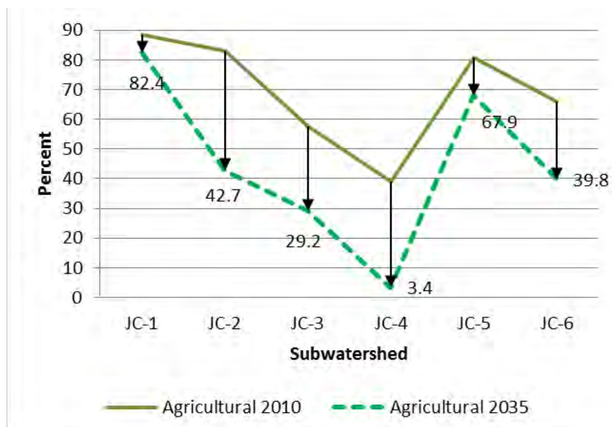
Figure I-4

EXISTING VERSUS PLANNED URBAN AND AGRICULTURAL LAND USE AMONG SUBWATERSHEDS WITHIN THE JACKSON CREEK WATERSHED: 2010 VS 2035

URBAN LANDS



AGRICULTURAL AND OTHER OPEN LANDS



Source: SEWRPC.

Figure I-5

ENDANGERED, THREATENED, AND SPECIAL CONCERN SPECIES IN THE JACKSON CREEK WATERSHED

PLANTS

Hairy Wild Petunia

Photo by Wisconsin Department of Natural Resources.

Narrow-leaved Vervain

Photo by Kitty Kohout.

Prairie Milkweed

Photo by William S. Alverson.

Purple Meadow-parsnip

Photo by Kitty Kohout.

Purple Milkweed

Photo by Thomas Meyer, WDNR.

Rope Dodder

Photo by Kitty Kohout.

Figure I-5 (continued)

PLANTS (continued)

Small White Lady's-Slipper

Photo by Dan Carter, SEWRPC.

Tufted Bulrush

Photo by Ryan O'Connor, WDNR.

Wafer-Ash

Photo by Photo by R. Schulenderg.

Waxleaf Meadowrue

Photo by Flickr (at https://farm4.static.flickr.com/3214/)

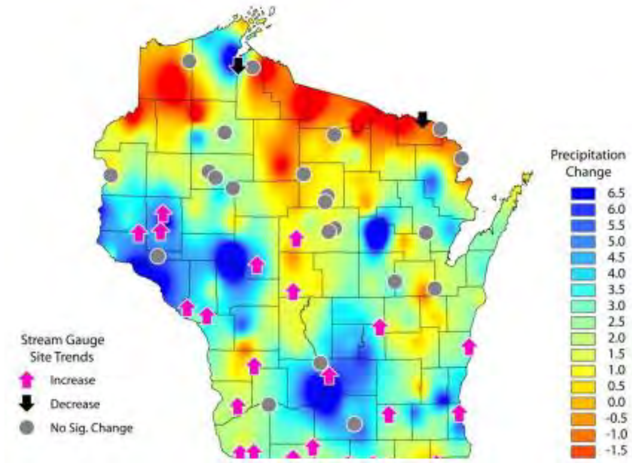
Yellow Gentian

NOTE: Additional sources of information on taxonomy, identification, habitats, and life history characteristics can be found at the following website locations:
http://dnr.wi.gov/topic/EndangeredResources/Plants.asp
http://plants.usda.gov/java/
http://herbarium.wisc.edu/

Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure I-6

RIVER BASEFLOW TRENDS AND PRECIPITATION CHANGE IN WISCONSIN: 1950-2006

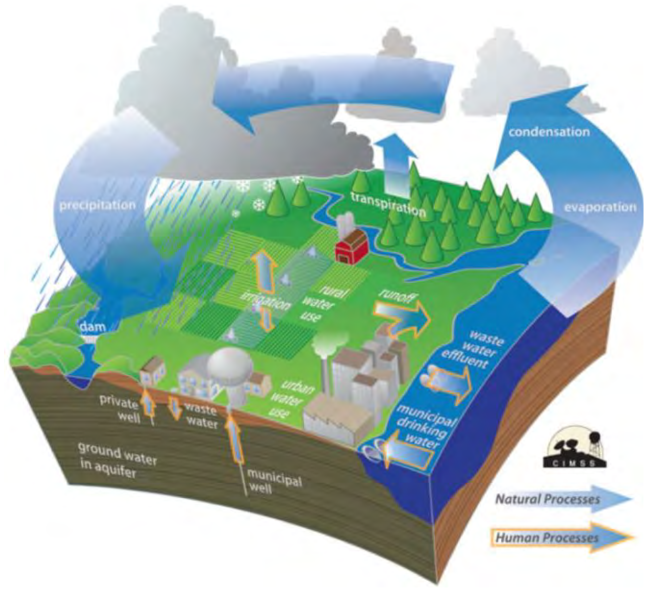


From 1950-2006, Wisconsin as a whole has become wetter, with an increase in annual precipitation of 3.1 inches. This observed increase in annual precipitation has primarily occurred in southern and western Wisconsin, while northern Wisconsin has experienced some drying. The southern and western regions of the State show increases in baseflow, corresponding to the areas with greatest precipitation increases.

Source: Wisconsin Initiative on Climate Change Impacts Water Resources Working Group and SEWRPC.

Figure I-7

HYDROLOGIC CYCLE OF WATER MOVEMENT



This schematic shows how human processes associated with land use development affect the natural processes of water moving through the hydrologic cycle. Water returns to the atmosphere through evaporation (process by which water is changed from liquid to vapor), sublimation (direct evaporation of snow and ice), and transpiration (process by which plants give off water vapor through their leaves).

Source: Wisconsin Initiative on Climate Change Impacts Water Resources Working Group and SEWRPC.

SEWRPC Community Assistance Planning Report No. 320

JACKSON CREEK WATERSHED PROTECTION PLAN

Chapter I

WATERSHED SETTING AND CHARACTERISTICS

TABLES

This Page Left Blank Intentionally

Table I-1

LAND USE REGULATIONS WITHIN THE JACKSON CREEK WATERSHED BY CIVIL DIVISION: 2014

Community	Type of Ordinance				
	General Zoning	Floodplain Zoning	Shoreland or Shoreland-Wetland Zoning	Subdivision Control	Erosion Control and Stormwater Management
Walworth County	Adopted	Adopted	Adopted	Adopted[a]	Adopted[b]
City of Delavan	Adopted	Adopted as part of City zoning ordinance	Adopted under City zoning ordinance	Adopted	Adopted[c]
City of Elkhorn	Adopted	--[d]	Adopted under City zoning ordinance[d]	Adopted	Adopted[e]
Town of Delavan	Regulated under County ordinance	Regulated under County ordinance	Regulated under County ordinance	Adopted[a]	Adopted[f]
Town of Geneva	Regulated under County ordinance	Regulated under County ordinance	Regulated under County ordinance	Adopted[a]	Adopted[g]
Town of Lafayette	Regulated under County ordinance	Regulated under County ordinance	Regulated under County ordinance	Adopted[a]	Adopted[h]
Town of Sugar Creek	Regulated under County ordinance	Regulated under County ordinance	Regulated under County ordinance	Adopted[a]	Adopted[h]

[a]*Both the Walworth County subdivision ordinance and the subdivision ordinances adopted by the Towns of Delavan, Geneva, Lafayette, and Sugar Creek apply within the affected Town. In the event of conflicting regulations in the Town and County ordinances, the more restrictive regulation applies.*

[b]*The Walworth County ordinance regulating erosion control and stormwater management is referred to as the County "Environment" Ordinance.*

[c]*The City of Delavan subdivision ordinance and building code include erosion control and stormwater management regulations. The City has not adopted a separate Erosion Control and Stormwater Management Ordinance.*

[d]*The Conservancy District in the City of Elkhorn Zoning Ordinance applies to floodplains and shorelands. The City zoning regulations are similar to State requirements for shoreland-wetlands included in Chapter NR 117 of the* Wisconsin Administrative Code, *but do not reflect State requirements for floodplain zoning included in Chapter NR 116 of the* Wisconsin Administrative Code.

[e]*The City of Elkhorn subdivision ordinance and building code include erosion control and stormwater management regulations. The City has not adopted a separate Erosion Control and Stormwater Management Ordinance.*

[f]*The Town of Delavan has adopted an erosion control ordinance. The Town is also regulated under the Walworth County erosion control and stormwater management ("Environment") ordinance. In the event of conflicting regulations in the Town and County ordinances, the more restrictive regulation applies.*

[g]*The Town of Geneva subdivision ordinance includes erosion control and stormwater management regulations. The Town has also adopted an ordinance regulating the removal of trees and other vegetation on construction sites. The Town is also regulated under the Walworth County erosion control and stormwater management ("Environment") ordinance. In the event of conflicting regulations in the Town and County ordinances, the more restrictive regulation applies.*

[h]*The Town of Lafayette and Town of Sugar Creek subdivision ordinances include erosion control and stormwater management regulations. The Towns are also regulated under the Walworth County erosion control and stormwater management ("Environment") ordinance. In the event of conflicting regulations in the Town and County ordinances, the more restrictive regulation applies.*

Source: SEWRPC.

Table I-2

LAND USE IN THE JACKSON CREEK WATERSHED: 2010-2035[a, b]

Category[c]	2010		2035		Change: 2010-2035	
	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent
Urban						
Residential	741	5.4	2,900	21.1	2,159	291.3
Commercial	140	1.0	441	3.2	301	215.1
Industrial	178	1.3	672	4.9	494	277.6
Governmental and Institutional	188	1.4	321	2.3	133	71.3
Transportation, Communication and Utilities	1,014	7.4	1,081	7.8	67	6.6
Recreational	201	1.5	299	2.2	98	48.8
Subtotal	2,462	17.9	5,714	41.5	3,252	132.1
Rural						
Agricultural and Open Lands[d]	9,917	72.0	6,667	48.4	-3,250	-32.8
Wetlands[e]	823	6.0	823	6.0	0	0.0
Woodlands	339	2.5	337	2.4	-2	-0.7
Water	232	1.7	232	1.7	0	0.0
Subtotal	11,311	82.1	8,059	58.5	-3,252	-28.8
Total	13,773	100.0	13,773	100.0	0	- -

[a]*As approximated by whole U.S. Public Land Survey one-quarter sections.*

[b]*As part of the regional land use inventory for the year 2000, the delineation of existing land use was referenced to real property boundary information not available for prior inventories. This change, which is also reflected in the 2010 inventory, increases the precision of the land use inventory and makes it more usable to public agencies and private interests throughout the Region. As a result of the change, however, year 2000 and later land use inventory data are not strictly comparable with data from the 1990 and prior inventories. At the county and regional level, the most significant effect of the change is to increase the transportation, communication, and utilities category, the result of the use of narrower estimated right-of-ways in prior inventories. The treatment of streets and highways generally diminishes the area of adjacent land uses traversed by those streets and highways in the 2000 land use inventory relative to prior inventories.*

[c]*Off-street parking of more than 10 spaces is included with the associated land use.*

[d]*It is important to note that farmed wetlands are included with the Agricultural and Open Lands category for the year 2010. However, if farmed wetland is adjacent to Primary Environmental Corridor (PEC) lands, it is included with the PEC lands category for the year 2035 planned land use.*

[e]*As part of the Wisconsin Department of Natural Resources Wisconsin Wetland Inventory (WWI) beginning in the year 2005, the wetlands were mapped to a much finer scale and greater level of detail (more wetland categories) than prior inventories. This change increased the accuracy and precision of wetland mapping throughout the Region. As a result of the change, however, year 2010 wetland inventory data are not comparable with data from the year 2000 and prior inventories. At the county and Regional level, the most significant effect of the change is that more, smaller wetlands were able to be delineated, which led to an overall increase in the number and total acreage of wetlands. At the local scale of this study, the most significant wetland area increases were due to an increase in the number of wetlands, farmed wetlands reverting back to wetlands due to inactivity/abandonment of agricultural cultivation activities, and expansion of boundaries within pre-existing wetland areas. However, there was also loss of wetland due to urban development, primarily related to residential and roadway construction.*

Source: SEWRPC.

Table I-3

ESTIMATED PERCENT CONNECTED IMPERVIOUS SURFACE FOR THE JACKSON CREEK WATERSHED

Subwatershed	2010	2035
JC-1	2.4	5.3
JC-2	1.5	10.4
JC-3	8.7	28.8
JC-4	18.4	32.9
JC-5	3.4	7.7
JC-6	2.5	9.8
Total Watershed	5.1	13.9

Source: SEWRPC.

Table I-4

ENDANGERED AND THREATENED SPECIES AND SPECIES OF SPECIAL CONCERN IN THE JACKSON CREEK WATERSHED

Common Name	Scientific Name	Status under the U.S. Endangered Species Act	Wisconsin Status
Plants			
Hairy Wild Petunia	*Ruellia humilis*	Not listed	Endangered
Narrow-leaved Vervain	*Verbena simplex*	Not listed	Special concern
Prairie Milkweed	*Asclepias sullivantii*	Not listed	Threatened
Purple Meadow-parsnip	*Thaspium trifoliatum var. flavum*	Not listed	Special concern
Purple Milkweed	*Asclepias purpurascens*	Not listed	Endangered
Rope Dodder	*Cuscuta glomerata*	Not listed	Special concern
Small White Lady's-Slipper	*Cypripedium candidum*	Not listed	Threatened
Tufted Bulrush	*Scirpus cespitosus*	Not listed	Threatened
Wafer-Ash	*Ptelea trifoliata*	Not listed	Special concern
Waxleaf Meadowrue	*Thalictrum revolutum*	Not listed	Special concern
Yellow Gentian	*Gentiana alba*	Not listed	Threatened

Source: Wisconsin Department of Natural Resources, Wisconsin State Herbarium, and SEWRPC.

Table I-5

DESCRIPTION OF HYDROLOGIC SOIL GROUPS (HSG)

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

Source: Natural Resources Conservation Service and Outagamie County Land Conservation Department.

Table I-6

HYDROLOGIC SOIL GROUPS OF THE JACKSON CREEK WATERSHED

Soil Hydrologic Group	Percent of Watershed
B	64.7
B/D	26.3
C	8.9
C/D	<1.0
A	<1.0
A/D	<1.0

Source: Natural Resources Conservation Service and SEWRPC.

SEWRPC Community Assistance Planning Report No. 320

JACKSON CREEK WATERSHED PROTECTION PLAN

Chapter I

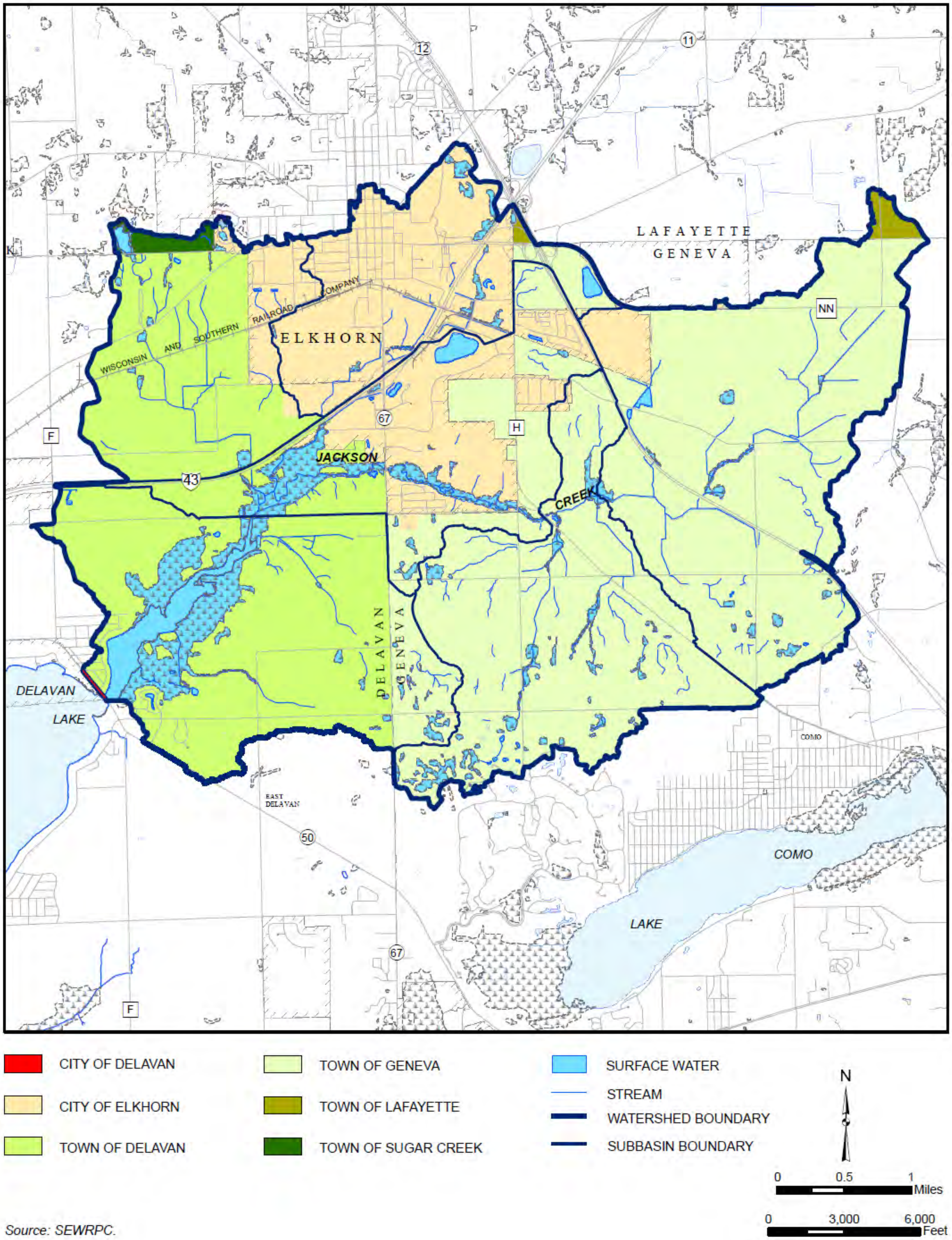
WATERSHED SETTING AND CHARACTERISTICS

MAPS

This Page Left Blank Intentionally

Map I-1

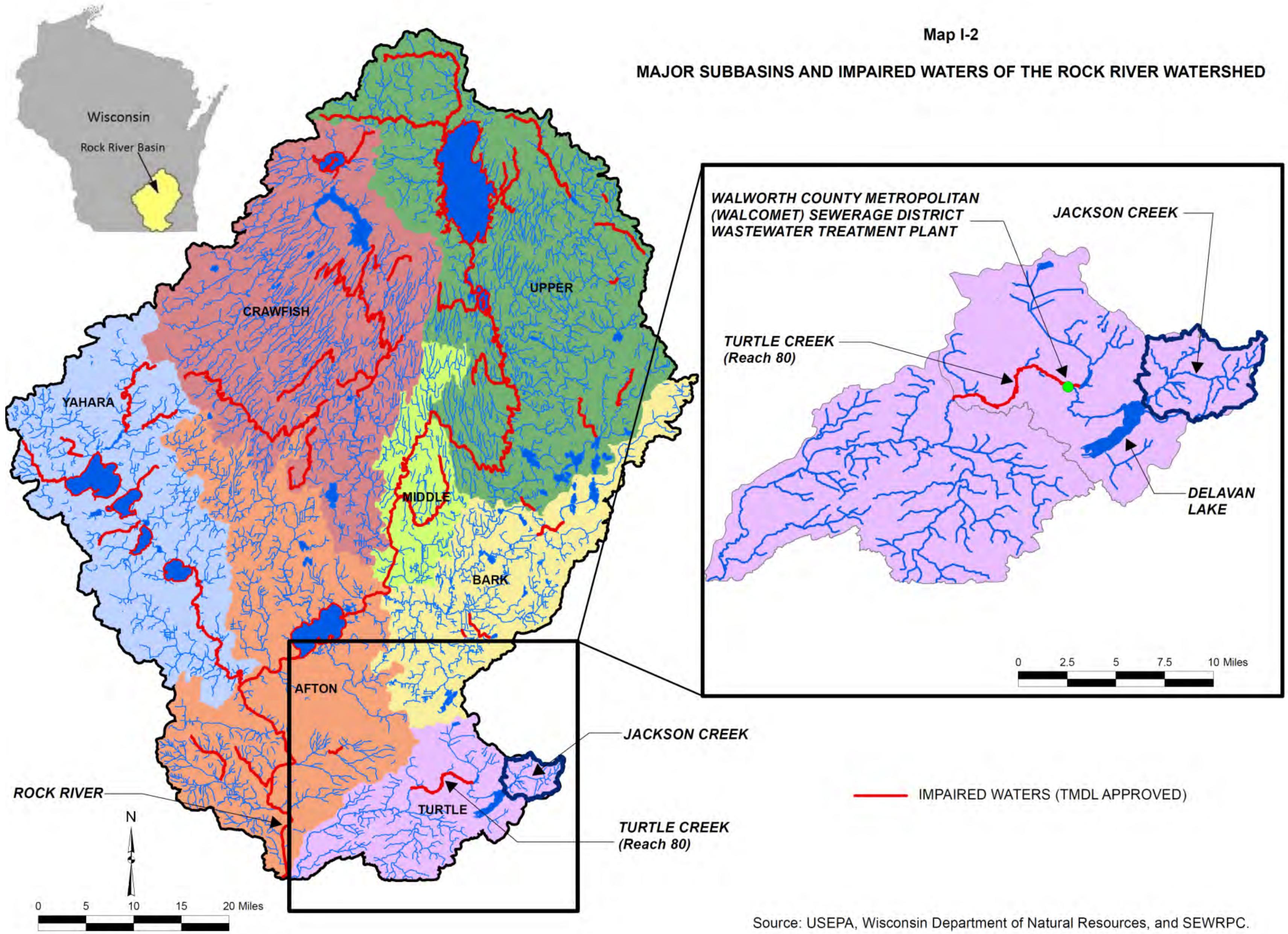
CIVIL DIVISIONS WITHIN THE JACKSON CREEK WATERSHED: 2014



Source: SEWRPC.

Map I-2

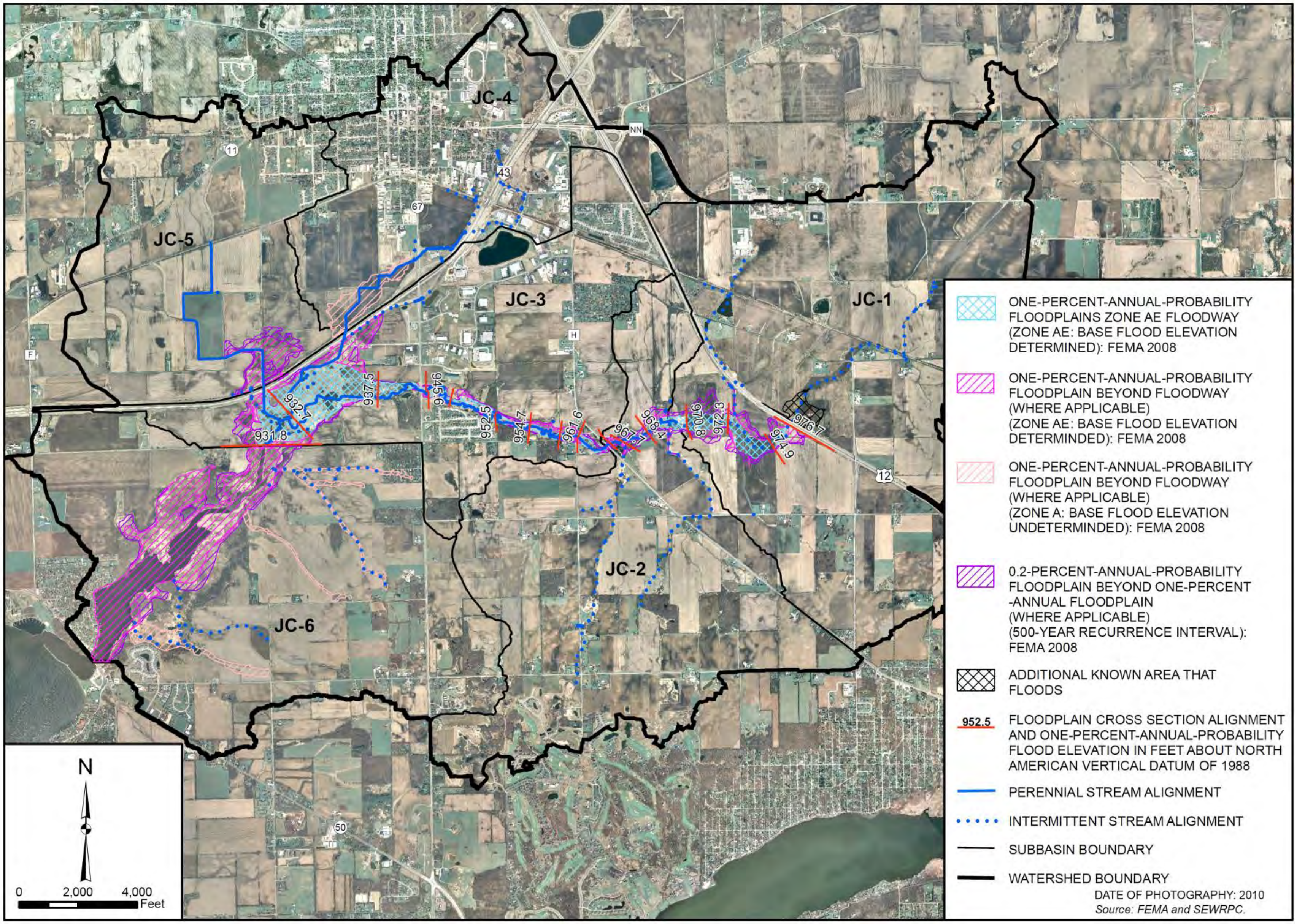
MAJOR SUBBASINS AND IMPAIRED WATERS OF THE ROCK RIVER WATERSHED



Source: USEPA, Wisconsin Department of Natural Resources, and SEWRPC.

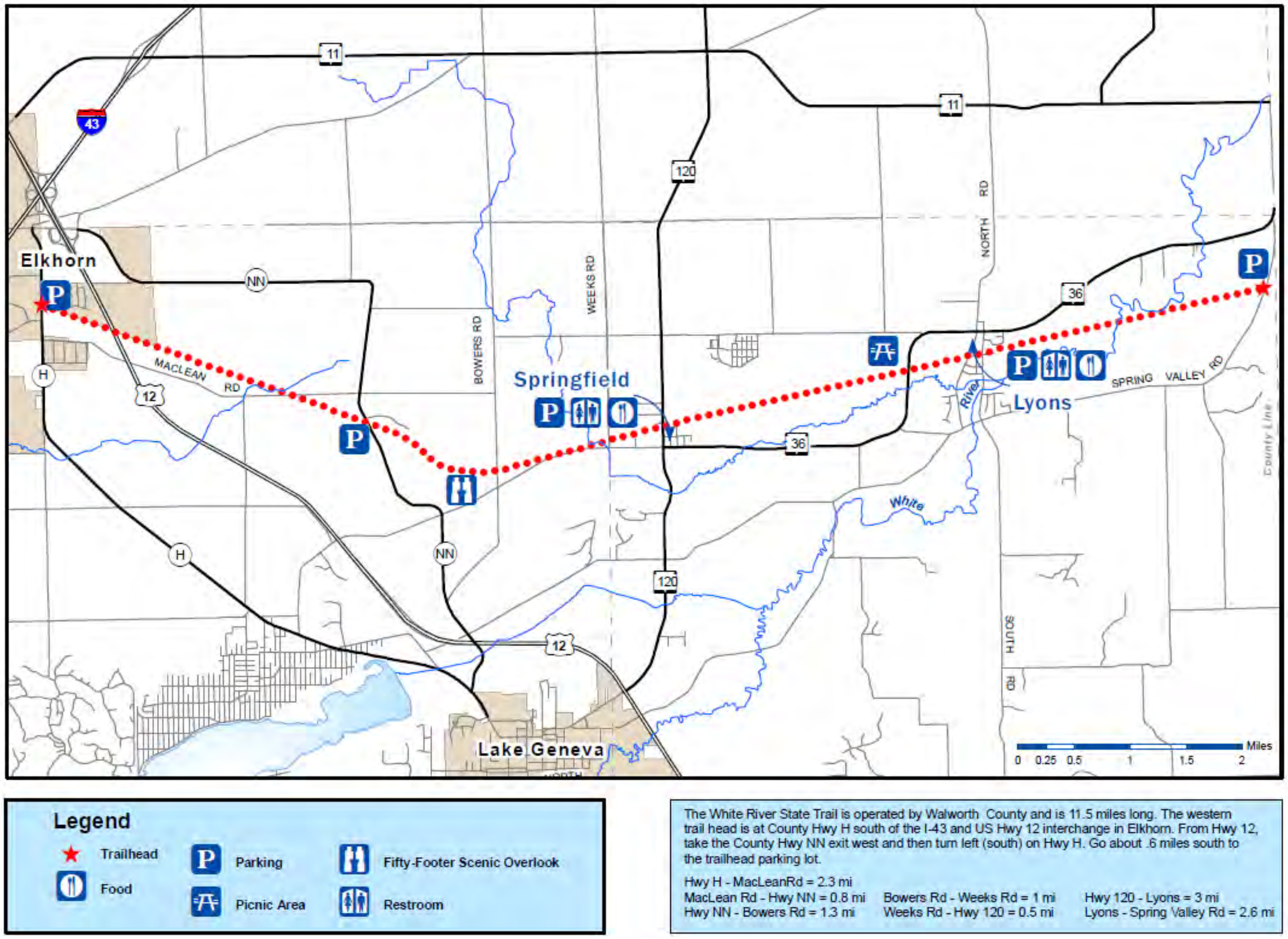
Map I-2A

FLOODWAYS AND FLOODPLAINS WITHIN THE JACKSON CREEK WATERSHED: 2015



Map I-2b

WHITE RIVER STATE TRAIL LOCATION MAP

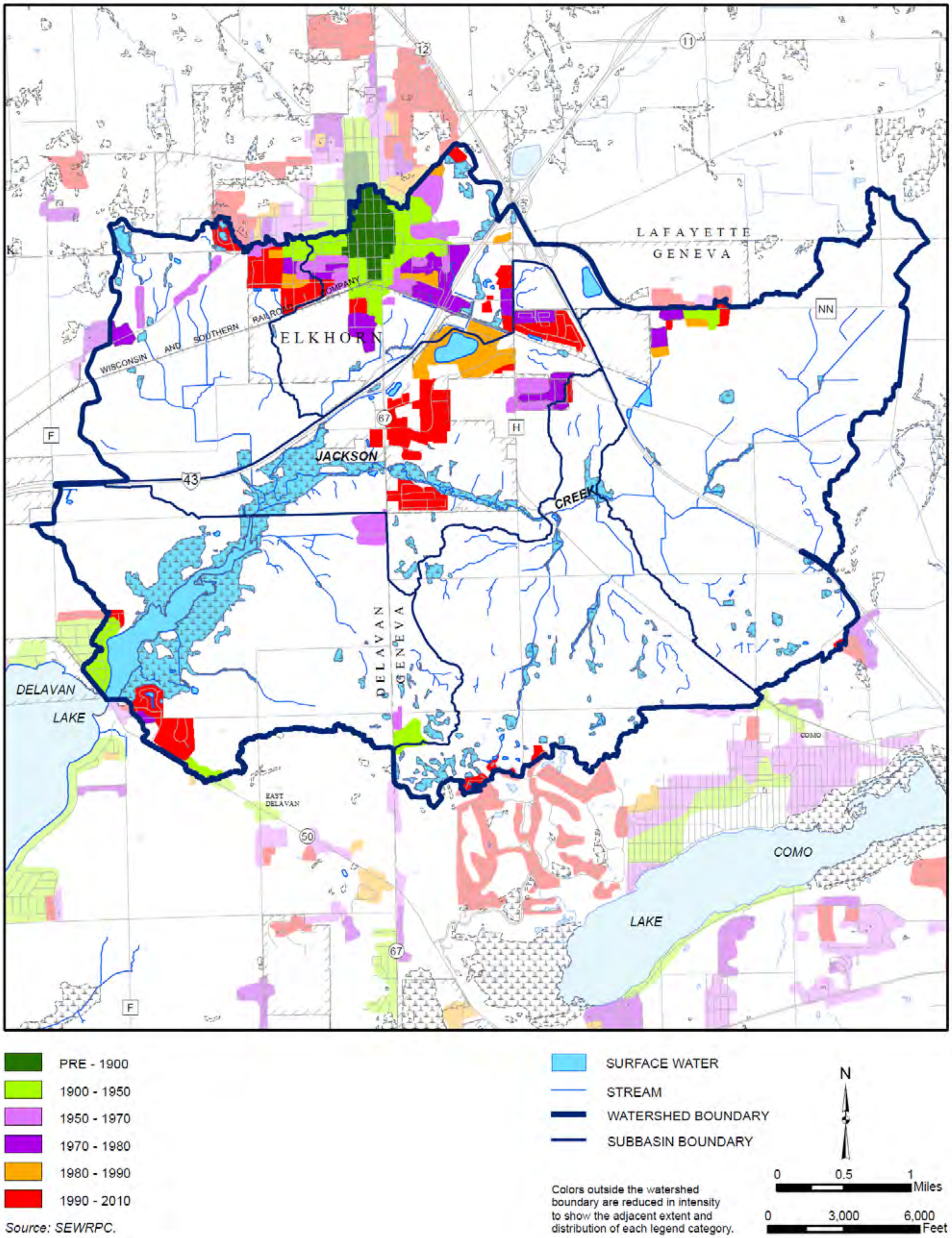


Source: Walworth County and SEWRPC.

PRELIMINARY DRAFT

Map I-3

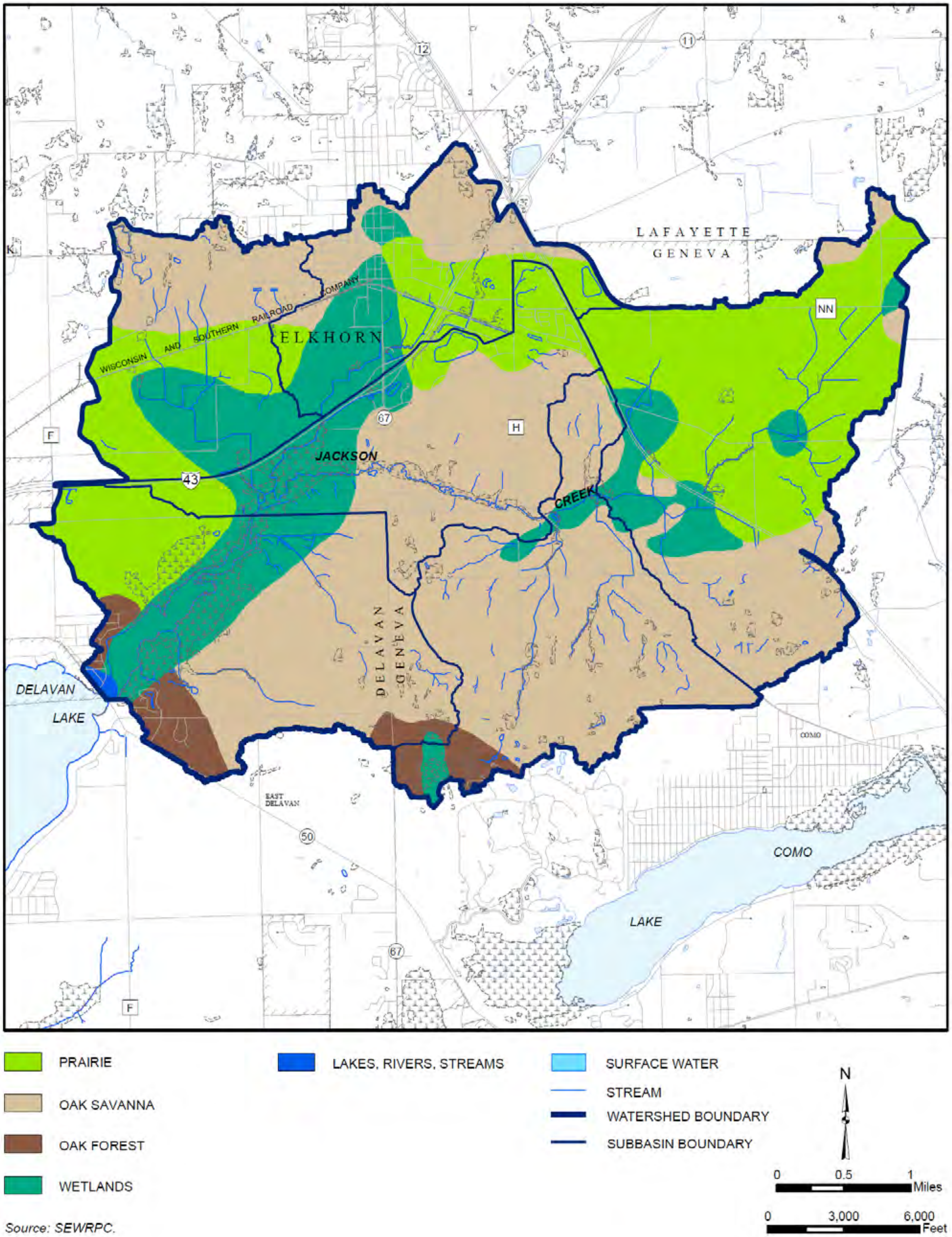
HISTORICAL URBAN GROWTH WITHIN THE JACKSON CREEK WATERSHED: 1850-2010



Source: SEWRPC.

Map I-4

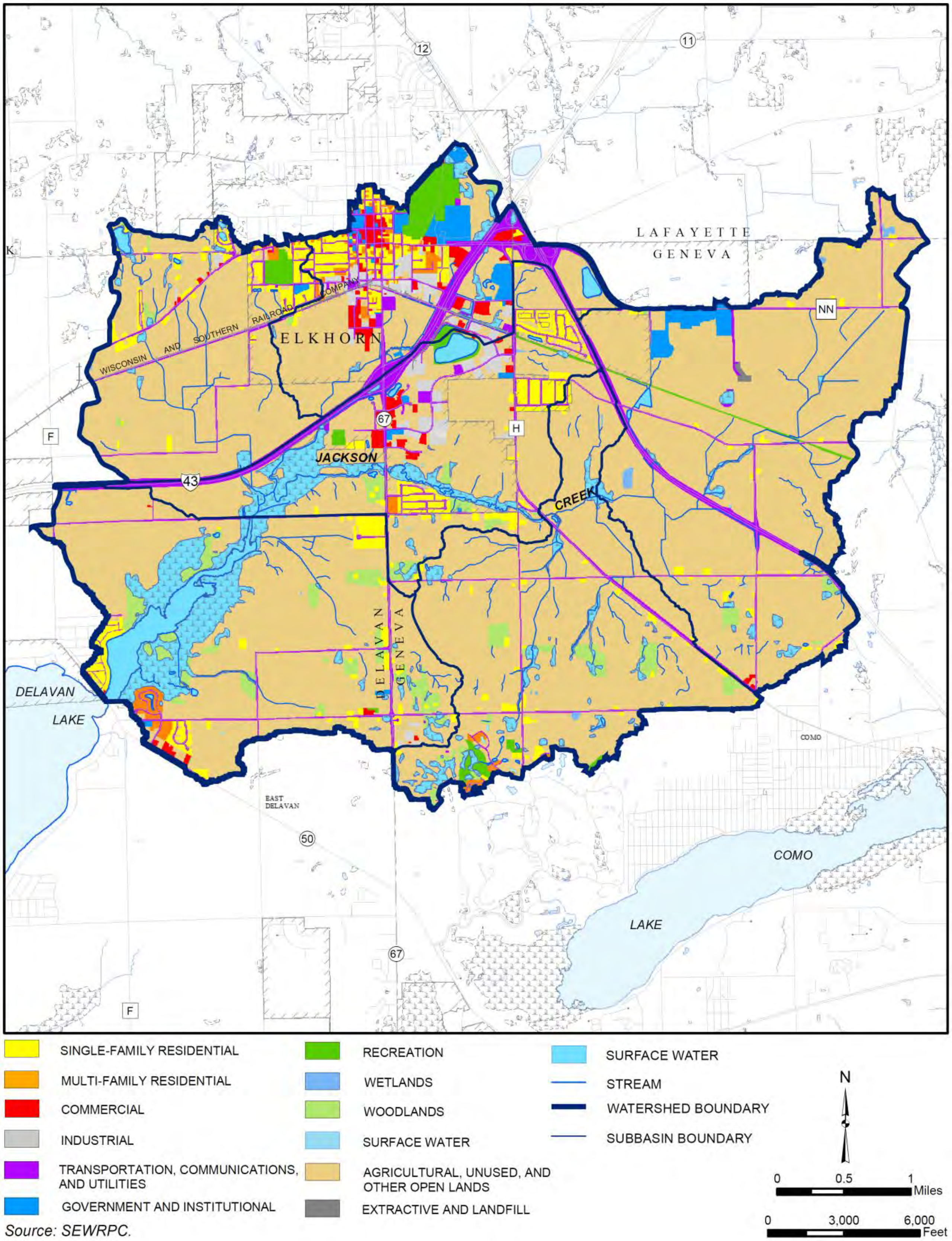
PRESETTLEMENT VEGETATION WITHIN THE JACKSON CREEK WATERSHED: 1836



Source: SEWRPC.

Map I-5

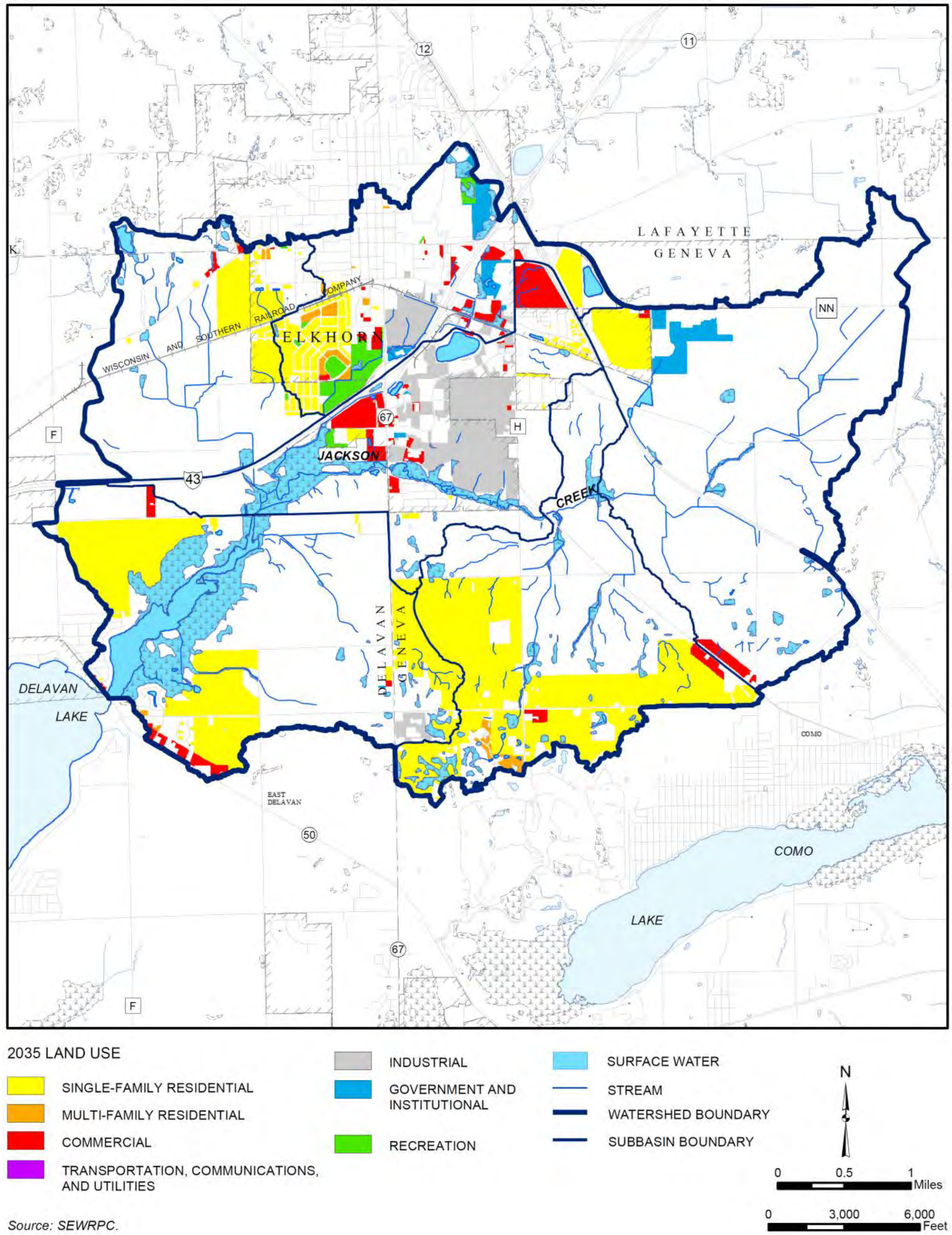
2010 LAND USE WITHIN THE JACKSON CREEK WATERSHED



Source: SEWRPC.

Map I-6

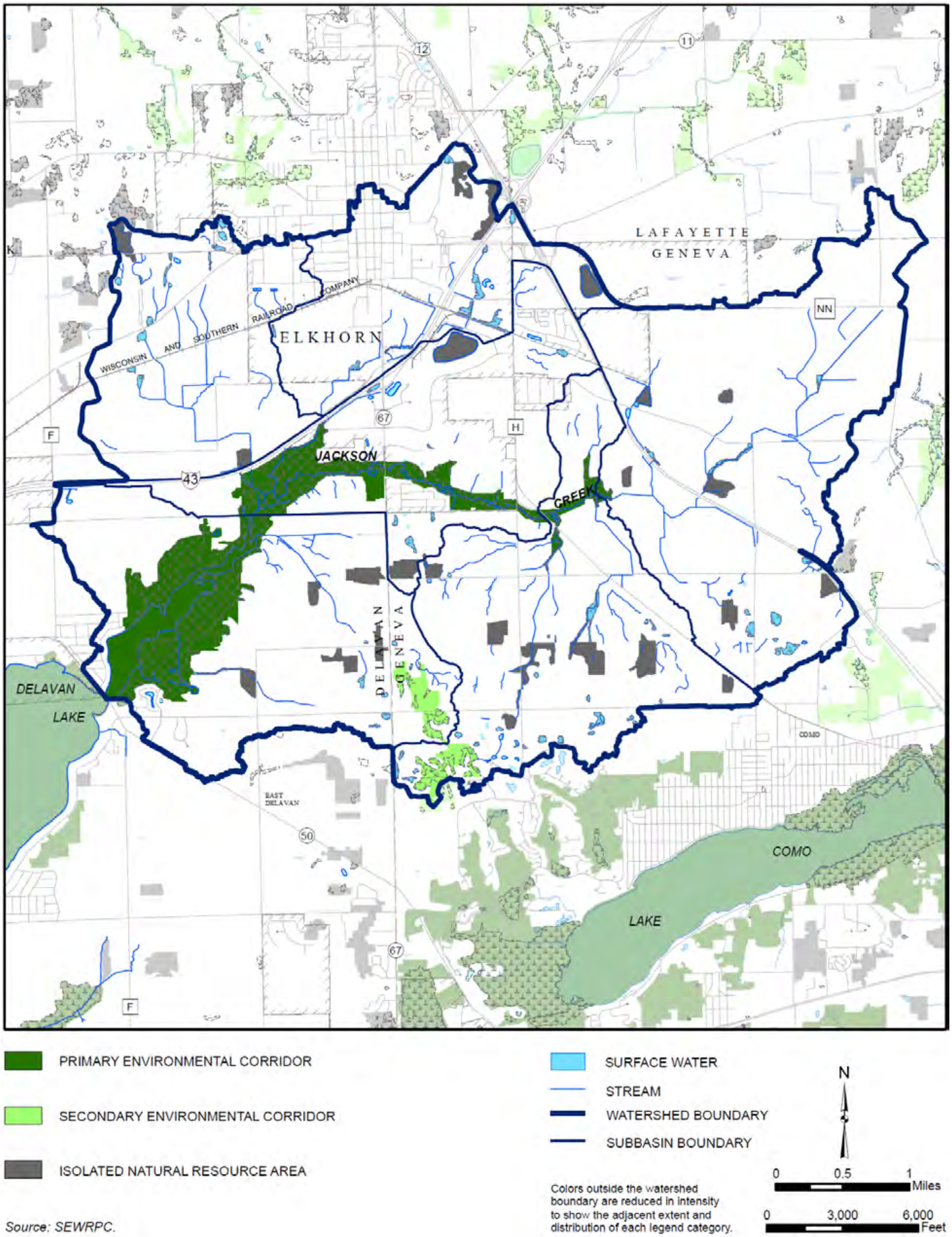
PLANNED URBAN DEVELOPMENT IN THE JACKSON CREEK WATERSHED—COLORS INDICATE THE LOCATIONS WHERE EXISTING YEAR 2010 AGRICULTURAL LAND, OPEN LAND, AND WOODLAND LAND USES ARE PROJECTED TO BE CONVERTED TO URBAN USES UNDER PLANNED YEAR 2035 CONDITIONS



Source: SEWRPC.

Map I-7

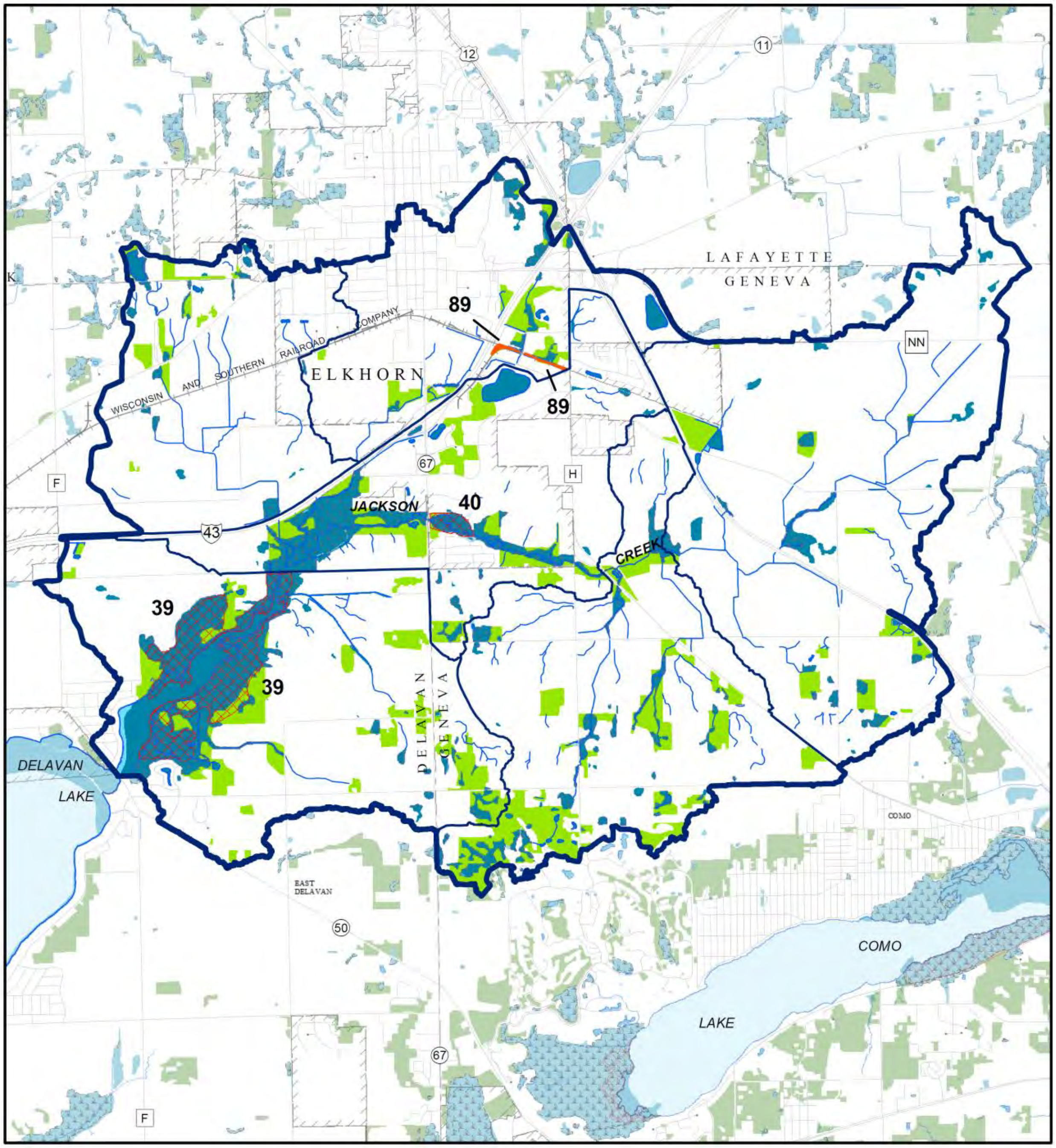
ENVIRONMENTAL CORRIDORS WITHIN THE JACKSON CREEK WATERSHED: 2010



Source: SEWRPC.

Map I-8

NATURAL AREAS, CRITICAL SPECIES HABITAT AREAS, WETLANDS, AND UPLAND COVER TYPES WITHIN THE JACKSON CREEK WATERSHED



NATURAL AREA

CRITICAL SPECIES HABITAT SITE

ALL UPLAND COVER TYPES

WETLANDS

40 SITE NUMBER IN SEWRPC PLANNING REPORT NUMBER 42

SURFACE WATER

STREAM

WATERSHED BOUNDARY

SUBBASIN BOUNDARY

Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

N

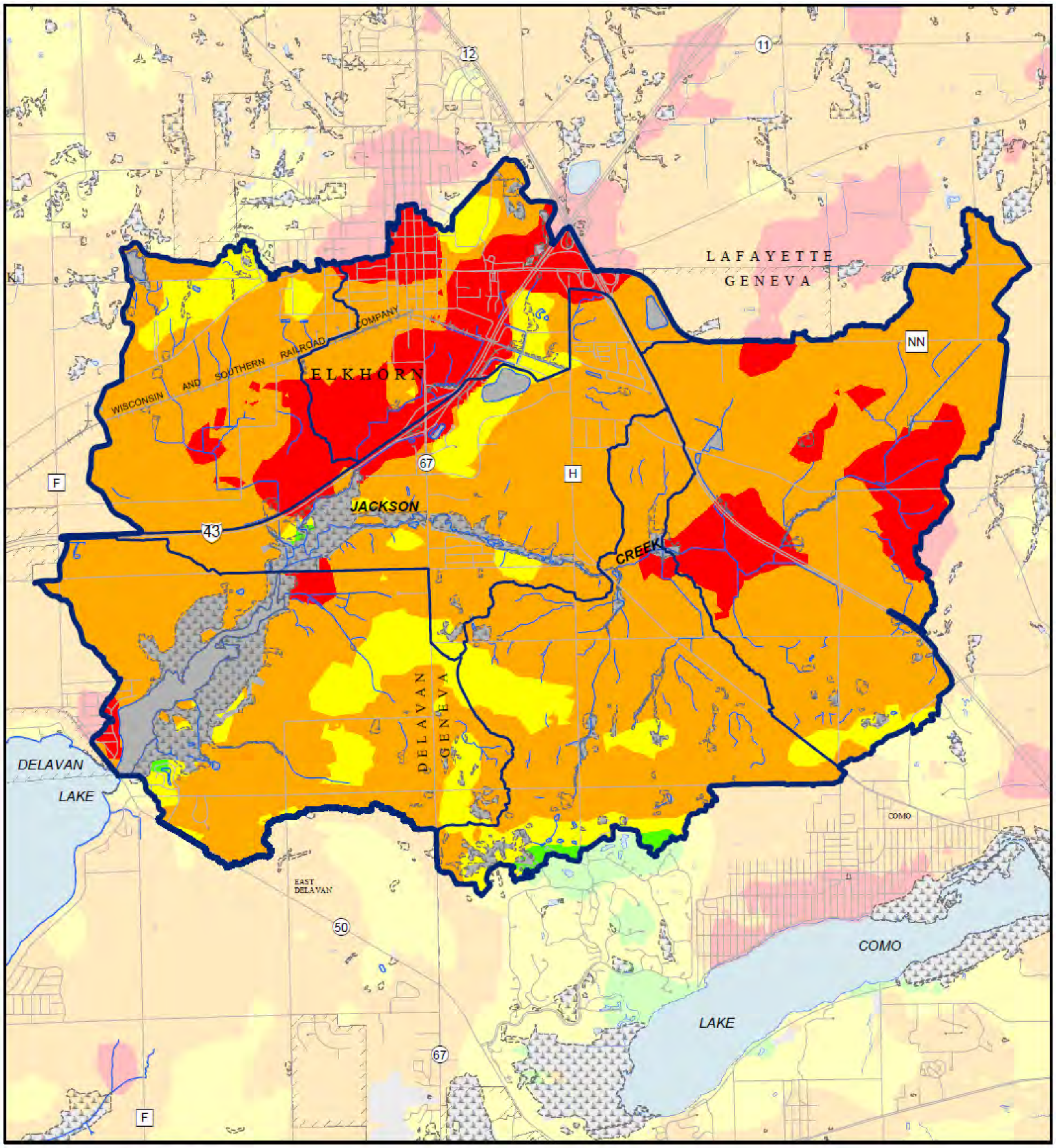
0 0.5 1 Miles

0 3,000 6,000 Feet

Source: SEWRPC.

Map I-8A

ESTIMATES OF GROUNDWATER RECHARGE POTENTIAL WITHIN THE JACKSON CREEK WATERSHED



LOW
MODERATE
HIGH
VERY HIGH
UNDEFINED

SURFACE WATER
STREAM
WATERSHED BOUNDARY
SUBBASIN BOUNDARY

N

0 0.5 1 Miles

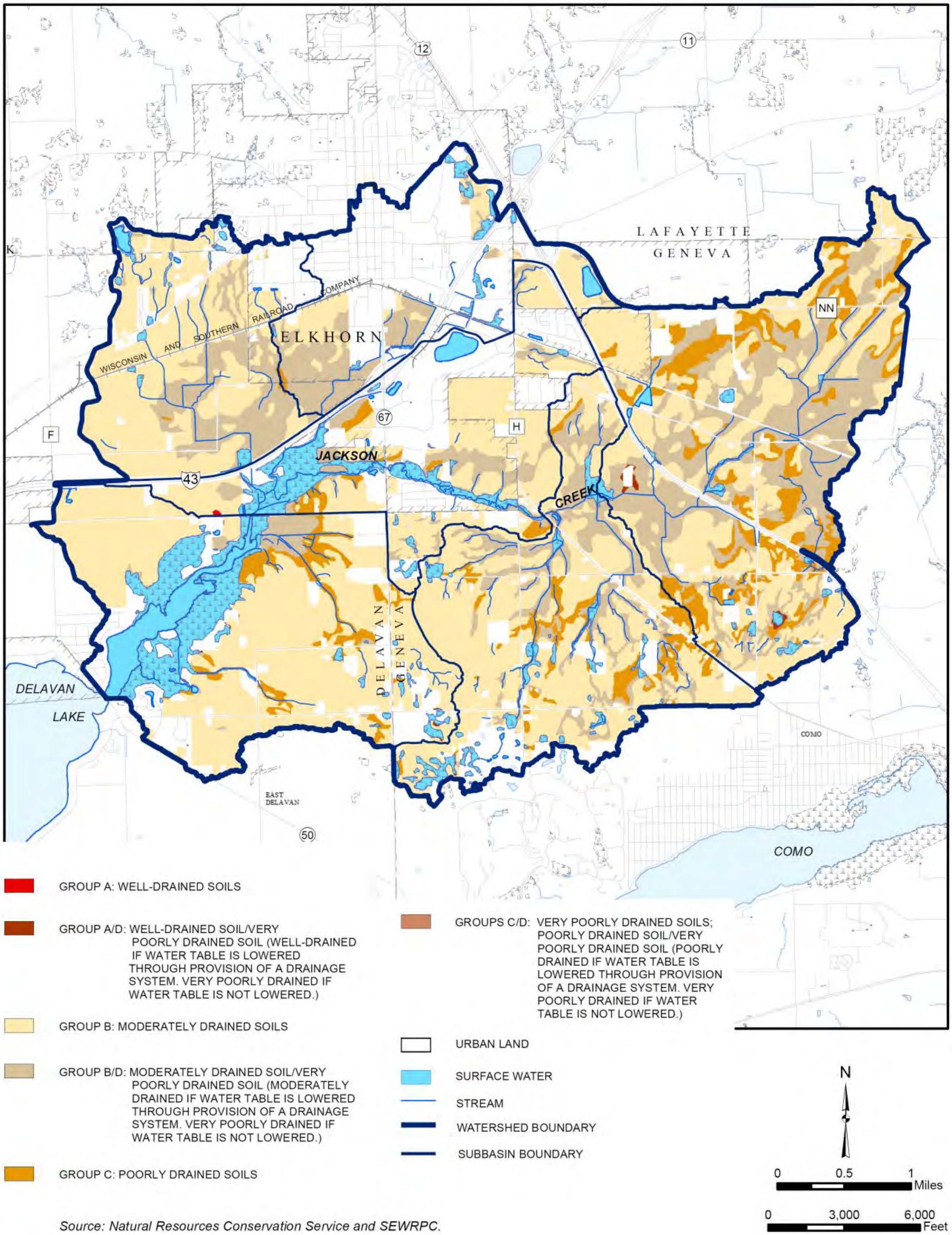
0 3,000 6,000 Feet

Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

Source: SEWRPC and Wisconsin Geological and Natural History Survey

Map I-9

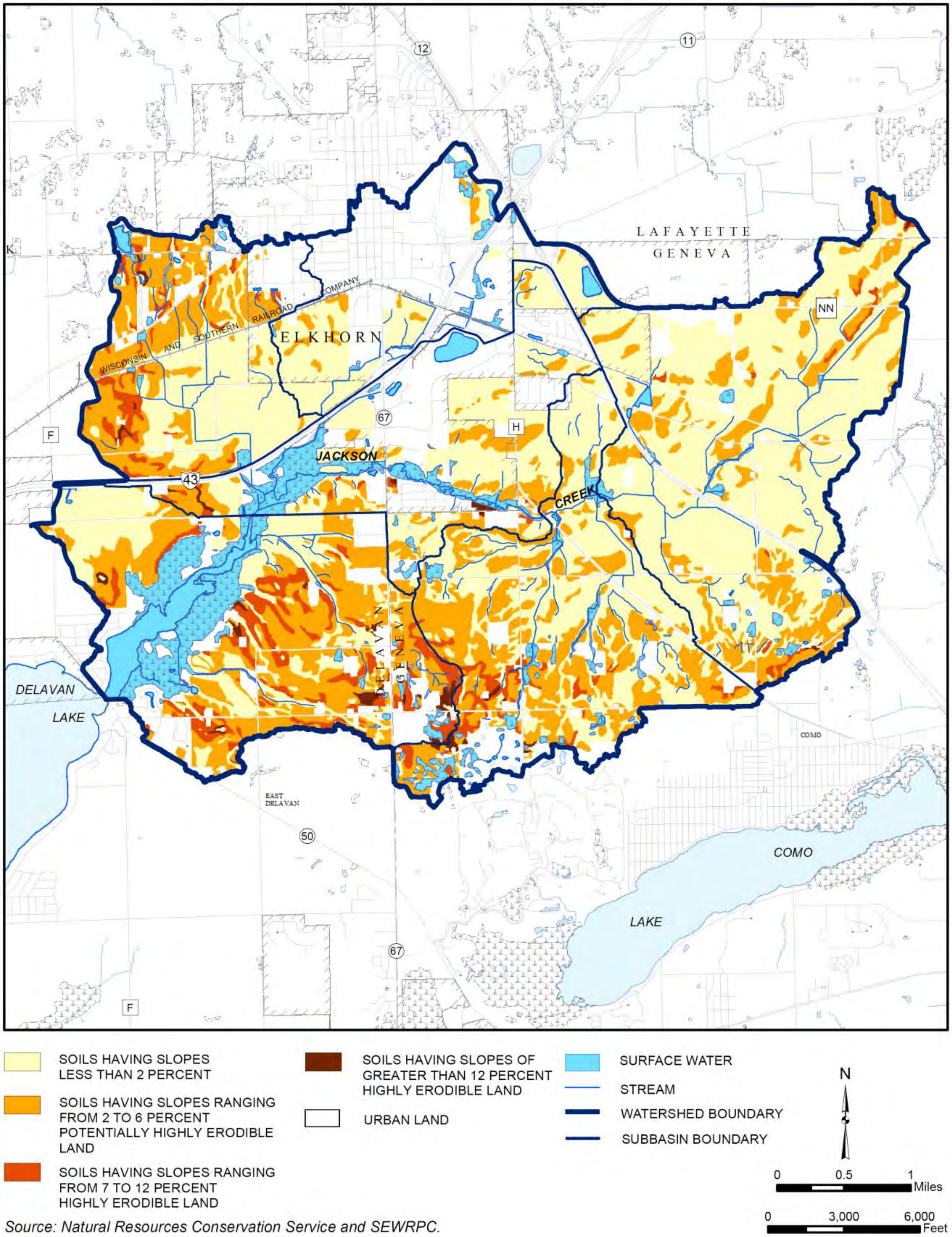
HYDROLOGIC SOIL GROUPS WITHIN AREAS OF 2010 AGRICULTURE LAND USE WITHIN THE JACKSON CREEK WATERSHED



Source: Natural Resources Conservation Service and SEWRPC.

Map I-10

LAND SLOPES WITHIN AREAS OF 2010 AGRICULTURE LAND USE WITHIN THE JACKSON CREEK WATERSHED



Source: Natural Resources Conservation Service and SEWRPC.

SEWRPC Community Assistance Planning Report No. 320

JACKSON CREEK WATERSHED PROTECTION PLAN

Chapter II

INVENTORY FINDINGS

INTRODUCTION

The health of a stream system is a direct reflection of its watershed. More specifically, changes in land use and water resources in a watershed affect the physical or chemical properties within streams, which in turn affects water quality, habitat, and resident biological communities. Hence, a stream's health is a result of the interaction of its physical, chemical, and biological components (see Figure II-1).

The condition of biological communities—which are collections of aquatic organisms—provides a direct measure of stream health. Reduced stream health is often associated with human-induced changes to the physical and chemical properties of streams that affect the condition of biological communities. Therefore, this chapter describes how land and water management activities within the Jackson Creek watershed have influenced the physical, chemical, and biological properties of this stream system. Describing and inventorying those influences on the stream system enables development of effective management strategies aimed at restoring stream health that support the recommended management measures detailed in Chapter III of this report.

This chapter presents an inventory and analysis of the surface waters and related features of the Jackson Creek watershed. Included is qualitative and quantitative information pertaining to 1) Physical Conditions—historical trends and current status of instream habitat quality within the Jackson Creek system; 2) Chemical Conditions—historical trends and potential limitations to water quality and fishery resources; and 3) Biological Conditions—fishes and other aquatic organisms and wildlife characteristics of Jackson Creek.

Environmental Factors Influenced by Agriculture and Urban Land Use

USGS scientists recently found that stream health was reduced at the vast majority of streams assessed in agricultural and urban areas across the nation.[1] The researchers found that the degree of ecological health within a stream system is directly related to the degree of human-induced changes in streamflow characteristics and water quality (nutrients and pesticides). Major findings and important implications of that study include:

- The presence of healthy streams in watersheds with substantial human influence indicates that it is possible to maintain and restore healthy stream ecosystems.
- Water quality is not independent of water quantity because flows are a fundamental part of stream health. Because flows are modified in so many streams and rivers, there are many opportunities to enhance stream health with targeted adjustments to flow management.
- Efforts to understand the causes of reduced stream health should consider the possible effects of nutrients and pesticides, in addition to modified flows, particularly in agricultural and urban settings.

More specifically, the land and water use activities associated with agricultural and urban land uses have been demonstrated to influence the hydrologic, chemical, and physical factors of the streams, which are briefly described below and illustrated in Figure II-2.[2]

Hydrologic Impacts

The natural timing, variability, and magnitudes of streamflow influence many of the key physical, chemical, and biological characteristics and processes of a healthy stream system. For example, recurring high flows from seasonal rainfall or snowmelt shape the basic structure of a river and its physical habitats, which in turn influences the types of aquatic organisms that can thrive. For many aquatic organisms, low flows impose basic constraints on the availability and suitability of habitat, such as the amount of the stream bottom that is actually submerged. The life cycles of many aquatic organisms are highly synchronized with the variation and timing of natural streamflows. For example, the reproductive period of some species like northern pike is triggered by the onset of spring runoff.

---

[1]*D.M. Carlisle and others,* The quality of our Nation's waters—Ecological health in the Nation's streams*, 1993-2005: U.S. Geological Survey Circular 1391, 2013 (available online at:*
http:// pubs.usgs.gov/circ/1391/*).*

[2]Ibid.

In general, human activities in agricultural settings alter the natural flow regime of streams and rivers through 1) subsurface drain tiles, which lower the water table and quickly route water to nearby streams; 2) ditching and straightening of headwater streams; and 3) irrigation, which supplements available water for crops. These changes can result in more rapid runoff, reduced streamflows during dry periods, and increased transport of sediments and pollutants. However, since there is a diversity of agricultural practices (see Figure II-2, Agricultural Stream), the impacts to stream ecosystems can be highly variable.

In an urban setting, human activities change the movement of water in a watershed through introduction of increased impervious surfaces, such as buildings and pavement for roadways and parking, which restrict the infiltration of precipitation into the groundwater system, combined with construction of artificial drainage systems (e.g., storm drains) that quickly move runoff to streams (see Figure II-2, Urban Stream). These impervious surfaces can lead to increased stormwater runoff and higher and more variable peak streamflows (see Figure II-3), which scour the streambed or banks and degrade the stream channel. Reduced infiltration to groundwater can lead to diminished streamflows during dry periods, particularly in stream systems where groundwater is the main source of base flow. In addition, in urban areas with a groundwater supply serving residents and industrial and commercial land uses, increases in the withdrawal of groundwater can also affect the natural flow regime of stream systems.

More specifically, recent research has shown that the hydrologic variables most consistently associated with changes in algal, invertebrate, and fish communities[3] are average flow magnitude; high flow magnitude, frequency and duration; and how rapidly the stream changes its width in response to changes in flow. As detailed in Chapter I of this report, the amount of urban development within portions of the Jackson Creek watershed are at high enough levels to potentially have negative effects on water quality and water quantity, and the amount of urbanization is projected to increase.

To some degree, impervious surface impacts can be mitigated through implementation of traditional stormwater management practices and emerging green infrastructure technologies, such as pervious pavement, green roofs, rain gardens, bioretention, and infiltration facilities. Emerging technologies differ from traditional stormwater practices in that they seek to better mimic the disposition of precipitation on an undisturbed landscape by retaining and infiltrating stormwater onsite. A number of nontraditional, emerging low impact development technologies have been implemented throughout the Southeastern Wisconsin Region, including disconnecting downspouts; installing rain barrels, green roofs, and rain gardens; and constructing biofiltration swales in parking lots and along roadways. Experience has shown that these emerging technologies can be effective.

---

[3]*Personal Communication, Dr. Jeffrey J. Steuer, U.S. Geological Survey.*

Location of impervious surfaces also determines the degree of direct impact they will have upon a stream. There is a greater impact from impervious surfaces located closer to a stream, because there is less time and distance for the polluted runoff to be naturally treated before entering the stream. A study of 47 watersheds in southeastern Wisconsin found that one acre of impervious surface located near a stream could have the same negative effect on aquatic communities as 10 acres of impervious surface located further away from the stream.[4] Because urban lands located adjacent to streams have a greater impact on the biological community, an assumption might be made that riparian buffer strips located along the stream could absorb the negative runoff effects attributed to urbanization. Yet, riparian buffers may not be the complete answer since most urban stormwater is delivered directly to the stream via a storm sewer or engineered channel and, therefore, enters the stream without first being filtered by the buffer. Riparian buffers need to be combined with other management practices, such as detention basins, grass swales, and infiltration facilities, to adequately mitigate the effects of urban stormwater runoff. Combining practices into such a "treatment train" can provide a higher level of pollutant removal and reduction in the volume of runoff, than can single, stand-alone practices. Stormwater and erosion treatment practices vary in their function, which influences their level of effectiveness. Location of a practice on the landscape, as well as proper construction and continued maintenance, greatly influences the level of pollutant removal and runoff volume management.

Urbanization also creates other problems. Accumulations of trash and debris in urban waterways and associated riparian lands are unsightly and can cause physical and/or chemical (i.e., toxic) damage to aquatic and terrestrial wildlife. Sometimes debris can accumulate to such an extent that it may limit recreation and the passage of aquatic organisms and/or cause streambank erosion.

Chemical Impacts

The unique water chemistry requirements and tolerances of aquatic species help to define their natural abundance in a given stream, as well as their geographic distribution. Many naturally occurring chemical substances in streams and rivers are necessary for normal growth, development, and reproduction of biological communities. For example, sufficient dissolved oxygen in water is necessary for normal respiration. Dissolved oxygen concentrations in streams and rivers is determined by the water temperature and by physical aeration processes influenced by the slope and depth of the stream. Similarly, small amounts of nutrients (nitrogen, phosphorus, and silica) are necessary for normal growth of aquatic plants.

---

[4]*L. Wang, J. Lyons, P. Kanehl, and R. Bannerman, "Impacts of Urbanization on Stream Habitat and Fish Across Multiple Spatial Scales,"* Environmental Management*, Volume 28, 2001, pages 255-266.*

Human activities often contribute additional amounts of these naturally occurring substances, as well as other synthetic (manmade) chemicals, to streams from point and nonpoint sources. Runoff from agricultural lands (see Agricultural Stream Ecosystem in Figure II-2) may contain 1) sediment from soil erosion on tilled lands; 2) nutrients from the application of fertilizer and manure; and 3) pesticides used in the past and present to control insects, weeds, rodents, bacteria, or other unwanted organisms. Runoff from urban lands (see Urban Stream Ecosystem in Figure II-2) may contain 1) sediment from construction activities; 2) nutrients and pesticides applied to lawns and recreational areas; and 3) petroleum compounds, trace metals, and deicing salts from roads and parking lots. Point sources include municipal and industrial wastewater effluent that, depending on the sources of wastewater and level of treatment, may contain different amounts of nutrients and other contaminants.

Physical Impacts

Physical habitat includes factors such as streambed substrates, water temperature, and large debris from streamside vegetation. Streambed substrates include the rocks, sediments, and submerged woody material in a stream. Streambed sediments may range in size and composition from large rocks to sand and silt that reflect the local geology. These substrates are important because they provide living space for many stream organisms. Stable substrates, such as cobbles and boulders, protect organisms from being washed downstream during high flows and, thus, generally support greater biological diversity than do less stable substrates, such as sand and silt.

Water temperature is crucial to aquatic organisms because it directly influences their metabolism, respiration, feeding rate, growth, and reproduction. Most aquatic species have an optimal temperature range for growth and reproduction. Thus, their distributions are largely determined by regional differences in climate and elevation along with more local effects from riparian (stream corridor) shading and groundwater influence. Water temperature also influences many chemical processes, such as the availability of oxygen in water for fish and other aquatic life.

The riparian zone is the land adjacent to the stream inhabited by plant and animal communities that rely on periodic or continual nourishment from the stream. The size and character of riparian zones are important to biological communities because these have a major influence on the amount of shelter and food available to aquatic organisms and the amount of sunlight reaching the stream through the tree canopy, which influences water temperature and the amount of energy available for photosynthesis. Riparian zones also influence the amount and quality of runoff that reaches the stream.

Land uses that affect streamflow, sediment availability, or riparian vegetation alter physical habitats in streams. Some agricultural practices (see Agricultural Stream Ecosystem in Figure II-2), such as conventional tillage near streambanks and drainage modifications, lead to increased sediment erosion, channelization, or removal of riparian vegetation. Increased sediment from erosion can fill crevices between rocks and cobble in the streambed, which reduces living space for many stream organisms. As watersheds urbanize (see Urban Stream Ecosystem in Figure II-2), some segments of streams may be cleared, ditched, straightened, and enclosed to facilitate drainage and the movement of floodwaters. These modifications increase stream velocity during storms, which can transport large amounts of sediment, scour stream channels, and remove woody debris and other natural structures that provide habitats for stream organisms. In addition, culverts and ditches can be barriers to aquatic organisms that need to migrate throughout the stream network. Humans can alter natural stream temperature through changes in the amount and density of the canopy provided by riparian trees. In some extreme cases, streams in urban areas are routed through conduits, culverts, and completely buried.

Jackson Creek Drainage Network

Water from rainfall and snowmelt flows into streams by one of two pathways: 1) either directly flowing overland as surface water runoff or 2) infiltrating into the soil, recharging the groundwater, and eventually reaching streams as baseflow. Ephemeral, or intermittent, streams generally flow only during the wet season or during large rainfall events. Perennial streams that flow year-round are primarily sustained by groundwater during dry periods. The surface water stream network within the Jackson Creek watershed is shown on Map II-1. Six sub-basin areas within this watershed are designated as JC-1 through JC-6, and are generally numbered from the upstream to downstream position in the watershed. In addition, Jackson Creek was further divided into four discrete reaches, which were established based on a number of considerations, including gradient, sinuosity, presence of dams and bridge and culvert crossings, and physical instream characteristics. An additional four reaches include unnamed tributaries A through E (see Map II-1). The summary statistics and recommendations in this report are organized according to these reaches and sub-basins.

WATER QUALITY

The Federal Clean Water Act (CWA) protects the nation's waters and requires states to 1) adopt water quality criteria that the USEPA publishes under 304 (a) of the Clean Water Act, 2) modify 304 (a) criteria to reflect site-specific conditions, or 3) adopt criteria based on other scientifically defensible methods. Water quality standards require assigning a designated use to the waterbody.

Clean water is vital to individual human health, healthy communities, and the economy. Having clean water upstream is essential to having healthy communities downstream. The health of rivers and lakes depend on the tributaries and wetlands where they begin. Streams and wetlands provide many benefits to communities by conveying and storing floodwaters, assimilating and filtering pollution, and providing habitat for fish and wildlife.[5]

[5]*See USEPA website for more information at http://www2.epa.gov/cleanwaterrule*

The Clean Water Rule: Definition of "Waters of the United States"

Protection for about 60 percent of the nation's streams and millions of acres of wetlands has been confusing and complex as the result of U. S. Supreme Court decisions in 2001 and 2006. The "Clean Water Rule: Definition of 'Waters of the United States'" was published by the United States Environmental Protection Agency (USEPA) and the U.S. Army Corps of Engineers on June 29, 2015, pursuant to the Federal Clean Water Act, to clarify which streams and wetlands comprise "water of the United States" that are regulated under the Act.[6] The Rule protects the types of waters that have historically been covered under the Clean Water Act. The Rule does not regulate most ditches and does not regulate groundwater, shallow subsurface flows or tile drains. It does not make changes to current policies on irrigation or water transfers or apply to erosional features. The rule does not create any new requirements for farmers. Activities like planting, harvesting and moving livestock have long been exempt from Clean Water Act regulation, and the Clean Water Rule preserves those exemptions.[7]

Water Quality Standards

Water quality standards are the basis for protecting the quality of surface waters. The standards implement portions of the Federal Clean Water Act by specifying the designated uses of waterbodies and setting water quality criteria to protect those uses. The standards also contain policies to protect high-quality waters and to protect waters from being further degraded. Water quality standards are established to sustain public health and public enjoyment of waters and for the propagation and protection of fish, aquatic organisms, and other wildlife.

In Wisconsin, water quality standards are established and enforced by the WDNR and are subject to approval by the USEPA. These standards consist of three elements: designated uses, water quality criteria, and an anti-degradation policy. These are set forth in Chapters NR 102, "Water Quality Standards for Wisconsin Surface Waters," NR 103, "Water Quality Standards for Wetlands," NR 104, "Uses and Designated Standards and Secondary Values," NR 105, "Surface Water Quality Criteria for Toxic Substances," and NR 207, "Water Quality Antidegradation," of the *Wisconsin Administrative Code*.

Designated Use and Impairments

The designated uses of a waterbody are a statement of the types of activities the waterbody should support—whether or not they are currently being attained. These uses establish water quality goals for the waterbody and determine the water quality criteria needed to protect the use. In Wisconsin, waterbodies are assigned four uses:

---

[6] *The Rule has been subject to several legal challenges. On October 9, 2015, the United States Court of Appeals for the Sixth Circuit issued an order temporarily blocking implementation of the Rule nationwide.*

[7] *http://www2.epa.gov/cleanwaterrule/what-clean-water-rule-does-not-do*

fish and aquatic life, recreation, public health and welfare, and wildlife. The fish and aquatic life use is further divided into several categories:

- Coldwater community,
- Warmwater sportfish community,
- Warmwater forage fish community,
- Limited forage fish community, and
- Limited aquatic life community.

Coldwater communities include surface waters capable of supporting a community of coldwater fish and other aquatic organisms or serving as a spawning area for coldwater fish species. Warmwater sportfish waters include surface waters capable of supporting a community of warmwater sport fish or serving as a spawning area for warmwater sport fish. Warmwater forage fish waters include those surface waters capable of supporting an abundant diverse community of forage fish and other aquatic organisms. Because identical water quality criteria apply to them, the warmwater sportfish and warmwater forage fish categories are sometimes referred to as "warmwater fish and aquatic life (FAL)." Limited forage fish waters include surface waters of limited capacity and naturally poor water quality or habitat. These waters are capable of supporting only a limited community of forage fish and other aquatic organisms. Limited aquatic life waters include surface waters of severely limited capacity and naturally poor water quality or habitat. These waters are capable of supporting only a limited community of aquatic organisms. The latter two categories are considered variance categories.

The WDNR also has classified some waters of the State as outstanding or exceptional resource waters. These waters, listed in Sections NR 102.10 and NR 102.11 of the *Wisconsin Administrative Code*, are not significantly impacted by human activities and are deemed to have significant value as fisheries, hydrologically or geographically unique features, outstanding recreational opportunities, and unique environmental settings.. However, there are no streams with these designations in the Jackson Creek watershed.

The water use objectives for fish and aquatic life for all streams in the Jackson Creek watershed are shown on Map II-2. Within the Jackson Creek watershed, all of the stream reaches are classified as warmwater fish and aquatic life communities and full recreational use. It should be noted that Jackson Creek between Mound Road and STH 50 constitutes the inlet to Delavan Lake. Because this is a portion of the Lake, water quality criteria for stratified drainage lakes apply to this section of the Creek. There are no designated coldwater communities, or outstanding or exceptional resource waters contained within the Jackson Creek watershed.

The water use objectives shown on Map II-2 are regulatory designations. They serve to define the water quality criteria that apply to these waters and form the basis for determining whether the level of water quality in them meets the expectations set forth in the Federal Clean Water Act and Wisconsin law. For management purposes, agencies such as the WDNR may also use other classification systems. These systems may be based on factors such as water temperature, stream discharge, stream depth, or stream width. While these systems may provide useful information about water quality and biological conditions within waterbodies and serve as a basis for evaluating such conditions, until they are reflected in water quality standards they lack the regulatory significance of the designated uses shown on Map II-2. For example, despite its regulatory warmwater fish classification described above, Jackson Creek is actually considered a Cool (Cold Transition Headwater) water fishery based upon recent research tools available from WDNR. This cool water designation is a more accurate depiction of this river system and how it functions and is supported by recent fisheries sampling (see *Biological Monitoring* section below for more details).

Surface Water Quality Criteria

Water quality standards also specify certain criteria that must be met to ensure that the designated uses of waterbodies are supported. These water quality criteria are statements of the physical, chemical, and biological characteristics of the water that must be maintained if the water is to be suitable for the designated uses. Some criteria are limits or ranges of chemical concentrations that are not to be exceeded. Others are narrative standards which apply to all waters.

The applicable water quality criteria for all water uses designated in Southeastern Wisconsin are set forth in Tables II-1 and II-2. Table II-1 shows the applicable water quality criteria for all designated uses for five water quality parameters—dissolved oxygen concentration, pH, fecal coliform bacteria concentration, total phosphorus concentration, and chloride concentration. It also shows the water quality criterion for temperature that applies to limited aquatic life communities. Table II-2 shows the water quality criteria for temperature. All of the streams in the Jackson Creek watershed have a seven-day, 10-percent probability low flow (7Q10) of less than 200 cubic feet per second (cfs).[8] Thus, as indicated in Table II-2, those streams are assigned the standards for "small warmwater communities."

In addition to the numerical criteria presented in the tables, there are narrative standards which apply to all waters. All surface waters must meet certain conditions at all times and under all flow conditions. Section NR 102.04(1) of the *Wisconsin Administrative Code* states that:

[8]*The 7Q10 is the seven-day consecutive low flow with an annual probability of occurrence of 10 percent.*

"Practices attributable to municipal, commercial, domestic, agricultural, land development or other activities shall be controlled so that all waters including the mixing zone and the effluent channel meet the following conditions at all times and under all flow conditions:

(a) Substances that will cause objectionable deposits on the shore or in the bed of a body of water shall not be present in such amounts as to interfere with public rights in the waters of the State.

(b) Floating or submerged debris, oil, scum or other material shall not be present in such amounts as to interfere with public rights in the waters of the State.

(c) Materials producing color, odor, taste, or unsightliness shall not be present in such amounts as to interfere with public rights in the waters of the State.

(d) Substances in concentrations or combinations which are toxic or harmful shall not be present in amounts found to be of public health significance, nor shall such substances be present in such amounts as to interfere with public rights in the waters of the State."

Other Water Quality Guidelines

There are several water quality constituents for which the State of Wisconsin has not developed official water quality criteria. For many of these constituents, it would be useful to have some guidelines that could be used to evaluate what particular values of these constituents indicate regarding the quality of surface waters. Table II-3 sets forth guidelines for several water quality constituents. These guidelines are drawn from a variety of sources including the Rock River Total Maximum Daily Load (TMDL) study,[9] studies conducted in support of the development of water quality criteria for the State of Wisconsin,[10] and studies presenting recommendations to states and tribes for water quality criteria development.[11] These sources consist of work completed by the USEPA and WDNR or studies conducted by the USGS on behalf of the WDNR. Table II-3 combines information from all

[9]*U.S. Environmental Protection Agency and Wisconsin Department of Natural Resources,* 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, *July 2011.*

[10]*D.M. Robinson, D.J. Graczyk, L. Wang, G. LaLiberte, and R. Bannerman,* Nutrient Concentrations and Their Relations to the Biotic Integrity of Wadeable Streams in Wisconsin, *U.S. Geological Survey Professional Paper No. 1722, 2006.*

[11]*U.S Environmental Protection Agency,* Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria: Rivers and Streams in Nutrient Ecoregion VII, *EPA 822-B-00-018, December 2000; U.S Environmental Protection Agency,* Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria: Lakes and Reservoirs in Nutrient Ecoregion VII, *EPA 822-B-00-009, December 2000.*

these sources to provide preferred guidelines for evaluating additional water quality constituents. These guidelines were developed specifically for Wisconsin and, in some cases, southeastern Wisconsin.

Three different types of guidelines are shown in Table II-3: TMDL target concentrations, recommended water quality criteria, and reference values. A TMDL target concentration represents a goal set by a TMDL study. It is a concentration or value of a constituent that defines acceptable water quality. A recommended water quality criterion is a scientific assessment of the effects of a water quality constituent on human health or aquatic life. Only when a recommended criterion is adopted by a state, tribe, or territory or promulgated by USEPA does it become the relevant standard for developing permit limits, assessing waters, and developing TMDLs. Finally, a reference value is a scientific assessment of the potential level of water quality that could be achieved in the absence of human activities. Unless they are adopted by the State or promulgated by USEPA as water quality criteria, these guidelines have no regulatory impact. Instead they serve as indicators of where the division between good and poor water quality lies and can be used to serve as proxies in lieu of adopted water quality criteria to better understand water quality conditions within the Jackson Creek watershed.

TMDL Requirements

Under the Federal Clean Water Act, states are required to develop Total Maximum Daily Loads (TMDLs) to address impaired waterbodies that are not meeting water quality standards. A TMDL includes both a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards and an allocation of that load among the various sources of that pollutant. The TMDL must also account for seasonal variations in water quality and include a margin of safety to account for uncertainty in predicting how well pollutant reductions will result in meeting water quality standards.

A TMDL allocates the allowable load between a wasteload allocation for point sources such as municipal wastewater treatment plants, industrial dischargers, concentrated animal feeding operations, and municipal separate storm sewer systems (MS4s); a load allocation for nonpoint sources such as agricultural sources, urban sources not covered under a discharge permit, and natural background loads; and a margin of safety. Wasteload allocations are implemented through limits established in discharge permits under the WPDES. Load allocations are implemented through a wide variety of Federal, State, and local programs as well as voluntary action by citizens. These programs may include regulatory, non-regulatory, or incentive-based elements, depending on the program. Implementation of load allocations is typically an adaptive process, requiring the collaboration of diverse stakeholders and the prioritization and targeting of available programmatic, regulatory, financial, and technical resources.

As part of the Rock River Basin, the Jackson Creek watershed is addressed in the Rock River TMDL that was approved in 2011.[12] This TMDL addresses impairments such as oxygen depletion, nuisance algae growth, reduced populations of submerged aquatic vegetation, water clarity problems, and degraded habitat resulting from high concentrations of total phosphorus (TP) and total suspended solids (TSS). It establishes wasteload allocations and load allocations for total phosphorus and TSS in 84 sub-basins of the Rock River Basin, including Sub-Basin 80 which contains Jackson Creek, Delavan Lake, Swan Creek, a section of Turtle Creek and their associated watersheds.

While no waterbodies within the Jackson Creek watershed are currently listed as impaired (see Map I-2), both Jackson Creek and Delavan Lake were recently added to the *WDNR's proposed 2016 list of impaired waters,* due to total phosphorus pollutant loads. In addition, Jackson Creek flows through Delavan Lake and Swan Creek into a section of Turtle Creek that is listed on the State's approved 2012 list of impaired waters as being impaired for low concentrations of dissolved oxygen resulting from high concentrations of total phosphorus.

The developers of the Rock River TMDL plan used two models to calculate loads of TP and TSS from nonpoint sources for all the subwatersheds in the Rock River Basin. The Soil & Water Assessment Tool (SWAT Version 98.1) was used to calculate loads from agricultural and natural areas (i.e., forests and wetlands) and the Source Loading and Management Model (SLAMM version 9.4, PV & Associates, 2009) was used to calculate loads from urban areas. Modeled pollutant loadings indicated that over the course of an average year, agricultural lands are the source of the majority of TP and TSS in the Basin. Wastewater treatment facilities contribute a significant amount of TP, but relatively little TSS. Loads of TSS and TP from natural background sources, urban areas, and facilities covered under general permits represent a small fraction of the total load. More specifically, unit-area nonpoint source loading of TP ranges from 0.203 to 0.238 pounds per acre and TSS ranges from 0.028 to 0.040 tons per acre for SWAT Sub-Basin 80, which includes the Jackson Creek watershed. The breakdown of daily TP and TSS loading capacity and allocations for Sub-Basin 80 are shown in Tables II-4 and II-5, respectively.

The TP loading capacity for Sub-Basin 80 was calculated as the load that will produce the monthly target concentration of 0.075 mg/l in approximately 7 out of 10 years. This target frequency was selected to ensure that loading capacity is not driven by high or low flows, but that water quality targets are met under most flow conditions. It should be noted that this monthly compliance rate will attain summer median targets in approximately 9 out of 10 years. Wasteload allocations are given for three classes of point sources: point sources covered under a Statewide WPDES general permit, MS4s, and wastewater treatment facilities (WWTFs). The annual wasteload allocation for this sub-basin is 4,381.87 pounds of phosphorus. Relative to the Jackson Creek

[12]Ibid.

watershed, two aspects of the wasteload allocation should be kept in mind. First, because there were no permitted MS4s within Sub-Basin 80 when this model was developed,[13] the daily allocation of phosphorus discharges for MS4s in this sub-basin is 0.00 pounds. Second, there is currently only one WWTF discharging into waters located in Sub-Basin 80—the Walworth County Metropolitan Sewerage District's (WalCoMet) wastewater treatment plant. This WWTF discharges into Turtle Creek and does not contribute pollutants to Jackson Creek or its tributaries. Thus, neither the MS4 nor the WWTF wasteload allocations within the Jackson Creek watershed are addressed in this plan. Load allocations for Sub-Basin 80 are given in Table II-4 for two classes of nonpoint sources: an allocation for natural background sources (i.e., recognition that all streams contain some natural amounts of phosphorus and sediment that make up a baseline or natural condition) and a combined allocation for agricultural sources and urban sources that are not required to be covered under a WPDES discharge permit. The annual load allocation for this sub-basin is 1,673.26 pounds of phosphorus.

Table II-5 shows the daily TSS loading capacity and allocations. The TSS loading capacity for Sub-Basin 80 was calculated using monthly regression equations from the Rock River Basin SWAT model to determine the TSS load that is typically associated with the total phosphorus loading capacity. The annual wasteload allocation for this sub-basin is 97.65 tons of total suspended solids. Because there were no permitted MS4s within Sub-Basin 80 when this model was developed and because the one wastewater treatment facility (WWTF) located in this sub-basin discharges into Turtle Creek, neither the MS4 nor the WWTF wasteload allocations are addressed within this plan. Load allocations for Sub-Basin 80 are given in Table II-5 for two classes of nonpoint sources: an allocation for natural background sources and a combined allocation for agricultural sources and urban sources that are not required to be covered under a WPDES discharge permit. The annual load allocation for this sub-basin is 652.36 tons of total suspended solids.

It should be noted that the daily loading capacities and allocations shown in Tables II-4 and II-5 vary by month of the year. This reflects the fact that average total phosphorus and TSS loading varies substantially among months of the year. This variation is primarily driven by seasonal patterns in precipitation and vegetative cover that influence runoff and erosion rates. These same seasonal patterns also affect stream flows, which is the basis for pollutant assimilative capacity. To account for these patterns, calculations of loading capacity given in the tables are based on monthly patterns in stream flow, and the allocation of loads among sources is based on monthly variation in their relative contribution to current loads.

[13]*The City of Elkhorn was designated as an MS4 after the TMDL was issued.*

Meeting the water quality targets set in the Rock River TMDL will require substantial reductions in nonpoint source loading. **For Sub-Basin 80, which includes Jackson Creek, this will require average percent reductions from baseline loads of 49 percent for total phosphorus and 25 percent for TSS**.[14]

Point Sources

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

Individual permits are issued to municipal and industrial waste water treatment facilities that discharge to surface and/or groundwater. WPDES permits include limits that are consistent with the approved TMDL wasteload allocations. Facilities are required to report phosphorus and sediment loads to the WDNR in Discharge Monitoring Reports (DMR). However, there are no WPDES permit holders that discharge in the Jackson Creek watershed. Nearly 37 percent of the watershed is located in a planned sanitary sewer service area as shown on Map II-3. These communities, the largest of which is the City of Elkhorn, are all served by the WalCoMet (see http://www.walcomet.org/). The City operates and maintains the system of collection sewers and lift stations throughout the community. WalCoMet owns, operates, and maintains wastewater treatment and sludge disposal facilities and discharges into Turtle Creek which, as shown on Map I-2, is well downstream of the Jackson Creek watershed.

To meet the requirements of the Federal Clean Water Act, the WDNR developed a permit Program under Wisconsin Administrative Code NR 216, "Storm Water Discharge Permits." A municipal separate storm sewer system (MS4) permit is required for a municipality that is either located within a Federally-designated urbanized area, has a population of 10,000 or more, or is designated for permit coverage by the WDNR. Municipal permits require stormwater management programs to reduce polluted stormwater runoff by implementing best management practices. NR 216 also requires certain types of industries in the State to obtain stormwater discharge permits from the WDNR, but there are no industrial stormwater permits issued in the Jackson Creek watershed. The general permit requires an MS4 holder to develop, maintain, and implement stormwater management programs to prevent pollutants from the MS4 from entering State waters. Examples of stormwater best management practices used by municipalities to meet permit conditions include detention basins, street sweeping, filter strips, bioretention facilities, and rain gardens.

---

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

The City of Elkhorn is the only designated MS4 community in the watershed area. The permit requires the City to reduce polluted stormwater runoff by implementing stormwater management programs with best management practices. Walworth County is not currently designated as an MS4, but the City of Elkhorn entered into an intergovernmental agreement with Walworth County for Stormwater Management Planning in January, 2015. The City and County intend to work cooperatively to create urban storm water public education messages. The City also plans to work with the County to develop construction and post-construction site pollution control ordinances.

State and Federal laws also require that Concentrated Animal Feeding Operations (CAFO) have Wisconsin Pollutant Discharge Elimination System (WPDES) permits. An animal feeding operation is considered a CAFO if it has 1,000 animal units or more. A smaller animal feeding operation may be designated a CAFO by the WDNR if it discharges pollutants to a navigable water or groundwater. Permits for CAFOs require that the production area has zero discharge. There are currently no permitted CAFOs in the watershed.

Nonpoint Source s

SEWRPC Regional Water Quality Management Plan

The initial adopted regional water quality management plan completed in 1979 by the Southeastern Wisconsin Regional Planning Commission identified that diffuse or nonpoint agricultural pollution, and to a lesser extent urban sources of pollution comprised the greatest proportion of the annual load in the Rock River Basin based upon conditions in 1975.[15] More specifically, agricultural nonpoint sources were estimated to contribute 88 percent of the total nitrogen, 55 percent of the total phosphorus, 81 percent of the biochemical oxygen demand (BOD), 96 percent of the fecal coliform, and 58 percent of the total suspended sediment annual loads. The initial plan generally recommended nonpoint source pollution control practices for both rural and urban lands designed to reduce the pollutant loadings from nonpoint sources by about 25 percent, in addition to urban construction erosion control, streambank erosion control, and onsite sewage disposal system management. Finally, this plan also recommended that detailed local-level nonpoint source control plans be developed to identity appropriate pollution control practices.

WDNR Turtle Creek Priority Watershed Plan

The Turtle Creek watershed, which includes Jackson Creek, was selected in 1981 as a priority watershed under the Wisconsin Nonpoint Source Water Pollution Abatement Program. Priority watersheds, including the Turtle Creek watershed, were selected because of the severity of water quality problems in the watershed, the importance of controlling nonpoint sources in order to attain water quality standards, and the capability and willingness of

[15]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan For Southeastern Wisconsin: 2000, Volumes One through Three, *1978 and 1979.*

local government agencies to carry out the planning and implementation of the project. A Turtle Creek Priority Watershed Plan was completed in 1984 in cooperation with local units of government, Walworth County, WDNR, and SEWRPC.[16] The upland erosion inventory conducted through the Turtle Creek Priority Watershed project showed that 98 percent of the soil loss occurring in this watershed was from croplands and the estimated total phosphorus load being delivered from the Jackson Creek subwatershed was 6,685 pounds per year based on 1980 land use conditions. Of this total load, it was further estimated that 29 percent or 2,000 pounds per year was derived from urban sources and 71 percent was from agricultural sources.[17] Hence, Jackson Creek was determined to be the major source of phosphorus to Delavan Lake and it was determined that a 75 percent reduction in the total phosphorus load was needed to effect any significant change in the trophic status in Delavan Lake.[18] The Turtle Creek priority watershed plan identified specific actions necessary to reduce the water quality problems related to nonpoint sources in the watershed; tasks necessary to carry out the actions presented in the plan; and the agencies responsible, and time frame, for completing those tasks. The project implementation phase was carried out from 1984 through1992 and included the following elements:

- Provision of streambank erosion control practices for selected sites ,
- Preparation of detailed conservation plans to develop management practices on cropland with high soil losses,
- Installation of facilities and management practices for problem barnyards,
- Installation of facilities and management practices for selected livestock operations to change manure spreading practices,
- Implementation of construction site erosion controls, institution of public information and education programs on nonpoint source pollution abatement, and institution of sound urban best management practices, and
- Construction of the Mound Road wet detention/wetland restoration project (see Figure II-4).

Since the 1990s many projects to reduce nonpoint pollution loads within the Jackson Creek watershed have been implemented, including reduced tillage, nutrient management plans, grass waterways, riparian buffers (see

---

[16]*Wisconsin Department of Natural Resources, Walworth County Land Conservation Committee, Rock County Land Conservation Committee, in cooperation with University of Wisconsin-Extension, USDA Soil Conservation Service, USDA Agricultural Conservation and Stabilization Service, and the Southeastern Wisconsin Regional Planning Commission,* Turtle Creek Priority Watershed Plan*, Madison, Wisconsin, 1984.*

[17]*Wisconsin Department of Natural Resources,* Turtle Creek Priority Watershed Plan-Amendment, The Delavan Lake Restoration Project*, August 1989.*

[18]*University of Wisconsin Water Resources Management Program, Delavan Lake: A Recovery and Management Study, Madison, Wisconsin, 1986.*

Upland Inventory section below), as well as construction site erosion control and stormwater management practices. This has led to a reduction in the overall pollution loads to Jackson Creek and Delavan Lake. However, as summarized above, the Rock River TMDL verified that the majority of pollution in the Jackson Creek watershed still come from nonpoint sources. Agriculture is still the dominant land use in the Jackson Creek watershed and modelling conducted for this plan indicates that cropland and eroding gullies account for about 72 percent of total nitrogen, 86 percent of total phosphorus, 67 percent of BOD, and 97 percent of total suspended sediment nonpoint source loads as summarized in the STEPL load analysis as summarized in Appendix B. Other nonpoint sources in the watershed include erosion from streambanks and runoff from golf courses, lawns, and impervious surfaces (see Appendix B for more details).

Nonpoint Source Regulations

In 2010, new State regulations in Wisconsin went into effect that restrict the use, sale, and display of turf fertilizer that is labeled as containing phosphorus or available phosphorus (Wis.Stats.94.643) The law states that turf fertilizer that is labeled as containing phosphorus or available phosphate cannot be applied to residential properties, golf courses, or publicly owned land that is planted in closely mowed or managed grass. The exceptions to the rule are as follows:

- Fertilizer that is labeled as containing phosphorus or available phosphate can be used for new lawns during the growing season in which the grass is established.
- Fertilizer that is labeled as containing phosphorus or available phosphate can be used if the soil is deficient in phosphorus, as shown by a soil test performed no more than 36 months before the fertilizer is applied. The soil test must be done by a soil testing laboratory.
- Fertilizer that is labeled as containing phosphorus or available phosphate can be applied to pastures, land used to grow grass for sod, or any other land used for agricultural production.

In 2010, the State also placed restrictions on the sale of some phosphorus-containing cleaning agents.[19] Wisconsin also has State standards pertaining to agricultural runoff. Wisconsin State Standards, Chapter NR 151, "Runoff Management," describes agricultural performance standards and prohibitions. This Chapter describes regulations relating to phosphorus index, manure storage and management, nutrient management, soil erosion, and tillage setback, as well as implementation and enforcement procedures for the regulations.

---

[19]*Section 100.28 of the* Wisconsin Statutes *bans the sale of cleaning agents for nonhousehold dishwashing machines and medical and surgical equipment that contain more than 8.7 percent phosphorus by weight. This statute also bans the sale of other cleaning agents containing more than 0.5 percent phosphorus by weight. Cleaning agents for industrial processes and dairy equipment are specifically exempted from these restrictions.*

Water Quality Monitoring

Water quality information summarized in this section includes data collected over about the last 50 years by the USGS, WDNR, Delavan Lake Sanitary District, Delavan Lake Watershed Initiative Network, and SEWRPC distributed among 20 sampling sites throughout the Jackson Creek watershed. Streamflow, has also been monitored at some of these sites, primarily by the USGS. Water quality and quantity monitoring sites in the Jackson Creek watershed are shown on Map II-4 and described in Table II-6.

Several things should be kept in mind regarding the data available for evaluating water quality in the Jackson Creek watershed. The data were collected by several agencies and organizations for a variety of purposes as part of a number of different studies. Each of these studies assessed a different group of water quality constituents. For some constituents, this means that data are only available for some portions of the watershed. Each study also sampled for a different period. These periods range from studies that collected a single sample at a site, through studies that collected over a season, to long-term sampling programs that collected data for over 20 years. Some sampling stations have been used by multiple agencies or in multiple studies (see Table II-6). While the use of multiple data sources has extended the period of record at these stations, differences among studies in the constituents sampled may allow for fewer time-based comparisons than would be expected based purely on the length of the period of record.

For analytical purposes, data from three time periods were examined: 1964-1975, 1976-2004, and 2005 through mid-2014. These analytical periods reflect the time period during which the data that were used to develop regional water quality management plan were collected (1964-1975), a historical period consisting of the time since the regional water quality management plan was released (1976-2004), and a recent period (2005-mid-2014).

Water Quantity Conditions

Figure II-5 shows the flow duration curve for Jackson Creek at the USGS stream gauge at Mound Road for the entire period of record. A flow duration curve is a plot of stream discharge data that shows the percentage of time that flow in a stream is equal to or greater than some specified value of interest. It summarizes the likelihood that any particular flow will be equaled or exceeded. It can be used in several different ways. For example, based upon the data, the graph shows that, over the period of record, discharge rarely exceeded 25 cubic feet per second (cfs). This volume of flow was equaled or exceeded only 10 percent of the time. Alternatively, the graph can be used to express the probability that discharge will equal or exceed any given rate. This probabilistic interpretation provides important information for a number of purposes including designing structures such as bridges and dams and flood mitigation.

Several features of streamflow at the gauge at Mound Road are summarized in Figure II-5. High flows can be characterized by the amount of discharge that is equaled or exceeded 10 percent of the time—in this case, 25 cubic feet per second (cfs). Similarly, low flows can be characterized by the amount of discharge that is equaled or exceeded 90 percent of the time. For Jackson Creek at Mound Road, this value would be about 0.9 cfs. A range of typical flows can be characterized by looking at a range of intermediate values, for instance the amount of discharge that are equaled 25 and 75 percent of the time. At Mound Road, the typical range of flow defined this way would be between about 1.85 cfs and 10.4 cfs.

Figure II-6 compares the flow duration curves for three stream gauges in the Jackson Creek watershed for the period October 1993 through September 1995, the only period for which discharge data were available at all three sites. It is important to note that the curves shown in the figure are based upon very short periods which may not be long enough to fully characterize the flow regimes at these sites. Because the same period is used for each curve, the figure is adequate for describing differences in flow regime among the three sites.

Figure II-6 shows several aspects of flow regimes within the watershed. First, the curve for the Mound Road gauge shown in this figure is different than the one shown in Figure II-5. This is because the data used to develop the curve shown in Figure II-6 are a subset of the data used to develop Figure II-6 and represent a shorter time period. Second, Figure II-6 shows that, along Jackson Creek, higher flows occur at the downstream gauges with the larger drainage area, as would be expected. Third, the likelihood of any particular magnitude of discharge occurring is generally different at each station, particularly for flows that are equaled or exceeded 30 percent or more of the time. For example, a discharge equal to or greater than 5.0 cfs would be expected to occur at the Mound Road site about 38 percent of the time. By contrast, at the Petrie Road and Tributary B sites discharge equal to or greater than 5.0 cfs would be expected to occur 11 percent of the time and 8 percent of the time, respectively. In part, this reflects the differences in the size of the drainage area tributary to each stream gauge. The drainage areas tributary to the gauges along Tributary B, at Petrie Road, and at Mound Road are approximately 1,500 acres, 5,700 acres, and 10,900 acres, respectively. This accounts for some of the differences between the flow duration curves at these sites, especially at high flows which are dominated by stormwater runoff and snowmelt. Fourth, the overall steepness of the flow duration curve gives an indication of the flashiness of a stream's flow regime in the vicinity of the stream gauge. Figure II-6 shows that the headwaters of Jackson Creek in the vicinity of the gauge at Petrie Road experience a flashier flow regime with higher high flows and lower low flows than does Tributary B in the vicinity of the gauge near IH 43. Fifth, based on the flow exceedence probability range of 25 percent to 75 percent, typical flows at the Petrie Road and Tributary B sites, generally range between about 0.5 cfs and 2.0 cfs.

Figure II-7 shows the seasonal pattern of streamflow in Jackson Creek at the stream gauge at Mound Road over the period of record. The data were disaggregated into months and the locations of the 10th percentile, 25th percentile, 50th percentile, 75th percentile, and 90th percentile ranks were determined for each month's data.[20] The 50th

[20]*A percentile rank is a percentage of values which are lower than a given value. For example, the 10th percentile represents the upper boundary of the lowest 10 percent of the data. The interpretation of this statistic is that on 10 percent of the dates in this month during the period of record, average daily discharge at this gauge was less than*
(Footnote Continued on Next Page)

percentile ranks indicate typical flow conditions at this gauge and shows a strong seasonal pattern. This pattern begins in January, when the flow in the stream is relatively low. From January through April, flow increases rapidly in response to snowmelt and spring rains. Peak flow typically occurs in April. Following this, flow decreases over late spring and summer. This decrease results from a number of factors, including the end of snowmelt, increases in evapotranspiration due to higher temperatures, and increased infiltration of precipitation due to soil having thawed. The lowest flows of the year usually occur in August or September. Flow then increases relatively slowly over the fall and winter, reaching a second peak in November-January. Peak flows in those months are typically much lower than the peaks that occur in April.

The other percentile ranks shown in Figure-II-7 indicate how discharge at this site can vary from the typical pattern described in the last paragraph. The distance between the 10th and 90th percentile lines indicate how variable discharge is in any month, with a greater distance indicating more variability. Discharge at the Mound Road gauge is much more variable during the late winter and spring than during the rest of the year. The lines for higher percentile ranks show one marked difference from the typical pattern. High discharge peaks occur during June in the 90th and 75th percentile ranks. These peaks reflect the June 2008 flood events which resulted from a combination of an extended period of rainy weather and two heavy rainfall events that occurred during the first two weeks of the month. Because the data record at this stream gauge is relatively short, about 17 years, this flood event heavily influences the magnitude of the 75th and 90th percentiles. It would have less influence on a longer data record.

The seasonal variations in discharge shown in Figure II-7 can exert a strong influence on the loads of pollutants carried by the stream. The pollutant load is the total amount of pollutant that the stream is carrying past some point (such as a stream gauge) over some time period. It is a function of both the concentration of the pollutant and the amount of streamflow. At a given concentration, higher streamflows result in higher pollutant loads. Similarly, at a given magnitude of flow, higher concentrations result in higher pollutant loads. The interaction between discharge and concentration can have complex effects on the sizes of the pollutant loads. Examples of this as they relate to Jackson Creek will be given later in this section in the discussion of specific water quality constituents.

Water Quality Conditions

In the analyses that follow, distributions of water quality data are shown using box plots to illustrate changes among stations from upstream to downstream over the three time periods between 1964 and 2014. Figure II-8 shows an example of the symbols used in box plots, as well as how they are used in a graph to make comparisons. In this type of graph, the center line marks the location of the median—the value in the data above which and below which half the instances lie. Along with the median, the two ends of the box mark the locations of the quartile divisions. These

(Footnote Continued from Previous Page)
or equal to this value. Similarly, the 90th percentile represents the upper boundary of the lowest 90 percent of the data and is interpreted in a similar manner.

ends indicate the values of the 25th and 75th percentile of the data. These three divisions divide the distribution into four quartiles which each contain one quarter of the instances. The length of the box shows the range of the central 50 percent of the instances. This is known as the interquartile range. The "whiskers" extending from the box show the range of instances that are within 1.5 box-lengths from the box (*i.e.,* within a length of 1.5 times the interquartile range from the box*)*. Stars indicate outliers that are more than 1.5 box-lengths but less than three box-lengths from the box. Open circles indicate extreme values that that lie more than three box-lengths from the box.[21]

Few water quality constituents were collected from streams within the Jackson Creek watershed consistently enough to be able to assess changes over time. At least two features of the data set contribute to this. First, several water quality constituents lack either sufficient historical data or sufficient recent data to permit the detection of differences between the historical periods and the recent period. Second, during some periods—most notably the recent period—collection of data for some constituents was restricted to only one or a few sampling stations. For example, during the period 1976 through 2004, about 500 samples were collected and analyzed for dissolved oxygen, pH, and specific conductance at six sampling stations along the Creek. During the period 2005 through mid-2014 seven samples were collected and analyzed for dissolved oxygen and pH and 18 samples were collected and analyzed for specific conductance. These samples were all collected at one sampling station. Because of these temporal and geographical differences in data collection, the available data for several water quality constituents is not sufficient for assessing whether existing conditions relative to these constituents are similar to, or different from, historical conditions.

For this study, dissolved oxygen, pH, total phosphorus, total nitrogen, total suspended solids, suspended sediment concentration, specific conductance, and temperature parameters were used to assess water quality conditions and changes in those conditions over time in Jackson Creek and its tributary streams. These water quality constituents are defined and discussed in the subsections that follow.

Additional information regarding the levels of compliance with water quality criteria and water use objectives in the Jackson Creek watershed is provided later in this section in the "Water Quality Summary" subsection.

Dissolved Oxygen

The concentration of dissolved oxygen in water is a major determinant of the suitability of a waterbody as habitat for fish and other aquatic organisms because most aquatic organisms require oxygen to survive. Though tolerances vary

---

[21]*Different statistical analysis software packages and statistical graphics software packages follow different conventions in the construction of box plots. In all conventions, the ends of the box represent the values of the 25th and 75th percentile and the box itself indicates the interquartile range. The conventions differ in what is represented by the ends of the whiskers. The box plots presented in this report follow the conventions used in the SYSTAT, version 13, software package.*

by species, most aquatic organisms have minimum oxygen requirements. For example, common carp (*Cyprinus carpio*) are very tolerant of concentrations of dissolved oxygen below 2.0 mg/l and can survive at concentrations below 1.0 mg/l.[22] Bluegill, on the other hand, depend on water with dissolved oxygen concentrations above 5.0 mg/l.[23]

Sources of dissolved oxygen in water include diffusion of oxygen from the atmosphere and photosynthesis by aquatic plants and suspended and benthic algae. Processes that remove dissolved oxygen from water include diffusion of oxygen to the atmosphere, respiration by aquatic organisms, and bacterial decomposition of organic material in the water column and sediment. Several factors can influence these processes, including the availability of light, the clarity of the water, the presence of aquatic plants, the presence of organic material in water or sediment, and the amount of water turbulence. Water temperature has a particularly strong effect for two reasons. First, the solubility of most gasses in water decreases with increasing temperature. Thus as water temperature increases, the water is able to hold less oxygen. Second, the metabolic demands of organisms and the rates of oxygen-demanding processes, such as bacterial decomposition of organic substances, increase with increasing temperature. As a result, the demands for oxygen in waterbodies tend to increase as water temperature increases.

Concentrations of dissolved oxygen in surface waters typically show a strong seasonal pattern that is driven by seasonal changes in water temperature. Highest concentrations usually occur during the winter. Concentrations decrease through the spring to reach a minimum during summer. Concentrations rise through the fall to reach maximum values in winter. Because the warmest water temperatures occur in the summer, this is the most important time of the year for determining physiological limitations for aquatic organisms based on dissolved oxygen concentrations. Dissolved oxygen concentrations in some waterbodies may also show daily fluctuations in which high concentrations occur during daylight due to photosynthesis and lower concentrations occur during periods of darkness when photosynthesis ceases and respiration increases.

As previously discussed, the minimum dissolved oxygen criterion for warmwater FAL streams such as Jackson Creek and its tributaries, is 5.0 milligrams per liter (mg/l) (see Table II-1).

Between 1964 and 2014, dissolved oxygen concentrations in Jackson Creek ranged between 0.0 and 22.2 mg/l, with a mean value of 6.10 mg/l. Figure II-9 shows dissolved oxygen concentrations at several sampling stations along the Creek. Historically, dissolved oxygen concentrations were below the applicable State water quality criterion in a substantial portion of samples collected from all sampling stations for which data are available. These low

---

[22] *U.S. Fish and Wildlife Service,* Habitat Suitability Index Models: Common Carp, *1982.*

[23] *U.S. Fish and Wildlife Service,* Habitat Suitability Index Models: Bluegill, *1982.*

concentrations limit the availability of these portions of the stream for use by fish and other aquatic organisms. The low dissolved oxygen concentrations may be related to decomposition of organic matter contained in sediment through chemical and biological processes, which removes oxygen from the overlying water.

Concentrations of the dissolved oxygen in all of the samples collected during the period 2005 through mid-2014 were above the State water quality criterion; however, it is likely that these data are not representative of existing conditions in the Creek. There are three reasons for this. First, samples for dissolved oxygen were collected at only one site, STH 50, during this period. Second, only seven samples were collected at this site during this period. That is a fairly small number upon which to base an assessment. Third, few of the samples collected during the 2005 through mid-2014 period were collected during summer months. Historically, summer is the season during which most of the exceedances of the dissolved oxygen criterion have occurred. Because of this, the relatively high concentrations of dissolved oxygen shown in Figure II-9 should be interpreted with caution.

The historical data in Figure II-9 show two patterns in dissolved oxygen concentrations in Jackson Creek. First, as the stream flows through the Delavan Lake inlet downstream from Mound Road, dissolved oxygen concentrations tend to decrease, reaching lowest values at the USGS's inlet site #2 and then increasing near the confluence with Delavan Lake. Second, dissolved oxygen concentrations in the Delavan Lake inlet appear to be more variable than concentrations at Mound Road. One aspect of this variability is that dissolved oxygen concentrations in many samples collected in the Delavan Lake inlet are sufficiently high to suggest that supersaturation of dissolved oxygen may be occurring. It is likely that this reflects the presence of dense beds of submerged plants and algae in the inlet. During the day photosynthesis by these plants causes dissolved oxygen concentration to increase, especially during days with clear, sunny conditions. During the night, photosynthesis does not occur. At this time, respiration by organisms and bacteria causes a decrease in dissolved oxygen concentration. If dense beds of plants are present in the stream or if sediment within the stream contains large amounts of organic material, the associated respiratory demands for oxygen are likely to be high, resulting in a large night-time decrease in dissolved oxygen concentration. Because of this, supersaturation of dissolved oxygen can indicate that a site is experiencing wide swings in dissolved oxygen concentration over the course of the day.

It is also likely that the Delavan Lake inlet is thermally stratified during the growing season. During thermal stratification, a layer of relatively warm water floats on top of a layer of cooler water. Thermal stratification is the result of differential heating of lake water and the resulting water temperature-density relationships at various depths within the water column. Water is unique among liquids in that it reaches its maximum density at about 4º C, while it is still in the liquid state. During stratification, the top layer, or epilimnion, of the waterbody is cut off from nutrient inputs from the sediment. At the same time, the bottom layer, or hypolimnion, is cut off from the atmosphere and sunlight penetration. Over the course of the summer, water chemistry and other conditions can become different between the layers of a stratified waterbody. The extent of difference is often determined by the productivity of the waterbody and the degree of nutrient enrichment to which the waterbody has been subjected. In southeastern Wisconsin, the development of summer thermal stratification begins in mid to late spring or early summer, reaches its maximum in late summer, and breaks down and disappears in the fall.

Thermal stratification can have a strong effect on dissolved oxygen concentrations in the water column, especially in a waterbody subject to nutrient enrichment. Bacterial decomposition of organic material can reduce the concentration of dissolved oxygen in the hypolimnion. If large amounts of organic material are present in the sediment or if sufficient organic material sinks into the hypolimnion from the epilimnion, dissolved oxygen concentrations can be reduced to levels too low to support many aquatic species.

pH

The acidity of water is measured using the pH scale. This is defined as the negative logarithm of the hydrogen ion (H+) concentration, which is referred to as the standard pH unit or standard units (stu). It is important to note that each unit of the scale represents a change of a factor of 10. Thus the hydrogen ion concentration associated with a pH of 6.0 stu is 10 times the hydrogen ion concentrations associated with a pH of 7.0 stu. A pH of 7.0 stu represents neutral water. Water with pH values lower than 7.0 stu has higher hydrogen ion concentrations and is more acidic, while water with pH values higher than 7.0 stu has lower hydrogen ion concentrations and is less acidic.

Many chemical and biological processes are affected by pH. The solubility and availability of many substances are influenced by pH. For example, many metals are more soluble in water with low pH than they are in water with high pH. In addition, the toxicity of many substances to fish and other aquatic organisms can be affected by pH. Different organisms are capable of tolerating different ranges of pH, with most preferring ranges between about 6.5 and 8.0 stu. For example, carp, suckers, and catfish generally prefer a pH range between 6.0 and 9.0 stu, although carp have been reported to tolerate water with pH values as low as 5.4 stu.[24] Sunfish, such as bass and crappies, prefer a narrower pH range between about 6.5 and 8.5 stu. Snails, clams, and mussels which incorporate calcium carbonate into their shells require higher pH values. Typically, they tolerate a range between about 7.5 and 9.0 stu. Some aquatic invertebrates prefer relatively narrow pH ranges. For example, many mayfly, stonefly, and caddisfly nymphs prefer water with pH values between 6.5 and 7.5 stu. Other aquatic invertebrates are able to tolerate much wider pH ranges. For example, mosquito larvae have been reported as living in natural waters with pH as low as 2.4 stu.[25]

---

[24]*J.E. McKee and H.W. Wolf,* Water Quality Criteria (second edition), *California State Water Quality Control Board, Publication No. 3-A, 1963.*

[25]*J.B. Lackey, "The Flora and Fauna of Surface Waters Polluted by Acid Mine Drainage,"* Public Heath Reports, Washington, *Volume 53, pages 1499-1507, 1938.*

Several factors influence the pH of surface waters. Because of diffusion of carbon dioxide into water and associated chemical reactions, rainfall in areas that are not impacted by air pollution has a pH of about 5.6 stu. The pH of rainfall in areas where air quality is affected by oxides of nitrogen or sulfur tends to be lower. The mineral content of the soil and bedrock underlying a waterbody has a strong influence on the waterbody's pH. Because much of the Jackson Creek watershed is underlain by carbonate bedrock such as dolomite, pH in the waterbodies of the watershed tends to be between about 7.0 and 9.0 stu. Pollutants contained in discharges from point sources and in stormwater runoff can affect a waterbody's pH. Photosynthesis by aquatic plants, phytoplankton, and algae can cause pH variations both on a daily and seasonal basis.

Figure II-10 shows pH at several sampling stations along the Creek. Over the entire period of record, the pH in Jackson Creek ranged between 7.2 and 9.6 stu, with a mean value of 7.9 stu. Values of pH were only rarely outside of the range of 6.0 stu to 9.0 stu specified in Wisconsin's water quality criteria (see Table II-1). Those pH values that were outside of this range were above 9.0 stu. At all of the sampling stations, most values of pH varied by less than ± 1.0 stu from the station's mean value.

The historical data in Figure II-10 show two patterns in the distribution of pH values in Jackson Creek. First, as the stream flows through the Delavan Lake inlet downstream from Mound Road, pH tended to decrease, reaching lowest values at the USGS inlet site No. 2. Beyond inlet site No. 2, pH tended to increase as the stream flowed toward the confluence with Delavan Lake. Second, pH values in the Delavan Lake inlet portion of the stream appear to be more variable than values at Mound Road.

Chloride

Chlorides of commonly occurring elements are highly soluble in water and are present in some concentration in all surface waters. Chloride is not decomposed, chemically altered, or removed from the water as a result of natural processes. Natural chloride concentrations in surface water reflect the composition of the underlying bedrock and soils, and deposition from precipitation events. Waterbodies in southeastern Wisconsin typically have very low natural chloride concentrations due to the dolomite bedrock found in the Region. These rocks are rich in carbonates and contain little chloride. Because of this, the sources of chloride to surface waters in the Jackson Creek watershed are largely anthropogenic, including sources such as salts used on streets, highways, and parking lots for winter snow and ice control; salts discharged from water softeners; and salts from treated wastewater and animal wastes. Because of the high solubility of chloride in water, if chloride is present, stormwater discharges are likely to transport it to receiving waters. High concentrations of chloride can affect aquatic plant growth and pose a threat to aquatic organisms. Impacts from chloride contamination begin to manifest at a concentration of about 250 milligrams per liter and become severe at concentrations in excess of 1,000 milligrams per liter.[26] The State of Wisconsin has promulgated two water quality criteria for chloride, and acute toxicity criterion and a chronic toxicity criterion (Table II-1). Under the acute toxicity criterion, the maximum daily concentration of chloride is not to exceed 757 mg/l more than once every three years. Under the chronic toxicity criterion, the maximum four-day concentration of chloride is not to exceed 395 mg/l more than once every three years.

No recent sampling data for chloride are available for the Jackson Creek watershed. Historically, most of the data on chloride concentrations in the watershed come from water samples that were collected from Jackson Creek at Mound Road over the period 1964 through 1975 and at STH 50 during spring and summer 1995. Chloride has not been sampled in the watershed since 1995.[27]

During the period 1964 through 1975, chloride concentrations in samples collected from Jackson Creek at Mound Road ranged between 30 mg/l and 315 mg/l, with a mean concentration of 170 mg/l. Two additional samples that were collected at this site in 1992 had concentrations well within this range. Chloride concentrations in samples collected from Jackson Creek at STH 50 between April and September 1995 ranged between 18 mg/l and 130 mg/l, with a mean concentration of 61 mg/l.

The available chloride data set is not adequate for assessing trends in chloride concentrations over time in surface waters in the Jackson Creek watershed. Despite this it may be possible to infer likely trends in chloride concentrations from those occurring in other surface waters of the Southeastern Wisconsin Region and the Rock River Basin. Long-term trends toward increasing chloride concentrations have been documented in surface waters of the Region. These increases have been detected in several stream and river systems[28] and several lakes.[29] Long-term trends toward increasing chloride concentrations have also been documented in the Yahara Lakes, which are located in the Rock

---

[26]*Frits van der Leeden, Fred L. Troise, and David Keith Todd,* The Water Encyclopedia, Second Edition, *Lewis Publishers, Inc., 1990.*

[27]*Specific conductance could be used as a surrogate to infer trends in chloride concentrations in Jackson Creek; however, there are few recent samples for this water quality constituent within the Jackson Creek watershed.*

[28]*For example, see SEWRPC Technical Report No. 39,* Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds, *November 2007; SEWRPC Community Assistance Planning Report No. 316,* A Restoration Plan for the Root River Watershed, *July 2014.*

[29]*For example see SEWRPC Community Assistance Planning Report No. 315,* A Water Resources Management Plan for the Village of Chenequa, Waukesha County, Wisconsin*, June 2014.*

River Basin.[30] Finally, there is some evidence that chloride concentrations may be increasing in shallow groundwater, which is the source of baseflow for streams and lakes.[31] This widespread trend toward increasing chloride concentrations in surface waters suggests that it is likely that chloride concentrations are increasing in surface waters throughout the Jackson Creek watershed. As previously noted, important sources of chlorides to lakes and streams in southeastern Wisconsin are anthropogenic in origin, and include salts used on streets and highways for winter snow and ice control, salts discharged from water softeners, and salts from treated wastewater and animal wastes.

Because winter deicing activities are a major contributor of chlorides to the environment, it would be expected that chloride concentrations in streams such as Jackson Creek would vary seasonally, with highest concentrations occurring during and after winter storm events and during periods of snowmelt in the winter and spring. This pattern has been observed in other streams. In two highly urbanized streams in the Menomonee River watershed, chloride concentrations as inferred from measurements of specific conductance reached levels known to be highly toxic to aquatic organism during the winter deicing season on several occasions. These high levels persisted for periods as long as 19 days.[32] It should be noted that, because of its high solubility, chloride can enter and accumulate in groundwater. This can result in contributions of chlorides to streams through inputs of groundwater-derived baseflow. These contributions can occur throughout the year. During low streamflow periods in particular, they may cause instream chloride concentrations to be elevated.[33]

The concentrations of chloride reported for historical samples collected from Jackson Creek are below the applicable water quality criteria. However, if chloride concentrations in surface waters of the watershed are increasing, it represents a decline in water quality for the entire Jackson Creek system. Because of this, the concentration of chloride in Jackson Creek is an important issue of concern.

Specific Conductance

Conductance measures the ability of water to conduct an electric current. Because this ability is affected by water temperature, conductance values are corrected to a standard temperature of 25ºC (77º Fahrenheit). This corrected value is referred to as specific conductance. Pure water is a poor conductor of electrical currents and exhibits low

---

[30]*Richard C. Lathrop, "Chloride and Sodium Trends in the Yahara Lakes,"* Research Management Findings, *No. 12, Wisconsin Department of Natural Resources, June 1988; Rick Wenta and Kristi Sorsa,* Road Salt – 2013, *Public Health Madison and Dane County, January 3, 2014.*

[31]*SEWRPC Community Assistance Planning Report No. 316,* op. cit.

[32]*SEWRPC Memorandum Report No. 204,* Development of a Framework for a Watershed-based Municipal Stormwater Permit for the Menomonee River Watershed, *January 2013.*

[33]*SEWRPC Community Assistance Planning Report No. 316,* op. cit.

values of specific conductance. For example, distilled water produced in a laboratory has a specific conductance in the range of 0.5 to 3.0 microSiemens per centimeter, a very low value. The ability of water to carry a current depends upon the presence of ions in the water, and on their chemical identities, total concentration, mobility, and electrical charge. Solutions of many inorganic compounds, such as salts, are relatively good conductors. As a result, specific conductance gives a measure of the concentration of dissolved solids in water, with higher values of specific conductance indicating higher concentrations of dissolved solids.

Under certain circumstances, measurements of specific conductance may act as a useful surrogate for measurements of the concentrations of particular dissolved materials. For example, measurements of specific conductance may be able to give indications of chloride concentrations in receiving waters. Analysis of data collected by the USGS suggests that there is a linear relationship between specific conductance and chloride concentration at higher values of conductance and chloride concentration.[34] This suggests that during periods when chloride is being carried into receiving waters by discharges of stormwater or snowmelt, ambient chloride concentrations could be estimated using specific conductance. The advantage to this is that specific conductance can be measured inexpensively in the field using a hand-held meter. Measurements of chloride concentrations require chemical analysis.

It should be noted that estimates from this sort of regression model should be interpreted with caution. A comparison of the chloride concentrations predicted by the USGS regression model to actual chloride concentrations in samples collected from the Root River found that the regression model usually predicted higher concentrations based upon specific conductance than were observed in the River (this is documented in SEWRPC Community Assistance Planning Report No. 316, *op. cit.*). Simultaneous collection of both specific conductance and chloride data could be helpful in refining the regression relationship. Such a refinement could potentially allow the substitution of specific conductance monitoring for some chloride monitoring with a potential cost savings.

Figure II-11 shows specific conductance at sampling stations along Jackson Creek. Over the period of record, specific conductance in the Creek ranged between 7 microSiemens per centimeter (μS/cm) and 1,708 μS/cm, with a median value of 621 μS/cm. The values in all but two samples were greater than 430 μS/cm. The data from the period 1976 through 2004 indicate that specific conductance in Jackson Creek tends to decrease from upstream to downstream through the Delavan Lake inlet. For example, median values during this period at Mound Road and STH 50 were 804 μS/cm and 610 μS/cm, respectively. Several processes could account for this spatial trend, including dilution of

---

[34] *Steven R. Corsi, David J. Graczyk, Steven W. Geis, Nathaniel L. Booth, and Kevin D. Richards, "A Fresh Look at Road Salt: Aquatic Toxicity and Water Quality Impacts on Local, Regional, and National Scales,"* Environmental Science & Technology, Volume 44. 2010.

dissolved substances by water entering the inlet; uptake of dissolved materials by algae, aquatic plants, and other organisms; precipitation of dissolved materials; and backwater effects from Delavan Lake.

Figure II-11 also shows that values of specific conductance detected at the Mound Road station were lower during the 1975-2004 period than they were during the 1964-1974 period. This could indicate either a decrease in the amount of dissolved substances in the Creek or a change in their composition. By contrast, values of specific conductance detected at the STH 50 station during the 2005-2014 period were similar to those detected during the 1975-2004 period, showing no evidence of any change.

Nutrients

Nutrients are elements and compounds needed for plant and algal growth. They are often found in a variety of chemical forms, both inorganic and organic, which may vary in their availability to plants and algae. Typically, plant and algal growth and biomass in a waterbody are limited by the availability of the nutrient present in the lowest amount relative to the organisms' needs. This nutrient is referred to as the limiting nutrient. Additions of the limiting nutrient to the waterbody typically result in additional plant or algal growth. Phosphorus is usually, though not always, the limiting nutrient in freshwater systems. Under some circumstances nitrogen can act as the limiting nutrient.

Sources of nutrients to waterbodies include both sources within the waterbody and sources in the contributing watershed. Within a waterbody, mineralization of nutrients from sediment, resuspension of sediment in the streambed, erosion of streambed and banks, and decomposition of organic material can contribute nutrients. Nutrients can also be contributed by point and nonpoint sources within the watershed.

Phosphorus

As noted above, phosphorus is usually, though not always, the limiting nutrient in freshwater systems. Three forms have been sampled in surface waters of the Jackson Creek watershed: total phosphorus, dissolved phosphorus, and orthophosphate. Total phosphorus consists of all of the phosphorus contained in material dissolved or suspended in water. It includes dissolved forms of phosphorus and forms that are incorporated in or bound to particulate matter. Dissolved phosphorus consists of the phosphorus contained in material dissolved in water. In both these types, the phosphorus may be present in a variety of chemical forms. Orthophosphate consists of one chemical form, phosphate groups (PO_4^{3-}), dissolved in the water. This is the form of phosphorus that is most readily available to aquatic plants and algae. Because the degree of eutrophication in freshwater systems generally correlates more strongly with total phosphorus concentration than with dissolved phosphorus or orthophosphate concentration, the State's water quality criteria are expressed in terms of total phosphorus and water quality sampling tends to focus on assessing total phosphorus concentrations than dissolved phosphorus or orthophosphate concentrations.

Phosphorus can be contributed to waterbodies from a variety of point and nonpoint sources. In rural settings, phosphorus from agricultural fertilizers or animal manure spread on fields may be contributed through discharges from drain tiles or direct runoff from fields into waterbodies. Phosphorus also may be contributed by poorly maintained or failing private onsite wastewater treatment systems. In urban settings, phosphorus from eroded soil, pet waste, leaves placed in the street in fall, and other sources may be discharged through storm sewer systems and through direct runoff into streams. Cross-connections between sanitary and storm sewer systems, illicit connections to storm sewer systems, and decaying sanitary and storm sewer infrastructure may contribute sanitary wastewater to waterbodies through discharges from storm sewer systems.

Phosphorus can be delivered to waterbodies in different chemical forms. The form in which it is delivered can depend greatly on the source of the contribution. For example, a high proportion of the phosphorus contributed to waterbodies from properly functioning drain tile consists of dissolved phosphorus. On the other hand, much of the phosphorus contributed to waterbodies through direct runoff from farm fields consists of phosphorus that is incorporated into or bound to sediment.

The Rock River TMDL sets a target concentration of 0.075 mg/l total phosphorus for streams in the TMDL Sub-Basin 80, including Jackson Creek.[35] The applicable water quality criterion for Jackson Creek upstream of Mound Road (river mile 1.9) and for tributaries flowing into Jackson Creek calls for concentrations of total phosphorus to not exceed 0.075 mg/l (see Table II-1). The applicable water quality criterion for Jackson Creek between Mound Road and STH 50 calls for concentrations of total phosphorus to not exceed 0.030 mg/l. This is because this section of the Creek constitutes the inlet to Delavan Lake and is considered a portion of the Lake.

Between 1964 and 2014, concentrations of total phosphorus in all samples collected from Jackson Creek ranged from below the limit of detection to 3.800 mg/l with a mean value of 0.263 mg/l and a median value of 0.210 mg/l. Between 1983 and 2014, concentrations of total phosphorus in in all samples collected from Tributary B of Jackson Creek ranged from below the limit of detection to 8.200 mg/l with a mean value of 0.411 mg/l and a median value of 0.260 mg/l.

Figure II-12 shows total phosphorus concentrations at several sampling stations along Jackson Creek. Several things are evident in this figure. The concentrations of total phosphorus detected at the sampling station at Mound Road since 1976 are dramatically lower than the concentrations detected during the period 1964 through 1975. Despite this decrease, concentrations of total phosphorus in Jackson Creek are quite high. In fact, at all of the sampling stations where concentrations of total phosphorus have been assessed, the concentrations of total phosphorus in the vast

---

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

majority of samples exceeded the current applicable water quality criterion for total phosphorus. At the Mound Road and Petrie Road sampling stations, the concentrations detected during the period 2005 through 2014 were similar to those detected during the period 1976 through 2004. At STH 50, the concentrations detected during the period 2005 through 2014 were slightly lower than those detected during the period 1976 through 2004. Historically, concentrations of total phosphorus were higher in the Delavan Lake inlet portion of the stream downstream from Mound Road than at sampling stations upstream. Concentrations of total phosphorus at sampling stations in the inlet also tended to decrease from upstream to downstream. At STH 50 concentrations were similar to those observed in upstream areas.

Figure II-13 compares concentrations of total phosphorus in Tributary B to concentrations at three sampling stations along Jackson Creek. Concentrations of total phosphorus detected in most samples collected at this sampling station were generally similar to those detected in samples collected at Jackson Creek at the Petrie Road; however, total phosphorus concentrations at the Tributary B station showed greater variability with occasional exceptionally high concentrations being detected in some samples.

Figure II-14 shows monthly patterns in total phosphorus concentrations at four sampling stations in the Jackson Creek watershed over the entire period of record. Two of these stations, Jackson Creek at Petrie Road and Tributary B "near Elkhorn," are located in smaller headwater portions of the watershed. Another station, Jackson Creek at STH 50, is located in the Delavan Lake inlet portion of the stream. Two patterns are evident. First, concentrations at the sampling stations in headwater areas tend to be higher and more variable than those in the mainstem of the stream or in the inlet. This is especially the case at the station on Tributary B. While concentrations in excess of 1.0 mg/l were occasionally detected at all four of these stations, they appear to be more common at the station on this tributary. Second, in every month a high proportion of samples have concentrations of total phosphorus that are higher than the applicable water quality criterion. This is the case at all four sampling stations.

Figure II-15 shows seasonal patterns in average daily instream loads of total phosphorus at four sampling stations in the Jackson Creek watershed during the years 1993-1995. These years were chosen for the sake of comparability. They are the only years for which total phosphorus load data are available for all four stations. Slightly different patterns occurred at upstream sites and downstream sites. These patterns reflect the fact that higher instream loads can result from either greater stream discharge, higher instream concentrations, or both.

The effect of the magnitude of discharge upon instream loads of total phosphorus is shown in Figure II-16. This figure compares the distribution of daily loads of total phosphorus to five categories of daily average discharge ranging from extremely high flows to extremely low flows. The categories of discharge reflect arbitrary divisions based on the flow duration curve shown in Figure II-5 with extremely high flows being those that are equaled or exceeded less than 10 percent of the time, high flows being those that are equaled or exceeded between 10 percent and 25 percent of the time, typical flows being those that are equaled or exceeded between 25 percent and 75 percent of the time, low flows being those that are equaled or exceeded between 90 percent and 75 percent of the time, and extremely low flows being those that are equaled or exceeded more than 90 percent of the time. The figure shows that higher flows are generally accompanied by higher loads. The figure also shows considerable variability in instream total phosphorus loads within each flow category. More importantly, with the exception of the loads shown for extremely high flows and extremely low flows, the range of loads seen at each flow category overlaps those of each of the other flow categories. This variability is not entirely due to the fact that each category represents a continuous range of flows. Correlation analysis shows that variation in daily average discharge accounts for about 74 percent of the variation in daily loads of total phosphorus.[36] Other factors must account for the remaining variation. Given that the instream load is calculated as the product of discharge and instream concentration, this other factor is the instream concentration of total phosphorus which in this data set accounts for as much as about 26 percent of the variation in instream total phosphorus load.

As shown in Figure II-15, average daily loads at all sites increased from relatively low levels in January to peak levels in April. This was followed at all sites by a decrease in the average daily loads in May. The increase in loads during the spring followed by the decrease in May was largely driven by changes in stream discharge, such as those shown in Figure II-7. During the spring thaw, discharge increased markedly as water from snowmelt and spring rains entered the stream. Discharge decreased during May. After May, instream loads at upstream stations followed different patterns than the patterns that occur at downstream stations.

At upstream sites such as the stations at Petrie Road and on Tributary B, loads decreased through the summer and fall, reaching lowest levels in October. While they rebounded somewhat in November and December, they remained relatively low until the spring thaw. The low loads during this portion of the year reflect the low amounts of discharge in these streams during these months. They also reflect the fact that instream concentrations of total phosphorus in these streams tend to be lower during the late fall and early winter than in the spring.

At downstream sites such as the stations at Mound Road and STH 50, instream loads increased after May, and remained relatively high through the summer. This occurred despite the fact that the seasonal pattern of discharge is that discharge decreases at these stations during the early summer and remains at relatively low levels through the late summer and early fall (see Figure II-7). The increase in loads during the summer was driven by increases in total phosphorus concentration over the levels that were present in May. Especially large increases were observed at the sampling station at STH 50, where the median concentration of total phosphorus during the period of 1993-1995 increased from 0.19 mg/l in May to 0.64 mg/l in August. In early fall, loads decreased, reflecting decreases in both

---

[36]*Spearman ρ correlation coefficient = 0.86, yielding a* $\rho^2 = 0.74$.

discharge and instream concentrations of total phosphorus. During the late fall, instream loads remained relatively low despite slight increases in discharge.

Nitrogen

A variety of nitrogen compounds that act as nutrients for plants and algae are present in surface waters. Typically, only a small number of forms of nitrogen are examined and reported in water quality sampling. Total nitrogen includes all of the nitrogen compounds and ions in dissolved or particulate form in the water. It does not include nitrogen gas, which is not usable as a nutrient by most organisms. Total nitrogen is a composite of several different compounds which vary in their availability to algae and aquatic plants and in their toxicity to aquatic organisms. Common inorganic constituents of total nitrogen include ammonia, nitrate, and nitrite. These are the forms that most commonly support algal and plant growth. Total nitrogen also includes a large number of nitrogen-containing organic compounds, such as amino acids, nucleic acids, and proteins that commonly occur in natural and polluted waters. These compounds are reported as organic nitrogen.

Nitrogen compounds can be contributed to waterbodies from a variety of point and nonpoint sources. In urban settings, nitrogen compounds from lawn fertilizers and other sources may be discharged through storm sewer systems and through direct runoff into streams. Cross-connections between sanitary and storm sewer systems, illicit connections to storm sewer systems, and decaying sanitary and storm sewer infrastructure may contribute sanitary wastewater to waterbodies through discharges from storm sewer systems. In rural settings, nitrogen compounds from chemical fertilizers and animal manure that are applied to fields may be contributed through discharges from drain tiles or direct runoff from fields into waterbodies. Nitrogen compounds may also be contributed by poorly maintained or failing private onsite wastewater treatment systems.

Occasionally, nitrogen acts as the limiting nutrient for algal and plant growth in freshwater systems. This usually occurs when concentrations of phosphorus are very high.

With the exception of ammonia, the State of Wisconsin has not promulgated water quality criteria for any nitrogen compounds. In the absence of specific State water quality criteria, guidelines for concentrations of total nitrogen, nitrate plus nitrite, and total Kjeldahl nitrogen that can be used to evaluate water quality conditions are shown in Table II-3. For nitrogen compounds, these guidelines are reference values which are scientific assessments of the potential level of water quality that could be achieved in the absence of human activities. Total Kjeldahl nitrogen consists of the concentration of nitrogen in the forms of ammonia and organic nitrogen. It should be noted that Wisconsin has issued acute and chronic toxicity criteria for ammonia. The values of these criteria in any waterbody at any time depend upon the water use objective for the waterbody, the ambient temperature, and the ambient pH.

Figure II-17 shows total nitrogen concentrations at sampling stations along Jackson Creek. Concentrations of total nitrogen in Jackson Creek ranged from below the limit of detection to 28.0 mg/l, with a median value of 5.50 mg/l. Despite the fact that the maximum value was seen at the STH 50 site in the Delavan Lake Inlet, higher concentrations were generally seen at the three upstream stations than at the STH 50 site. This was especially the case during the period 2005-2014.

Three patterns are evident in the data presented in Figure II-17. First, concentrations of total nitrogen in almost all samples collected from Jackson Creek were greater than the guideline values given in Table II-3. In fact, at most stations they are considerably higher. These high concentrations indicate that nitrogen is a problem and an important water quality issue in this watershed. Second, concentrations of total nitrogen in Jackson Creek decrease from upstream to downstream. This can reflect at least two different processes that may be occurring in the Creek. The decrease may reflect the incorporation of some nitrogen compounds into the tissue of plants. The decreases may also reflect the settling of particulate material containing nitrogen compounds, especially within the Delavan Lake inlet portion of the Creek. It should be noted that these two processes are not mutually exclusive and both may be influencing total nitrogen concentrations within Jackson Creek. Third, at the Petrie Road and Mound Road sampling stations, concentrations of total nitrogen collected during the period 2005 through mid-2014 were not very different from those collected during previous historical periods. The concentrations detected in samples collected at the STH 50 sampling stations during the period 2005 through mid-2014 appear to be lower than the concentrations in samples collected during the period 1975-2004. This result should be interpreted with caution because only a small number of samples were available from the period 2005 through mid-2014 and they may represent a statistical fluke.

As previously noted, total nitrogen consists of several different classes of inorganic and organic nitrogen compounds. All of these would need to be simultaneously sampled to completely characterize the existing state of nitrogen chemistry in a waterbody. This was done for only a very small percentage of the total nitrogen samples collected in the Jackson Creek watershed. Despite this, comparison of the average concentrations of different chemical forms of nitrogen in samples collected from the Jackson Creek watershed can give a sense of the relative contributions of each of these compounds to total nitrogen in Jackson Creek.

The median concentration of nitrate plus nitrite in Jackson Creek was about 4.0 mg/l. In those samples in which both nitrate and nitrite were analyzed separately, nitrate concentrations were about eight to nine times higher than nitrite concentrations. Median concentrations of organic nitrogen were less than 1.0 mg/l and median concentrations of ammonia were less than 0.1 mg/l. Based upon this comparison of average concentrations, it is likely that most of the total nitrogen present in Jackson Creek is present in the form of nitrate. It should be noted that this conclusion does not necessarily indicate that nitrogen entered the stream as nitrate. The chemistry of nitrogen in aquatic systems is complex. In the presence of oxygen, bacteria may convert ammonia and organic nitrogen compounds to nitrite or nitrate.

The range of concentrations of total nitrogen detected in samples from tributaries streams in the Jackson Creek watershed is similar to that observed in samples from the mainstem of the Creek. The average concentrations observed in these streams are slightly lower, with median values of 4.45 mg/l and 4.40 mg/l detected in Tributaries A and B, respectively. Comparison of average concentrations of different chemical forms of nitrogen in samples collected from these streams suggests nitrogen in Tributaries A and B is present largely in the form of nitrate.

Concentrations of total nitrogen are considerably higher in streams of the Jackson Creek watershed than reference levels that indicate the potential level of water quality that could be achieved in the absence of human activities. These high concentrations indicate that nitrogen is a problem and an important water quality issue in this watershed.

Suspended Sediment Concentration/Total Suspended Solids

Suspended material in surface waters consists of particles of sand, silt, and clay; planktonic organisms; and fine organic and inorganic debris. The composition of suspended material varies with characteristics of the watershed and pollution sources.

Energy in water motions keeps particulate material suspended. Because the density of these particles is greater than the density of water, they will settle out of the water in the absence of water motions such as flow or turbulence. The rate at which a particle settles is a function of its size, density, and shape. In general, larger and denser particles will settle more quickly than smaller and less dense particles. Flow and mixing will keep particles suspended, with stronger flow or mixing being required to keep larger or denser particles suspended. This has implications for suspended material in waterbodies. In streams, for example, higher concentrations and larger and denser suspended particles are associated with higher water velocities—both in fast-moving sections of streams and during high flow periods. If water velocities are great enough, they may cause resuspension of sediment from the bed or erosion from the bed and banks of the stream. By contrast, deposition of suspended material may occur in slow-moving streams or during periods of low flow, with progressively smaller and lighter particles being deposited with decreasing water motions. The result of this is that concentrations of suspended material and the nature of the suspended particles in a waterbody vary, both spatially and over time.

Some best management practices (BMPs) that are designed to reduce sediment contributions to waterbodies take advantage of this relationship between water motions and suspension of particulate material. Part of the way that sedimentation ponds work is through slowing water motions down. This causes suspended particles to settle out of the water column, and can reduce the amount of sediment released to receiving waters. This mechanism will also act to reduce contributions of any material that is associated with the particles through incorporation into particles or adsorption onto the particle surfaces. For example, because phosphorus is often a constituent of sediment particles or adsorbed to the surface of such particles, settling of suspended particles in these ponds will act to reduce the amount of phosphorus released from the ponds. When the pond water depth is reduced due to the accumulation of sediment water moving through a pond can also act to resuspend sediment. Under these conditions, such ponds can act as a source of sediment and associated pollutants to receiving waters.

Sources that contribute suspended material to waterbodies include sources within the waterbody and sources in the contributing watershed. Within a waterbody, resuspension of sediment in the beds of waterbodies and erosion of beds and banks can contribute suspended materials. Suspended materials can also be contributed by point and nonpoint pollution sources within the watershed. Concentrations of suspended materials in most discharges from point sources are subject to effluent limitations through the WPDES permit program that limit the concentrations and amounts of total suspended solids that can be discharged. A variety of nonpoint sources can also contribute suspended materials to waterbodies. Many BMPs for urban and rural nonpoint source pollution are geared toward reducing discharges of suspended materials.

Several different measures can be used to examine the amount of suspended materials in water. These methods differ both in the approach taken and in the characteristics actually being measured. Two measures are commonly used to assess the bulk concentration of suspended materials in water: total suspended solids (TSS) and suspended sediment concentration (SSC). Both of these are based upon weighing the amount of material retained when a sample is passed through a filter. They differ in the details of sample handling and subsampling. It is important to note that these two measures are not comparable to one another.[37] Turbidity is another measure of the amount of suspended materials in water. Turbidity measures how much light is scattered as it passes through water. Higher concentrations of suspended materials in water are generally associated with greater scattering of light. A final measure is the concentration of chlorophyll-*a*, which estimates the biomass of phytoplankton suspended in the water. It should be noted that chlorophyll-*a* concentrations have not been monitored in Jackson Creek or its tributaries, although they have been extensively monitored downstream within Delavan Lake. The vast majority of suspended material samples available for Jackson Creek consist of samples analyzed for SSC or TSS.

High concentrations of suspended solids can cause several impacts in waterbodies. High turbidity is a result of high concentrations of suspended solids. High concentrations of suspended solids reduce the penetration of light into the water, reducing the amount of photosynthesis. In addition, suspended particles absorb more heat than water does. As a result, this can lead to an increase in water temperature in streams. Both of these effects can lead to lower concentrations of dissolved oxygen. High concentrations of suspended solids can clog the gills of fish and other

---

[37] *J.R. Gray, G.D. Glysson, L.M Turcios, and G.E. Schwartz,* Comparability of Suspended-Sediment Concentration and Total Suspended Solids Data, *U.S. Geological Survey Water-Resources Investigations Report No. 00-4191, 2000.*

aquatic organisms, stressing them physiologically—in some cases fatally. Deposition of sediments may alter the substrate, making it unsuitable as habitat for aquatic organisms, or changing channel characteristics. In addition, as a result of physical and chemical interactions, other materials may adsorb to particles suspended in water. Examples include poorly soluble organic molecules, such as polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and pesticides; nutrients, such as phosphate and nitrate ions; metals, such as copper and zinc ions; and microorganisms, such as bacteria and viruses. As a result, some pollutants may be carried into, or transported within, waterbodies in association with suspended material. In areas where sediment is deposited, reservoirs of these pollutants may accumulate in the sediment. While the State of Wisconsin has not promulgated water quality criteria for suspended solids, the Rock River TMDL sets a target concentration of 26 mg/l TSS for streams in the TMDL Sub-basin 80, including Jackson Creek and its tributaries.[38]

Figure II-18 shows TSS concentrations at sampling stations along Jackson Creek. Concentrations of TSS in Jackson Creek ranged between 1.0 mg/l and 310 mg/l over the period of record with a median concentration of 4.0 mg/l and a mean concentration of 17.2 mg/l. SSC in Jackson Creek ranged between 0.4 mg/l and 5,750 mg/l with a median concentration of 31.0 mg/l and a mean concentration of 64.9 mg/l. For both of the measures of suspended material, the mean concentrations were higher than the median concentrations. This indicates that the distributions of concentrations of these water quality constituents are highly skewed, with higher concentrations being relatively rare and lower concentrations being more common. When high concentrations of TSS and SSC occur, they are usually associated with high stream discharge.

Figure II-18 shows that concentrations in most samples from the period 2005 through mid-2014 are greater than the target concentrations of 26 mg/l set under the Rock River TMDL. Over this period, concentrations in about 37 percent of the samples collected were less than or equal to 26 mg/l. Concentrations from the period 1975-2004 were lower than this guideline value; however, this is based upon a small data set and may not be representative of conditions in the stream at that time. The figure shows evidence of the skewed distribution of concentrations that was discussed in the previous paragraph, especially at the Mound Road sampling station. While the available data are not adequate to describe upstream to downstream trends in TSS concentration in the Creek, the presence of sediment on the stream bed in the Delavan Lake inlet and the accumulation of sediment in the nearby Town sedimentation basins (see Figure II-4) indicate that some settling of suspended material occurs in this portion of the Lake. It is important to note that some of this sediment may be resuspended and transported downstream during high flow events.

Figure II-19 shows seasonal patterns in average daily instream loads of suspended sediment at four sampling stations in the Jackson Creek watershed during the years 1993-1995. These years were chosen for the sake of comparability.

---

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

They are the only years for which suspended sediment load data are available for all four stations. With some variations among the sites, similar patterns occurred at all four sites. These patterns reflect the fact that higher instream loads can result from greater stream discharge, higher instream concentrations, or both. During the late winter and early spring, average daily loads at these sites increased from relatively low levels in January to peak values in April. Average daily loads decreased from the April values through late spring and summer to reach the lowest values of the year in the September or October. Average daily loads increased through the fall and early winter to reach a secondary peak in December.

Superimposed on this general pattern are differences among the sites in variability. During some months, loads at the two upstream sites—Jackson Creek at Petrie Road and Tributary B near Elkhorn—show higher variability than those at the downstream sites (Figure II-19). This is especially apparent during the months of June and July at both sites and the month April at the Petrie Road site. This likely reflects variability in stream discharge.

Turbidity

Turbidity is a measure of the clarity of water. It results from light being scattered and absorbed by particles and molecules rather than being transmitted through the water. Turbid water appears cloudy. Turbidity is caused by fine material that is suspended in the water, such as particles of silt, clay, finely divided organic and inorganic material, and planktonic organisms. Colored substances that are dissolved in the water can also contribute to turbidity. There are several ways of measuring turbidity. It is often measured using a nephelometer, which is a specialized optical device that measures the amount of light scattered when a beam of light is passed through a sample. The unit of measurement for this method is called a nephelometric turbidity unit (ntu), with low values indicating high water clarity and high values indicating low water clarity. Other methods involve measuring the depth of water through which a black and white disk remains visible. For lakes and ponds, this is often done at the site using a Secchi disk. For streams this is done using a transparency tube. High turbidity can significantly reduce the aesthetic quality of lakes and streams, having a harmful impact on recreation. It reduces the penetration of light into the water, reducing the amount of photosynthesis. In addition, suspended particles absorb more heat than water does. As a result, high turbidity can lead to an increase in the water temperature in streams. Both of these effects can lead to lower concentrations of dissolved oxygen.

Turbidity can be strongly influenced by streamflow. During periods of low flow, turbidities are low, usually less than 10 ntu. During periods of high flow, water velocities are faster and water volumes are greater. This can stir up and suspend material from the stream bed, causing higher turbidities. If high flows are the result of precipitation or snowmelt, particles from the surrounding land are washed into the stream. This can make the water a muddy brown color, indicating water that has higher turbidity values.

Turbidity can harm fish and other aquatic life by reducing food supplies, degrading spawning beds, and affecting gill function. It can also reduce the growth of aquatic plants. The State of Wisconsin has not promulgated water quality criteria for turbidity.

Turbidity values in Jackson Creek ranged from below the limit of detection to 14 ntu, with median values of 2.2 ntu. Most of the values of turbidity were below 6 ntu. It should be noted that few turbidity samples were available for the Jackson Creek watershed. Most of the available data were collected during the period 1975-2004.

Water Temperature

The temperature of a waterbody is a measure of the heat energy it contains. Water temperature drives numerous physical, chemical, and biological processes in aquatic systems. Processes affected by temperature include the solubility of substances in water, the rates at which chemical reactions progress, metabolic rates of organisms, the settling rates of small particles, and the toxicity of some substances. For example, the solubility of many gases in water decreases as water temperature increases. The solubility of oxygen in water is an example of this—colder water can hold more dissolved oxygen. By contrast, the solubility of many solids in water increases as water temperature increases. Temperature is a major determinant of the suitability of waterbodies as habitat for fish and other aquatic organisms. Each species has a range of temperatures that it can tolerate and smaller range of temperatures that are optimal for growth and reproduction. These ranges are different for different species. As a result, very different biological communities may be found in similar waterbodies experiencing different temperature regimes. In Wisconsin for example, high-quality warmwater systems are characterized by many native species, including cyprinids, darters, suckers, sunfish, and percids that typically dominate the fish assemblage. In contrast to warmwater streams, coldwater systems are characterized by few native species, with salmonids (trout) and cottids (sculpin) dominating, and they lack many of the taxonomic groups that are important in high-quality warmwater streams.

Air temperatures affect water temperatures, especially in smaller waterbodies. Solar heating strongly influences water temperature and factors that affect the incidence of light on waterbodies or light penetration through waterbodies can affect temperature. The presence of suspended material or colored dissolved material in the water column can increase the absorbtion of light by the waterbody, leading to heating. Water temperature follows a seasonal cycle, with lowest temperatures occurring during winter and highest occurring during summer. Water temperature can also be affected by discharges of groundwater, stormwater runoff, and discharges from point sources.

SEWRPC staff deployed continuous monitoring devices at eight locations to measure water temperatures and one additional site to monitor air temperatures from 2012 through 2013. These devices were programmed to record temperature in hourly increments. Table II-6 and Map II-4 describe the locations, river miles, and collection dates for those continuous monitoring devices.

Figure II-20 shows water temperatures from five sites and air temperatures from one site in the Jackson Creek watershed over a 70-day period running from midsummer to early fall 2012. Between July 25, 2012 and June 5, 2013, water temperatures in streams in the Jackson Creek watershed ranged from about -0.2ºC to 31.0ºC, with a mean value of 8.5ºC and a median value of 6.2ºC. The data show that air temperatures are major determinants of water temperatures. Air temperature affects water temperature on at least two different time scales. On a shorter time scale, daily fluctuations in water temperature at all sites tend to mirror those in air temperature. It should be noted that the magnitudes of these daily fluctuations in water temperature are much less those in air temperature. Over the period shown in Figure II-20, the average difference between the daily maximum air temperature and the daily minimum air temperature was 13.3ºC. At sites within the Jackson Creek watershed, the average daily differences between maximum and minimum water temperatures ranged between 1.3ºC at the CTH H site and 5.2ºC at the Mound Road site.

There are a couple reasons why the magnitudes of the fluctuations in water temperature are less than that in air temperature. First, water has a higher heat capacity than air. Because of this, a given amount of water must absorb more heat than the same amount of air to increase its temperature by a given amount. Similarly, a given amount of water must lose more heat than the same amount of air to decrease its temperature by a given amount. Second, discharges of groundwater into the stream will tend to reduce the magnitude of daily water temperature fluctuations. This is especially the case during low flow periods when groundwater discharge can constitute a substantial portion of streamflow. This effect is especially apparent in the temperature record from the CTH H site (Figure II-20) where daily water temperature fluctuations were exceptionally small. The Jackson Creek watershed experienced severe drought during spring through fall 2012. During this period it is likely that most of the flow at this site was derived from groundwater discharge and that the water temperatures at this site strongly reflected the temperature of the groundwater.

Water temperatures also reflect air temperatures on longer time scales. For example, Figure II-20 shows that the seasonal decrease in average air temperature during September was mirrored in decreases in water temperature at all five stream sites. Hence, water temperatures at a particular site are dependent upon both the current and preceding daily air temperature conditions. So, as daily temperatures decrease over time, water temperatures within the streams tend to get cooler. Warming works the same way. This is illustrated in Figure II-21 which shows a 70-day record of air and water temperatures at the same sites during spring 2013.

From mid-summer through early fall 2012, water temperatures in Jackson Creek and its tributaries showed an overall decreasing trend (Figure II-20). During this cooling period, most of the sites were similar to one another in terms of their mean and minimum daily temperatures and average range of daily temperature variation. The exception to this generalization was the site on Jackson Creek at CTH H. The Mound Road site on Jackson Creek was the warmest of the five sites examined. In part, this reflects the fact that this site is located downstream from the other sites that were examined. Water temperatures at this site are influenced by gains and losses of heat taking place upstream. Water temperatures during this period at three of the other sites—Jackson Creek at STH 67, Tributary A upstream from the wetland complex, and Tributary B near IH 43—were similar to, but slightly cooler than, those at Mound Road. Average daily mean temperatures at these sites were within about 4.0ºC and average daily minimum temperatures were within about 3.5ºC of those at Mound Road. Water temperatures at the site on Jackson Creek at CTH H were substantially cooler, with an average daily mean temperature 7.9ºC cooler and average daily minimum temperature 6.0ºC degrees cooler than those at Mound Road. This probably reflects the strong influence that groundwater discharge has on water temperatures at this site.

During mid-summer through early fall 2012, there was a definite pattern among the sites in the average range of daily water temperature variations (Figure II-20). The largest daily variations occurred at the Mound Road site on Jackson Creek, which had an average difference between the daily maximum and minimum temperatures of 5.2ºC. Slightly smaller daily variations occurred at the STH 67 site on Jackson Creek, where the average daily temperature range was 4.9ºC. Even smaller daily variations occurred at the stations on Tributaries A and B, where the average daily temperature ranges were 3.6ºC and 3.8ºC, respectively. Very small daily variations occurred at the CTH H site on Jackson Creek, where the average daily temperature range was 1.3ºC. This pattern is the opposite of what would be expected based upon the volumes of water flowing past each of these stations. It would be expected that greater daily variations in water temperature would occur at upstream and tributary stations than at downstream stations. The pattern present among these stations probably reflects buffering of daily water temperatures at upstream and tributary stations by groundwater discharge into the stream. It should be noted that during the time period shown in Figure II-20, the Jackson Creek watershed was experiencing severe drought conditions. Because of this, it is likely that groundwater discharges comprised a larger than normal fraction of stream discharge at some or all of these sites. Thus, the data shown in Figure II-20 may not depict typical conditions during mid-summer through early fall in Jackson Creek and its tributaries.

During spring 2013, water temperatures in Jackson Creek and its tributaries showed an overall increasing trend (Figure II-21). During this warming period, most of the sites were similar to one another in terms of their mean and minimum daily temperatures and average range of daily temperature variation. Again, the site on Jackson Creek at CTH H was an exception to this generalization. The site on Tributary A upstream from the wetland complex was the warmest of the five sites examined. Water temperatures during this period at three of the other sites—Jackson Creek at Mound Road, Jackson Creek at STH 67, and Tributary B near IH 43—were similar to, but slightly cooler than, those in Tributary A. Average daily mean temperatures at these sites were within about 0.7ºC and average daily minimum temperatures were within about 1.9ºC of those at the Tributary A site. Water temperatures at the site on Jackson Creek at CTH H were substantially cooler, with an average daily mean temperature 1.4ºC cooler and an average daily minimum temperature 2.7ºC degrees cooler than those at the Tributary A site. This probably reflects the strong influence that groundwater discharge has on water temperatures at CTH H. The smaller difference observed between average temperatures in Jackson Creek at CTH H and the other sites seen during spring 2013 probably reflects two differences between this period and the period shown in Figure II-20. First, spring is a time of higher flows in these streams (see Figure II-7). These higher flows result from snowmelt and precipitation and act to reduce the effect of groundwater discharges on the temperature of the stream. Second, during spring 2013 the Jackson Creek watershed was no longer experiencing severe drought conditions. This would contribute to higher instream flows, which would act to reduce the effect of groundwater discharges on the temperature of the stream.

The pattern among the sites in the average range of daily water temperature variations during spring 2013 was different from the pattern seen the previous summer. The largest daily variations occurred at the CTH H site on Jackson Creek, which had an average difference between the daily maximum and minimum temperatures of 4.6ºC. The relatively large daily temperature fluctuations at this site probably result from reduced influence of groundwater inputs resulting from the higher flows from runoff that occurred during the spring and the fact that the Jackson Creek watershed was no longer experiencing drought conditions. The smallest daily variations in water temperature occurred at the Mound Road site on Jackson Creek, where the average daily temperature range was 1.8ºC. The presence of a weir at Mound Road probably contributes to the relatively small daily temperature variations at this site observed during this period. This weir impounds a large volume of water which requires large inputs of heat to warm and large losses of heat to cool.

The ambient temperature as well as the acute and sublethal water quality criteria for temperature in warmwater streams and lakes are further defined and set forth in Table II-2. In 2012 and 2013 daily maximum temperatures at the stations sampled in Jackson Creek met the applicable acute temperature criteria about 93 percent of the time or more. Most exceedances of the acute temperature criteria occurred during the months June through September.

Compliance with the sublethal water quality criteria for temperature showed a more complicated pattern. The calendar week average of daily maximum temperatures at the stations sampled in section of the mainstem upstream of Petrie Road and Tributaries A and B met the applicable sublethal criteria at least 93 percent of the time. Lower levels of compliance were seen at stations in the downstream portions of the mainstem of Jackson Creek. The calendar week average of daily maximum temperatures at the stations sampled in section of the mainstem between Petrie Road and Mound Road met applicable sublethal criteria about 70 percent of the time. The calendar week average of daily maximum temperatures at the stations sampled in section of the mainstem between Mound Road and STH 50 met applicable sublethal criteria about 82 percent of the time. Exceedences occurred in all months except the winter months of December through February.

Water temperature data collected indicated that the Jackson Creek and associated tributaries would be likely to support a sustainable warmwater fishery. However, at many of the sites within the Jackson Creek water temperatures exceed the applicable acute criteria for some portion of the summer months and the applicable sublethal criteria during much of the year. This indicates that temperatures are likely impacting the quality of the fishery in this stream system.

Effects of the Mound Road Constructed Wetland Detention Basins

In 1992, a wetland restoration was implemented in Jackson Creek upstream of Mound Road. The purpose of this restoration was to reduce sediment and nutrient loading to downstream waters, including the Delavan Lake inlet section of Jackson Creek and Delavan Lake. Elements of this project included enlarging an existing 15-acre wetland to 95 acres. In addition, three retention ponds were constructed (see Figure II-4). These ponds received flow from Jackson Creek and Jackson Creek Tributaries A and B and released it into the wetland through outlet swales.

In cooperation with the Town of Delavan, the USGS conducted a 32-month study examining the performance of this constructed wetland.[39] The primary objective of the study was to assess the effectiveness of the wetland as a retention system for suspended sediment and nutrients. The study included continuous monitoring of stream discharge in two streams flowing into the wetland and the wetland outflow, intermittent monitoring of discharge in a third inflowing stream, periodic and storm runoff sampling to determine sediment and nutrient concentrations, and measurement of sediment accumulation in the ponds. Data were collected over the period from February 1993 through September 1995.

Table II-7 shows suspended sediment loadings at various sites within the Jackson Creek based upon U.S. Geological Survey (USGS) sampling data. The average annual sediment loading to the inlet (Jackson Creek at Mound Road) reported by the USGS was about 600 tons of sediment, though this mass showed considerable variability during the period of record. Based upon a finer scale analysis, the USGS study concluded that the wetland retained about 46 percent of inflow sediment over the study period. Retention of sediment varied seasonally during the year, with about 74 percent of inflowing sediment being trapped during the May-September growing season, but only about 34 percent being trapped during the October-April nongrowing season. This difference is probably due to the greater density of vegetation in the wetland during the growing season.

The levels of nutrient retention within the wetland were lower and patterns of nutrient retention were less consistent than those reported for suspended sediment. Over the course of the study, the wetland retained about 19 percent of total phosphorus and 11 percent of dissolved orthophosphate, the form of phosphorus most readily available to algae and plants. The wetland retained even lower portions of the inflowing nitrogen compounds, with about 8 percent of

---

[39]*G.L. Goddard and J.F. Elder,* Retention of Sediments and Nutrients in Jackson Creek Wetland near Delavan Lake, Wisconsin, 1993-1995, *U.S. Geological Survey Water-Resources Investigations Report No. 97-4014, 1997; J.F. Elder and G.L. Goddard,* Sediment and Nutrient Trapping Efficiency of a Constructed Wetland near Delavan Lake, Wisconsin, 1993-1995, *U.S. Geological Survey Fact Sheet FS-232-96, 1996.*

the combined ammonia and organic nitrogen and less than 1 percent of the dissolved nitrate plus nitrite nitrogen flowing into the wetland being retained over the course of the study. The wetland served as a net source of dissolved ammonia, with ammonia loads being about 22 percent higher in the outflow than in the inflow.

These overall percentages obscure a rather complicated pattern of retention of nutrients in, and release of nutrients from, the wetland. This pattern has at least three aspects to it that are illustrated through an examination of its effect on phosphorus loads:

1) There were interannual differences in performance of the wetland relative to nutrients. These are shown in Table II-8, which shows annual phosphorus loads at several sites in the Jackson Creek watershed. During water years 1994 and 1995, it is estimated that about 4,000 pounds and 2,100 pounds of phosphorus entered the Mound Road wetland from Jackson Creek and Tributary B, while approximately 3,300 pounds and 2,400 pounds of phosphorus were exported from the wetland at Mound Road.[40] Thus, the constructed wetland would appear to have the attributes of both a source—during 1995—and a sink—during 1994—of phosphorus.

2) There are differences in the performance of the wetland relative to nutrients. The USGS study found that most of the retention of phosphorus occurred during winter high flow periods.[41] In fact, during water year 1994 almost all of the retention of phosphorus in the wetland occurred in February. During other months, especially spring and summer months, the wetland system exported more phosphorus than entered it. The increased mobilization of phosphorus during the spring and summer may be due to anaerobic conditions in the wetland caused by higher rates of microbial respiration during periods of warmer temperatures.[42] These releases were accompanied by higher proportional releases of orthophosphate, the form of phosphorus that is most readily available for uptake by algae and aquatic plants. Thus relative to phosphorus, the principal function of the wetland appears to be to modify the timing and the chemical form of the delivery of the phosphorus load to the inlet.

3) The USGS study noted that net releases of nutrients over shorter time periods were commonly observed for all nutrients. It also noted that these releases frequently occurred during the growing season. This could potentially make these nutrients available to algal and plant communities downstream.

---

[40]*A water year begins October 1 of the previous calendar year and runs through September 30. For example, water year 1990 ran from October 1, 1989 through September 30, 1990.*

[41]*Goddard and Elder, 1997,* op.cit.

[42]*W.J. Mitsch and J.G. Gosselink,* Wetlands *(2nd edtion), Van Nostrand Reinhold, 1993.*

The dynamics of nutrients within the wetland do not appear to be strongly coupled to the dynamics of suspended sediment. Given that nutrients in streams are often associated with particulate material, coupling of nutrient dynamics to suspended sediment dynamics would be expected. This expectation would suggest that retention of suspended sediment would be accompanied by retention of nutrients. This did not happen in the Mound Road wetland complex—net release of nutrients often coincided with substantial retention of sediments. This suggests that biogeochemical processes within the wetland periodically mobilized sediment-associated nutrients, releasing them to the water.

Water Quality Summary

Jackson Creek has a very high loading of nutrients and suspended solids in the water. A visual assessment of Jackson Creek during a peak storm or runoff event clearly shows high amounts of sediment being carried as seen in Figure II-21a. Algae blooms are also prominent in the downstream reaches during the summer months (see Figure II-21a). By looking at the trends in suspended solids, total phosphorus, and discharge in Jackson Creek, the highest amounts of pollutant loading occurs during the spring and during high flow events (see Figures II-14,15,16, and 19). This indicates that a significant amount of the pollutants can be attributed to runoff.

Recent and historical data indicate that several water quality problems are either present or may be present in streams of the Jackson Creek watershed:

- During the period 2005 through mid-2014, the recommended water use objectives were only being partially achieved. Review of the data from this period shows the following:
    - Table II-9 presents a comparison of water quality constituents in the streams of the Jackson Creek watershed to applicable water quality criteria for the most recent period of record from 2005 through mid-2014. This comparison looks at water quality conditions throughout the year and through the examination of ambient levels of four water quality constituents: water temperature, pH, and concentrations of dissolved oxygen and total phosphorus. In the case of water temperature, ambient levels were compared to two applicable criteria—one which applies to acute effects to aquatic organisms and another which applies to chronic conditions.
        - No data from the Jackson Creek watershed were available to assess compliance with the criteria for chloride or fecal coliform bacteria.
        - Based upon a limited number of samples, dissolved oxygen concentrations from sampling stations located in the section of Jackson Creek between Mound Road and STH 50 appear to comply with the applicable water quality criteria. No data were

available to assess compliance with the dissolved oxygen criteria in upstream sections of the Creek or in tributaries to Jackson Creek.

- Daily maximum water temperatures in Jackson Creek and Tributaries A and B to Jackson Creek rarely exceeded the applicable acute criterion for temperature. In most sections of these streams where data were available to assess compliance with this criterion, the daily maximum temperatures were equal to or less than the applicable criterion over 98 percent of the time. The one exception to this occurred in the section of Jackson Creek between Petrie Road and Mound Road. In this section of the Creek, daily maximum temperatures complied with the applicable criterion about 93 percent of the time.

- In two sections of Jackson Creek, the weekly means of the daily maximum water temperatures commonly exceeded the applicable sublethal criterion for temperature. In the section of the Creek between Petrie Road and Mound Road, weekly means of the daily maximum water temperatures complied with the applicable criterion about 70 percent of the time. Similarly, in the section of the Creek between Mound Road and STH 50, weekly means of the daily maximum water temperatures complied with the applicable criterion about 82 percent of the time. In the section of Jackson Creek upstream from Petrie Road and Tributaries A and B, daily maximum water temperatures complied with the applicable criterion over 93 percent of the time.

- Concentrations of total phosphorus in samples collected at sampling stations along Jackson Creek and Tributary B were usually above the applicable water quality criterion. Less than 10 percent of the samples collected from these streams had phosphorus concentrations that were in compliance with State standards. The concentration of total phosphorus in the one sample collected from Tributary A during the period 2005 through mid-2014 was in compliance with the applicable water quality criterion. It should be noted that the only other sampling for total phosphorus in Tributary A occurred during the period 1993 through 1995. Total phosphorus concentrations in 60 percent of these samples were less than or equal to 0.075 mg/l, which is the currently applicable water quality criterion for this stream.

- Based on limited data, pH in the section of Jackson Creek between Mound Road and STH 50 is usually within the range specified by the State's water quality criterion. In one sample taken in this section, pH was slightly higher than the maximum value specified in the criterion.

- Table II-10 presents a similar comparison of water quality constituents in the streams of the Jackson Creek watershed to applicable water quality criteria for the May through October growing season during the period beginning in 2005 and continuing through mid-2014. Comparison of the values in Tables II-9 and II-10 shows that the levels of compliance with the applicable water quality criteria for total phosphorus achieved during the growing season were similar to those achieved during the rest of the year. During the growing season, substantially lower rates of compliance were achieved for the sublethal temperature criteria, especially in the sections of the mainstem of Jackson Creek between Petrie Road and STH 50. In these sections of the Creek, the weekly means of the daily maximum water temperatures often to usually exceed this standard, with exceedances occurring in almost 40 percent of weeks assessed in the section of the Creek between Mound Road and STH 50 and over 50 percent of weeks assessed in the section of the Creek between Petrie Road and Mound Road.

- Few recent data are available to assess dissolved oxygen concentrations in Jackson Creek or its tributary streams. In a substantial portion of samples collected during the period 1976 through 2004, dissolved oxygen concentrations were less than the State's water quality criteria for warmwater fish and aquatic life of 5.0 mg/l.

- The low dissolved oxygen concentrations are likely the result of high concentrations of nutrients. While concentrations of total phosphorus in surface waters of the watershed have decreased from the levels detected prior to 1976, they remain high. Concentrations of total phosphorus in the vast majority of samples collected since 2004 exceed the applicable water quality criteria of 0.075 mg/l for streams and 0.030 mg/l for the portion of Jackson Creek that constitutes the Delavan Lake inlet. High concentrations of nitrogen compounds, which constitute the other major plant nutrient, are also present in surface waters of the watershed. For example, concentrations of total nitrogen in streams of the watershed are considerably higher than reference levels that indicate the potential level of water quality that could be attained in the absence of human activities. It is likely that these high concentrations of nutrients are causing water quality problems in streams within the watershed and contributing to water quality problems in surface waters located downstream from Jackson Creek.

- Concentrations of total suspended solids (TSS), which measures the amount of material suspended in the water column, are high. TSS concentrations in most samples (63 percent) collected since 2004 were higher than the target concentrations of 26 mg/l set in the Rock River TMDL.

- While water temperatures in streams of the watershed are generally supportive of a warm water fishery, they sometimes exceed State water quality criteria for temperature. At some sites, daily maximum water temperatures during summer months occasionally exceed the State's acute water quality criteria for temperature. In addition, at some sites the calendar week averages of daily maximum water temperature often exceed the State's sublethal water quality criteria for temperature during spring, summer, and fall months.

Based upon these water quality problems, the surface waters of the Jackson Creek watershed appear to be only partially achieving their designated water use objective of warmwater fish and aquatic life. Given that no recent sampling has been conducted for fecal coliform bacteria or *Escherichia coli*, it is not possible to assess whether surface waters of the Jackson Creek watershed are achieving their designated water use objective of recreational use.

The Federal Clean Water Act considers waterbodies that do not meet the applicable water quality standards to be impaired and requires that states periodically submit a list of impaired waters to the USEPA for approval. It also requires the states to develop TMDLs to address impaired waters. Jackson Creek and its tributaries were not listed as being impaired waters as of year 2014, but both Jackson Creek and Delavan Lake were recently added to the WDNR's proposed 2016 list of impaired waters due to total phosphorus pollutant loads. Water from Jackson Creek and its tributaries flows through Delavan Lake and Swan Creek into an impaired section of Turtle Creek. This section is considered impaired due to low concentrations of dissolved oxygen related to high concentrations of total phosphorus.

As a part of the Rock River Basin, the Jackson Creek watershed is addressed under the Rock River TMDL.[43] This TMDL sets water quality targets and establishes wasteload allocations and load allocations for total phosphorus and totals suspended solids in 84 sub-basins of the Rock River watershed, including a sub-basin which contains the watersheds of Jackson Creek, Delavan Lake, Swan Creek, and a section of Turtle Creek. Meeting the water quality targets set in the Rock River TMDL will require substantial reductions in nonpoint source loading. For the sub-basin containing the Jackson Creek watershed, this will require average percent reductions from baseline loads of 49 percent and 25 percent for total phosphorus and TSS, respectively.

Biological Conditions

The quality of streams and rivers is often assessed based on measures of the chemical or physical properties of water. However, a more comprehensive perspective includes resident biological communities. Guidelines to protect human health and aquatic life have been established for specific physical and chemical properties of water and have become useful yardsticks for assessing water quality. Biological communities provide additional crucial

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

information because they live within streams for weeks to years and, therefore, integrate through time the effects of changes to their chemical or physical environment.[44]

In addition, biological communities are a direct measure of stream health—an indicator of the ability of a stream to support aquatic life. Thus, the condition of biological communities, integrated with key physical and chemical properties, provides a comprehensive assessment of stream health. The presence and abundance of species in a biological community are a function of the inherent requirements of each species for specific ranges of physical and chemical conditions. Therefore, when changes in land use and water management in a watershed cause physical or chemical properties of streams to exceed their natural ranges, vulnerable aquatic species are eliminated, and this ultimately impairs the biological condition and stream health.[45]

Aquatic and terrestrial wildlife communities have educational and aesthetic values, perform important functions in the ecological system, and are the basis for certain recreational activities. The location, extent, and quality of fishery and wildlife areas and the type of fish and wildlife characteristic of these areas are important determinants of the overall quality of the environment in the Jackson Creek watershed.

Fisheries Classification

A stream model has recently been developed by the WDNR to classify stream reaches into their biotic community by fish occurrence and abundance, as well as the ecological conditions that largely determine the biotic community (i.e., stream flow and water temperature).[46] The proposed natural community classification has 11 natural community classes as summarized in Table II-11, which have unique physical and biological characteristics.[47] This model was developed to provide an objective, standardized, and ecologically meaningful framework to classify streams.[48]

---

[44]*D.M. Carlisle and others,* The Quality of Our Nation's Waters—Ecological Health in the Nation's Streams*, 1993–2005: U.S. Geological Survey Circular 1391, 2013 (available online at:* http:// pubs.usgs.gov/circ/1391/*).*

[45]Ibid.

[46]*John Lyons, "Patterns in the species composition of fish assemblages among Wisconsin streams,"* Environmental Biology of Fishes *Volume 45, 1996, pages 329-341.*

[47]*John Lyons, "Proposed temperature and flow criteria for natural communities for flowing waters," February 2008, updated October 2012.*

[48]*John Lyons, "Wisconsin Department of Natural Resources, An Overview of the Wisconsin Stream Model," January 2007.*

Results of the stream model as provided by WDNR generally indicate that the entire Jackson Creek system is a cool (cold transition) headwater stream as shown on Map II-5, which is generally supported by the observed water temperature data and fishery assemblages. The definition of such a stream condition is:

> Small, usually perennial streams with cold to cool summer temperatures. Coldwater fishes are common to uncommon (<10 per 100 m), transitional fishes are abundant to common, and warmwater fishes are uncommon to absent. Headwater species are abundant to common, mainstem species are common to absent, and river species are absent.

According to WDNR researchers coolwater streams, which are intermediate in character between coldwater ‘‘trout’’ streams and more diverse warmwater streams, occur widely in temperate regions, including the State of Wisconsin.[49] Fish assemblages in coolwater streams tend to be variable but are generally intermediate in species richness and overlapped in composition with coldwater and warmwater streams.

As shown on Map II-5, likely due to scale limitations, the WDNR model did not classify all reaches of the Jackson Creek system and it also did not indicate any ephemeral (i.e., intermittent) or macroinvertebrate channels. There are numerous intermittent stream reaches in the Jackson Creek watershed as indicated on Map II-5 (see the *Stream Conditions* subsection below), which only flow after precipitation events (i.e., no base flow), although water may remain in the channel long after rain events. The ephemeral channels are characterized by no fish and few or no aquatic invertebrates. Whereas, macroinvertebrate channels are characterized by few or no fish present, but a variety of aquatic invertebrates are common, at least seasonally.

This model also classified one tributary to Jackson Creek as a cool (warm transition) headwater fishery and one as a cool (cold transition) headwater fishery. Although the coolwater classifications are probably appropriate, more information would need to be collected to verify these classifications.

Through calculation of the Index of Biotic Integrity (IBI), data on the fish community can provide insight into the overall health of the stream ecosystem. Fish catches can also reveal trends in the populations of rare and sport fish species. The overall goal of monitoring is to better document the current status of Jackson Creek and its tributaries and to provide an early warning of declines in environmental quality and fisheries associated with human development in the watershed. Due to the fundamental differences among warmwater, coolwater, and coldwater

---

[49]*Lyons et al 2009*

streams, a separate Index of Biotic Integrity was developed to assess the health of each of these types of streams.[50] Therefore, the coolwater index is most appropriate for the fisheries assessment of Jackson Creek.

Based upon the fisheries assessments conducted between 2006 through 2013 by WDNR in Jackson Creek, the Creek seems to generally have remained as an excellent coolwater fishery among several sites within the mainstem of this system. Considering that this system experienced a severe drought in the summer of 2012, the excellent classification in 2013 demonstrates the resiliency of this system. This indicates that the Jackson Creek system is sustained by shallow groundwater inputs and demonstrates the importance of continuing to protect groundwater recharge in this watershed.

Although the fish IBI is useful for assessing environmental quality and biotic integrity in streams, it is most effective when used in combination with additional data on physical habitat, water quality, macroinvertebrates, and other biota when evaluating a site.[51] Supplemental data from macroinvertebrates surveys conducted by the WDNR are summarized below.

Fish Species Diversity

A review of the fish data collected in Jackson Creek between 1968 and 2013 indicates that the lower portions of the Creek have improved from six to eleven species per survey to about eight to 13 species per survey in the more recent sample dates in 2006 through 2013 as shown in Table II-12. In addition, this increase in species richness seems largely due to an increase in the number of species and abundance of coolwater or transitional species, which is a very positive sign and likely associated with improved water quality. The coolwater tolerant species observed in Jackson Creek include brook stickleback, central mudminnow, creek chub, and white sucker. Northern pike, which is the only sensitive coolwater species, was also observed at nearly all sites and as far as three miles upstream of Mound Road. Since northern pike are not adapted for life in strong currents, they occur more frequently in lakes than in rivers, where they inhabit backwaters and pools. So, these juvenile northern pike found within Jackson Creek are evidence of successful natural reproduction, which indicates that there is suitable spawning habitat, juvenile rearing habitat (particularly vegetated cover), and adequate water quality within this system. Researchers have determined that the availability of suitable spawning habitat is the most limiting factor for this species, which most often limits the abundance and distribution of northern pike in lakes, reservoirs, and slow moving rivers. Therefore, shallow vegetated areas that are inundated in the spring, such as flooded marshes, flooded terrestrial riparian vegetation in tributary streams, or weedy bays, provide suitable spawning habitat,

---

[50]*John Lyons, "Development and Validation of an Index of Biotic Integrity for Coldwater Streams in Wisconsin,"* North American Journal of Fisheries Management*, Volume 16, May 1996.*

[51]*John Lyons,* General Technical Report NC-149, op. cit.

provided that high water levels are maintained throughout the embryo and fry stages.[52] The consistent presence of the sensitive northern pike and the other coolwater species is an indication of sustained good water quality in Jackson Creek.

The surveys also indicate that the Jackson Creek fishery contains a mixture of warmwater fish species as shown in Table II-12 that 1) are tolerant of pollution, 2) have an intermediate tolerance of pollution, or 3) are sensitive to pollution. The warmwater tolerant species include black bullhead, bluntnose minnow, common carp, fathead minnow, green sunfish, and yellow bullhead. The warmwater intermediate species include bigmouth shiner, black crappie, bluegill, common shiner, grass pickerel, hornyhead chub, largemouth bass, mimic shiner, pumpkinseed, and stoneroller species. However, it is important to note that the black crappie, bluegill, pumpkinseed, and largemouth bass—panfish and gamefish species that are highly sought by fisherman—were only observed in the most recent surveys. However, despite these improvements to the fishery, there are several intermediate warmwater species that include the bigmouth shiner, grass pickerel, mimic shiner, and stonerollers that have not been observed in Jackson Creek since the late 1960s or early 1970s (Table II-12). This may be a cause of concern and demonstrates the importance of continued monitoring on this system.

Another excellent sign of a healthy fishery was the distribution and abundance of rainbow darter since 2006 among all four stations sampled (see Map II-5 and Figure II-21b WDNR sampling), which is a sensitive warmwater fish species. This species is a native North American fish. Like many other darter species, it has the ability to maintain position on the substrate in flowing water. This unique ability plays a key role in its microhabitat preference and enables it to inhabit small, fast-moving streams and small to medium-sized rivers. This microhabitat preference has been suggested to be due to oxygen levels in the water during season changes or other factors, such as feeding or shelter-related habitat preferences. Rainbow darters grow to two to three inches in length and have a lifespan of about four years. The rainbow darter also prefers to spawn in clean, fast flowing rocky riffle habitats from March through June. The male reproductive form is resplendent in bright oranges and iridescent blue spots, stripes, and checks (see front cover of this report). The rainbow darter is classified as insectivorous, primarily feeding on small invertebrates such as insects and crayfish. The species is very sensitive and has a low tolerance to pollution and silt, so its presence in Jackson Creek is an indication of good water quality and high quality riffle habitats.

Approximately 90 percent of the fish species found within Jackson Creek also reside within Delavan Lake. Hence, just as there is an important linkage in water quality between Jackson Creek and Delavan Lake, there is

[52]*Inskip, P. D. Habitat Suitability Index Models: Northern Pike. U.S. Dept. Int., Fish and Wildlife Service, FWS/OBS-82/10.17. 40 pp., 1982.*

also a vital connection between Delavan Lake and its tributaries regarding the abundance and diversity of the fishery. The ability to migrate between a tributary and lake environment for thermal refuge, overwintering, spawning, feeding, or other essential life history requirement is what helps to sustain a healthy fishery. For example, Jackson Creek and the Delavan Lake inlet area probably contain the highest quality potential spawning habitat for northern pike as well as for other species such as largemouth bass within or adjacent to Delavan Lake. Unfortunately, due to the presence of the sheet pile gauging weir that acts like a dam, Jackson Creek is not connected to the Delavan Lake Inlet or Delavan Lake under normal flows. Hence, this gaging weir is the greatest limiting factor to the short- and long-term protection and sustainability of the fishery in both Jackson Creek and Delavan Lake and is important issue to address under this plan (see *Stream Crossings and Dams* subsection below).

Mussels

Freshwater mussels are large bivalve (two-shelled) mollusks that live in the sediments of rivers, streams, and some lakes. Mussels are considered one of the most endangered families of animals in North America. These soft-bodied animals are enclosed by two shells made mostly of calcium and connected by a hinge. Mussels can typically be found anchored in the substrate, with only their siphons occasionally exposed. They typically favor sand, gravel, and cobble substrates. They play an important role in aquatic ecosystems by helping stabilize river bottoms; serving as natural water filters; providing excellent spawning habitat for fish; and serving as food for fish, birds, and some mammals. Live mussels and relic shells provide a relatively stable substrate in dynamic riverine environments for a variety of other macroinvertebrates, such as caddis flies and mayflies, and for algae.

Mussels are viewed as important, sensitive indicators of changing environmental conditions. Water and sediment quality are important habitat criteria for mussels. Most species of freshwater mussels prefer clean running water with high oxygen content, and all species are susceptible to pollution, including pesticides, heavy metals, ammonia, and algal toxins. Mussels can be used to document changes in water quality over long periods of time since they are long-lived. Shells accumulate metals from both water and sediment, so testing heavy metal concentrations in shells can tell researchers when water in a given area was first contaminated. The presence or absence of a particular mussel species provides information about long-term water health. Because juvenile forms of mussels are more susceptible to pollution than the adult forms, finding juveniles with few adults nearby may indicate a newly colonized area. In general, having healthy diverse populations of mussels means the water quality is good.

Mussels have never been sampled for in the Jackson Creek watershed, so their abundance and diversity within this system is unknown. Hence, it is recommended that local partners work with WDNR to conduct surveys on Jackson Creek as part of their Mussel Monitoring Program of Wisconsin.[53]

Macroinvertebrates

Macroinvertebrate analyses were conducted at four locations on Jackson Creek by the WDNR on the same dates as the fisheries samples from 2006 to 2013 as shown on Map II-5. Different types of macroinvertebrates are more tolerant of poor water pollution than others. The number and type of macroinvertebrates present in a stream can provide an indicator of water quality. Hence, multiple indices that include the Hilsenhoff Biotic Index (HBI), Family- Level Biotic Index (FBI),[54] Index of Biotic Integrity (IBI), HBI Max 10, species richness, genera richness, and percent EPT (percent of individuals or Genera comprised of Ephemeroptera, Plecoptera, and Trichoptera) were used to classify macroinvertebrate and environmental quality in Jackson Creek as shown in Table II-13. The four sites that were surveyed in 2013 on Jackson Creek ranged from very poor to good quality, but the majority of the rankings indicated a fair quality condition (see Table II-13). This ranking was supported by a moderate species richness, genera richness, and percent EPT values for individuals and genera.

Based on comparison of 2013 ratings to the ratings for the only previous sample site collected in 2006 at site number 2 (see Table II-13), in the vicinity of site 2 Jackson Creek seems to have increased in macroinvertebrate quality from poor to fair condition. Since there was only sample collected in 2006, this comparison this may or may represent an improvement throughout Jackson Creek in general. However, this does indicate that there has been an improvement in the abundance and diversity of macroinvertebrates at site 2 since 2006.[55] Wisconsin researchers have generally found that as the amount of human land disturbance increases, such as in the Jackson Creek watershed, the subsequent macroinvertebrate community diversity and abundance decreases. The results of this information indicates that although there may have been some recent improvements in the macroinvertebrate community, there is significant potential for improvement. So, continued monitoring of the macroinvertebrate community will be an important and effective tool or biological indicator to assess changes in water quality in the future, particularly as the recommendations in this plan to improve water quality are implemented.

---

[53]*Heather Kaarakka, Wisconsin Department of Natural Resources, "Several paths to build up mussels,"* Wisconsin Natural Resources Magazine*, June 2010 (*http://dnr.wi.gov/wnrmag/2010/06/mussels.htm).

[54]*William L. Hilsenhoff,* Rapid Field Assessment of Organic Pollution with Family-Level Biotic Index*, University of Wisconsin- Madison, 1988.*

[55]*M.T. Barbour, J. Gerritsen, B.D. Snyder, and J.B. Stribling,* Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish*, Second Edition, EPA 841-B-99-002, U.S. Environmental Protection Agency, Office of Water, Washington, D.C., 1999.*

POLLUTANT LOADING MODEL

As previously noted (see *TMDL Requirements* subsection), the most current pollution load and wasteload allocations and load and wasteload reduction goals for the impaired portion of Turtle Creek (Sub-Basin 80) (see Tables II-4, II-5, and II-14) were developed under the Rock River TMDL. The SWAT model developed under the TMDL study indicated that agriculture is the main contributing source of sediment and phosphorus in the Turtle Creek watershed that includes Swan Creek, Delavan Lake, Jackson Creek, and all the tributaries draining into these waterbodies. Therefore, **to be consistent with the Rock River TMDL nonpoint source load reduction requirements, load reduction goals for the Jackson Creek watershed need to meet or exceed 49 percent for total phosphorus and 25 percent for total suspended sediment requirements as shown in Table II-14.** Figure II-21c shows the estimated monthly mean daily instream loads and load reduction goals for total phosphorus and suspended sediment at the Mound Road USGS monitoring station, which is the mouth of Jackson Creek, for the period from 1993 through 2014. Based upon this data the measured total annual mean instream load for total phosphorus was 183.7 pounds per day and suspended sediment was 23.5 tons per day. Therefore, based upon the percent reduction goals, it is estimated that there will need to be an annual reduction of about 90 pounds per day of total phosphorus and 5.9 tons per day of suspended sediment in the Jackson Creek watershed.

To better refine pollutant loading and sources within the Jackson Creek watershed, a separate USEPA Spreadsheet Tool for Estimating Pollutant Load (STEPL) model was applied under this study.[56] STEPL employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various best management practices (BMPs). STEPL provides a user-friendly Visual Basic (VB) interface to create a customized spreadsheet-based model in Microsoft (MS) Excel. It computes watershed surface runoff; nutrient loads, including total nitrogen, phosphorus, and 5-day biological oxygen demand (BOD); and sediment delivery based on various land uses and management practices. For each of the six sub-basins (JC-1 through JC-6) within the watershed, the annual nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using generalized BMP efficiencies. STEPL model results for pollutant loading and load reductions are shown in Appendix B.

It is important to note that although it is likely that the pollutant loads estimated using the STEPL model overestimate the actual loads entering Jackson Creek, based on comparison to measured instream loads

[56]*Information on the STEPL model can be found on the website* http://it.tetratech-ffx.com/steplweb/.

summarized above and other modeling techniques such as SWAT,[57] STEPL is an effective tool to assess existing load allocations and potential reductions for planning purposes.

The pollutant modeling results from the STEPL analysis in this study and the modeling results from the aforementioned Rock River TMDL study both demonstrated that agricultural land is the main contributing source of pollutants in the Jackson Creek watershed. Figure II-21d shows that the highest loads of nitrogen, phosphorus, BOD and sediment would be expected to come from cropland and eroding gullies within the Jackson Creek watershed. Cropland and eroding gullies accounted for about 72 percent of total nitrogen, 86 percent of total phosphorus, 67 percent of BOD, and 97 percent of total suspended sediment annual nonpoint source loads. Thus, the majority of the targeted management measures in this plan are focused on cropland BMPs as summarized in Chapter III of this report. Pasture, feedlots, septic systems, and streambanks were also determined to contribute to pollutant loads, but these are much less significant than cropland and gully sources.

In addition, although urban nonpoint source pollutant loads only accounted for a small proportion of the existing total load, based upon the planned year 2035 levels of urban development (see Map I-6), these loads would be expected to approximately double in the absence of best management practices to reduce nonpoint source pollution loads from areas of existing and planned development.[58]. Therefore, reduction of urban nonpoint source loads is an important issue that needs to be addressed in this plan, particularly within sub-basins JC-2, JC-3, JC-4, and JC-6.

Nonpoint Source Load Capacity for Reduction

Due to the extensive data on instream daily loads of phosphorus and suspended sediment collected for numerous years in Jackson Creek, it is possible to compare these instream loads with the modeled loads for Sub-Basin 80. Such a comparison should be interpreted with caution (see below), but it would also potentially help to better understand the load reductions that could be achieved towards meeting the Sub-basin 80 Rock River TMDL load reduction goals through addressing projects within the Jackson Creek portion of this basin.

---

[57]*Outagamie County Land Conservation Department,* Nonpoint Source Implementation Plan for the Plum and Kankapot Creek Watersheds*, 2014.*

[58]*Performance standards for control of urban nonpoint source pollution from existing and new development are set forth in Chapter NR 151, "Runoff Management," of the* Wisconsin Administrative Code. *The City of Elkhorn, which has been designated as an MS4 community subject to Wisconsin Pollutant Discharge Elimination System permit requirements under Chapter NR 216, "Storm Water Discharge Permits," of the* Wisconsin Administrative Code, *is required to meet those standards. In addition, new urban development within the watershed outside of the City would also be required to meet the post-construction standards for control of nonpoint source pollution as set forth in Chapter NR 151.*

As previously noted in the "TMDL Requirements" subsection above, the load allocations for phosphorus and sediment in Sub-Basin 80 (including Jackson Creek, Delavan Lake, Swan Creek, the impaired portion of Turtle Creek, and the tributaries draining into these waterbodies) are summarized in Tables II-4 and II-5.

Figure II-22 shows a comparison of daily total phosphorus loads measured at the sampling station at Mound Road to two quantities given in or calculated from the Rock River TMDL: the daily loading capacity for total phosphorus for Sub-Basin 80 and the daily total loading capacity minus the daily wasteload allocation for the WalCoMet wastewater treatment plant. Figure II-23 shows a similar comparison for sediment loads at the same sampling station. In these figures, the loading capacity represents the mass of the pollutant that can be added to surface waters of Sub-Basin 80 (including Jackson Creek, Delavan Lake, Swan Creek, the impaired portion of Turtle Creek, and the tributaries draining into these waterbodies) and still result in concentrations in the impaired portion of Turtle Creek that will not exceed the targets set in the TMDL, based on the State's water quality criterion for total phosphorus of 0.075 mg/l. The daily total loading capacity minus the daily wasteload allocation for the WalCoMet wastewater treatment plant represents the total of the portion of the loading capacity that accounts for background loads of the pollutant along with the mass of the pollutant that can be added to surface waters of Sub-Basin 80 by nonpoint sources and sources covered under Wisconsin Pollutant Discharge Elimination System (WPDES) general discharge permits. Load allocations for nonpoint sources account for the largest fraction of this quantity.

The comparisons given in Figures II-22 and II-23 should be interpreted with caution. The TMDL Sub-Basin 80 loading capacities shown in the figure represent the daily amounts of total phosphorus and sediment which can be delivered to surface waters throughout the Sub-Basin without causing an exceedence of water quality standards. The box plots show the range of measured daily instream total phosphorus loads and sediment loads in Jackson Creek at a location that comprises approximately 15.3 percent of the total drainage area at the outlet of TMDL Sub-Basin 80 on Turtle Creek. Despite the need for cautious interpretation, the figures can give some insight regarding the availability of opportunities to meet the load reductions.

Figure II-22 shows that the daily instream loads of total phosphorus observed at the sampling station at Mount Road often exceed the total loading capacity for total phosphorus determined for Sub-Basin 80 under the TMDL study. Figure II-22 also shows that the daily instream total phosphorus loads in Jackson Creek at Mound Road are generally on the same order as the portion of the TMDL Sub-Basin 80 loading capacity that is set aside in the TMDL for background loads of total phosphorus and discharges by nonpoint sources and sources covered under WPDES general permits. In fact, depending upon the month of the year, the daily instream total phosphorus loads for Jackson Creek equal or exceed the portion of the loading capacity that is set aside in the TMDL for background loads of total phosphorus and discharges by nonpoint sources and sources covered under WPDES general permits from all of Sub-Basin 80 between about one quarter and almost one half of the time. Similarly,

Figure II-23 shows that the Jackson Creek daily instream loads of suspended sediment observed at the sampling station at Mound Road often exceed the total loading capacity for suspended sediment determined by the TMDL for Sub-Basin 80, although to a lesser degree than is the case for total phosphorus. The correspondence between the magnitudes of the instream loads at Mound Road and the portion of the loading capacity set aside in the TMDL for background loads and discharges by nonpoint sources and sources covered under WPDES general permits generally indicates that **there is ample opportunity in the Jackson Creek watershed for reducing contributions of total phosphorus and total suspended solids through the installation of BMPs. Such reductions could be used either to meet the nonpoint source loading reductions called for in the TMDL or to provide reductions in order to offset discharges from the WalCoMet wastewater treatment plant through programs such as water quality trading or adaptive management.**

WATERSHED INVENTORY RESULTS

The staffs of the U.S. Department of Agriculture (USDA) National Resources Conservation Service (NRCS), WDNR, Walworth County Land Use and Resource Management, and Kettle Moraine Land Trust (KMLT) assisted the SEWRPC staff in gathering information on livestock operations, gullies, potentially restorable wetlands, riparian buffers, and farming practices throughout the watershed. SEWRPC staff also conducted a survey on streambank erosion conditions and instream habitat conditions for the mainstem of Jackson Creek and selected tributaries from 2012 through 2014.

Current Management Practices/Projects Summary

There have been a number of conservation projects installed within the Jackson Creek watershed over the last 25 years and these projects include:

- Conservation tillage practiced on approximately 75 percent of the cropland in the watershed,
- No till practiced on approximately 10 percent of the cropland in the watershed,
- Nutrient management plans for 25 percent of the cropland in the watershed, ,
- Cover crop practices on five percent of the cropland in the watershed,
- Protection and/or establishment of 1,123 acres of riparian buffers, and
- Installation of 42,998 linear feet of grassed waterways.

As shown in Figure II-24, based on application of the USEPA STEPL model, these projects are providing significant annual pollutant load reductions to Jackson Creek, and are helping the watershed to meet approximately 35 percent and 11 percent of pollutant load reduction in Total Phosphorus (TP) and Total Suspended Sediment (TSS) goals, respectively (see Appendix B). Hence, maintenance of these practices is an important element of this plan to ensure that they are still functioning as designed. However, it is important to note that these existing practices are not enough to achieve the load reduction goals needed to meet the TMDLs for Sub-Basin 80 as summarized above. A description of current practices and proposed projects are discussed in more detail below. The proposed goals were developed over several meetings with the Jackson Creek working group including Walworth County, WDNR, and NRCS staff.

Feedlot Inventory Results

Locations of current livestock operations were compiled in consultation with local NRCS, KMLT, and Walworth County LURM staff, and from USDA 2012 agriculture census data, air photo interpretation, and windshield surveys. It was estimated that there are approximately 13 active livestock operations or feedlots with an estimated 575 dairy cattle, 67 sheep, 42 horses, nine turkeys, and eleven ducks in the Jackson Creek watershed. Onsite barnyard inventories were not conducted on any of these sites, so the exact number of animal units are unknown. However, none of these farms is a large enough operation to be classified as a permitted Concentrated Animal Feeding Operation or CAFO. Locations of the feedlots or livestock operations in the watershed are shown in Map B-1 of Appendix B.

Feedlot area estimates were made using geographic information system (GIS) data and tools and 2010 digital, color orthophotographs obtained by Walworth County under a program administered by SEWRPC for the largest sites that could be identified in the watershed. Those areas were used in the STEPL model to estimate pollution loads (Appendix B). Based upon this data, it was estimated that runoff from feedlots constitutes approximately 13.8 percent of the nitrogen, 5.4 percent of the phosphorus, 7.4 percent of the BOD, and none of the sediment load from agriculture each year as shown in Figure II-21d. Thus, feedlot runoff from livestock operations is generally not a significant source of nutrient loads in this watershed. In addition, there was no evidence of trampled streambanks or cattle observed in Jackson Creek and Walworth County staff was not aware of any significant problems associated with livestock operations within the watershed.[59] It is likely that these fairly small operations can reduce any annual loads with low cost, clear water diversions and roof gutters. Although barnyard runoff management is not a high priority in terms of nutrient loading in this watershed, it is always an important issue as long as any animal units are kept within the watershed.

Upland Inventory

Agricultural uplands were inventoried using GIS data and tools, Walworth County and NRCS information, and digital, color orthophotography. A tool developed by the WDNR called EVAAL[60] (Erosion Vulnerability Assessment for Agricultural Lands) was also used to determine priority areas for best management practices in the

[59]*Personal Communication, Brian Smetna, Walworth County LURM.*

[60]*Information on EVAAL can be found on the website* http://dnr.wi.gov/topic/nonpoint/evaal.html.

watershed. The tool estimates the vulnerability of a field to erosion and can be used to determine internally drained areas, the potential for gully erosion, and the potential for sheet and rill erosion.

Tillage Practices and Residue Management

Crop residue levels do not remain static and often a producer's crop rotation plan will dictate changes to the tillage practice at the end of a growing season. For this reason, an annual inventory of tillage conditions is not as useful as understanding the current and recent year practices as well as trends. Estimates provided by County staff and qualitative observations as shown in Figure II-25 indicate that there is a range of low to high residue practices that are being practiced within the watershed. In addition, visible signs of erosion are prominent throughout the watershed. Gullies and rills were visible on many fields. As noted above, some form of conservation tillage is practiced on approximately 75 percent of the cropland in the watershed, and no till cultivation is practiced on an additional 10 percent. No till is far more effective in reducing nutrient and sediment runoff, and the overall goal for this watershed is for farmers to change from conventional and less effective forms of conservation tillage, increasing no till practices from being applied on 10 percent of the cropland to being applied on 60 percent. Application of STEPL indicates that implementation of 60 percent no till practices within the Jackson Creek watershed could produce pollutant load reductions of 33,586 lbs. of nitrogen, 10,158 lbs. of phosphorus, 15,428 lbs. of BOD, and 1,929 tons of sediment from croplands on an annual basis (see Figure II-24).

Cover Crops

The benefits of establishing cover crops include reducing soil erosion, reducing the need for synthetic fertilizers, building organic matter in the soil, and improving local waterways. Contrary to early concerns by farmers and other conservationists, use of cover crops actually leads to increased yields not a decrease.[61] Cover crops, or plants such as winter wheat (see Figure II-25) are planted and grown before the cash crop season. According to a recent survey funded by the USDA Sustainable Agriculture Research and Education program and the American Seed Trade Association, during the 2014-15 growing season, more than 1,200 farmers found that corn yields rose on average 3.7 bushels per acre (2.1 percent) and soybean yields increased 2.2 bushels per acre (4.2 percent) when planted in fields with cover crops. This was the third year in a row where the farmers who were surveyed observed an increase in yield when cover crops were incorporated.

Cover crops are currently being used on 430 acres, or about five percent of the cropland, in the Jackson Creek watershed. Under this plan, a goal was adopted to establish cover crops on 50 percent of the cropland within the Jackson Creek watershed. The anticipated load reductions attributable to such a level of cover crop establishment are 14,995 lbs. of nitrogen, 3,543 lbs. of phosphorus, 6,231 lbs of BOD, and 974 tons of sediment from croplands

[61] *2015 Cover Crop Survey Analysis, see website: http://www.sare.org/Learning-Center/From-the-Field/North-Central-SARE-From-the-Field/2015-Cover-Crop-Survey-Analysis*

on an annual basis (See Figure II-24). In addition, such practices are expected to greatly improve overall soil health in the watershed.

Nutrient Management

Nutrient management plans are conservation plans designed to address concerns related to soil erosion, manure management, and nutrient applications. Nutrient management plans must meet the standards of the Wisconsin NRCS 590 Standard.

Based upon Walworth County LURM records, there are currently 2,151 acres, or about 25 percent of the cropland in the watershed, under a nutrient management plan. All agricultural operators in the watershed should have nutrient management plans, so the remaining 75 percent or 6,545 acres is the ultimate goal for this watershed. Implementation of nutrient management plans for all cropland within the Jackson Creek watershed is expected to provide pollutant load reductions of 8,971 lbs. of nitrogen, 3,772 lbs. of phosphorus, 7,417 lbs. of BOD, and 1,159 tons of sediment on an annual basis (see Figure II-24). It is important that the County LURM monitors to insure full and effective implementation of nutrient management plans.

Soil Health/Quality Indicators

The Phosphorus Index (PI) and soil phosphorus concentrations under nutrient management plans have been tracked by Walworth County on a limited basis. The PI is calculated by estimating average runoff phosphorus delivery from each field to the nearest surface water in a year given the field's soil conditions, crops, tillage, manure and fertilizer applications, and long term weather patterns. The higher the number the greater the likelihood that the field is contributing phosphorus to local waterbodies. Better tracking of soil test phosphorus concentration and phosphorus index (PI) in the watershed can be useful in prioritizing fields for improved management practices; however, there are many additional physical, chemical, and biological soil quality indicators available for farmers, conservationists, and soil scientists to assess and manage soil health (see Appendix E). The soil quality indicators as summarized in Appendix E directly relate soil quality with soil function, so these are more straightforward and effective parameters to assess and manage soil health than the PI. Therefore, it is recommended that farmers, conservationists, and soil scientists supplement the PI by using physical, chemical, and biological soil quality indicators to assess and manage cropland and pasture soil health within the Jackson Creek watershed. As more landowners in the watershed sign up for nutrient management plans, more soil quality indicators will be monitored and data will become available to assess and improve soil function for this watershed.

Erosion Vulnerability

Priority fields for conservation practices were evaluated using slope data (see Map I-10) and the EVAAL tool erosion score. Cropland with steep slopes is more likely to have runoff and erosion problems. Any cropland with a mean cropland slope of two percent or greater was considered a priority field for conservation practices (see

Soil Erodibility section in Chapter I of this report). More specifically, fields with slopes of 2 to 6 percent were designated as high priority, and fields with 6 percent or higher slope were considered critical.

The mean erosion score calculated using EVAAL was determined for each Common Land Unit (CLU) in the Jackson Creek watershed as shown on Map II-6,[62] which was consistent with the slope data as shown in Map I-10. The erosion score is based on stream power index, NRCS runoff curve number, precipitation data, elevation, and USLE factors C and K.[63] This tool does not predict erosion rates, but estimates the probability of a field having more erosion problems than neighboring fields. The results of this analysis indicates that, similar to historical conditions,[64] the Jackson Creek watershed continues to have a relatively high potential for sediment and nutrient loading to Delavan Lake compared to other areas within the Delavan Lake watershed. Within the Jackson Creek watershed sub-basins JC-6, JC-5, JC-2, and JC-3 (in descending order) contained the greatest proportions of high and very high erosion vulnerability scores, which corresponded to the greatest proportions of high priority and critical fields. The use of best management practices (BMPs) such as cover crops, no tillage, nutrient management plans, gully stabilization, and establishment of riparian buffers/wetland restoration practices on all priority fields will be necessary to achieve pollution load reductions. Critical fields should be kept in continuous cover and/or use a no till system. The EVAAL results shown on Map II-6 should be used to facilitate prioritization of the implementation of agricultural BMPs within the Jackson Creek watershed.

Potential Restorable Wetlands

Wetlands provide a number of benefits such as water quality improvement, wildlife habitat, and flood mitigation. According to the USEPA a typical one-acre wetland can store about one million gallons of water.[65] Restoring wetlands in the watershed area will provide water storage and reduce sediment and phosphorus loading. Establishing restored wetlands, particularly as riparian buffers (see *Riparian Corridor Conditions* subsection below), can help reduce pollution loads from tile drains, barnyards, and upland runoff, and can be implemented in areas where frequent crop damage occurs due to flooding.

---

[62]*The EVAAL Tool Erosion Scores were developed by WDNR for the Delavan Lake watershed, which includes the Jackson Creek watershed.*

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

[64]*Turtle Creek Priority Watershed Plan, 1984, op cit.; Turtle Creek Priority Watershed Plan-Amendment, 1989, op. cit.*

[65]*U.S. Environmental Protection Agency (USEPA),* Wetlands: Protecting Life and Property from Flooding*, May 2006, USEPA843-F-06-001, Website:http://water.epa.gov/type/wetlands/outreach/upload/Flooding.pdf.*

Hydric soils characteristic of wetland conditions formed under conditions where the ground was saturated with water for long enough periods of time to cause changes in the soil properties. These unique soils and growing conditions fostered a suite of plant species that thrive in wet, oxygen-deprived soil. The very few wetlands remaining in the Jackson Creek watershed are found along the main stem of the Creek. Pella silt loam, the predominant hydric soil type, is very productive when the water table is lowered. Tile systems discharging to the main stem of the Creek are extensive throughout watershed.

Under the Rock River TMDL study, each subwatershed was analyzed to identify locations of potentially restorable wetlands (PRW) using the Wisconsin Wetlands Inventory, hydric soils, and land cover data.[66] A candidate area for wetland restoration was defined as any wetland that was historically a wetland but has since been drained due to tiling and ditching or has been filled in. A wetland was considered potentially restorable if it met hydric soil criteria and was not in an urban area. The TMDL analysis estimated that there are about 2,927 acres of potentially restorable wetlands in the Delavan Lake and Jackson Creek watersheds combined. The modeled load reductions also showed that if 80 percent of the potentially restorable wetlands are restored it is estimated that sediment loads would be reduced from 58 to 85 percent of and phosphorus loads would be reduced from 46 to 68 percent in the Delavan Lake and Jackson Creek watersheds. Hence, according to the analysis, restoring wetlands could result in a significant reduction in pollutant loading, and would be a key component to address nonpoint source soil erosion.

Two metrics, "Wetland Restoration Relative Need" and "Wetland Restoration Relative Potential Opportunity," were developed under the Rock River Basin TMDL to prioritize efforts among sub-basins in implementing wetland restoration as an approach to meeting TMDL load allocations throughout the Rock River Basin. Relative Need is a landscape-scale measure of the degree to which wetland restoration in a sub-basin has the potential to make an improvement in wetland functions, such as flood storage, water quality improvement, and habitat provision. Relative Need reflects both the relative amount of wetlands lost and the prevalence of original (pre-settlement) wetlands. It is expressed as the ratio of lost wetland acres to remaining wetland acres, multiplied by the percent of the sub-basin that was originally wetland. Map II-7 shows the distribution of Relative Need across the Rock River Basin, and indicates that a large portion of the Jackson Creek watershed contains the highest relative need and some of the greatest potential to restore wetland in the entire Basin.

Using the WDNR potentially restorable wetlands GIS layer, potential wetland restoration sites in the Jackson Creek watershed were evaluated for their feasibility for restoration based on location and size. Any wetland less than five acres was considered economically infeasible and removed from consideration. Any site that was located

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

in an area of existing or ongoing development was eliminated. After these adjustments were made, there were approximately 1,929 acres of potentially restorable wetland located within the Jackson Creek watershed as shown on Map II-8. Sub-basin JC-1 contains 850 acres of PRW, which is more than twice the amount of PRW in any other sub-basin. Sub-basins JC-2 and JC-5 each contain the next highest areas of PRW with 358 acres and 315 acres, respectively. Collectively, sub-basins JC-3, JC-4, and JC-6 comprise the remaining 422 acres of PRW.

Implementing restoration of wetlands will be difficult since it involves taking agriculture land out of production. Of the 1,929 acres of PRW, restoration of approximately 1,122 acres was determined to be potentially feasible based on being located within the 1,000-foot optimal habitat buffer zone (see *Riparian Corridor Conditions* subsection below). Of the 1,122 acres about 124 acres, 463 acres, and 535 acres reside within 75-foot, 400-foot, and 1,000-foot buffer width distances, respectively, from Jackson Creek and its associated tributaries. These important riparian areas were considered a high priority to protect and restore function to reduce pollution loads and improve wildlife within this watershed.

The load reductions associated with these potential wetland restorations are shown in Figure II-26 and summarized in the *Existing and Potential Restorable Wetlands/Riparian Buffer Practices* section in Appendix B of this report. Restoring wetlands for the purpose of water storage in this watershed would mitigate flooding of agricultural land and streambank erosion. Potentially restorable wetland areas are also potential sites for constructed floodplain benches associated with a two-stage channel design to reduce pollution loads and streambank erosion and/or opportunities to modify tile drainage. Potential wetland restoration sites will have to be further evaluated prior to any planning and implementation.

Agricultural Tile Drainage

Tile outlets draining directly to Jackson Creek or its tributaries were identified as part of the stream inventory conducted between 2012 and 2014. Locations of the tiles are shown on Map B-1 in Appendix B. This information, coupled with information from NRCS and County staff, indicates it is likely that the great majority or all of the fields within this watershed contain a tile drainage system. Tile drains in fields can act as a conduit for nutrient transport to streams if not managed properly. Treating tile drainage at the outlet and better management of nutrient/manure applications on fields can reduce the amount of phosphorus reaching Jackson Creek. Some options for treating tile drainage at the outlet include constructing a floodplain bench associated with a two-stage channel design and installation of drainage water control structures to retain water in the soil column beneath fields under certain conditions.

Riparian Corridor Conditions

Healthy riparian corridors help to protect water quality, groundwater, fisheries and wildlife, and ecological resilience to invasive species, and can reduce potential flooding of structures and harmful effects of climate change.[67] The health of riparian corridors is largely dependent upon width and continuity. Therefore, efforts to protect and expand the remaining riparian corridor width and continuity are the foundation for protecting and improving the fishery, wildlife, and recreation within the Jackson Creek watershed.

The provision of buffer strips along waterways represents an important intervention that addresses anthropogenic sources of contaminants. Even relatively small buffer strips provide a degree of environmental benefit, as suggested in Table II-15 and Figure II-27 and further discussed in Appendix C.[68] The Wisconsin Buffer Initiative (WBI) further developed two key concepts that are relevant to this plan: 1) riparian buffers are very effective in protecting water resources and 2) riparian buffers need to be a part of a larger conservation system to be most effective.[69] However, it is important to note that the WBI limited its assessment and recommendations solely to the protection of water quality, and did not consider the additional values and benefits of riparian buffers. Research clearly shows that riparian buffers can have many potential benefits, such as flood mitigation, prevention of channel erosion, provision of fish and wildlife habitat, enhancement of environmental corridors, and water temperature moderation (see Appendix C). However, the nature of the benefits and the extent to which the benefits are achieved is site-specific. Consequently, the ranges in buffer width for each of the buffer functions shown in Figure II-27 are large. Buffer widths should be based on desired functions, as well as site conditions. For example, based upon a number of studies of sediment removal, buffer widths ranging from about 25 to nearly 200 feet achieved removal efficiencies of between 33 and 92 percent, depending upon local site differences such as soil type, slope, vegetation, contributing area, and influent concentrations, to name a few. Figure II-27 shows that for any particular buffer width, for example 75 feet, the buffer can provide multiple benefits, ranging from water temperature moderation to enhancement of wildlife species diversity. Benefits not shown in the figure include bank stabilization, which is an important concept in utilizing buffers for habitat protection (see Appendix C).

---

[67]*N.E. Seavy, et al., "Why Climate Change Make Riparian Restoration More Important than Ever: Recommendations for Practice and Research,"* Ecological Restoration*, Volume 27, Number 3, September, 2009, pages 330-338; "Association of State Floodplain Managers, Natural and Beneficial Floodplain Functions: Floodplain Management—More Than Flood Loss Reduction, 2008,"* www.floods.org/NewUrgent/Other.asp.

[68]*Data were drawn from A. Desbonnet, P. Pogue, V. Lee, and N. Wolff, "Vegetated Buffers in the Coastal Zone – A Summary Review and Bibliography," CRC Technical Report No. 2064. Coastal Resources Center, University of Rhode Island, 1994.*

[69]*University of Wisconsin-Madison, College of Agricultural and Life Sciences,* The Wisconsin Buffer Initiative*, December 2005.*

While it is clear from the literature that wider buffers can provide a greater range of values for aquatic systems, the need to balance human access and use with the environmental benefits to be achieved suggests that a 75-foot-wide riparian buffer provides a minimum width necessary to contribute to good water quality and a healthy aquatic ecosystem. In general, most pollutants are removed within a 75-foot buffer width. However, from an ecological point of view, 75-foot-wide buffers are inadequate for the protection and preservation of groundwater recharge or wildlife species. Riparian buffer strips greater than 75 feet in width provide significant additional physical protection of streamcourses, owing to their function in intercepting sediment and other contaminants mobilized from the land surface as a result of natural and anthropogenic activities. These wider buffers also serve to sustain groundwater recharge and discharge relationships, and biological benefit, as a result of the habitat available within the shoreland and littoral areas associated with streams and lakes.[70]

For example, the highest quality environmental corridors, natural areas, and vegetation communities are located within and adjacent to the riparian buffer network throughout the Jackson Creek watershed as shown on Map I-8. In other words, riparian buffers are a vital conservation tool that provides the connectivity among landscapes to improve the viability of wildlife populations within the habitats comprising the primary and secondary environmental corridors and isolated natural resource areas.[71]

As previously mentioned, healthy and sustained aquatic and terrestrial wildlife diversity is dependent upon adequate riparian buffer width and habitat diversity. Specifically, recent research has found that the protection of wildlife species is determined by the preservation or protection of core habitat within riparian buffers with widths ranging from a minimum of 400 feet to an optimal 900 feet or greater as summarized in Appendix C. These buffer areas are essential for supporting healthy populations of multiple groups of organisms, including birds, amphibians, mammals, reptiles, and insects and their various life stages. For example, some species of birds, amphibians, turtles, snakes, and frogs have been found to need buffer widths as great as 2,300 feet, 1,500 feet, 3,700 feet, 2,300 feet, and 1,900 feet, respectively, for at least part of their life histories. Hence, preservation of riparian buffers to widths of up to 1,000 feet or greater represents the optimal condition for the protection of wildlife in the Jackson Creek watershed.[72]

---

[70]*See, for example, Brian M. Weigel, Edward E. Emmons, Jana S. Stewart, and Roger Bannerman, " Buffer Width and Continuity for Preserving Stream Health in Agricultural Landscapes,"* Wisconsin Department of Natural Resources Research and Management Findings*, Issue 56, December 2005.*

[71]*Paul Beier and Reed F. Noss, "Do Habitat Corridors Provide Connectivity?,"* Conservation Biology*, Volume 12, Number 6, December 1998.*

[72]*The shoreland zone is defined as extending 1,000 feet from the ordinary high water mark of lakes, ponds, and flowages and 300 feet from the ordinary high water mark of navigable streams, or to the outer limit of the floodplain, whichever is greater. To be consistent with this concept and to avoid confusion, the optimum buffer*
(Footnote Continued on Next Page)

Map II-9 shows the major natural cover types both within and outside of the existing riparian buffers distributed throughout the Jackson Creek watershed. This inventory shows that the riparian buffers are comprised of a variety of wetland (emergent/wet meadow, flats, forested, and scrub/shrub) and upland (brush, grassland, upland conifer, and deciduous) vegetation communities. Each of these habitats is necessary to support the life history requirements of multiple wildlife species. For example, amphibians and reptiles have been reported to utilize numerous habitat types that include seasonal (ephemeral) wetlands, permanent wetlands (lakes, ponds, and marshes) (see Figure II-28), wet meadows, bogs, fens, small and large streams, springs and seeps, hardwood forest, coniferous forest, woodlands, savannahs, grasslands, and prairies.[73] Hence, it is this mosaic of habitats and the ability of organisms to travel between them at the correct times in their lives to survive, grow, and reproduce, which is essential to support an abundant and diverse wildlife community throughout this watershed.

The development patterns and infrastructure that humans create on the landscape lead to a number of obstructions that can limit both the availability of wildlife habitat as well as the ability for organisms to travel between habitats. These obstructions are primarily a result of roadways, railways, and buildings that fragment the natural landscape. Therefore, an effective management strategy to protect wildlife abundance and diversity in the Jackson Creek watershed would be to maximize critical linkages between habitat areas on the landscape, ensuring the ability of species to access these areas. Examples of critical linkages include the following:

- Water's edge (lake, pond, river, wetland) to terrestrial landscapes (i.e., riparian buffer width);
- Water's edge to water's edge (e.g., river to ephemeral pond, lake to ephemeral pond, permanent pond to ephemeral pond); and
- Habitat complexes or embedded habitats-Wetland to upland (e.g., seep to prairie) and upland to upland (e.g., grassland to woodland).

In addition, connecting the secondary environmental corridor (SEC) land and multiple isolated natural resource areas (INRAs) throughout the Jackson Creek watershed to the larger primary environmental corridor (PEC) areas,

(Footnote Continued from Previous Page)
width for wildlife protection is defined as extending 1,000 feet from the ordinary high water mark on both sides of the lakes, ponds, and navigable streams in the watershed.

[73]*Kingsbury, B.A. and J. Gibson (editors),* Habitat Management Guidelines for Amphibians and Reptiles of the Midwestern United States*, Partners in Amphibian and Reptile Conservation Technical Publication HMG-1. 2nd Edition, 2012, 155 pages.*

as well as building and expanding upon the existing protected lands, represent a sound approach to enhance the corridor system and wildlife areas within the watershed.

Existing and Potential Riparian Buffers

Map B-2 in Appendix B shows the current status of existing and potential riparian buffers at the 75-foot, 400-foot, and 1,000-foot widths and priority potential restorable wetland areas along Jackson Creek and its major tributary streams. Buffers on Map II-10 were primarily developed from 2010 digital orthophotographs and the 2010 WDNR Wisconsin Wetland Inventory, and from inventories of PEC, SEC, and INRA. Polygons were created using geographic information system (GIS) techniques to delineate contiguous natural lands (i.e., nonurban and nonagricultural lands) comprised of wetland, woodland, and other open lands adjacent to waterbodies. Those lands comprise a total of about 1,123 acres, or about 8 percent, of the total land area (not including water area) within the Jackson Creek watershed. As shown in Map II-10 and Figure II-29, the most extensive existing buffers were found within sub-basins JC-6 and JC-3. Those buffers comprise about 17 percent (459 acres) and 15 percent (307 acres) of the total land area in each sub-basin, respectively. In contrast, sub-basins JC-1, JC-2, and JC-4 only contain about 3.5 to 5.6 percent buffers. JC-5 contains less than two percent of buffers. Comparison between the existing buffers versus the potential buffers at the 75-foot, 400-foot, and 1,000-foot widths throughout the Jackson Creek watershed indicates that the existing buffers contain some areas whose widths exceed 1,000 feet from the edge of the stream, which indicates they are providing significant water quality and wildlife protection (see Map II-10). These extensive buffers are associated with the Lake Lawn Wetland Complex and Jackson Creek Wetland natural areas. However, a large proportion of the agricultural areas throughout the watershed show encroachments into the 75-foot and 400- foot riparian zones as shown on Map II-10. In particular, the most significant encroachments into the riparian zone among waterways within the 75-foot width are located within sub-basins JC-1 and JC-2 that are estimated to have a potential of 37.8 and 36.8 acres of potential buffers, respectively. In descending order, the remaining sub-basins contain the following potential areas within the 75-foot buffer width: JC-5 (19.2 acres), JC-4 (17.7 acres), JC-6 (9.6 acres), and JC-3 (2.6 acres). Based upon this analysis, Figure II-29 shows that there is the potential to double the amount of riparian buffers throughout the watershed, adding about 1,122 acres, for a total area of 2,245 acres, or 16.6 percent of the watershed. The analysis also shows that the greatest potential to establish buffers exists within the JC-1, JC-2, JC-4, and JC-5 sub-basins at the 75-foot, 400-foot, and 1,000-foot widths.

Riparian Buffer Protection and Prioritization Strategies

All riparian buffers provide some level of protection that is greater than if there were no buffer at all. However, wider buffers provide a greater number of functions (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 out to the 75-foot, 400-foot, and 1,000-foot widths as summarized above provides the framework upon which to protect and improve water quality and wildlife within the Jackson Creek watershed. This framework can be achieved through a combination of strategies that include land acquisition, regulation, and best management practices.

Land Acquisition

The prioritization for acquisition of these lands (including PEC, SEC, and INRA, and natural areas (NAs)) should be based upon the following order of importance (from highest to lowest priority):

1. Existing riparian buffer (protect what exists on the landscape),
2. Potential riparian buffer lands up to 75 feet wide (minimum level of protection for pollutants),
3. Potential restorable wetlands within 1,000 feet of Jackson Creek or its tributaries (see Map B-2 in Appendix B) (priority for pollutant removal and wildlife habitat protection),
4. Potential riparian buffer lands up to 400 feet wide (minimum wildlife protection), and
5. Potential riparian buffer lands up to 1,000 feet wide (optimum wildlife protection).

In addition, special consideration should be given to 1) the acquisition of riparian buffers in locations designated as having high to very high groundwater recharge potential as shown on Map I-8A in Chapter I of this report and 2) connecting and expanding critical linkages among habitat complexes to protect wildlife abundance and diversity. Furthermore, connecting the SEC land and multiple INRAs throughout the Jackson Creek watershed to the larger PEC areas, as well as building and expanding upon the existing protected lands, represents a sound approach to enhance the corridor system and wildlife areas within the watershed.

Regulatory and Other Opportunities

Chapter NR 115, "Wisconsin's Shoreland Protection Program," of the *Wisconsin Administrative Code* establishes there is a minimum 35-foot development setback running parallel to the ordinary high water mark of navigable lakes, streams, and rivers. There also is a required minimum tillage setback standard of five feet from the top of the channel of surface waters in agricultural lands called for under Section NR 151.03 of the *Wisconsin Administrative Code*. Instream field observations in the watershed and orthophotograph interpretation indicate that Jackson Creek and its tributaries on agricultural lands were meeting the five-foot tillage setback. As summarized above, not having an adequate 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 35-foot buffer requirement are adequate to achieve the pollutant load reduction goals and resource protection concerns. Therefore, a minimum goal of 75-foot buffer widths is recommended for all waterways in the Jackson Creek watershed to address pollutant reduction goals, and buffers of 1,000 feet or greater are recommended to address resource protection concerns such as flooding, water quality and quantity (groundwater recharge and maintenance of baseflow discharge), natural area and wildlife habitat and diversity, and recreation (see Map II-10).

It is important to note that crop yield losses have been found to be greatest along the edges of drainage ditches that tend to get flooded as shown in Figure II-30. Therefore adding a buffer to these areas would not be taking prime production areas out of a field. Fields with high slopes (Map I-10) and high erosion scores (Map II-6 and Figure II-25), and fields where the minimum riparian buffer width of 75 feet is not being met (Map II-10) and/or crop land is located within the one hundred year recurrence interval floodplain (Map I-2a), and fields containing potentially restorable wetlands within a 1,000 feet of a waterway (Map B-2 in Appendix B) will be considered priority fields for installation of riparian buffers. In addition, in expanded riparian buffers on cropland, the 75 feet adjacent to the waterway are envisioned to be harvestable buffers, so that farmers can periodically harvest the grasses to feed livestock. Expansion of 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. Hence, this will likely be the last chance to establish such critical protective boundaries around waterways before urban structures and roadway networks are constructed.

Primary environmental corridors (PEC) 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 protections for vulnerable existing and potential riparian buffers would be to increase the extent of primary environmental corridor designated lands within the Jackson Creek watershed. In particular, there is only one PEC in the Jackson Creek watershed, which comprises the Delavan Lake Inlet and mainstem of Jackson Creek (see Map I-7). Therefore, this PEC presents the greatest opportunity to expand primary environmental corridors. Since this area already meets 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. For example, if connections could be made between the PEC and either SEC or INRA, these might be upgraded to PEC. This has the greatest potential where tributaries intersect with the mainstem of Jackson Creek, where expansion of riparian buffer lands could be used to create connections and expand natural corridors.

Wetlands located within PEC lands have been designated as Advanced Delineation and Identification (ADID) 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 set forth in Section NR 151.125 of the Wisconsin Statutes, require establishment of 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.[74] Hence, these wetlands would have additional protections from being filled and from being encroached by future development, and, thus, retain their riparian buffer functions.

Best Management Practices and Programs for Riparian Buffers

A large portion of the existing and potential riparian buffers are privately owned within urban and agricultural areas of the watershed. It is the private landowner's choice to establish a buffer. In addition, although riparian buffers can be effective in mitigating the negative water quality effects attributed to urbanization and agricultural management practices, they cannot on their own address all of 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, green roofs, and rain gardens to mitigate the effects of urban stormwater runoff. In addition, riparian buffers need to be combined with other management practices, such as barnyard runoff controls, manure storage, contour plowing, constructing grassed waterways, and reduced tillage, to mitigate the effects of agricultural runoff. Therefore, the recommended best management practices to improve and protect water quality in both urban and agricultural areas are essential elements for the protection of water quality and quantity and wildlife within the Jackson Creek watershed.

Recent research has indicated that converting up to eight percent of cropland at the field edge from production to create wildlife buffer habitat leads to increased yields in the cropped areas of the fields, and this positive effect became more pronounced with time.[75] As a consequence, despite the initial loss of cropland for habitat creation, overall yields for the entire field were maintained and even increased for some crops compared to the control areas. Although it took about four years for the beneficial effects on crop yield to manifest themselves in this research project, this increase in yields was largely attributed to an 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, establishment of buffers or sacrificing marginal cropland edges to create wildlife buffer habitat or potential restorable wetland within the Jackson Creek watershed may actually lead to increased crop yields, so this practice may be economically feasible over the long-term for farmers and rented farmland. More importantly, these results also demonstrate that lower yielding field edges within Jackson Creek such as the one shown in Figure II-30 can be better used as non-crop

[74]*Runoff from impervious surfaces located within the protective area must be adequately treated with stormwater best management practices.*

[75]*Richard Pywell et. al. 2015.*

habitats to provide services supporting enhanced crop production, benefits for farmland biodiversity, and protection of water and soil health.[76]

In Wisconsin, the USDA offers technical assistance and funding to support installation of riparian buffers and wetlands on agricultural lands. A 14- to 15-year contract must be entered into by the landowner or operator and the land is only eligible under certain conditions, but normally must be recently in agricultural production or use. Because the program requires a lengthy contract 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 that offers 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 should be developed for the Jackson Creek watershed.

Gully and Concentrated Flow Stabilization

GIS data along with digital, color orthophotographs and information from the Walworth County staff were used to estimate the location and extent of gullies and concentrated flow in fields in the Jackson Creek watershed. A total of about 271,392 linear feet or 51.4 miles of potential gullies/concentrated flow areas were identified as shown in Map B-1 in Appendix B. Those gullies were estimated to produce about 21 percent of the annual nitrogen load, 33 percent of the annual phosphorus load, 23 percent of the annual BOD load, and 80 percent of the annual sediment load in the Jackson Creek watershed as shown in Figure II-21d (see Map B-1 in Appendix B for more details). Sub-basins JC-1, JC-2, JC-5, and JC-6 contain the greatest lengths of gullies. The locations of the gullies and concentrated flow areas corresponded well with the high and very high erosion vulnerability EVAAL scores shown on Map II-6.

Approximately 42,998 linear feet (8.1 miles) of grassed waterways have been installed, and an additional 49,478 linear feet (9.4 miles) are proposed to be installed, in the high priority sites as shown in Map B-1 in Appendix B. The existing and potential load reductions associated with the installed and proposed grassed waterway projects among sub-basins are shown in Figure II-31. It is also important to note that it may be possible to stabilize concentrated flow areas while still promoting productive agricultural practices if the concentrated flow areas are seeded with permanent cover crops and no-till practices are followed.

Stream Conditions

SEWRPC staff conducted field inventories from April 2012 through November 2013 to quantitatively and qualitatively characterize the physical characteristics of streams within the Jackson Creek watershed. Both quantitative and qualitative measures were largely based upon the WDNR Baseline Monitoring protocols for

---

[76] *Richard Pywell et. al. 2015.*

instream fisheries habitat assessment.[77] A total of 109 cross sections surveys were obtained throughout the watershed and the number of transects ranged from 11 to 16 per mile, depending on the reach sampled (see Maps F-1 through F-5 in Appendix F). An additional 69 and 35 maximum water depths were recorded in pool and riffle habitats, respectively, to assess habitat number and quality in order to supplement information between cross sections where the full complement of data was collected. Physical characteristics measured and/or noted included water and sediment depth, low flow and bankfull channel width and depth, substrate composition, undercut bank, bank slopes, bank erosion, and floodplain connectivity, where appropriate. The remaining cover, or cover-related, parameters that include overhanging vegetation, woody debris, macrophytes, algae, and shading were each qualitatively estimated as none, low, moderate, and high abundances to assess overall habitat cover quality.[78] Locations of trash and other debris in or adjacent to the stream channel were also mapped. Finally, a fish passage and navigational hazard assessment was conducted for the mainstem of Jackson Creek.

Streambank Erosion

The WDNR 24K Hydrography data set supplemented with two-foot contour interval land surface elevation data were used to determine the location of streams in the watershed area. There are more than 17 miles of perennial and intermittent streams in the Jackson Creek watershed. Streambank erosion was inventoried by walking the streams with a handheld GPS device. Information on soil type, height, length, and bank slope were collected and photos were taken. Lateral recession rate was determined using criteria in Table II-16 and soil density was determined by soil type using NRCS Technical Guidance.[79] The lowest density value for the soil types and the lowest value for lateral recession were used for all calculations as summarized in Appendix B. Approximately six miles of the mainstem and three miles of the tributaries of Jackson Creek were inventoried. Most of the streambanks within the areas surveyed are in fair to good condition. However, of the nine miles inventoried about 1.1 miles, or 5,872 linear feet, of stream were actively eroding as shown in Map II-11. More specifically, about 40 percent of the erosion sites or 2,365 linear feet were considered to have slight lateral recession rates, 21 percent (1,242 linear feet) moderate lateral recession, and 39 percent (2,265 linear feet) severe lateral recession.

---

[77] *WDNR, Guidelines for Evaluating Habitat of Wadable Streams, Bureau of Fisheries Management and Habitat Protection, Monitoring and Data Assessment Section, Revised June 2000; Timothy Simonson, John Lyons, and Paul Kanehl, "Guidelines for Evaluating Fish Habitat in Wisconsin Streams,"* General Technical Report NC-164*, 1995; and Lihzu Wang, John Lyons, and Paul Kanehl, "Development and Evaluation of a Habitat Rating System for Low-Gradient Wisconsin Streams,"* North American Journal of Fisheries Management*, Volume 18, pages 775-785, 1998.*

[78] *Edward T. Rankin, The Quality Habitat Evaluation Index [QHEI]: Rationale, Methods, and Application, State of Ohio Environmental Protection Agency, November 1989.*

[79] *Natural Resources Conservation Services (NRCS), Streambank Erosion. Field Office Technical Guide, November 2003, Retrieved from: efotg.nrcs.usda.gov/references/public/WI/StreambankErosion.doc*

Sediment loss calculations for inventoried sites were determined using STEPL and are shown in Appendix B. Soil eroded from streambanks was estimated to account for about 0.1 percent of the annual nitrogen load, 0.2 percent of the annual phosphorus load, 0.1 percent of the annual BOD load, and 0.5 percent of the annual sediment load in the Jackson Creek watershed as shown in Figure II-21d. As shown on Map II-11 sub-basin JC-3, primarily downstream of STH 67, and sub-basins JC-1 and JC-2 between USH 12 and CTH H contained the greatest proportions of the severe (Sites 1-11, and 23) and moderate (Sites 18-22 and 24-37) erosion sites within the Jackson Creek watershed. Although the inventory data indicates that streambank erosion is not a significant source of nonpoint source pollution in this watershed when compared to pollutant loads from cropland and gullies, this sediment load is directly contributing to the degradation of instream fisheries habitat and pollutant loads into Jackson Creek. Therefore, the erosion sites containing the severe and moderate lateral recession rates are a high priority for restoration.

The locations of the majority of the worst eroding sites as shown on Map II-11 correspond well with the channelized reaches combined with low floodplain connectivity (i.e., disconnected or partially connected) areas (see Figure II-32). In contrast, the most stable reach in this watershed is within sub-basin JC-3 between STH 67 and CTH H within the Kettle Moraine Jackson Creek Preserve area, which contains a highly meandering stream channel and well-connected floodplain that functions to dissipate erosive water velocities during high flow conditions (see Figure II-32). In other words, the erosion is an artifact of the channelization which increases channel slope and decreases floodplain connectivity, creating the conditions for streambank erosion that will continue without intervention. Intervention in this case can range from remeandering the stream to its historic condition to two-stage channel design construction to slope stabilization with bioengineering and/or selective hard armoring with riprap stone, where appropriate (see *Stream Restoration* section below and Chapter III for more details). However, it is also important to note that increased tile and ditch drainage as well as urbanization are contributing to excess runoff to the streams. Thus, best management practices that involve slowing the flow of water to the stream will be needed. Such practices include wetland restorations/riparian buffers, grassed waterways, and stormwater and green infrastructure BMPs in the urbanizing areas.

There are 12 severe and 19 moderate priority erosion sites that have been identified as potentially feasible sites for restoration (see Map II-11 and Map B-3 in Appendix B). To the extent practicable, the severe erosion sites should take priority over the moderate sites. All of these priority erosion sites are located on private lands, so coordination with a willing landowner will be necessary for cost share, design, permitting, and equipment access.

Livestock can cause significant degradation to streams if not managed properly, but there was no sign of degradation due to livestock access among stream reaches within the areas surveyed. It is important to continue to limit livestock access to the stream to protect Jackson Creek from excessive erosion and nutrient loading.

Slope and Sinuosity

Stream characteristics, such as slope, length, and sinuosity are determined by a combination of geological history (i.e., glaciation) and human intervention (i.e., lake impoundments and channelization). Based upon this information, it was determined that there were four distinct stream reaches in the Jackson Creek as set forth on Map II-1 and Table II-17. In addition, several of the major tributaries to Jackson Creek, including unnamed Tributaries A through E were also assessed as part of this project (see Map II-1). The extent of the physical data collected within Jackson Creek and other reaches within this watershed as part of this study is shown in Appendix F.

The longitudinal slope of a channel is the ratio of elevation change between two points on the channel bed to the length of the channel between the same two points. Slope is an indicator of stream energy or power. The lower the slope, the lower the energy, and the slower the water flows. Stream slopes within mountainous stream systems are typically greater than 10 percent. However, slopes within the Jackson Creek and tributary reaches are more indicative of lowland streams found in Southeastern Wisconsin and generally do not exceed 0.5 percent, as shown in Table II-17. In general, the mainstem reaches contain much lower slopes than the tributaries, but all stream reaches contain fairly gentle slopes ranging from about 0.13 to 0.93 percent. It is important to note that the higher-sloped reaches (i.e. greater than 0.5 percent), particularly tributaries C, D, and E are an artifact of channelization that shortened stream lengths.

Healthy streams naturally meander or migrate across a landscape over time. Sinuosity is a measure of how much a stream meanders. It is defined as the ratio of channel length between two points on a channel to the straight-line distance between the same two points. Sinuosity or channel pattern can range from straight to a winding pattern, or meandering. Channelized sections of streams that have been straightened typically have low sinuosity or a number closer to one. Stream reaches within the Jackson Creek have sinuosities that range from 1.10 to 1.47 in 2010 as shown in Table II-17, and include both channelized and nonchannelized segments.

Comparison of the historic 1941 versus 2010 stream alignments as shown on Map II-12 shows that this system was generally somewhat more sinuous prior to 1941 (see Table II-17). The actual distance of stream channel lost from the pre-settlement period is likely significantly greater, but because of a lack of aerial photography prior to 1941, it is unknown where the original stream channel was located. Examination of the 1941 aerial photographs indicates that large sections of the streams within the watershed had already been straightened to facilitate the intense agricultural use of the land. Most of the remaining channelization that occurred after 1941 was to accommodate the construction of highways and local roads.

Straightening meandering stream channels or "channelization" was once a widely used and accepted technique in agricultural management. The U.S. Department of Agriculture NRCS (formerly Soil Conservation Service) cost shared such activities up to the early 1970s within southeastern Wisconsin.[80] The objectives of channelization were to reduce floods on lands adjacent to the channelized reaches by conveying stormwater runoff more rapidly, to facilitate drainage of low-lying agricultural land, and to allow more efficient farming in rectangular fields. In many cases channelization was accompanied with the installation of drain tiles within the farm fields to better facilitate water movement off the field and to lower groundwater levels. Numerous tiles were observed throughout the mainstem and tributaries of Jackson Creek, and their locations and distributions are shown in Maps F-1 though F-5 in Appendix F. Through channelization and installation of drain tiles, farmers attempted to protect their crops by lowering the groundwater table and increasing the capacity to convey water downstream. Channelization can lead to instream hydraulic changes that can decrease or interfere with the connection between the channel and overbank areas during floods. This may result in reduced filtering of nonpoint source pollutants by riparian area vegetation and soils and increased erosion of the banks. Channelization can also lead to increased water temperature, due to the loss of riparian vegetation, and it can alter instream sedimentation rates and paths of sediment erosion, transport, and deposition. For example, the most heavily channelized sections of stream assessed under this study, particularly Reaches 1, 2, and 4, contained some of the greatest amounts of streambank erosion. In addition to the loss of stream length, channel straightening causes a major decrease in the number of pool and riffle structures within the stream system. Pool-riffle sequences are often found in meandering streams, where pools occur at meander bends and riffles at crossover stretches.[81] Therefore, channelization activities, as traditionally accomplished without mitigating features, generally lead to a diminished suitability of instream and riparian habitat for fish and wildlife, which was also observed in reaches of Jackson Creek and its tributaries that were channelized where there is a lack of riffle habitat (see Map II-13).

Streams are transport systems for water and sediment and are continually eroding and depositing sediments, which causes the stream to migrate. When the amount of sediment load entering a stream is equal to what is being transported downstream—and stream widths, depths, and length remain consistent over time—it is common to refer to that stream as being in a state of “dynamic equilibrium.” In other words, the stream retains its physical dimensions (equilibrium), but those physical features are shifted, or migrate, over time (dynamic). For example, it is not uncommon for a low-gradient stream in Southeastern Wisconsin to migrate more than one foot within a single year. Reaches in the Jackson Creek watershed that were not channelized, particularly Reach 3, still exhibit healthy meanders that have migrated only slightly over the nearly 70 years between 1941 and 2010 as shown on Map II-12 (see Inset 2). This reach also contains the highest quality habitat in the entire watershed (see *Habitat Quality* subsection below).

---

[80]*Personal Communication, Gene Nimmer, NRCS engineer.*

[81]*N.D. Gordon, et al.,* Stream Hydrology*, John Wiley and Sons, April 1993, page 318.*

These observations, combined with onsite survey data and known sediment loads generally indicate that the channelized reaches of Jackson Creek have unstable streambed and streambanks, and are not in a state of dynamic equilibrium. However, it is important to note that this instability is largely related to the channelization and floodplain connectivity. The Jackson Creek system is partially-connected or disconnected from its floodplain in several areas of the watershed, particularly within Reach 1, which is about 21 percent disconnected; Reach 2 which is about 19 percent disconnected; and the entire length of Reach 4, which is partially disconnected (see Map II-11). In contrast, Reach 3 is well-connected to the floodplain. Floodplain connectivity can be defined in several ways such as the bank height ratio, entrenchment ratio, or stage/discharge relationships. A good connection between Jackson Creek and its floodplain is critical in helping to protect the streambed and streambanks by allowing flood flows to dissipate into the floodplain and reducing water velocities that would cause erosion, while at the same time allowing sediments and other pollutants to be deposited into the floodplain. In addition, in reaches with an extensive floodplain and/or riparian buffer the River system naturally makes adjustments to changes in discharge and sediment loads. It is also important to note that the extent of meandering increases with the area tributary to the stream reach, so as tributary area increases, so does the width of the meander belt (see Appendix C).

Stream Reach Dynamics

There is a general increase in stream wetted widths as well as mean and maximum water depths in Jackson Creek from upstream to downstream among Reaches 1 through 4 as shown in Figure II-33 and Map II-14. These measurements were obtained for approximate low flow conditions for this system during a period of prolonged dry weather. A low flow is a seasonal phenomenon that usually occurs in summer and is an important component of the flow regime regarding the ability of a river or stream to support adequate water quality and health of the aquatic community. Figure II-33 shows increases in the highest measured width from about 11 feet in Reach 1 to 25 feet in Reach 3 to more than 40 feet in the most downstream Reach 4 where there is a backwater effect from the series of ponds just upstream of Mound Road. The figure also shows that depths range from zero to more than two feet. Water depths of zero were recorded in Reach 1 and the upper portion of Reach 2, because these are intermittent streams and there was no discharge in these areas at the time of the measurements.

There is an important difference between low flow versus bankfull channel conditions. Low flow, commonly referred to as low-water discharge, and sustained, or fair weather, runoff are not determinants of overall streambed and streambank channel shape and form. In contrast, the bankfull discharge is considered to be the channel-forming or effective discharge.[82] It is also defined by the discharge that occurs when water just begins to leave the channel and spread onto the floodplain. The quantity and movement of both water and sediment is what

[82]*Leopold, L. B. (1994). A view of the river. Cambridge: Harvard University Press.*

determines channel dimension and shape, and effective discharge is the amount of water (volume per unit time) that transports the most sediment over the long term for any given stream system (see Appendix G for more details). Therefore, bankfull channel dimensions are important characteristics of stream power or channel forming discharge, which represents the highest water velocities and ability to transport sediments. The effective discharge typically occurs only a few times annually and is generally defined as the 1.5-year recurrence interval flow event.[83]

As shown in Figure II-34 the channel forming discharge or bankfull channel dimensions increase among reaches from upstream (Reach 1) to downstream (Reach 4) as the drainage area increases. Mean bankfull channel width and depth conditions show an increase from about 10 to 18 feet in width and 1.5 to 2.5 feet in depth. Based upon the stream gauge and modeled data it is estimated that the bankfull discharges in Jackson Creek are about 91 cubic feet per second (cfs) in Reaches 1 and 2, 200 cfs in Reach 3, and 218 cfs in Reach 4 (upstream of the Mound Road detention basins).[84]

Based upon the channel slope and depths of flow, Reach 1 was estimated to be able to transport sediment sizes up to very course sand (1.0 to 2.0 millimeters in diameter). Hence, this reach can easily transport all substrate particles equal to very course sand and smaller, which includes course to very fine sands, course to very fine silts, and coarse to very fine clays. This is consistent with observations that this reach was dominated by hard claypan with pockets of gravel and cobble substrates. A claypan is a dense, compact, slowly permeable layer in the subsoil having a much higher clay content than the overlying material. Claypans are usually hard when dry, and plastic and sticky when wet and limit or slow the downward movement of water through the soil. The organic silts and fine sands do not accumulate in this reach, because they are easily transported downstream.

Reach 2 was estimated to be able to transport sediment sizes up to fine gravels (4.0 to 8.0 millimeters in diameter), which are slightly larger particles than can be transported in Reach 1. This reach was similar to Reach 1 and was dominated by claypan and pockets of cobble substrates. However, this reach also contained greater amounts of organic silt substrates, which was due to a greater proportion of deeper pool habitats as well as beaver dams where these sediments can accumulate.

---

[83]*V.T. Chow,* Open-Channel Hydraulics*, McGraw Hill, New York, 1988.*

[84]*This discharge data was calculated for these reaches using flow data recorded at the Mound Road station from 1994 through 2009. Note computed flows at the Mound Road gage were 139 cubic feet per second (cfs), 588 cfs, 960 cfs, and 1,233 cfs for the 1.1-year, 2.0-year, 5-year, and 10-year recurrence interval floods, respectively.*

In comparison, Reaches 3 and 4 were estimated to be able to transport the largest sediment sizes up to medium gravels (8.0 to 16.0 millimeters in diameter). The riffle habitat located within Reach 4 as shown in Figure II-35 demonstrates that the particle diameter sizes on the channel bed are significantly larger than the medium sized gravels, because these substrates are more stable and less easily transported than the smaller medium sized gravels being carried downstream. However, due to the more natural sinuosities of these reaches, they also contain the greatest diversity and mixture of clay, silt, sand, cobble, and boulder substrates and instream habitats (see *Habitat Quality* subsection below). Silt and unconsolidated sediments are greatest in the upstream areas of Reach 3 associated with a low gradient-wetland complex and active beaver dams. As described above, it is very normal for low gradient streams to flow through wetlands and contain a high proportion of soft organic substrates and sometimes poorly defined channels. Hence, it is expected that these areas would be dominated by soft organic substrates, and the beaver dam impoundments facilitate deposition of silts and unconsolidated sediments in this area. Silt and unconsolidated sediments also dominate in the lower downstream portions of Reach 4 where the backwater conditions created by the Mound Road detention basins slow water velocities and facilitate deposition of these finer substrates within the channel and within the detention basins, which was the objective of constructing these detention basins (see the *Effects of the Mound Road Constructed Wetland Detention Basins* subsection above for more details).

The bankfull channel dimensions and associated discharge is critically important when considering potential projects to restore eroded streambanks and for fisheries habitat within Jackson Creek. If a newly reconstructed stream channel is improperly sized it could lead to excessive erosion to the channel bed or banks (i.e., too narrow or shallow) or aggradation (i.e., too deep or wide). Therefore, it is very important that any stream restoration within Jackson Creek incorporate appropriate bankfull channel dimensions as one of the design parameters along with the associated geomorphological parameters such as slope; sinuosity; belt width; radius of curvature of the bends; substrate sizes; and low flow pool, riffle, and run habitat dimensions (see *Stream Functions Pyramid - A Tool for Assessing Success of Stream Restoration Projects* subsection below). Reach 3, the Kettle Moraine Jackson Creek Preserve reach, can be used as a reference reach for stream restoration design parameters and goals within the mainstem of Jackson Creek. However, it is important to note the channel forming discharge of bankfull channel dimension can change, particularly as a watershed becomes more urbanized. Greater urbanization is associated with greater amounts of impervious surfaces, which increases runoff that can lead to increases in discharge and stream power causing the stream to increase in size (erode its streambed or streambanks) in response. Thus, monitoring bankfull channel conditions over time is also a good way to track the health of the stream in terms of its ability to maintain its dimensions and/or whether or not it is in equilibrium with the adjacent land uses and management practices within the watershed.

Habitat Quality

Jackson Creek is a low-gradient stream system, which is characterized by a gradient of about 0.005 feet/feet or lower. High quality, low gradient streams tend to lack riffles and have relatively slow currents, small substrate particle sizes, and well developed meandering (i.e., high sinuosity) channel morphology. Such systems often flow through wetlands and may have very soft, unconsolidated (i.e., organic) substrates and poorly defined channels in some cases. Such characteristics have made low-gradient streams candidates for channelization for agricultural development along with installation of tiles to improve drainage, which is what has occurred to a large extent in the Jackson Creek system.

Despite the extensive channelization that has occurred in this watershed, the amount, quality, and diversity of available instream fisheries habitat ranges from fair to excellent based upon results of the low gradient stream habitat index (Table II-18). As shown in Table II-18 this index incorporates several habitat variables that are well established as strongly influencing fish communities and biotic integrity.[85] Those habitat variables include channelization percent and age, instream cover, bank erosion, sinuosity, standard deviation of thalweg depth, and buffer vegetation.

Reach 3 contains the highest quality habitat (excellent) rating compared to all the other reaches in the watershed for each of the habitat variables. Not surprisingly, this is also associated with the highest quality fishery observations in the watershed as well. Reach 4 contains the next highest quality ratings ranging from fair to excellent, which is a reflection that this reach contains lower quality habitat in the downstream portions and higher quality habitat in the upper portions (generally upstream of the private drive culvert crossing). The lower portions of Reach 4 were more highly channelized prior to 1941 and, more recently, in the early 1990s to construct the Mound Road detention ponds. Streams can recover from past channelization, which is why the criteria of channelization age is included in the habitat quality rating (i.e., more years post channelization is associated with a higher quality score). However, research has shown that there are limits to the ability of streams to recover from past channelization, particularly in low gradient streams. For example, despite channelization that has occurred 20 or more years ago in the lower portions of Reach 4, this lower portion contains much poorer habitat diversity in terms of instream cover, substrates, habitat types, and increased erosion compared to the upper portions of this reach that were not channelized (see *Streambank Erosion* subsection for more details). However, Reach 4, much like Reach 3, has retained an excellent overall quality of instream thalweg depth diversity and excellent quality protective riparian buffers as well as the best instream cover compared to all other stream reaches within the watershed. Figure II-35 shows a good example of typical instream cover variables that includes

[85] *Lihzu Wang, John Lyons, and Paul Kanehl, "Development and Evaluation of a Habitat Rating System for Low-Gradient Wisconsin Streams,"* North American Journal of Fisheries Management*, Volume 18, pages 775-785, 1998.*

submergent and emergent macrophytes (i.e., vegetation), overhanging vegetation, boulders, and woody debris. It is important to note that in general there is an overall lack of instream woody debris not only in Reaches 3 and 4, but in the entire stream system, probably due to the limited forested canopy adjacent to the mainstem and tributaries throughout the watershed.

In contrast, past channelization combined with limited riparian buffer protection have occurred to a much greater degree in Reaches 1 and 2 of Jackson Creek than in the other mainstem reaches, and the habitat quality of Reaches 1 and 2 ranged from poor to good, but was overall dominated by a fair quality rating. Reach 2 has a good diversity of thalweg depth compared to Reach 1. This is also consistent with a greater degree of instream substrate diversity and pool and riffle habitats and associated water depths in Reach 2 compared to Reach 1 (see Maps II-13 and 14). However, both these reaches suffer from a general lack of instream cover and moderate to low levels of streambank erosion.

Similar to mainstem Reaches 1 and 2, tributary reaches A through E have also been significantly modified due to channelization and they contain limited riparian buffer protection. These tributaries generally have poor to fair habitat quality, with the exception of reaches C and D that have developed a good diversity of thalweg depth compared to the other tributaries. Streambank erosion was not a severe problem in the tributaries that were assessed.

It is important to note that the lowest habitat scores in all cases were associated with the modified sections of streams that were highly channelized. Although the streams continue to recover from past channelization, it is clear that the channelized segments limit habitat quality within Jackson Creek and will not likely recover on their own without more intensive intervention. Hence, these channelized areas provide the greatest potential for instream habitat recovery within the Jackson Creek watershed. In addition, Jackson Creek has a high potential for recovery for two key reasons. First, this riverine system contains good quality source populations of macroinvertebrate and fishery assemblages. Therefore, creation or rehabilitation of habitats are likely to lead to increased abundance and distribution of these key ecological indicators. Second, there are several opportunities to restore some of the most degraded reaches in this system to their original, or near original, channel configuration to reduce streambank erosion, flooding, and high water pollutant loads and to improve fisheries habitat. In addition, remeandering can also help restore hyporheic (i.e., under) flow, which is the subsurface area beneath and alongside a streambed where there is mixing of shallow groundwater and surface water. The flow dynamics and behavior in this zone are recognized to be important for surface water/groundwater interactions to improve water quality (reduce instream water temperatures and improve dissolved oxygen), potentially attenuate contaminants,[86] and promote fish spawning. Map II-15 shows an example of the relationship between the historical 1941 stream alignments that used to flow through the historical Wet Alluvium land versus the existing ditched stream that was constructed through a different hydrologic soil group Pella Silt Loam. Map II-15 combined with onsite observations demonstrates the differences in these hydrologic soil groups and shows the differences in the hyporheic alluvium. Therefore, returning this stream to its original channel would restore instream habitat and floodplain connectivity and reduce streambank erosion, but it would also restore the connection of the surface water in this channel to the relict alluvium to restore hyporheic flows.

Trash and Debris
Although the accumulation of trash and debris is not part of the habitat scores as summarized above, these materials degrade the aesthetics of the stream system and can cause physical and/or chemical (i.e., toxic) damage to aquatic and terrestrial wildlife. Therefore, Commission staff recorded and mapped the significant trash and debris that was encountered during the comprehensive survey conducted in the spring of 2012 and summer of 2013 (specific details in Appendix F, Maps F-1 through F-5). There was a very limited amount of trash or debris observed within Jackson Creek or its tributaries.

However, it is important to note that there appeared to be very poor water quality (i.e. high turbidity with white chalky color and no observable macroinvertebrates within the creek) within the upper areas of Tributary E between the detention pond and the Walworth County Public Works building as shown in Figure II-35a. This reach is directly downstream from the Public Works building, which includes a large parking lot where equipment is stored as well as a salt storage facility, which appears to drain directly into Tributary E. Therefore, it is recommended that this facility and parking lot be inspected to ensure that they are not discharging or draining excessive sediments or other contaminants into Tributary E, which flows into Jackson Creek.

Stream Crossings and Dams
Bridges and culverts can affect stream widths, water and sediment depths, velocities, and substrates. These structures also have the potential to pose physical and/or hydrologic barriers to fisheries and other aquatic organisms. Therefore, SEWRPC staff conducted an inventory of 12 structures on the mainstem of Jackson Creek, describing structure condition and assigning a fish passage rating as summarized in Table II-19 and the photos in Figure II-36. The majority of the structures were identified to be passable, but two structures were considered barriers to passage. These structures are also considered navigation hazards.

---

[86]*Justin E. Lawrence et. al., "Hyporheic Zone in Urban Streams: A Review and Opportunities for Enhancing Water Quality and Improving Aquatic Habitat by Active Management," Environmental Engineering Science, Volume 30(8): 480-501, August 2013.*

Structure No. 2 at River Mile (RM) 3.1 was rated as a partial barrier to fish passage and Structure No. 1 at RM 1.9 was considered to be a complete barrier. Structure No. 2 is only considered to be limiting fish passage under low-flow conditions, due to inadequate water depths at this private crossing (see Figure II-37). However, due to the small 12-inch diameters of the three culvert pipes at this location, it may also be limiting or partially limiting to fish passage at higher flows from excessive water velocities. Structure No. 1 is a sheet pile USGS gauging weir structure at the upstream side of the Mound Road crossing that is acting like a low-head dam and is considered a complete barrier to fish passage for native species and other wildlife. As shown in Figure II-37, this structure impounds water just like a dam. During both low and high flow conditions there is drop in water elevation across the structure, so it is essentially a complete barrier for upstream migration to native fishes at all discharges except for any extreme flow events where the weir is totally submerged and there would be no elevation difference in the water elevation upstream versus downstream of this structure. Although common carp (*Cyprinus carpio*) have been observed jumping this barrier, this invasive nonnative species is an active swimmer that can leap obstacles up to three feet high and negotiate torrential flows.[87] This mobility enhances the risk of further spread into areas currently uninhabited by common carp.[88] Unlike common carp, native fish species have limited swimming and jumping abilities, which makes this low-head dam a significant barrier.[89]

Although there are only two barriers to fish passage along the streams inventoried within the Jackson Creek watershed, their combined impact on fish communities could potentially be significant. This is particularly true of the weir/low-head dam, which significantly limits the ability to move between Delevan Lake and Jackson Creek.[90] For example, northern pike, a highly sought gamefish species, has limited leaping and swimming abilities and is likely not able to traverse this structure.[91]

---

[87]*FishBase 2003; and, Merrick, J.R. and G.E. Schmida, 1984. Australian freshwater fishes: biology and management. Griffin Press Ltd., South Australia. 409 p. DOI http://dx.doi.org/*

[88]*Koehn, John D., "Carp (Cyprinus carpio) as a powerful invader in Australian waterways", Freshwater Biology, 49(7), 882-894, July 2004.*

[89]*A. D. Ficke, C. A. Myrick, and N. Jud, "The Swimming and Jumping Ability of Three Small Great Plains Fishes: Implications for Fishway Design", Transactions of the American Fisheries Society, 140:1521–1531, 2011.*

[90]*M. W. Diebel, M. Fedora, S. Cogswell, and J. R. O'hanley, "Effects Of Road Crossings On Habitat Connectivity For Stream-Resident Fish, River Research And Applications", Published online in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/rra.2822, Copyright © John Wiley & Sons, Ltd., 2014.*

[91]*Will Wawrzyn, WDNR,* A Management Plan for Restoring a Sustainable Population of Northern Pike in the Milwaukee Estuary Area of Concern (AOC)*, 2009; Luther Aadland, Minnesota DNR,* Reconnecting Rivers: Natural Channel Design in Dam Removal and Fish Passage*, January 2010.*

The private drive culvert is also a major concern, since it separates the deeper water habitats in the downstream reaches from shallower habitats in the upstream reaches of Jackson Creek. Culverts tend to have a destabilizing influence on stream morphology and can create selective barriers to fish migration because swimming abilities vary substantially among species and size-classes of fish, affecting their ability to traverse the altered hydrologic regime within the culverts.[92] Fish of all ages require freedom of movement to fulfill needs for feeding, growth, and spawning. Such needs generally cannot be found in only one particular area of a stream system. These movements may be upstream or downstream and occur over an extended period of time, especially in regard to feeding. In addition, before winter freeze-up, fish tend to move downstream to deeper pools for overwintering. Fry and juvenile fish also require access up and down the stream system while seeking rearing habitat for feeding and protection from predators. The recognition that fish populations are often adversely affected by culverts has resulted in numerous designs and guidelines that have been developed to allow for better fish passage and to help ensure a healthy sustainable fisheries community.[93]

Therefore, it is recommended that both these structures be retrofitted or removed to improve passage. It may be possible to retrofit the USGS weir at Mound Road (Structure No. 1, RM 1.9) by increasing the notch opening to improve passage, however, this opening should also allow for safe navigation for kayaks and canoes. Hence, it may be more feasible to remove this sheet piling weir and reconstruct with riprap stone to allow for fish passage under all discharges as well as allow safe navigation for kayaks and canoes (e.g., see Figure II-38). If such modifications were made, the USGS streamflow gauging operation would have to be reconfigured to enable a stable elevation-discharge relationship to be established. The three private drive culverts comprising Structure No. 2 (RM 3.1) are recommended to be removed or replaced with a more appropriate structure such as an open bottom bridge crossing or single adequately sized culvert.[94] However, if the private landowner is willing, there is a

[92]*Stream Enhancement Research Committee, "Stream Enhancement Guide," Province of British of Columbia and the British Columbia Ministry of Environment, Vancouver, 1980.; and, Thomas M. Slawski and Timothy J. Ehlinger, "Fish Habitat Improvement in Box Culverts: Management in the Dark?"* North American Journal of Fisheries Management*, Volume 18, 1998, pages 676-685.*

[93]*B.G. Dane,* A Review and Resolution of Fish Passage Problems at Culvert Sites in British Columbia*, Canada Fisheries and Marine Sciences Technical Report 810, 1978. Chris Katopodis, "Introduction to Fishway Design," Freshwater Institute Central and Arctic Region Department of Fisheries and Oceans, January, 1992.*

[94]*Criteria and guidelines for stream crossings to allow fish passage and maintain stream stability can be obtained in the following sources: British Columbia Ministry of Forests, Fish-stream crossing guidebook, For. Prac. Br., Min. For., http://www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/Guidetoc.htm, Victoria, B.C. Forest Practices Code of British Columbia guidebook, 2002; UW-Extension and WDNR, Fish Friendly Culverts, 2002; Washington Department of Fish and Wildlife, Habitat and Lands Program, Environmental Engineering Division, Fish Passage Design at Road Culverts: A Design Manual for Fish Passage at Road Crossings, Washington, March 3, 1999; and Minnesota DNR, Best Practices for Meeting DNR General Public Waters Work Permit GP 2004-0001, March 2006.*

potential third option which would be to divert the stream back to the historic channel upstream of the current private crossing. This alternative would have multiple benefits such as 1) eliminating the cost of mitigation of the existing private drive structure or a replacement structure, 2) providing a significant improvement in water quality by diverting the actively flowing stream away from the most severe streambank erosion sites on Jackson Creek and reconnecting this reach to its historical stream alignment and floodplain (i.e., restore floodplain connectivity), 3) significantly improving the amount and diversity of instream and riparian buffer habitats, and 4) improving fish passage and potential navigation by kayak or canoe.

Beaver Dams

Beavers can cut trees and alter environments to a greater extent than any other mammal except humans. Their ability to increase landscape heterogeneity by felling trees and constructing impoundments and canals goes beyond their immediate needs for food and shelter. They can dramatically alter nutrient cycles and food webs in aquatic and terrestrial ecosystems by modifying hydrology and selectively removing riparian trees.[95] The activities of beavers in streams provide examples of natural alterations to ecosystem structure and dynamics. Beaver activity may result in differing degrees of alterations that 1) modify channel geomorphology and hydrology; 2) increase retention of sediment and organic matter; 3) create and maintain wetlands; 4) modify nutrient cycling and decomposition dynamics by wetting soils, altering the hydrologic regime, and creating anaerobic zones in soils and sediments; 5) modify the riparian zone, including the species composition and growth form of plants; 6) influence the character of water and materials transported downstream; and 7) modify instream aquatic habitat, which ultimately influences community composition (e.g., fish and macroinvertebrates) and diversity.[96]

Beaver dams are not permanent structures. Without constant maintenance the dams will be breached and blowouts will occur. In addition, dams are frequently abandoned when beavers move on to new areas, depending on food and habitat availability. There is no set time frame within which beavers inhabit areas and maintain dams. It has been documented that dams can be maintained over long periods of time, or used only seasonally. It is likely that, under normal conditions, beaver dams are obstructions for most fish species in terms of upstream passage. Most fish species can travel downstream without problems; however, it is unknown how passable beaver dams are under high flow conditions.

---

[95]*A.M. Ray, et al., Macrophyte succession in Minnesota beaver ponds,* Canadian Journal of Botany*, Volume 79, 2001, pages 487-499.*

[96]*R.J. Naiman, J.M. Melillo, J.E. Hobbie, Ecosystem alteration of boreal forest streams by Beaver (Castor canadensis),* Ecology*, Volume 67, 1986, pages 1254-1269.*

Beaver dams have been shown to enhance fisheries over watershedwide scales. When beavers impound streams by building dams, they substantially alter stream hydraulics in ways that benefit many fish species.[97] Early research suggested that beaver dams might be detrimental to fish, primarily by hindering fish passage, and it has been demonstrated that beaver dams seasonally restrict movement of fishes.[98] Until recently, it was common for fish managers to remove beaver dams. However, more than 80 North American fishes have been documented in beaver ponds, including 48 species that commonly use these habitats, and the beaver ponds' overall benefit to numerous fishes has been well documented, causing managers to rethink the practice of removing beaver dams.[99] In agricultural areas, beaver dams may impound water and submerge drain tile outlets, reducing the effectiveness of the tile systems and adversely affecting crops. Therefore, for the reasons cited above, this is a complicated and controversial issue, so decisions to remove beaver dams should be addressed on a case-by-case basis.

Beaver activity in terms of beaver chew and felled trees was limited to the upper areas of Reach 3 and lower areas of Reach 2 within Jackson Creek. There was one beaver dam observed downstream of STH 67 in Reach 4, but that dam was abandoned and breached at the time of the survey. In contrast, several well-maintained beaver dams were observed on Jackson Creek as shown in Appendix F (Map F-1). These beaver dams were impounding water to depths of approximately one to two feet, which created deeper pool and run habitats in this section of the stream than would normally occur and facilitated deposition of sediments. No structures were nearby where this localized flooding would be a concern.

Based on these observations, it is probable that beaver dams were not significantly affecting the abundance and diversity of the fishery in the Jackson Creek watershed during the time of this inventory, but they do have the potential to limit fish passage, particularly by northern pike trying to migrate into upstream tributaries to lay their eggs. These impoundments did not appear to be affecting drain tile outlets on nearby fields, but it is possible that some tile outlets may be affected. On the other hand, it is also known that beaver dams, and the wetland that they create, are great additions to the diversity of both instream habitat and the riparian corridor buffers for multiple wildlife species. Therefore, it is important to continue to monitor beaver activity and take action where appropriate, but also note that there are important tradeoffs to be considered between fish passage and natural wetland creation. These efforts should be particularly focused in the locations where beaver dams have been

---

[97] *J.W. Snodgrass, and G.K. Meffe, Influence of beavers on stream fish assemblages: effects of pond age and watershed position,* Ecology, *Volume 79, 1998, pages 926-942.*

[98] *I.J. Schlosser, Dispersal, boundary processes, and trophic-level interactions in streams adjacent to beaver ponds,* Ecology*, Volume 76, 1995, pages 908-925.*

[99] *M.M. Pollock, et al., The importance of beaver ponds to coho salmon production in the Stillaguamish River Basin, Washington, USA,* North American Journal of Fisheries Management*, Volume 24, 2004, pages 749-760.*

observed as part of this survey and where those beaver dams lie within migratory routes for northern pike spawning habitat upstream from the Jackson Creek confluence with the Delavan Lake Inlet. However, it is important to keep in mind that beaver are an important part of the overall native wildlife within this river system and their associated dams are a low cost way to establish vital wetland habitat within this system.

Habitat Quality Summary

In summary, Jackson Creek Reaches 3 and 4 contain the highest quality habitat, ranging from fair to excellent. In particular, Reach 3 contains excellent ratings for all dimensions of habitat conditions and should serve as a template or reference reach to be achievable for all other reaches for the mainstem of Jackson Creek. Mainstem Reaches 1 and 2 scores ranged from fair to good and tributary reaches A through E scores ranged from poor to fair, mostly due to the combination of channelization and limited riparian buffers. This analysis does indicate that there have been a number of modifications to the Jackson Creek system, however, this system has great potential for recovery and there are many opportunities to improve habitat quantity and quality throughout the watershed (see *Instream Restoration Priorities* section in Chapter III of this report).

Channelization has been extensive throughout the Jackson Creek watershed and that is one of the major determinants of limited instream habitat and biological condition—particularly in the upper Reaches 1 and 2 of Jackson Creek and headwater tributaries A through E. In all cases, despite having more than 70 years to recover from channelization, these reaches have not been able to redevelop more natural or appropriate sinuosities. Therefore, it is obvious that, due to the low slopes or energies within this river system, the only way to restore stream function within this system is to physically reconstruct it. Reconstructing meanders or restoring a more natural sinuosity, particularly in low-gradient systems like the Jackson Creek, is one of the most effective ways to restore instream habitat and the ability of this system to transport sediment and to function more like a healthy river system (see Figure II-39). In particular, the highest priorities or best locations to restore stream function are where the pre-existing channel lengths that were cut off during channel straightening still exist. For -example, several locations on the mainstem of the Jackson Creek in Reaches 4 and 2, as shown on Map II-12 (see Insets 1 and 3), could easily be restored to flow back into the old channel with minimal effort and cost. Even if the old stream channel has been buried or its alignment cannot be determined, there are many opportunities to rehabilitate or increase stream sinuosities and associated habitat and stream function within these channelized sections of stream using the two-stage stream design (see Figure II-40).

The moderate and high streambank erosion sites were considered to be an excessive problem throughout the majority of the Jackson Creek system as shown on Map II-11, particularly within Reaches 4, 2, and 1.

Recent research has revealed that channelized streams minimize water residence time and biological nutrient processing, which can be mitigated by restoring floodplain connectivity to reduce pollutant loads and improve metabolism in agricultural streams.[100] The benefits of floodplain restoration are most apparent during high flow events (during inundation) and floodplains are more effective at assimilating nutrients when the floodplains are vegetated with appropriate native plants. Hence, it is recommended to improve the connectivity of Jackson Creek to its floodplain by reconnecting historical stream channels (i.e., remeandering) and reconstructing new channels and/or two-stage channel systems (see Figures II-39 and 40) based upon the template or reference Reach 3/Kettle Moraine Wetland Reserve in the middle portions of Jackson Creek. This has the added benefits of improving instream habitat and reducing streambank erosion. Priority areas for potential remeandering, reconnecting the historical channel, and/or construction of two-stage channel design are located in the disconnected and partially connected floodplain areas as shown on Map II-11.

Two structures were considered to be significant barriers to fish passage throughout the Jackson Creek watershed and are considered a high priority to restore fish passage to the extent practicable (see Table II-19). Under normal flow conditions both of the sites are considered complete barriers to fish passage and the stream gauge weir is also a barrier to safe navigation for canoes and kayaks.

STREAM RESTORATION

Restoration is not solely applicable to severely degraded streams. Although it can be used as an effective tool to return a degraded system to a pre-disturbance condition, restoration is also an important tool for preventing environmental degradation.[101]

Restoration has been defined in a number of different ways. On the most basic level, restoration is the process of returning a damaged ecosystem to its condition prior to disturbance.[102] The long-term goal of restoration is to

---

[100]*Sarah S. Roley, et al., "Floodplain restoration enhance denitrification and reach-scale nitrogen removal in an agricultural stream", Ecological Applications, Volume 22(1), pages 281-297, 2012; Sarah S. Roley, et al., "The influence of floodplain restoration on whole-stream metabolism in an agricultural stream: insights from a 5-year continuous dataset; and, Sarah S. Roley, Jennifer L. Tank, and Maureen A. Williams, "Hydrologic connectivity increases denitrification in the hyporheic zone and restored floodplains of an agricultural stream", Journal of Geophysical Research, Volume 117, pages 1-16, 2012.*

[101]*USEPA, Ecological Restoration - EPA 841-F-95-007, November 1995, see website http://water.epa.gov/type/watersheds/archives/chap1.cfm*

[102]*Cairns, John, Jr. The status of the theoretical and applied science of restoration ecology. The Environmental Professional, Volume 13, pp. 186-194, 1991.*

imitate an earlier natural, self-sustaining ecosystem that is in equilibrium with the surrounding landscape.[103] A National Research Council report defines restoration as a holistic process:[104]

> *Restoration is ... the return of an ecosystem to a close approximation of its condition prior to disturbance. In restoration, ecological damage to the resource is repaired. Both the structure and the functions of the ecosystem are recreated ... The goal is to emulate a natural, functioning, self-regulating system that is integrated with the ecological landscape in which it occurs.*

As with other water resource management alternatives, restoration must address questions concerning practicality, predictability of outcomes, and overall effectiveness of specific techniques.[105] Additionally, because ecological systems are complex and may take years to reach equilibrium or fully demonstrate the effects of restoration and other management activities, seeing or measuring results of restoration efforts may take a long time.

Therefore, in this report, **ecological restoration is defined as an important tool for preventing environmental degradation and as a means of restoring degraded chemical, physical, and/or biological components of the Jackson Creek system to an improved condition**. Strengthening structural or functional elements through restoration can help increase a stream system's tolerance to stressors which lead to environmental degradation. By so doing, water quality and aquatic and terrestrial habitat will be improved, which, in turn, will lead to improvements in the aquatic and terrestrial communities that depend on that water.[106]

This watershed protection plan envisions that restoration techniques be applied as a management action within the context of the Rock River Total Maximum Daily Load (TMDL) reduction goals in conjunction with traditional regulatory actions (such as point source permits) and voluntary programs (such as implementation of nonpoint source BMPs) to address the numeric or narrative water quality criterion, standards, or designated uses for Jackson Creek as summarized above. In the context of the TMDL, restoration can also address nonattainment of a designated use (e.g., a coolwater fishery) or a narrative criterion that refers explicitly to habitat quality or

---

[103]*Berger, John J. The federal mandate to restore: laws and policies on environmental restoration. The Environmental Professional, Volume 13, pp. 195-206, 1991.*

[104]*National Research Council,* Restoration of Aquatic Systems: Science, Technology, and Public Policy*, Washington, DC., 1992.*

[105]*Caldwell, Lynton Keith, "Restoration ecology as public policy," The Environmental Professional, Volume 13, pp. 275-284, 1991.*

[106]*T Travis Brown, Terry L. Derting, and Kenneth Fairbanks, "The Effects of Stream Channelization and Restoration on Mammal Species and Habitat in Riparian Corridors," Journal of the Kentucky Academy of Science 69(1):37-49. 2008*

biological diversity. The management strategy recommended in this case is to combine some or all options involving nonpoint source load reductions, BMPs, and instream ecological restoration techniques. It is important to note that stream restoration is an important and vital pollutant reduction strategy to meet TMDL goals for nutrient and sediment reductions, but stream restoration should not be implemented for the sole purpose of nutrient or sediment reduction for this watershed.[107]

Scope of Restoration

Restoration must consider all sources of stress on a stream and is therefore not restricted to instream mitigation of impacts. The health and protection of a waterbody cannot be separated from the watershed ecosystem, and restoration must address all watershed processes that degrade an ecological system (e.g., sediment loading from eroding gullies or construction sites or increased polluted runoff from impervious areas). The intimate connection of rivers and watersheds is succinctly expressed by Doppelt and others:[108]

> *Most people think of rivers simply as water flowing through a channel. This narrow view fails to capture the actual complexity and diversity of riverine systems, and is one of the reasons for failed policies. In the past 15 years many scientific studies and reports have documented that riverine systems are intimately coupled with and created by the characteristics of their catchment basins, or watersheds. The concept of the watershed includes four-dimensional processes that connect the longitudinal (upstream-downstream), lateral (floodplains-upland), and vertical (hyporheic or groundwater zone-stream channel) dimensions, each differing temporally.*

Therefore, restoration is an integral part of a broad, watershed-based approach for achieving Federal, State, and local water resource goals. Specifically, restoration is the re-establishment of the chemical, physical, and biological components of an aquatic ecosystem that have been compromised by stressors such as point or nonpoint sources of pollution, habitat degradation, hydromodification (i.e., channelization), and others that are summarized above.

Restoration Techniques

This plan emphasizes and endorses the use of natural restoration techniques. Natural techniques that restore a system's ability to approach a pre-disturbance condition such as through stream channel remeandering and/or two-

---

[107]*Richard Starr, Bill Stack, and Lisa Fraley-McNeal, "Stream Restoration as a Pollutant Reduction Strategy," Center for Watershed Protection's 2014 Watershed & Stormwater Management Webcast Series September 10, 2014.*

[108]*Doppelt, B., M. Scurlock, C. Frissell, and J. Karr.* Entering the Watershed: A New Approach to Save America's River Ecosystems*, The Pacific Rivers Council, Island Press, Washington, DC, and Covelo, CA, 1993.*

stage channel design are distinct from treatment technologies or artificial structures that are inserted into the system. Natural restoration techniques also use materials indigenous to the ecosystem and concepts such as natural channel design into the dynamics of a river system in an attempt to create conditions in which ecosystem processes can withstand and diminish the impact of stressors that lead to environmental degradation.

This plan recommends a comprehensive watershed perspective for restoration that considers interactions among stressors in developing effective long-term solutions. To facilitate assessment and the development of management strategies, three zones have been identified for categorizing stressors and restoration strategies and associated management activities. In actuality, however, the zones below are broadly connected ecologically.

- The instream zone is generally the area that contains the stream's non-peak flows. Instream techniques are applied directly in the stream channel (e.g., channel reconfiguration and realignment to restore geometry, meanders, sinuosity, substrate composition, structural complexity, re-aeration, or streambank stability).

- The riparian corridor includes the stream channel and also extends some distance out from the water's edge and can vary based on differences in local topography, stream bottom, soil type, water quality, elevation, and surrounding vegetation. Riparian techniques are applied outside of the stream channel in the riparian corridor (e.g., re-establishment of vegetative canopy, increasing the width of riparian corridor, or restoring cropland to wetland and/or upland habitat).

- The upland zone consists of those areas beyond the riparian corridor within a stream's watershed that generate nonpoint source runoff into the stream and whose infiltration and topographic characteristics control stream hydrology. Upland, or surrounding watershed, techniques (e.g., agricultural and urban best management practices or BMPs) are generally related to the control of nonpoint source inputs from the watershed, including hydrologic runoff characteristics from increased imperviousness of the watershed.

Stream restoration can be a mosaic of instream, riparian, and upland techniques, including BMPs, to be used in combination to eliminate or reduce the impact of stressors (both chemical and nonchemical) on aquatic ecosystems and reverse the degradation and loss of ecosystem functions. Instream restoration practices often need to be accompanied by techniques in the riparian area and/or the surrounding watershed. For example, restoration may involve rebuilding the infrastructure of a stream system (e.g., reconfiguration of channel morphology, re-establishment of riffle substrates, re-establishment of riparian vegetation, and stabilization of streambanks, accompanied by control of excess sediment and chemical loadings within the watershed) to achieve and maintain stream integrity.

Balancing and integrating instream, riparian, and surrounding watershed approaches is essential. A restoration plan could involve a combination of techniques, depending on environmental conditions and stressors to be addressed. Instream and riparian techniques directly restore the integrity of stream habitat, whereas surrounding watershed techniques focus on the elimination or mitigation of sources of stressors that cause the habitat degradation. Because surrounding watershed techniques tend to facilitate a system's ability to restore itself, instream techniques may not always be necessary. In addition, if instream and/or riparian techniques are selected to restore the integrity of the physical habitat, measures that eliminate or mitigate sources of stressors that caused the degradation should also be included; otherwise, the restoration effort may fail. Therefore, surrounding watershed techniques should, as a general rule, be considered prior to or in conjunction with the use of instream and riparian techniques. Because many projects need to address both causes and symptoms of stream degradation, combining instream, riparian, and surrounding watershed approaches is often appropriate and is recommended in this watershed plan for Jackson Creek.

Stream Functions Pyramid - A Tool for Assessing Success of Stream Restoration Projects

The USEPA and the U.S. Fish and Wildlife Service developed a function-based framework for stream restoration goals, performance standards, and standard operating procedures.[109] The framework consists of the stream functions pyramid, a five-level, hierarchical framework that categorizes stream functions and the parameters that describe those functions as shown in Figure II-41.

Stream restoration practitioners have long been struggling with how to determine the success of restoration projects. Part of the problem lies in failure to link stream restoration with the restoration of stream function. For example, many restoration project goals fail to recognize the full range of stream functions and how they support each other. Federal mitigation guidelines already require stream restoration practitioners to determine the functional improvement of their project.

The difference in the pre-restoration functional condition and the post restoration functional condition is known as functional lift. The functional lift can be used to quantify the overall benefit of any proposed stream restoration project or to develop stream mitigation credits.

[109]*Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs, C. Miller. 2012. A Function-Based Framework for Stream Assessment and Restoration Projects. US Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC EPA 843-K-12-006; Fischenich, J.C., Functional objectives for stream restoration, EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-52). Vicksburg, MS: U.S. Army Engineer Research and Development Center, 2006, www.wes.army.mil/el/emrrp*

The stream functions pyramid provides a framework for assessing stream functions, setting design goals, and evaluating performance. The pyramid shows that restoration of functions must occur in a certain order for maximum functional lift to occur, but it is important to note that there is an iterative process among these levels over time while working towards achieving the desired goals and adjusting as necessary.

Hydrology functions create the base of the pyramid. These functions determine how much water is produced by the watershed and include measures such as the rainfall-runoff relationship and bankfull discharge determination. Hydraulic functions are shown above hydrology functions and describe the flow dynamics in the channel and floodplain where floodplain connectivity and flow dynamics are critical measures. Geomorphic functions are next and integrate the hydrology and hydraulic functions to transport sediment and create diverse bed forms.

Once this structure is in place, physiochemical functions can improve, including increased dissolved oxygen, lower stream temperature, denitrification, and organic processing. The biological functions are at the top of the pyramid because they rely on all of the other functions. The biological functions include the life cycles of fish and macroinvertebrates and riparian conditions.

The stream functions pyramid helps practitioners set goals to ensure that the design addresses the appropriate functions. Research has shown that many assessment protocols and project designs ignore the base level functions of hydrology, hydraulics, and geomorphology. Conversely, it is not always obvious or understood that land use practices or implementation of agricultural or urban BMPs are actually a form of stream restoration, which is a major component of a comprehensive approach to watershed management.

Hence, it is recommended that this hierarchical framework and associated functional lift be used to help guide project implementation in setting design goals and evaluating performance for the Jackson Creek watershed. For example, as previously mentioned two of the major goals in this watershed plan are to improve water quality by reducing phosphorus and sediment loads from adjacent land uses (i.e., functional levels 1-4) and improve fisheries and habitat to increase the abundance and diversity of a native coolwater fishery (i.e., functional levels 1-5). In addition, the pyramid can be used to design monitoring plans that quantify functional lift by using the baseline functional capacity of the stream corridor as summarized in the sections above concerning the hydrology, hydraulics, geomorphology, physicochemical, and biological parameters and reference conditions throughout the watershed. Figure II-41 illustrates the relationships between function-based parameters and the five levels of the functional categories and their interdependence. The design should focus on improving impaired functions, rather than just focusing on channel form (i.e., improving channel dimension, pattern and profile). Monitoring can then quantify the improvement or lift in each of those functions.[110] Inherent in the achievement of these water quality and fishery goals will be a concomitant improvement in other dimensions and goals of this plan that include recreation, economic development, property values, quality of life, and aesthetics.

[110] *Richard Starr, US Fish and Wildlife Service, Chesapeake Bay Field Office, see website http://www.fws.gov/chesapeakebay/Newsletter/Fall11/Pyramid/Pyramid.html*

00229164.DOC
300-1115
TMS
06/15/15

SEWRPC Community Assistance Planning Report No. 320

JACKSON CREEK WATERSHED PROTECTION PLAN

Chapter II

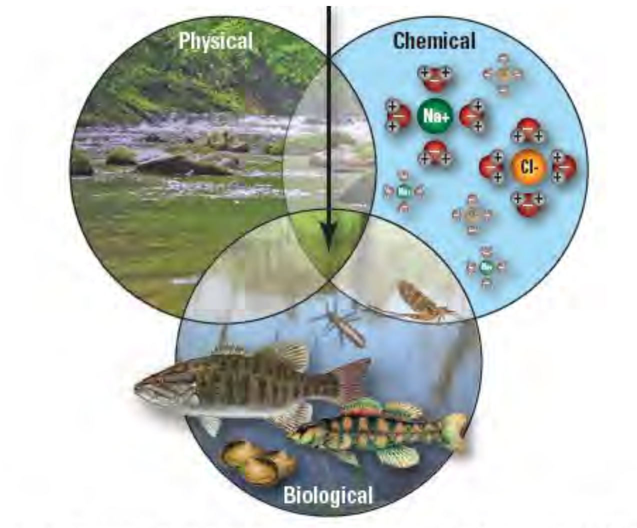
INVENTORY FINDINGS

FIGURES

(This Page Left Blank Intentionally)

Figure II-1

ECOLOGICAL STREAM HEALTH



This simple diagram shows that a stream's ecological health (or "stream health") is the result of the interaction of its biological, physical, and chemical components. Stream health is intact if (1) its biological communities (such as algae, macroinvertebrates, and fish) are similar to what is expected in streams under minimal human influence and (2) the stream's physical attributes (such as streamflow) and chemical attributes (such as salinity or dissolved oxygen) are within the bounds of natural variation.

Source: Modified from D.M. Carlisle and others, The quality of our Nation's waters—Ecological health in the Nation's streams, 1993–2005: U.S. Geological Survey Circular 1391*, 120 p.,* http://pubs.usgs.gov/circ/1391/*, 2013, and SEWRPC.*

Figure II-2

ILLUSTRATIONS OF THE DYNAMIC COMPONENTS OF NATURAL, AGRICULTURAL, AND URBAN STREAM ECOSYSTEMS

NATURAL STREAM ECOSYSTEM

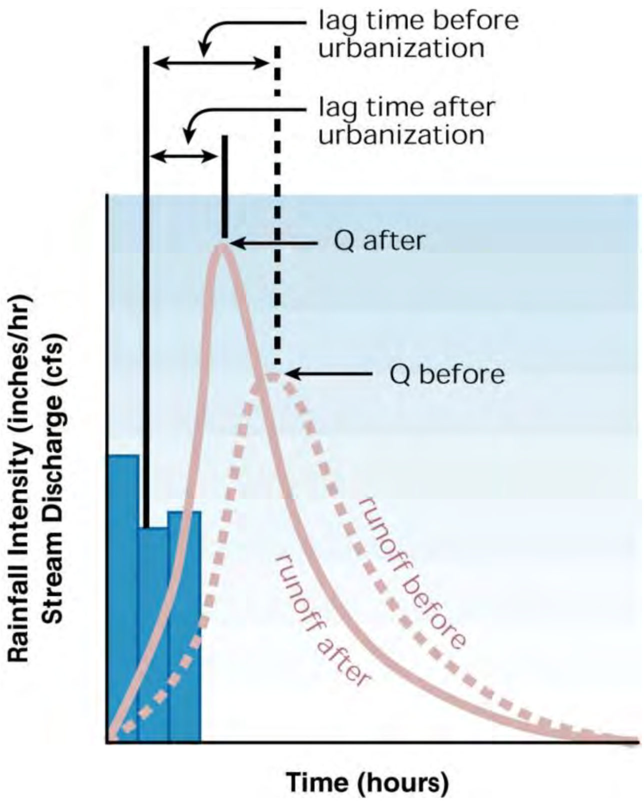
AGRICULTURAL STREAM ECOSYSTEM

URBAN STREAM ECOSYSTEM

Source: Illustrations by Frank Ippolito/www.productionpost.com. Modified from D.M. Carlisle and others, The quality of our Nation's waters—Ecological health in the Nation's streams, 1993–2005: U.S. Geological Survey Circular 1391*, 120 p.,* http://pubs.usgs.gov/circ/1391/*, 2013, and SEWRPC.*

Figure II-3

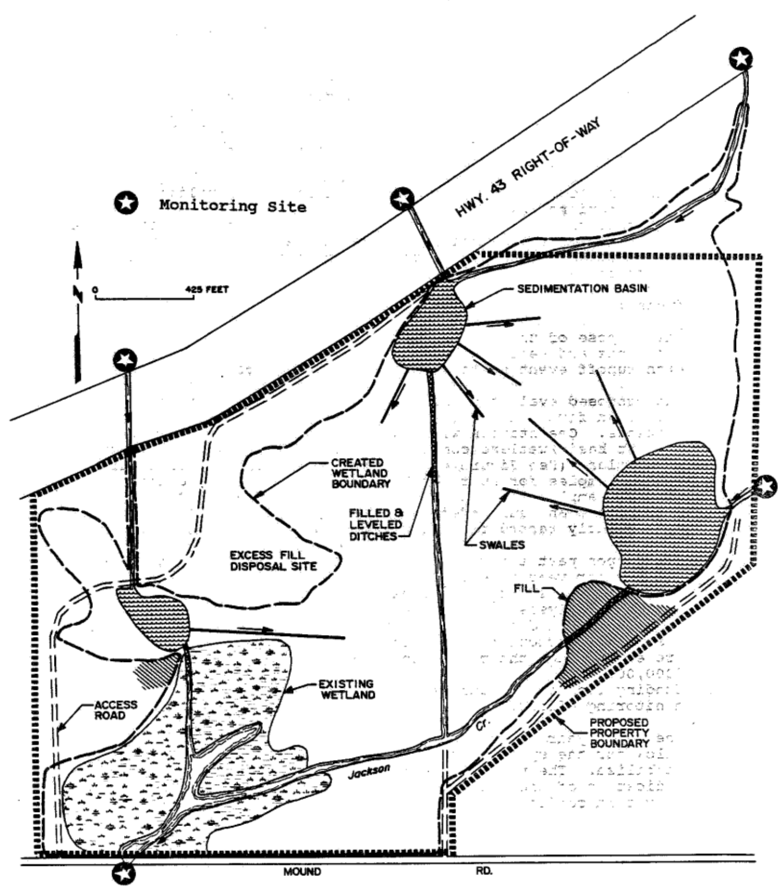
A COMPARISON OF HYDROGRAPHS BEFORE AND AFTER URBANIZATION



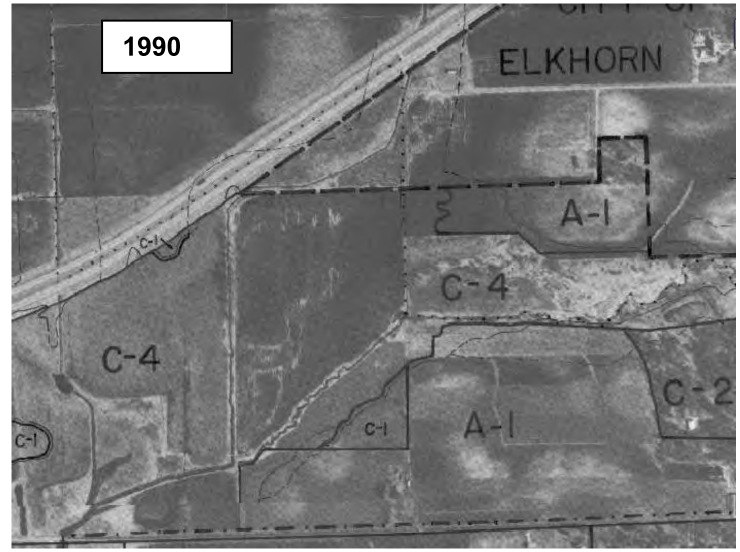
Source: Federal Interagency Stream Restoration Working Group (FISRWG), Stream Corridor Restoration: Principles, Processes, and Practices, *October 1998.*

Figure II-4

ORIGINAL 1989 DESIGN DIAGRAM AND AERIAL PHTOTGRAPHS OF THE SEDIMENTATION BASINS UPSTREAM OF MOUND ROAD: PRE-CONSTRUCTION 1990 vs POST-CONSTRUCTION 1995



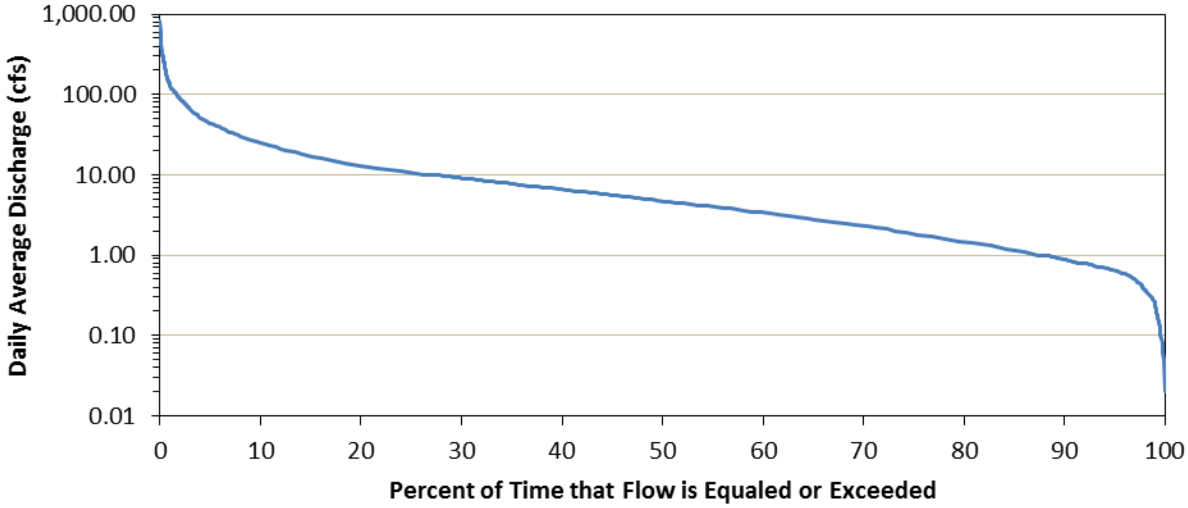
NOTE: Channels downstream of each pond were originally filled and disconnected when the ponds were constructed in 1992 just as shown in the original design, but channels formed naturally from the outlet of each pond due to headcutting and erosional processes to form a connection with the mainstem of Jackson Creek by 1995.



Source: WDNR and SEWRPC.

Figure II-5

**FLOW DURATION CURVE FOR JACKSON CREEK
AT MOUND ROAD: OCTOBER 1993 THROUGH OCTOBER 2014**

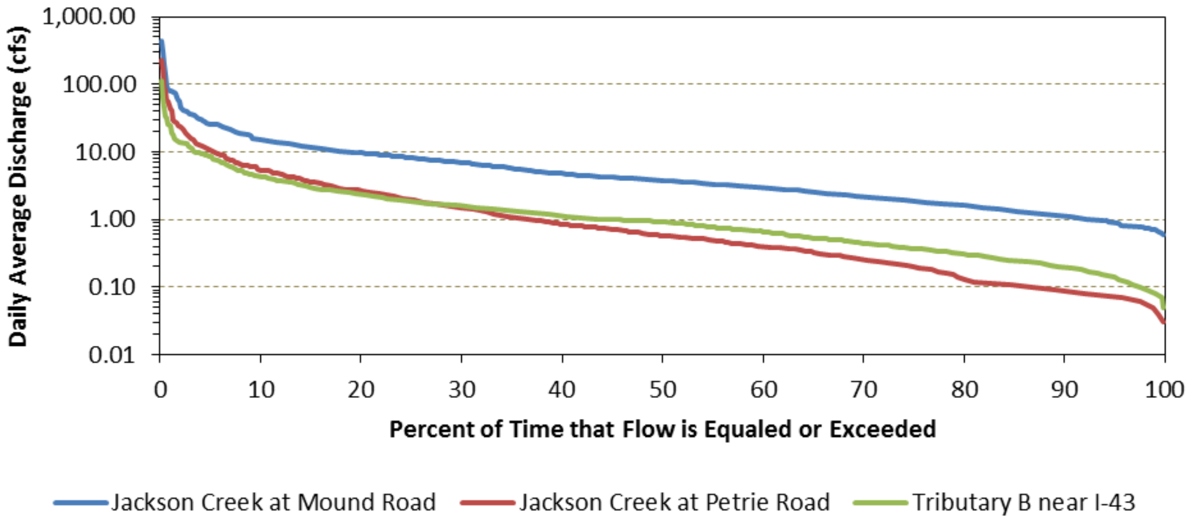


NOTE: No data were available for the period October 1, 2009, through December 31, 2012.

Source: U.S. Geological Survey and SEWRPC.

Figure II-6

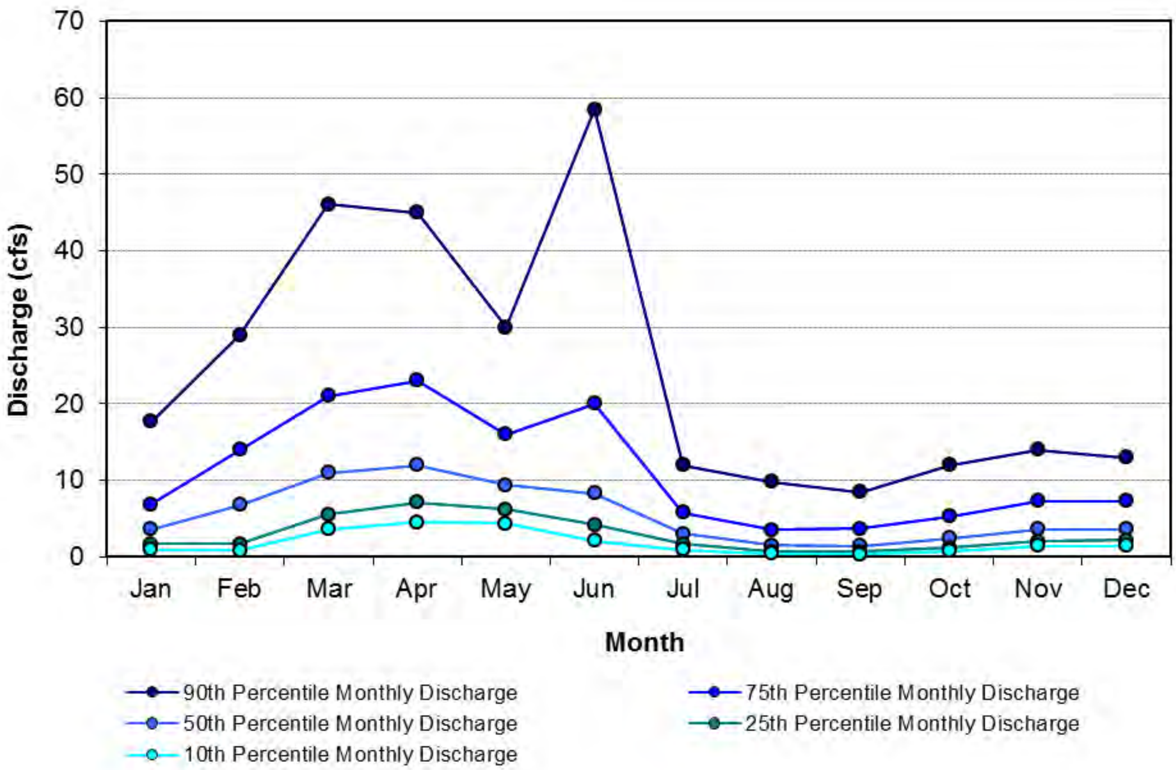
COMPARISON OF FLOW DURATION CURVES FOR STREAM GAUGES IN THE JACKSON CREEK WATERSHED: OCTOBER 1993 THROUGH SEPTEMBER 1995



Source: U.S. Geological Survey and SEWRPC.

Figure II-7

MONTHLY PERCENTILES OF STREAM FLOW IN JACKSON CREEK AT THE USGS GAUGE AT MOUND ROAD: 1993-2014

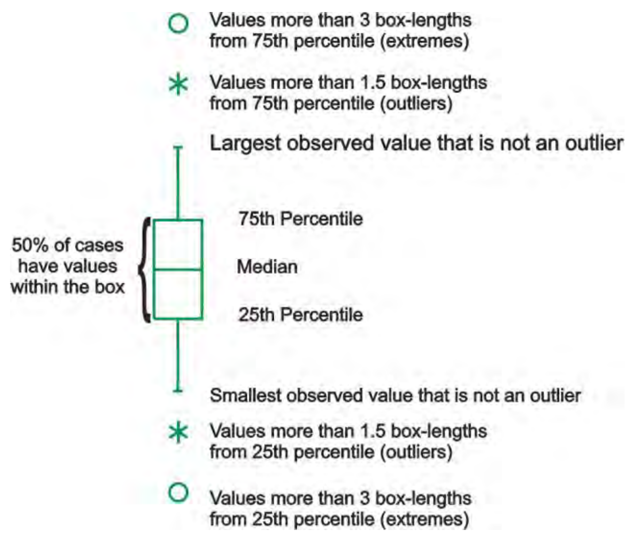


NOTE: No data were available for the period October 1, 2009, through December 31, 2012.

Source: U.S. Geological Survey and SEWRPC.

Figure II-8

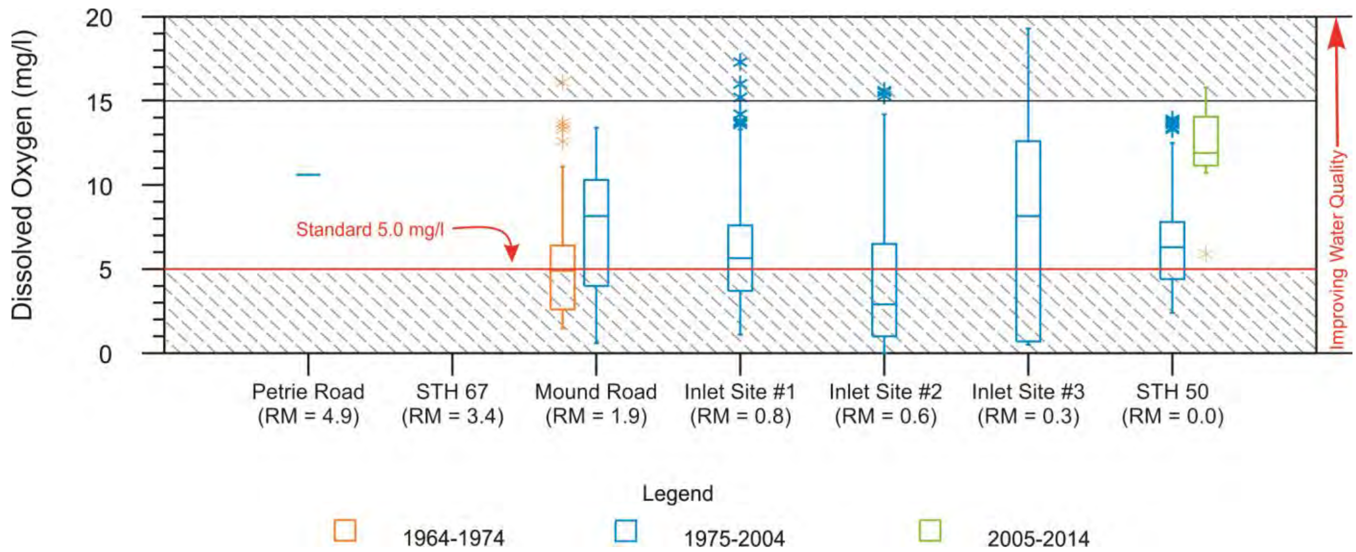
EXPLANATION OF SYMBOLS USED IN BOX-PLOT GRAPHS



Source: SEWRPC.

Figure II-9

DISSOLVED OXYGEN CONCENTRATIONS AT WATER QUALITY SAMPLING STATIONS ALONG JACKSON CREEK: 1964-2014



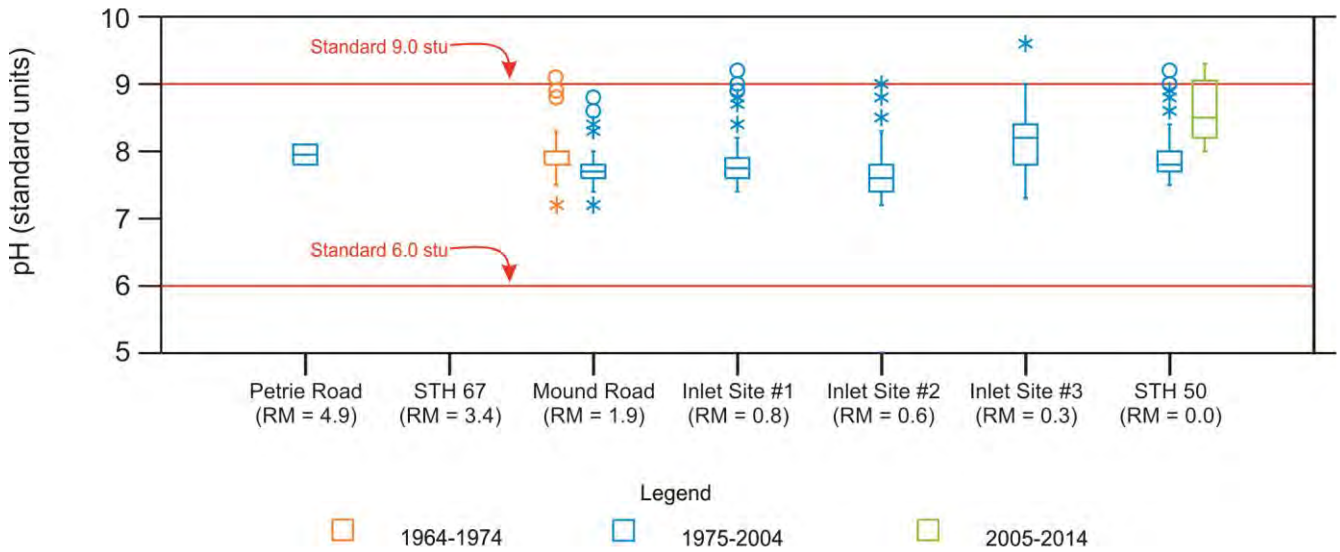
NOTE: See Figure II-8 for description of symbols. See Table II-6 and Map II-4 for locations of sample sites.

Saturation levels of dissolved oxygen of 140 percent and higher can cause fish kills. A 15 Mg/l dissolved oxygen concentration translates to a saturation of approximately 150 percent at an average water temperature of 14 degrees Celsius.

Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, Delavan Lake Sanitary District, Delavan Lake Watershed Initiative Network, and SEWRPC.

Figure II-10

pH AT WATER QUALITY SAMPLING STATIONS ALONG JACKSON CREEK: 1964-2014

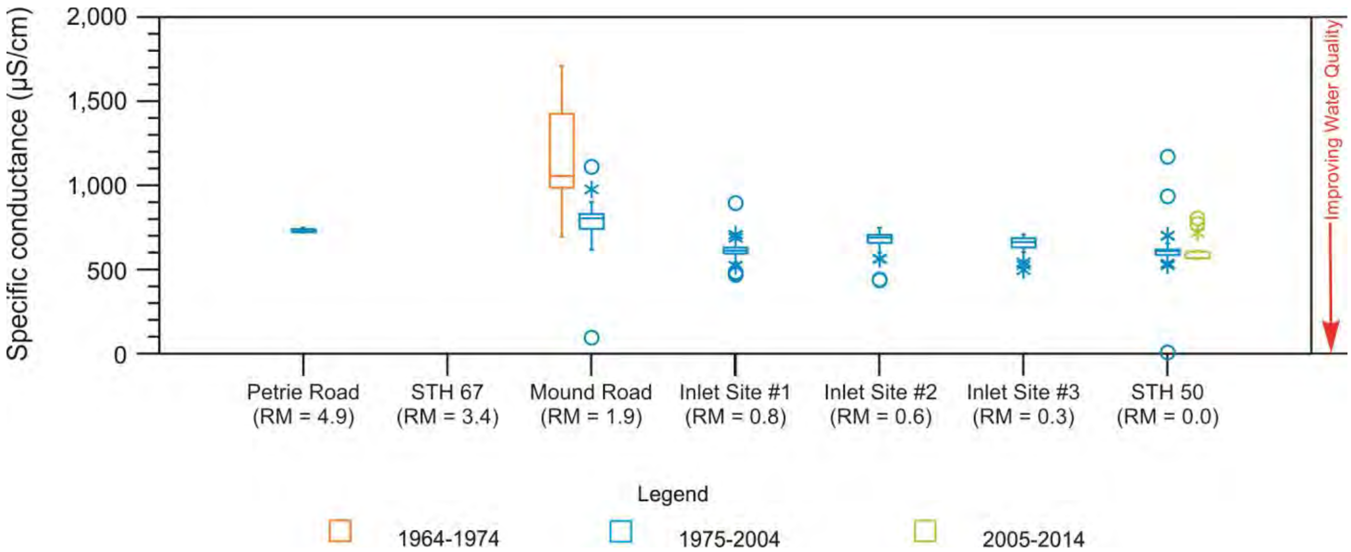


NOTE: See Figure II-8 for description of symbols. See Table II-6 and Map II-4 for locations of sample sites.

Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, Delavan Lake Sanitary District, Delavan Lake Watershed Initiative Network, and SEWRPC.

Figure II-11

SPECIFIC CONDUCTANCE AT WATER SAMPLING STATIONS ALONG JACKSON CREEK: 1964-2014

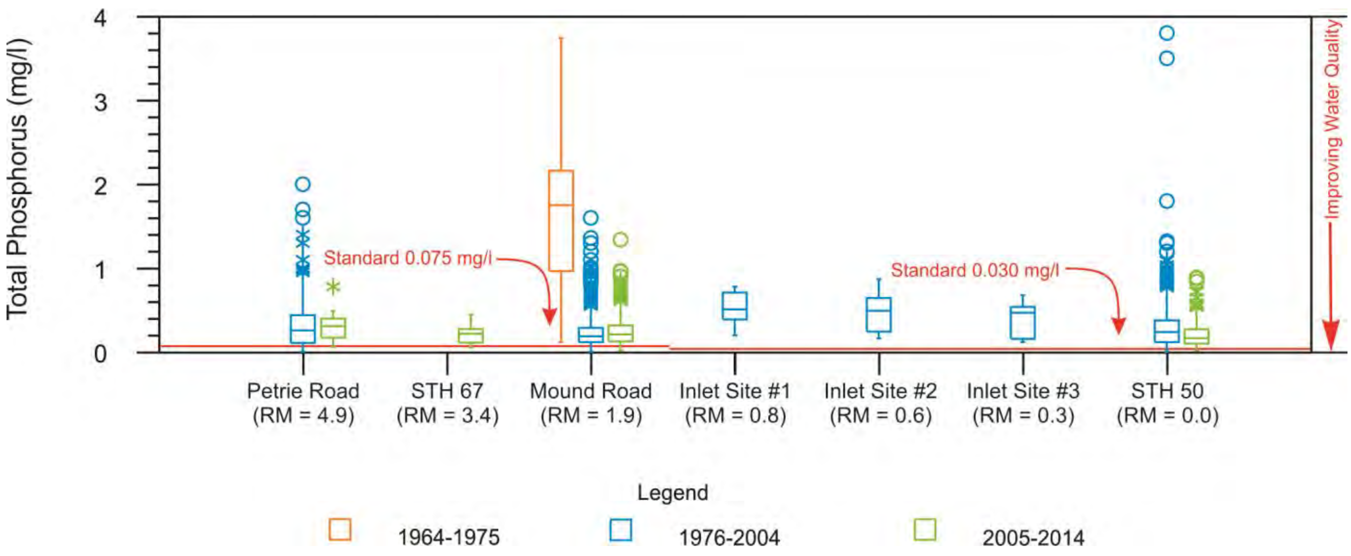


NOTE: See Figure II-8 for description of symbols. See Table II-6 and Map II-4 for locations of sample sites.

Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, Delavan Lake Sanitary District, Delavan Lake Watershed Initiative Network, and SEWRPC.

Figure II-12

TOTAL PHOSPHORUS CONCENTRATIONS AT WATER QUALITY SAMPLING STATIONS ALONG JACKSON CREEK: 1964-2014

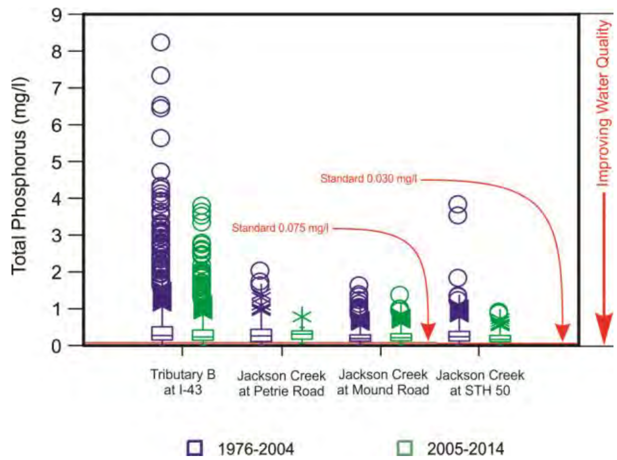


NOTE: See Figure II-8 for description of symbols. See Table II-6 and Map II-4 for locations of sample sites.

Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, Delavan Lake Sanitary District, Delavan Lake Watershed Initiative Network, and SEWRPC.

Figure II-13

TOTAL PHOSPHORUS CONCENTRATIONS AT SITES WITHIN THE JACKSON CREEK WATERSHED: 1976-2014

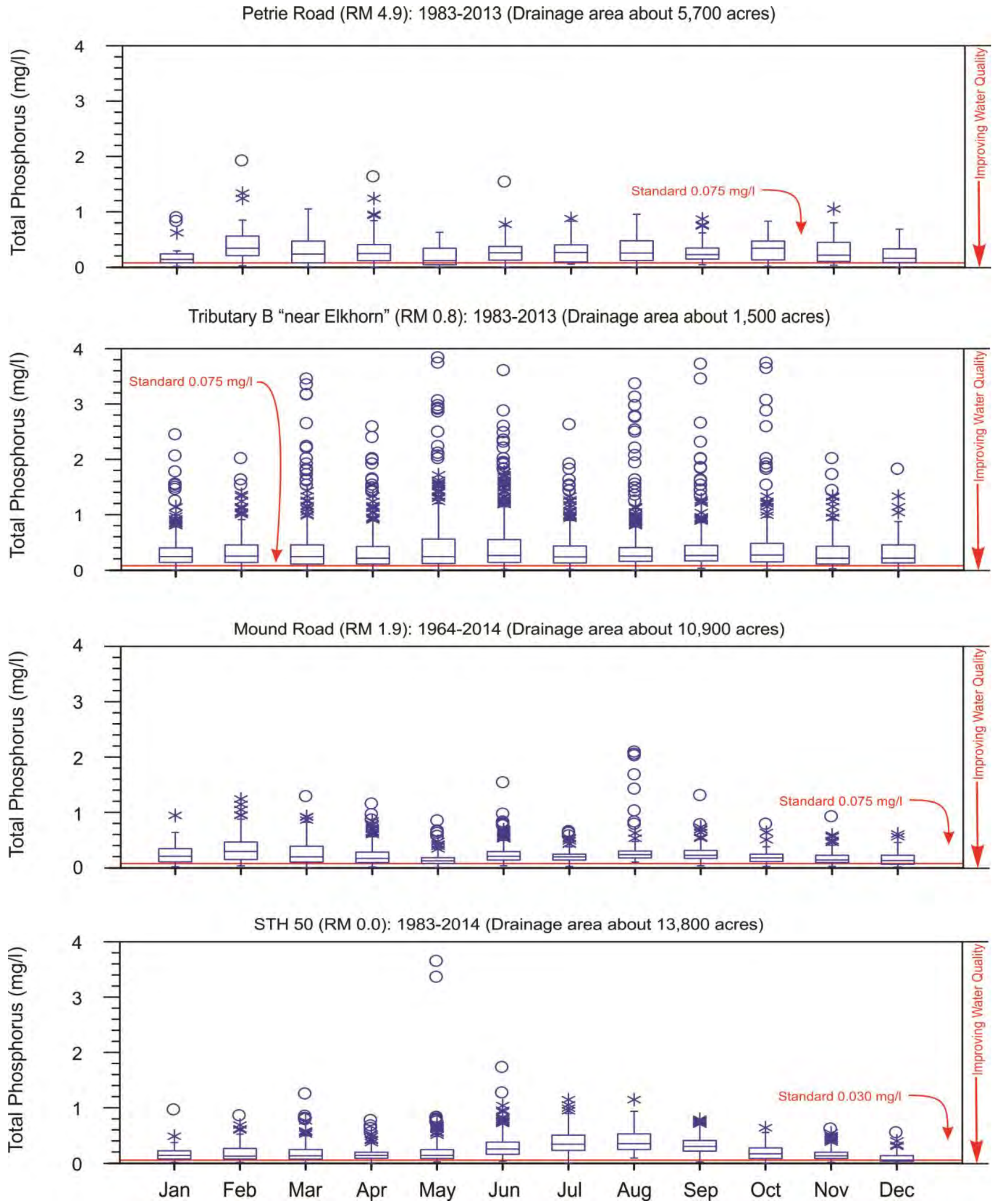


NOTE: See Figure II-8 for description of symbols. See Table II-6 and Map II-4 for locations of sample sites.

Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, Delavan Lake Sanitary District, Delavan Lake Watershed Initiative Network, and SEWRPC.

Figure II-14

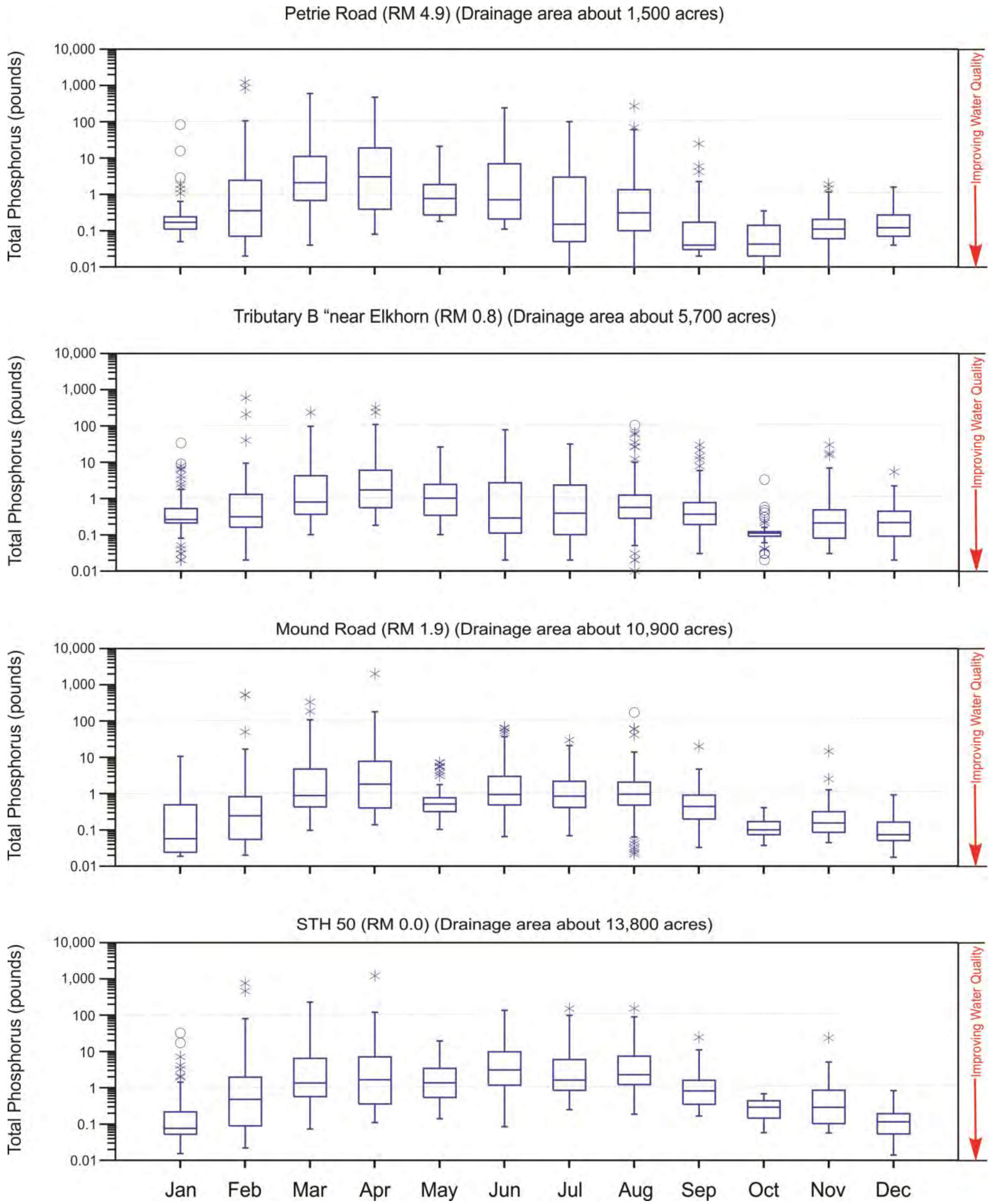
AVERAGE DAILY TOTAL PHOSPHORUS CONCENTRATIONS AT WATER QUALITY SAMPLING STATIONS ALONG JACKSON CREEK: 1964-2014



Source: U. S. Geological Survey, Wisconsin Department of Natural Resources, Delavan Lake Sanitary District, Delavan Lake Watershed Initiative Network, and SEWRPC.

Figure II-15

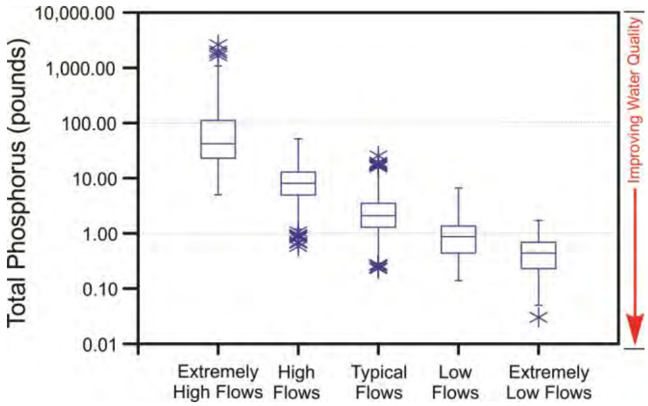
DAILY LOADS OF TOTAL PHOSPHORUS AT WATER QUALITY SAMPLING STATIONS ALONG JACKSON CREEK: 1993-1995



Source: U.S. Geological Survey and SEWRPC.

Figure II-16

DAILY LOADS OF TOTAL PHOSPHORUS AS RELATED TO AVERAGE DAILY DISCHARGE IN JACKSON CREEK AT MOUND ROAD: 1993-2009, 2013



NOTE: Flow levels are define using levels shown in the flow duration curve shown in Figure II-5:

Extremely high flows are equaled or exceeded less than 10 percent of the time;

High flows are equaled or exceeded between 25 and 10 percent of the time;

Typical flows are equaled or exceeded between 75 and 25 percent of the time;

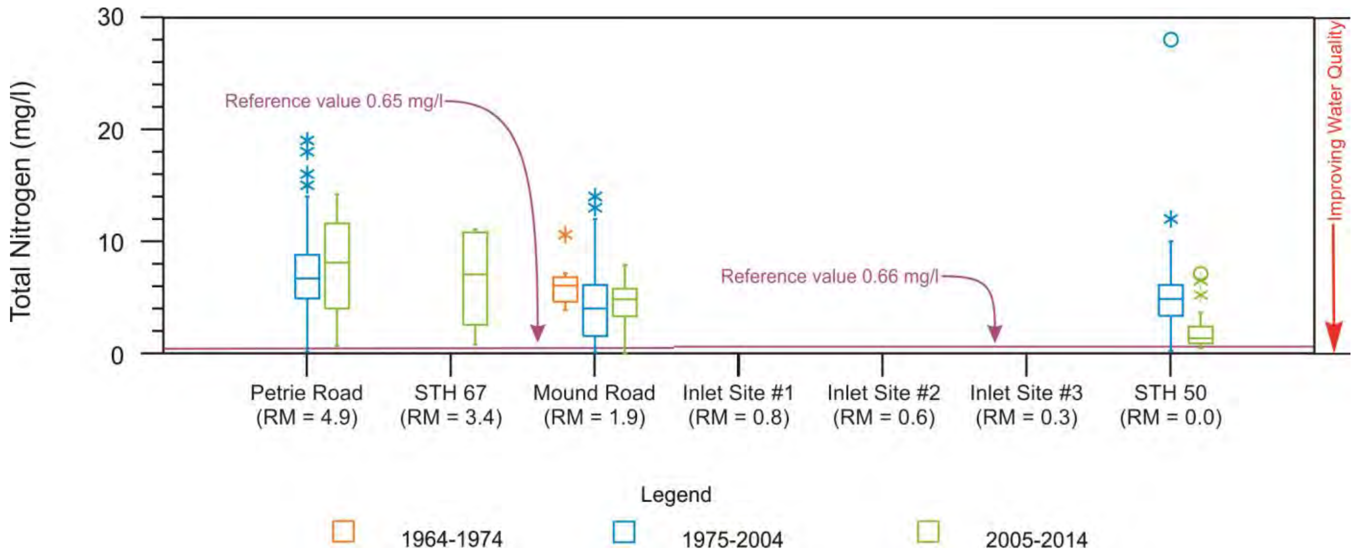
Low flows are equaled or exceeded between 90 and 75 percent of the time: and

Extremely low flows are equaled or exceeded more than 90 percent of the time.

Source: U.S. Geological Survey and SEWRPC.

Figure II-17

TOTAL NITROGEN CONCENTRATIONS AT WATER QUALITY SAMPLING STATIONS ALONG JACKSON CREEK: 1964-2014

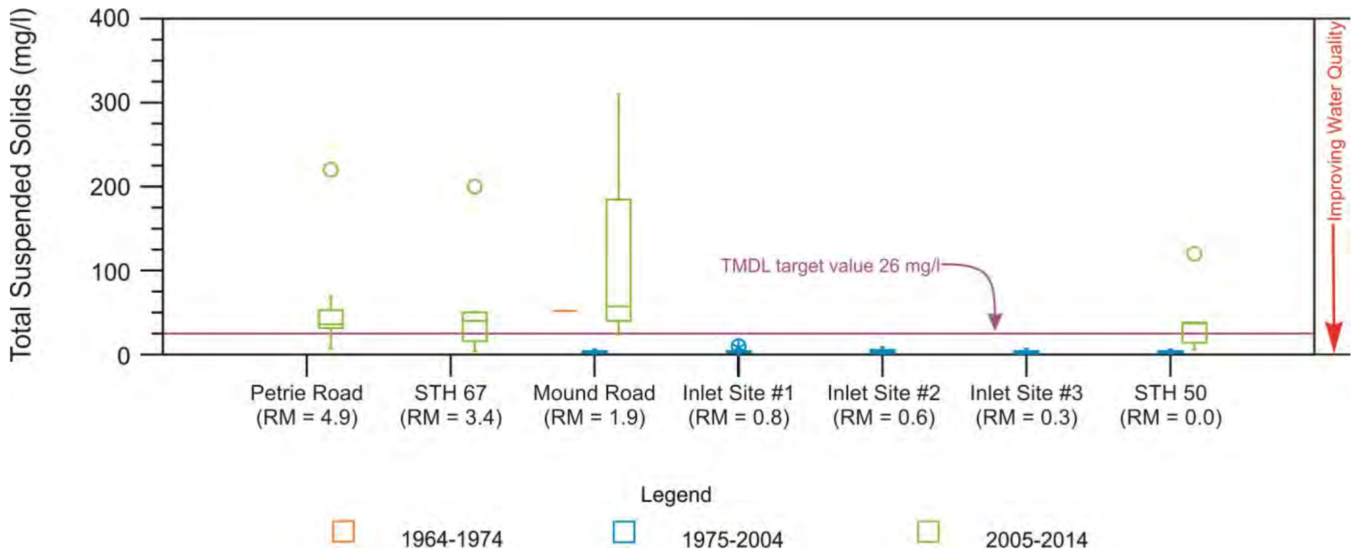


NOTE: See Figure II-8 for description of symbols. See Table II-6 and Map II-4 for locations of sample sites.

Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, Delavan Lake Sanitary District, Delavan Lake Watershed Initiative Network, and SEWRPC.

Figure II-18

TOTAL SUSPENDED SOLIDS CONCENTRATIONS AT WATER QUALITY SAMPLING STATIONS ALONG JACKSON CREEK: 1964-2014

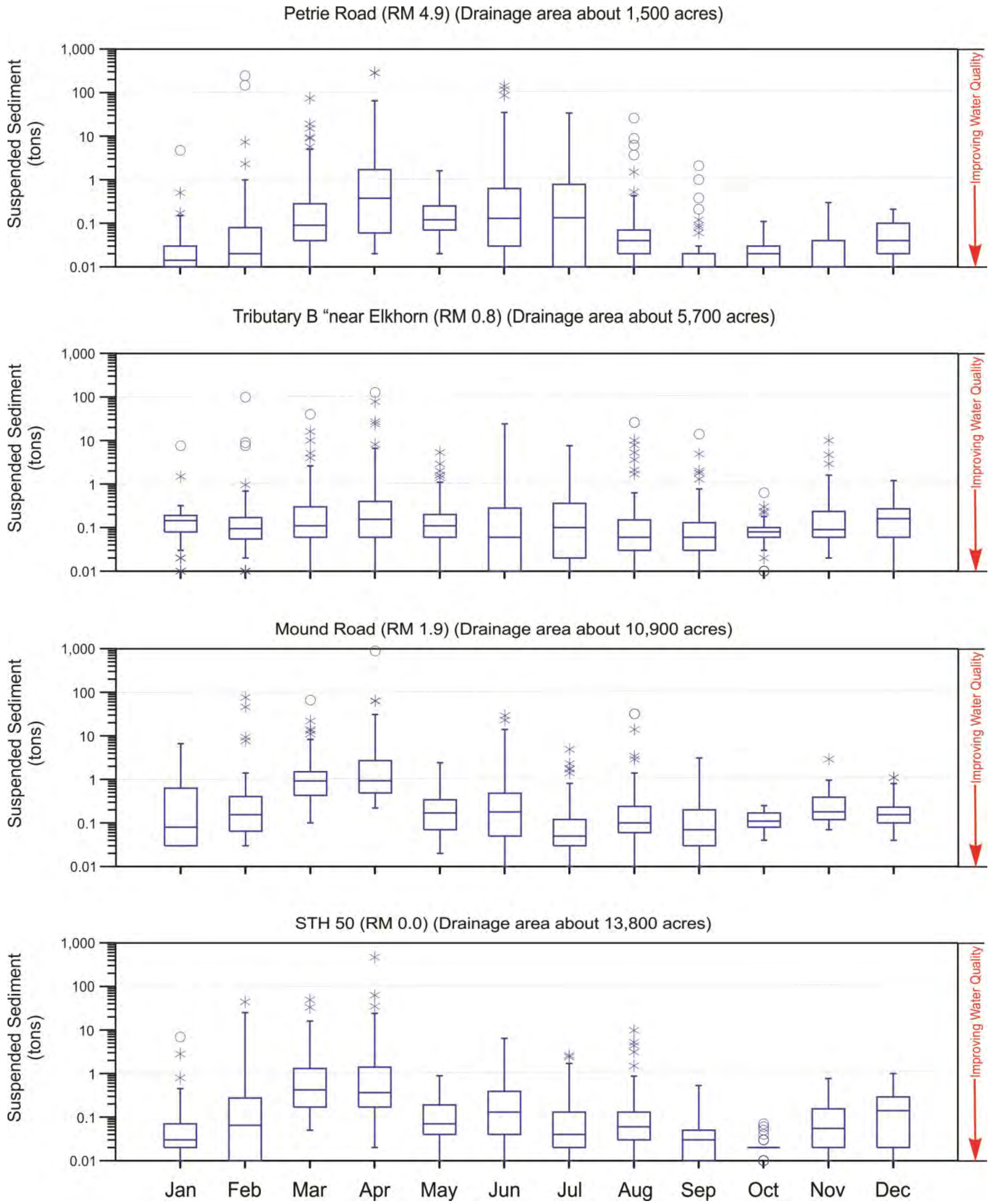


NOTE: See Figure II-8 for description of symbols. See Table II-6 and Map II-4 for locations of sample sites.

Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, Delavan Lake Sanitary District, Delavan Lake Watershed Initiative Network, and SEWRPC.

Figure II-19

DAILY LOADS OF SUSPENDED SOLIDS AT WATER QUALITY SAMPLING STATIONS ALONG JACKSON CREEK: 1993-1995

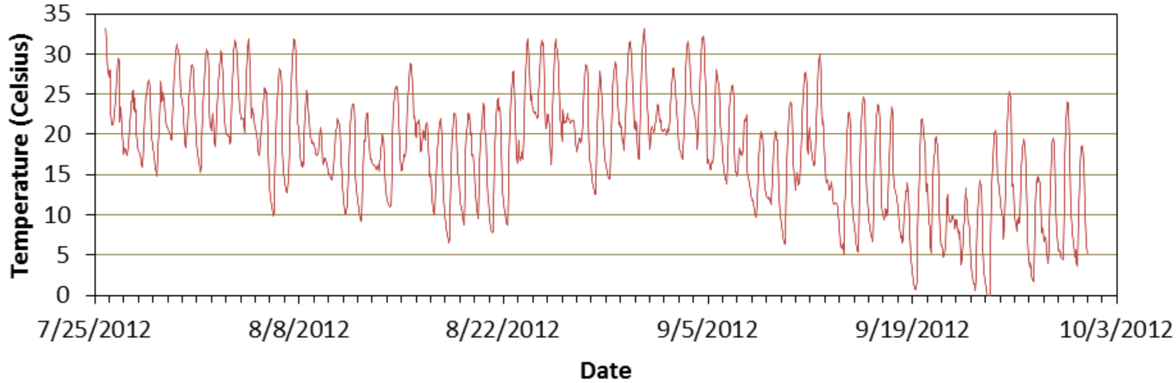


Source: U.S. Geological Survey and SEWRPC.

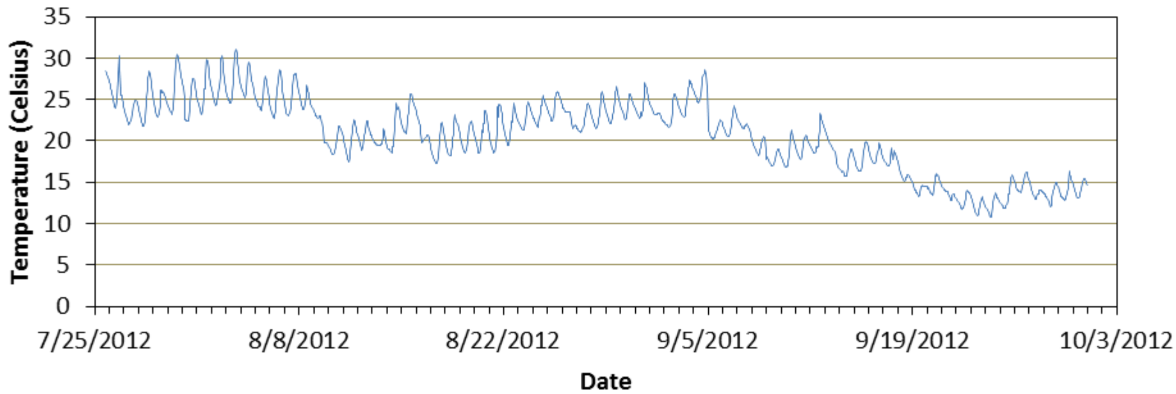
Figure II-20

CONTINUOUSLY RECORDED TEMPERATURE FOR SITES WITHIN THE JACKSON CREEK WATERSHED: JULY 25, 2012 THROUGH OCTOBER 3, 2012

Air Temperature



Tributary B near IH 43



Jackson Creek at CTH H

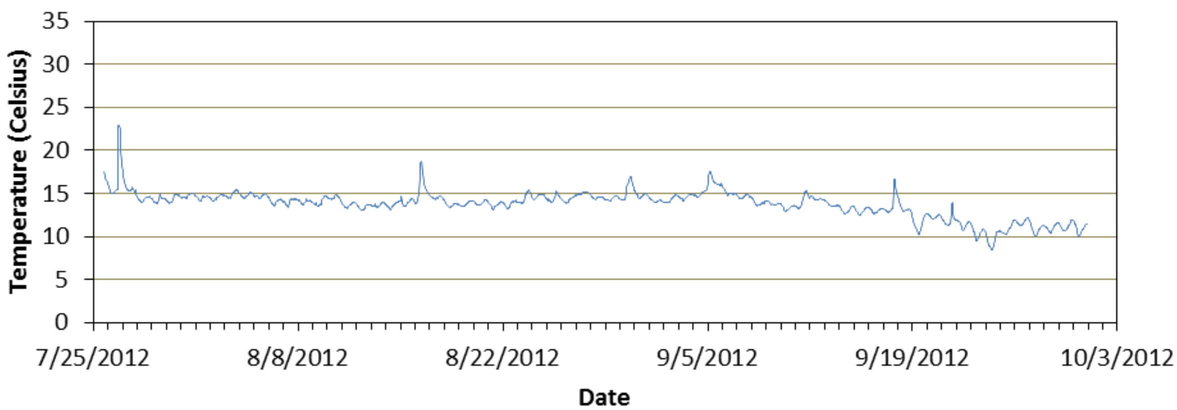
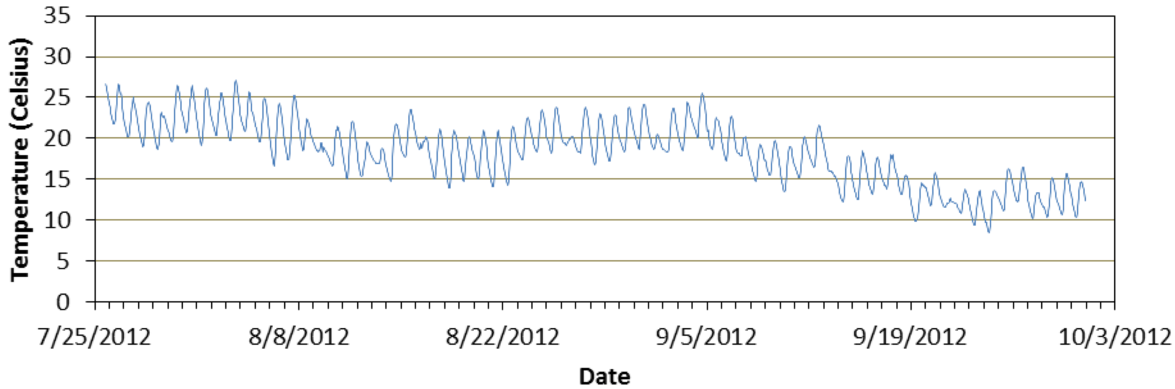
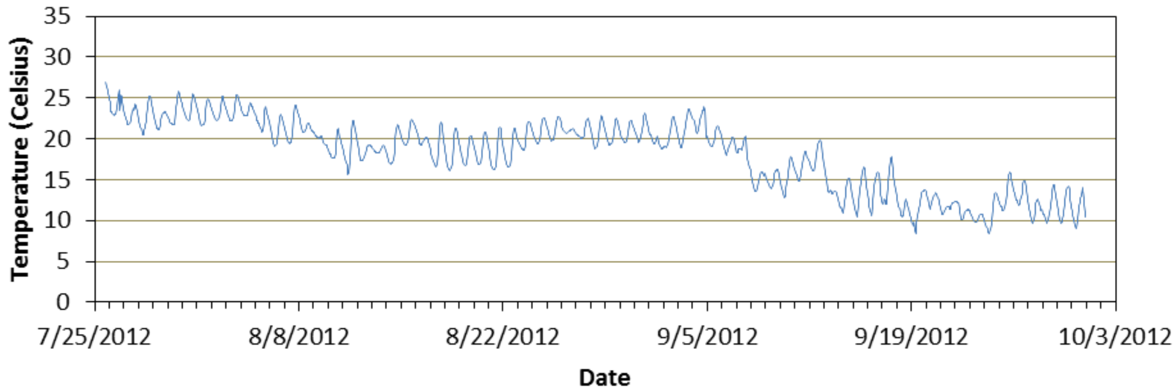


Figure II-20 (continued)

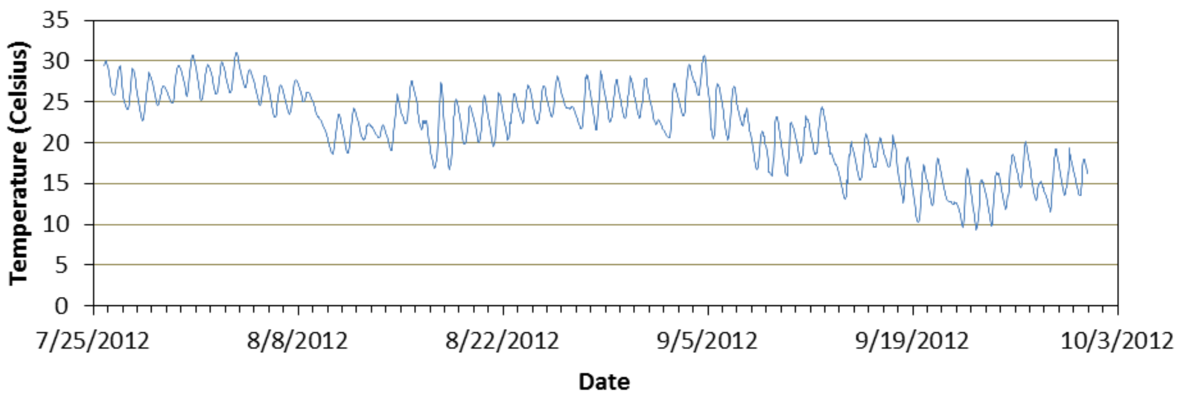
Jackson Creek at STH 67



Tributary A upstream of Wetland Complex



Jackson Creek at Mound Road

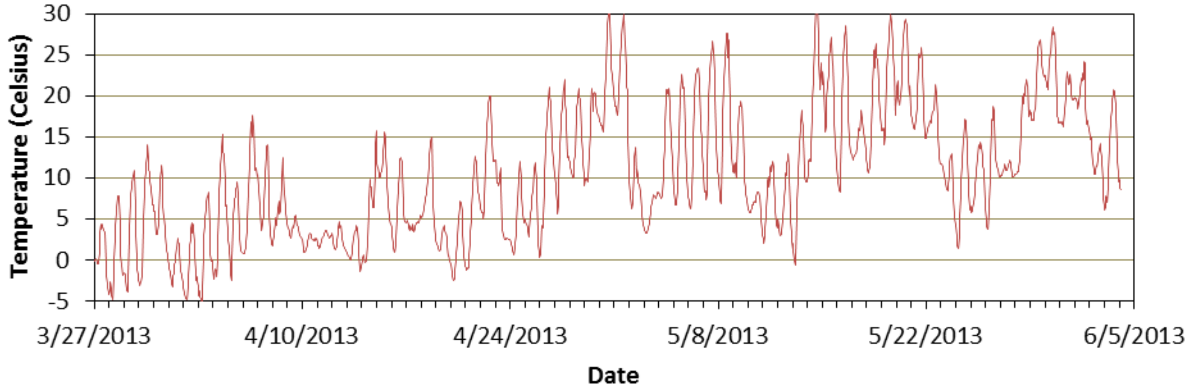


Source: SEWRPC.

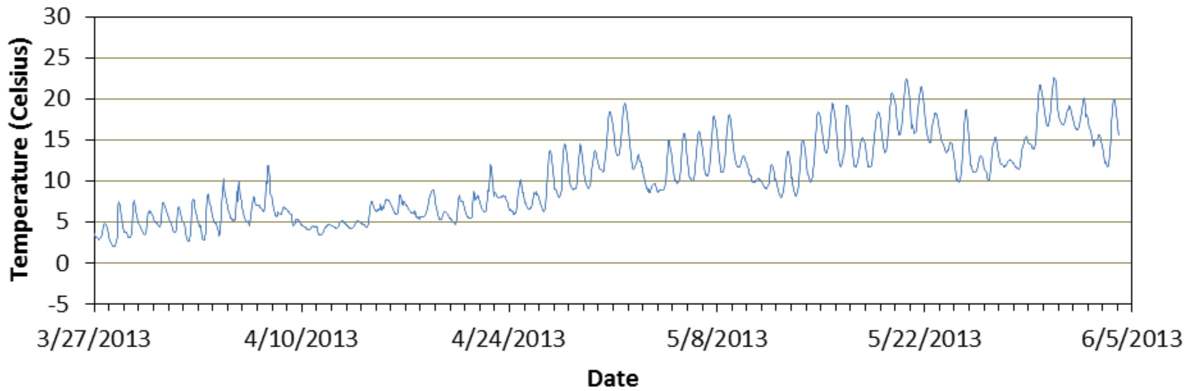
Figure II-21

CONTINUOUSLY RECORDED TEMPERATURE FOR SITES WITHIN THE JACKSON CREEK WATERSHED: MARCH 27, 2013 THROUGH JUNE 5, 2013

Air Temperature



Tributary B near IH 43



Jackson Creek at CTH H

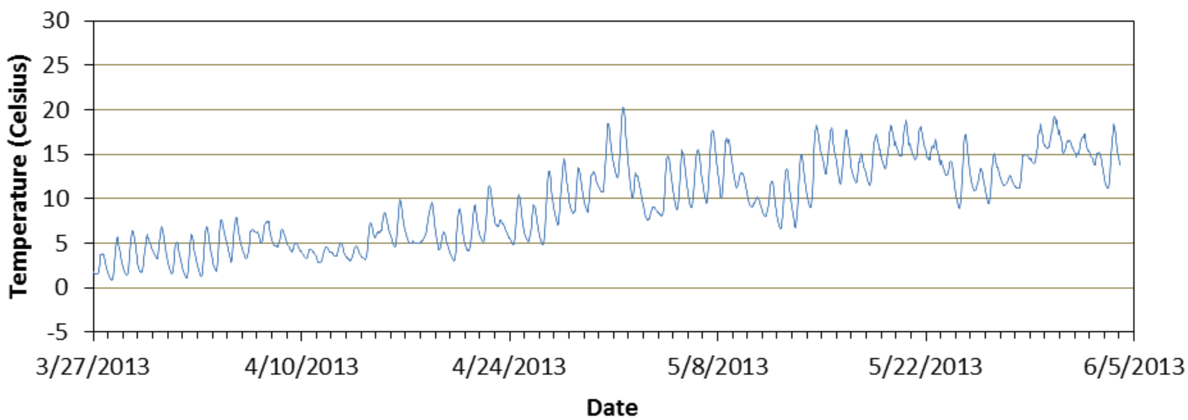
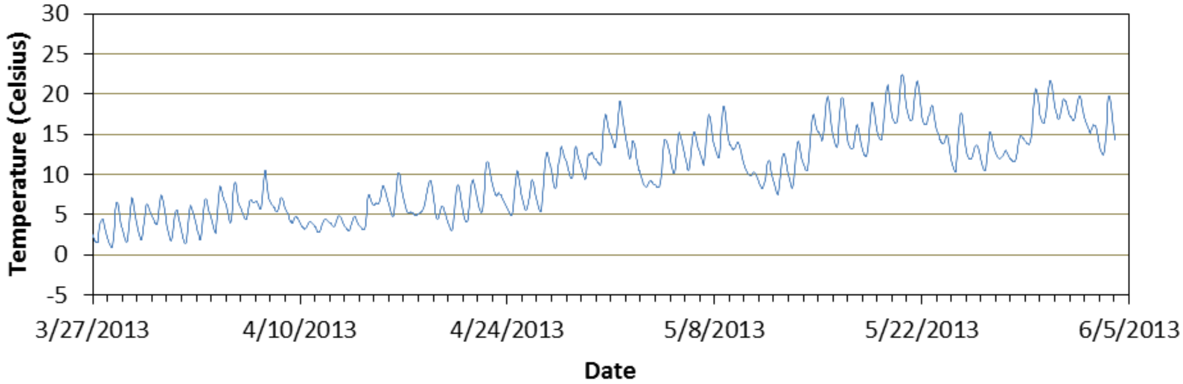
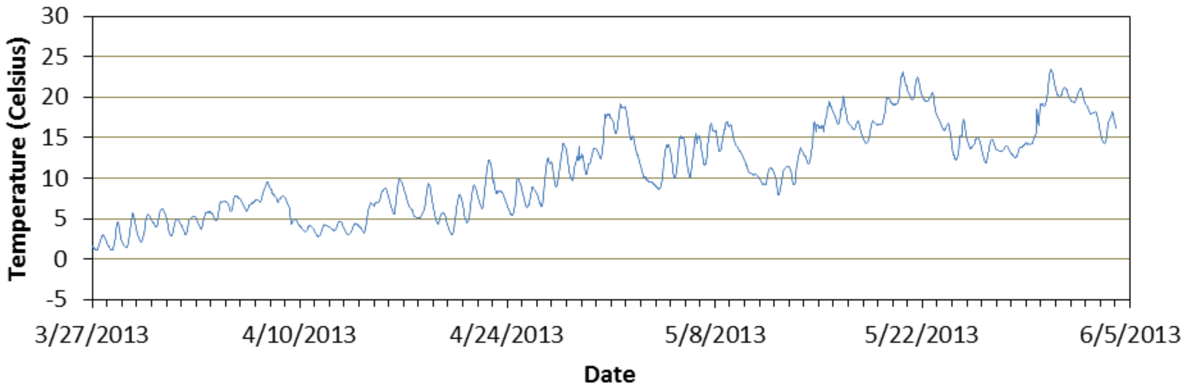


Figure II-21 (continued)

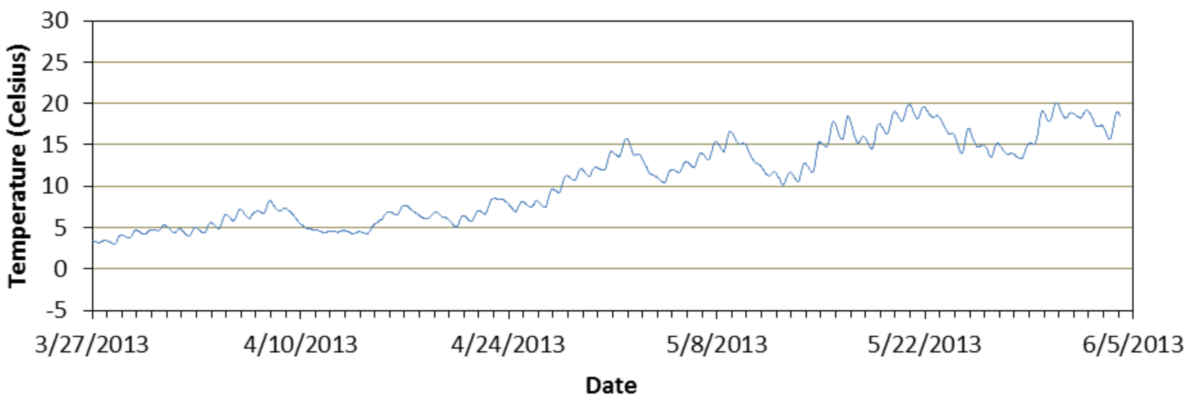
Jackson Creek at STH 67



Tributary A upstream of Wetland Complex



Jackson Creek at Mound Road



Source: SEWRPC.

Figure II-21a

HIGH SUSPENDED SEDIMENT LOADS IN TRIBUTARY B AND NORTH SEDIMENT BASIN DURING THE STORM EVENT ON JUNE 13, 2008, AND ALGAL BLOOMS IN JACKSON CREEK WATERSHED ON JULY 23,2012

West Sediment Basin-Upstream of Mound Road

Delavan Lake Inlet-Just downstream of Mound Road

Source: SEWRPC.

Figure II-21b

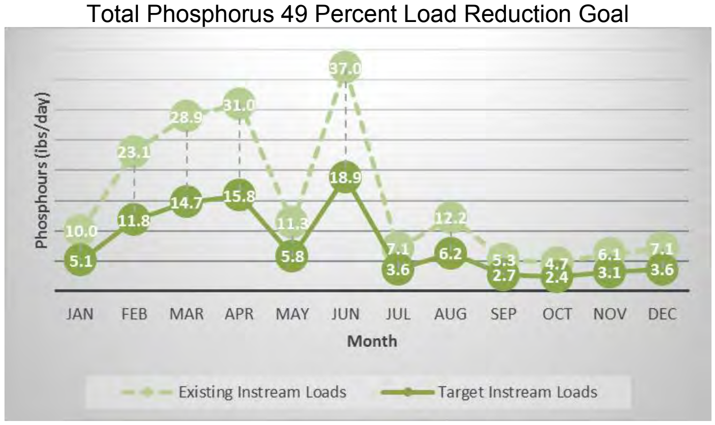
WDNR STAFF ELECTROFISHING SURVEY ON JACKSON CREEK AND ADULT RAINBOW DARTERS: JULY 16, 2013

Source: Maggie Zoellner, Kettle Moraine Land Trust and SEWRPC.

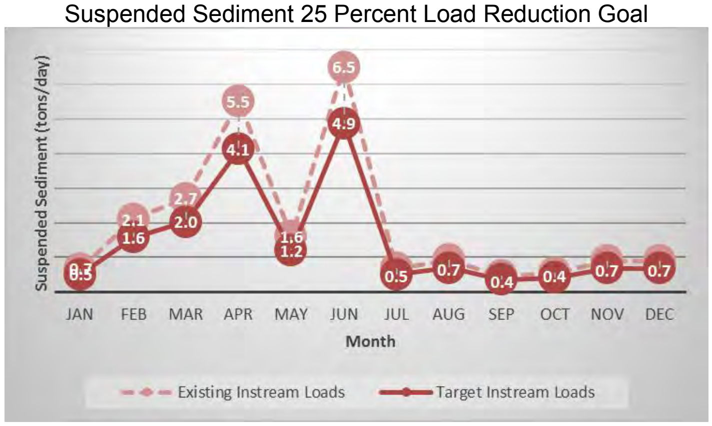
Figure II-21c

JACKSON CREEK WATERSHED MEASURED MONTHLY MEAN DAILY INSTREAM LOADS AND ESTIMATED LOAD REDUCTION GOALS FOR TOTAL PHOSPHORUS (LBS/DAY) AND SUSPENDED SEDIMENT (TONS/DAY) AT THE MOUND ROAD MONITORING GAGE: 1993-2014

Total Phosphorus 49 Percent Load Reduction Goal



Suspended Sediment 25 Percent Load Reduction Goal

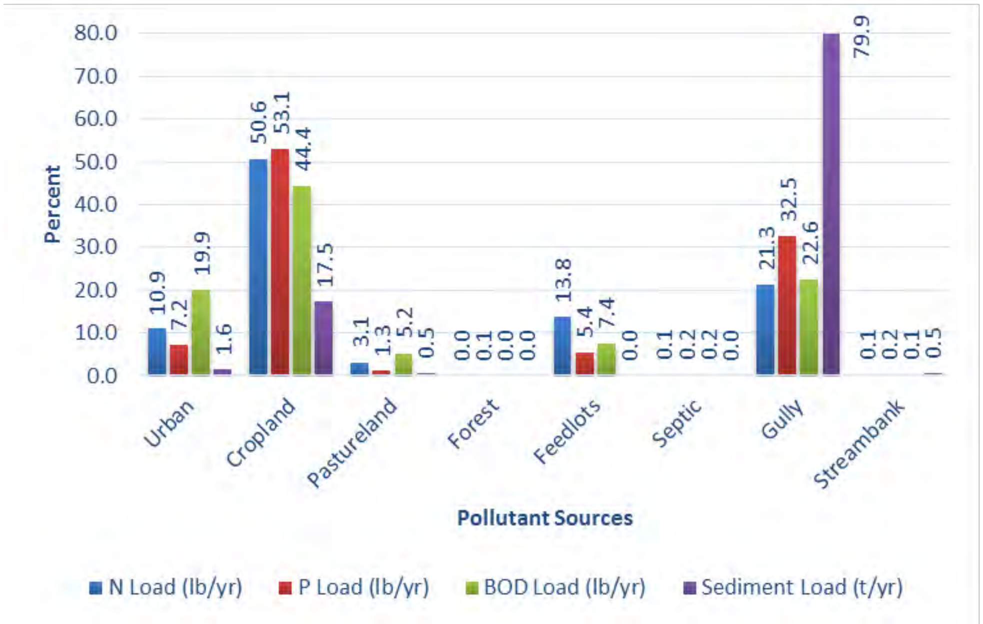


NOTE: Data were not available for years 2010, 2011, and 2012 or the months of October, November, and December in years 2009 and 2014.

Source: USGS and SEWRPC.

Figure II-21d

PROPORTION OF NITROGEN (N), PHOSPHORUS (P), BIOCHEMICAL OXYGEN DEMAND (BOD), AND SEDIMENT LOADS AMONG POLLUTANT SOURCES WITHOUT BEST MANAGEMENT PRACTICES (BMPs) WITHIN THE JACKSON CREEK WATERSHED: 2010

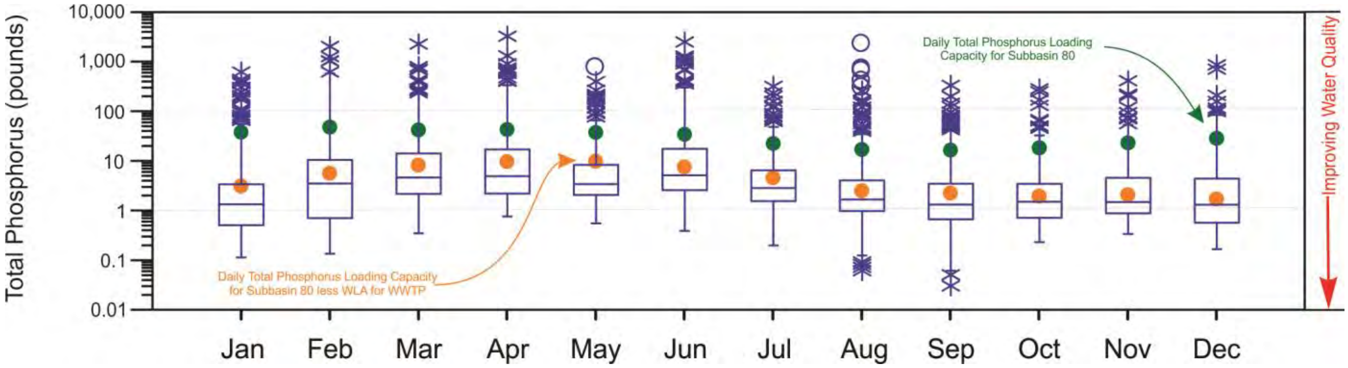


NOTE: This modeled information, developed using STEPL, was based upon year 2010 land use and accounts for known installed practices or conditions up to year 2014, where applicable.

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

Figure II-22

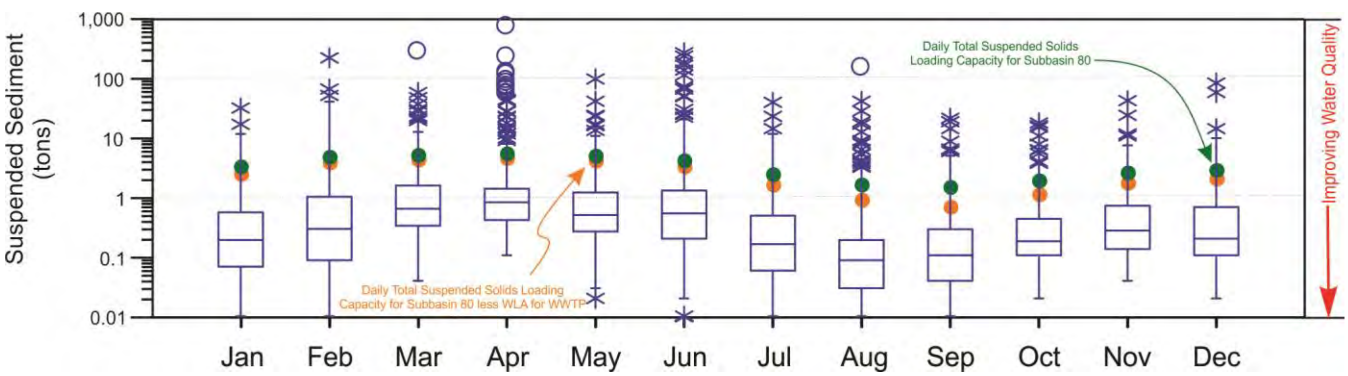
DAILY LOADS OF TOTAL PHOSPHORUS AT MOUND ROAD: 1993-2009, 2013



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

Figure II-23

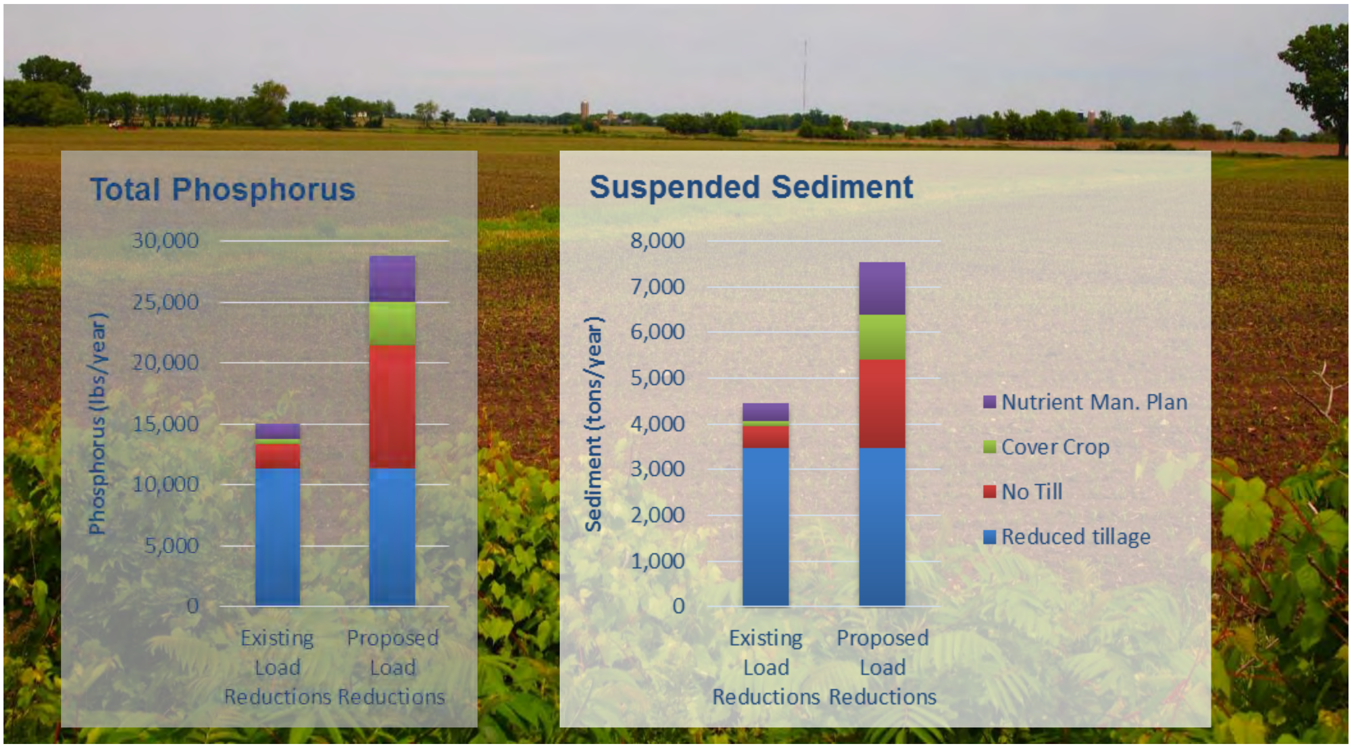
DAILY LOADS OF SUSPENDED SEDIMENT AT MOUND ROAD: 1993-2009, 2013



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

Figure II-24

EXISTING AND RECOMMENDED ANNUAL STEPL LOAD REDUCTIONS AMONG AGRICULTURAL BMPs APPLIED TO CROPLAND FOR TOTAL PHOSPHOURS (LBS/YEAR) AND SUSPENDED SEDIMENT (TONS/YEAR) WITHIN THE JACKSON CREEK WATERSHED: 2015



NOTE: The load reductions for nitrogen and BOD are not included in this graph, but were proportionally similar to the phosphorus and sediment load reductions shown (see Appendix B for details).

Source: SEWRPC.

Figure II-25

EXAMPLES OF FARMING PRACTICES WITHIN THE JACKSON CREEK WATERSHED

LOW RESIDUE WITH EROSION AND CONCENTRATED FLOW

HIGH RESIDUE/NO TILL FARMING PRACTICE

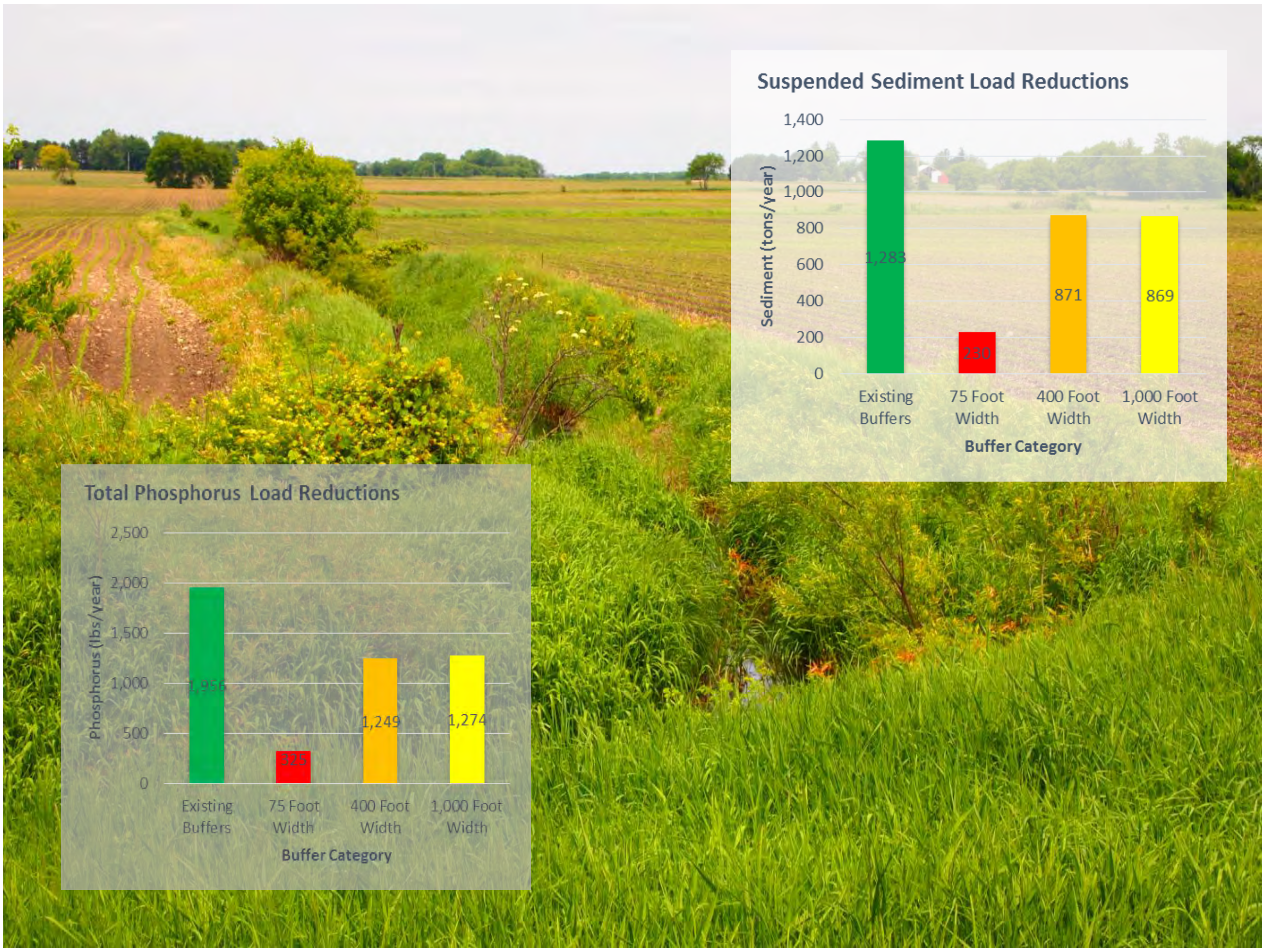
COVER CROP WINTER WHEAT NO-TILL PLANTED INTO SHREDDED CORN STALKS

NOTE: The cover crop photo was the only photo not from the Jackson Creek watershed.

Source: Maggie Zoellner, Kettle Moraine Land Trust, NRCS, and SEWRPC.

Figure II-26

ESTIMATED ANNUAL POLLUTANT LOAD REDUCTIONS FOR EXISTING RIPARIAN BUFFERS AND PROPOSED RIPARIAN BUFFERS/POTENTIALLY RESTORABLE WETLAND AMONG WIDTH CATEGORIES FOR TOTAL PHOSPHOURS (LBS/YEAR) AND SUSPENDED SEDIMENT (TONS/YEAR) WITHIN THE JACKSON CREEK WATERSHED: 2015
(AREAS CORRESPOND WITH MAP B-2 IN APPENDIX B)

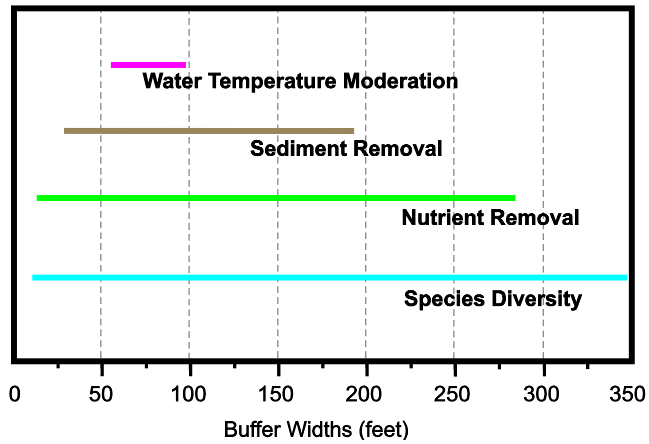


NOTE: The load reductions for nitrogen and BOD are not included in this graph, but were proportionally similar to the phosphorus and sediment load reductions shown.

Source: SEWRPC.

Figure II-27

RANGE OF BUFFER WIDTHS FOR PROVIDING SPECIFIC BUFFER FUNCTIONS



NOTE: Site-specific evaluations are required to determine the need for buffers and specific buffer characteristics.

Source: Adapted from A. J. Castelle and others, "Wetland and Stream Buffer Size Requirements-A Review," Journal of Environmental Quality*, Vol. 23.*

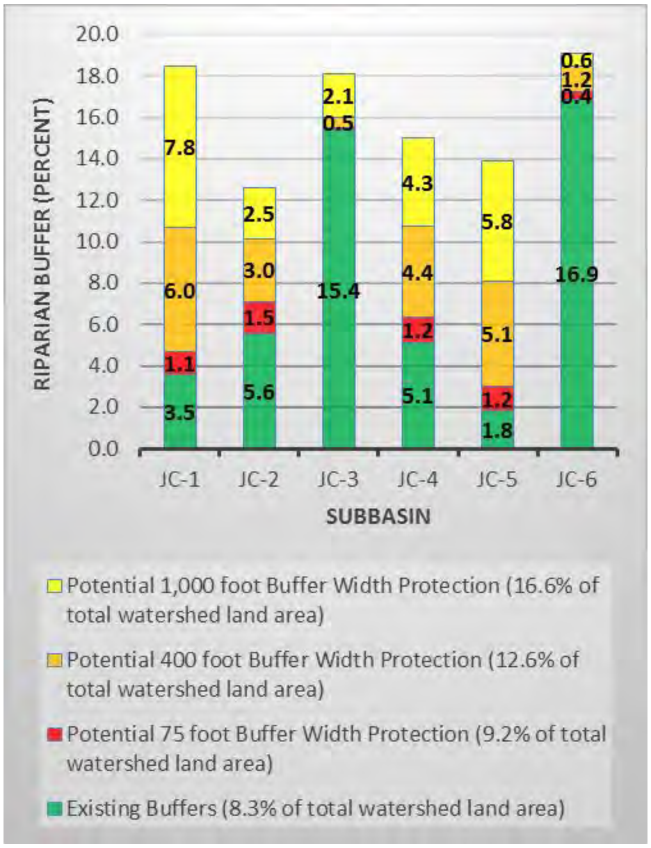
Figure II-28

MIGRATING WATERFOWL AND BASKING TURTLE WITHIN THE NORTH DETENTION BASIN UPSTREAM OF MOUND ROAD: JUNE 4, 2013

Source: SEWRPC.

Figure II-29

PERCENT EXISTING AND POTENTIAL BUFFERS AMONG EACH SUBBASIN WITHIN THE JACKSON CREEK WATERSHED: 2010 (AREAS CORRESPOND TO MAP II-10)



Source: SEWRPC.

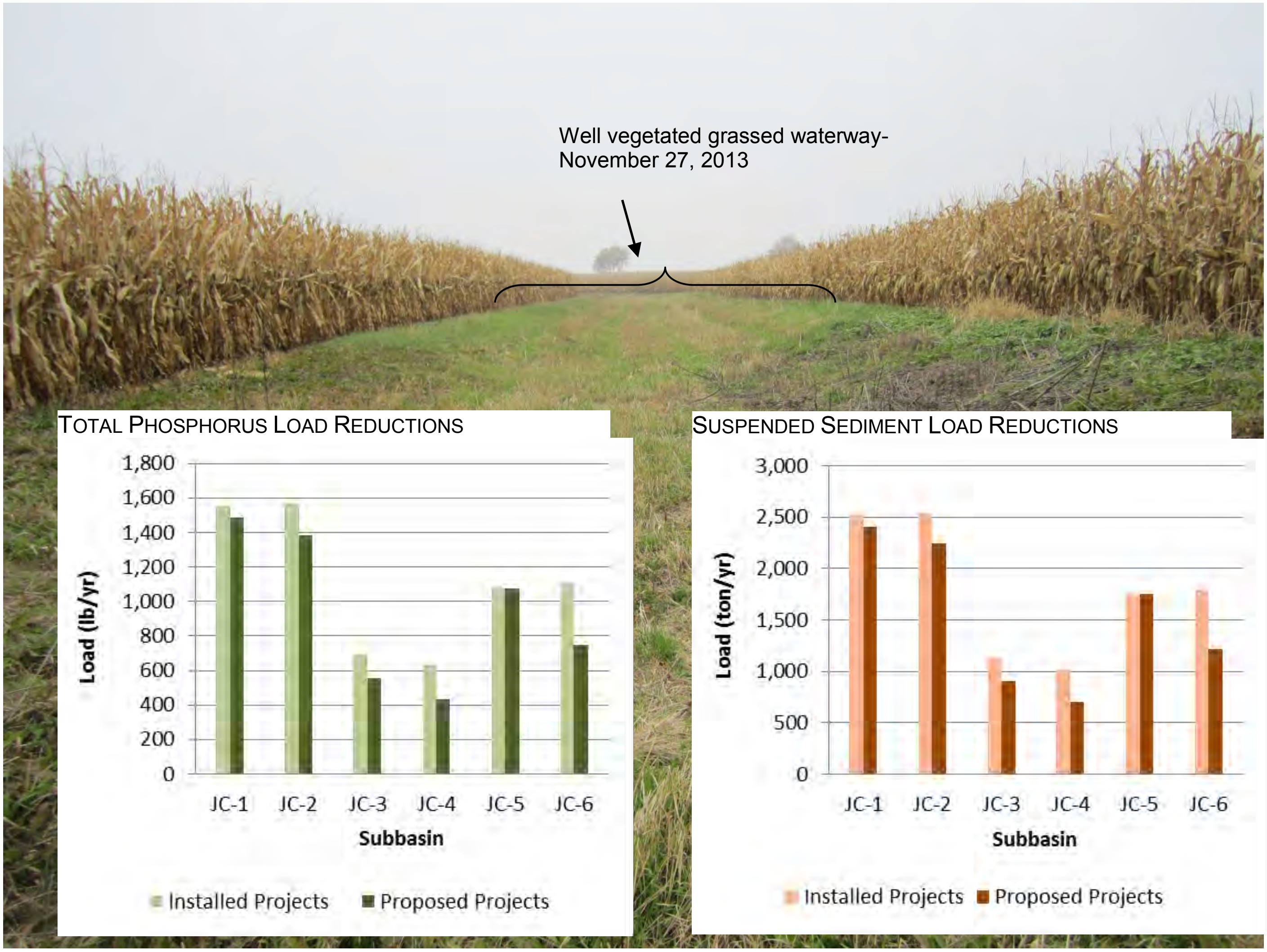
Figure II-30

EXAMPLE OF FAILED AND STRESSED CROPS ADJACENT TO A DRAINAGE DITCH/UNNAMED TRIBUTARY DUE TO FLOODING IN THE JACKSON CREEK WATERSHED: 2015

Source: Maggie Zoellner, Kettle Moraine Land Trust, and SEWRPC.

Figure II-31

ANNUAL POLLUTANT LOAD REDUCTIONS FOR INSTALLED AND PROPOSED GRASSED WATERWAYS AMONG SUBBASINS FOR TOTAL PHOSPHORUS (LBS/YEAR) AND SUSPENDED SEDIMENT (TONS/YEAR) WITHIN THE JACKSON CREEK WATERSHED: 2015



NOTE: The load reductions for nitrogen are not included in this graph, but were proportionally similar to the phosphorus and sediment load reductions shown.

Source: SEWRPC.

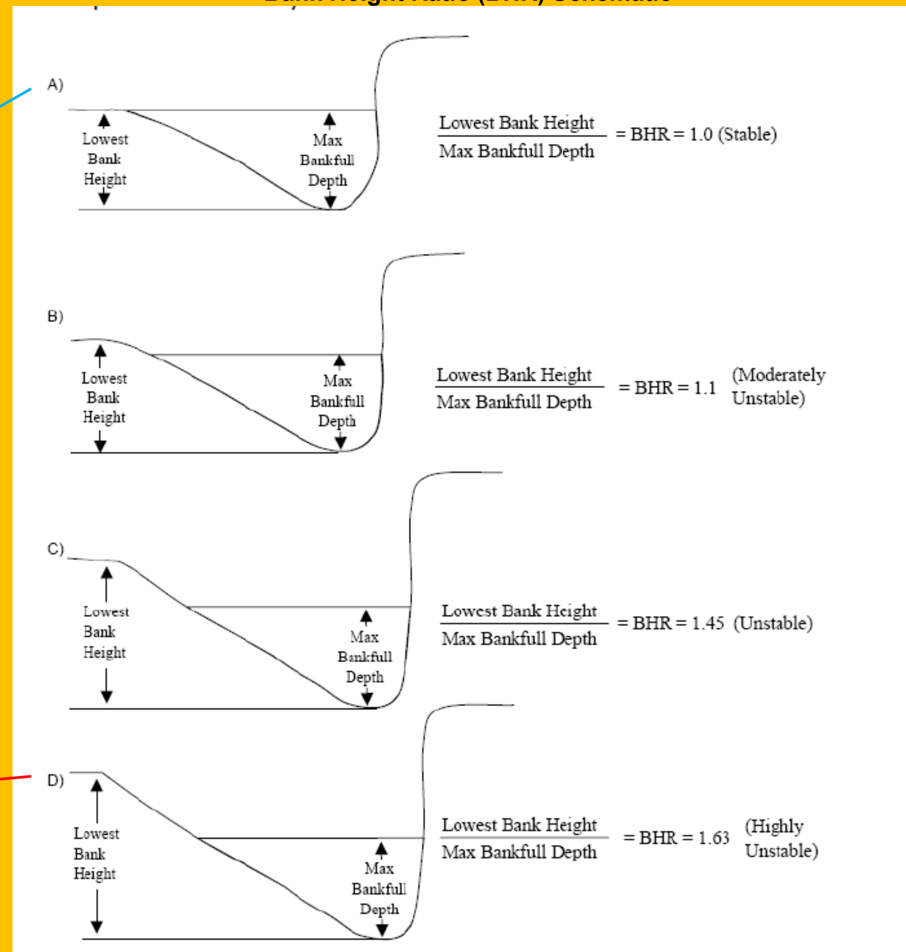
Figure II-32

FLOODPLAIN CONNECTIVITY COMPARISON AMONG REACHES AND SCHEMATIC OF BANK HEIGHT RATIO (BHR) WITHIN THE MAINSTEM OF JACKSON CREEK: 2012-2013

Reach 3-Connected Floodplain & Stable Streambanks

Reach 4-Disconnected Floodplain & Unstable Streambanks

Bank Height Ratio (BHR) Schematic

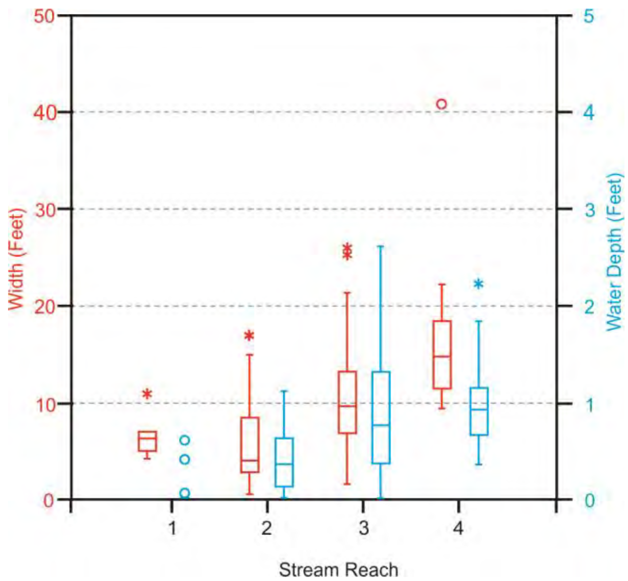


Note: BHR is the height of the top of the bank divided by the bankfull discharge height. Typically measured from the toe. The BHR is a relative measure of the floodplain connectivity to the bankfull channel.

Source: W. Barry Southerland, Fluvial Geomorphologist, NRCS, http://www.ars.usda.gov/SP2UserFiles/Place/30501000/esd/talks07/geomorph_terms.pdf, and SEWRPC.

Figure II-33

MEAN STREAM WATER WIDTH AND DEPTH AMONG REACHES IN THE JACKSON CREEK WATERSHED: 2012-2013

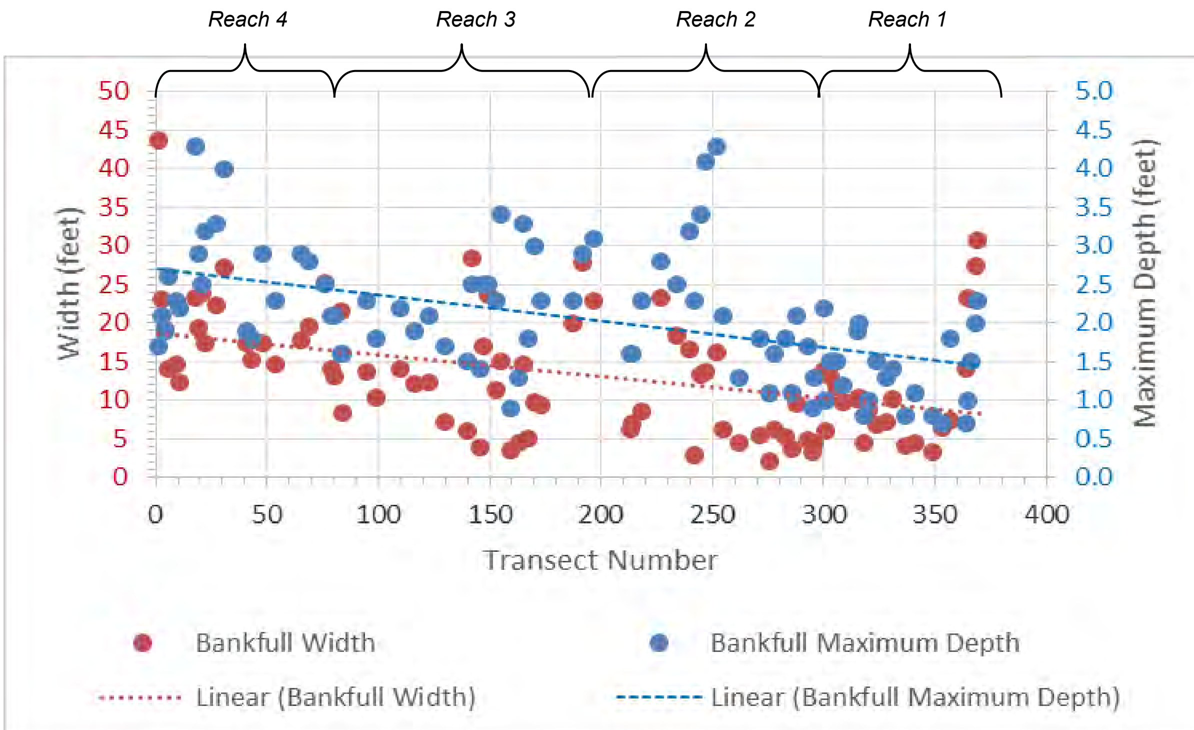


NOTE: See Figure II-8 for description of symbols.

Source: SEWRPC.

Figure II-34

BANKFULL WIDTH AND MAXIMUM DEPTH CONDITIONS AMONG REACHES WITHIN THE MAINSTEM OF JACKSON CREEK: 2012-2013



Source: SEWRPC.

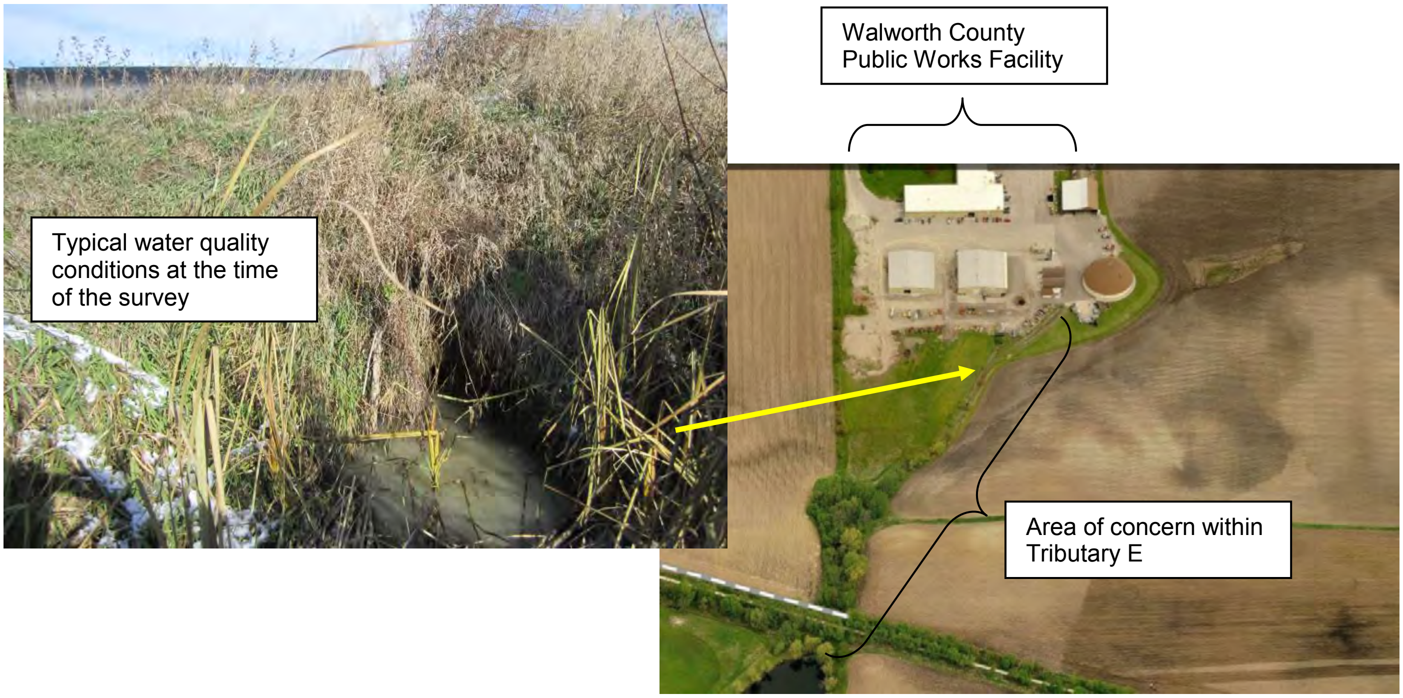
Figure II-35

EXAMPLES OF INSTREAM COVER WITHIN THE JACKSON CREEK WATERSHED: 2012-2013

Source: SEWRPC.

Figure II-35a

WATER QUALITY AREA OF CONCERN WITHIN TRIBUTARY E OF THE JACKSON CREEK WATERSHED: November 13, 2013



Source: Earthstar Geographics SIO © 2015 Microsoft and SEWRPC.

Figure II-36

STREAM CROSSINGS AND DAM LOCATIONS WITHIN THE JACKSON CREEK WATERSHED: 2012-2013

1- MOUND ROAD AND WEIR
JACKSON CREEK (RM 1.9)

2- PRIVATE CULVERTS
JACKSON CREEKFARM (RM 3.1)

3- STH 67
JACKSON CREEK (RM 3.4)

4- PETRIE ROAD
JACKSON CREEK (RM 4.9)

5- CTH H
JACKSON CREEK (RM 5.2)

6- PRIVATE DRIVE
JACKSON CREEK (RM 5.3)

7- FARM CROSSING
JACKSON CREEK (RM 6.1)

8- FARM CROSSING
JACKSON CREEK (RM 6.3)

9- STH 12
JACKSON CREEK (RM 6.7)

10- MACLEAN ROAD
JACKSON CREEK (RM 7.3)

11- FARM CROSSING
JACKSON CREEK (RM 7.5)

12- WHITE RIVER REC. TRAIL
JACKSON CREEK (RM 7.7)

Source: SEWRPC.

Figure II-37

FISH PASSAGE BARRIERS WITHIN THE JACKSON CREEK WATERSHED: 2012-2013

Structure No. 2 at River Mile 3.1-Partial Barrier

- *Inadequate depths and separation of flows into three different pipes limits passage under low flows and during high flow/high velocity events, due to limited swimming abilities and/or behavior.*

Structure No. 1 at River Mile 1.9-Complete Barrier

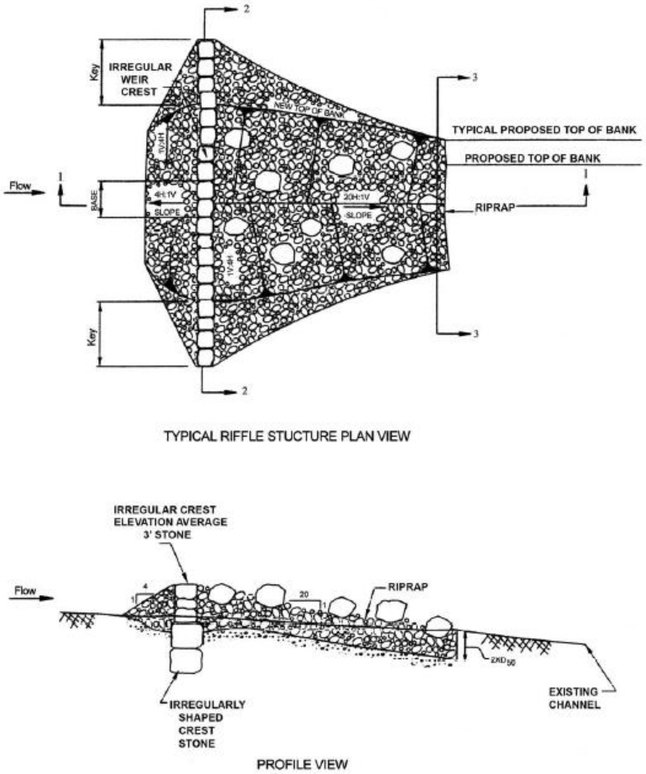
- *Stream gauge is a dam limiting fish passage for native fish species for all flows except extreme flooding events, due to limited jumping abilities and/or behavior*
- *This gauge is not navigable for kayaks or canoes*

Common carp are active swimmers that can leap obstacles up to three feet high and negotiate torrential flows. This mobility enhances the risk of further spread into areas uninhabited by common carp.

Source: USGS and SEWRPC.

Figure II-38

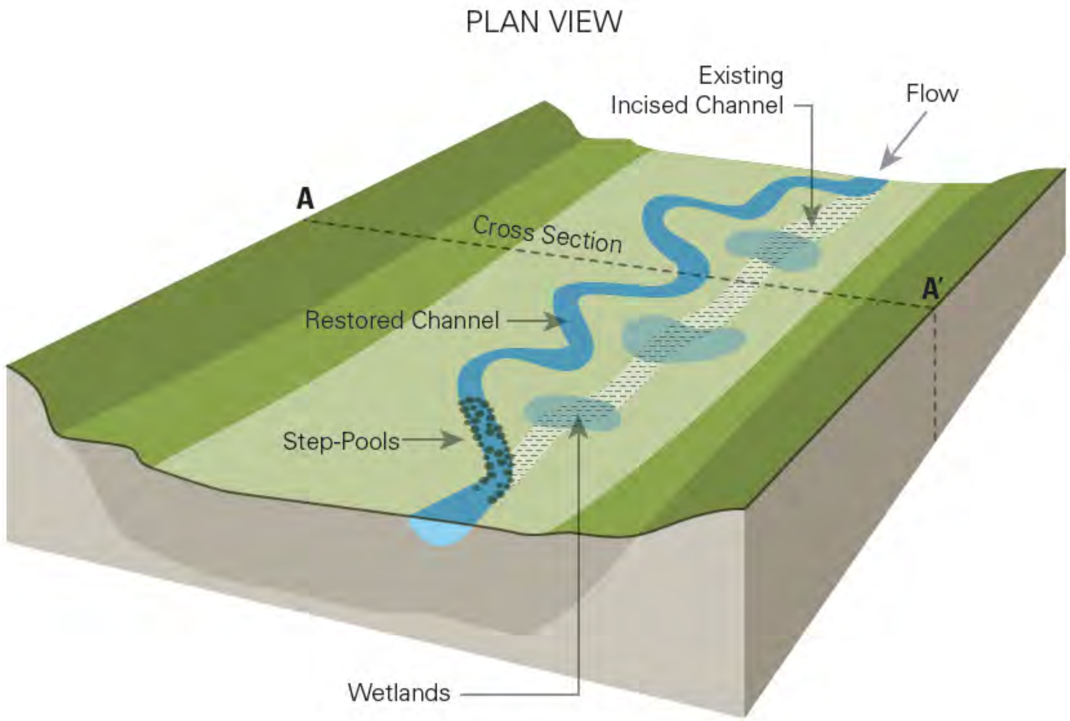
A TYPICAL DESIGN OF A ROCK RIFFLE STRUCTURE

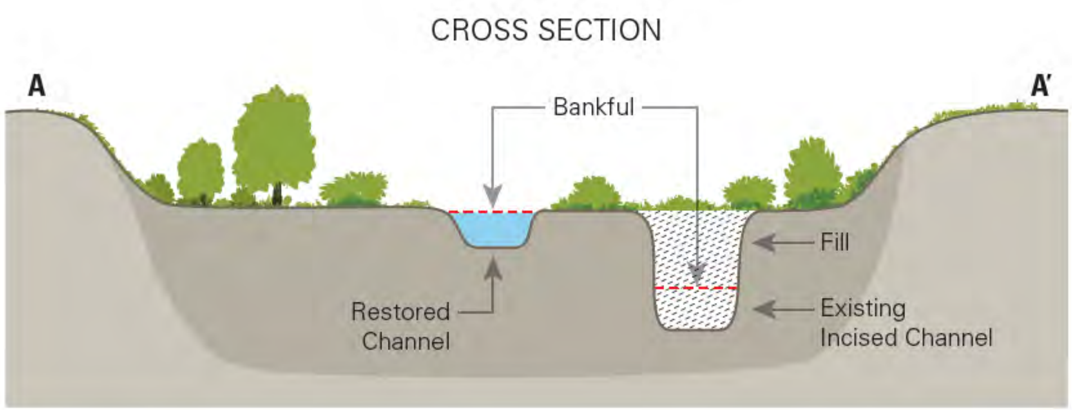


Source: David T. Williams, Ph.D., P.E., David T. Williams and Associates, Engineers, david@dtwassoc.com and William White, John Beardsley, Scott Tomkins, Waukegan River Illinois National Nonpoint Source Monitoring Program Project, Illinois State Water Survey, January 2011.

Figure II-39

POTENTIAL STREAM RESTORATION DESIGN EXAMPLE FOR JACKSON CREEK TO IMPROVE STREAM FUNCTION THROUGH DIVERTING OR RECONSTRUCTING A MORE NATURAL MEANDERING CHANNEL FROM A CHANNELIZED/INCISED CONDITION

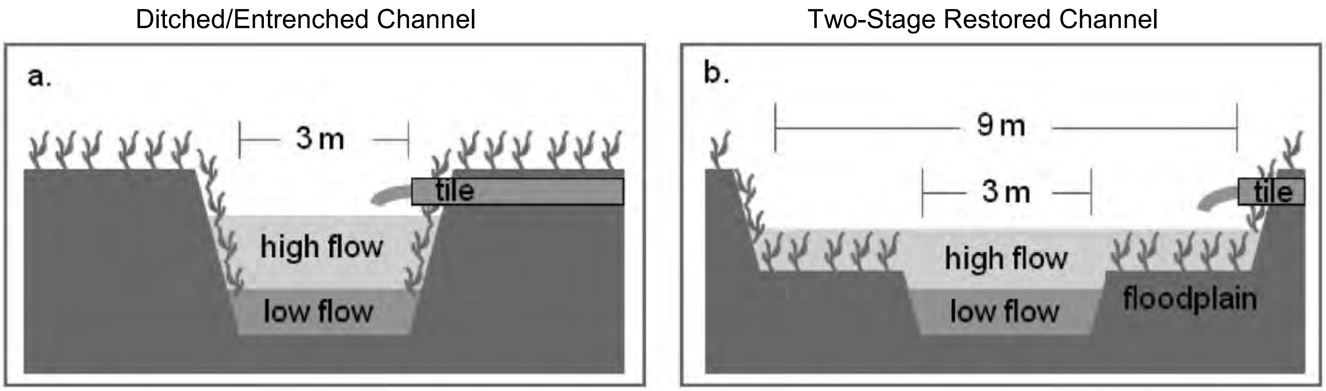




Source: Rosgen Priority Level 1 restoration approach adapted from Harman, W., et al. 2012. A Function-Based Framework for Stream Assessment and Restoration Projects. US Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC EPA 843-K-12-006.

Figure II-40

SCHEMATIC OF A TWO-STAGE DESIGN CHANNEL

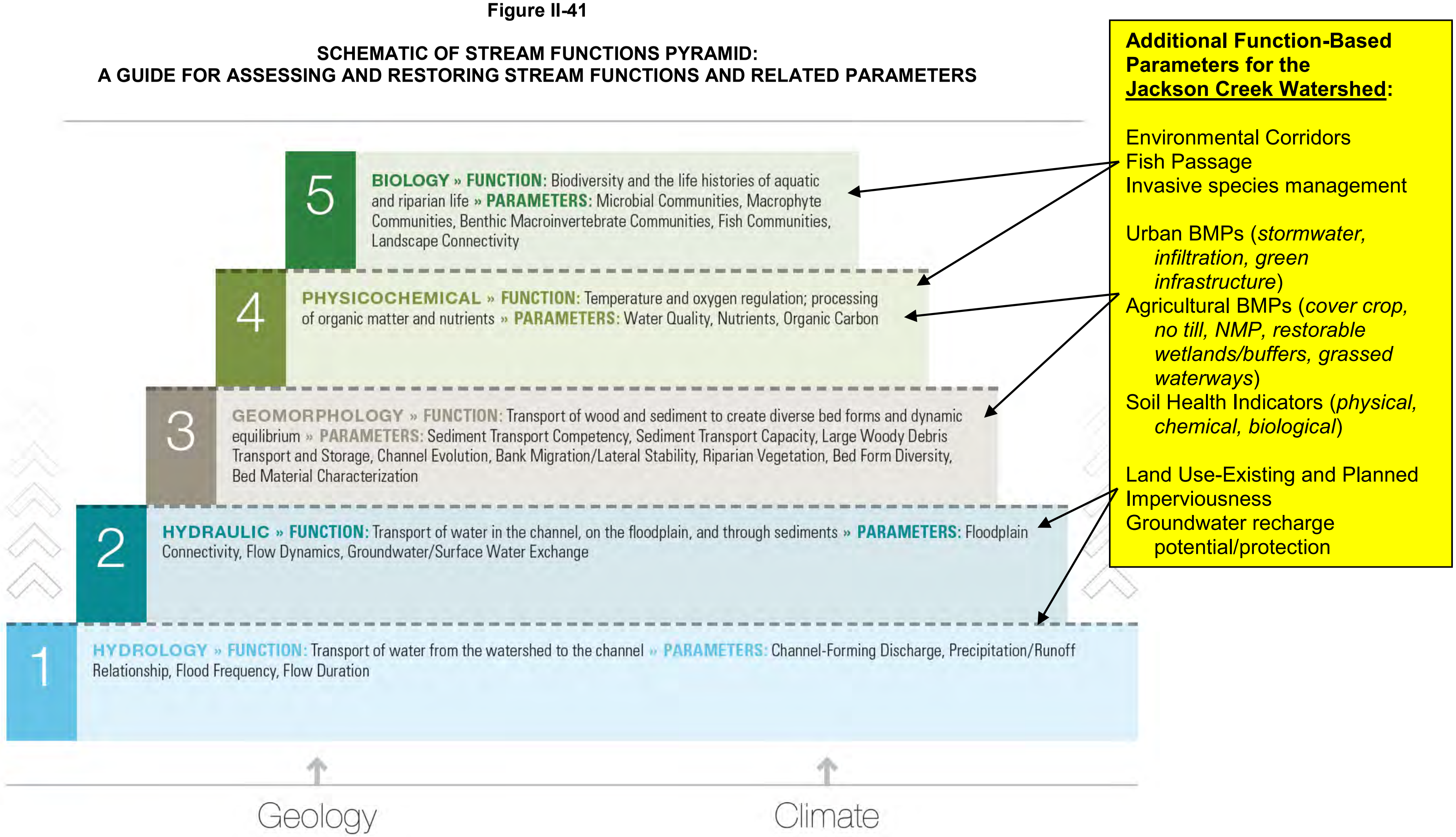


NOTE: The two-stage ditch design: a) Trapezoidal channel, with steep slopes, lack of floodplain connectivity, and drain tile, prior to floodplain restoration; b) restored two-stage ditch, with drain tiles cut back. The dark gray represents water levels during base flow and the light gray represents water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

Source: Adapted from the Nature Conservancy and Sarah S. Roley, Jennifer L. Tank, and Maureen A. Williams, Hydrologic connectivity increases denitrification in the hyporheic zone and restored floodplains of an agricultural stream, Journal Of Geophysical Research, Vol. 117, G00N04, doi:10.1029/2012JG001950, 2012, and SEWRPC.

Figure II-41

SCHEMATIC OF STREAM FUNCTIONS PYRAMID:
A GUIDE FOR ASSESSING AND RESTORING STREAM FUNCTIONS AND RELATED PARAMETERS



Source: Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs, C. Miller. 2012. A Function-Based Framework for Stream Assessment and Restoration Projects. US Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC EPA 843-K-12-006; Fischenich, J.C., Functional objectives for stream restoration, EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-52). Vicksburg, MS: U.S. Army Engineer Research and Development Center, 2006, www.wes.army.mil/el/emrrp; and SEWRPC

CAPR-320 CH-2 TABLES DRAFT (00229162).DOC
300-1115
TMS
06/12/15

SEWRPC Community Assistance Planning Report No. 320

JACKSON CREEK WATERSHED PROTECTION PLAN

Chapter II

INVENTORY FINDINGS

TABLES

(This Page Left Blank Intentionally)

Table II-1

APPLICABLE WATER QUALITY CRITERIA FOR STREAMS AND LAKES IN SOUTHEASTERN WISCONSIN

Water Quality Parameter	Designated Use Category[a]						Source
	Coldwater Community	Warmwater Fish and Aquatic Life	Limited Forage Fish Community (variance category)	Special Variance Category A[b]	Special Variance Category B[c]	Limited Aquatic Life Community (variance category)	
Temperature (°F)	See Table II-2					86.0 °F	NR 102 Subchapter II
Dissolved Oxygen (mg.L)	6.0 minimum 7.0 minimum during spawining	5.0 minimum	3.0 minimum	2.0 minimum	2.0 minimum	1.0 minimum	NR 102.04(4) NR 104.04(3) NR 102.06(2)
pH Range (standard units)	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	NR 102.04(4)[d]
Fecal Coliform Bacteria (MFFCC)							NR 102.04(5) NR104.06(2)
Geometric Mean	200	200	200	1,000	1,000	200	
Single Sample Maximum	400	400	400	2,000	- -	400	
Total Phosphorus (mg/l)							NR 102.06(3) NR 102.06(4) NR 102.06(5) NR 102.06(6)
Designated Streams[e]	0.100	0.100	0.100	0.100	0.100	0.100	
Other Streams	0.075	0.075	0.075	0.075	0.075	- -	
Stratified Reservoirs	0.030	0.030	0.030	0.030	0.030	- -	
Unstratified Reservoirs	0.040	0.040	0.040	0.040	0.040	- -	
Stratified Two-story Fishery Lakes	0.015	0.015	0.015	0.015	0.015	- -	
Stratified Drainage Lakes	0.030	0.030	0.030	0.030	0.030	- -	
Unstratified Drainage Lakes	0.040	0.040	0.040	0.040	0.040	- -	
Stratified Seepage Lakes	0.020	0.020	0.020	0.020	0.020	- -	
Unstratified Seepage Lakes	0.040	0.040	0.040	0.040	0.040	- -	
Chloride (mg/l)							NR 105.05(2) NR 105.06(5)
Acute Toxicity[f]	757	757	757	757	757	757	
Chronic Toxicity[g]	395	395	395	395	395	395	

[a]*NR 102.04(1) All surface waters shall meet the following conditions at all times and under all flow conditions: substances that will cause objectionable deposits on the shore or in the bed of a body of water, floating or submerged debris, oil, scum, or other material, and materials producing color, odor, taste or unsightliness shall not be present in such amounts as to interfere with public rights in waters of the State. Substances in concentrations which are toxic or harmful to humans shall not be present in amount found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant, or aquatic life.*

[b]*As set forth in Chapter NR 104.06(2)(a) of the* Wisconsin Administrative Code.

[c]*As set forth in Chapter NR 104.06(2)(b) of the* Wisconsin Administrative Code.

[d]*The pH shall be within the stated range with no change greater than 0.5 unit outside the estimated natural seasonal maximum and minimum.*

[e]*Designated in Chapter NR 102.06(3)(a) of the* Wisconsin Administrative Code. *There are no designated streams in the Jackson Creek watershed.*

[f]*The acute toxicity criterion is the maximum daily concentration of a substance which ensures adequate protection of sensitive species of aquatic life from the acute toxicity of that substance and will adequately protect the designated fish and aquatic life use of the surface water if not exceeded more than once every three years.*

[g]*The chronic toxicity criterion is the maximum four-day concentration of a substance which ensures adequate protection of sensitive species of aquatic life from the chronic toxicity of that substance and will adequately protect the designated fish and aquatic life use of the surface water if not exceeded more than once every three years.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table II-2

AMBIENT TEMPERATURES AND WATER QUALITY CRITERIA FOR TEMPERATURE FOR NONSPECIFIC STREAMS AND LAKES IN SOUTHERN WISCONSIN[a]

Month	Cold Water Communities			Large Warmwater Communities[b]			Small Warmwater Communities[c]			Limited Forage Fish Communities[d]			Inland Lakes and Impoundments[e]		
	Ta	**SL**	**A**	**Ta**	**SL**	**A**	**Ta**	**SL**	**A**	**Ta**	**SL**	**A**	**Ta**	**SL**	**A**
January	35	47	68	33	49	76	33	49	76	37	54	78	35	49	77
February	36	47	68	33	50	76	34	50	76	39	54	79	39	52	78
March	39	51	69	36	52	76	38	52	77	43	57	80	41	55	78
April	47	57	70	46	55	79	48	55	79	50	63	81	49	60	80
May	56	63	72	60	65	82	58	65	82	59	70	84	58	68	82
June	62	67	72	71	75	85	66	76	84	64	77	85	70	75	86
July	64	67	73	75	80	86	69	81	85	69	81	86	77	80	87
August	63	65	73	74	79	86	67	81	84	68	79	86	76	80	87
September	57	60	72	65	72	84	60	73	82	63	73	85	67	73	85
October	49	53	70	52	61	80	50	61	80	55	63	83	54	61	81
November	41	48	69	39	50	77	40	49	77	46	54	80	42	50	78
December	37	47	69	33	49	76	35	49	76	40	54	79	35	49	77

NOTE: Acronyms for temperature criteria categories include; **Ta**-ambient temperature, **SL**-sublethal temperature, and **A**-acute temperature. The ambient temperature, sublethal water quality criterion, and acute water quality criterion specified for any calendar month shall be applied simultaneously to establish the protection needed for each identified fish and other aquatic life use. The sublethal criteria are to be applied as the mean daily maximum temperature over a calendar week. The acute criteria are to be applied as the daily maximum temperature. The ambient temperature is used to calculate the corresponding acute and sublethal criterial and for determining effluent limitations in discharge permits under the Wisconsin Pollutant Discharge Elimination System.

[a]*As set forth in Section NR 102.25 of the* Wisconsin Administrative Code.

[b]*Waters with a fish and aquatic life use designation of "warmwater sportfish community" or "warmwater forage fish community" and unidirectional 7Q10 flows greater than or equal to 200 cubic feet per second. The 7Q10 flow is the seven-day consecutive low flow with a 10 percent annual probability of occurrence (10-year recurrence interval).*

[c]*Waters with a fish and aquatic life use designation of "warmwater sportfish community" or "warmwater forage fish community" and unidirectional 7Q10 flows less than 200 cubic feet per second. The 7Q10 flow is the seven-day consecutive low flow with a 10 percent annual probability of occurrence (10-year recurrence interval).*

[d]*Waters with a fish and aquatic life use designation of "limited forage fish community."*

[e]*Values are applicable for those lakes and impoundments south of STH 10.*

Source: Wisconsin Department of Natural Resources.

Table II-3

GUIDELINES FOR WATER QUALITY CONSTITUENTS IN SOUTHEASTERN WISCONSIN FOR WHICH WATER QUALITY CRITERIA HAVE NOT BEEN PROMULGATED

Water Quality Parameter	Stream Guideline	Lake and Reservoir Guideline	Category	Source
Total Suspended Solids (mg/l)	26	- -	TMDL target concentration	Rock River TMDL[a]
Nitrogen				
Total Nitrogen (mg/l)	0.65[b]	0.66	Streams: reference value Lakes: recommended criterion	USGS/WDNR[c] USEPA[d]
Nitrate plus Nitrite (mg/l)	0.94	0.04	Reference value	USEPA[d,e]
Total Kjeldahl Nitrogen (mg/l)	0.65	0.54	Reference value	USEPA[d,e]
Chlorophyll-*a* (*µ*g/l)	1.50[f]	2.63	Recommended criteria	USEPA[d,e]
Transparency tube (cm)[g]	> 115	- -	Reference value	USGS/WDNR[c]
Secchi Depth (m)	- -	3.33[h]	Recommended criterion	USEPA[d]
Turbidity (ntu)	1.70[i]	- -	Recommended criterion	USEPA[e]

[a]*U.S. Environmental Protection Agency and Wisconsin Department of Natural Resources,* 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, *July 2011.*

[b]*This is a reference value developed by USGS and WDNR for streams for this portion of Wisconsin. It should be noted that USEPA has developed a similar reference value for the southern Wisconsin till plains area of 1.30 mg/l and a recommended criterion for Nutrient Ecoregion VII (mostly glaciated dairy region) of 0.54 mg/l.*

[c]*D.M. Robertson, D J. Graczyk, L. Wang, G. LaLiberte, and R. Bannerman,* Nutrient Concentrations and Their Relations to the Biotic Integrity of Wadeable Streams in Wisconsin, *U.S. Geological Survey Professional Paper No. 1722, 2006.*

[d]*U.S. Environmental Protection Agency,* Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria: Lakes and Reservoirs in Nutrient Ecoregion VII, *EPA 822-B-00-009, December 2000.*

[e]*U.S. Environmental Protection Agency,* Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria: Rivers and Streams in Nutrient Ecoregion VII, *EPA 822-B-00-018, December 2000.*

[f]*This is consistent with the finding by USGS and WDNR of reference values for chlorophyll-*a *in wadeable streams in Wisconsin between 1.20 and 1.70* µ*g/l. It should be noted that the guideline and reference values are based upon fluorometric analysis of chlorophyll-*a *concentrations. Other values may apply for chlorophyll-*a *concentrations that were determined using other techniques.*

[g]*This is based on the use of a minimum transparency tube length of 120 cm.*

[h]*For the southern Wisconsin till plains area, the USEPA found a reference value for secchi depth of 3.19 m.*

[i]*It should be noted that the guideline and recommended criterion are based upon nephelometric analysis of turbidity. Other values may apply for turbidity determined using other techniques.*

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

Table II-4

DAILY TOTAL PHOSPHORUS ALLOCATIONS FOR ROCK RIVER WATERSHED SUB-BASIN 80 FROM THE ROCK RIVER WATERSHED TMDL

Allocation Component	Daily Total Phosphorus Load (pounds per day)												Annual Load Allocation (pounds per year)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Wasteload Allocation													
General Permit Sources	0.16	0.24	0.20	0.16	0.33	0.51	0.65	0.42	0.35	0.15	0.14	0.07	102.90
MS4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WWTF	36.87	44.08	36.17	35.67	30.44	29.49	20.35	16.76	16.53	18.74	23.39	29.06	4,278.97
Subtotal	37.03	44.32	36.37	35.83	30.77	30.00	21.00	17.18	16.88	18.89	23.53	29.13	4,381.87
Load Allocation													
Background	1.20	1.45	1.47	0.32	0.21	0.11	0.29	0.31	0.32	0.09	0.07	0.01	176.18
Ag/Non-Permitted Urban	1.93	3.92	6.19	8.64	8.70	6.65	3.68	1.98	1.78	1.91	2.08	1.83	1,497.08
Subtotal	3.13	5.37	7.66	8.96	8.91	6.76	3.97	2.29	2.10	2.00	2.15	1.84	1,673.26
Total Loading Capacity	40.16	49.69	44.03	44.79	39.68	36.76	24.97	19.47	18.98	20.89	25.68	30.97	6,055.13

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

Table II-5

DAILY TOTAL SUSPENDED SOLIDS ALLOCATIONS FOR ROCK RIVER WATERSHED SUB-BASIN 80 FROM THE ROCK RIVER WATERSHED TMDL

Allocation Component	Daily Total Suspended Solids Load (tons per day)												Annual Load Allocation (tons per year)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Wasteload Allocation													
General Permit Sources	0.02	0.03	0.02	0.02	0.03	0.05	0.06	0.04	0.04	0.02	0.02	0.01	10.94
MS4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WWTF	0.56	0.62	0.56	0.58	0.56	0.58	0.56	0.52	0.58	0.56	0.58	0.56	86.71
Subtotal	0.58	0.60	0.58	0.60	0.59	0.63	0.62	0.56	0.62	0.58	0.60	0.57	97.65
Load Allocation													
Background	0.05	0.05	0.05	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.01	6.63
Ag/Non-Permitted Urban	1.71	2.58	2.87	3.06	2.79	2.26	1.17	0.69	0.53	0.86	1.29	1.50	645.73
Subtotal	1.76	2.63	2.92	3.08	2.81	2.27	1.17	0.69	0.53	0.86	1.30	1.51	652.36
Total Loading Capacity	2.34	3.28	3.50	3.68	3.40	2.90	1.79	1.25	1.15	1.44	1.90	2.08	750.01

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

Table II-6

WATER QUALITY AND/OR QUANTITY SAMPLING STATIONS WITHIN THE JACKSON CREEK WATERSHED: 1964-2014

Stream	Stream Reach	River Mile (see Map II-4)[a]	Location	Source of Data	Site Identification	Period of Record
Jackson Creek	JC-1	7.8	MacLean Road west of CTH NN	SEWRPC- Temperature Logger	1163220	12/20/2012 – 1/4/2013 6/3/2013 – 6/4/2013
		7.3	MacLean Road near Como Road	Delavan Lake WIN	DLWIN-3	9/27/2011
	JC-2	5.3	Upstream of CTH H	SEWRPC- Temperature Logger	1163221	7/26/2012 – 6/4/2013
		5.2	CTH H	Delavan Lake WIN	DLWIN-4	9/27/2013
				WDNR	10039764	8/21/2013
	JC-3	4.9	Petrie Road	USGS	5431014	10/7/1983 – 10/2/1995
				Delavan Lake Sanitary District	DLSD-3	3/11/2013 – 8/21/2013
				Delavan Lake WIN	DLWIN-2	9/27/2011
		4.2	Creek Drive	WDNR	10039765	8/21/2013
		3.4	STH 67	Delavan Lake Sanitary District	DLSD-5	3/11/2013 – 7/30/2013
				WDNR	10014361	8/21/2013
		3.4	STH 67	SEWRPC- Temperature Logger	1163199	7/26/2012 – 6/4/2013
		3.2	Schulz Culvert	SEWRPC- Temperature Logger	1163214	7/26/2012 – 6/4/2013
		3.1	Jackson Creek upstream of Farm Crossing	WDNR	10039766	8/21/2013
		2.9	Downstream of Schulz Culvert	SEWRPC- Temperature Logger	1163205	7/26/2012 – 11/29/2012
		1.9	Mound Road	SEWRPC- Temperature Logger	1163208	7/26/2012 – 6/4/2013
					Rk-11	3/30/1964 – 8/21/1975
				USGS	5431016	10/7/1983 – 7/15/2014
					54310161	7/15/1993 – 6/14/1994

PRELIMINARY DRAFT

Stream	Stream Reach	River Mile (see Map II-4)[a]	Location	Source of Data	Site Identification	Period of Record
					54310162	7/15/1993 – 9/14/1994
				WDNR	653026	8/28/1992
					10039841	6/8/1994 – 7/13/2014
				Delavan Lake Sanitary District	DLSD-2	3/11/2013 – 7/30/2013
	JC-6	1.0	Delavan Lake near Lake Lawn	WDNR	653240	4/25/1994
Jackson Creek	JC-6	0.8	Delavan Lake Inlet Site 3	USGS	54310166	5/5/1993 – 7/12/1994
		0.6	Delavan Lake Inlet Site 2	USGS	54310168	5/5/1993 – 9/15/1994
		0.3	Delavan Lake Inlet Site 1	USGS	54310163	5/5/1993 – 7/29/1993
		0.0	STH 50	USGS	5431017	10/7/1983 – 5/15/2014
				WDNR	653067	2/8/2004 – 7/15/2014
				Delavan Lake Sanitary District	DLSD-1	3/11/2013 – 7/30/2013
Tributary A	JC-3	0.1	Upstream of Pond	SEWRPC- Temperature Logger	1163219	7/26/2012 – 6/4/2013
	JC-5	0.8	Marsh Road	USGS	54310158	3/8/1993 – 5/17/1995
				Delavan Lake WIN	DLWIN-6	9/27/2011
Tributary B	JC-4	0.8	Near Elkhorn	USGS	54310157	10/7/1983 – 10/1/2009
				Delavan Lake WIN	DLWIN-1	11/12/2010 – 11/2/2011
	JC-3	0.7	O'Connor Road	Delavan Lake Sanitary District	DLSD-4	3/11/2013 – 7/30/2013
		0.4	Near I-43	SEWRPC- Temperature Logger	1163227	7/26/2012 – 6/4/2013

[a]For sites on Jackson Creek the river mile is the distance upstream from the confluence with Delavan Lake at STH 50. For tributaries to Jackson Creek, river mile is the distance upstream from the confluence with Jackson Creek.

Source: SEWRPC.

Table II-7

ANNUAL LOADS OF SUSPENDED SEDIMENT AT SELECTED LOCATIONS IN THE JACKSON CREEK WATERSHED: 1990-1998

Water Year[a]	Jackson Creek at Petrie Road (tons)	Jackson Creek Tributary B near Elkhorn (tons)	Jackson Creek at Mound Road (tons)	Jackson Creek at STH 50 (tons)
1990	- -[b]	220	- -[b]	460
1991	- -[b]	280	- -[b]	270
1992	- -[b]	180	- -[b]	140
1993	1,400[c]	580	- -[b]	- -[b]
1994	455	220	250	155
1995	130	180	290	95
1996	- -[b]	440	1,700	- -[b]
1997	- -[b]	380	525	- -[b]
1998	- -[b]	- -[b]	240	- -[b]

[a]*A water year begins October 1 of the previous year and runs through September 30 of the numbered year. For example, water year 1990 ran from October 1, 1989 through September 30, 1990.*

[b]*Data not available.*

[c]*Data cover the period February 1993 through October 1993.*

Source: U. S. Geological Survey.

Table II-8

MEASURED TOTAL PHOSPHORUS LOADS AT SELECTED LOCATIONS IN THE JACKSON CREEK WATERSHED: 1990-1998

Water Year[a]	Jackson Creek at Petrie Road (pounds)	Jackson Creek Tributary B near Elkhorn (pounds)	Jackson Creek at Mound Road (pounds)	Jackson Creek at STH 50 (pounds)
1990	- -[b]	1,200	- -[b]	6,300
1991	- -[b]	1,200	- -[b]	3,900
1992	- -[b]	1,200	- -[b]	8,100
1993	6,250[c]	1,200[c]	- -[b]	- -[b]
1994	2,700	1,300	3,300	6,000
1995	1,200	900	2,400	4,600
1996	- -[b]	1,700	7,400	7,800
1997	- -[b]	1,400	4,700	5,400
1998	- -[b]	1,200	2,500	5,000

[a]*A water year begins October 1 of the previous year and runs through September 30 of the numbered year. For example, water year 1990 ran from October 1, 1989 through September 30, 1990.*

[b]*Data not available.*

[c]*Data cover the period February 1993 through October 1993.*

Source: U. S. Geological Survey.

Table II-9

WATER QUALITY CHARACTERISTICS OF STREAMS IN THE JACKSON CREEK WATERSHED: 2005-2014

Stream Reach	Stream Length (miles)	Codified Water Use Objective[a]	Percent of Samples Meeting Water Quality Criteria (total number of samples indicated in parentheses)								
			Dissolved Oxygen	Temperature		Chloride		Total Phosphorus	Fecal Coliform Bacteria		pH
				Sublethal	Acute	Chronic	Acute		Single Sample	Geometric Mean	
Jackson Creek above Petrie Road	4.0	FAL	- -	100 (45)	100 (332)	- -	- -	9.1 (11)			
Jackson Creek from Petrie Road to Mound Road	3.0	FAL	- -	70.3 (397)	92.7 (2,803)	- -	- -	7.3 (961)	- -	- -	- -
Jackson Creek from Mound Road to STH 50[b]	1.9	FAL	100.0 (7)	81.5 (151)	99.5 (1,081)	- -	- -	4.7 (702)	- -	- -	71.4 (7)
Tributary A	- -	FAL	- -	100 (44)	100 (314)	- -	- -	100 (1)	- -	- -	- -
Tributary B	2.3	FAL	- -	93.2 (44)	98.1 (314)	- -	- -	8.9 (981)	- -	- -	- -
Tributary C	- -	FAL	- -	- -	- -	- -	- -	- -	- -	- -	- -
Tributary D	- -	FAL	- -	- -	- -	- -	- -	- -	- -	- -	- -
Tributary E	- -	FAL	- -	- -	- -	- -	- -	- -	- -	- -	- -

[a] *FAL indicates warmwater fish and aquatic life.*

[b] *This section of stream is also known as the Delavan Lake Inlet. Water quality characteristics for this section were compared to the applicable standards for lakes and impoundments.*

Source: SEWRPC.

Table II-10

WATER QUALITY CHARACTERISTICS OF STREAMS IN THE JACKSON CREEK WATERSHED DURING THE GROWING SEASON: 2005-2014

Stream Reach	Stream Length (miles)	Codified Water Use Objective[a]	Percent of Samples Meeting Water Quality Criteria (total number of samples indicated in parentheses)								
			Dissolved Oxygen	Temperature		Chloride		Total Phosphorus	Fecal Coliform Bacteria		pH
				Sublethal	Acute	Chronic	Acute		Single Sample	Geometric Mean	
Jackson Creek above Petrie Road	4.0	FAL	- -	100 (17)	100 (135)	- -	- -	14.3 (7)			
Jackson Creek from Petrie Road to Mound Road	3.0	FAL	- -	48.7 (187)	85.2 (1,385)	- -	- -	4.6 (461)	- -	- -	- -
Jackson Creek from Mound Road to STH 50[b]	1.9	FAL	100.0 (5)	61.2 (71)	99.1 (537)	- -	- -	3.4 (377)	- -	- -	- -
Tributary A	- -	FAL	- -	100 (17)	100 (133)	- -	- -	100 (1)	- -	- -	- -
Tributary B	2.3	FAL	- -	82.4 (17)	95.5 (133)	- -	- -	9.1 (560)	- -	- -	- -
Tributary C	- -	FAL	- -	- -	- -	- -	- -	- -	- -	- -	- -
Tributary D	- -	FAL	- -	- -	- -	- -	- -	- -	- -	- -	- -
Tributary E	- -	FAL	- -	- -	- -	- -	- -	- -	- -	- -	- -

[a] *FAL indicates warmwater fish and aquatic life.*

[b] *This section of stream is also known as the Delavan Lake Inlet. Water quality characteristics for this section were compared to the applicable standards for lakes and impoundments.*

Source: SEWRPC.

Table II-11

PROPOSED WATER TEMPERATURE AND FLOW CRITERIA FOR DEFINING NATURAL STREAM BIOLOGICAL COMMUNITIES AND THE PROPOSED PRIMARY INDEX OF BIOTIC INTEGRITY (IBI) FOR BIOASSESSMENT

Natural Community	Maximum Daily Mean Water Temperature (˚F)	Annual 90 Percent Exceedence Flow (ft^3/s)	Primary Index of Biotic Integrity
Ephemeral	Any	0.0	N/A
Macroinvertebrate	Any	0.0-0.03	Macroinvertebrate
Cold Headwater	<69.3	0.03 -1.0	Coldwater Fish
Cold Mainstem	<69.3	>1.0	Coldwater Fish
Cool (Cold-Transition) Headwater	69.3-72.5	0.03-3.0	Headwater Fish
Cool (Cold-Transition) Mainstem	69.3-72.5	>3.0	Cool-Cold Transition Fish
Cool (Warm-Transition) Headwater	72.6-76.3	0.03-3.0	Headwater Fish
Cool (Warm-Transition) Mainstem	72.6-76.3	>3.0	Cool-Warm Transition Fish
Warm Headwater	>76.3	0.03-3.0	Headwater Fish
Warm Mainstem	>76.3	3.0-110.0	Warmwater Fish
Warm River	>76.3	>110.0	River Fish

Source: References for IBIs: Macroinvertebrate–Weigel 2003; Coldwater Fish–Lyons et al. 1996; Headwater Fish–Lyons 2006; Coolwater Fish–Lyons, in preparation; Warmwater Fish–Lyons 1992; River Fish–Lyons et al. 2001.

Table II-12

FISH SPECIES COMPOSITION BY PHYSIOLOGICAL TOLERANCE AND SITES IN THE JACKSON CREEK WATERSHED: HISTORICAL SAMPLES IN RED (1968, 1975, AND 1978)[a] VERSUS RECENT SAMPLES IN BLUE (2006, 2011, AND 2013)

Species According to Their Relative Tolerance to Temperature	Stream Sites (see Map II-5)									
	Site 1		Site 2					Site 3	Site 4	
	1968	2013	1975	1978	2006	2011	2013	2013	1968	2013
Transitional										
Sensitive										
Northern Pike	- -	3 (1.7)	- -	5	- -	- -	- -	2 (1.1)	- -	6 (4.4)
Tolerant										
Brook Stickleback	- -	- -	- -	- -	115 (49.5)	- -	20 (8.6)	32 (18.3)	- -	3 (2.2)
Central Mudminnow	- -	- -	2	- -	5 (2.2)	1 (0.8)	7 (3.0)	2 (1.1)	- -	2 (1.5)
Creek Chub	- -	- -	15	2	- -	1 (0.8)	- -	- -	present	- -
White Sucker	present	29 (16.1)	30	10	47 (20.3)	16 (13.3)	200 (86.2)	268 (153.1)	present	87 (63.7)
Warmwater										
Sensitive										
Rainbow Darter	- -	40 (22.2)	- -	- -	38 (16.4)	7 (5.8)	94 (1.7)	3 (1.7)	- -	12 (8.8)
Intermediate										
Bigmouth Shiner	- -	- -	13	52	- -	- -	- -	- -	present	- -
Black Crappie	- -	1 (0.6)	- -	- -	- -	- -	- -	- -	- -	- -
Bluegill	- -	34 (18.9)	- -	- -	- -	- -	2 (0.9)	7 (4.0)	- -	29 (21.2)
Common Shiner	present	42 (23.3)	present	present	451 (194.4)	15 (12.5)	112 (48.3)	56 (32.0)	present	9 (6.6)
Grass Pickerel	present	- -	- -	- -	- -	- -	- -	- -	present	- -
Hornyhead Chub	- -	12 (6.7)	89	53	142 (61.2)	9 (7.5)	82 (35.3)	11 (6.3)	- -	- -
Largemouth Bass	- -	7 (3.9)	- -	- -	- -	- -	4 (1.7)	3 (1.7)	- -	9 (6.6)
Mimic Shiner	- -	- -	- -	3	- -	- -	- -	- -	- -	- -
Pumpkinseed	- -	- -	- -	- -	- -	- -	1 (0.4)	1 (0.6)	- -	- -
Stonerollers	- -	- -	present	27	- -	- -	- -	- -	present	- -
Tolerant										
Black Bullhead	- -	- -	- -	- -	- -	- -	1 (0.4)	- -	- -	2 (1.5)
Bluntnose Minnow	present	9 (5.0)	present	34	63 (27.2)	3 (25.0)	242 (104.3)	122 (69.7)	- -	3 (22.0)
Common Carp	- -	- -	2	present	- -	- -	- -	- -	- -	- -
Fathead Minnow	present	- -	- -	- -	- -	- -	- -	69 (0.394)	- -	- -
Green Sunfish	present	2 (1.1)	1	- -	2 (0.9)	8 (6.7)	24 (10.3)	2 (1.1)	present	42 (30.8)
Yellow Bullhead	- -	- -	1	- -	- -	- -	- -	- -	- -	- -
Total Catch	Unknown	179 (99.4)	Unknown	Unknown	863 (371.2)	60 (50.0)	789 (340.1)	587 (335.4)	Unknown	219 (160.4)
Total Number of Species	6	10	11	10	8	8	12	13	7	11
Cool-Cold Transition IBI Score	- -	Excellent	- -	- -	Excellent	Excellent	Excellent	Excellent	- -	Excellent

NOTE: Total catch includes total number of all fishes caught and catch per unit effort in parenthesis was standardized to Total Catch per 100 meters of stream length sampled.

[a]*Due to unknown sampling gear and total counts for all species, it was not possible to calculate an IBI for the historical dates.*

Source: WDNR and SEWRPC.

Table II-13

WATER QUALITY RATINGS USING MACROINVERTEBRATE INDICES AMONG SITES WITHIN JACKSON CREEK: 2006 and 2013

Parameters	Stream Sites (see Map II-5)				
	Site 1	Site 2		Site 3	Site 4
	2013	2006	2013	2013	2013
HBI (Hilsenhoff Biotic Index)	Fair (5.95)	Poor (7.52)	Fair (5.80)	Fair (6.0)	Fairly Poor (6.53)
FBI (Family-Level Biotic Index)	Fairly Poor (6.08)	Poor (7.23)	Fair (5.43)	Fair (5.35)	Fair (5.70)
IBI (Index of Biotic Integrity)	Fair(4.44)	Poor (2.77)	Good (6.50)	Fair (4.97)	Very Poor (0.81)
HBI Max 10	5.89	6.29	5.78	6.20	6.53
Percent EPT (Ephemeroptera, Plecoptera, and Trichoptera)-Individuals	5	8	6	0	0
Percent EPT-Generas	8	18	10	3	0
Species Richness	30	17	42	31	17
Genera Richness	26	17	41	31	17

Source: WDNR and SEWRPC.

Table II-14

REQUIRED AVERAGE PERCENT POLLUTANT LOAD REDUCTIONS FOR SUB-BASIN 80 OF THE ROCK RIVER TMDL: 2011

Pollutant	Nonpoint Source Pollution Sources	MS4 Systems[a]	Wastewater Treatment Plants[b]	Nonpermitted Urban Sources
Total Phosphorus	49	- -	75	19
Total Suspended Solids	25	- -	1	15

[a]No load reductions were established for Municipal Separate Storm Sewer Systems (MS4), because there were no permitted MS4s discharging into surface waters of Sub-Basin 80 during development of the Rock River TMDL report. Now that the City of Elkhorn is a permitted MS4 community that discharges into Sub-Basin 80, WDNR will need to establish MS4 wasteload allocations and pollutant load reductions goals for Sub-Basin 80.

[b]The Walworth County Metropolitan Sewerage District (Walcomet) is the only wastewater treatment plant within Sub-Basin 80. Walcomet serves communities within the Jackson Creek watershed, but this plant does not discharge treated effluent into Jackson Creek.

Source: USEPA, WDNR, and SEWRPC.

Table II-15

EFFECT OF BUFFER WIDTH ON CONTAMINANT REMOVAL

Buffer Width Categories (feet)	Contaminant Removal (percent)[a]				
	Sediment	Total Suspended Sediment	Nitrogen	Phosphorus	Nitrate-Nitrogen
1.5 to 25					
Mean	75	66	55	48	27
Range	37-91	31-87	0-95	2-99	0-68
Number of Studies	7	4	7	10	5
25 to 50					
Mean	78	65	48	49	23
Range	- -	27-95	7-96	6-99	4-46
Number of Studies	1	6	10	10	4
50 to 75					
Mean	51	- -	79	49	60
Range	45-90	- -	62-97	0-99	- -
Number of Studies	5	- -	2	2	1
Greater than 75					
Mean	89	73	80	75	62
Range	55-99	23-97	31-99	29-99	- -
Number of Studies	6	9	8	7	1

[a]*The percent contaminant reductions in this table are limited to surface runoff concentrations.*

Source: University of Rhode Island Sea Grant Program.

Table II-16

STREAM EROSION LATERAL RECESSION RATE DESCRIPTIONS

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

Source: Natural Resources Conservation Service.

Table II-17

PHYSICAL CHARACTERISTICS OF MAINSTEM STREAM REACHES WITHIN THE JACKSON CREEK WATERSHED:

Reaches (see Map II-_)	Reach Length (miles) 1941	Reach Length (miles) 2010	Sinuosity 1941	Sinuosity 2010	Minimum Elevation (feet above NGVD29)	Maximum Elevation (feet above NGVD29)	Slope (percent)
Mainstem							
Jackson Creek 1	1.66	1.60	1.22	1.20	994	996	0.02
Jackson Creek 2	1.50	1.44	1.23	1.20	962	972	0.13
Jackson Creek 3	1.90	1.86	1.50	1.47	940	962	0.22
Jackson Creek 4	1.62	1.47	1.40	1.37	930	940	0.13
Tributaries							
Tributary A	1.05	1.63	1.10	1.10	930	960	0.30
Tributary B	1.90	2.90	1.28	1.22	930	996	0.41
Tributary C	1.06	1.80	1.21	1.13	962	1050	0.93
Tributary D	0.77	1.67	1.08	1.20	966	1012	0.52
Tributary E	--	1.30	--	1.10	970	1022	0.83

NOTE: The differences in reach lengths between years were due to limitations in the ability to discern a stream channel on the historic aerial maps.

Source: SEWRPC.

Table II-18

LOW GRADIENT STREAM HABITAT CRITERIA SCORES AMONG REACHES WITHIN THE JACKSON CREEK WATERSHED: 2012 and 2013

Habitat Criteria	Mainstem Reaches (see Map II-1)				
	4	3	2	1	- -
Channelization (percent)	10-60	0 (natural)	61-100	61-100	- -
Channelization (age)	10-20	0 (natural)	>20	>20	- -
Instream Cover (percent)	11-14	>15	5-10	5-10	- -
Bank Erosion (percent)	7-50	<7	7-50	7-50	- -
Sinuosity (ratio)	1.21-1.40	>1.40	1.05-1.20	1.05-1.20	- -
Thalweg Depth (Standard Deviation)	>0.40	>0.40	0.02-0.40	0.05-0.25	- -
Buffer Vegetation (percent)	>90	>90	20-50	20-50	- -
	Tributary Reaches (see Map II-1)				
	A	B	C	D	E
Channelization (percent)	61-100	61-100	61-100	61-100	61-100
Channelization (age)	10-20	10-20	>20	>20	>20
Instream Cover (percent)	Not Assessed	Not Assessed	5-10	5-10	<5
Bank Erosion (percent)	Not Assessed	Not Assessed	7-50	7-50	<7
Sinuosity (ratio)	1.05-1.20	1.05-1.20	1.05-1.20	1.05-1.20	1.05-1.20
Thalweg Depth (Standard Deviation)	Not Assessed	Not Assessed	0.02-0.40	0.02-0.40	0.05-0.25
Buffer Vegetation (percent)	<20	<20	20-50	<20	<20

NOTE: The red, yellow, green, and blue fill colors are associated with poor, fair, good, and excellent habitat criteria scores, respectively.

Source: Adapted from Wang et. al., Development and Evaluation of a Habitat Rating System for Low-Gradient Wisconsin Streams, North American Journal of Fisheries Management , 18:775-785, 1998, and SEWRPC.

Table II-19

STRUCTURE DESCRIPTION, LOCATION, CONDITION, AND FISH PASSAGE RATING ASSESSMENT WITHIN THE MAINSTEM OF JACKSON CREEK WATERSHED: 2012-2013

Stream Reach	Structure Number	Description	Road Crossing	River Mile	Culvert/Bridge Length (feet)	Ditch Erosion	General Condition of Structure	Limiting Water Depth (feet)	Embedded Depth (feet)	Fish Passage Rating	Recommended Actions
Jackson Creek- 4	1	Metal weir/ USGS stream gauge at bridge crossing	Mound Road	1.9	- -	Fair	Good	- -	None, dam impounding surface water	Barrier to fish passage	Remove or retrofit to allow passage for fishes and navigation
	2	Concrete crossing with three circular corrugated metal culverts. Middle culvert is a two-foot diameter pipe and the two outer culverts are 1.5-feet in diameter	Private Crossing	3.1	20.5 to 26.0	Stable	Good	0.2	0.0, culverts are perched 1.0-1.5 feet above streambed at outlet	Barrier to fish passage	Remove or replace with a single cell culvert
Jackson Creek- 3	3	Concrete span bridge with side slopes and abutments	STH 67	3.4	42.7	Stable	Good	2.1	- -	Passable	None
	4	Concrete and wood bridge with abutments	Petrie Road	4.9	30.0	Moderate	Good	2.9	- -	Passable	None
Jackson Creek- 2	5	Concrete bridge with abutments	CTH H	5.2	44.0	Stable	Good	2.4	- -	Passable	None
	6	Concrete bridge with abutments	Private driveway	5.3	26.6	Minor	Fair	1.4	- -	Passable	None
	7	Two four-foot-diameter corrugated metal culverts	Private culvert crossing	6.1	24.0	Minor	Fair	0.3	- -	Passable	None
	8	One four-foot-diameter corrugated metal culvert	Private culvert crossing	6.3	22.0	Stable	Good	0.5	0.05	Passable	None
Jackson Creek-1	9	Two 11-foot-wide, 7-foot-high; one 11-foot-high, 5.6-foot-wide concrete box culverts	USH 12	6.7	175.2	Stable	Good	1.9	2.0	Passable	None
	10	One 6.8-foot-wide, 4.7-foot-high and corrugated metal elliptical culvert	Maclean Road	7.3	50.5	Stable	Good	0.2	- -	Passable	Repair damaged inlet.
	11	One four-foot-diameter; one 1.3-foot-diameter; one one-foot-wide, 1.3-foot-high corrugated metal culverts	Private crossing	7.5	19.6	Severe	Fair	- -	- -	Passable	Erosion control
	12	Wood bridge with side slopes	White River Recreational Trail bridge	7.7	- -	Stable	Good	- -	- -	Passable	None

NOTE: The red indicated high priority and yellow color indicates moderate priority ratings or problems to address fish passage issues in the watershed.

Source: SEWRPC

#229163
300-1115
TMS/pk
09/09/14, 08/12/15

SEWRPC Community Assistance Planning Report No. 320

JACKSON CREEK WATERSHED PROTECTION PLAN

Chapter II

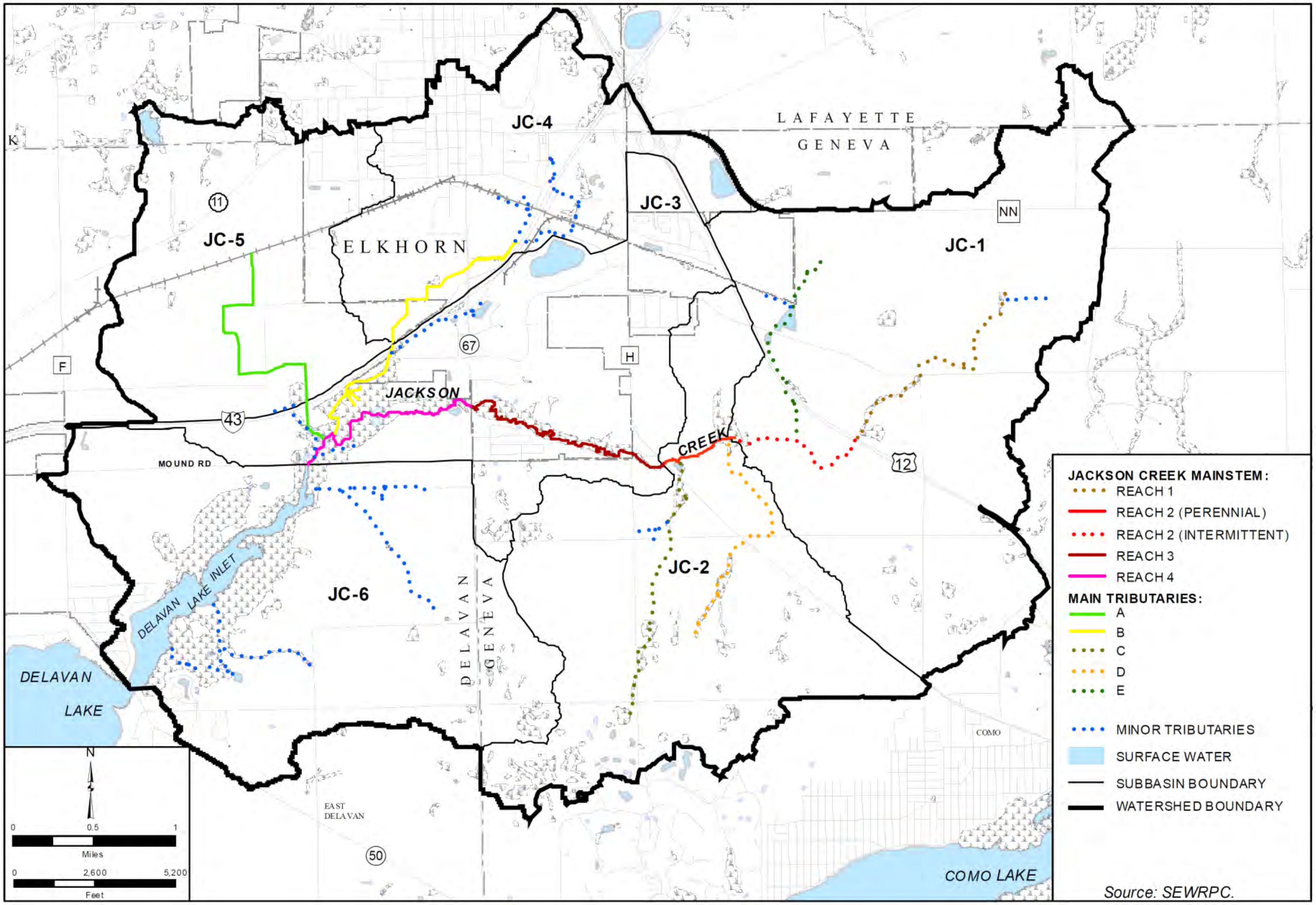
INVENTORY FINDINGS

MAPS

This Page Left Blank Intentionally

Map II-1

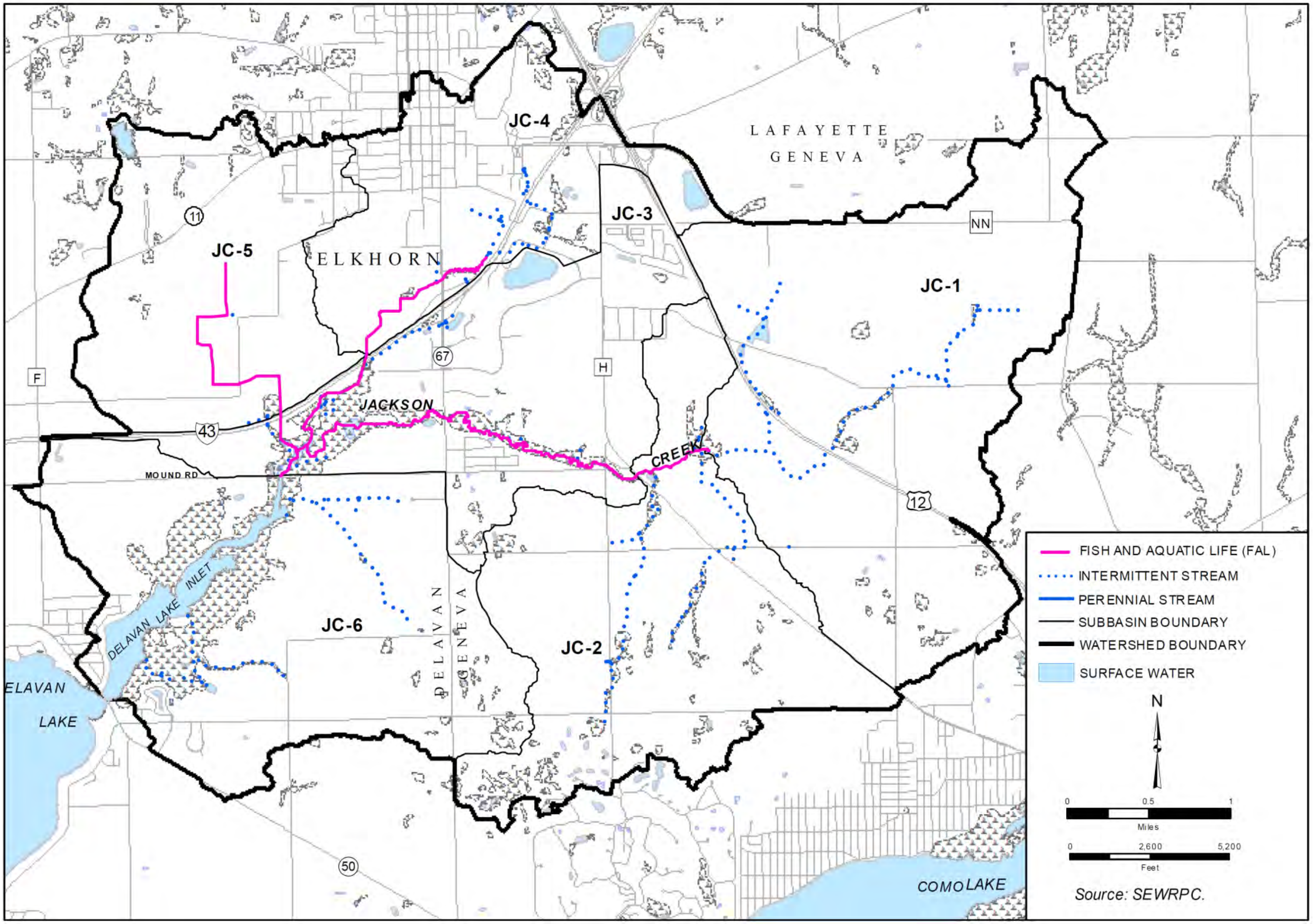
STREAM REACHES AND SUBBASINS WITHIN THE JACKSON CREEK WATERSHED: 2014



Source: SEWRPC.

Map II-2

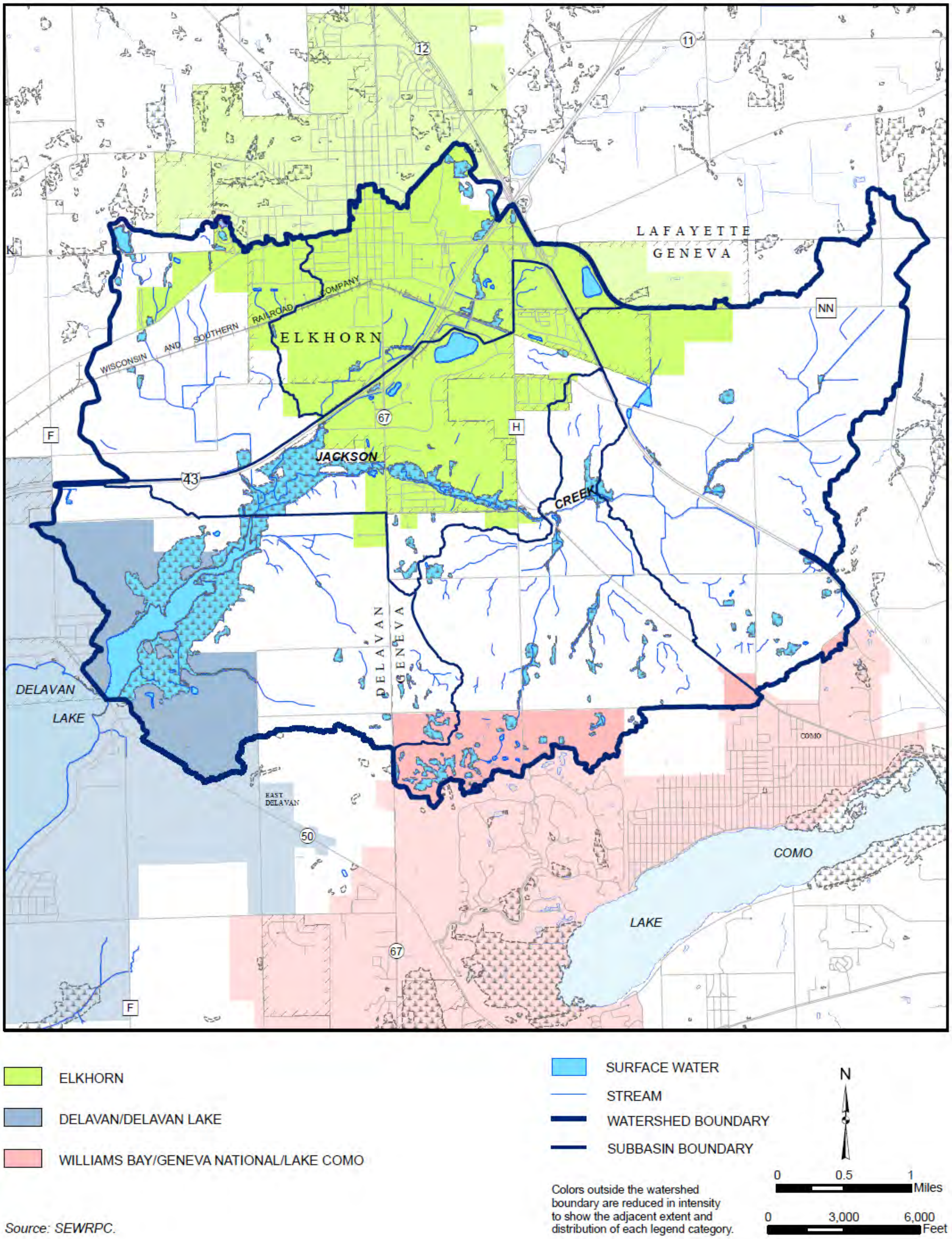
WATER USE OBJECTIVES FOR STREAMS WITHIN THE JACKSON CREEK WATERSHED: 2014



PRELIMINARY DRAFT

Map II-3

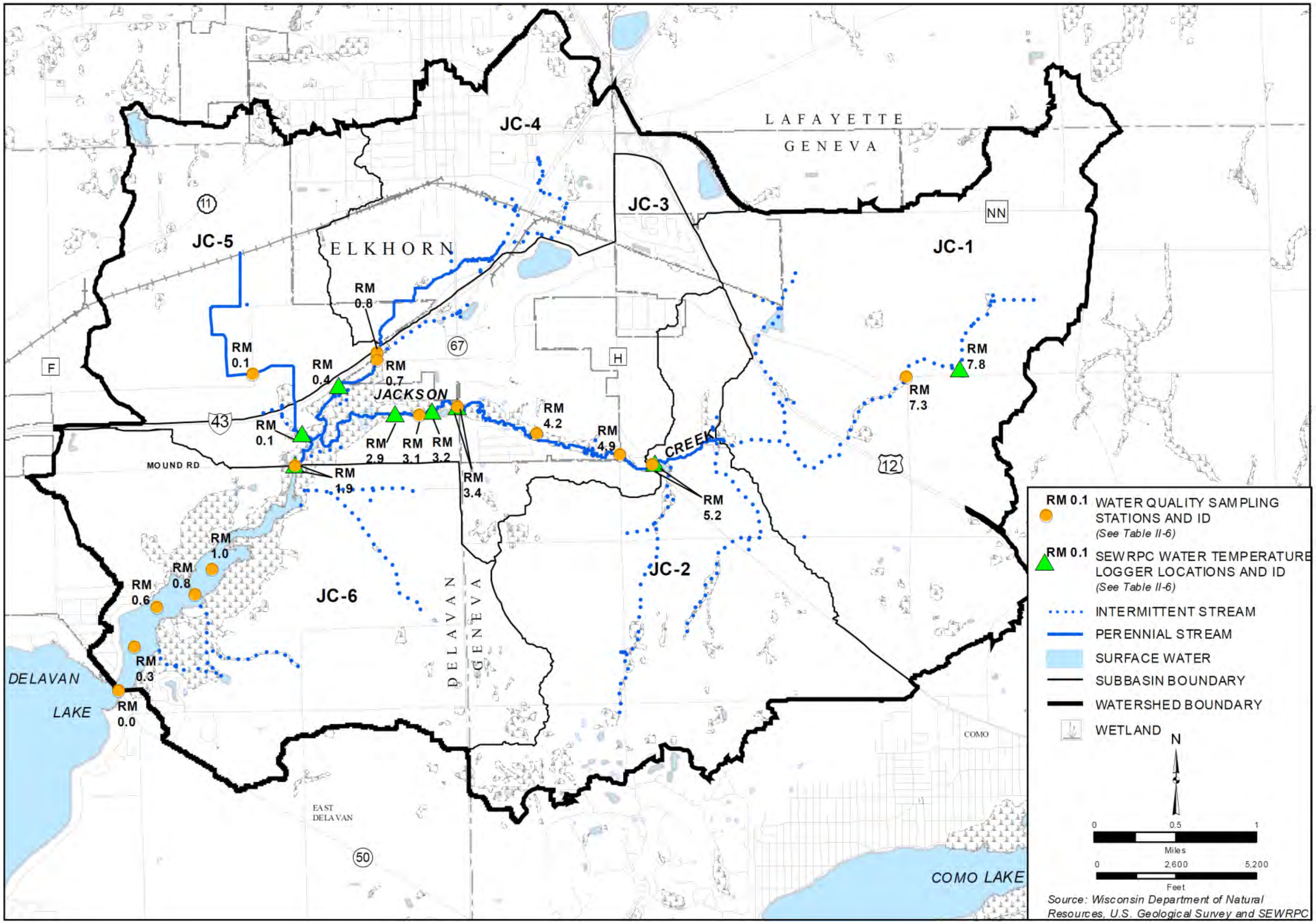
ADOPTED SANITARY SEWER SERVICE AREAS WITHIN THE JACKSON CREEK WATERSHED: 2014



Source: SEWRPC.

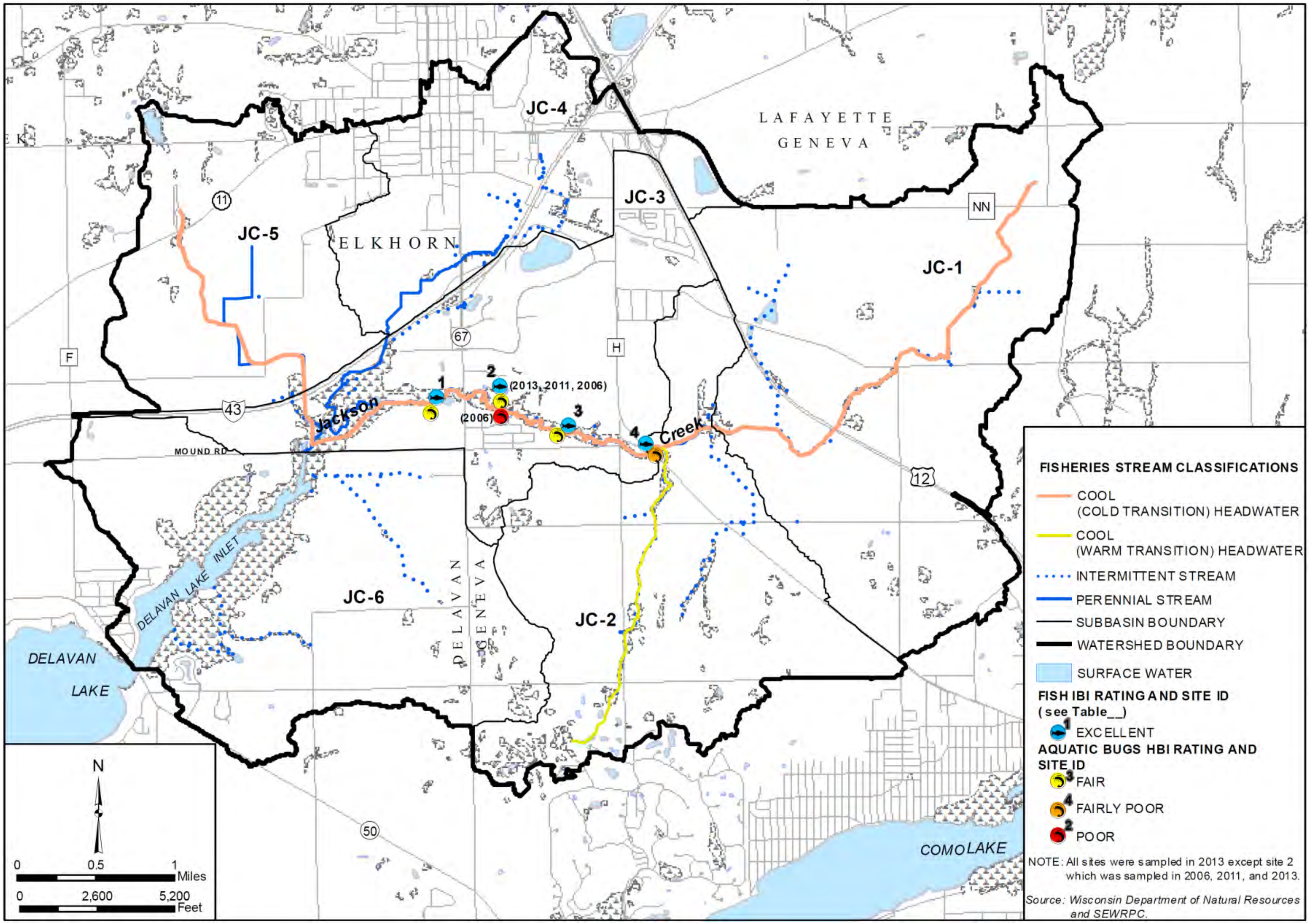
Map II-4

WATER CHEMISTRY, STREAM FLOW, AND TEMPERATURE MONITORING STATIONS WITHIN THE JACKSON CREEK WATERSHED: 1964-2014



Map II-5

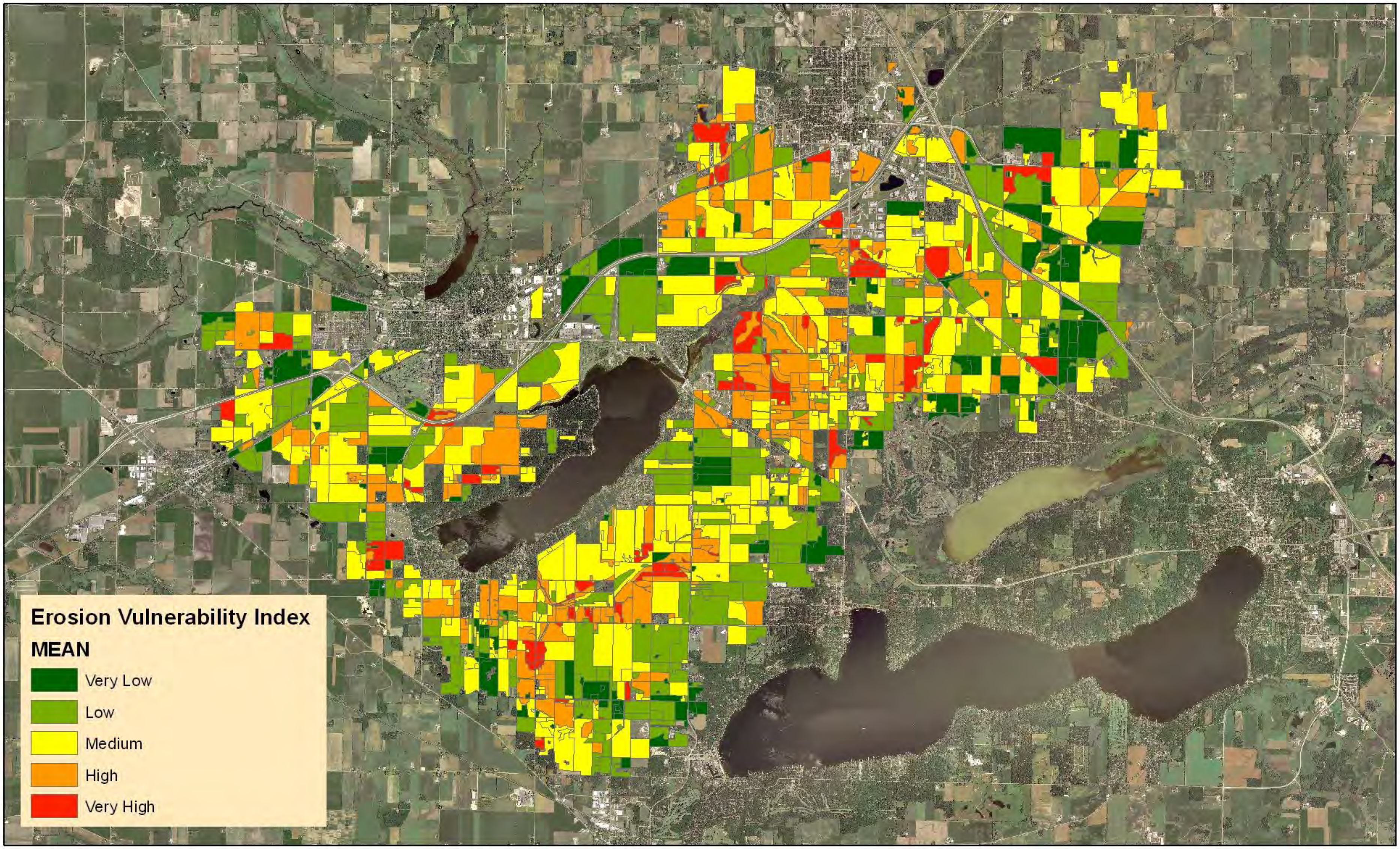
FISH AND AQUATIC BUGS SAMPLING LOCATIONS AND FISHERIES STREAM CLASSIFICATIONS WITHIN THE JACKSON CREEK WATERSHED: 2006, 2011 AND 2013



PRELIMINARY DRAFT

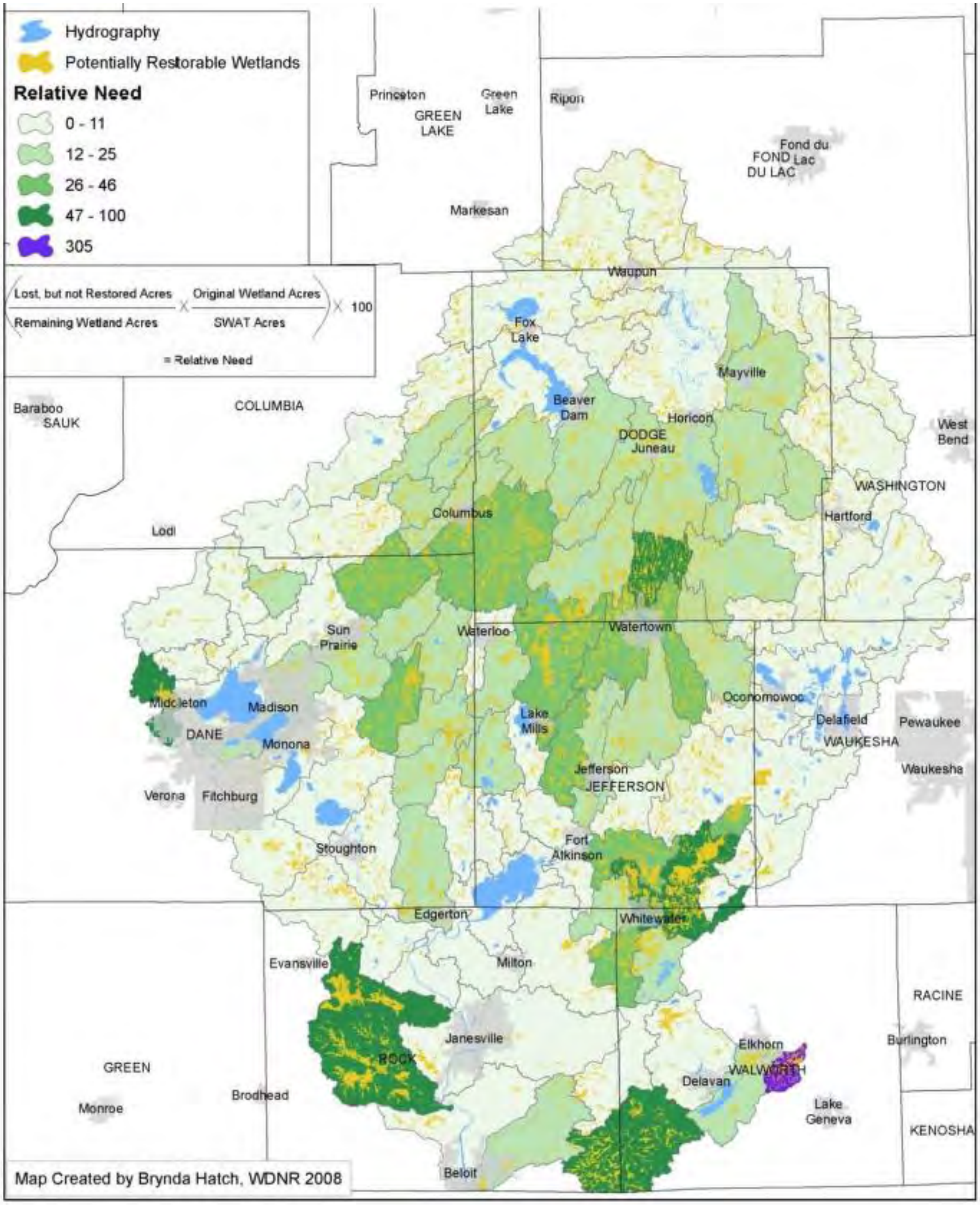
Map II-6

EROSION VULNERABLITY ASSESSMENT OF AGRICULTUAL LANDS (EVAAL) WITHIN THE JACKSON CREEK AND DELAVAN LAKE WATERSHED: 2015



NOTE: EVAAL analysis completed using National Agricultural Statistic Services Cropland Data for 2009 through 2013.
Source: WDNR.

Map II-7
WETLAND RESTORATION RELATIVE NEED IN THE ROCK RIVER BASIN: 2011

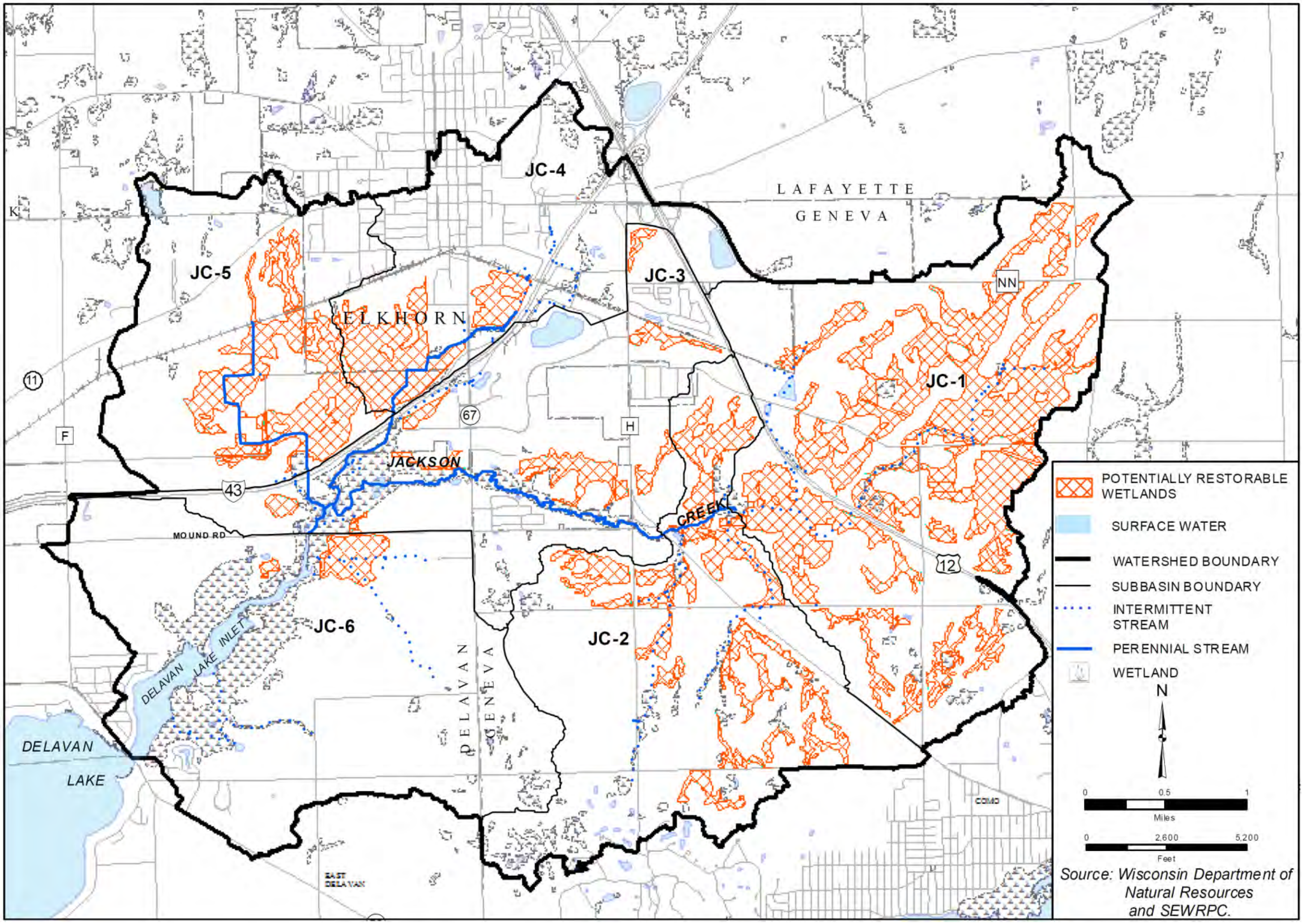


NOTE: Relative Need is expressed as the ratio of lost wetland acres to remaining wetland acres, multiplied by the percent of the sub-basin that was originally wetland.

Source: USEPA and WDNR.

Map II-8

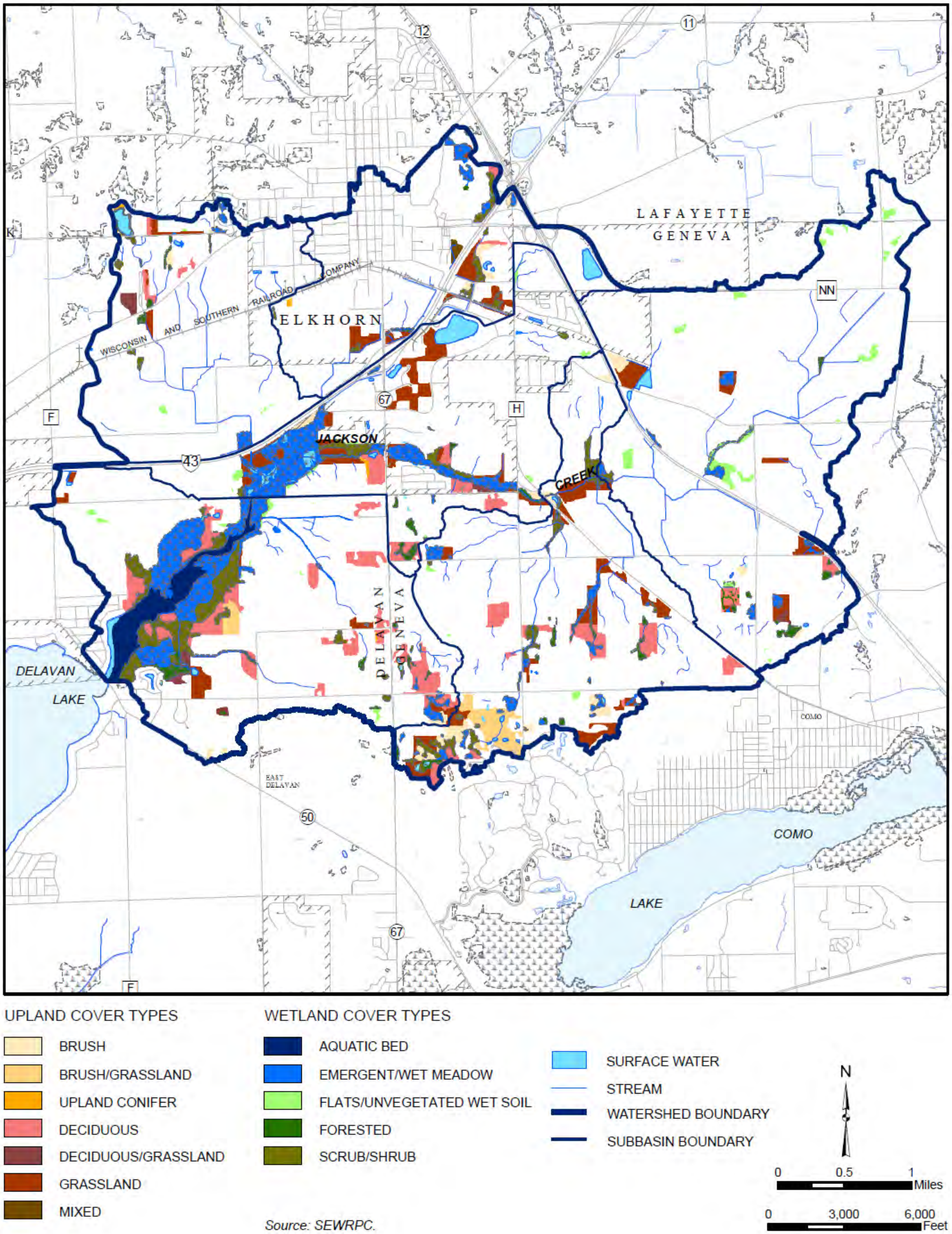
POTENTIALLY RESTORABLE WETLANDS GREATER THAN 5 ACRES WITHIN THE JACKSON CREEK WATERSHED: 2015



PRELIMINARY DRAFT

Map II-9

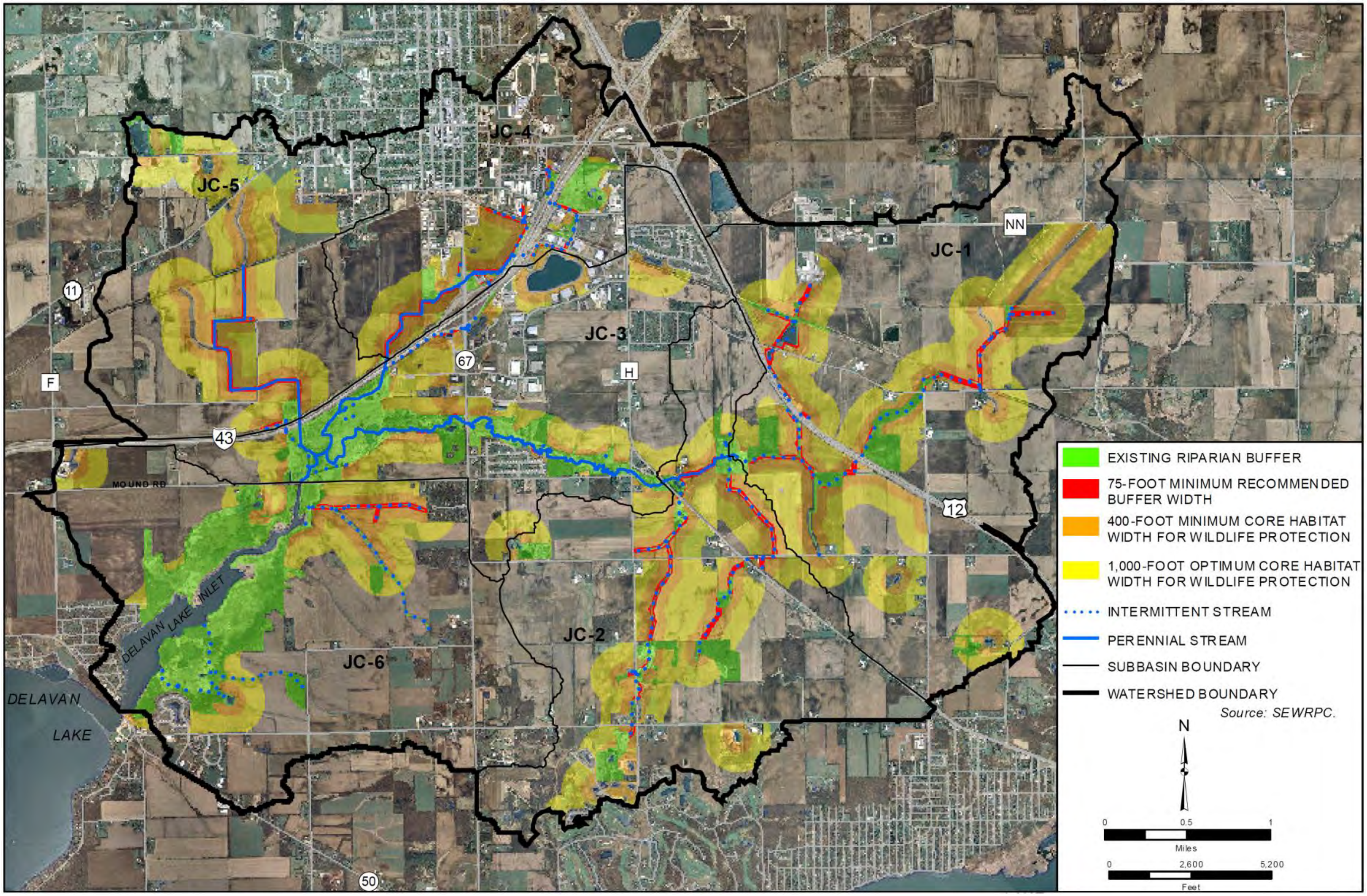
UPLAND AND WETLAND COVER TYPES WITHIN THE JACKSON CREEK WATERSHED: 2005 AND 2010



Source: SEWRPC.

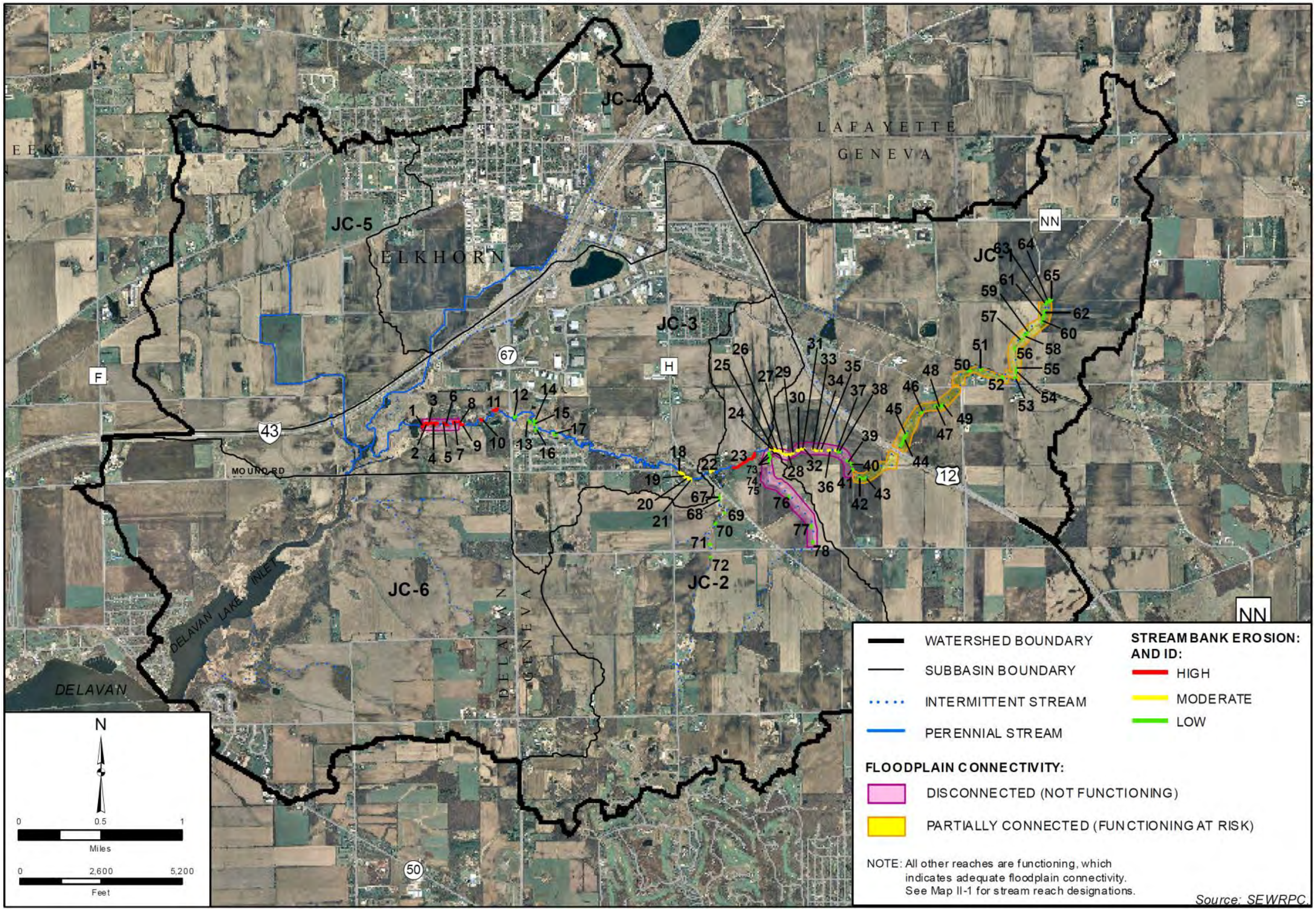
Map II-10

EXISTING RIPARIAN BUFFER AND POTENTIAL BUFFER ZONES WITHIN THE JACKSON CREEK WATERSHED: 2010



Map II-11

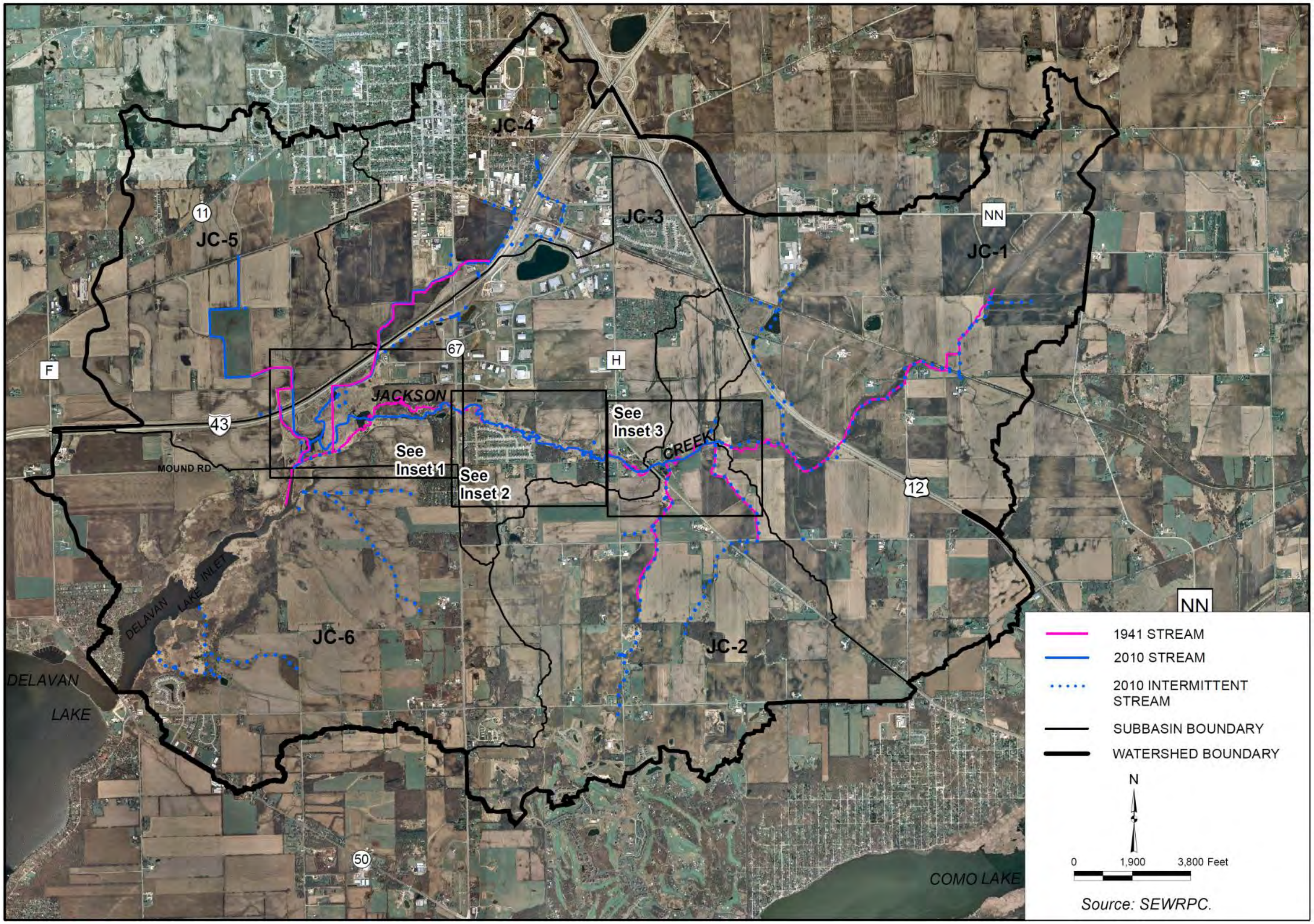
STREAMBANK EROSION AND FLOODPLAIN CONNECTIVITY WITHIN JACKSON CREEK: 2013



Source: SEWRPC.

Map II-12

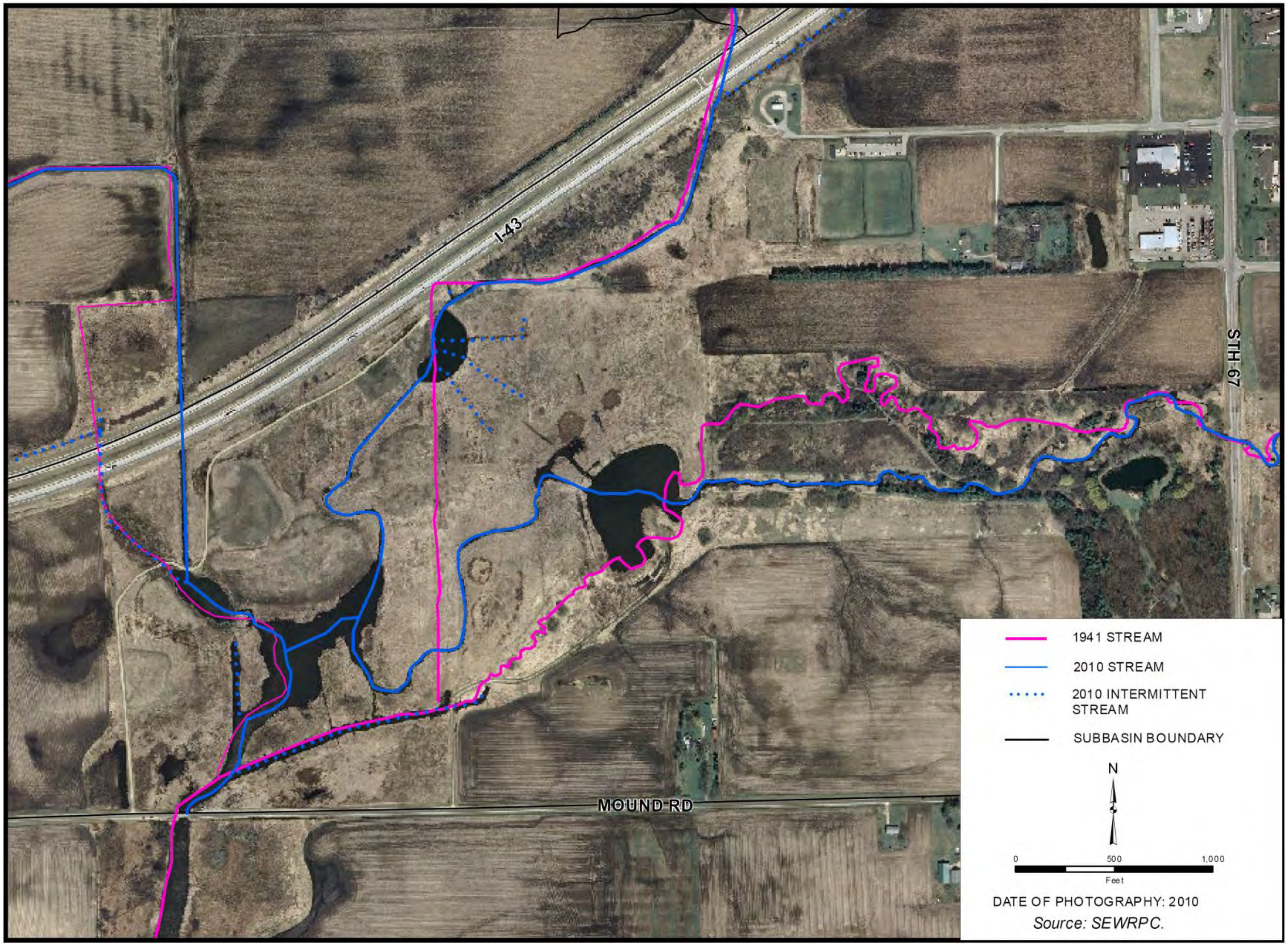
COMPARISON OF HISTORICAL AND CURRENT STREAM CHANNEL CHANGES WITHIN THE JACKSON CREEK WATERSHED: 1941 vs. 2010



PRELIMINARY DRAFT

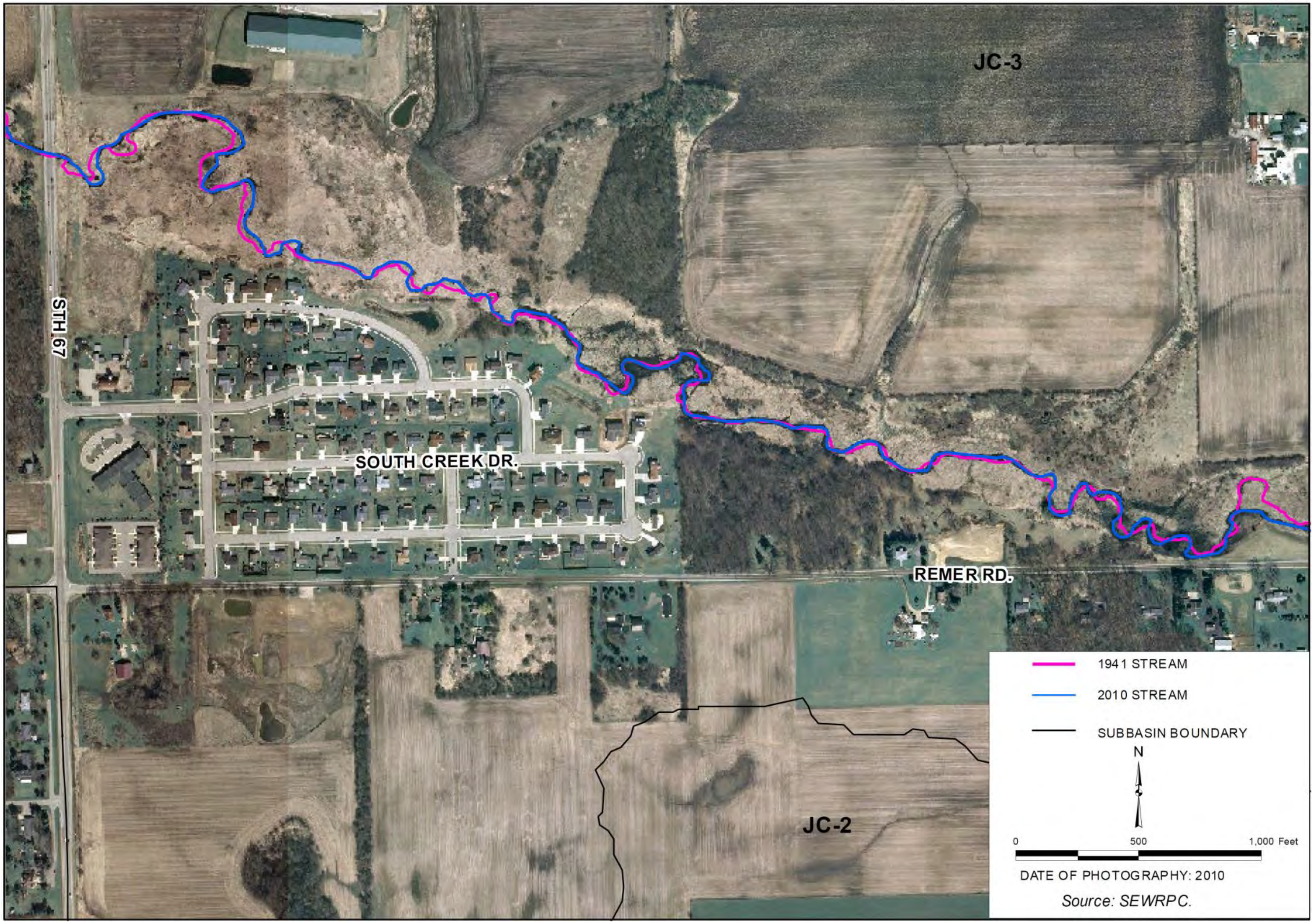
Inset 1 to Map II-12

COMPARISON OF HISTORICAL AND CURRENT STREAM CHANNEL CHANGES WITHIN THE JACKSON CREEK WATERSHED: 1941 vs. 2010



Inset 2 to Map II-12

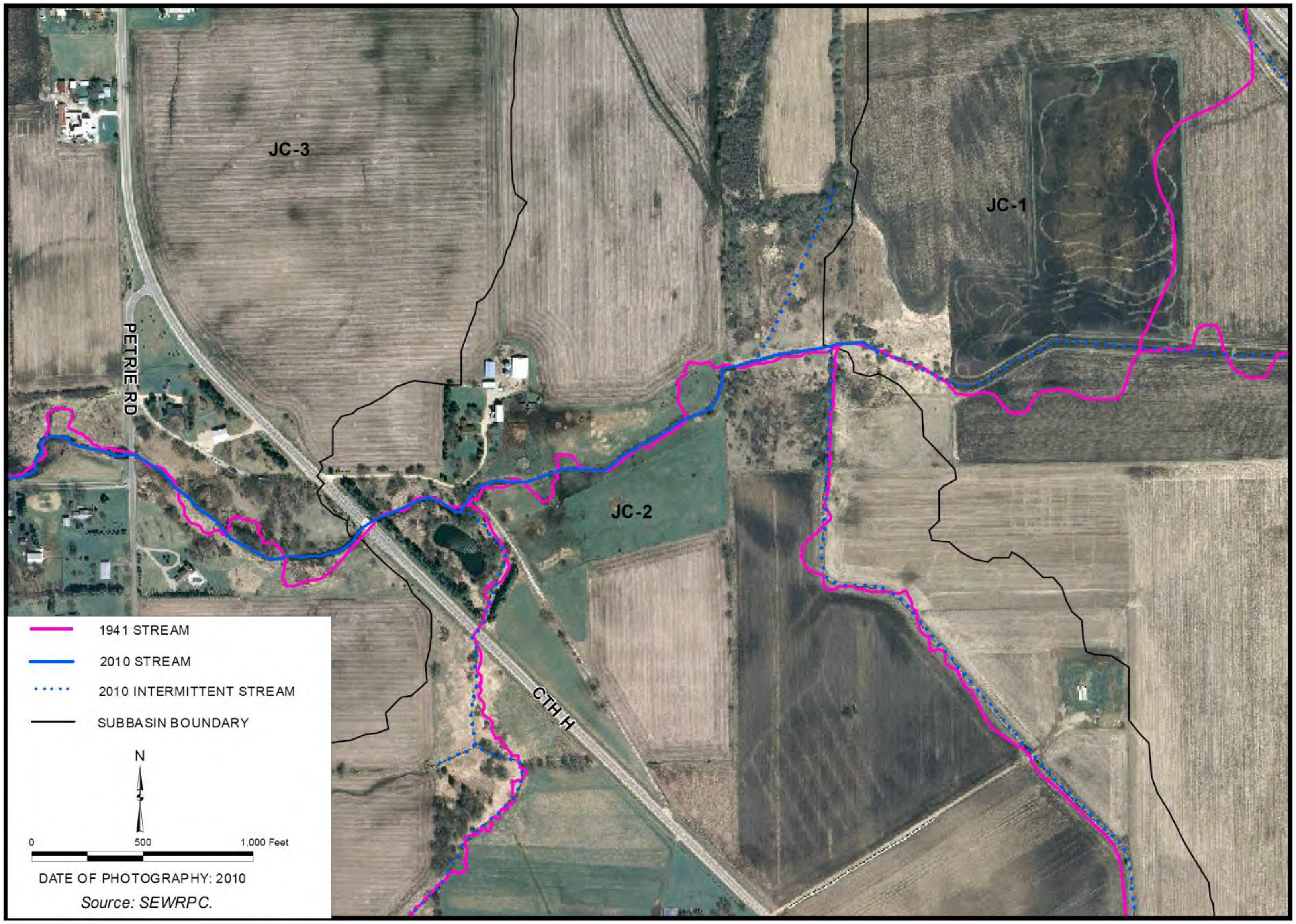
COMPARISON OF HISTORIC AND CURRENT STREAM CHANNEL CHANGES WITHIN THE JACKSON CREEK WATERSHED: 1941 vs. 2010



PRELIMINARY DRAFT

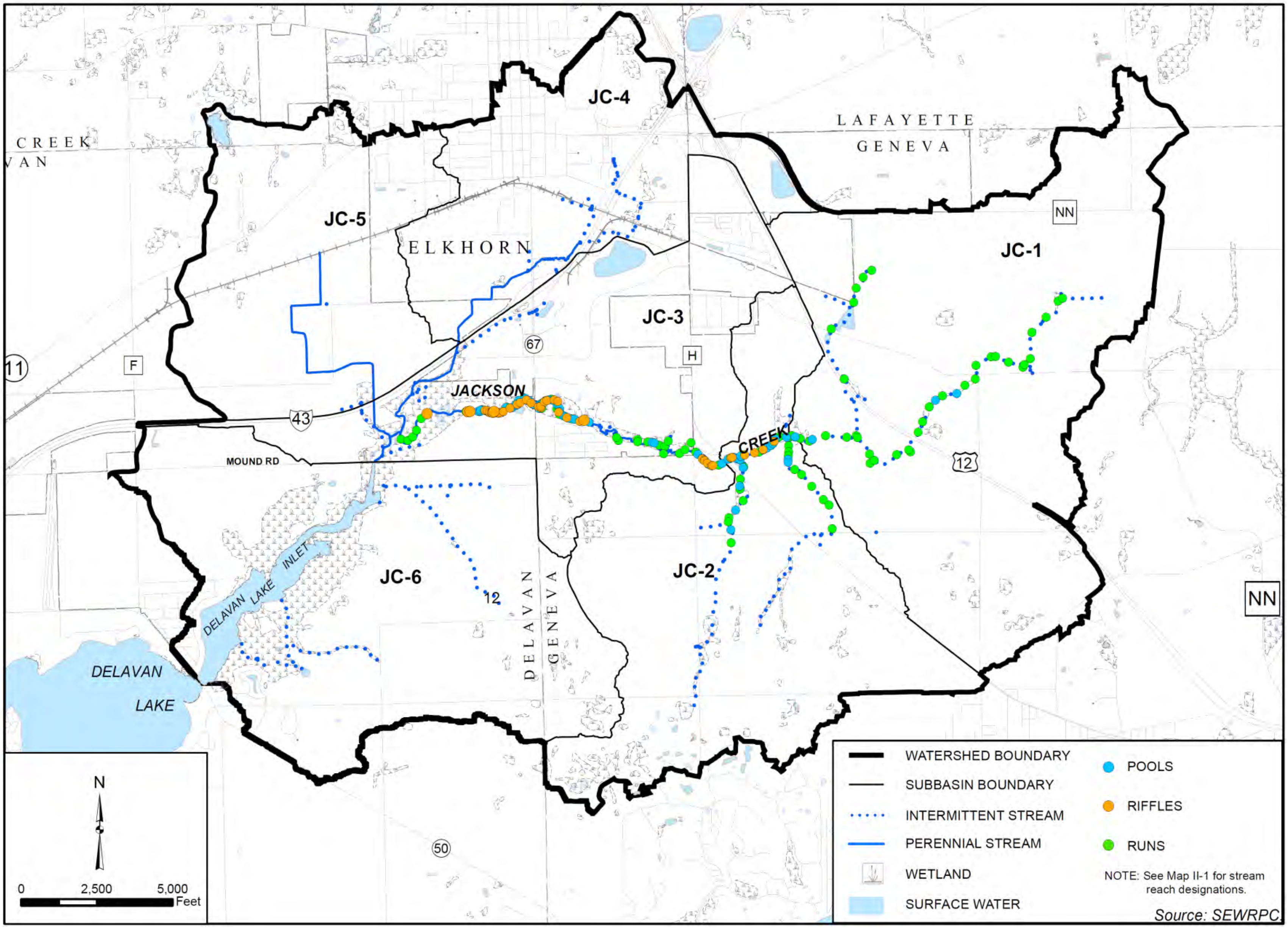
Inset 3 to Map II-12

COMPARISON OF HISTORICAL AND CURRENT STREAM CHANNEL CHANGES WITHIN THE JACKSON CREEK WATERSHED: 1941 vs. 2010



Map II-13

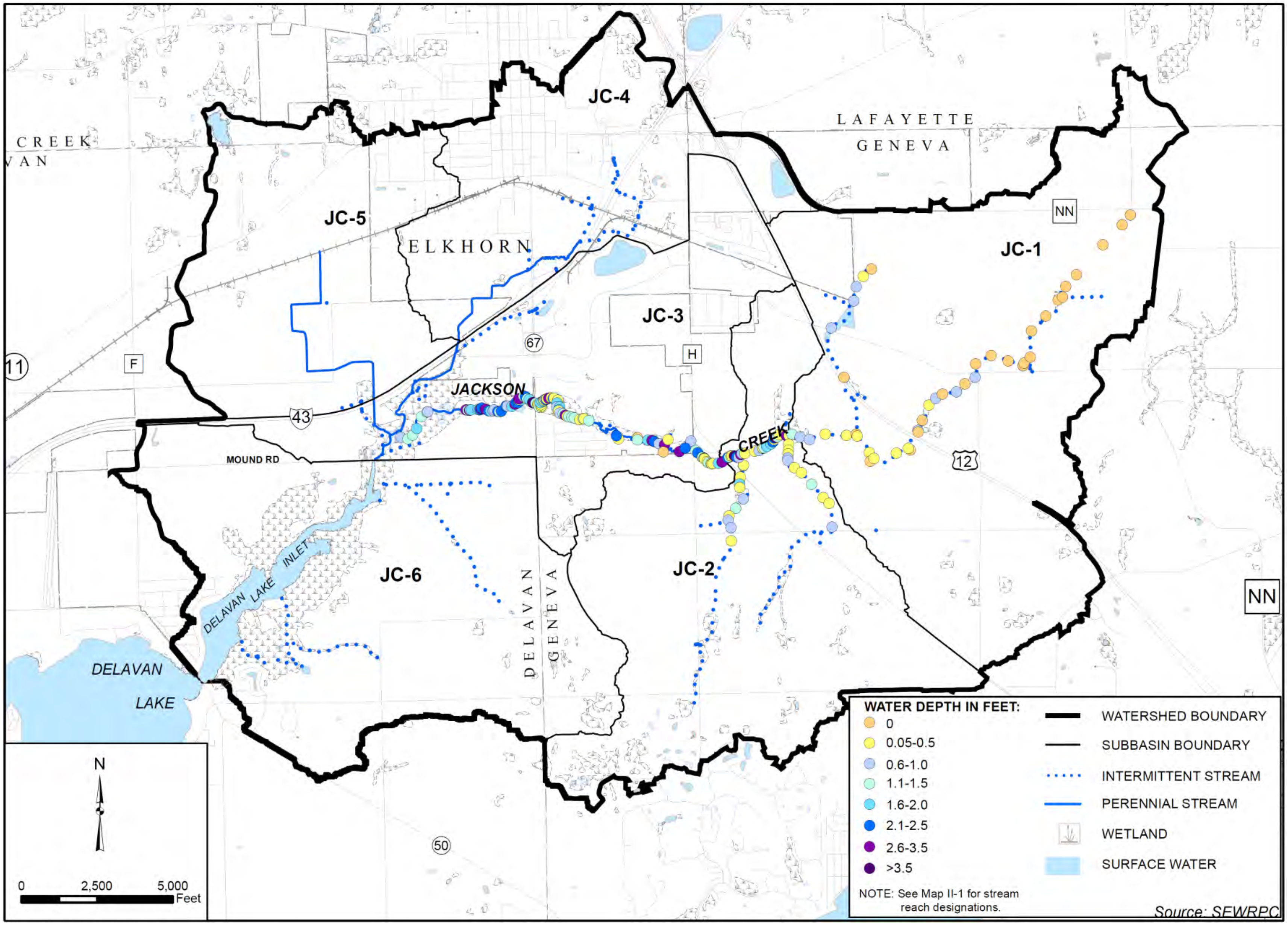
AQUATIC HABITAT TYPES WITHIN THE JACKSON CREEK WATERSHED: 2012-2013



PRELIMINARY DRAFT

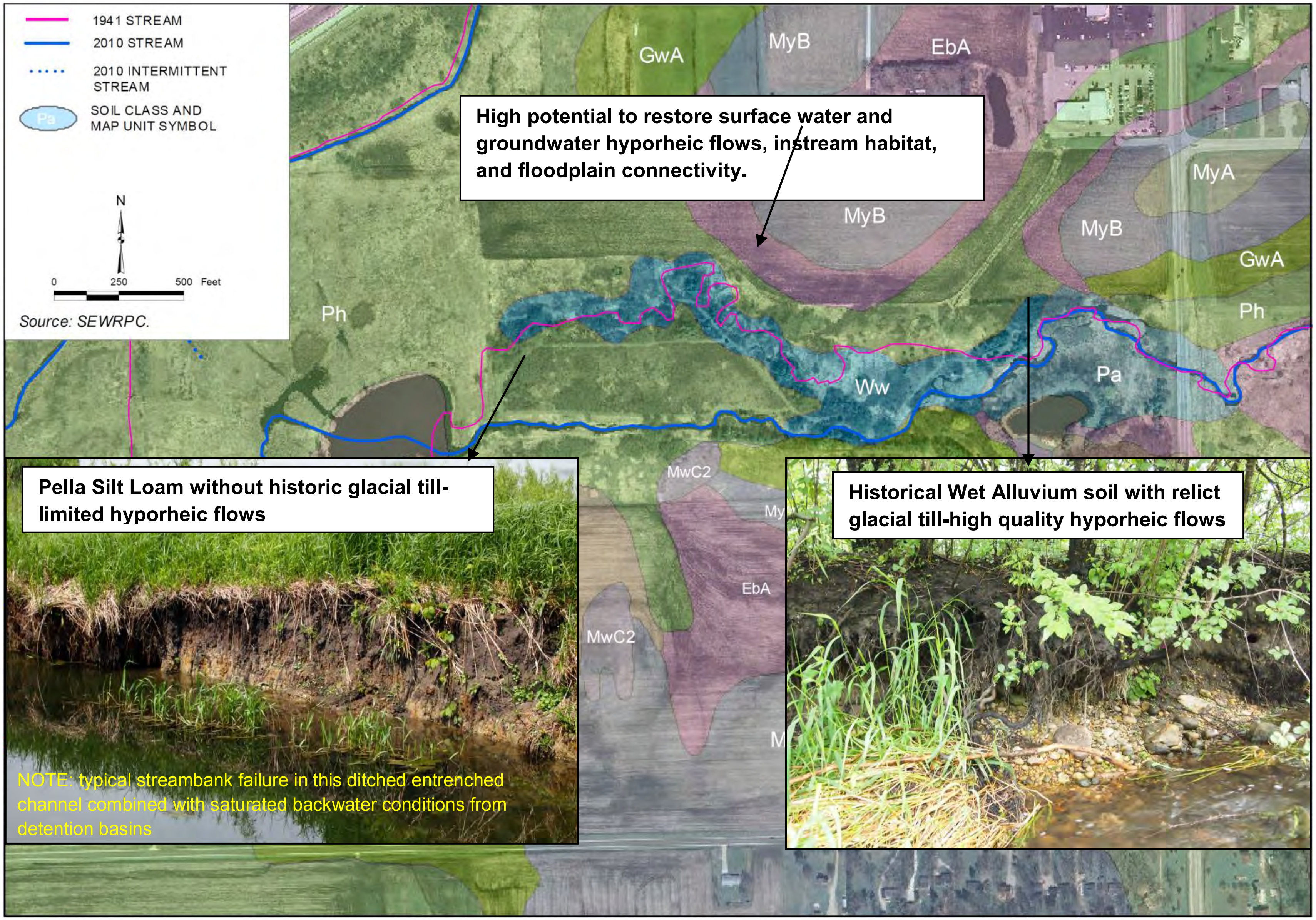
Map II-14

MAXIMUM WATER DEPTHS MEASURED WITHIN THE JACKSON CREEK WATERSHED: 2012-2013



Map II-15

COMPARISON OF HISTORICAL AND CURRENT STREAM CHANNEL ALIGNMENTS AND SOIL CLASSIFICATIONS WITHIN THE DOWNSTREAM REACHES OF JACKSON CREEK: 1941 vs. 2010



PRELIMINARY DRAFT

SEWRPC Community Assistance Planning Report No. 320

JACKSON CREEK WATERSHED PROTECTION PLAN

Chapter III

PLAN RECOMMENDATIONS

WATERSHED GOALS, MANAGEMENT OBJECTIVES, AND IMPLEMENTATION

This protection plan is designed to serve as a practical guide for the management of water quality within the Jackson Creek watershed and for the management of the land surfaces that drain directly and indirectly to the stream and, consequently, to downstream waterbodies, including Delavan Lake, Turtle Creek, and ultimately the Rock River. Hence, developing an approach for meeting the pollution load limits established under the Rock River TMDL was a major focus of this watershed plan. However, that focus was only one component of the overall watershed goals and management objectives that were established to address critical issues in the watershed based on watershed inventory results and stakeholder meetings as shown in Table III-1.

This watershed protection plan was prepared in the context of the Southeastern Wisconsin Regional Planning Commission's (SEWRPC) regional water quality management plan,[1] the Turtle Creek priority watershed plan,[2] Delavan Lake management plans, the state of the Rock River basin plan,[3] the Walworth County Land and Water

[1]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan For Southeastern Wisconsin: 2000, Volumes One through Three, *1978. SEWRPC Memorandum Report No. 93, A Regional Water Quality Management Plan For Southeastern Wisconsin: An Update and Status Report, March 1995.*

[2]*WDNR, Turtle Creek Priority Watershed Plan, March 1984; WDNR, Turtle Creek Priority Watershed Plan Amendment-The Delavan Lake Restoration Project, August 1989; and, WDNR, Turtle Creek Priority Watershed Bioassessment Final Report, WDNR Publication No. PUBL- WR-359 94, 1994.*

[3]*Wisconsin Department of Natural Resources in cooperation with the Rock River Basin partnership team and stakeholders,* Your River Neighborhood ~ The Rock River Basin, The State of the Rock River Basin*, PUBL # WT-668-2002, April 2002.*

Resources Management Plan (LWRMP),[4] the Walworth County multi-jurisdictional comprehensive plan,[5] and the Rock River TMDL study.[6] Therefore, this plan represents a refinement of these regional, county, and watershed-scale plans and it enables successful implementation of recommendations at a smaller, 21.5 square mile (13,773-acre) watershed scale. In particular, the Walworth County Land and Water Resources Management Plan (LWRMP) priority issues, goals, objectives, and implementation work plan elements formed the basis of the recommendations outlined below. Hence, continued implementation and funding to support the work plan elements in the County's LWRMP within the Jackson Creek watershed is critical to the successful implementation of this plan.

The improvements that would result from implementing the recommendations in this plan would represent steps toward achieving the overall goal of restoring and improving the water resources of the Jackson Creek watershed consistent with the goals identified in Table III-1. However, this watershed protection plan goes beyond incorporating recent and ongoing watershed management programs and initiatives. Consequently, the successful implementation of this plan is contingent upon a strategy of community coordination, partnership among stakeholders, and development of farmer-led watershed-based improvements to develop innovative solutions (see the Engagement Strategy subsection within the Information and Education section below).

Linking the TMDL to Implementation

The Rock River TMDL was approved by the U.S. Environmental Protection Agency (USEPA) and the Wisconsin Department of Natural Resources (WDNR) in 2012, and relied largely on modelled data to quantify pollutant loads and load (unpermitted nonpoint source) and wasteload (permitted point source) allocations. It is important to consider both the TMDL and additional information obtained since its completion when developing the implementation actions that may improve water quality within the Jackson Creek watershed. It should be noted that due to the nature of modeling uncertainty and the fact that agricultural nonpoint source loads are not regulated under the Federal Clean Water Act (CWA), achieving the wasteload allocations contained in the TMDL study would be expected to improve water quality conditions, but would not necessarily result in attainment of the phosphorus and sediment standards in Jackson Creek. Although TMDL load and wasteload allocations were used to establish the

---

[4]*Walworth County Land Conservation Committee,* Walworth County Land and Water Resource Management Plan 2010-2020*, April 2010.*

[5] *SEWRPC Community Assistance and Planning Report No. 288,* A Multi-Jurisdictional Comprehensive Plan For Walworth County: 2035, November 2009.

[6]*U. S. Environmental Protection Agency and Wisconsin Department of Natural Resources,* 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*, July 2011.*

benchmark goals, the success of the management actions proposed under this plan will be improvements in measured ambient or instream water quality rather than attainment of load and wasteload allocations.

The local partners within the Jackson Creek watershed may utilize an adaptive management approach in the implementation of the management actions described within this report. The management actions discussed in detail in subsequent sections were chosen because it is anticipated that they will have the greatest effect on improving water quality within the Jackson Creek watershed. As actions are implemented, water quality data are collected, and new information and technology become available, Walworth County, in consultation with the Federal, State, and local municipalities and partners, will discontinue actions that are deemed ineffective and add actions that may not be included in this report.

MANAGEMENT MEASURES IMPLEMENTATION

The Jackson Creek watershed plan presents recommended management measures needed over the next 10 years to improve and/or restore the hydrologic, hydraulic, geomorphologic, physiochemical, and biological functions of this system as summarized in Table III-1. The plan indicates 1) a timeline for when specific practices and projects, referred to as targeted management measures, should be completed; 2) estimated costs for practice and project implementation, 3) agencies responsible for implementation to meet targeted load reductions for the TMDL, and 4) general management measures to meet the goals and management objectives of this plan. This chapter includes an information and education component to incorporate recent and ongoing watershed management programs and initiatives, information on potential funding sources, and recommendations for measuring and assessing implementation success.

Consistent with the CWA, the plan is designed to address the physical, chemical, and biological health of the watershed and its water resources. The plan recommendations are divided into four main management objectives (see Table III-1) that include:

- To reduce the loads of sediment and phosphorus from upland sources to improve water quality and enhance and restore stream form and function;
- Reduce the volume and velocity of runoff from upland areas to streams, increase soil infiltration, and protect groundwater recharge;
- Maintain and expand wetland, fish, and wildlife habitats; and,
- Increase recreational opportunities, public awareness of water quality issues, and participation in watershed conservation activities.

These recommendations provide guidance for the management of the water resources within the watershed with respect to a variety of general and specific factors and issues that contribute to the problems related to impairing the hydrologic, hydraulic, geomorphologic, physiochemical, and biological functions of Jackson Creek as detailed in Chapter II. While the presentation of recommendations is organized according to the four main management objective sections below, the implementation of many of these recommendations will also have beneficial effects among multiple dimensions of stream function as demonstrated in Figure II-41. Hence, it is important to keep in mind that the stream functions pyramid provides a framework to assess stream functions, set design goals, and evaluate performance. The pyramid shows that restoration of functions must occur in a certain order for maximum functional lift (improvement) to occur, and that there is an iterative process among these levels over time while working towards achieving the desired goals and adjusting management actions as necessary for the 10-year timeframe and beyond. This iterative process is described in the "Information and Education" and the "Measuring Plan Progress and Success" subsections below.

Recommended Actions Associated with Management Objective to Reduce the Loads of Sediment and Phosphorus from Upland Sources to Improve Water Quality and to Enhance and Restore Stream Form and Function

Rural nonpoint runoff is the greatest source of pollutant loads, and potential load reductions, within the Jackson Creek watershed, thus, the majority of the targeted management measures are focused on cropland best management practices (BMPs) as shown in Table III-2. 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. Installation of grassed waterways was also identified as having a high potential to reduce pollutant loads in this system. Streambank erosion sites were identified and prioritized. Although the streambank erosion sites proportionally contribute the least amount of pollutant loads compared to other impairments, due to their proximity to streams of the watershed, addressing these problems areas would immediately improve water quality as well as enhance instream fisheries habitat and wildlife.

Existing runoff management standards have been established by the State of Wisconsin. Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code* provides runoff management standards and prohibitions for agriculture. However, 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.[7] Although this plan recognizes the importance of continued funding and staff to ensure adherence to State and local standards, it goes beyond reliance on regulation and enforcement. This plan's focused strategy is to rely on empowered local decision makers crafting unique solutions that work for the Jackson Creek watershed in an effort to ultimately exceed compliance standards. Implementing the recommended management measures will require coordination and partnership and funding of a dedicated staff

[7] *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.*

position for this purpose. This strategy is designed to augment ongoing programs such as the continued collaboration of the Walworth County Land Conservation Department and the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) in working with landowners to implement innovative and effective conservation practices.

Point Source Pollution

As summarized in Chapter II, **there are no permitted wasteload allocations that discharge to Jackson Creek, so point source target load reductions were not considered further in this plan**. The sewered areas of the watershed are served by the Walworth County Metropolitan Sewerage District (WalCoMet) which discharges treated wastewater well downstream of Delavan Lake on Turtle Creek (see Map I-2). However, the City of Elkhorn has recently been designated an MS4 community and is currently working with WDNR on developing its Wisconsin Pollutant Discharge Elimination System (WPDES) permit. In addition, it is also important to note that the WDNR is currently developing targeted TMDL wasteload allocations for the City of Elkhorn within the portions of the City that are tributary to the Rock River. Although Walworth County is not designated as an MS4 community, they are collaborating with the City of Elkhorn to meet the City's permit requirements.

Targeted Load Reductions

Pollution load reductions for upland BMPs, gullies, and streambanks were estimated using the USEPA Spreadsheet Tool for Estimating Pollutant Loading (STEPL) as shown in Table III-3. Based upon the Rock River TMDL model agricultural baseline loading for Turtle Creek (model Reach 80 which includes the Jackson Creek subwatershed), a 49 percent reduction in Total Phosphorus (TP) and 26 percent reduction in Total Suspended Sediment (TSS) were used as target load reductions for this plan.

Percent reductions for each of the targeted management measures were based on the STEPL modeled total existing loads without controls for the Jackson Creek watershed of 53,533 pounds TP per year and 35,366 tons TSS per year (see Figure II-21d in Chapter II of this report).[8]

Based upon prior agricultural BMPs applied to cropland, gully stabilization, and riparian buffers implemented throughout the watershed as summarized in Chapter II, it is estimated that the Jackson Creek watershed is already achieving 35 percent and 26 percent pollutant load reductions in TP and TSS, respectively, as noted in Table III-3. Those percent reductions equate to approximate annual load reductions of 18,570 pounds TP and 9,286 tons TSS in the Jackson Creek watershed. This indicates that the existing load reduction for TP is only 14 percentage points

[8]*Although it is likely that these modelled pollutant loads are an overestimate of the loads that would be delivered to Jackson Creek (compared to other modeling techniques and known instream loads), STEPL is an effective and flexible tool to assess existing loads and potential reductions by management practice for planning purposes.*

lower than the reduction of 49 percent established under the TMDL study and that the load reduction for TSS currently meets the 26 percent TMDL reduction goal. However, based upon the existing measured instream loads for TP and TSS in Jackson Creek upstream of Delavan Lake, these load reductions have not resulted in meeting the water quality criteria established under the TMDL study for Reach 80, indicating that additional controls on stormwater runoff are needed in the watershed.

The load reductions anticipated through implementation of the targeted management measures recommended under this plan are estimated to be 23,553 pounds (44 percent) of TP per year and 11,279 tons (32 percent) of TSS per year (see Table III-3). Hence, the existing load reductions achieved within the Jackson Creek watershed as noted previously, combined with the proposed pollutant load reductions associated with the recommended targeted management measures called for under this plan, would achieve reductions of approximately 79 percent in TP and 58 percent in TSS in the Jackson Creek watershed. Thus, the pollutant load reductions that could be achieved within the Jackson Creek watershed portion of the Turtle Creek watershed following implementation of the recommended agricultural, gully, and streambank priority projects, would be expected to exceed the overall reductions of 49 percent for TP and 26 percent for TSS established under the TMDL study for the Turtle Creek watershed as a whole. More importantly, such load reductions are much more likely to affect or improve measured instream loads to achieve the monthly and annual load reduction goals for TP and TSS as measured at the Mound Road station (see Figure II-21c).

Agricultural Best Management Practices (BMPs) - (Table III-2, Part 1)

Although it is difficult to specify at the watershed planning level where agricultural BMPs will be implemented within the Jackson Creek watershed, since such specification depends on factors such as the receptiveness of landowners to such installations, the availability of adequate cost share funding, and technical assistance, this section is intended to provide some guidance for prioritizing projects. As a general rule effectiveness of BMPs in improving water quality decreases with distance from a waterbody. Therefore, **it is recommended that the highest priority agricultural lands for BMP implementation be lands that are to waterways**, which means that any parcels containing waterbodies such as tributaries, stream, ponds, or wetlands are considered the highest priority. **In addition to the proximity to waterways, one or more of the following conditions are recommended to be applied in prioritizing the locations for implementation of agricultural BMPs:**

- Parcels within floodways and/or floodplains as designated by the federal Emergency Management Agency (FEMA) (see Map I-2A),
- Parcels adjacent to primary environmental corridors, secondary environmental corridors, or isolated natural areas (see Map I-7),
- Parcels with high to very high groundwater recharge potential (see Map I-8A),
- Parcels containing highly erodible land/steep slopes (see Map I-10), and

- Parcels containing the highest EVAAL (Erosion Vulnerability Assessment for Agricultural Lands) scores (see Map II-6).

This prioritization scheme is designed to first address those sites for which pollutant loads can be most cost-effectively reduced. **If lands do not meet one or more of these criteria for establishing priority locations for agricultural BMPs, it does not mean that BMPs should be discouraged on those lands. It is likely that reaching the watershed-wide target load reductions would require locating BMPs in both those areas where the BMPs would be most effective and in areas of somewhat lesser effectiveness.**

Increase No-Till from 10 to 60 Percent

Removing crop residue through tillage operations leads to soil erosion. When soil is tilled, more soil is exposed to erosive forces, leading to nutrient and sediment laden surface runoff. No-till farming is the practice where the 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 washoff of nonpoint source pollutants. No-till benefits are recognized in several areas.

By not turning soil over to prepare a seed bed, the soil structure of pores and channels formed throughout the soil surface layers remains intact and not become compacted, allowing precipitation to effectively infiltrate and resulting in less surface runoff. 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 fertilizers. Soil with higher organic matter generally has the capacity to absorb and hold more water, and then release 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. The benefits of no-till are not realized until the practice has been in place for many 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 interdependent farming practices, and likely to investing in purchasing new equipment or modifying existing equipment.

Increase Cover Crops from 5 to 50 percent

The establishment of cover crops is the practice of 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. Other less common, but also effective cover crops include oats, spring wheat, hairy vetch, red clover, turnips, canola, radishes, and triticale.

Cover crops can help reduce phosphorus and sediment loads by reducing erosion and improving infiltration. Cover crops grow and remain during the fallow months when corn and soybean fields would be bare. The use of cover crops for erosion control requires maintaining nearly continuous ground cover to protect the soil against raindrop impact. Having continuous plant cover increases infiltration, reduces flow and runoff across the soil surface, and binds soil particles to plant roots.

A cover crop slows the velocity of runoff from rainfall and snowmelt, reducing soil loss due to sheet and rill erosion. 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 will increase organic matter in the soil, leading to improvements in soil structure, stability, and increased moisture and nutrient holding capacity for plant growth.

Recent findings based on an annual cover crop survey by the USDA Sustainable Agriculture Research and Education program, recommend that a variety of strategies be employed to convince farmers 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.[9]

To achieve targeted load reductions, the number of acres planted to cover crops in watershed area should increase from 5 to 50 percent. This means keeping the existing acreage in cover crops and utilizing this practice on an additional 3,873 acres.

The Erosion Vulnerability Analysis of Agricultural Lands (EVAAL) analysis will help prioritize where in the watershed cover crops could be considered. The EVAAL analysis indicates fields that are vulnerable to erosion from precipitation. EVAAL is a guide and a useful starting point, however additional information is needed on past and current farming practices, future production goals, historical land use, and other landowner considerations to refine and further prioritize realistic cover crop opportunities.

---

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

Increase Nutrient Management Plans from 25 to 100 percent

The goal of a nutrient management plan is to reduce excess nutrient applications to cropland and to thereby reduce nutrient runoff to lakes, streams, and groundwater. Nutrient management plans consider the amounts, types of forms of nutrients, and timing of nutrient application to obtain desired yields while minimizing the risk of surface water and groundwater contamination. The plan must be prepared by a qualified planner, which may be the farmer or a certified crop adviser. Soil testing is done on each field so the farmer knows where nutrients are needed and where they are not, and also takes into account tillage and residue management practices. Plans help farmers allocate nutrients economically while also helping to ensure they are not over-applying nutrients, which could cause water quality impacts.

Install Additional Grass Waterways

A grassed waterway is used to carry runoff water from the field. 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, the installation of subsurface drains, underground outlets or other hard engineered components may be necessary. An effective grass waterway carries runoff water from the field and the grass prevents the water from forming a gulley. The vegetation may also trap some sediment washed from cropland, absorb some chemicals and nutrients in the runoff water, and provide cover for small birds and animals. Grass waterways fill with sediment over time and need to be rejuvenated by removing sediments, regrading, and planting.

A total of 45 high priority grassed waterways (49,478 linear feet or 9.4 miles) are proposed to be installed as shown in Map B-1 in Appendix B. Map B-2 also identifies where the high priority grassed waterways intersect with steep slopes, which could be an important factor in prioritizing installation of this BMP within the Jackson Creek watershed. **Map B-1 shows the location of 25 installed grassed waterways as well as numerous low priority grassed waterways both of which are recommended to be periodically inspected to ensure that they are functioning as designed or are not deteriorating, respectively.**

Initiate Assessment and Evaluation of BMPs

The 10-year targeted management measures matrix in Table III-2 details the milestones and indicators for each practice. In addition, as described below, the assessment of the health of the soil in fields where management recommendations are implemented will foster dialog applicable to multiple objectives of this plan that goes beyond only making recommendations regarding improving surface water quality.

Soil Health Indicator

Soil is made up of different sized mineral particles (sand, silt, and clay), organic matter, and numerous species of living organisms. Soil health is the capacity of soil to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation. Soil properties can change in response to management or climate impacts. Various soil properties can be measured and thus make good indicators of soil quality.

Indicators can be physical, chemical, or biological properties, processes, or characteristics of soils. One physical indicator useful for assessing soil health is the rate at which water infiltrates. The infiltration rate is the time it takes a given amount of water to enter the soil and is expressed as inches per hour. Infiltration will vary depending upon the amount of sand, silt, and clay that makes up a particular soil type. Infiltration rate is also dependent upon how intact the structure and system of pores and channels are within the soil. Soils with well-developed structure and continuous channels infiltrate water quickly and less runoff occurs. Some management practices such as no-till and the use of cover crops, increase organic matter and have a positive effect on soil quality and infiltration rates. No-till also improves soil health by minimizing compaction and breaking of soil pores and channels. This in turn increases the amount of water that soils can absorb. Other management practices, such as tilling the soil when wet, adversely affect soil quality by increasing compaction. Sufficient water must infiltrate the soil profile for optimum crop production. Water that infiltrates through porous soils recharges groundwater aquifers and helps to sustain the baseflow in streams.

It is recommended that soil health be monitored as part of the implementation plan on properties where agricultural BMPs are implemented by using the physical, chemical, and/or biological indicators of soil health as summarized in Appendix E. For example, documenting that water infiltration rates improve over time, or is sustained at rates indicating healthy soil structure, will validate the continued use of the particular BMPs.

Convert 8.3 Percent of the Watershed Area to Riparian Buffers/Restored Wetland (Table III-2, Part 2)

There are very few wetlands remaining in the Jackson Creek watershed. The few existing wetlands are found along the main stem of the Creek. Pella silt loam, the predominant hydric soil type in the watershed, is very productive when the water table is lowered. The water table has been lowered in many locations by tile systems that are installed four feet or more below the ground surface for the purpose of draining water from the soils and conveying it to Jackson Creek or a tributary to the Creek. Extensive tile systems are located along the Creek valley.

As summarized in Chapter I of this report, the pre-settlement wetlands in the Jackson Creek watershed likely contained prairie elements, particularly wetlands that were not seasonally inundated for prolonged periods (see restoration Appendix D). Areas in permanent vegetation, some wetlands, and native grassland habitats in particular, also infiltrate water and reduce polluted runoff. Restoration of wetland and associated upland prairie habitats, particularly within the 1,000-foot optimal wildlife habitat riparian buffer zone, is an important recommendation to achieve the water quality and wildlife goals of this plan. Wetland restoration can be done by disabling drain tile, installing water control structures, and establishing embankments to settle out sediment and associated nutrient loads.

Restoring wetlands will increase the diversity of native plants, provide wildlife habitat for species of concern, and improve both the biological and hydrological connectivity of the watershed, which is further described in the "Protect and Expand Riparian Buffers" subsection below.

However, implementing restoration of wetlands will be difficult since it involves taking agriculture land out of production. Therefore, of the total 1,929 acres of potential restorable wetland throughout the entire watershed, restoration of approximately 1,122 acres was determined to be potentially feasible (see Riparian Corridor Conditions section in Chapter II of this report). More specifically, **It is recommended to restore a total of 1,122 acres of wetland/riparian buffers (124 acres within the 75-foot wide zone adjacent to the stream, 463 acres within the 400-foot zone, and 535 acres within the 1,000-foot zone) along Jackson Creek and its associated tributaries (as shown on Map B-2 in Appendix B) to help meet the pollutant load reduction goals for this watershed.** That level of restoration would double the amount of existing wetland/riparian buffers within the Jackson Creek watershed from about 8.3 to 16.6 percent of the watershed area.

Harvestable Buffers

Although converting cropland to restored wetland within 1,000 feet of a waterway is considered a high priority, expansion of riparian buffers to a minimum width of 75 feet on each side adjacent to all waterways as shown on Map B-2 in Appendix B is considered the highest priority in terms of pollutant load reduction in the Jackson Creek watershed. In addition, 75-foot-wide riparian buffers are envisioned to be harvestable, so that farmers can periodically harvest the grasses to feed livestock. Expansions of restored wetland/riparian buffers to the 400 and 1,000 foot widths are most likely to be located where crop yield losses have been found to be greatest, such as in fields with steep slopes or high erosion scores or fields within the one-percent-annual-probability (100-year recurrence interval) floodplain. As described in Chapter II, crop yield losses have been found to be greatest along the edges of drainage ditches that tend to get flooded such as shown in Figure III-1. Therefore, converting such marginal, relatively low-yield cropland to a buffer may not necessarily reduce overall yields as summarized in the "Best Management Practices/Programs for Riparian Buffers" section in Chapter II of this report. In addition, restoration of wetlands within riparian buffers out to the 400- and 1,000-foot widths is most likely to be achievable when agricultural land is converted to urban uses. Such fields where this is planned to occur are shown on Map B-2 in Appendix B. This will likely be the last opportunity to establish such critical protective boundaries around waterways before urban structures and roadway networks are constructed (see the "Maintain and Expand Wetland, Fish, and Wildlife Habitat" subsection below for more details.

Restore and Stabilize Degraded Streambanks (Table III-2, Part 3)

The survey conducted by SEWRPC staff assessed erosion sites based on bank slope, length, and height of active erosion at each site. To rank priority streambank stabilization sites, the SEWRPC staff estimated the annual load of sediment contributed to the Creek by each site. Results of these surveys are summarized in Figure II-21d in Chapter II of this report and shown on Map B-3 in Appendix B. All the erosion sites and their associated severity are detailed in the "STEPL Load Reduction Results for Streambank Restoration Practices" section in Appendix B.

The estimated costs for recommended streambank stabilization projects within the Jackson Creek watershed are set forth in Table III-3. Those costs were estimated based on an assumed typical stabilization approach and they include mobilization, regrading and revegetating banks, and rock toe stabilization. Additional costs of engineering, permitting, inspection, and other contingency costs were not included. In all cases it is **recommended that revegetation of the banks using bioengineering techniques be employed as part of the stabilization method to the extent possible.**

Based on the results of the surveys conducted within the Jackson Creek watershed, this plan makes the following recommendations regarding streambank erosion:

1. That 12 severely eroding sites totaling 2,265 lineal feet and 19 moderate eroding sites totaling 1,242 lineal feet be stabilized to address pollutant loads as identified on Map III-2.
2. That 47 low priority erosion sites totaling approximately 2,365 lineal feet as identified on Map III-2 be monitored and addressed if they become worse or more severe.
3. That the design and implementation of the streambank stabilization projects ensure that the stream is reconnected to its floodplain when practicable, and that consideration be given to restoring stream reaches to their historical channel alignment prior to channelization and/or two-stage channel design configuration (see "Streambank Erosion and Restoration Priorities" section below).[10]
4. That water quality be improved by reducing the volume and velocity of runoff from upland areas to streams through increasing soil infiltration and protecting groundwater recharge.

[10]*If restoration of floodplain connectivity and/or addressing channelization were incorporated into the pollutant reduction estimates for the severe and moderate eroding streambank sites within the Jackson Creek watershed, the pollutant load reductions would be significantly higher than what was modeled using STEPL.*

Reduce the Volume and Velocity of Runoff from Upland Areas to Streams, Increase Soil Infiltration, and Protect Groundwater Recharge

> In some cases, load reductions and/or specific targeted goals associated with recommendations within this section have been addressed under management measures described above (e.g., riparian buffers). In other cases load reduction goals were either not quantified due to them being outside the scope of this project (e.g., green infrastructure projects) or not lending themselves to quantification (e.g., protection of groundwater recharge areas). However, implementation of those recommendations would lead to pollutant load reductions beyond what was modeled and will be vital to the long-term protection of Jackson Creek within the 10-year timeframe and beyond. Implementation of these recommendations would contribute to improving the hydrologic, hydraulic, geomorphology, physiochemical, and biological functions of this stream system to achieve the water quality (Tables II-1 though II-5), habitat quality (Table II-18), and biological quality (Tables II-12 and II-13) criteria and/or targets for the Jackson Creek watershed.

Both agricultural and urban development have brought significant changes to the landscape and have produced profound effects on the surface water hydrology within the Jackson Creek watershed. These landscape changes historically have included modification of the drainage patterns, especially with respect to tributaries; hardening of surfaces; alteration of groundwater infiltration within urbanized areas; straightening and ditching of streams; and installation of drain tile systems in agricultural areas. These changes to the landscape generally act to increase the volume and rate of runoff from precipitation events, leading to flashiness in stream flow. This flashiness reduces streambank and streambed stability, increases pollutant loading, and changes the sediment dynamics within the stream system. These changes in turn reduce the availability of habitat and degrade its quality.

The objective of the recommendations set forth below is to promote restoration of the hydrologic and hydraulic function of Jackson Creek and its associated watershed so that stream discharges more closely emulate the levels that are thought to have occurred prior to agricultural or urban development. Specifically, decreases in average-flow magnitude, high-flow magnitude, high-flow frequency, and/or high-flow duration are sought to provide potential improvements to the algal, invertebrate, and fish communities within the Jackson Creek watershed.

Agricultural Surface Water Hydrology

Extensive networks of drain tile have been installed over large areas of agricultural land to clear fields of rainwater as rapidly as possible and keep them productive. Most stream channels located in agricultural areas of the watershed have been deepened and straightened to facilitate the flow of water from agricultural subsurface drainage outlets, to maximize conveyance of agricultural drain water, to maximize the amount of land available for cultivation, and to make the land easier to cultivate. The following recommendations are intended to mitigate the impacts of channelization and installation of drain tile on the surface water hydrology:

1. **It is recommended that natural surface hydrology be restored by reducing, to the extent feasible, unnecessary drain tile systems and retrofitting needed systems.** Specific measures that can be taken to accomplish this recommendation include:
   - Investigating drainage patterns and available drain tile system maps to determine whether there are operational systems that are no longer necessary and remove or disconnect any unneeded tile systems that are found.
   - Integrating water control structures within drain tile systems to reduce tile flow during periods when a higher water table would not present a problem for crop production. (See "General Rural Nonpoint Source Pollution Control Measures" subsection below for information on drainage water management.)
2. **It is recommended that natural landscape elements be restored to slow down water and reduce flashiness and its negative effects on aquatic habitat quality.** Specific measures that can be taken to accomplish this recommendation include:
   - **Improving the connectivity of Jackson Creek to its floodplain,** improving instream habitat, and reducing streambank erosion **by reconnecting historical stream channels (i.e., remeandering) and reconstructing new channels and/or two-stage channel design systems** located in the disconnected and partially connected floodplain areas **as shown on Map III-2 insets 1 through 4, based upon the template of reference Reach 3 within the Kettle Moraine Wetland Reserve in the middle portions of Jackson Creek.** Recent research has revealed that channelized streams minimize water residence time and biological nutrient processing, which can be mitigated by restoring floodplain connectivity to reduce pollutant loads and improve metabolism in agricultural streams. The benefits of floodplain restoration are most apparent during high flow events (during inundation) and floodplains are more effective at assimilating nutrients when the floodplains are vegetated with appropriate native plants as shown on Map III-2 Insets 1 through 4.
   - Considering expanding buffers to include areas of high and very high groundwater recharge potential.
   - Considering installing saturated buffers in agricultural areas of the watershed, where feasible. (See "General Rural Nonpoint Source Pollution Control Measures" subsection below for information on saturated buffers.)

General Rural Nonpoint Source Pollution Control Measures

Nonpoint source pollution contributed by rural stormwater runoff constitutes the major source of water pollution in the Jackson Creek watershed. Therefore, in addition to the targeted management measures summarized above, the following additional strategies are also recommended.

1. **That a collaborative model of water quality improvement based on the St. Croix/Red Cedar River Basin Farmer-Led Watershed Council Project be developed through farmer engagement in the Jackson Creek watershed** (see Appendix H). This program would be designed to improve water quality in Jackson Creek through reduced pollutant loads; to increase knowledge about, and engagement with, water quality issues, including the adoption of conservation practices; and to develop leadership around water quality issues among farmers in the watershed. This farmer-led project could be a model for other watersheds in the Rock River basin. Implementing the recommended management measures will require coordination and partnership (see the Information and Education section below) and funding a dedicated Walworth County LURM staff position for this purpose (see "Cost Analysis" and "Funding Sources" sections below).
2. **That implementation of the agricultural BMPs summarized above (see "Targeted Load Reductions" subsection above) be a higher priority on agricultural fields that are located in areas of high and very high groundwater recharge** (see Map III-1).
3. **That the application of practices to reduce soil loss from cropland be expanded to attain erosion rates less than "T," the tolerable soil loss rate.**[11] This is envisioned to be accomplished through a combination of practices including, but not limited to, expanded no till, grassed waterways, use of cover crops, and riparian buffers (see Targeted Management Measures in Tables III-2 and III-3). The applicable measures should be determined by the development of farm management plans which are consistent with the County land and water resource management plans.
4. **That nutrient management plans be prepared for all agricultural operations in the watershed that do not currently have them, and that manure and other nutrients be applied to fields in accordance with nutrient management plans** (see Targeted Management Measures in Table III-2 and III-3). **The provision of barnyard runoff control systems and six months of manure storage are also recommended for all livestock operations in the watershed as well as maintaining exclusion of livestock from waterbodies and adjacent riparian areas.** To facilitate this, **it is recommended that the WDNR consider increasing levels of cost-share funding to enable a higher**

[11] *"T-value" is the tolerable soil loss rate—the maximum level of soil erosion that will permit a high level of crop productivity to be sustained economically and indefinitely, as determined by the U.S. Natural Resource Conservation Service. "Excessive" cropland erosion refers to erosion in excess of the tolerable rate, or T-value.*

level of implementation of the best management practices needed to meet the NR 151 performance standards.

5. **That pilot projects be conducted under field conditions in the watershed to evaluate the performance of two potential strategies for treating tile drainage—drain water management and saturated buffers.—those pilot projects would help determine whether these practices would be useful in reducing contributions of pollutants, especially nutrients, from agricultural fields with tile drainage.**

   Because of the nature of the soils present in portions of the watershed, much of the agricultural land is artificially drained through the use of subsurface drain tile. These tiles often discharge directly into streams, or into ditches that discharge into streams. Because they provide a direct pathway from fields to surface waterbodies, drain tiles can allow water and pollutants to bypass agricultural BMPs, especially riparian buffers, reducing their effectiveness. Research conducted at the University of Wisconsin Discovery Farms illustrates this bypass effect.[12] 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 tile (i.e., tile blow outs), about 65 percent of the total phosphorus and the majority of 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.

   Because the performance of drainage water management and saturated buffers with respect to removing phosphorus and with respect to the types of conditions present within the Jackson Creek watershed are not well understood, it would be desirable to conduct pilot projects in the watershed under which these practices could be installed and their performance evaluated. County conservation staff could use the results of such pilot projects to devise strategies for addressing the "bypassing effect" of drain tiles for each of these practices as summarized below.

   a) **Drainage water management** is the practice of using a water control structure in a main, submain, or lateral drain to vary the depth of water at the drain outlet. When this is done, the water table must rise above the invert elevation of the outlet for drainage to occur. This allows the minimum depth of the water table under the field to be controlled to reduce flow from the tile during periods when a higher water table would not present a problem for crop production. For example, for a field managed using a corn-soybean rotation, the outlet water depth, as determined by the control structure, would be:

---

[12]*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.*

- Raised after harvest to limit drainage outflow and reduce the delivery of nutrients to ditches and streams during the off-season;
- Lowered in early spring and again in the fall so the drain can flow freely before field operations, such as planting or harvesting; and
- Raised again after planting and spring field operations to create the potential to store water for the crop to use during the summer.

Drainage water management can reduce nutrient loads to receiving streams. Studies have found reductions in annual nitrate loads ranging between 15 percent and 75 percent, depending upon location, climate, soil type, and cropping practice.[13] Few data are available regarding the performance of this practice with respect to phosphorus.

b) **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. While no data have yet been collected regarding the performance of saturated buffers with respect to phosphorus, it would be expected that uptake by plants growing within the buffers would reduce the amount of phosphorus contributed to streams.

Urban Surface Water Hydrology

Historically, the approach to managing increases in rates and volumes of runoff within urbanized areas often involved the construction of storm sewer and/or open channel systems to convey stormwater as quickly and efficiently as possible to streams. In recent years, flooding, water quality impairment, and environmental degradation have demonstrated the need for an alternative approach to urban stormwater management. Consequently, current approaches to stormwater management seek to manage runoff using a variety of measures, including detention, retention, infiltration, and filtration, better mimicking the disposition of precipitation on an undisturbed landscape.

1. **It is recommended that natural surface hydrology be restored to the degree practicable by reducing impervious cover and associated runoff in urbanized areas.** Specific measures that can be taken to accomplish this recommendation include:

[13]*University Cooperative Extension Service Publication No. WQ-44, August, 2006.*

- In addition to implementing the recommendations described in the "Protect Areas of High Groundwater Recharge Potential" subsection below, it is recommended that new urban development be accomplished to minimize impacts on areas of high groundwater recharge potential and that infiltration practices be installed in cases where development affecting areas of high groundwater recharge potential cannot reasonably be avoided or in areas where development already exists. If new urban development is to take place in areas of high recharge potential, it is recommended that this development incorporate green technologies designed to maintain infiltration functions consistent with high groundwater recharge potential.

2. **It is recommended that natural landscape elements be restored to "slow down water" and reduce the magnitude of flashiness in stream flow and its negative effects on aquatic habitat quality.** Specific measures that can be taken to accomplish this recommendation include:

    - **Based on planned land use changes between now and 2035, it is recommended that riparian buffers and environmental corridors be established, expanded, or protected from development[14] to allow the capture of significant rainfall in Sub-basin JC-4; and also Sub-basins JC-2, JC-3, and JC-6, which are next most likely to suffer loss of stream function and habitat (see Map B-2 in Appendix B).** As noted in Chapter I, when impervious services increase, negative changes to streams are often linked. If steps are not taken to mitigate these negative effects, Jackson Creek will lose biological integrity.
    - **The use of green infrastructure to manage stormwater in the Jackson Creek watershed is recommended**. The USEPA defines green infrastructure as follows (see http://www.epa.gov/green-infrastructure/what-green-infrastructure):

      "Green infrastructure uses vegetation, soils, and other elements and practices to restore some of the natural processes required to manage water and create healthier urban environments. At the city or county scale, green infrastructure is a patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the neighborhood or site scale, stormwater management systems that mimic nature soak up and store water. …an approach to wet weather management that is cost-effective, sustainable, and environmentally friendly. Green infrastructure management approaches and technologies infiltrate, evapotranspire, capture, and reuse stormwater to maintain or restore natural hydrologies."[15]

---

[14]*Restrictions on development in primary environmental corridors, and certain secondary environmental corridors, are already applied throughout the Southeastern Wisconsin Region under the sanitary sewer service area planning process conducted by the Regional Planning Commission in its role as the designated areawide water quality planning agency for the Region.*

[15]*U.S. Environmental Protection Agency,* Reducing Stormwater Costs through Low Impact Development Strategies and Practices, *2007.*

This is an approach that helps infiltrate and store rainwater in more natural ways. Green infrastructure complements the gray infrastructure, such as sanitary sewer pipes, storm sewers, and water reclamation facilities that have been, and will continue to be, the backbone for meeting water quality and stormwater management goals. While green infrastructure cannot entirely replace the capacity of gray infrastructure in urban areas, it can improve water quality through treatment of stormwater runoff and reduce the volume of stormwater runoff to Jackson Creek during small storms.

- **It is recommended that the counties and municipalities in the Jackson Creek watershed review their codes to identify barriers to the implementation of green infrastructure practices within their jurisdictions.** Municipal codes and ordinances have a broad impact on the use of green infrastructure. Depending on their specifics, they can provide incentives for, or present barriers to, the implementation of green infrastructure by the private and public sectors. Modifications to local codes, ordinances, and review processes can encourage municipalities, builders, and developers as well as property owners to implement green infrastructure practices.

Urban Stormwater Runoff Pollution Control Measures

Although rural nonpoint source loads are currently substantially greater than urban nonpoint source loads in the watershed, a review of planned land use conditions indicates that urban loads will be increasing. Therefore, addressing urban stormwater runoff is an important element that needs to be included in this plan. The following recommendations are targeted at reducing the contributions of pollutants from these sources through a variety of strategies:

1. **It is recommended that urban nonpoint source controls be implemented that are consistent with the standards set forth in NR 151.** By implementing controls to meet or exceed the standards of NR 151, municipalities will address the control of construction site erosion; the control of stormwater pollution from areas of existing and planned urban development, redevelopment, and infill; and infiltration of stormwater runoff from areas of new development.
2. **It is recommended that the City of Elkhorn design its illicit discharge detection and elimination (IDDE) program developed under the City MS4 permit to monitor outfalls to reduce** pathogens and fecal indicator bacteria.
3. **It is recommended that Walworth County continue to work closely with the City of Elkhorn in the development of its permit, information and education program, and stormwater infrastructure mapping.**
    - **It is recommended that the City of Elkhorn and Walworth County develop a standard digital format, labelling, and coordinate system for mapping stormwater infrastructure**to

establish a format that can be applied by other municipalities in the future, enabling inventories among municipalities to be readily compared and merged at the scale of watersheds.

- Consider inspection of Walworth County's salt storage facility and parking lot as identified in Figure II-35a in Chapter II of this report to ensure that it is not discharging or draining into the unnamed Tributary E.
- Consider installing floating islands or floating treatment wetland technologies in existing and/or planned wet stormwater detention basins or stormwater wetlands, where applicable, as shown in Figure III-2, to reduce nutrient and other pollutant loads from entering Jackson Creek.

4. **It is recommended that the Town of Delavan and WDNR reconstruct a more natural meandering stream channel in the wetland immediately upstream of Delavan Lake as shown on Map III-2 and Inset 1 and consider installing floating wetland island treatments and/or disconnecting two of the wetland detention ponds. Those actions** would help reduce pollutant loads to Jackson Creek. This design would be more consistent with the original design concept for these detention basins as shown in Figure II-4 in Chapter II of this report, with the exception that a more naturalized stream channel also be constructed (see the "Maintain and Restore Instream Habitat" subsection below). In this design scenario, the disconnected stormwater detention basins would not release water under normal low flow conditions, preventing discharge of pollutants from these basins; however, they would continue to function during high water events to capture and retain both sediment and phosphorus. This is a complicated issue and more information may be necessary to determine the best and most cost effective approach to managing this series of detention basins to improve their effectiveness in pollutant removal.

5. **It is recommended that, at a minimum, County-enforced inspection and maintenance programs be implemented for all new or replacement private onsite wastewater treatment systems (POWTS) constructed after the date on which the County adopted private sewage system programs, that voluntary County programs be instituted to inventory and inspect POWTS that were constructed prior to the dates on which the County adopted private sewage system programs, and that the WDNR and the County work together to strengthen oversight and enforcement of regulations for disposal of septage and to increase funding to adequately staff and implement such programs.** Regulations regarding POWTS set forth by the Wisconsin Department of Safety and Professional Services in Section SPS 383.255 of the *Wisconsin Administrative Code* mandate an expansion of county and municipal POWTS programs. Under the current rules, units of government are required to complete inventories of POWTS in their jurisdictions by October 1, 2017, and have the other elements of the program in place by October 1, 2019. Thus, **it is recommended that the county and municipalities in the watershed implement expanded POWTS programs in accordance with the deadlines given in SPS 383.255**.

6. **Should any CAFOs be established within the watershed, it is recommended that nutrient management requirements for such operations be based upon the conditions given in their WPDES permits.**

Protect Areas of High Groundwater Recharge Potential

Groundwater recharge within the Jackson Creek watershed supplies water to the shallow aquifers, which, in turn, provide the baseflow to the Creek and its tributaries. Baseflow is essential to maintaining the natural hydrology, instream habitat, and the overall health of the Creek, particularly during the droughts and low-flow periods which may occur more frequently as climate change occurs. This indicates that the maintenance and improvement of groundwater recharge is a crucial part of any plan that hopes to maintain or improve water quality and instream habitat conditions within the watershed.

Traditional urban development increases the area of impervious surfaces which, in the absence of green infrastructure or other land development measures to promote infiltration of runoff, reduces infiltration volumes into the shallow aquifer. This reduction in infiltration reduces the baseflows provided by the shallow groundwater system. This loss of baseflow can lead to substantial loss in stream depth and volume, 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 the intermittent, coolwater and warmwater fishery. The 2035 planned land use data presented in Chapter I of this report show that some planned land use changes are located in areas that have been identified as having high and very high groundwater recharge potential (see Map III-1). Maintaining the groundwater recharge provided by these areas is important in order to preserve baseflows to the surface water system of the watershed.

1. **Specific recommended management measures to protect groundwater recharge potential include:**
   - Examination of the latest maps to identify and avoid areas of high and very high groundwater recharge potential prior to the approval of new development plans by local governments;
   - Protection and preservation of areas classified as high and very high groundwater recharge through conservation easements, land purchases, or voluntary incentive-based measures. Such protection should also incorporate preservation of environmental corridors, isolated natural resource areas, prime and other agricultural areas, and open lands that are associated with cluster, or open space, developments that facilitate groundwater recharge;
   - Consideration of groundwater recharge potential when locating new buildings. This consideration should include review of development proposals to avoid where possible locating buildings and other impervious infrastructure in areas of high and very high groundwater recharge potential;

- Consideration of groundwater recharge areas during the siting, design, and installation of sewers, water lines, and other buried utilities which could intercept groundwater flows.

It is recognized that in some cases, it will not be possible to avoid locating urban development on or near areas of high groundwater recharge. In these cases, it is even more crucial to take measures to maintain both groundwater levels and groundwater quality.

2. **It is recommended that mitigation measures be implemented to reduce the impacts of any future urban development on groundwater recharge quality and quantity.** Specific measures that can be taken to accomplish this recommendation include:
   - Reviewing and updating as necessary, local and county land use regulations to promote where appropriate, cluster, or open space, development practices that provide for the clustering of new development within the watershed so as to minimize potential reductions in groundwater recharge.
   - Maintaining infiltration and recharge rates as close to existing rates as practicable by incorporating runoff management recommendations for enhancing infiltration using low-impact design standards in accordance with the regional water supply plan.[16] Some examples of infiltration techniques and low-impact design include:
     - Bioretention cells
     - Curb and gutter elimination
     - Grassed swales
     - Green parking design
     - Infiltration trenches
     - Permeable pavement
     - Rain barrels and cisterns
     - Riparian buffers
     - Sand and organic filters
     - Soil amendments
     - Tree boxes
     - Vegetated filter strips
     - Vegetated roofs

Under current conditions, the extent of urban development within the Jackson Creek watershed is sufficient to negatively affect the groundwater quantity and quality in shallow aquifers, and in turn water quantity and water

---

[16]*SEWRPC Planning Report No. 52,* A Regional Water Supply Plan for Southeastern Wisconsin*, December 2010.*

quality within the Jackson Creek and its tributaries. Implementing projects that seek to restore the natural precipitation infiltration characteristics have the potential to mitigate these effects.

3. **It is recommended that measures be taken to reduce the impact of existing urban development on groundwater recharge and groundwater quality.** Specific measures that can be taken to accomplish this recommendation include:
   - Increasing the infiltration of urban runoff at those sites where it can be achieved without degrading groundwater quality;
   - Retrofitting current urban development to improve infiltration of rainfall and snowmelt using innovative BMPs that are associated with low-impact development including bioretention and rain garden projects,[17] disconnection of downspouts from sewer systems, installation of porous pavement, and other green infrastructure practices, as recommended above (also see the information on green infrastructure provided in the preceding "Urban Surface Water Hydrology" section); and
   - Applying the stormwater management technical standards developed by the WDNR in the design of stormwater management facilities. In particular, the potential for pollutants to enter groundwater through infiltration should be considered in the design of infiltration facilities such as, infiltration trenches, infiltration basins, bioretention facilities, rain gardens, grassed swales, and stormwater detention basins. This consideration is especially important in areas with shallow depths to groundwater.

Although infiltration into soils provides some level of pollution reduction, shallow aquifers can be vulnerable to pollution. Within the Jackson Creek watershed there are specific areas associated with particular land uses that could potentially contribute pollutants to groundwater. These areas include golf courses and agricultural fields associated with high groundwater recharge areas which could act as sources of pollution due to over-fertilization and pesticide use. They also include urban and residential areas, which could act as sources of a variety of urban runoff pollutants, including chloride, gasoline, heavy metals, fertilizers, and pesticides. Pollutants contributed by these areas can infiltrate into groundwater during rain events. This pollution needs to be prevented to the greatest extent practicable to avoid contaminating the groundwater and the baseflow of Jackson Creek and its tributaries.

[17] *Roger Bannerman, WDNR and partners; Menasha Biofiltration Retention Research Project, Middleton, WI, 2008; N.J. LeFevre, J.D. Davidson, and G.L. Oberts,* Bioretention of Simulated Snowmelt: Cold Climate Performance and Design Criteria, *Water Environment Research Foundation (WERF), 2008; William R. Selbig and Nicholas Balster,* Evaluation of Turf Grass and Prairie Vegetated Rain Gardens in a Clay and Sand Soil: Madison, Wisconsin, Water Years 2004-2008*, In cooperation with the City of Madison and Wisconsin Department of Natural Resources, USGS Scientific Investigations Report, in draft.*

4. **It is recommended that pollution reduction measures be implemented in areas, such as golf courses, that are located in areas of high groundwater recharge potential**. Specific measures that can be taken to accomplish this recommendation include:
   - Reduce or eliminate the application of fertilizers and pesticides to the extent practicable on other land uses prone to nutrient and chemical pollution which are located in areas of high and very high groundwater recharge. It is particularly important that nutrient and chemical applications not occur during periods when groundwater levels are known to be high.

Recommended Actions Associated With Management Objective to Maintain and Expand Wetland, Fish, and Wildlife Habitats

Implementation of plan recommendations related to habitat would lead to further pollutant load reductions beyond what was modeled under this study and will be vital to the long-term protection of Jackson Creek within the 10-year timeframe and beyond. Implementation of these recommendations would contribute to improving the hydrology, hydraulic, geomorphology, physiochemical, and biological functions of this stream system to achieve the water quality (Tables II-1 though II-5), habitat quality (Table II-18), and biological quality (Tables II-12 and II-13) criteria and/or targets for the Jackson Creek watershed.

The presence of healthy wildlife communities, including populations of animals such as deer, fish, amphibians, reptiles, birds, and small mammals, is a significant indicator of a healthy watershed. This is largely because wildlife populations require large, well-connected natural areas, which are associated with good water quality and good aquatic and terrestrial habitat. The presence of healthy wildlife populations provides recreational opportunities, such as bird watching, hunting, fishing, and nature hiking.

Maintain and Improve Wildlife Habitat

The environmental corridors and isolated natural resource areas (Map I-7), as well as the Lake Lawn Wetland Complex and Jackson Creek Wetlands designated natural areas (Map I-8) contain the most pristine lands in the watershed. These areas are crucial to wildlife maintenance and enhancement due to their continuity, size, and proximity to Jackson Creek and its associated tributaries. Map III-3 is provided to guide wildlife enhancement activities toward protecting, enhancing, and connecting these resources. This map indicates the location of primary and secondary environmental corridors and isolated natural areas. It also indicates the vulnerable existing and potential buffer areas in the watershed, which are identified to provide guidance as to where buffer development and land purchase and easements should be focused when attempting to enhance wildlife. As summarized above within the "Targeted Load Reductions" subsection, increasing the amount of riparian buffers/restored wetland by 8.3 percent to meet pollutant load reductions within the priority areas as shown in Map B-2 in Appendix B will also help to achieve significant improvements to fish and wildlife habitat within the Jackson Creek watershed. This would double the amount of existing wetland/riparian buffers within the Jackson Creek watershed from about 8.3 to 16.6 percent, and such an amount of buffered lands is also consistent with known goals to protect and restore wildlife in other watersheds.[18] Therefore, these important riparian areas are considered a high priority to reduce pollutant loads as well as to protect and restore hydrological function and improve wildlife within this watershed. In addition, consideration should also be given to protecting networks of wetland and upland habitat communities in both rural and urban settings.

In general, the goals of the recommendations included on Map III-3 are to protect and expand primary and secondary environmental corridors to the extent feasible while maximizing connections between isolated natural areas and the corridors. These connections can be prioritized for expansion by establishing buffers out to the 75-foot, 400-foot, and 1,000-foot distances as shown on Map III-3. Measures taken to carry out these recommendations will ultimately greatly benefit the wildlife in the Jackson Creek watershed.

To maintain and improve wildlife populations in the Jackson Creek watershed, the following recommendations have been developed:

1. **It is recommended that wildlife habitat be preserved and expanded through protection of primary environmental corridors, secondary environmental corridors and isolated natural resources areas (Map I-7) where feasible; natural areas and critical species habitats (Map I-8); and through establishment of additional riparian buffers** (see Map III-3 and Map B-2 in Appendix B)**.** Establishment of riparian buffers should occur particularly at those sites where development of a buffer can be located contiguous with an environmental corridor or natural area and may result in a potential expansion and/or protection of such areas. Specific measures that can be taken to accomplish this recommendation include:
   - Implementing recommendations for the acquisition and protection of wetland and woodland/upland areas that have been identified for acquisition in the adopted regional natural areas and critical species habitat protection and management plan.[19] Implementation of these recommendations, in addition to those set forth in the adopted park and open space plan for

---

[18]*Environment Canada,* How Much Habitat is Enough? *Third Edition, Environment Canada, Toronto, Ontario, 2013*

[19]*SEWRPC Planning Report No. 42*, A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin, *September 1997*; *SEWRPC,* Amendment to the Natural Areas and Critical Species Habitat Protection and Management Plan for the Southeastern Wisconsin Region, *December 2010*.

Walworth County,[20] would complement the protection and preservation of environmentally sensitive lands.

- The management and restoration of wetlands and upland buffers should be prioritized near and within existing natural areas. In particular, installation of grassland buffers upslope from the Jackson Creek Wetlands and the Lake Lawn Wetland Complex and restoration of farmed wetland adjacent to the Jackson Creek Wetlands would alleviate further degradation to the remaining high quality natural communities within these natural areas.
- Conducting targeted vegetation inventories to assess floristic quality as well as invasive species presence and abundance to guide management of existing natural areas and newly restored riparian buffers/wetland and upland habitat areas.
- Conserving and managing wooded areas that contain oak or hickory for future oak and hickory recruitment.

2. **It is recommended that habitat fragmentation be reduced by preserving and further enhancing connections between riparian buffer areas, open spaces, critical species habitat sites, and natural areas.** Specific measures that can be taken to accomplish this recommendation include:
   - Establishing corridors and buffers of natural habitat connecting isolated wetlands to nearby upland areas to allow reptiles and amphibians safe access to upland habitats necessary for certain life history stages. In general, priority should be given to the restoration of wetlands and upland buffers that enhance or create upland-wetland habitat complexes or increase connectivity between Jackson Creek, its associated natural areas and other wetlands, and nearby stands of existing woodland;
   - Maintaining connections between streams and overbank floodplains so as to continue to protect and preserve fish and wildlife habitat and water quality benefits, making use of open space lands, riparian corridors, and park lands in floodprone areas, as appropriate;
   - Maintaining connections between streams and wetlands, wetland and upland complexes, wetlands and ephemeral and/or perennial ponds, and multiple ponds, all of which provide redundancy in available habitat quality and quantity necessary to help ensure wildlife diversity; and
   - For existing and future roadway projects, considering various pre- and post-construction measures to prevent, mitigate, or compensate for road impacts on surrounding habitats and wildlife, particularly when crossing waterways.[21] The expansion of the road network contributes

---

[20]*SEWRPC Community Assistance Planning Report No. 135,* A Park and Open Space Plan for Walworth County*, March 2014.*

[21]*Forman, R. T. T., et al.,* Road Ecology: Science and Solutions*, Island Press, Washington, D.C. 481 pp., 2003.*

to landscape fragmentation, which is recognized as one of the major threats to biodiversity for amphibians, reptiles, and mammals. In addition to reduction of road casualties, project success should also be based upon restoring ecological processes. Goals of a successful mitigation project should consider including the following six elements.[22] Actions to implement projects would have to be coordinated with the WDNR, the Highway Division of the County Public Works Department, local public works departments, and/or the Wisconsin Department of Transportation (WisDOT):

- Reduction of roadkill rates following mitigation;
- Maintenance of habitat connectivity;
- Persistence of gene flow among populations;
- Affirmation that biological requirements are met;
- Allowance for dispersal and recolonization; and
- Maintenance of processes and ecosystem function to support sustainable populations of target organisms.

3. **It is recommended that best management practices aimed at maintaining wildlife be implemented. These practices should consist of voluntary, educational, or incentive-based programs.** Specific measures that can be taken to accomplish this recommendation include:
   - Encouraging agricultural landowners to enroll in Federal programs which provide incentives to restore habitats on agricultural lands such as the Conservation Reserve Program, the Wetland Reserve Program, the Wildlife Habitat Incentives Program, or the Landowner Incentive Program;
   - Encouraging homeowners and businesses within the 1,000-foot optimal habitat zone to consider landscaping that would enhance wildlife by providing connections (see Appendix C) or lanes through the properties. These programs should encourage the use of native plants that provide cover and food for wildlife.

Protect and Expand Riparian Buffers

As discussed above, protection and expansion of riparian buffers is an essential component to address both pollutant load reductions (see "Targeted Load Reductions" subsection above) and protection of wildlife. Riparian buffers protect water quality, groundwater quality and recharge, fisheries, wildlife, and ecological resilience to invasive species, and they may reduce potential flooding of structures and harmful effects of climate change (see Appendix

[22] *Kimberly M. Andrews, J. Whitfield Gibbons, and Denim M. Jochimsen,* Literature Synthesis of the Effects of Roads and Vehicles on Amphibians and Reptiles*, Federal Highway Administration (FHWA), U.S. Department of Transportation, Report No. FHWA-HEP-08-005, Washington, D.C., 151 pp., October 2006.*

C). Hence, preservation and development of riparian buffers are key to the existing and future economic, social, and recreational well-being of the Jackson Creek watershed.

As noted above and identified in Map III-3, while this plan recommends protecting and expanding riparian buffer regions to a minimum 75-foot width for water quality protection and, where feasible, an optimum 1,000-foot width for wildlife protection, it is important to note that, for water quality and wildlife protection, the presence of a buffer is always better than the absence of one, even if only to prevent some pollution or allow for better aquatic habitat. Therefore, **it is recommended that efforts be made to establish buffered areas, to the maximum extent practicable up to the optimum width of 1,000 feet and beyond that width in special cases where feasible.**

Specifically land managers and policy makers should focus on the following recommendations in regards to riparian buffers:

1. **It is recommended that existing buffers (see Map III-3) be managed and preserved to the degree practicable. Specific measures that can be taken to accomplish this include:**
    - Eradicating invasive species should be to the extent possible to allow native plant species to become established. Partnerships between landowners, communities, schools, volunteer groups, service organizations, local governments, and through participation in programs offered by the WDNR are critical in managing a healthy buffer system (see Appendices C and D).
    - Restoring and establishing native vegetation where needed. Vegetation with a high capability to sequester nitrogen and phosphorous should be considered.
    - Conducting educational campaigns and generally promoting low-impact use of existing buffer areas.
2. **It is recommended that existing riparian buffers be protected through acquisition, purchase, and regulation (See Map B-2 in Appendix B to implement this recommendation). Specific measures that can be taken to accomplish this recommendation include:**
    - Acquiring public land via donation or purchase and establishing public or private conservation easements on critical lands;
    - Continuing to apply limits on development within SEWRPC-delineated primary environmental corridors and connecting "vulnerable" existing and potential buffer lands to primary environmental corridors, secondary environmental corridors, and isolated natural resource areas where feasible. Additional buffer lands may be added to primary environmental corridors if they

meet the criteria for inclusion in a corridor, thus extending the restrictions on development that are inherent to primary environmental corridors;[23] and

- Enforcing local zoning regulations to encourage establishment of riparian buffers within the 1-percent-annual-probability floodplain, particularly when the zoning of land changes from agricultural to urban uses.

3. **It is recommended that riparian buffers be established to the extent practicable throughout the watershed with a minimum goal of a 75-foot width and an optimal goal of a 1,000-foot width (Map III-3), to meet pollution load reduction goals through establishment of 1,122 acres of riparian buffers/restored wetlands as shown on Map B-2 in Appendix B** (see "Targeted Load Reductions" subsection). These important riparian areas are considered a high priority to protect and restore hydraulic and hydrologic function, to reduce pollutant loads, and improve wildlife within this watershed. Specific measures that can be taken to accomplish this recommendation include:
   - Establishing undisturbed vegetation along perennial, intermittent, and ephemeral waterways in both urban and rural areas to the extent practicable. The use of native species should be considered where possible;
   - Considering installation of harvestable riparian buffers where practicable while the lands remain in agricultural uses; and,
   - When lands are converted from agricultural to urban uses, considering establishing larger buffers widths for Jackson Creek and its associated tributaries at the 400-foot and 1,000-foot optimal widths or to the 1-percent-annual-probability floodplain boundary, whichever is greater.

4. **It is recommended that connections and pathways be established between riparian buffer areas to ensure connectivity and continuity of buffers, environmental corridors, and natural areas. Specific measures that can be taken to accomplish this recommendation include:**
   - Creative landscaping to promote safe travel corridors and creating essential habitat features within and adjacent to corridors in either urban or agricultural landscapes such as shown in Figure III-3 (i.e. creating ephemeral wetlands or naturalizing stormwater detention basins);
   - Where possible, protecting against fragmentation of riparian buffers by limiting both creation of new road crossings of the mainstem of Jackson Creek and tributary streams and encroachment by development and other infrastructure that impacts the structure and function of these areas and reduces their ability to adequately protect waterways and wildlife habitat; and
   - Removing abandoned or nonessential roads and other stream crossings where appropriate.

---

[23]*The City of Elkhorn does not have an upland conservancy zoning district, but if the PEC is located in the City's sewer service area any development in the PEC would have to be consistent with SEWRPC environmental corridor guidelines.*

Maintain and Restore Instream Habitat

It is very important to preserve and improve aquatic habitat wherever possible to maintain a healthy community of aquatic organisms. This includes maintaining and improving, to the extent practical, the physical, chemical, and hydrologic characteristics within the Jackson Creek watershed, as well as the habitat integrity, through invasive species management, preservation of riparian buffers, protection of groundwater recharge, preservation and protection of spawning areas and riffles, and restoration of streambeds and banks where appropriate. As habitat among reaches and the connectedness of the stream system are improved over time, there will be improved aquatic organism populations and overall health. Hence, these recommendations are designed to restore natural functions in the Jackson Creek watershed and to mitigate the negative impacts that many years of alteration have exacted and provide essential habitat for fish and wildlife.

Since at least the early 1900s the Jackson Creek system has been substantially altered through channelization, agricultural and urban development, road construction, construction of stormwater conveyance systems, placement of fill, and other actions related to agricultural and urban development. These changes have physically, chemically, and hydrologically degraded aquatic habitat.

Aquatic organisms, including fish, mussels, and insects, are essential to maintaining aquatic health by assuring an ecological balance and also contribute to the maintenance of a healthy fishery and the associated recreational benefits. To maintain these assets within the Jackson Creek watershed, it is important to ensure good aquatic habitat, water quality, and water quantity.

To maintain and restore fish and wildlife habitat in the Jackson Creek watershed, the following recommendations have been developed:

1. Protecting and expanding the existing highest quality fishery and aquatic habitat within the Jackson Creek watershed as described in Chapter II of this report, shown on Map II-5, and shown in Table II-18.
2. Protecting identified riffles and spawning areas (see Map III-2, potential northern pike spawning areas and potential riffle spawning habitat).
3. Restoring, enhancing, and/or rehabilitating the identified "problem" stream channels through remeandering projects and streambank rehabilitation (see Map III-2, Map Insets 1 through 4).

In addition, several other measures are recommended to improve aquatic habitats as set forth on Map III-2 and further described in the following subsections.

Streambank Erosion and Restoration Priorities

The energy of flowing water in a stream is dissipated along the stream length by turbulence, streambank and bed erosion, and sediment resuspension. In general, increases in the amount of both urban development and land alterations associated with agriculture may be expected to result in increases in streamflow rates and volumes that result in an increased potential for streambank and streambed erosion. Streambank and streambed erosion destroys aquatic habitat, spawning areas, and feeding areas; contributes to downstream water quality degradation by releasing sediments to the water; and provides material for subsequent sedimentation downstream. This sedimentation, in turn, covers valuable benthic habitats, impedes navigation, and fills wetlands. Hence, **implementing high priority streambank modification and riparian buffer pollutant load reduction goals as summarized above is an essential component of improving wildlife habitat and ecological resilience to protect against threats from invasive species and climate-induced changes in the Jackson Creek watershed** (see "Targeted Load Reductions" section above).

It is important to note that the most severe erosion sites on this system are an artifact of, or associated with, channelization that occurred many years ago on Jackson Creek. Removing the curves or meanders in a river or creek increases the streambed slope and water velocities, and disables the ability of the stream to store and transport sediments. In addition, channelized streams are often further removed from the floodplain through placement of spoils from the excavation for the straightened channel or downcutting of the streambed, due to the increased longitudinal bed slope of the straightened channel. Therefore, the only way to properly address the majority of the eroding sites is to restore connectivity of a stream with the floodplain and reconstruct meanders to restore the ability of the stream to properly function. Restoring the channelized reaches of Jackson Creek to a more natural state will decrease the pollutant loads by reducing streambank erosion. The stream will also be able to remove pollutants by increasing water residence time (longer meandering stream length) and biological nutrient processing (connected floodplain). Restoring natural meanders also has the added benefit of dramatically improving the number and diversity of essential deep pool and shallow riffle habitats that will improve the quality and diversity of the biological community. Therefore, this plan makes the following recommendations:

1. **It is recommended that floodplain connectivity, channelization, and streambank erosion be simultaneously addressed to remediate the severe and moderate eroding sites within the Jackson Creek watershed, where feasible.** In addition, it is important to note that pollutant load reductions would be higher than what was modeled using STEPL, if restoring floodplain connectivity and/or addressing channelization were incorporated as part of the design to address the streambank erosion sites.
2. Following completion of streambank stabilization projects, **it is recommended that assessments be conducted periodically to evaluate the condition and functioning of the stabilization project**.

While a large portion of the stream network in the Jackson Creek watershed have been surveyed for streambank erosion as part of this study, several miles of stream remain unassessed. The unassessed portions consist entirely of tributary streams. Sediment from potentially eroding streambank sites in portions of the watershed that have not been assessed for streambank erosion undoubtedly could be affecting downstream aquatic habitat. The presence of this sediment may partially offset gains made through bank stabilization projects located downstream. To address this possibility, this plan makes the following recommendation:

3. **It is recommended that streambank stability surveys be conducted on streams in the watershed that have not yet been assessed.** These assessments should be conducted on a stream reach basis, with all streams within a reach being assessed before beginning assessments in other reaches. In addition, the remedial actions to reduce sediment from streambank erosion should be accomplished from upstream to downstream within a given reach, to the extent practicable. This approach will help prevent upstream eroded sediment from degrading high-quality habitat areas downstream and within the mainstem of Jackson Creek.

Recent research has revealed that channelized streams minimize water residence time and biological nutrient processing, which can be mitigated by restoring floodplain connectivity to reduce pollutant loads and improve metabolism in agricultural streams.[24] The benefits of floodplain restoration are most apparent during high flow events (during inundation), Floodplains are more effective at assimilating nutrients when they are vegetated with appropriate native plants. This plan makes the following recommendations:

4. I**t is recommended that the connectivity of Jackson Creek to its floodplain be improved by reconnecting historical stream channels (i.e., remeandering) and reconstructing new channels and/or two-stage channel systems (see Figure II-40), the characteristics of** which should be based upon the template or Reference Reach 3 in the middle portions of Jackson Creek. This has the added benefits of improving instream habitat and reducing streambank erosion (see "Agricultural Surface Water Hydrology" subsection above). Priority areas for potential remeandering, reconnecting the historical channel, and/or construction of two-stage channel design are shown on Map III-2 and Insets 1 through 4.

[24]*Sarah S. Roley, et al., "Floodplain restoration enhance denitrification and reach-scale nitrogen removal in an agricultural stream", Ecological Applications, Volume 22(1), pages 281-297, 2012; Sarah S. Roley, et al., "The influence of floodplain restoration on whole-stream metabolism in an agricultural stream: insights from a 5-year continuous dataset; and, Sarah S. Roley, Jennifer L. Tank, and Maureen A. Williams, "Hydrologic connectivity increases denitrification in the hyporheic zone and restored floodplains of an agricultural stream", Journal of Geophysical Research, Volume 117, pages 1-16, 2012.*

5. In addition, **it is also recommended that overall wildlife habitat be enhanced by adding features such as strategically-placed downed trees, brush, rock, or ephemeral wetlands to the floodplain to** (see "Maintain and Improve Wildlife Habitat" subsection above).

The trapezoidal configuration used in the agricultural ditches found in this watershed was designed to move water downstream quickly during runoff events. While this design can provide sufficient flood conveyance, its ecological performance is poor. Several factors related to its design leads to this poor performance. The channels are typically oversized relative to the amount of baseflow discharge passing through them. This produces baseflows that lack adequate depth and velocity to move sediment through the reach, which leads to sediment deposition and often requires costly maintenance to maintain the designed flow capacity. The shallow depths and slow velocities in these channels do not provide sufficient habitat for aquatic organisms and they allow summer water temperatures to rise above the temperatures that many aquatic organisms are able to tolerate. As a result, these channels often have poor quality communities of aquatic organisms. Finally, these channels typically have steeply sloped banks that abut the edge of the stream, leading to unstable banks as sediment deposits force flows into one bank or the other.[25] Therefore, reconnecting a stream to its historical floodplain and recreating a more natural stream system will improve instream function (see "Stream Restoration" section in Chapter II of this report).

Two-stage channels are designed based on geomorphic principles and use of this design in Jackson Creek should be based upon the reference reach low flow and bankfull (i.e., channel forming discharges, see Appendix G) channel conditions in the middle portion of the watershed. This design incorporates benches that function as floodplains and attempts to restore or create some natural alluvial channel processes. Figure II-40 shows that under most flow conditions the main channel in this design is the low-flow channel. By limiting the width of this channel, enough flow can be maintained in the channel during low-flow periods to keep nutrient-rich sediments moving and prevent sediment deposition and accumulation. The upper benches allow space for the stream to flow out of its banks and spread out during heavy runoff events. This dissipates the energy and erosive potential of larger flows. During heavy runoff events, finer sediments are allowed to settle out over the newly created floodplain instead of clogging the main channel, reducing maintenance costs. The stability of the ditch banks are improved because the toe of the ditch bank meets the bench rather than the channel bottom.

In addition to providing improved drainage functions, the two-stage channel design has the potential to create and maintain improved aquatic habitat. The narrower and deeper main channel provides greater water depth during low-flow periods. Grasses on the benches can provide cover and shade the low-flow channel. This combination of factors

[25]*U.S. Department of Agriculture Natural Resources Conservation Service, "Two Stage Channel Design," Part 654* Stream Restoration Design National Engineering Handbook*, August 2007.*

results in reduced water temperatures within the low-flow channel. Substrate conditions within the main channel are improved because the narrower channel allows for better conveyance of sediments during low-flow periods and allows for the fine sediments to be deposited on the benches during higher flows. This results in a channel bed consisting of coarser materials, which is a more favorable spawning area for fish. Two-stage channel designs have also been known to restore the natural meander patterns of streams over time, creating pool habitat that fish use for resting and riffle habitats for spawning.

This plan makes the following recommendation regarding channelized reaches within Jackson Creek:

6. **It is recommended a more natural stream system be created by restoring or reconstructing its historical stream sinuosity and pool-riffle habitats through reconnection with historical channels and reconstructing a new channel and/or two-stage channel systems.** The template for natural stream restoration and floodplain connectivity designs should be based upon the template or reference low-flow and bankfull reach conditions in the middle portions of Jackson Creek. **Priority areas for potential remeandering, reconnecting with the historical channel, and/or construction of two-stage channel design are located in the reaches shown on Map III-2 and Insets 1 through 4.**

Aquatic Organism Passage

Recreational fishing is an important economic activity in the Southeastern Wisconsin Region and Delavan Lake. The maintenance and continuity of the species of economic importance (i.e., gamefish species) and those species on which they depend is associated to a large degree with the protection and restoration of appropriate habitat. To this end, efforts to remove obstructions to fish migration along the mainstem and tributaries of Jackson Creek are key considerations for the long-term restoration of the fishery. Examples of these obstructions include dams or weirs, roadway culverts, and channelized river reaches. Removal and/or retrofitting of these obstructions should be accompanied by the restoration or re-creation of habitat within the stream and riparian corridor. Such habitat is essential for resting, rearing, feeding, and spawning of fishes and other organisms. This will help to improve the biotic integrity of the streams within the Jackson Creek watershed.

To maintain and restore fish and aquatic organism passage throughout the Jackson Creek watershed, the following recommendations have been developed:

1. Removal and/or retrofitting of obstructions identified on Map III-2, accompanied by the restoration or re-creation of habitat within the stream and riparian corridor, as this is essential for resting, rearing, feeding, and spawning of fishes and other organisms. **Priority for improving passage should be to restore connectivity and habitat quality between the mainstem of Jackson Creek and the Delavan Lake Inlet (weir at Mound Road) and between the mainstem of the Creek and its tributaries.** The description and recommended actions for each of these structures are summarized below:

- **It is recommended that operation of the U.S. Geological Survey (USGS) gauging station at Mound Road (RM 1.9) be continued to monitor discharge and water quality, but that the sheet piling weir at this station be removed or modified to improve fish and other aquatic organism passage and provide safe navigation for kayaks and canoes.** The weir could either be replaced with an electronic stage sensor (submersible pressure transducers or noncontact sensors) that meets USGS accuracy requirements,[26] or reconstructed to allow for fish passage under all discharges and safe navigation **under normal discharge conditions (see Figure II-38).**
- **The private drive culverts at River Mile 3.1 are recommended to be either removed or replaced with a ford crossing or single cell structure (e.g., open bottom box culvert or elliptical pipe with appropriate widths that match Jackson Creek bankfull dimensions and which is embedded below the streambed to promote fish passage).**[27] However, if the private landowner of this property is willing and funding can be procured, there is a potential third option at this site, which would be to divert the stream back to the historical channel upstream of the current private crossing as shown on Inset 1 to Map III-2. This alternative would have multiple benefits that include:
    - No need to spend any money on the mitigation of the existing private drive structure or a replacement structure;
    - Significant improvement in water quality by diverting the actively flowing stream away from the most severe streambank eroding sites on Jackson Creek and reconnecting this reach to its historical floodplain;
    - Significant improvement in the amount and diversity of instream and riparian buffer habitats; and,
    - Improved fish passage and navigation by kayak or canoe.

2. Stream crossings tend to have a cumulative impact on the stream and adjacent lands, as well as an impact on the quality of water and the fishery. Therefore, it is important to reduce the linear fragmentation of the existing riparian buffers by either removing crossings where possible or by not increasing the number of crossings where practical. It is recognized that police, fire protection, and

---

[26] *Sauer, V.B., and Turnipseed, D.P.,* Stage measurement at gaging stations: U.S. Geological Survey Techniques and Methods book 3*, chap. A7, 45 pages, 2010. (Also available at http://pubs.usgs.gov/tm/tm3-a7/.)*

[27] *B.G. Dane, "A Review and Resolution of Fish Passage Problems at Culvert Sites in British Columbia," Canada Fisheries and Marine Sciences Technical Report 810, 1978. Chris Katopodis, "Introduction to Fishway Design," Freshwater Institute Central and Arctic Region Department of Fisheries and Oceans, January, 1992.*

emergency medical service access is an overriding consideration that must be applied in determining whether the objective of removing a crossing is feasible. This recommendation is only meant to apply to situations where more road crossings are present than are necessary to ensure adequate traffic carrying capacity and adequate access for emergency services.

3. Encourage development of plans for replacement and/or retrofitting obstructions at all mainstem and tributary road crossings to incorporate improvements to aquatic and other organism passage over time as opportunities present themselves (e.g., structure failure, major blockage, or bridge reconstruction or replacement). The recognition that fish populations and other wildlife are often adversely affected by culverts has resulted in numerous designs and guidelines to allow for better fish passage and to help ensure a healthy sustainable fisheries community.[28]
   - These plans should be developed in partnership with the relevant municipality, the Highway Division of the County Public Works Department. Actions to improve passage would have to be coordinated with the WDNR, the County Public Works Department, local public works departments, and/or the Wisconsin Department of Transportation.
   - Consider annual or biannual surveys on the Jackson Creek system to assess capabilities to maintain fish passage at all road or railway crossings, particularly identifying obstructions due to debris accumulation, and to identify where actions need to be taken to improve passage.
4. Consider annual or biannual surveys on the Jackson Creek system to monitor beaver activity and address beaver dams that are obstructing aquatic organism passage, present impediments to navigation, or creating flooding conditions on a case-by-case basis as necessary.
5. Although there was limited trash and other debris creating obstructions within the Jackson Creek system, **it is recommended that annual or semi-annual surveys be conducted in riparian and instream areas and all trash and debris identified be removed to improve the aesthetics and to protect wildlife.**

Large Woody Debris

Branches, tree limbs, root wads, and entire trees that fall into, and collect along, streams are commonly referred to as large woody debris (LWD). LWD plays a vital role in the hydraulic, geomorphic, and biological function of the streams and floodplains within the Jackson Creek watershed, which includes wetlands, ponds, creeks, and the

[28]*B.G. Dane, "A Review and Resolution of Fish Passage Problems at Culvert Sites in British Columbia," Canada Fisheries and Marine Sciences Technical Report 810, 1978. Chris Katopodis, "Introduction to Fishway Design," Freshwater Institute Central and Arctic Region Department of Fisheries and Oceans, January, 1992.*

Delavan Lake Inlet waterway.[29] LWD helps control the shape of the channel and provides cover, shelter, resting areas, and feeding opportunities for aquatic organisms over the course of their complex life histories. In addition, the interaction between LWD, water, and sediment has a significant effect on channel form and process, increasing geomorphic complexity and the quality of aquatic habitat.[30] In general, large woody debris was limited throughout most of the Jackson Creek system. Except for accumulations at the beaver dams, no major obstructions or debris jam blockages were observed.

1. **It is recommended that, removal of LWD from streams within the Jackson Creek watershed be discouraged, unless it is located in a reach used for recreational paddling and is a barrier to navigation, or is causing streambank erosion.** It is recognized that this will need to be balanced with reasonable removal efforts that are required to maintain safety, reduce the risk of property damage, and maintain aquatic organism passage.
2. Similarly, **it is also recommended that both submerged and floating trees be introduced into riparian wetlands and waterways such as the Mound Road Wetland Ponds and Delavan Lake Inlet area to enhance fish, amphibian, and reptile habitats**.
3. **It is recommended to periodically monitor for woody debris accumulations within the watershed, particularly at road crossings or associated with streambank erosion, and to dismantle and/or remove them if they become a problem.**

Recommended Actions Associated With Management Objective to Increase Recreational Opportunities, Public Awareness of Water Quality Issues, and Participation in Watershed Conservation Activities

The recommendations within this section are designed to enhance both public understanding of the plan and participation to implement plan recommendations through engagement with the natural resources that the Jackson Creek watershed has to offer. More specifically, this section contains recommendations related to expanding recreational opportunities, an information and education component, and details on how to measure and track plan implementation progress and success in the future, which include interim measurable milestones and established criteria.

[29]*Kingsbury, B.A. and J. Gibson, Habitat Management Guidelines for Amphibians and Reptiles of the Midwestern United States, Partners in Amphibian and Reptile Conservation (PARC), Technical Publication HMG-1, 2nd Edition, 2012.*

[30]*C.J. Brummer, T.B. Abbe, J.R. Sampson, and D.R. Montgomery, "Influence of Vertical Channel Change Associated with Wood Accumulations on Delineating Channel Migration Zones,"* Geomorphology*, Volume 80, pp. 295-309, 2006.*

Recreational Use and Access

This section presents recommendations related to recreational use of, and access to, the surface water system in the Jackson Creek watershed. These include recommendations related to potential trails, boating access, and recreation. Because an overriding consideration related to the recreational use of surface waters is whether the water is safe for human contact, this section also presents recommendations for reducing instream concentrations of fecal indicator bacteria and the pathogens for which these bacteria act as a surrogate.

Recreational activity also has the added benefit of maximizing the investment of watershed residents in the health of the Jackson Creek watershed through providing opportunities for residents to "build a relationship with the River." This relationship can then influence residents and business owners to make an effort to implement BMPs and, in general, actively seek to maintain and/or improve the conditions of the watershed in which they enjoy recreating. By improving recreational opportunities and the recreational experience within the Jackson Creek watershed, people will build this relationship and ensure a culture which ultimately cares about the well-being of the Creek.

In general, the Creek, tributary streams and their associated park and open space lands are in close proximity to other economic and cultural resources of the watershed. This provides opportunities for linking recreation by connecting these landscape features through an integrated system of roads, trails, paths, and waterways. As embodied in the regional park and open space plan, the County and local open space plans, the County land and water resource management plan, and the County comprehensive plan, the objective of this target is to maintain and expand access to the water resources of the Jackson Creek watershed, as well as to take advantage of the opportunities for education within those areas.

To facilitate the enhancement of recreation on Jackson Creek, SEWRPC staff walked the Creek and identified major recreational hindrances and opportunities. These findings are summarized below and include recommendations related to potential future bike and walking trails, potential access sites, and navigational hazards (see Map III-2, Inset 1).

Land Based Trail Expansion

As described in Chapter I of this report, the White River Trail provides the only significant recreational trails in the watershed and there is no trail linkage between Jackson Creek and Delavan Lake. Hence, there is potential for expansion of walking and/or biking trails, particularly in the lower reaches of Jackson Creek, on lands held in public and private protection. Therefore, **it is recommended that Walworth County, the Town of Delavan, and other local partners consider expanding walking and/or biking trails along the Jackson Creek corridor, to the extent practicable, between the Town of Delavan Community Park at STH 50, the Mound Road Wetland Ponds north of Mound Road, and the White River Trailhead at CTH H.** However, it is important to note that these areas do include FEMA 1-percent-annual-probability floodplain (see Map I-2a), which may have some restrictions related to recreation that must be adhered to as described in NR 116, Wisconsin's Floodplain Management Program of the *Wisconsin Administrative Code*.

Jackson Creek Water Trail

It is recommended that Walworth County and the Town of Delavan consider the development of a water trail between the Delavan Lake Inlet and Jackson Creek from the Town of Delavan Community Park to the Mound Road Wetland Ponds. A "water trail" is a designated trail on a lake or stream that regularly exhibits sufficient water depths to navigate small watercraft such as a canoe or kayak with unobstructed passageways while providing safe and convenient access points, and may contain support facilities such as parking areas, restrooms, and picnic areas.

Field surveys by SEWRPC staff during 2012 and 2013 documented that water depths in the mainstem of the River between the confluence of Jackson Creek with the Delavan Lake Inlet up to as far as STH 67 are sufficient to permit navigation by canoes or kayaks during at least a portion of the year. Thus, it is envisioned that this part of Jackson Creek and the Delavan Lake Inlet waterway would accommodate low-impact, non-motorized watercraft such as canoes and kayaks along several miles of streams and shoreline areas of small ponds.

Important factors for establishing water trails include safe and convenient access to a waterway with unobstructed passageways, adequate support facilities, and safe portaging areas. Identifying and providing signs indicating scenic, historical, and natural view points along the waterway should also be considered. The establishment of a water trail would promote the responsible use and enjoyment of Jackson Creek and Delavan Lake Inlet, which would further serve as a place for solitude and respite from the urban environment, while providing educational and recreational opportunities such as sight-seeing and fishing for outdoor enthusiasts.

The development of this water trail would be contingent on a number of factors or considerations. Several of those, along with specific recommendations related to establishment of a water trail are provided below:

- A decision by Walworth County and the Town of Delavan to create and maintain such a trail.
- Securing funding to construct adequate and safe parking and access to the water. Based on the costs given in the Walworth County park and open space plan,[31] the cost of installation of a canoe/carry-in boat access site, including trails, is estimated at $55,000. In contrast, the Town of Delavan Community Park already contains adequate parking and carry-in and trailer boat access facilities as well as extensive park services and programs, including a fishing pier (see http://townofdelavan.com/community/community-

[31]*SEWRPC Community Assistance Planning Report No. 135, 3rd Edition,* op. cit.

parks/community-park/); thus, no additional improvements would likely be needed at this location to provide access at the Community Park.

  - If funding allows, **it is recommended that a handicap accessible canoe/kayak landing be installed on the mainstem of Jackson Creek or one of the Mound Road Wetland Ponds upstream or north of Mound Road (see Figure III-4).**

- ***Consideration of removing or reconstructing the current USGS stream gauge/steel sheet piling slotted weir to allow for safe navigation of canoes or kayaks*** as well as continued monitoring of streamflow and water quality. Removal or reconstruction of the weir would improve recreation and the fishery in Delavan Lake and Jackson Creek. Currently, boaters cannot navigate over the weir, so boats have to be portaged across Mound Road. **It is recommended that the weir be replaced with an electronic stage sensor or equivalent that meets USGS accuracy requirements,[32] or reconstructed to ensure safe navigation** (e.g., see Figure-II-38). It is important to note that any modifications to this structure would require recalibration of flows along with phosphorus and sediment loads, so researchers would be able to compare historical and current loads at this station. However, the final decision regarding the weir at Mound Road rests with the Delavan Lake Sanitary District (DLSD) and the Town of Delavan, subject to regulatory oversight from the WDNR, and funding.

Information and Education

This information and education component of this plan is designed to increase participation in conservation programs and implementation of conservation practices by informing the landowners and farm operators of assistance and tools available to them and providing emerging information on cover crop, no-till implementation strategies, and other recommended BMPs. Creating education and partnership opportunities for elected officials and representatives of organizations active in the watershed are also integral to the information and education plan. Riparian landowners and the general public will need to be informed of the importance of land and water connections and the necessity of improving in-stream and wildlife habitat and water quality.

Civic Engagement

Civic engagement is essential to the implementation of watershed plans. Technical advisors and funding agencies are key to successfully completing watershed projects, but having an engaged core of committed municipalities, citizens, business leaders, grassroots organizations, and local agencies is paramount. When the entire group is willing and able to understand each other's goals and are committed to work together, implementation plans become successful on the ground projects. Stakeholders who are affected by the watershed plan, who can provide

---

[32]*Sauer, V.B., and Turnipseed, D.P.,* Stage measurement at gaging stations: U.S. Geological Survey Techniques and Methods book 3*, chap. A7, 45 pages, 2010. (Also available at http://pubs.usgs.gov/tm/tm3-a7/.)*

information on the issues in the watershed, and who work to implement existing programs or plans that incorporate similar goals should actively participate.

Driving Forces

Within the watershed, stakeholders have worked together at varying scales to improve water quality for many decades. In the 1980s the watershed was part of the Turtle Creek Priority Watershed Project that facilitated the implementation of agricultural BMPs through joint efforts of the County, WDNR, and NRCS.[33]

In the early 1990s, through the combined efforts of the Delavan Lake Sanitary District, Town of Delavan, Wisconsin Department of Natural Resources, and U.S. Geological Survey a massive rehabilitation project was completed in Delavan Lake, which receives the waters of Jackson Creek.[34]

More recently, interest in improving the quality of water in that Lake, led to the formation of a community based working group, the Delavan Lake Watershed Initiative Network (WIN). The mission of the Delavan Lake WIN is to use a watershed approach to attain healthy, sustainable water quality in Delavan Lake that meets the needs of the surrounding human and ecological community (see Appendix I for more details). Delavan Lake WIN is composed of community groups, State and Federal government agencies, nonprofit organizations, and other local interest groups. The diverse membership worked collaboratively to implement recommendations found in the 2002 Delavan Lake management plan by organizing, prioritizing, and coordinating land management and outreach activities.[35] Cooperative agreements were established with the USDA and Walworth County to provide technical guidance to farmers and additional funds became available to implement agricultural management improvement projects to improve water quality. Grass waterways were installed, fields converted to cover crop rotations, reduced tillage practices were implemented, and stream side buffer strips installed.

In 2014, the USEPA directed that the majority of funds available through the Clean Water Act for pollution abatement projects are to be used in watersheds with a WDNR- and USEPA approved watershed plan that meets the USEPA nine key elements of a watershed-based plan. Since Jackson Creek is located within the Rock River basin, and the basin has been designated as impaired by excess phosphorus and sediment, it is necessary to establish and implement a plan to meet the USEPA goal indicated in Section 101(a)(2) of the Clean Water Act: "water quality

---

[33]*WDNR,* Turtle Creek Priority Watershed Plan*, March 1984.*

[34]*For more details see Dale M. Robertson, Gerald L. Goddard, Daniel R. Helsel, and Kevin L. MacKinnon, "Rehabilitation of Delavan Lake, Wisconsin," Lake and Reservoir Management, Vol. 16, No. 3, pp. 155-176, 2000.*

[35]*SEWRPC,* A Lake Management Plan for Delavan Lake, Walworth County, Wisconsin*, Community Assistance Planning Report No. 253, 2002.*

which provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water, wherever attainable".

Stakeholders

Efforts to educate, inform, and engage Jackson Creek watershed stakeholders about the Jackson Creek watershed protection plan process has been accomplished through the convening of stakeholder and community meetings. Stakeholder input has been a key factor in developing objectives, and refining priority projects and programs. Community input about issues of concern is reflected in the results of a questionnaire that was distributed early in the outreach effort. Community meetings have also provided a means to develop goals, share progress on the development of the protection plan and receive stakeholder input. The questionnaire results established that urban and agricultural runoff, sedimentation, water clarity, wetland protection, and garbage and trash in natural areas topped the list of water concerns (see Table III-4).

Stakeholders Identified

- Agricultural Producers
- Businesses
- Cities of Delavan and Elkhorn
- Crop Advisors
- Delavan Lake Improvement Association
- Delavan Lake Sanitary District
- Lake Improvement Organizations
- Land Trusts
- Landowners
- Rock River Coalition
- School Districts
- Southeastern Wisconsin Regional Planning Commission
- Towns of Delavan, Geneva, and Walworth
- Universities and Colleges
- University of Wisconsin Extension Service
- USDA - Farm Service Agency
- USDA - Natural Resources Conservation Service
- Walworth County
- Walworth County Metropolitan Sewerage District
- Wisconsin Department of Natural Resources

Goals

The goals and recommended actions for this information and education plan are based on the USEPA 2008 effective information and education watershed plan components as well as questionnaire results; work group meetings; and input from USEPA, NRCS, WDNR, and Walworth County.[36] This includes elements such as creating appropriate messages to targeted audiences, distributing the message, and periodic evaluation of the program. Most importantly it is envisioned that the identified stakeholders within and adjacent to the Jackson Creek watershed continue to partner and work together as illustrated in the community engagement graphic (Figure III-5).

The goal of the Jackson Creek watershed protection plan is to provide information that local decision makers, farmers and landowners, and watershed residents can use to improve and protect the natural resources of the Jackson

[36] *U.S. Environmental Protection Agency (USEPA),* Handbook for Developing Watershed Plans to Restore and Protect Our Waters*, USEPA 841-B-08-002, March 2008.*

Creek watershed as identified in Table III-1. More specifically, to promote active stewardship among residents, farmers, landowners, businesses, community associations, as well as governmental and non-governmental organizations.

To increase public awareness of water quality issues and increase participation in watershed conservation activities, the education and information plan will include the following elements and specific actions (proposed timelines are summarized in Table III-5):

- Inform the general public about the fish and wildlife species known to reside in the watershed, their habitat requirements, and management practices required to sustain them.
- Inform agricultural landowners and operators about the plan, its recommended BMPs, and technical and funding assistance available.
- Inform nonresident agricultural landowners about local, State and Federal opportunities for funding and technical assistance.
- Inform riparian landowners about opportunities to improve wildlife habitat, and provide information about programs to fund expanding riparian buffers and restoring wetlands.
- Inform local officials about the protection plan and its goals, and work with them to adopt this plan through partnership building (see "Measuring Plan Progress and Success" subsection below).
- Promote increased stewardship through enhancements of recreational use and access, where practicable.
- Host workshops, meetings, and events that landowners can attend to learn about conservation practices.

Engagement Strategy

Different target audiences require different educational messages delivered in a customized fashion. The agricultural landowners are the audience with the greatest potential to reduce pollutant loads and partner to expand wetland and wildlife habitat. It is estimated that nearly 80 percent of the lands in agricultural row crop production are farmed through lease agreements. The landowners who lease their properties often plan to sell their land when development pressure creates a favorable market. Engaging both the landowner and operator requires understanding their perspectives and goals. This will require a greater amount of effort and resources than the other defined target audiences. Farmer-led watershed improvement efforts are working effectively in several locations in the Midwest. **Utilizing a farmer-led model (see Appendix H) and asking professional agronomy advisors to support the education efforts is recommended**.

Other Watershed Initiatives

The Rock River Coalition is a nonprofit organization founded in 1994 that works to build alliances and consensus among all stakeholders to protect the Rock River watershed. Its members are private citizens, businesses, conservation and historic organizations, Chambers of Commerce, and local and state agency staff. Their mission is to educate and provide opportunities for people of diverse interests to work together to improve the environmental, recreational, cultural, and economic resources of the Rock River Basin. The Coalition addresses issues related to the water quality of the Rock River by developing programs such as stream and wetland monitoring programs, and convening a task force to improve urban stormwater runoff.

Measuring Plan Progress and Success

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

Adoption of the watershed protection plan by the local legislative bodies and the existing local, County, State, and Federal agencies concerned is recommended and also an essential component of tracking progress and success as well as highly desirable to assure a common understanding among these various entities. In addition, formal plan adoption may also be required for some State and Federal financial aid eligibility. Adoption of the recommended watershed protection plan will assist a unit or agency of government to more fully integrate the protection plan elements into existing work plans and enable staffs to program the necessary implementation work.

Due to the uncertainty of any modeling effort and the efficiency of the best management practices, an adaptive management approach should be taken with the Jackson Creek subwatershed (see Figure III-6). After the implementation of practices and monitoring of water quality, the effectiveness of the plan should be evaluated annually and every five years coincident with the Walworth County LWRMP update (see "Tracking of Progress and Success of Plan" subsection below). If progress is not being made, the plan will be reevaluated. Adjustments should be made to the plan based on plan progress and any additional new data, management tools, and/or BMPs.

Evaluation of Existing Water Quality Monitoring and Data Collection Programs

Due to extensive monitoring by USGS in partnership with the DLSD and the Town of Delavan, particularly at the Mound Road station, there is an extensive long-term dataset for daily precipitation, stream discharge, total phosphorus, and suspended sediment concentrations and loads within the Jackson Creek watershed. This dataset was useful for establishing the annual and monthly targeted instream loads and load reduction goals for Jackson Creek. Therefore, continued monitoring at this station and periodic monitoring at three additional stations in upstream areas at Petrie Road, Tributary A, and Tributary B for these parameters (see Map II-4) will be instrumental in detecting changing trends in the future. More specifically, continued monitoring at these stations may also be used in the future to support the following objectives:

- Determining water quality standards attainment,

- Identifying causes and sources of water quality impairments,
- Supporting the implementation of water management programs, and
- Supporting the evaluation of program effectiveness.

The WDNR periodically conducts biological sampling in the watershed. Most recently, in 2014 it conducted fishery and macroinvertebrate surveys at three sampling stations in the mainstem of Jackson Creek, which largely indicated that the biological community is meeting fair to excellent quality standards, but no mussel survey has ever been conducted in this river system.

The Town of Delavan and the DLSD monitor sediment depth in the detention basins upstream of Mound Road. The DLSD also monitors for invasive species and conducts regular water quality monitoring throughout Delavan Lake, including participation in the WDNR Citizen Lake Monitoring program.

Identification of Additional Monitoring Needs

There are partial data available to assess the full complement of physical, chemical, and biological water quality and designated use standards that need to be assessed to measure the progress and effectiveness of the watershed plan. More specifically, there are limited data within Jackson Creek on dissolved oxygen, water temperature, pH, chloride, and nitrogen compounds. No recent sampling has been conducted on fecal coliform bacteria or *Escherichia coli* to be able to adequately determine if water used objectives are being met.

There are no current volunteer monitoring sites established on the mainstem of Jackson Creek or any of its tributaries. Water Action Volunteers (WAV) is a statewide program for Wisconsin citizens who want to learn about and improve the quality of Wisconsin’s streams and rivers (see website for more details http://watermonitoring.uwex.edu/wav/). The program is coordinated through a partnership between the WD NR and the University of Wisconsin – Cooperative Extension. Between May and October, temperature, dissolved oxygen, streamflow, and transparency are monitored monthly by most WAV citizen monitors. Volunteer monitors also assess the aquatic and streamside habitat as well as the stream's macroinvertebrate community, using a biotic index. Habitat assessments are completed once a year, in the summer, while the biotic index is generally assessed twice a year, once in the spring and again in the fall. Level 2 and 3 monitors assess such parameters as total phosphorus, chloride and specific conductance, and occasionally E. coli bacteria, as well as deploy continuous hourly temperature data recorders.

Stream Water Quality Monitoring Recommendations

It is important to assess the condition of water quality, biological communities, and habitat in the watershed and determine whether these conditions are improving or deteriorating. It is, therefore, important to establish and maintain a robust program to monitor and assess conditions within the watershed. Such a monitoring program should integrate and coordinate the use of the monitoring resources of multiple agencies and groups, generate monitoring data that are scientifically defensible and relevant to the decision-making process, and manage and report data in ways that are meaningful and understandable to decision makers and other affected parties. This watershed protection plan recommends maintaining the existing monitoring network and expanding monitoring in the watershed to continue to fill data gaps. Toward these ends, the plan includes the following recommendations for water quality monitoring:

1. **That current water quality monitoring program activities in the Jackson Creek watershed continue, and the efforts of the agencies conducting these activities be supported and maintained.**
2. **That the water quality monitoring network in the Jackson Creek watershed be expanded and modified as recommended below. It is envisioned that this would be administered through the Rock River Coalition's Monitoring Program using methods developed by the state-wide Water Action Volunteers Program (WAV), a collaboration between the Wisconsin Department of Natural Resources (WDNR) and the University of Wisconsin-Cooperative Extension (UWEX).**[37]
   - **That up to five Tier 1 WAV monitoring stations be established at each of the locations during the growing season from May to October, as summarized below.** Although Tier 2 or 3 WAV monitoring was not budgeted at these stations, it would be highly desirable, if funding opportunities are found. However, it is important to note that the priority, number of stations, or most appropriate tier of monitoring should be coordinated among project partners and any modifications to the current USGS monitoring**:**
     - The *Petrie Road site* on the mainstem of Jackson Creek (RM 4.9 on Map II-4) can be used to monitor JC1 and JC2 watershed areas;
     - The *private culvert/bridge crossing* location on the Schulz property (RM 2.9 on Map II-4) can be used to assess the JC3 watershed area, which is upstream of the influence of the stormwater detention basins;
     - The old *USGS Station No. 54310157* on Tributary B near the soccer fields and City of Elkhorn, shown as RM 0.7 on Map II-4 can be used to monitor the JC4 area;
     - The *Marsh Road site* on Tributary A can be used to monitor the JC5 watershed area, which is the old USGS Station No. 54310158 and is shown as RM 0.1 on Map II-4; and

[37] *Rock River Coalition Citizens Stream Monitoring Portal, http://rockrivercoalition.org/projects/citizen-stream-monitoring/; Water Action Volunteer Citizen Stream Monitoring Program, http://watermonitoring.uwex.edu/wav/monitoring/.*

- If practicable, the *Mound Road site* (RM 1.9 on Map II-4) can be used to assess changes in the entire watershed upstream as well as effects from the wetland detention basins. It may be difficult and/or dangerous to access this site during high water discharges and it is likely too deep to adequately assess by wading, so special precautions would need to be taken.

- **The current USGS stream gaging and water quality monitoring program should be continued in the watershed, but also consider the following modifications:**
  - Consider expanding the number of water quality constituents monitored at the Mound Road station to include one or more of the following parameters at least during the growing season (from May to October) of each year: dissolved oxygen, pH, water temperature, fecal indicator bacteria, specific conductance, five-day biochemical oxygen demand, chloride, alkalinity, hardness, Kjeldahl nitrogen, nitrate-nitrogen, ammonia-nitrogen, nitrite-nitrogen.
  - Consider reestablishment of precipitation-based sampling during the growing season (from May to October) at one or all three previously monitored stations listed below, depending upon the locations of agricultural BMPs implemented. If established, also consider expanding the number of water quality constituents monitored as listed above.
    - Petrie Road on the mainstem of Jackson Creek, USGS station No. 5431014;
    - Marsh Road on Tributary A, USGS Station No. 54310158; and
    - Tributary B near Elkhorn, USGS Station No. 54310157.
- **That the WDNR continue to conduct biological monitoring of fishes and macroinvertebrates at the three stations previously sampled, as indicated on Map II-5, at a minimum of once every three to five years.**
- **That local partners consider conducting other wildlife surveys such as for mussels, amphibians, and reptiles within Jackson Creek with WDNR staff and/or other wildlife experts.**

All data from the sites should be analyzed by a State-certified lab to analyze trends and gauge the impact of watershed management practices. The monitoring program should follow the guidance set forth in WDNR protocols and laboratory analysis should follow standards as applicable for stream monitoring.[38] In addition, to assist data reporting and to ensure that data be preserved in a safe and reliable source and be publicly available, **it is recommended that, to the extent practicable, all water quality monitoring be conducted as part of a managed and publically available program to such as the USGS National Water Information System (NWIS) database , WDNR Surface Water Integrated Monitoring System (volunteer access) (SWIMS) database, and the USEPA Storage and Retrieval Data Warehouse (volunteer access) (STORET) database**.

[38]*Wisconsin State Laboratory of Hygiene, see website at http://www.slh.wisc.edu/research/capabilities/*

The USGS monitoring costs for the Mound Road station plus two lake grab sample points (DLSD collects these and sends them to laboratory) is estimated to be $29,100 per year based on year 2014 sampling, which includes maintenance and completion of an annual monitoring presentation/report. The costs for one or more additional parameters would depend on the parameter chosen and their sampling frequency. To adequately assess if Jackson Creek is meeting water quality objectives, 1) the minimum water quality constituents that need to sampled would include all water quality constituents listed as part of the WAV Tier 1, 2, and 3 monitoring and 2) no less than one sample per month should be collected and analyzed throughout the growing season from May to October.

It is anticipated that volunteers will collect monitoring data on a monthly basis in Jackson Creek from May through October, starting in 2016 as part of the Rock River Coalition/WAV Stream Monitoring program. It is estimated that this will cost approximately $1,600 per site for laboratory analysis costs for Tier 1 monitoring plus $2,000 per year to cover all five watershed sites for equipment, supplies, shipping and replacement parts. Thus, the total cost for five sites is estimated to be $10,000 per year, and $100,000 over 10 years (see Table III-6).[39] It is anticipated that recruitment, training, and volunteer support costs will be incorporated as part of the technical services staff support as identified in Table III-7.

Field Catchment Monitoring

It is recommended that Walworth County, in collaboration with NRCS, WDNR, and local partners, conduct edge-of-field runoff monitoring along the edge of fields east of the inlet and south of Mound Road in assessment area JC6 to compare and demonstrate the effectiveness of sediment and nutrient reduction practices within field catchments. The load reductions within this area could be great, particularly for grassed waterway construction, due to the steeper slopes in this subwatershed. The edge-of-field monitoring is recommended because this entire subwatershed drains to the Delavan Lake Inlet, which makes it difficult to detect any load reductions from the land surface within this subwatershed. Sample collection will follow standard collection and handling procedures for each parameter. Photographic documentation of catchment conditions, treatment practices, and runoff characteristics will also be conducted and used for outreach and education purposes.

Edge of field monitoring would likely have a specified time period for monitoring associated with the installation of agriculture BMPs. It is estimated that installation of one edge of field station would cost approximately $18,800 while annual maintenance and data collection costs would approximate $80,000 over the 10 year period (see Table III-6).

[39] *In addition, for about $90 per sample, the University of Wisconsin-Steven Point lab can analyze total suspended solids, chloride, ammonium nitrogen, nitrate + nitrite, reactive and total phosphorus, and total Kjeldahl nitrogen.*

It is also recommended that remote technology such as aerial photos be considered to assist in monitoring areas throughout the watershed. Vegetated assessments could potentially be conducted by local partners in collaboration with NRCS, WDNR, and SEWRPC staff.

Periodically Analyze Monitoring Data and Report Results

Data analysis is an integral component of the water quality management process. For monitoring programs to be useful in guiding management decisions, generating good data is not enough. The data must be processed and presented in a manner that aids understanding of the spatial and temporal patterns in water quality. The data must be placed into a context that reveals the existing state of water quality conditions and any changes or trends occurring in those conditions. This should be a context that takes the natural processes and characteristics of the watershed into account, that allows the impact of human activities upon the watershed to be understood, and that enables the consequences of management action to be predicted. Establishing such a context requires that monitoring data be periodically analyzed, interpreted, and summarized. This should be done at a frequency that provides decision makers and managers with reasonably current information while recognizing the substantial effort that is required to analyze and interpret data from all the sites within the watershed.

Therefore, to assist data reporting, **it is recommended that all water quality monitoring be conducted as part of a monitoring program, that data be preserved in a safe and reliable source, and that the data be publicly available.**

It is recommended that monitoring data for the Jackson Creek watershed be collated, analyzed, and reported at one- -year intervals, and incorporated in the County land and water resource management plan at five-year intervals. The analyses, results, and conclusions of these reports should be published and made available to the public and to the agencies and organizations involved in the management of the Jackson Creek watershed.

<u>Implementation Tracking Mechanism</u>

For this plan to be most effective, it is important to track the projects and recommendations that are implemented. This could be best accomplished by having a reporting mechanism through which the organizations implementing recommendations of this plan report the initiation and completion of projects to some agency or agencies that would oversee the monitoring of implementation. The role of the overseeing agency or agencies would be to receive these reports, periodically compile this information, and evaluate the status of the implementation of the watershed restoration plan.

As described in more detail in the "Tracking of Progress and Success of Plan" subsection below, **it is recommended that all organizations acting to implement this plan report the initiation and completion of projects implementing plan recommendations to Walworth County LURM.**

Evaluating the State of Plan Implementation

It is recommended that the Jackson Creek Watershed Plan Advisory Group be maintained as a continuing advisory committee to provide advice and coordination for plan implementation and to evaluate the state of implementation of this plan. Consideration should be given to adding members to this Group as needed, with these additional members being drawn primarily from local units of governments and private organizations that are actively implementing plan recommendations.

It is recommended that the Advisory Group meet annually (at a minimum) at the request of one or more of its members to evaluate the status of plan implementation. This evaluation will include review of the project reports from all group members as well as other available information relevant to evaluating plan implementation.

The Advisory Group will evaluate progress in plan implementation against the milestones set forth in Table III-2. These milestones reflect the land areas affected, load reductions, and schedule for plan implementation given in Tables III-3 and 5. Based upon its evaluation, the Advisory Group will make a determination as to whether plan implementation is proceeding in accordance with the schedule. Based upon this determination it will provide advice to organizations implementing the plan regarding implementation strategies.

As part of its review process, and consistent with the adaptive management approach as shown in Figure III-6, the Advisory Group will examine the plan and efforts to implement it to determine whether any adjustments or modifications in plan recommendations or priorities are warranted. The issues that should be addressed in this review include, but are not limited to:

- Whether conditions within the watershed have changed in ways that require adjustment of the plan,
- Whether public priorities with respect to the focus areas of the plan have changed,
- Whether the regulatory environment with respect to the focus areas of the plan has changed,
- The degree and extent of progress made in implementing recommended actions,
- Whether the elements and priorities of the plan should remain unchanged or need modification,
- Whether new plan elements are needed, and
- Whether applicable funding programs and levels of funding have changed.

Tracking of Progress and Success of Plan

The State requires that Walworth County administer a variety of programs and regulations related to the protection of land and water resources throughout the County. Hence, Walworth County LURM is already committed to monitoring, tracking, and evaluating conservation activities, actions, policies, and programs to address land and water resources management concerns and issues as part of their five-year workplan (Land and Water Resources Management Plan). Therefore, **it is recommended that Walworth County LURM be responsible for tracking progress of this plan, however, the extent of this tracking is largely contingent upon collaboration and support of local partners and subject to the availability of Federal, State, and local sources of funding to support staff and program support costs (i.e., hiring an additional technical staff member for Walworth County dedicated to the implementation of this plan as shown in Table III-7). Walworth County LURM will need to work with NRCS, WDNR, and local partner staff to track progress and implement practices. Reports will be completed annually, and an intensive review and analysis of plan implementation success will be conducted at a five-year interval coincident with the schedule of the 2020 and 2025 County Land Water Resources Management/Work Plans.**

Progress and success of the Jackson Creek Watershed Project will be tracked based on the following four metrics; 1) Information and education activities and participation, 2) Pollution reduction evaluation based on BMPs installed, 3) Water quality monitoring, and 4) Administrative review (see below for more details).

Nearly all the local partners or Advisory Group members implement information and education activities throughout the watershed, so **it is important that each of these agencies and/or organizations provide a brief summary update of activities to Walworth County LURM for inclusion in the annual watershed report. The Advisory Group should consider designating a member to attend the annual Rock River Coalition (RRC) meeting to stay informed regarding ongoing progress and activities in the larger Rock River basin.**

1. Information and education reports should include:
    a. Number of landowners/operators in the watershed.
    b. Number of eligible landowners/operators in the watershed.
    c. Number of landowners/operators contacted.
    d. Number of cost-share agreements signed.
    e. Number and type of information and education (I&E) activities held, who led the activity, how many were invited, how many attended, and any measurable results of I&E activities.
    f. Number of informational flyers/brochures distributed per given time period.
    g. Number of individual contacts with landowners in the watershed.
    h. Comments or suggestions for future activities.

2. Pollution reduction management measures reporting should consider the following elements:
   a. Planned and completed BMPs.
   b. Pollutant load reductions and percent of goal planned and achieved.
   c. Cost-share funding source of planned and installed BMPs.
   d. Numbers of field checks to make sure management plans (nutrient management, grazing management) are being followed by landowners.
   e. Number of field checks to make sure practices are being operated and maintained properly.
   f. The agricultural fields and practices selected and funded by a point source to meet permit compliance requirements through adaptive management or water quality trading will be carefully tracked to assure that Section 319 funds are not being used to implement practices that are part of a point source permit compliance strategy.
   g. Number of new and alternative technologies and management measures used and incorporated into plan.
3. Water Quality Monitoring Reporting Parameters:
   a. Annual summer and monthly mean total phosphorus and total suspended solids concentrations and loading values from USGS stream monitoring stations.
   b. Annual mean and monthly streamflow and peak flow from USGS stream monitoring stations.
   c. Total phosphorus, dissolved reactive phosphorus, total suspended solids, and clarity data from volunteer grab sampling (Rock River Coalition Monitoring Program).
   d. Edge of field monitoring results.
   e. Macroinvertebrate Index of Biotic Integrity (Rock River Coalition Monitoring Program).
   f. Fishery Index of Biotic Integrity by WDNR or University staff.
4. Administrative Review tracking and reporting should include:
   a. Status of grants relating to project.
   b. Status of project administration including data management, staff training, and BMP monitoring.
   c. Status of nutrient management planning and easement acquisition and development.
   d. Number of cost-share agreements.
   e. Total amount of money spent on cost-share agreements.
   f. Total amount of landowner reimbursements.
   g. Staff salary and fringe benefits expenditures.
   h. Staff travel expenditures.
   i. Information and education expenditures.
   j. Equipment, materials, and supply expenses.
   k. Professional services and staff support costs.
   l. Total expenditures for the County.

m. Number of water quality trading/adaptive management contracts.

Information and Education Indicators of Success

The indicators of success and targeted schedule of completion are provided in Table III-5.

Water Quality Monitoring Indicators of Success

Water quality monitoring indicators of success for the Jackson Creek watershed are listed in Table III-8, and targeted instream mean monthly loads for water quality monitoring at the Mound Road station are shown in Table III-9. Other plan recommendations, particularly some of those focused on habitat improvement, may produce ancillary water quality benefits, but such benefits were not directly quantifiable in terms of a pollutant load reduction (e.g., floodplain connectivity or fish passage improvements). Indicators of success for management measures are set forth in Table III-2 and additional hydrologic, hydraulic, geomorphologic, physiochemical, and biological functional parameters to monitor are listed in Figure II-41 (see Functional Pyramid section in Chapter II of this report).

COST ANALYSIS

Cost estimates based on current USDA-NRCS total costs for payment rates, incentives payments to get necessary farmer participation, and current conservation project installation rates are summarized in Table III-10. Current conservation project installation rates were obtained through conversations with county conservation technicians, UW-Extension, and NRCS staff. The total cost to implement the watershed plan over 10 years is estimated to be **$6,978,374**.

Summary of Cost Analysis

- **$5,836,174** to implement best management practices (see Table III-3)
- **$27,200** needed for Information and Education (see Table III-5)
- **$489,800** needed for Water Quality Monitoring (see Table III-6)
- **$625,200** needed for technical assistance (see Table III-7)

Operation and Maintenance

This plan will require a landowner to agree to a 10-year maintenance period for practices such as vegetated buffers/wetland restoration, grassed waterways, and streambank stabilization. For practices such as no till, cover crops, and nutrient management, landowners are required to maintain the practice for each period that cost sharing is available. Upon completion of the operation and maintenance period, point sources may be able to work with operators and landowners to continue implementation of the BMPs under a pollutant trading agreement (non USEPA 319 monies).

FUNDING SOURCES

There are many State and Federal programs that currently provide funding sources for conservation practices as listed below, but there are a couple of newer funding opportunities within the Jackson Creek watershed worth describing. First, beginning in 2016, Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) has developed a new granting program specifically for farmer-led projects to protect water quality in Wisconsin. Second, the Adaptive management (AM) and water quality trading (WQT) programs also are potential sources of funding to implement water quality improvement projects in this watershed if the Walworth County Metropolitan Sewerage District (WalCoMet, see http://walcomet.org/) decides to address its permitted phosphorus point source loads through either of these programs. WalCoMet is considering multiple options, so the application of adaptive management and water quality trading depend upon the program WalCoMet ultimately adopts.

Federal and State Funding Sources

Brief descriptions of available funding programs are set forth below:

- **Environmental Quality Incentives Program (EQIP)—**Federal program provides financial and technical assistance to implement conservation practices that address resource concerns. Farmers receive flat rate payments for installing and implementing runoff management practices.
- **Conservation Reserve Program (CRP)—**A Federal land conservation program administered by the Farm Service Agency. Farmers enrolled in the program receive a yearly rental payment for environmentally sensitive land that they agree to remove from production. Contracts are 10 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, and shallow water areas for wildlife.
- **Conservation Reserve Enhancement Program (CREP)—**Federal program provides funding for practice installation, rental payments, and an installation incentive. A 15-year contract or perpetual contract conservation easement can be entered into. Eligible practices include filter strips, buffer strips, wetland restoration, tall grass prairie and oak savanna restoration, grassed waterway, and permanent native grasses.
- **Agricultural Conservation Easement Program (ACEP)—**New Federal 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.
- **Targeted Runoff Management (TRM) Grant Program—**State program 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.

- **Conservation Stewardship Program (CSP)—**Federal program 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.
- **Farmable Wetlands Program (FWP)—**Federal program designed to restore previously farmed wetlands and wetland buffer to improve both vegetation and water flow. The Farm Service Agency runs the program through the Conservation Reserve Program with assistance from other government agencies and local conservation groups.
- **Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP)—** Beginning in 2016, grants will become available for farmer-led projects to protect water quality in Wisconsin. DATCP will be administering this grant program. Grant funding will be available for farmer-led activities to reduce nonpoint source pollution in their watersheds.[40] Farmer-led groups must:
    - Include at least five eligible farmers who form a group in collaboration with a government agency, an educational organization, or a nonprofit conservation group.
    - Help other farmers in the watershed voluntarily work to reduce nonpoint source pollution.
    - Contribute at least 50 percent of the costs that are eligible for grant funds.

Land Trusts

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

Adaptive Management and Water Quality Trading

Adaptive management and water quality trading can provide a more economically feasible option for point source dischargers to meet their wasteload allocation. Point sources provide funding for best management practices to be applied in a watershed and receive credit for the reduction from that practice. Section 319 nonpoint source funds cannot be used implement practices that are part of a point source permit compliance strategy. Adaptive management focuses on compliance with phosphorus criteria while water quality trading focuses on compliance with a discharge limit (see Table III-11).

---

[40]*See website at http://datcp.wi.gov/Environment/Land_and_Water_Conservation/index.aspx?Id=237*

Adaptive management is a phosphorus compliance option that allows point and nonpoint sources (e.g., agricultural producers, stormwater utilities, and developers) to work together to improve water quality in those waters not meeting phosphorus water quality standards. This option recognizes that the excess phosphorus accumulating in lakes and streams comes from a variety of sources, and that reductions in both point and nonpoint sources are frequently needed to achieve water quality goals. By working in their watershed with landowners, municipalities, and counties to target sources of phosphorus runoff, point source dischargers can minimize their overall investment while helping achieve compliance with water quality-based criteria and improving water quality. Guidance is available from the WDNR that describes adaptive management and how to develop a successful adaptive management strategy.[41] Adaptive management is only applicable to phosphorus discharges.

Water quality trading may be used by WPDES permit holders to demonstrate compliance with water quality-based effluent limitations. This approach may be used for several different pollutants, including phosphorus. Generally, water quality trading involves a point source facing relatively high pollutant reduction costs compensating another party to achieve less-costly pollutant reduction with the same or greater water quality benefit. Water quality trading provides point sources with the flexibility to acquire pollutant reductions from other sources in the watershed to offset their point source load so that they will comply with their own permit requirements. Guidance is available from the WDNR that describes water quality trading and developing trades.[42]

---

[41] *Wisconsin Department of Natural Resources,* Adaptive Management Technical Handbook: A Guidance Document for Stakeholders, *Guidance Number 3800-2013-01, January 7, 2013.*

[42] *Wisconsin Department of Natural Resources,* A Water Quality Trading How To Manual, *Guidance Number 3400-2013-03, September 9, 2013; Wisconsin Department of Natural Resources,* Guidance for Implementing Water Quality Trading in WPDES Permits, *Guidance Number 3800-2013-04, August 21, 2013.*

SEWRPC Community Assistance Planning Report No. 320

JACKSON CREEK WATERSHED PROTECTION PLAN

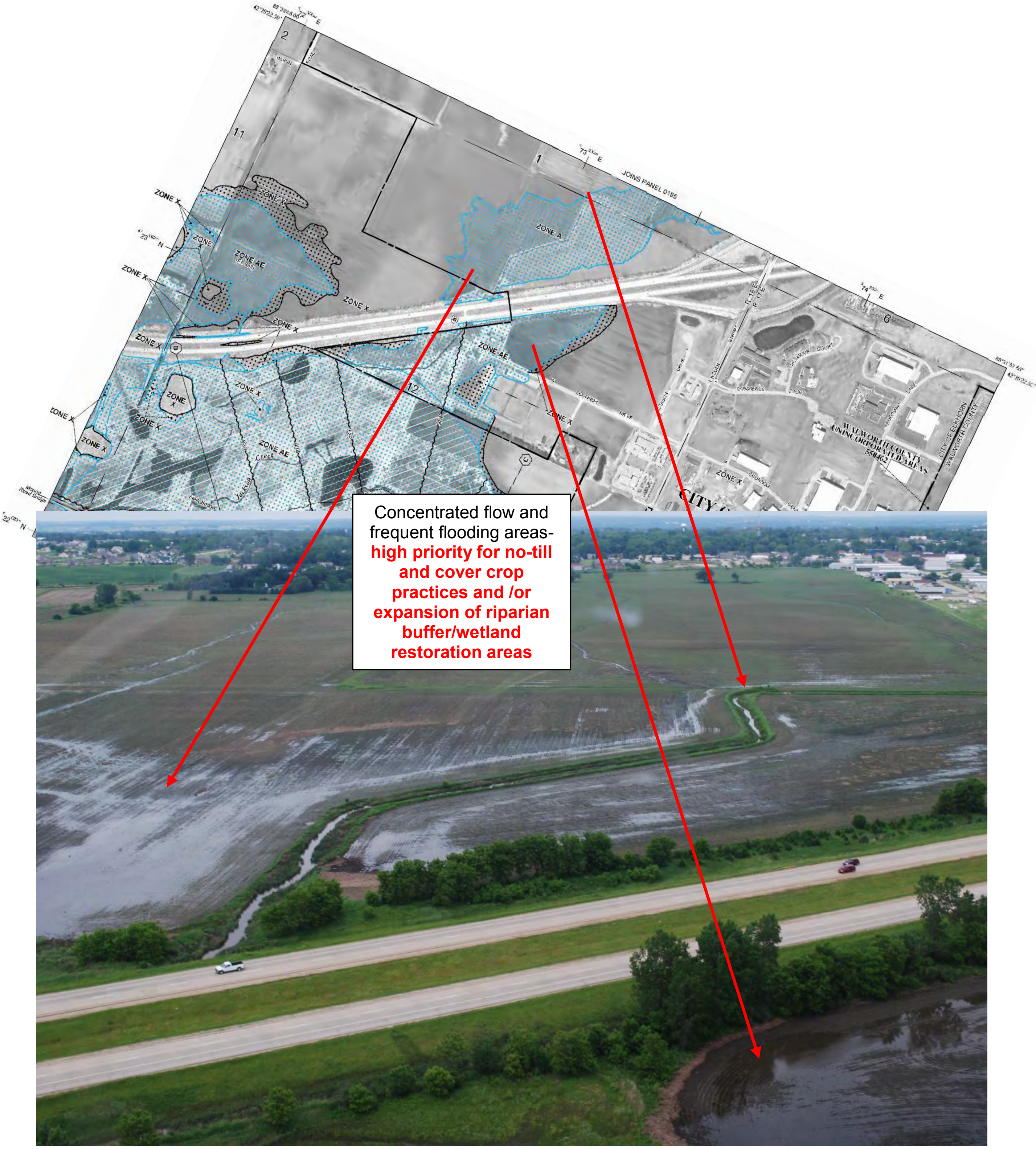
Chapter III

PLAN RECOMMENDATIONS

FIGURES

Figure III-1

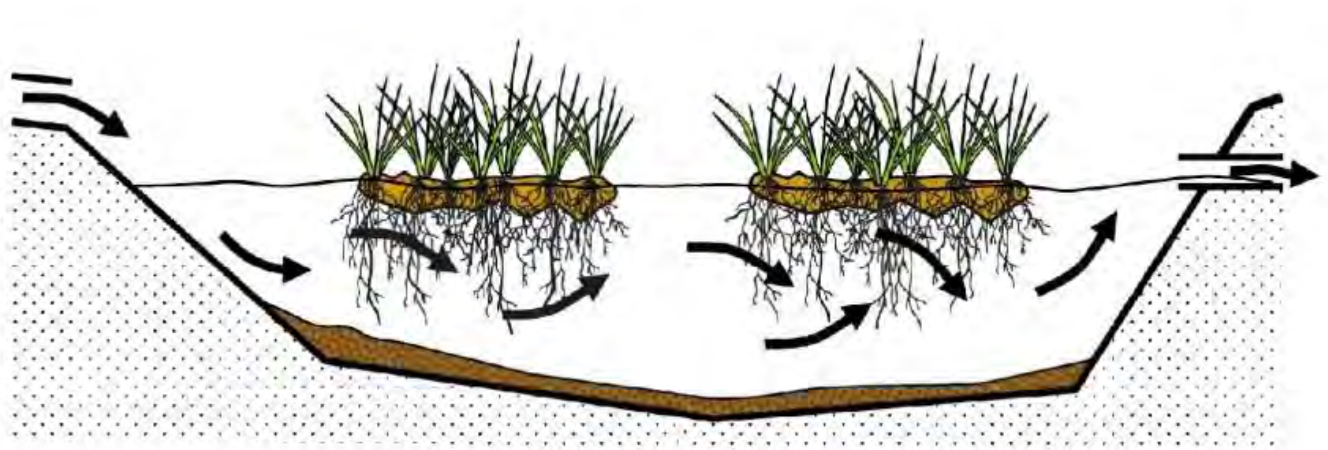
APPROXIMATE FLOODPLAIN BOUNDARY ZONE A UPSTREAM (WEST) OF USH 12 AND ACTUAL FLOODING CONDITIONS ON JUNE 13, 2008 AT 2:00PM ON TRIBUTARY B WITHIN THE JACKSON CREEK WATERSHED



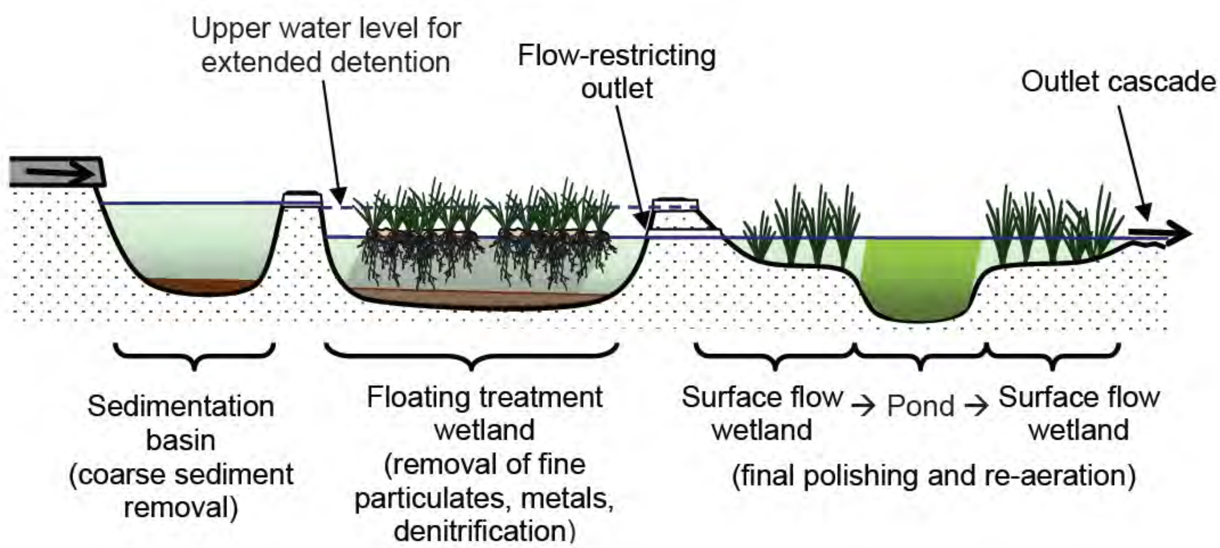
Source: FEMA and SEWRPC.

Figure III-2

SCHEMATIC OF FLOATING TREATMENT WETLAND (FTW) 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: Ian Dodkins; Anouska Mendzil; and Leela O'Dea, Floating Treatment Wetlands (FTWs) in Water Treatment: Treatment efficiency and potential benefits of activated carbon, Prepared for: FROG Environmental Ltd, March 2014; Headley, T.R. 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.

Figure III-3

EXAMPLES OF HABITAT IMPROVEMENT PROJECTS IN AGRICULTURAL AND URBAN LANDSCAPES FOR AMPHIBIANS AND REPTILES

RECREATION OR RECONNECTION OF WETLAND AND UPLAND HABITATS

REMOVING OBSTACLES AND SIGNAGE CAN IMPROVE SAFETY AND EFFECTIVENESS OF TRAVEL BETWEEN HABITATS

BURNING CAN BE AN EFFECTIVE MANAGEMENT TOOL

ROADSIDE FENCES CAN REDUCE MORTALITY

Source: Partners in Amphibian and Reptile Conservation (PARC), Habitat Management Guidelines for Amphibians and Reptiles of the Midwestern United States*, Technical Publication HMG-1, 2nd Edition. 2012.*

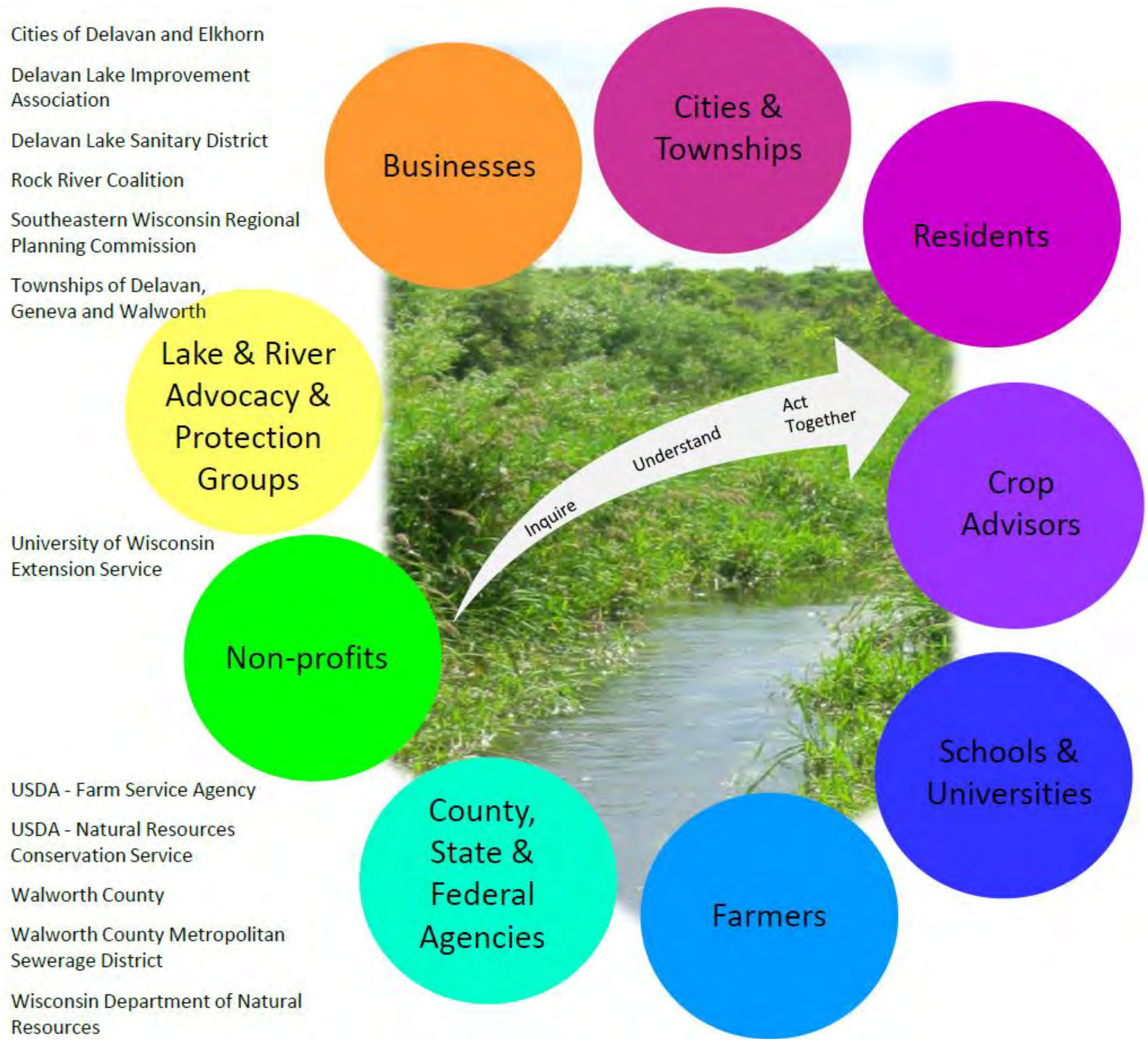
Figure III-4

UNIVERSALLY ACCESSIBLE PADDLE CRAFT LAUNCH ON THE BLACK RIVER IN PORT HURON, MICHIGAN

Source: Greg Farnham, Coordinator, Rock River Trail Initiative.

Figure III-5

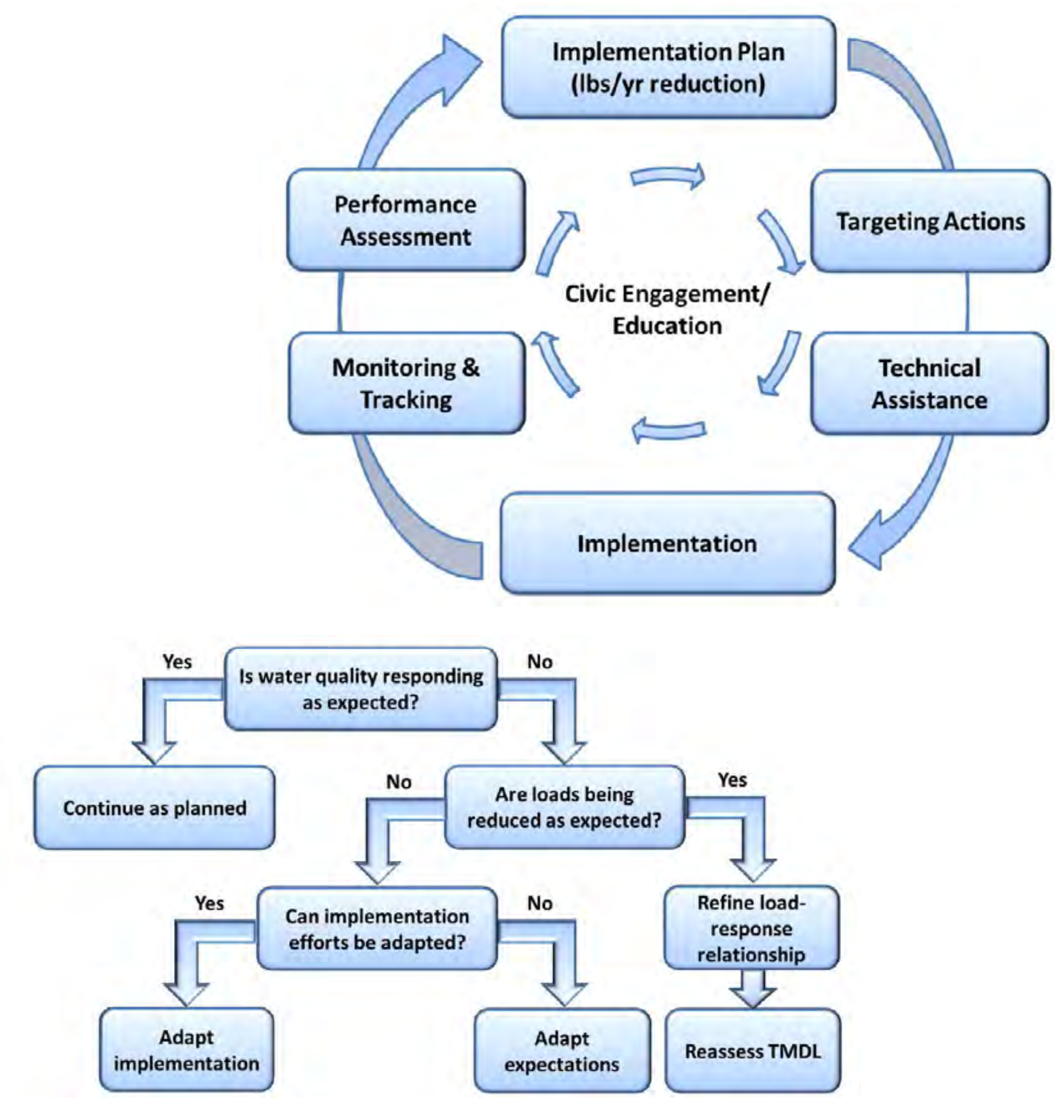
COMMUNITY ENGAGEMENT STRATEGY WITHIN THE JACKSON CREEK WATERSHED



Source: Kettle Moraine Land Trust and SEWRPC.

Figure III-6

ADAPTIVE MANAGEMENT IMPLEMENTATION FRAMEWORK AND EVALUATION PROCESS (ADAPTED FROM THE IMPLEMENTATION PLAN FOR LAKE ST. CROIX)



Source: Implementation Plan for Lake St. Croix 2013 and SEWRPC.

SEWRPC Community Assistance Planning Report No. 320

JACKSON CREEK WATERSHED PROTECTION PLAN

Chapter III

PLAN RECOMMENDATIONS

TABLES

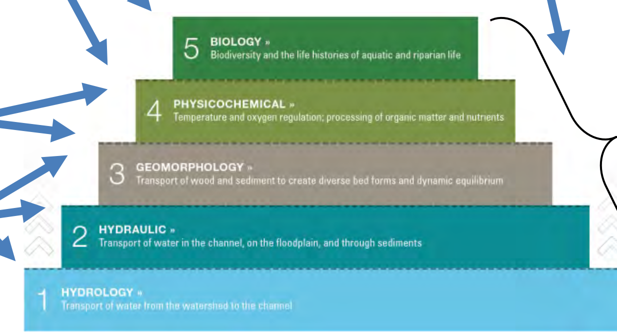
Table III-1

JACKSON CREEK WATERSHED GOALS AND MANAGEMENT OBJECTIVES

Goal	Indicators	Cause or Source of Impact	Management Objective
Promote active stewardship among residents, farmers, landowners, businesses, community associations, as well as governmental and non-governmental organizations.	Dialog & Bridging Events; Network Development; Customized Information and Education; Multiple information streams/ meetings to promote Capacity & Leadership training; improvements in recreational access and use	Lack of awareness, environmental services not given programmatic value, lack of funding,	Increase recreational opportunities, public awareness of water quality issues, and participation in watershed conservation activities
Manage and develop lands in a manner that is consistent with the protection of living resources: avoid habitat fragmentation and encourage the preservation and enhancement of wetlands and wildlife corridors including providing and preserving connections with upland habitats and through sensitive landscaping practices.	Riparian buffers/ wetlands, wetland-upland complexes, streambank erosion, stream channelization/ditching, limited floodplain connectivity, fishery quality, macroinvertebrate quality, floristic quality index	Inadequate riparian vegetation, ditching, loss of wetlands, increased fragmentation within and among natural areas and environmental corridors, excessively groomed landscapes	Maintain and expand wetland, fish, and wildlife habitats
Minimize the further degradation of surface water and preserve, restore, and maintain the high quality of all waterbodies within the watershed	Surface water quality to achieve WDNR/ USEPA water quality standards including, but not limited to, total phosphorus and total suspended sediment	High phosphorus levels causing algal growth and decreased dissolved oxygen. Cropland and barnyard runoff, lack of funding	Reduce the loads of sediment and phosphorus from upland sources to improve water quality and to enhance and restore stream form and function.
Identify opportunities to improve the quality of the land and water (including groundwater) resources within the watershed by reducing both nonpoint agricultural and urban runoff.	Peak flow discharges and flooding during heavy precipitation events, groundwater recharge, streambank stability, fishery quality, macroinvertebrate quality, and improved soil health	Increased impervious area from urban development, inadequate stormwater practices, tile drainage and ditching in agricultural fields, poor soil health, lack of funding to implement Best Management Practices (BMPs)	Reduce the volume and velocity of runoff from upland areas to streams, increase soil infiltration, and protect groundwater recharge

Source: Source: Harman, W., A Function-Based Framework for Stream Assessment and Restoration Projects *2012, and SEWRPC.*

STREAM FUNCTIONS PYRAMID (see Figure II-41)



Within this hierarchical framework, higher-level functions are supported by lower level functions

Table III-2

10-YEAR TARGETED MANAGEMENT MEASURES PLAN MATRIX

Recommendations	Indicators	Milestones			Timeline	Funding Sources[a]	Implementation[b]
		0 to 3 Years	3 to 7 Years	7 to 10 Years			
1) **Agricultural BMPs:** Reduce the sediment and phosphorus loads from agricultural fields and uplands[c]							
a) Increase use of no till from 10 percent of agricultural land to 60 percent (promote transition of conservation tillage to no till practices)	Number of acres of cropland with conservation practice applied	1,075	2,153	1,075	0-10 years	EQIP, TRM, CSP, AM, WQT	NRCS, LURM
b) Increase use of cover crops from the current 5 percent of agricultural land to 50 percent	Number of acres of cropland with conservation practice applied	968	1,937	968	0-10 years	EQIP, TRM, CSP, AM, WQT	NRCS, LURM
c) Increase implementation of land under nutrient management plans from 25 percent of agricultural land to 100 percent	Number of acres of cropland with conservation practice applied	773	1,547	773	0-10 years	EQIP, TRM, CSP, AM, WQT	NRCS, LURM
d) Install grassed waterways in priority areas (see Map B-1 in Appendix B)	Number of linear feet of grassed waterways installed	12,369	24,740	12,369	0-10 years	EQIP, CREP, AM, WQT	NRCS, LURM, Local Partners
e) Install subsurface drainage/outlets where necessary	Number of linear feet of drainage/outlets installed	3,092	6,186	3,092	0-10 years	EQIP, CREP, AM, WQT	NRCS, LURM, Local Partners
f) Document decrease in surface water runoff by evaluating soil infiltration rates on select projects above	Number of farms/agricultural landowners checked	20	25	15	0-10 years	N/A	LURM, NRCS, Local Partners
2) **Riparian Buffers/Wetland Restoration**							
a) Install 75-foot-wide minimum riparian buffers/harvestable buffers (see Map B-2 in Appendix B)	Number of acres of riparian buffers installed	31	62	31	0-10 years	CREP/CRP, EQIP, AM, WQT	NRCS, LURM, Local Partners

Recommendations	Indicators	Milestones			Timeline	Funding Sources[a]	Implementation[b]
		0 to 3 Years	3 to 7 Years	7 to 10 Years			
b) Restore wetlands to establish and/or expand riparian buffers within 75- to 400-foot-wide zone (see Map B-2 in Appendix B)	Number of acres of riparian buffers installed	115	233	115	0-10 years	CREP/CRP, EQIP, AM, WQT	NRCS, LURM Local Partners,
c) Restore wetlands to establish and/or expand riparian buffers within 400- to 1,000-foot-wide zone (see Map B-2 in Appendix B)	Number of acres of riparian buffers installed	133	269	133	0-10 years	CREP/CRP, EQIP, AM, WQT	NRCS, LURM Local Partners,
3) Restore and stabilize degraded streambanks							
a) Restore high priority eroded streambanks by use of re-meandering to historical channel alignment and/or two-stage channel construction and use of riprap and/or biostabilization, where appropriate (see Map III-1)	Number of linear feet of streambank stabilized and channel restored	1,115	250	900	0-10 years	EQIP, WQT	NRCS, LURM, WDNR, Local Partners
b) Restore moderate priority eroded streambanks by use of re-meandering to historical channel alignment and/or two-stage channel construction and use of riprap and/or biostabilization, where appropriate (see Map III-1)	Number of linear feet of streambank stabilized and channel restored	502	340	400	0-10 years	EQIP, WQT	NRCS, LURM, WDNR, Local Partners

[a]Environmental Quality Incentives Program (*EQIP), Conservation Reserve Program (CRP), Conservation Stewardship Program (CSP), Conservation Reserve Enhancement Program (CREP), Targeted Runoff Management (TRM), Water Quality Trading (WQT), and Adaptive Management (AM).*

[b]*Natural Resources Conservation Service (NRCS), Walworth County Land Use & Resource Management (LURM), Wisconsin Department of Natural Resources (WDNR), and* Local Partners *include the following: Cities of Delavan and Elkhorn; Towns of Delavan, Geneva, and Walworth; Delavan Lake Improvement Association; Delavan Lake Sanitary District; Walworth County Metropolitan Sewerage District; Rock River Coalition; and Kettle Moraine Land Trust, Inc.*

[c]*A combination of the listed practices will be applied to agricultural fields to get the desired load reductions indicated by the TMDL study. 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 (see Appendix B)*

Source: NRCS; Walworth County; Kettle Moraine Land Trust, Inc.; and SEWRPC.

Table III-3

ESTIMATED LOAD REDUCTIONS FOR WATERSHEDWIDE MANAGEMENT MEASURES: 2015[a]
(percent reduction calculated from USEPA STEPL modeling)

Management Measure Category	Total Units (size/length)	Total Cost[b]	Estimated Load Reduction[a]			
			TP (pounds per year)	Percent	TSS (tons per year)	Percent
Agricultural BMPs Applied to Cropland[c]						
No Till	4,303 acres	$84,511	10,158	19.0	1,929	5.5
Cover Crops	3,873 acres	$232,961	3,543	6.6	974	2.8
Nutrient Management Plans	6,545 acres	$346,885	3,772	7.1	1,159	3.3
Gully Stabilization						
Grassed Waterways	49,478 feet	$262,977	3,174	6.0	5,152	14.6
Subsurface Drainage/Outlets	12,370 feet		N/A	N/A	N/A	N/A
Riparian Buffers/Wetland Restoration						
75-foot-wide minimum riparian buffers	124 acres	$4,488,000	325	0.6	230	0.7
75-to 400-foot-wide riparian buffers/ wetland restoration	463 acres		1,249	2.3	871	2.5
400- to 1,000-foot-wide riparian buffers/ wetland restoration	535 acres		1,274	2.4	869	2.5
Streambank Restoration						
High Priority Sites	2,265 feet	$420,840	49	0.1	80	0.2
Moderate Priority Sites	1,242 feet		9	<0.1	15	<0.1
Total	- -	**$5,836,174**	**23,553**	**44.0**	**11,279**	**31.9**

NOTE: This table only shows the pollutant reductions for Total Phosphorus (TP) and Total Suspended Sediment (TSS) as addressed under the Rock River TMDL, but nitrogen and BOD were also modeled as summarized in Appendix B. The percent reductions are expressed relative to the total existing load without controls.

[a] *Based upon past Agricultural BMPs applied to cropland, gully stabilization, and riparian buffers implemented throughout the watershed, it is estimated that the Jackson Creek watershed is already achieving a 35 percent and 26 percent pollutant load reduction in Total Phosphorus (TP) and Total Suspended Sediment (TSS), respectively. Therefore, the existing load reductions combined with the proposed pollutant load reductions would achieve load reductions of approximately 79 percent for TP and 58 percent for TSS relative to the uncontrolled condition.*

[b] *See Table III-10.*

[c] *A combination of practices will likely need to be applied to the majority of the crop fields in the watershed, but it is difficult to know where such practices would be adopted. So, the upland practices have separate existing levels of implementation and target goals and were modelled individually. However, it is important to note that when multiple practices are installed in series they are much more effective than if they were implemented separately. Therefore, the modelled load reductions (see Appendix B) are likely a conservatively low estimate of potential load reductions in this watershed, which should be kept in mind when tracking progress of project implementation in the future.*

Source: Natural Resources Conservation Service, Walworth County, Kettle Moraine Land Trust, and SEWRPC.

Table III-4

SURVEY RESULTS ON RANKING CURRENT WATER QUALITY AND QUANTITY ISSUES IN THE JACKSON CREEK WATERSHED: 2012

Water Quality and Quantity Issues	Average Score (Ranked 1-High, 5-Low)
Sedimentation	1.3
Urban runoff	1.4
Agricultural runoff	1.4
Water Clarity	1.5
Wetland protection	1.6
Garbage and trash in natural areas	1.6
Invasive species	1.7
Extent of algae	1.7
Groundwater Recharge	1.8
Fishery quality	1.9
Upland (prairie or woodland) protection	1.9
Pesticide use	2.0
Streambed and bank erosion	2.1
Water Supply	2.1
Bugs	2.2
Ordinance enforcement	2.2
Bacteria related to swimming	2.2
Urbanization	2.3
Big gamefish quality	2.3
Weed growth	2.3
Development of new ordinances	2.4
Flooding	2.6
Water depth	2.6
Temperature	3.1
Traffic noise	3.3
Other; Economy/Funding, Education/Awareness, Outreach	5.0

Source: Kettle Moraine Land Trust and SEWRPC.

Table III-5

INFORMATION AND EDUCATION PLAN IMPLEMENTATION MATRIX

Information and Education Plan Implementation Matrix							
		Schedule					
Target Audience	**Actions**	**0–2 Years**	**2–5 Years**	**5–10 Years**	**Cost**	**Implementation**	**Outcome/ Evaluation Metric**
General Public	Media notices in newspapers and community newsletters, public presentations, and installation of signage	Notice in two local newspapers about completion of Jackson Creek Protection Plan.	- -	Install watershed signs to create interest to see what watershed project is about		LURM, Local Partners	General public is aware of protection plan, understand how the Plan is relevant to them as well as Inform them about the fish and wildlife species known to reside in the watershed, their habitat requirements, and management practices required to sustain them.
		At least one presentation to municipal representatives, landowners, and general public.	- -	- -	$1,000	LURM, Local Partners	
	Create educational display for County Fair, local libraries, and government offices	At least one educational display exhibited at County Fair and two other venues.	At least two educational displays exhibited at government offices, and local events.	- -	$3,600	LURM, Local Partners	People who live, work and recreate in the watershed will understand how the plan improves their community and life, and have a better understanding of how they impact the resources in the watershed. They will be informed of progress and new recommendations for improvements and protections.
	Utilize municipal and community organization websites to post watershed project information	Two Stakeholder groups develop a website page or social media site for watershed plan news and activities.	- -	- -	$2,200	LURM, Local Partners	
	Distribute information to watershed residents about Jackson Creek Protection Plan goals and recommended actions.	A fact sheet or publication is created about the Plan goals, recommended actions and opportunities for civic involvement and is mailed to residents.	The fact sheet or publication is updated about the Plan goals, recommended actions and opportunities for civic involvement, and is distributed to residents.	The fact sheet or publication is updated to reflect Plan goals, recommended actions and opportunities for civic involvement, and is distributed to residents.	$6,000	LURM, Local Partners	

Information and Education Plan Implementation Matrix

Target Audience	Actions	Schedule			Cost	Implementation	Outcome/ Evaluation Metric
		0–2 Years	2–5 Years	5–10 Years			
Riparian Landowners	Distribute information to riparian landowners about management actions to protect and promote wildlife habitat, and information about programs to fund riparian buffers and wetlands.	A fact sheet is developed and distributed to riparian landowners about Plan goals, recommended BMPs and available resources.	At least 5 site meetings are held with riparian landowners.	- -	$2,500	LURM, NRCS, WDNR, UWEX, Local Partners	Riparian landowners will recognize the unique multipurpose functions of the riparian corridor, and learn about resources available to help them improve management of their lands, and restore/improve in stream conditions.
Agricultural Landowners and Operators	Distribute educational information materials about BMPs, and available resources to support implementation.	A fact sheet is developed and distributed to agricultural landowners and operators about Plan goals, recommended BMPs and available resources.	- -	- -	$1,500	LURM, NRCS, UWEX, WDNR, Local Partners	Agricultural landowners and operators will be informed about recommended BMPs, funding, and technical assistance resources.
	Individual meetings with landowners and operators to provide information and offer technical assistance.	At least 25 personal contacts are made with landowners, and 10 personal contacts are made with operators.	At least 25 personal contacts are made with landowners, and 10 personal contacts are made with operators.	At least 25 personal contacts are made with landowners, and 10 personal contacts are made with operators.	$3,000	LURM, NRCS, UWEX, Local Partners	The interest in BMPs will increase among agricultural landowners and operators.
	Create opportunities for agricultural landowners and operators to share information and build strong connections with other stakeholders through field meetings, workshops.	At least two group meetings are held.	At least two workshops or tours are held at a demonstration site.	- -	$3,000	LURM, NRCS, WDNR, UWEX, Local Partners	Agricultural landowners and operators will see successful BMPs and gain knowledge needed to implement similar practices.
		At least one educational meeting is held to share information on integrating recommended BMPs effectively.	- -	- -	$1,000	LURM, NRCS, WDNR, UWEX, Local Partners	Agricultural landowners and operators will learn emerging strategies in cover crop rotations, reduced tillage, and nutrient management.

Information and Education Plan Implementation Matrix							
		Schedule					
Target Audience	Actions	0–2 Years	2–5 Years	5–10 Years	Cost	Implementation	Outcome/ Evaluation Metric
Non-Resident Agricultural Landowners	Convene a webinar designed for absent agricultural property owners informing them of the watershed plan, recommendations and available resources.	At least one webinar is held for landowners who lease agriculture lands.	- -	- -	$1,000	LURM, NRCS, WDNR, UWEX, Local Partners	Non-resident landowners will understand the various strategies available to implement BMPs when working with a lease.
Elected Officials	Convene meetings with local officials and community group representatives to encourage new community connections to foster customized solutions to implementation obstacles.	Presentations are given to at least four municipal board councils.	At least two workshops are held for local officials.	- -	$2,400	LURM, Local Partners	Increased interest among municipalities to restore and improve the natural hydrological functions of Jackson Creek, and partner on recommended projects and programs.
				Total Materials Cost	$27,200	- -	- -

[a]*Natural Resources Conservation Service (NRCS), University of Wisconsin-Extension (UWEX), Walworth County Land Use & Resource Management (LURM), Wisconsin Department of Natural Resources (WDNR), and*

[b]Local Partners *include the following: Cities of Delavan and Elkhorn; Towns of Delavan, Geneva, and Walworth; Delavan Lake Improvement Association; Delavan Lake Sanitary District; Walworth County Metropolitan Sewerage District; Rock River Coalition; and Kettle Moraine Land Trust, Inc.*

Source: Walworth County LURM; Kettle Moraine Land Trust, Inc.; and SEWRPC.

.

Table III-6

ESTIMATED COSTS FOR WATER QUALITY MONITORING RECOMMENDATIONS

Water Quality Monitoring	Cost[a]
Volunteers can collect monitoring data monthly from May – October for a cost of $1,600 per site plus $2,000 per year for equipment, supplies, shipping and replacement parts for all five sites ($1,600/year x 5 sites + $2,000 x 10 years)	$100,000
USGS monitoring costs for Mound Rd. plus 2 lake sample points (DLSD collects these). Includes annual monitoring presentation/report. ($29,100/year * 10 years)	$291,000
Edge of Field Monitoring Station Install for basin JC6 ($18,800)	$18,800
Edge of Field Monitoring Maintenance & Collection of Data ($8,000/year)	$80,000
Total Cost	**$489,800**

[a]*Recruitment, training, volunteer support included as part of staff coordinator position.*

Source: Rock River Coalition; Delavan Lake Sanitary District; Kettle Moraine Land Trust, Inc.; and SEWRPC.

Table III-7

ESTIMATED COSTS FOR INFORMATION AND EDUCATION RECOMMENDATIONS

Information and Education	Cost (dollars)
Conservation/Project Coordinator Staff hours (1,000 hours of staff time per year for ten years)	$312,600
Agronomist Staff hours (1,000 hours of staff time per year for ten years)	$312,600
Total Cost	**$625,200**

Note: Materials such as postage, printing, paper, and other presentation materials costs are not included in this estimate.

Source: SEWRPC.

Table III-8

WATER QUALITY MONITORING INDICATORS OF SUCCESS FOR JACKSON CREEK WATERSHED: 2015-2025

Monitoring Recommendation	Indicators	Current Values	Target Value or Goal	Milestones			Implementation	Funding
				Short-Term (four years)	Medium-Term (seven years)	Long-Term (10 years)		
Surface Water Monitoring/ Monitoring Based on Measured Instream Loads at the USGS Mound Road Gauge	Number of pounds of phosphorus per year	183.7	93.7	161.2	116.2	93.7	USGS, DLSD, WDNR	USGS, WDNR, DLSD, WalCoMet, AM, Town of Delavan, City of Elkhorn
	Number of pounds of phosphorus per growing season (May – October)	77.5	39.5	68.0	49.0	39.5		
	Number of pounds of phosphorus per month	See Table III-9						
	Number of tons total suspended sediment per year	23.5	17.6	22.0	19.0	17.6		
	Number of tons total suspended sediment per growing season (May – October)	10.7	5.5	9.4	6.8	5.5		
	Number of tons total suspended sediment per month	See Table III-9						
Surface Water Monitoring for all stations								
Water Quality Indicators	Tables II-1 through II-5						USGS, DLSD, WDNR	USGS, WDNR, DLSD, WalCoMet, AM, Town of Delavan, City of Elkhorn
Habitat Quality Indicators	Table II-18						WDNR	WDNR
Biological Quality Indicators	Tables II-12 and II-13						WDNR	WDNR

Source: U.S. Geological Survey and SEWRPC.

Table III-9

MEAN MONTHLY WATER QUALITY MONITORING INDICATORS OF SUCCESS FOR THE JACKSON CREEK WATERSHED BASED ON MEASURED INSTREAM LOADS AT THE USGS MOUND ROAD GAUGE: 2015-2025

Indicators	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Current Phosphorus Mean Monthly Instream Loads	9.96	23.1	28.9	31	11.3	37	7.07	12.2	5.25	4.66	6.13	7.12
Target Value or Goal (reflecting 49 percent reduction) Phosphorus Mean Monthly Instream Load lbs/day	5.1	11.8	14.7	15.8	5.8	18.9	3.6	6.2	2.7	2.4	3.1	3.6
Current Suspended Sediment Mean Monthly Loads tons/day	0.67	2.1	2.7	5.5	1.6	6.5	0.68	0.93	0.47	0.55	0.9	0.9
Target Value or Goal (reflecting 25 percent reduction) Suspended Sediment Mean Monthly Instream Load tons/day	0.50	1.58	2.03	4.13	1.2	4.88	0.51	0.70	0.35	0.41	0.68	0.68

NOTE: Yellow highlight area indicates summer months May through October.

Source: U.S. Geological Survey and SEWRPC.

Table III-10

ESTIMATED COST FOR MANAGEMENT MEASURES AND TECHNICAL ASSISTANCE

BMP	Quantity[a]	Cost per Unit (dollars)	Total Cost[b] (dollars)
Upland Control			
No Till[c] (acres)	4,303	19.64	84,511
Cover Crops[c] (acres)	3,873	60.15	232,961
Nutrient Management[c] (acres)	6,545	53.00	346,885
Grass Waterways (linear feet)	49,478	4.44	219,682
Subsurface Drainage/outlets (linear feet)	12,370	3.50	43,295
Riparian Buffers/Wetland Restoration (acres)	1,122	4,000.00	4,488,000
Streambank Erosion Control			
Bank Stabilization (linear feet)	3,507	120.00	420,840
Technical Assistance			
Conservation/Project Coordinator[d]	0.5 staff	- -	312,600
Agronomist[d]	0.5 staff	- -	312,600

[a]*See Table III-3.*

[b]*The upland BMP costs reflect all known costs involved in the BMP installation and not just the standard 75 percent cost share amount. This is a more realistic expression of the true costs for such projects, which have to be absorbed by either the farmer/landowner or by another stakeholder to implement such projects in this watershed.*

[c]*Estimated costs based on cost-sharing for three years.*

[d]*Estimated costs based on full-time employment for 10 years.*

Source: Natural Resources Conservation Service; Walworth County; Kettle Moraine Land Trust, Inc.; and SEWRPC.

Table III-11

COMPARISON OF ADAPTIVE MANAGEMENT AND WATER QUALITY TRADING

Adaptive Management	Water Quality Trading
Receiving water is exceeding phosphorous loading criteria	The end-of-pipe discharge is exceeding the allowable limit
More flexible and adaptive to allow cropland practices to show reductions over extended time period	Not as flexible as adaptive management, needs to show stable reductions year to year
Does not use "trade ratios" as modeling factor	Uses "trade ratios" as margin of error factor
Uses stream monitoring to show compliance	Uses models such as SNAP+ or BARNY to show compliance with reduction in loading
Typically used for phosphorus compliance only	Can be used for a variety of pollutants, not just phosphorus
Can be used to quantify phosphorus reductions for up to 15 years	Can be used to demonstrate compliance indefinitely as long as credits are generated

Source: Outagamie County Land Conservation Department, Nonpoint Source Implementation Plan for the Plum and Kankaput Creek Watersheds*, 2014; and SEWRPC.*

#228194 – JACK CREEK WTRSHD PROT PLAN CH-3 MAPS DRAFT
300-1115
TMS/kmd
08/12/15

SEWRPC Community Assistance Planning Report No. 320

JACKSON CREEK WATERSHED PROTECTION PLAN

Chapter III

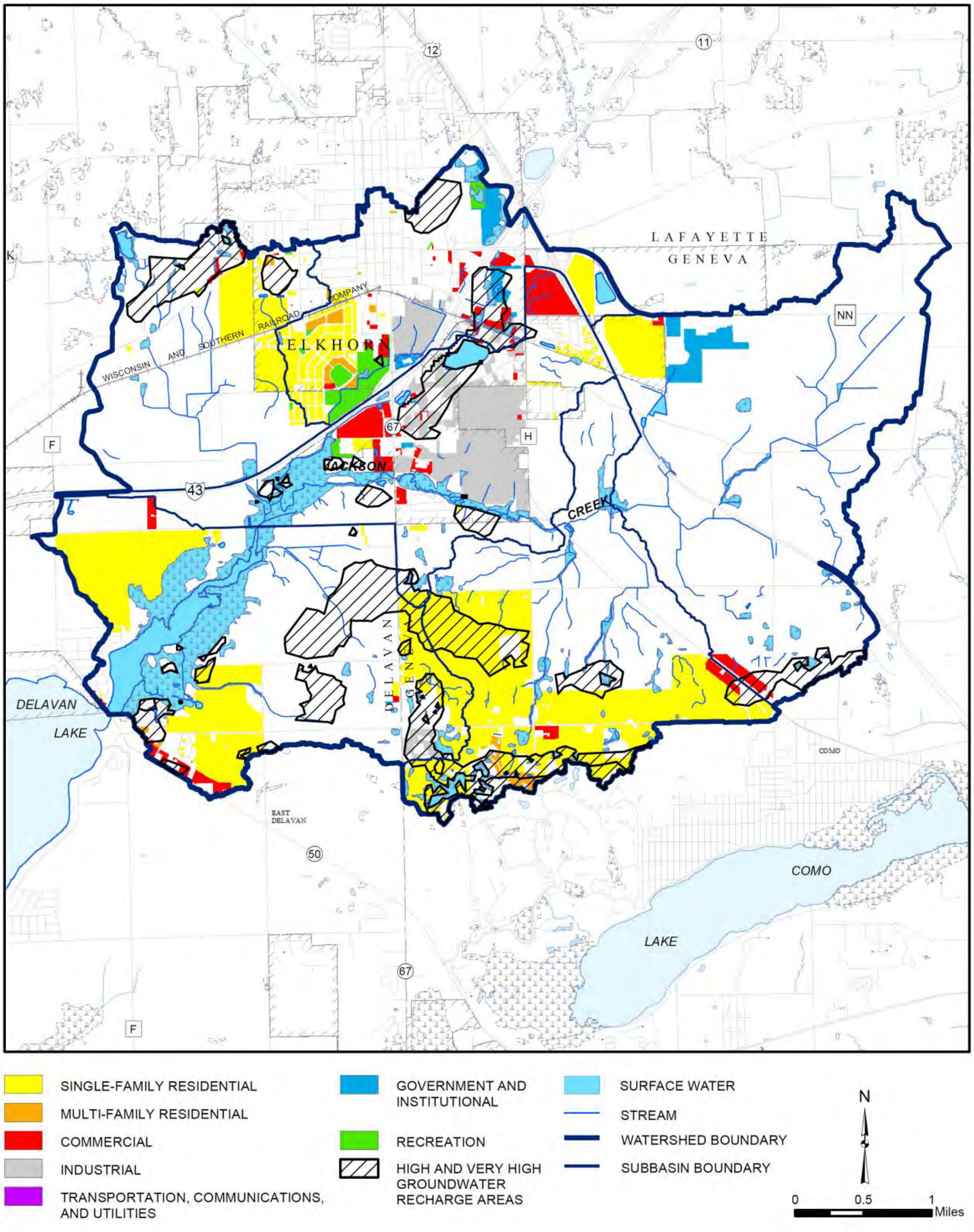
PLAN RECOMMENDATIONS

MAPS

This Page Left Blank Intentionally

Map III-1

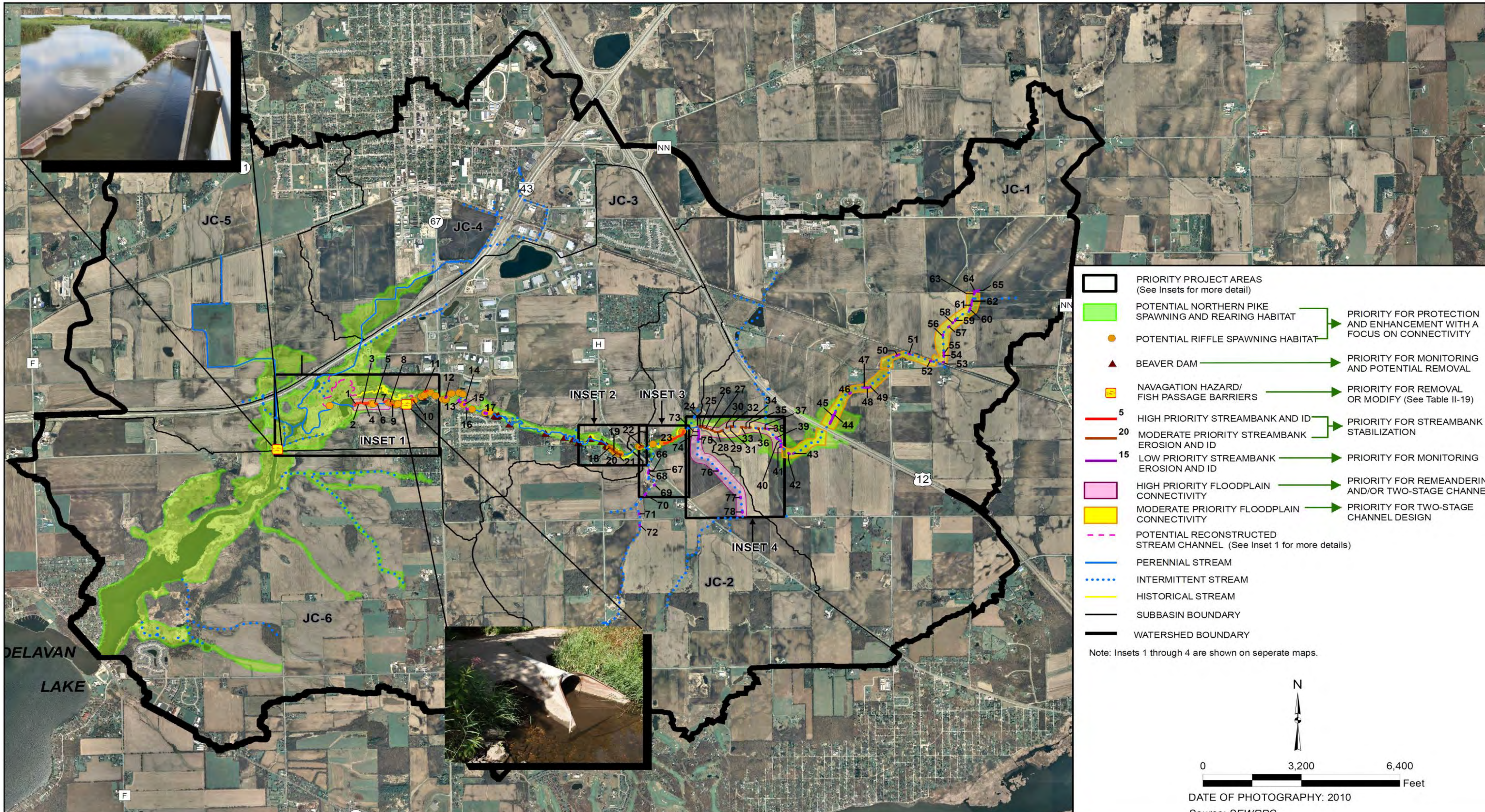
PRIORITY AREAS OF HIGH GROUNDWATER RECHARGE PROTECTION WITHIN AREAS OF PLANNED URBAN DEVELOPMENT IN THE JACKSON CREEK WATERSHED: 2010 THROUGH 2035



Source: SEWRPC.

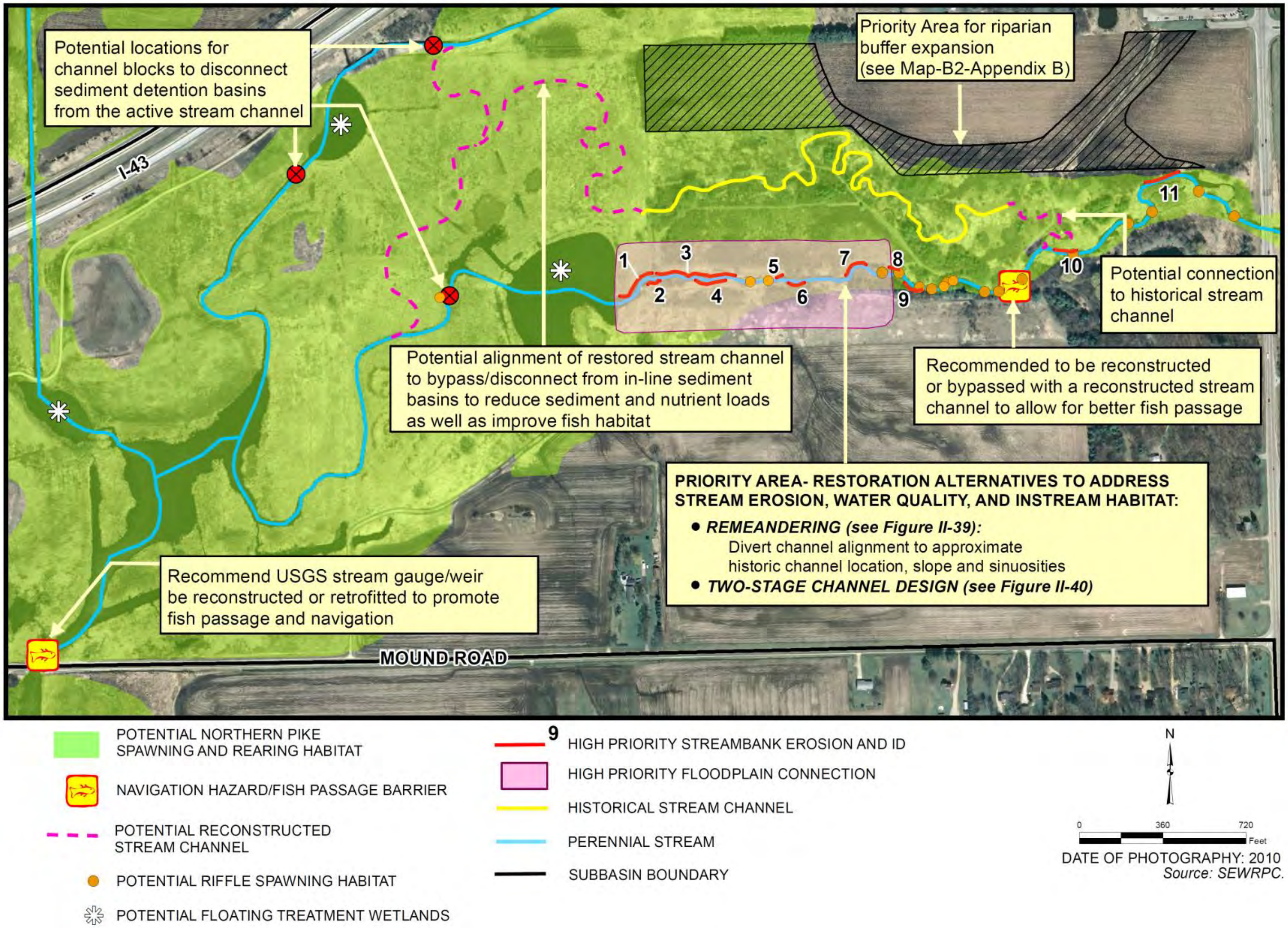
Map III-2

POTENTIAL WATER QUALITY AND AQUATIC HABITAT ENHANCEMENT RECOMMENDATIONS WITHIN THE JACKSON CREEK WATERSHED: 2015



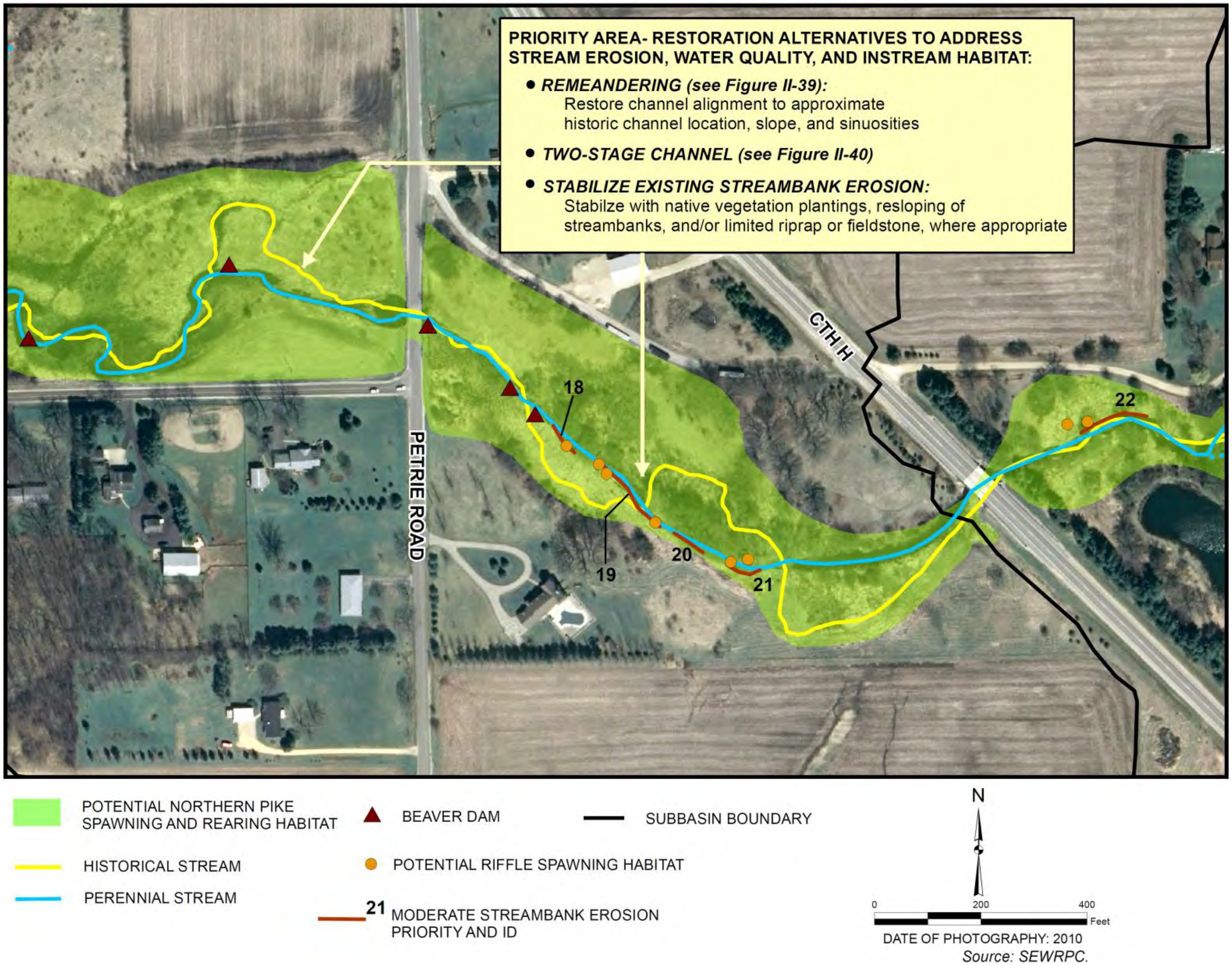
Inset 1 of Map III-2

POTENTIAL WATER QUALITY AND AQUATIC HABITAT ENHANCEMENT RECOMMENDATIONS WITHIN THE JACKSON CREEK WATERSHED: 2015



Inset 2 of Map III-2

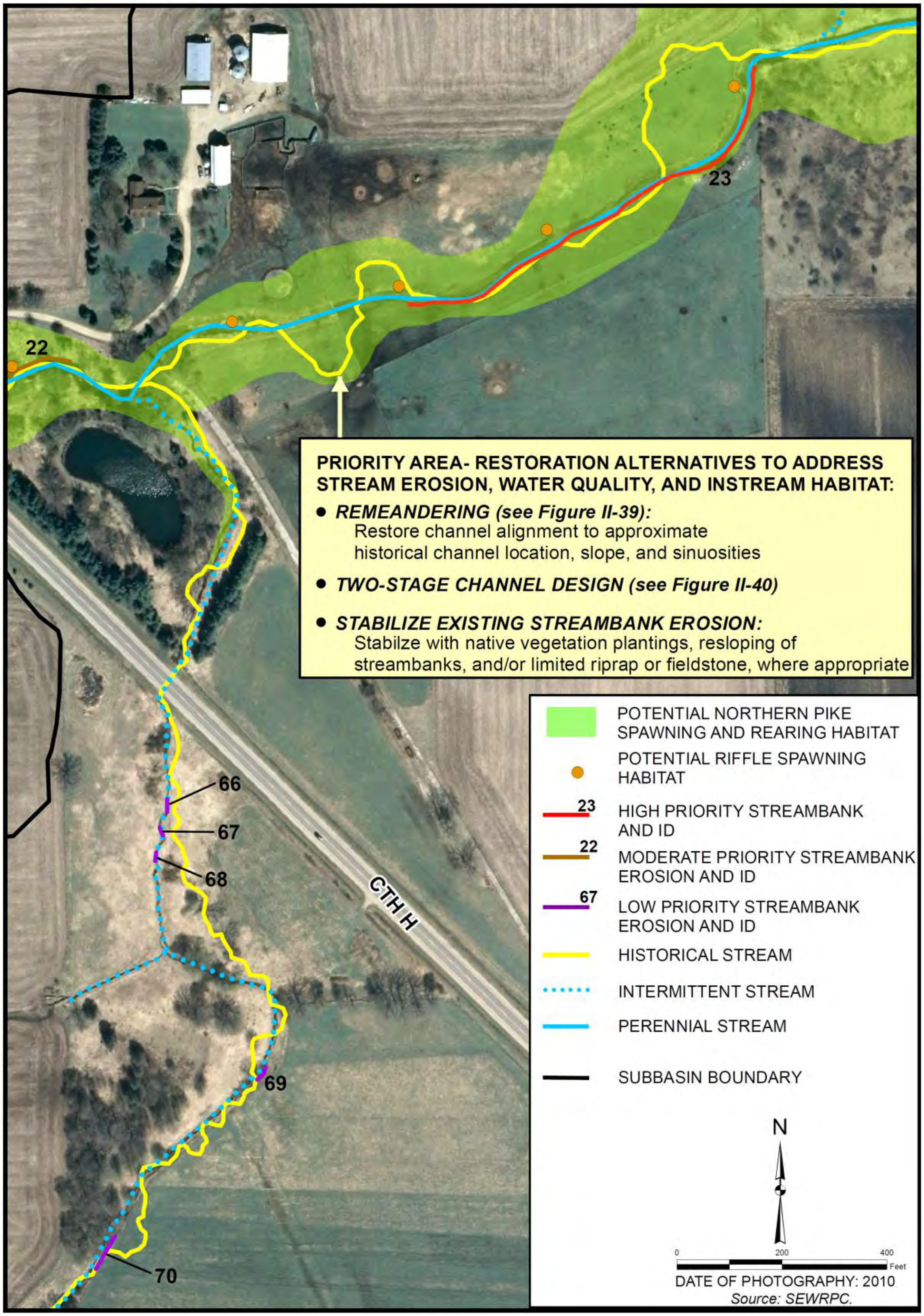
POTENTIAL WATER QUALITY AND AQUATIC HABITAT ENHANCEMENT RECOMMEDATIONS WITHIN THE JACKSON CREEK WATERSHED: 2015



PRELIMINARY DRAFT

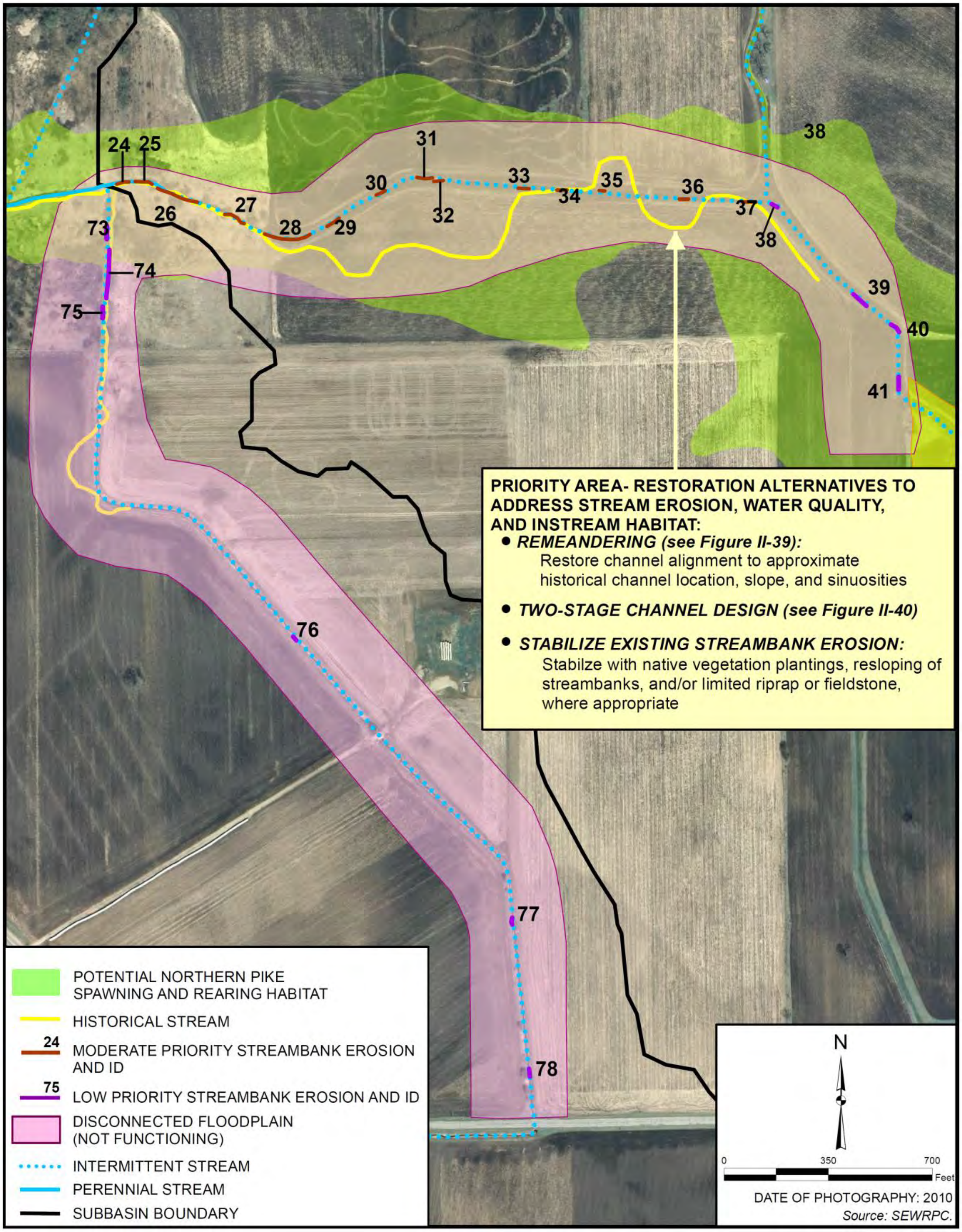
Inset 3 of Map III-2

POTENTIAL WATER QUALITY AND AQUATIC HABITAT ENHANCEMENT RECOMMENDATIONS WITHIN THE JACKSON CREEK WATERSHED: 2015



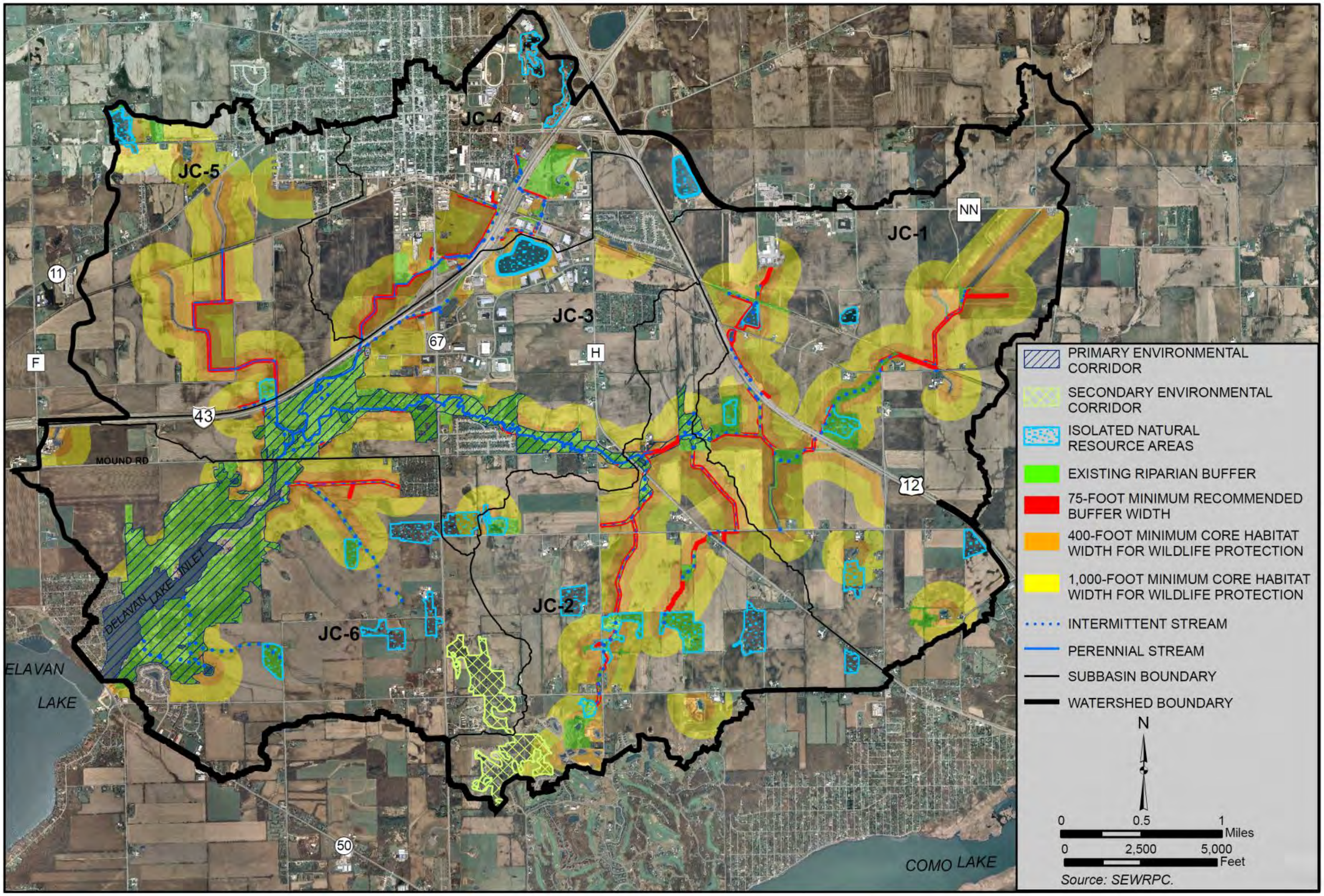
Inset 4 of Map III-2

POTENTIAL WATER QUALITY AND AQUATIC HABITAT ENHANCEMENT RECOMMENDATIONS WITHIN THE JACKSON CREEK WATERSHED: 2015



Map III-3

ENVIRONMENTAL CORRIDORS AND PROPOSED PRIORITY RIPARIAN BUFFER PROTECTION AREAS WITHIN THE JACKSON CREEK WATERSHED: 2015



APPENDIX

Appendix A

INFORMATIONAL MEETING ATTENDEES, WORK GROUP MEMBERS, TECHNICAL ASSISTANCE, AND GRANT PARTNERS CONTRIBUTING TO DEVELOPMENT OF THE JACKSON CREEK WATERSHED PROTECTION PLAN, AND THE DELAVAN LAKE WATERSHED INITIATIVE NETWORK (DL WIN) COMMITTEE

INFORMATIONAL/COMMUNITY MEETING DATES AND LOCATIONS:

February 22, 2012	**Lake Lawn Resort** 2400 E. Geneva St. Delavan, WI 53115
December 12, 2012	**Delavan Lake Sanitary District** 2990 County Road F South Delavan, WI 53115
October 30, 2014	**Lake Lawn Resort** 2400 E. Geneva St. Delavan, WI 53115
February 11, 2015	**Walworth County Metropolitan Sewerage District** 975 W. Walworth Avenue Delavan, WI 53115

INFORMATIONAL MEETING ATTENDEES

Name	Affiliation
Ken Adams	Concerned Citizen
Fay Amerson	Walworth County
Kay Beers	Town of Delavan
Richard Beers	Town of Delavan
Eugene Boeger	City of Elkhorn Landowner
Ed Brien	Delavan Lake Sanitary District Commissioner
Roy Carlson	Lake and Pond Solutions Co.
Donald Drichse	Town of Delavan
Larry Ellis	Concerned Citizen
Debra Gasser	Delavan Resident
Kate Grabow	Delavan Township Resident
Merilee Holst	Geneva Lake Conservancy
Kim Jedlicka	Delavan Township Supervisor
Marsha Lauer	Concerned Citizen
Jeehye Lee	USDA NRCS
Dan Lemanski	Town of Delavan Lake Committee
Brian Lennie	Stantec - City of Elkhorn Engineer
Patrick Maher	Concerned Citizen
Mark Mullikin	Concerned Citizen
David Patzelt	Sho-Deen Coorporation
Jerry Petersen	Kettle Moraine Land Trust
Larry Rey	Geneva Town Property Owner
Cindi Salazar	Concerned Citizen
Kurt Schulz	Delavan Township
Herb Sessner	Town of Delavan Supervisor
Vince Sipola	Inlet Shore Subdivision
John Stollenwerk	Concerned Citizen
J. Strepek	Concerned Citizen
John Surinak	Delavan Lake Sanitary District Commissioner
Shari Wisniewski	Delavan Lake Sanitary District

WORK GROUP PLAN CONTRIBUTORS

Name	**Affiliation**
Peter Berrini	Town of Delavan consultant
Andrew Craig	WDNR
Jim Deluca	Delavan Lake Sanitary District
Mike Gilbertson	WDNR
Kate and Marc Grabow	Land Owner
Charlie Handel	Delavan Lake Sanitary District
Brad Huza	Walworth County Metropolitan Sewage District
Mary Knipper	Wisconsin Lakes President
Sean Kollmer	Delavan Lake Sanitary District
Lars Olson	NRCS Walworth County
John Olson	Town of Delavan Administrator
Dave Patzelt	Sho-Deen Corporation
Jerry Petersen	Kettle Moraine Land Trust
Mark Riedel	WDNR
Rachel Sabre	WDNR
Ryan Simons	Town of Delavan Chair
Brian Smetana	Walworth County Land Use Agricultural Conservationist
Maggie Zoellner	Kettle Moraine Land Trust

TECHNICAL ASSISTANCE CONTRIBUTORS

Name	**Affiliation**
Matt Komiskey	USGS Physical Scientist
Tim Lizotte	WDNR Wildlife Biologist
Nancy Sheehan	Rock River Coalition Program Manager, Volunteer Stream Monitoring Program
Mark Steinfest	USDA NRCS
Andy Yencha	University of Wisconsin Extension Basin Educator
Maggie Zoellner	Kettle Moraine Land Trust

GRANT PARTNER/SUPPORTERS

City of Delavan
City of Elkhorn
Delavan Lake Improvement Association
Delavan Lake Sanitary District
Kettle Moraine Land Trust
Kikkomans Food Foundation, Inc.
Southeastern Wisconsin Regional Planning Commission
University of Wisconsin-Extension
Walworth County
Wisconsin Department of Natural Resources

DELAVAN LAKE WATERSHED INITIATIVE NETWORK (DL WIN) COMMITTEE MEMBERS

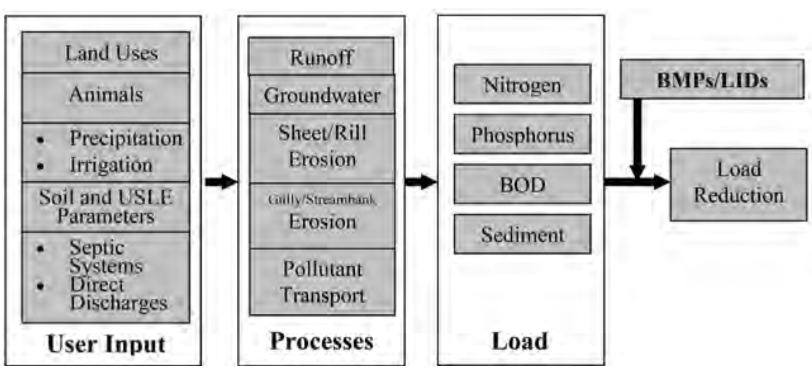
Name	Affiliation
Josh Clements	University of Wisconsin Extension Basin Educator
Jim D'Antuono	WDNR Basin Water Leader
Karla Eggink	Former Walworth County Metropolitan Sewerage District Administrator
Bruce Eshelman	UW- Whitewater Biology Professor
Gerri Green	Walworth County Lakes Association Representative
Charlie Handel	Delavan Lake Sanitary District Lake Operations Manager
Sue Heffron	Delavan Lake Improvement Association President
Greg Igl	USDA - Natural Resource Conservation Service District Conservationist
Maureen McBroom	Former WDNR Stormwater Specialist
Tom Oasen	Farm Service Agency County Executive Director
Jerry Petersen	Kettle Moraine Land Trust President
Peg Reedy	University of Wisconsin Extension Agribusiness Agent
Pam Schense	WDNR Water Management Specialist
Tom Slawski	Southeastern Wisconsin Regional Planning Commission Chief Biologist
Gail Swaine	Delavan Lake Sanitary District Administrator
Susan Tesarik	Wisconsin Lakes Education Director
Jeff Thornton	Former Southeastern Wisconsin Regional Planning Commission Principal Planner
Karen Von Huene	Wisconsin Lakes Executive Director
Mark Wendorf	City of Delavan Public Works Director
Terry Weter	City of Elkhorn Public Works Director
Shari Wisniewski	Delavan Lake Sanitary District Treasurer
Maggie Zoellner	DL WIN Project Manager, Kettle Moraine Land Trust

Appendix B

STEPL POLLUTANT LOADING RESULTS FOR THE JACKSON CREEK WATERSHED

Spreadsheet Tool for the Estimation of Pollutant Load *(excerpt from STEPL 4.1 User's Guide)*:
The Spreadsheet Tool for the Estimation of Pollutant Load (STEPL) employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various best management practices (BMPs). It computes surface runoff; nutrient loads, including nitrogen, phosphorus, and 5-day biological oxygen demand (BOD5); and sediment delivery based on various land uses and management practices. The land uses considered are urban land, cropland, pastureland, feedlot, forest, and a user-defined type. The pollutant sources include major nonpoint sources such as cropland, pastureland, farm animals, feedlots, urban runoff, and failing septic systems. The types of animals considered in the calculation are beef cattle, dairy cattle, swine, horses, sheep, chickens, turkeys, and ducks. For each watershed, the annual nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (from sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using the known BMP efficiencies.

The input data include state name, county name, weather station, land use areas, agricultural animal numbers, manure application months, population using septic tanks, septic tank failure rate, direct wastewater discharges, irrigation amount/frequency, and BMPs for simulated watersheds. When local data are available, users may choose to modify the default values for USLE parameters, soil hydrologic group, nutrient concentrations in soil and runoff, runoff curve numbers, and detailed urban land use distribution. Pollutant loads and load reductions are automatically calculated for total nitrogen, total phosphorus, BOD5, and sediment.



STEPL is designed for the Grants Reporting and tracking System of the U.S. Environmental Protection Agency.

STEPL Version 4.2 released in April 2013 was used to model the pollutant loads
(see website at http://it.tetratech-ffx.com/steplweb/)

STEPL Data Inputs:
State: Wisconsin **County:** Walworth

Weather Station: WI Milwaukee WSO Airport
Landuse Area (Acres)
Data Source: Jackson Creek watershed and six subwatershed areas (identified as W1 through W6 in the model sheets) were delineated by SEWRPC staff using 2010 data. Landuse information is based on existing year 2010 and planned year 2035 SEWRPC data. The feedlot acreages were only based on four sites that were discernable using aerial photography and ground truthing, while the remaining sites were too small to estimate acres for modelling, and these numbers were not changed when modelling for the planned 2035 land use load conditions. The wetland land use acreages were not included in this land use model to approximate pollutant loads (see ***Existing and Potentially Restorable Wetlands/Riparian Buffer*** *section below).*
Existing Conditions: Year 2010

1. Input watershed land use area (ac) and precipitation (in)

Watershed	Urban	Cropland	Pastureland	Forest	User Defined	Feedlots	Feedlot Percent Paved	Total
W1	291.2	2739.7	190.7	20.1	0	0	0-24%	3241.7
W2	191	1692.9	305.6	89.3	0	4.4	0-24%	2283.2
W3	564.8	878.3	301.8	48.2	0	0	0-24%	1793.1
W4	846.4	415	171.1	5.3	0	0	0-24%	1437.8
W5	268.2	1225.9	105	11.3	0	0	0-24%	1610.4
W6	300	1653.8	216.6	164.9	0	15.8	0-24%	2351.1

8. Input or modify urban land use distribution

Watershed	Urban Area (ac.)	Commercial %	Industrial %	Institutional %	Transportation %	Multi-Family %	Single-Family %	Urban-Cultivated	Vacant (developed)	Open Space %	Total % Area
W1	291.2	1	0	29.3	56.9	0	12.8	0	0	0	100
W2	191	0	0	16.1	47.5	9	27.4	0	0	0	100
W3	564.8	6.3	14.6	6.3	42.4	1	29.4	0	0	0	100
W4	846.4	9.8	9.5	23.7	36.2	4.7	16.1	0	0	0	100
W5	268.2	1.5	2.1	11.5	40	3.7	41.2	0	0	0	100
W6	300	4.7	3.1	2	34.6	11.2	44.4	0	0	0	100

Planned Conditions: Year 2035

1. Input watershed land use area (ac) and precipitation (in)

Watershed	Urban	Cropland	Pastureland	Forest	User Defined	Feedlots	Feedlot Percent Paved	Total
W1	498.3	2532.6	190.7	20.1	0	0	0-24%	3241.7
W2	1164.2	823.8	201.6	89.3	0	4.4	0-24%	2283.3
W3	1146.2	419.2	179.6	48.2	0	0	0-24%	1793.2
W4	1382.4	35.1	15	5.3	0	0	0-24%	1437.8
W5	478	1016.1	105	11.3	0	0	0-24%	1610.4
W6	1047.7	1024.7	98.1	164.9	0	15.8	0-24%	2351.2

8. Input or modify urban land use distribution

Watershed	Urban Area (ac.)	Commercial %	Industrial %	Institutional %	Transportation %	Multi-Family %	Single-Family %	Urban-Cultivated	Vacant (developed)	Open Space %	Total % Area
W1	498.3	5.6	0	32.4	33.3	0	28.7	0	0	0	100
W2	1164.2	1.8	0	2.6	8	3.3	84.3	0	0	0	100
W3	1146.2	15.5	40.8	3.3	21.2	0.5	18.1	0	0	0.6	100
W4	1382.4	9.6	12.1	18.9	25.9	5	22.2	0	0	6.3	100
W5	478	2.2	1.2	6.4	23.6	3	63.2	0	0	0.4	100
W6	1047.7	5	3.2	0.6	9.9	3.5	77.8	0	0	0	100

Agricultural Animals

Data Source: Agricultural animal distribution is based on USDA Census of Agriculture 2012 and consultation with local NRCS and Walworth County staff. It is important to note that these numbers were not changed when modelling for the planned 2035 land use load conditions.

2. Input agricultural animals

Watershed	Beef Cattle	Dairy Cattle	Swine (Hog)	Sheep	Horse	Chicken	Turkey	Duck	# of months manure applied
W1	0	0	0	10	6	0	2	2	8
W2	0	0	0	16	10	0	2	2	8
W3	0	0	0	15	10	0	1	2	8
W4	0	0	0	9	6	0	1	1	8
W5	0	0	0	5	3	0	1	2	8
W6	0	575	0	12	7	0	2	2	8
Total	0	575	0	67	42	0	9	11	

Septic Systems

Data Source: The total number of septic systems were provided by the model default, but were distributed amongst the subwatershed based on area of rural lands. These numbers were not changed for the planned 2035 estimated pollutant loads.

3. Input septic system and illegal direct wastewater discharge data					
Watershed	No. of Septic Systems	Population per Septic System	Septic Failure Rate, %	Wastewater Direct Discharge, # of People	Direct Discharge Reduction, %
W1	293	2	0.96	0	0
W2	201	2	0.96	0	0
W3	118	2	0.96	0	0
W4	59	2	0.96	0	0
W5	133	2	0.96	0	0
W6	189	2	0.96	0	0

Hydrologic Soil Group

Data Source: Hydrological soil group is based on STATSGO database and the most dominant soil type was chosen for each subwatershed.

5. Select average soil hydrologic group (SHG), SHG A = highest infiltration and SHG D = lowest infiltration								
Watershed	SHG A	SHG B	SHG C	SHG D	SHG Selected	Soil N conc.%	Soil P conc.%	Soil BOD conc.%
W1	○	●	○	○	B	0.080	0.031	0.160
W2	○	●	○	○	B	0.080	0.031	0.160
W3	○	●	○	○	B	0.080	0.031	0.160
W4	○	●	○	○	B	0.080	0.031	0.160
W5	○	●	○	○	B	0.080	0.031	0.160
W6	○	●	○	○	B	0.080	0.031	0.160

STEPL EXISTING 2010 VERSUS PLANNED 2035 LAND USE LOAD COMPARISONS BY SUBWATERSHED FOR NITROGEN (N), PHOSPHORUS (P), BIOLOGICAL OXYGEN DEMAND (BOD), AND SEDIMENT

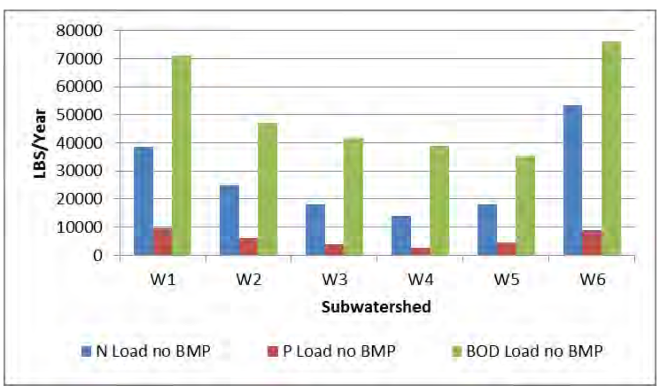
Existing Land Use: 2010

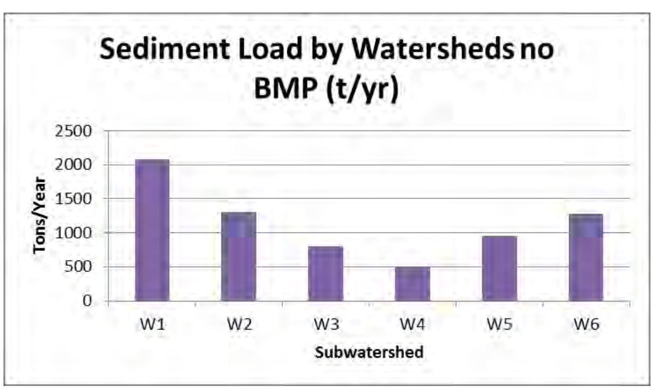
1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)
	lb/year	lb/year	lb/year	t/year
W1	38561.0	9736.6	70988.3	2074.7
W2	24968.7	6133.7	47045.8	1306.9
W3	18015.8	3976.0	41727.6	807.0
W4	13861.7	2732.6	38807.8	505.6
W5	18247.9	4519.4	35318.9	952.8
W6	53404.1	8916.7	76067.3	1280.5
Total	167059.2	36015.0	309955.8	6927.6

2. Total load by land uses (no BMP)

Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
Urban	23237.11	3835.86	79987.98	555.87
Cropland	107482.66	28450.69	178139.77	6181.15
Pastureland	6642.67	683.56	20841.26	186.85
Forest	68.54	32.91	165.45	3.68
Feedlots	29384.32	2916.41	29825.35	0.00
User Defined	0.00	0.00	0.00	0.00
Septic	243.92	95.53	995.99	0.00
Gully	0.00	0.00	0.00	0.00
Streambank	0.00	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00	0.00
Total	167059.22	36014.97	309955.80	6927.56





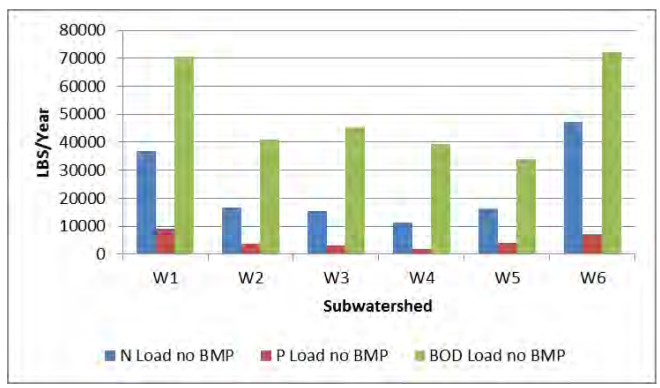
Planned Land Use: 2035

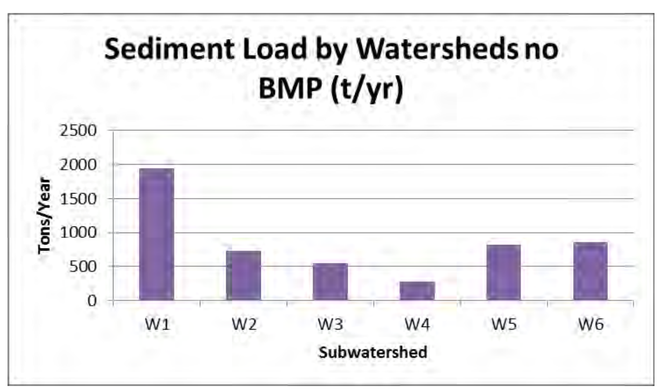
1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)
	lb/year	lb/year	lb/year	t/year
W1	36836.3	9188.5	70551.8	1943.3
W2	16563.7	3735.5	40902.8	734.9
W3	15496.5	2951.2	45212.8	546.4
W4	11210.0	1849.2	39478.0	276.1
W5	16344.8	3950.9	34102.6	818.5
W6	47362.7	7189.6	72029.6	865.7
Total	143814.0	28864.8	302277.6	5185.0

2. Total load by land uses (no BMP)

Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
Urban	36967.50	6056.21	137406.95	864.06
Cropland	73084.28	19345.42	121128.51	4202.94
Pastureland	4065.47	418.35	12755.34	114.36
Forest	68.54	32.91	165.45	3.68
Feedlots	29384.32	2916.41	29825.35	0.00
User Defined	0.00	0.00	0.00	0.00
Septic	243.92	95.53	995.99	0.00
Gully	0.00	0.00	0.00	0.00
Streambank	0.00	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00	0.00
Total	143814.02	28864.84	302277.58	5185.04

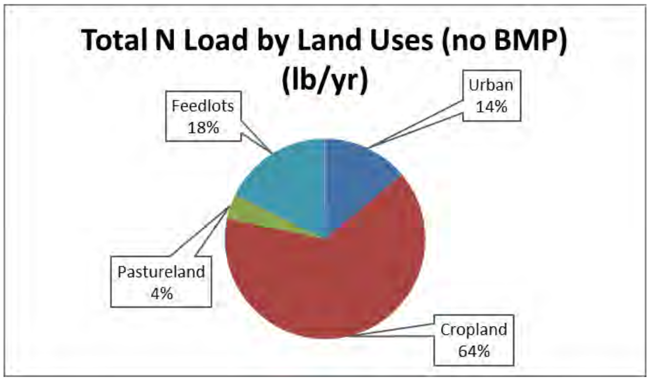


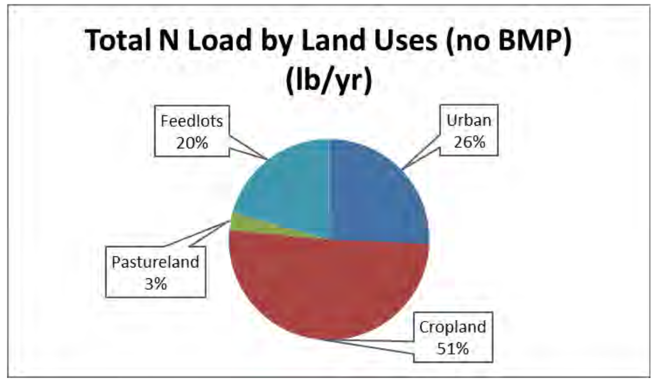


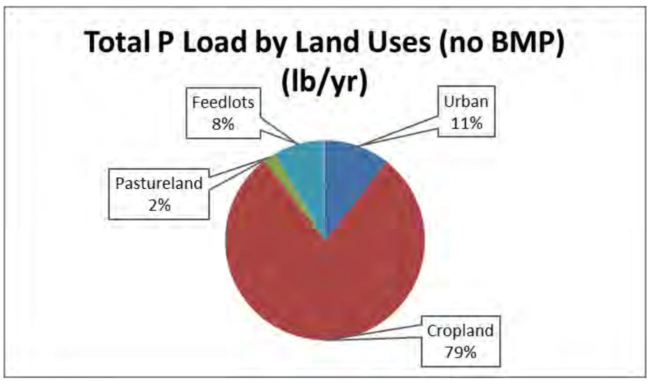
STEPL EXISTING 2010 VERSUS PLANNED 2035 LAND USE LOAD COMPARISONS BY SUBWATERSHED FOR NITROGEN (N), PHOSPHORUS (P), BIOLOGICAL OXYGEN DEMAND (BOD), AND SEDIMENT (cont.)

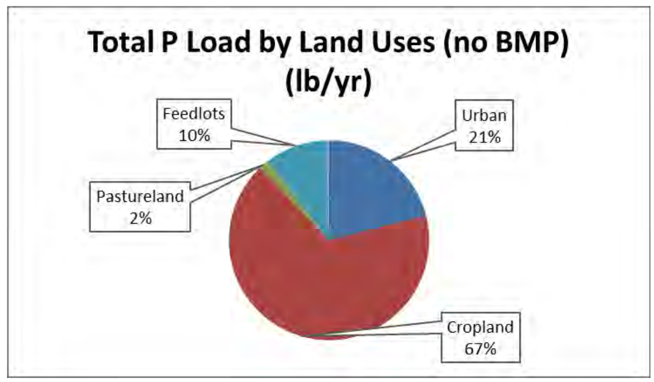
Existing Land Use: 2010

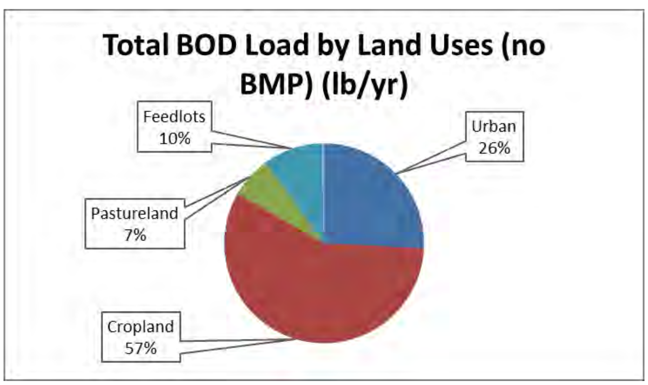
Planned Land Use: 2035

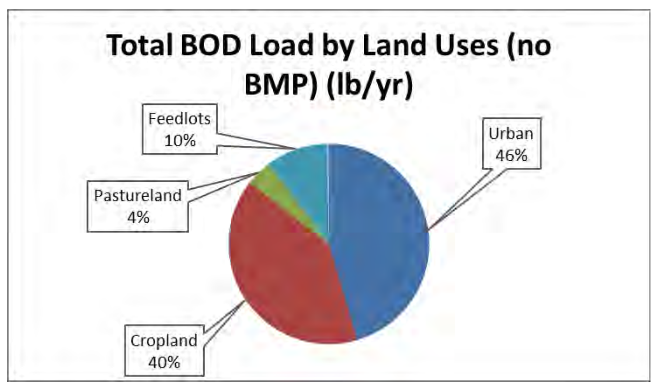


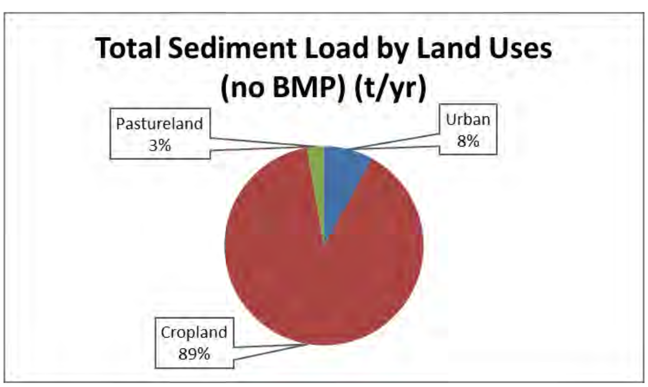


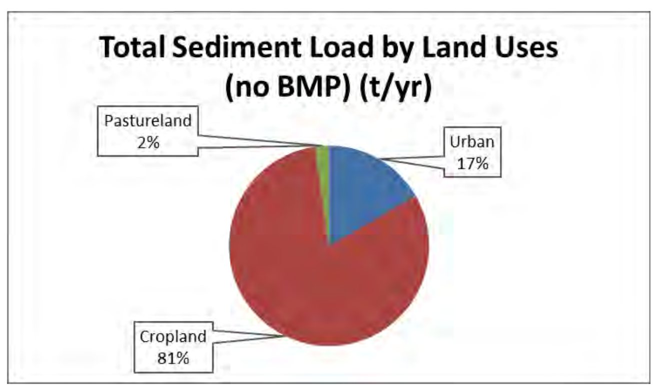












STEPL LOAD REDUCTION RESULTS FOR AGRICULTURAL BEST MANAGEMENT PRACTICES (BMPs) FOR CROPLAND

Agricultural BMP's applied to Cropland:
Individual BMP efficiency values for nitrogen, phosphorus, biological oxygen demand, and sediment were based on values used by the Chesapeake Bay Model (CBM) and data from the Minnesota Department of Agriculture as well as input from Walworth County and NRCS staff.[1]Although it is well established that combined BMP efficiencies can greatly increase the overall percent reduction for pollutants such as detailed in the Plum-Kankaput Creek Watershed Plan,[2] it was beyond the scope of this project to determine the proportions of each of these practices being applied to each field in the Jackson Creek watershed. However, the overall proportions of existing and proposed BMPs for fields throughout the Jackson Creek watershed were provided by Brian Smetana, Walworth County Land Use and Resource Management. Therefore, each practice was modelled separately to show existing load reductions and feasible planned load reductions as summarized below.

Table B-1

STEPL BMP PRACTICES AND EFFICIENCIES USED IN THE JACKSON CREEK WATERSHED MODELLING

Conservation Practice	Existing Practices Implemented (percent of agricultural lands)	Proposed Practices Implemented (percent of agricultural lands)	Efficiency				Data Source
			N	P	BOD	Sediment	
Reduced Tillage	75%	60% No-Till	0.55	0.45	ND	0.55	MDA
No-Till	10%	60%	0.59	0.69	ND	0.78	MDA
Nutrient Management	25%	100%	0.08	0.15	ND	0.25	CBM
Cover Crop	5%	50%	0.30	0.25	ND	0.35	MDA
Riparian Buffers/Potentially Restorable Wetland	Acres (percent of total land area in watershed)	Acres (percent of total land area in watershed)					
Existing Buffers	1,123 (8.3%)	1,123 (8.3%)	0.675	0.66	ND	0.625	MDA
75 foot buffers	- -	124 (0.9%)	0.675	0.66	ND	0.625	MDA
75 to 400 foot buffers	- -	463 (3.4%)	0.714	0.75	ND	0.75	MDA
400 to 1,000 buffers	- -	535 (4.0%)	0.852	0.75	ND	0.75	MDA
	Subtotal	2,245 (16.6%)					

Source: SEWRPC.

[1]*Simpson, Thomas, and Sarah Weammert, Developing Best Management Practice Definitions and Effectiveness Estimates for Nitrogen, Phosphorus and Sediment in the Chesapeake Bay Watershed. University of Maryland Mid-Atlantic Water Program, 2009; Minnesota Department of Agriculture, Miller, T. P., J. R. Peterson, C. F. Lenhart, and Y. Nomura,* The Agricultural BMP Handbook for Minnesota*, , September 2012,* http://www.leg.state.mn.us/lrl/lrl.asp

[2]*Outagamie County Land Conservation Department,* Nonpoint Source Implementation Plan for the Plum and Kankapot Creek Watersheds*, Appendix D, STEPL load reduction results for combined BMP's for cropland & pastureland practices, streambank restoration, riparian buffer, and wetland restoration, 2014.*

STEPL LOAD REDUCTION RESULTS FOR REDUCED TILLAGE PRACTICES

Existing Conditions: 75 percent Reduced Tillage

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
W1	38561.0	9736.6	70988.3	2074.7	14115.1	3238.8	5195.1	811.7	24445.9	6497.8	65793.2	1263.0
W2	24968.7	6133.7	47045.8	1306.9	8721.9	2001.3	3210.1	501.6	16246.8	4132.4	43835.7	805.3
W3	18015.8	3976.0	41727.6	807.0	4525.1	1038.3	1665.5	260.2	13490.8	2937.7	40062.1	546.8
W4	13861.7	2732.6	38807.8	505.6	2138.1	490.6	786.9	123.0	11723.6	2242.0	38020.9	382.6
W5	18247.9	4519.4	35318.9	952.8	6315.9	1449.2	2324.6	363.2	11932.0	3070.2	32994.3	589.6
W6	53404.1	8916.7	76067.3	1280.5	8520.5	1955.1	3136.0	490.0	44883.6	6961.6	72931.3	790.5
Total	167059.2	36015.0	309955.8	6927.6	44336.6	10173.2	16318.2	2549.7	122722.6	25841.7	293637.6	4377.8

Proposed Conditions: 60 Percent No-Till (see below)

STEPL LOAD REDUCTION RESULTS FOR NO-TILL PRACTICES

Existing Conditions: 10 percent No-Till

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
W1	38561.0	9736.6	70988.3	2074.7	2138.5	646.8	982.3	153.5	36422.5	9089.8	70006.0	1921.2
W2	24968.7	6133.7	47045.8	1306.9	1321.4	399.7	607.0	94.8	23647.3	5734.0	46438.8	1212.0
W3	18015.8	3976.0	41727.6	807.0	685.6	207.4	314.9	49.2	17330.2	3768.6	41412.7	757.8
W4	13861.7	2732.6	38807.8	505.6	323.9	98.0	148.8	23.3	13537.8	2634.6	38659.0	482.3
W5	18247.9	4519.4	35318.9	952.8	956.9	289.4	439.6	68.7	17291.0	4230.0	34879.4	884.2
W6	53404.1	8916.7	76067.3	1280.5	1290.9	390.4	593.0	92.7	52113.2	8526.3	75474.3	1187.8
Total	167059.2	36015.0	309955.8	6927.6	6717.3	2031.6	3085.6	482.1	160341.9	33983.3	306870.2	6445.4

Proposed Conditions: 60 Percent No-Till (see below)

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
W1	38561.0	9736.6	70988.3	2074.7	12831.2	3880.8	5894.1	921.0	25729.8	5855.8	65094.3	1153.8
W2	24968.7	6133.7	47045.8	1306.9	7928.6	2398.0	3642.0	569.1	17040.1	3735.7	43403.8	737.8
W3	18015.8	3976.0	41727.6	807.0	4113.5	1244.1	1889.5	295.2	13902.4	2731.9	39838.1	511.8
W4	13861.7	2732.6	38807.8	505.6	1943.6	587.8	892.8	139.5	11918.1	2144.8	37915.0	366.1
W5	18247.9	4519.4	35318.9	952.8	5741.4	1736.5	2637.4	412.1	12506.5	2783.0	32681.6	540.8
W6	53404.1	8916.7	76067.3	1280.5	7745.5	2342.6	3557.9	555.9	45658.6	6574.1	72509.3	724.6
Total	167059.2	36015.0	309955.8	6927.6	40303.7	12189.8	18513.8	2892.8	126755.5	23825.2	291442.0	4034.8

STEPL LOAD REDUCTION RESULTS FOR NUTRIENT MANAGEMENT PLAN PRACTICES

Existing Conditions: 25 percent Nutrient Management Plan

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
W1	38561.0	9736.6	70988.3	2074.7	952.0	400.3	787.1	123.0	37609.0	9336.3	70201.2	1951.7
W2	24968.7	6133.7	47045.8	1306.9	588.3	247.3	486.4	76.0	24380.5	5886.4	46559.4	1230.9
W3	18015.8	3976.0	41727.6	807.0	305.2	128.3	252.3	39.4	17710.6	3847.6	41475.3	767.6
W4	13861.7	2732.6	38807.8	505.6	144.2	60.6	119.2	18.6	13717.5	2672.0	38688.6	487.0
W5	18247.9	4519.4	35318.9	952.8	426.0	179.1	352.2	55.0	17821.9	4340.3	34966.7	897.8
W6	53404.1	8916.7	76067.3	1280.5	574.7	241.6	475.2	74.2	52829.4	8675.1	75592.1	1206.2
Total	167059.2	36015.0	309955.8	6927.6	2990.3	1257.3	2472.5	386.3	164068.9	34757.7	307483.3	6541.2

Proposed Conditions: 100 percent Nutrient Management Plan

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
W1	38561.0	9736.6	70988.3	2074.7	3808.0	1601.1	3148.6	492.0	34753.0	8135.5	67839.8	1582.8
W2	24968.7	6133.7	47045.8	1306.9	2353.0	989.3	1945.5	304.0	22615.7	5144.4	45100.3	1002.9
W3	18015.8	3976.0	41727.6	807.0	1220.8	513.3	1009.4	157.7	16795.0	3462.7	40718.2	649.3
W4	13861.7	2732.6	38807.8	505.6	576.8	242.5	476.9	74.5	13284.9	2490.1	38330.9	431.1
W5	18247.9	4519.4	35318.9	952.8	1703.9	716.4	1408.8	220.1	16544.0	3803.0	33910.1	732.7
W6	53404.1	8916.7	76067.3	1280.5	2298.7	966.5	1900.6	297.0	51105.4	7950.2	74166.7	983.5
Total	167059.2	36015.0	309955.8	6927.6	11961.2	5029.1	9889.8	1545.3	155098.1	30985.8	300066.0	5382.3

STEPL LOAD REDUCTION RESULTS FOR COVER CROP PRACTICES

Existing Conditions: 5 percent Cover Crop

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
W1	38561.0	9736.6	70988.3	2074.7	529.0	125.3	220.4	34.4	38032.0	9611.2	70768.0	2040.3
W2	24968.7	6133.7	47045.8	1306.9	326.9	77.5	136.2	21.3	24641.8	6056.2	46909.6	1285.6
W3	18015.8	3976.0	41727.6	807.0	169.6	40.2	70.7	11.0	17846.2	3935.8	41657.0	796.0
W4	13861.7	2732.6	38807.8	505.6	80.1	19.0	33.4	5.2	13781.6	2713.6	38774.4	500.4
W5	18247.9	4519.4	35318.9	952.8	236.7	56.1	98.6	15.4	18011.2	4463.4	35220.3	937.4
W6	53404.1	8916.7	76067.3	1280.5	319.3	75.7	133.0	20.8	53084.8	8841.0	75934.2	1259.7
Total	167059.2	36015.0	309955.8	6927.6	1661.7	393.7	692.3	108.2	165397.5	35621.3	309263.5	6819.4

Proposed Conditions: 50 percent Cover Crop

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
W1	38561.0	9736.6	70988.3	2074.7	5290.2	1253.4	2204.0	344.4	33270.8	8483.1	68784.4	1730.4
W2	24968.7	6133.7	47045.8	1306.9	3268.9	774.5	1361.9	212.8	21699.8	5359.2	45684.0	1094.1
W3	18015.8	3976.0	41727.6	807.0	1695.9	401.8	706.6	110.4	16319.9	3574.1	41021.1	696.6
W4	13861.7	2732.6	38807.8	505.6	801.3	189.9	333.9	52.2	13060.4	2542.8	38474.0	453.4
W5	18247.9	4519.4	35318.9	952.8	2367.1	560.9	986.2	154.1	15880.8	3958.6	34332.7	798.8
W6	53404.1	8916.7	76067.3	1280.5	3193.4	756.6	1330.4	207.9	50210.7	8160.1	74736.8	1072.6
Total	167059.2	36015.0	309955.8	6927.6	16616.9	3937.1	6922.9	1081.7	150442.3	32077.9	303032.9	5845.9

STEPL LOAD REDUCTION RESULTS FOR GULLY/GRASSED WATERWAY PRACTICES

Load Reductions from concentrated flow gullies/grassed waterways were calculated with the STEPL Model Spreadsheet, which is the same as the Region 5 Model Spreadsheet. A BMP efficiency of 70 percent was used for the 25 installed and 45 proposed grassed waterways in this watershed as summarized below. Both of these models estimate the annual tons of gross erosion as sediment delivered at the edge of field. Since the plan is looking at load reductions to the stream system a delivery ratio needs to be applied.[3] Ephemeral gully delivery rates for an integrated (connected) system are typically 50 to 90 percent.[4] A delivery ratio of 70 percent was assumed for gully erosion to calculate actual loads to Jackson Creek, which was the same used for the Plum-Kankaput Plan.[5] An average gully size of 4.0 foot top width, 3.0 foot bottom width, and 1.0 foot of depth was used to model load estimates for the total lineal feet of drainages determined by GIS methods and each of the flow path lengths for installed and proposed waterways provided by Walworth County as listed below and shown in Map B-1.

Total Load of all mapped concentrated flow drainages/gullies for the Jackson Creek watershed (see Map B-1)

1. Total load by subwatershed(s)					Actual Load with a 70% sediment delivery ratio			
Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
W1	16085.0	6192.7	32170.0	10053.1	11259.5	4334.9	22519.0	7037.2
W2	13823.0	5321.9	27646.1	8639.4	9676.1	3725.3	19352.3	6047.6
W3	6031.9	2322.3	12063.7	3769.9	4222.3	1625.6	8444.6	2638.9
W4	5780.5	2225.5	11561.1	3612.8	4046.4	1557.9	8092.8	2529.0
W5	11309.8	4354.3	22619.5	7068.6	7916.8	3048.0	15833.7	4948.0
W6	11561.1	4451.0	23122.2	7225.7	8092.8	3115.7	16185.5	5058.0
Total	64591.3	24867.6	129182.6	40369.6	45213.9	17407.4	90427.8	28258.7

Gully	Top Width (ft)	Bottom Width (ft)	Depth (ft)	Length (ft)	Years to Form	BMP Efficiency (0-1)	Soil Textural Class	Soil Dry Weight (ton/ft3)	Nutrient Correction Factor	Annual Load (ton)	Load Reduction (ton)
Gully1	4	3	1	67584	1	0.7	Silt Loam	0.0425	1	10053.1200	7037.1840
Gully2	4	3	1	58080	1	0.7	Silt Loam	0.0425	1	8639.4000	6047.5800
Gully3	4	3	1	25344	1	0.7	Silt Loam	0.0425	1	3769.9200	2638.9440
Gully4	4	3	1	24288	1	0.7	Silt Loam	0.0425	1	3612.8400	2528.9880
Gully5	4	3	1	47520	1	0.7	Silt Loam	0.0425	1	7068.6000	4948.0200
Gully6	4	3	1	48576	1	0.7	Silt Loam	0.0425	1	7225.6800	5057.9760

[3] *Outagamie County Land Conservation Department,* Nonpoint Source Implementation Plan for the Plum and Kankapot Creek Watersheds*, Appendix D. Region 5 Model Inputs for gully stabilization, 2014.*

[4] *Natural Resources Conservation Services (NRCS),* Erosion and Sediment Delivery. Field Office Technical Guide*, March 1998, http://efotg.sc.egov.usda.gov/references/public/IA/Erosion_and_sediment_delivery.pdf*

[5] *Outagamie County Land Conservation Department, 2014, Op. cit.*

Existing Conditions: Total load reductions for installed grassed waterways (see Map B-1)

	1. Total load by subwatershed(s)					Annual Load with 70% Sediment Delivery Ratio							
Length (ft)	**Gully No. (see Map _)**	**N Load (no BMP)**	**P Load (no BMP)**	**BOD Load (no BMP)**	**Sediment Load (no BMP)**	**N Reduction**	**P Reduction**	**BOD Reduction**	**Sediment Reduction**	**N Load (with BMP)**	**P Load (with BMP)**	**BOD (with BMP)**	**Sediment Load (with BMP)**
		lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
1326.4	1	315.7	121.5	631.4	197.3	221.0	85.1	442.0	138.1	66.3	25.5	132.6	41.4
2544.8	2	605.7	233.2	1211.3	378.5	424.0	163.2	847.9	265.0	127.2	49.0	254.4	79.5
1644	3	391.3	150.6	782.5	244.5	273.9	105.4	547.8	171.2	82.2	31.6	164.3	51.4
2414.1	4	574.6	221.2	1149.1	359.1	402.2	154.8	804.4	251.4	120.7	46.5	241.3	75.4
1156	5	275.1	105.9	550.3	172.0	192.6	74.1	385.2	120.4	57.8	22.2	115.6	36.1
2784.8	6	662.8	255.2	1325.6	414.2	463.9	178.6	927.9	290.0	139.2	53.6	278.4	87.0
2280.1	7	542.7	208.9	1085.3	339.2	379.9	146.2	759.7	237.4	114.0	43.9	227.9	71.2
3194.6	8	760.3	292.7	1520.6	475.2	532.2	204.9	1064.4	332.6	159.7	61.5	319.3	99.8
659.7	9	157.0	60.4	314.0	98.1	109.9	42.3	219.8	68.7	33.0	12.7	65.9	20.6
1664.8	10	396.2	152.5	792.4	247.6	277.4	106.8	554.7	173.3	83.2	32.0	166.4	52.0
1393.6	11	331.7	127.7	663.4	207.3	232.2	89.4	464.3	145.1	69.7	26.8	139.3	43.5
1941.7	12	462.1	177.9	924.2	288.8	323.5	124.5	647.0	202.2	97.0	37.4	194.1	60.7
602.9	13	143.5	55.2	287.0	89.7	100.4	38.7	200.9	62.8	30.1	11.6	60.3	18.8
1676.5	14	399.0	153.6	798.0	249.4	279.3	107.5	558.6	174.6	83.8	32.3	167.6	52.4
732.5	15	174.3	67.1	348.7	109.0	122.0	47.0	244.1	76.3	36.6	14.1	73.2	22.9
1526.7	16	363.4	139.9	726.7	227.1	254.3	97.9	508.7	159.0	76.3	29.4	152.6	47.7
1286.4	17	306.2	117.9	612.3	191.4	214.3	82.5	428.6	133.9	64.3	24.8	128.6	40.2
2808	18	668.3	257.3	1336.6	417.7	467.8	180.1	935.6	292.4	140.3	54.0	280.7	87.7
1456.9	19	346.7	133.5	693.5	216.7	242.7	93.4	485.4	151.7	72.8	28.0	145.6	45.5
2865	20	681.9	262.5	1363.7	426.2	477.3	183.8	954.6	298.3	143.2	55.1	286.4	89.5
1155	21	274.9	105.8	549.8	171.8	192.4	74.1	384.8	120.3	57.7	22.2	115.5	36.1
3026.6	22	720.3	277.3	1440.7	450.2	504.2	194.1	1008.5	315.1	151.3	58.2	302.5	94.5
2349	23	559.1	215.2	1118.1	349.4	391.3	150.7	782.7	244.6	117.4	45.2	234.8	73.4
253.9	24	60.4	23.3	120.9	37.8	42.3	16.3	84.6	26.4	12.7	4.9	25.4	7.9
253.6	25	60.4	23.2	120.7	37.7	42.2	16.3	84.5	26.4	12.7	4.9	25.3	7.9
	Total	10233.4	3939.9	20466.9	6395.9	7163.4	2757.9	14326.8	4477.1	2149.0	827.4	4298.0	1343.1

Proposed Conditions: Total load reductions for proposed priority grassed waterways (see Map B-1)

	1. Total load by subwatershed(s)					Actual Load with 70% Sediment Delivery Ratio							
Length (ft)	Gully No. (see Map _)	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
		lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
776.9	1	184.9	71.2	369.8	115.6	129.4	49.8	258.9	80.9	38.8	14.9	77.7	24.3
2300.9	2	547.6	210.8	1095.2	342.3	383.3	147.6	766.7	239.6	115.0	44.3	230.0	71.9
260.7	3	62.1	23.9	124.1	38.8	43.4	16.7	86.9	27.1	13.0	5.0	26.1	8.1
1360.6	4	323.8	124.7	647.6	202.4	226.7	87.3	453.3	141.7	68.0	26.2	136.0	42.5
1911.9	5	455.0	175.2	910.1	284.4	318.5	122.6	637.0	199.1	95.6	36.8	191.1	59.7
1623.4	6	386.4	148.7	772.7	241.5	270.5	104.1	540.9	169.0	81.1	31.2	162.3	50.7
520.9	7	124.0	47.7	248.0	77.5	86.8	33.4	173.6	54.2	26.0	10.0	52.1	16.3
1548.3	8	368.5	141.9	737.0	230.3	257.9	99.3	515.9	161.2	77.4	29.8	154.8	48.4
490.2	9	116.7	44.9	233.3	72.9	81.7	31.4	163.3	51.0	24.5	9.4	49.0	15.3
838.2	10	199.5	76.8	399.0	124.7	139.6	53.8	279.3	87.3	41.9	16.1	83.8	26.2
577.4	11	137.4	52.9	274.8	85.9	96.2	37.0	192.4	60.1	28.9	11.1	57.7	18.0
1265.3	12	301.1	115.9	602.3	188.2	210.8	81.2	421.6	131.8	63.2	24.3	126.5	39.5
453.0	13	107.8	41.5	215.6	67.4	75.5	29.1	151.0	47.2	22.6	8.7	45.3	14.2
703.2	14	167.4	64.4	334.7	104.6	117.2	45.1	234.3	73.2	35.1	13.5	70.3	22.0
1119.8	15	266.5	102.6	533.0	166.6	186.6	71.8	373.1	116.6	56.0	21.5	111.9	35.0
1293.9	16	307.9	118.6	615.9	192.5	215.6	83.0	431.1	134.7	64.7	24.9	129.3	40.4
1430.6	17	340.5	131.1	681.0	212.8	238.3	91.8	476.7	149.0	71.5	27.5	143.0	44.7
796.6	18	189.6	73.0	379.2	118.5	132.7	51.1	265.4	82.9	39.8	15.3	79.6	24.9
617.8	19	147.0	56.6	294.1	91.9	102.9	39.6	205.8	64.3	30.9	11.9	61.8	19.3
611.8	20	145.6	56.1	291.2	91.0	101.9	39.2	203.8	63.7	30.6	11.8	61.2	19.1
770.0	21	183.3	70.6	366.5	114.5	128.3	49.4	256.6	80.2	38.5	14.8	77.0	24.1
2135.3	22	508.2	195.7	1016.4	317.6	355.7	137.0	711.5	222.3	106.7	41.1	213.4	66.7
613.8	23	146.1	56.2	292.2	91.3	102.3	39.4	204.5	63.9	30.7	11.8	61.4	19.2
208.1	24	49.5	19.1	99.1	31.0	34.7	13.3	69.3	21.7	10.4	4.0	20.8	6.5
924.4	25	220.0	84.7	440.0	137.5	154.0	59.3	308.0	96.3	46.2	17.8	92.4	28.9
283.3	26	67.4	26.0	134.8	42.1	47.2	18.2	94.4	29.5	14.2	5.5	28.3	8.8
2191.7	27	521.6	200.8	1043.3	326.0	365.1	140.6	730.3	228.2	109.5	42.2	219.1	68.5
1137.7	28	270.8	104.3	541.6	169.2	189.5	73.0	379.1	118.5	56.9	21.9	113.7	35.5
272.3	29	64.8	24.9	129.6	40.5	45.4	17.5	90.7	28.3	13.6	5.2	27.2	8.5
553.0	30	131.6	50.7	263.2	82.3	92.1	35.5	184.3	57.6	27.6	10.6	55.3	17.3
276.6	31	65.8	25.3	131.6	41.1	46.1	17.7	92.1	28.8	13.8	5.3	27.6	8.6
1082.8	32	257.7	99.2	515.4	161.1	180.4	69.5	360.8	112.8	54.1	20.8	108.2	33.8
513.0	33	122.1	47.0	244.2	76.3	85.5	32.9	170.9	53.4	25.6	9.9	51.3	16.0
505.0	34	120.2	46.3	240.4	75.1	84.1	32.4	168.3	52.6	25.2	9.7	50.5	15.8
2399.9	35	571.2	219.9	1142.4	357.0	399.8	153.9	799.7	249.9	119.9	46.2	239.9	75.0
2512.6	36	598.0	230.2	1196.0	373.7	418.6	161.2	837.2	261.6	125.6	48.3	251.2	78.5
723.1	37	172.1	66.3	344.2	107.6	120.5	46.4	240.9	75.3	36.1	13.9	72.3	22.6
2456.2	38	584.6	225.1	1169.2	365.4	409.2	157.5	818.4	255.8	122.8	47.3	245.5	76.7
2159.3	39	513.9	197.9	1027.8	321.2	359.7	138.5	719.5	224.8	107.9	41.5	215.8	67.5
3547.8	40	844.4	325.1	1688.8	527.7	591.1	227.6	1182.1	369.4	177.3	68.3	354.6	110.8
249.5	41	59.4	22.9	118.8	37.1	41.6	16.0	83.1	26.0	12.5	4.8	24.9	7.8
441.4	42	105.0	40.4	210.1	65.7	73.5	28.3	147.1	46.0	22.1	8.5	44.1	13.8
1400.0	43	333.2	128.3	666.4	208.3	233.2	89.8	466.5	145.8	70.0	26.9	139.9	43.7
823.8	44	196.1	75.5	392.1	122.5	137.2	52.8	274.5	85.8	41.2	15.9	82.3	25.7
795.7	45	189.4	72.9	378.8	118.4	132.6	51.0	265.1	82.9	39.8	15.3	79.5	24.9
	Total	11775.7	4533.6	23551.3	7359.8	8243.0	3173.5	16485.9	5151.8	2472.9	952.1	4945.8	1545.6

STEPL LOAD REDUCTION RESULTS FOR EXISTING AND POTENTIAL RESTORABLE WETLANDS/RIPARIAN BUFFER PRACTICES

Based upon discussions with Santina Wortman, U.S. Ecological Protection Agency (EPA), Tetra Tech staff, and, Peter Vincent and Ralph Reznick from the Michigan Department of Environmental Quality (DEQ), it was determined that the wetland BMP efficiency applied only to the converted cropland area approach was the most appropriate method to determine pollutant load reductions. This approach uses the acres of cropland to be converted to wetland and applies a wetland detention BMP efficiency to calculate reductions. Given that there were distinct riparian buffer areas identified throughout the Jackson Creek watershed with consistent topography and soils, this allowed us to vary the BMP efficiencies by distances as summarized in Table B-1 above.

Existing Conditions: Load Reductions from Existing Riparian Buffers (see Map B-2)

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
W1	1295.0	413.3	2629.4	287.3	828.1	260.4	1149.3	179.6	466.8	152.9	1480.1	107.7
W2	1465.4	466.5	2976.1	323.5	937.4	293.9	1294.2	202.2	528.0	172.6	1681.9	121.3
W3	2537.2	753.0	5178.0	485.0	1635.0	476.1	1939.8	303.1	902.2	276.9	3238.2	181.9
W4	874.3	281.2	1774.2	197.0	558.6	177.1	787.9	123.1	315.7	104.1	986.3	73.9
W5	375.8	122.8	761.7	87.3	239.7	77.3	349.3	54.6	136.1	45.5	412.3	32.8
W6	3624.1	1060.7	7403.3	672.2	2338.7	671.1	2688.7	420.1	1285.4	389.6	4714.6	252.1
Total	10171.6	3097.5	20722.7	2052.3	6537.5	1955.9	8209.3	1282.7	3634.2	1141.7	12513.4	769.6

Proposed Conditions: Load Reductions for installation of 75 Foot Width Riparian Buffers/Potentially Restorable Wetland (see Map B-2)

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
W1	463.4	150.9	939.6	106.9	295.7	95.0	427.6	66.8	167.7	55.9	512.0	40.1
W2	452.3	147.3	917.0	104.4	288.6	92.7	417.7	65.3	163.7	54.6	499.3	39.2
W3	41.2	14.0	83.3	10.3	26.2	8.8	41.1	6.4	15.0	5.2	42.2	3.9
W4	232.9	76.8	471.9	55.0	148.4	48.3	220.2	34.4	84.5	28.5	251.7	20.6
W5	250.7	82.5	508.0	59.1	159.8	51.9	236.4	36.9	90.9	30.6	271.6	22.2
W6	133.9	44.6	271.1	32.2	85.2	28.0	128.9	20.1	48.7	16.5	142.2	12.1
Total	1574.6	516.0	3190.9	368.0	1004.0	324.7	1471.9	230.0	570.6	191.3	1719.0	138.0

Proposed Conditions: Load Reductions for installation of 75 to 400 Foot Width Riparian Buffers/Potentially Restorable Wetland (see Map B-2)

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
W1	2085.7	659.2	4238.0	453.9	1541.5	494.4	2178.7	340.4	544.2	164.8	2059.3	113.5
W2	844.9	271.9	1714.5	190.6	625.2	204.0	915.0	143.0	219.7	68.0	799.6	47.7
W3	136.5	45.4	276.2	32.8	101.2	34.0	157.5	24.6	35.2	11.3	118.7	8.2
W4	761.5	245.6	1545.1	172.5	563.6	184.2	828.0	129.4	197.9	61.4	717.2	43.1
W5	955.5	306.8	1939.4	214.6	707.0	230.1	1029.9	160.9	248.6	76.7	909.5	53.6
W6	417.6	136.2	846.5	96.7	309.3	102.2	464.1	72.5	108.3	34.1	382.4	24.2
Total	5201.7	1665.1	10559.8	1161.1	3847.8	1248.8	5573.1	870.8	1353.9	416.3	4986.7	290.3

Proposed Conditions: Load Reductions for installation of 400 to 1,000 Foot Width Riparian Buffers/Potentially Restorable Wetland (see Map B-2)

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
W1	2180.9	651.0	4449.3	422.0	1720.4	488.3	2025.5	316.5	460.5	162.8	2423.8	105.5
W2	696.6	225.0	1413.2	158.3	541.8	168.8	759.9	118.7	154.8	56.3	653.3	39.6
W3	518.8	168.5	1052.0	119.2	403.1	126.4	572.1	89.4	115.7	42.1	479.9	29.8
W4	738.2	238.2	1497.7	167.4	574.3	178.7	803.5	125.5	163.9	59.6	694.2	41.8
W5	1067.0	341.9	2166.0	238.6	831.3	256.4	1145.1	178.9	235.8	85.5	1020.9	59.6
W6	223.4	73.7	452.5	52.9	173.1	55.3	253.7	39.6	50.3	18.4	198.8	13.2
Total	5424.9	1698.3	11030.6	1158.3	4243.9	1273.7	5559.8	868.7	1180.9	424.6	5470.8	289.6

STEPL LOAD REDUCTION RESULTS FOR STREAMBANK RESTORATION PRACTICES

Total length, height, and severity of each eroding streambank sites within Jackson Creek were determined from direct assessment by SEWRPC staff in year 2013 and were used for inputs into the STEPL model. The tables below indicate impaired streambank inputs as well as pollutant loads and load reductions. All of the streambank erosion sites are located on Map B-3. The amount of sediment loss and pollutant loads due to stream bank erosion actually delivered to Jackson Creek depends on factors such as channelization, straightening, modification, and amount of disturbed channels. By using the NRCS Field Office Technical Guide for Erosion and Sediment Delivery, a sediment delivery ratio of 75 percent was used. A BMP efficiency of 75 percent was used to calculate load reductions for these eroding sites. W1 through W6 indicates the subwatersheds within the Jackson Creek watershed.

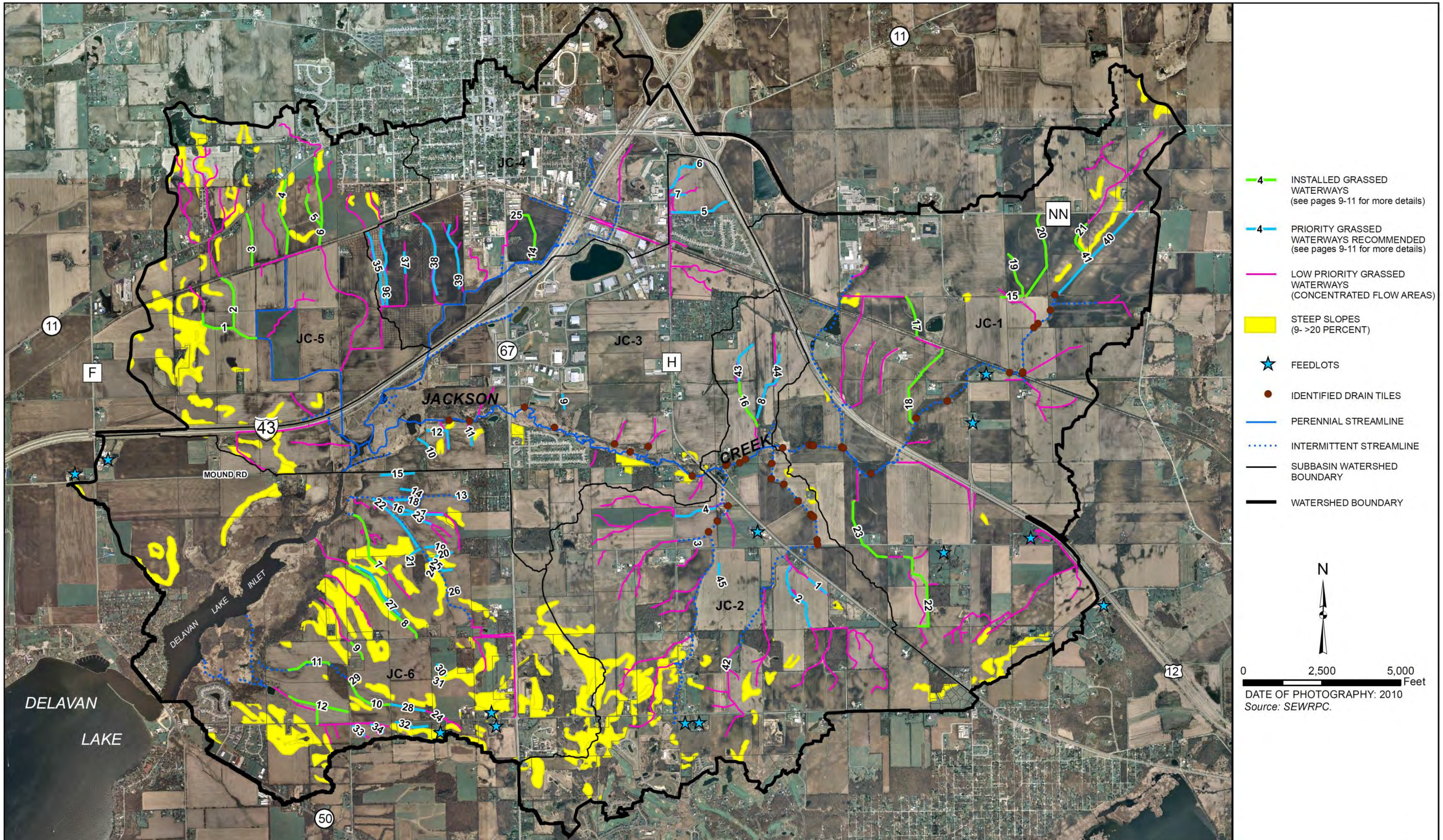
2. Impaired streambank dimensions in the different watersheds

Strm Bank	Length (ft)	Height (ft)	Lateral Recession	Rate Range (ft/yr)	Rate (ft/yr)	BMP Efficiency (0-1)	Soil Textural Class	Soil Dry Weight (ton/ft3)	Nutrient Correction Factor	Annual Load (ton)	Load Reduction (ton)
Bank1	190	5	3. Severe	0.3 - 0.5	0.4	0.75	Silt Loam	0.0425	1	16.1500	12.1125
Bank2	60	5	3. Severe	0.3 - 0.5	0.4	0.75	Silt Loam	0.0425	1	5.1000	3.8250
Bank3	350	5	3. Severe	0.3 - 0.5	0.4	0.75	Silt Loam	0.0425	1	29.7500	22.3125
Bank4	130	5	3. Severe	0.3 - 0.5	0.4	0.75	Silt Loam	0.0425	1	11.0500	8.2875
Bank5	35	5	3. Severe	0.3 - 0.5	0.4	0.75	Silt Loam	0.0425	1	2.9750	2.2313
Bank6	80	5	3. Severe	0.3 - 0.5	0.4	0.75	Silt Loam	0.0425	1	6.8000	5.1000
Bank7	120	5	3. Severe	0.3 - 0.5	0.4	0.75	Silt Loam	0.0425	1	10.2000	7.6500
Bank8	50	5	3. Severe	0.3 - 0.5	0.4	0.75	Silt Loam	0.0425	1	4.2500	3.1875
Bank9	100	5	3. Severe	0.3 - 0.5	0.4	0.75	Silt Loam	0.0425	1	8.5000	6.3750
Bank10	100	3	3. Severe	0.3 - 0.5	0.4	0.75	Silt Loam	0.0425	1	5.1000	3.8250
Bank11	150	3	3. Severe	0.3 - 0.5	0.4	0.75	Silt Loam	0.0425	1	7.6500	5.7375
Bank12	50	2.6	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.7183	0.5387
Bank13	100	2.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	1.3813	1.0359
Bank14	40	2.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.5525	0.4144
Bank15	40	2.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.5525	0.4144
Bank16	40	2.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.5525	0.4144
Bank17	80	2.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	1.1050	0.8288
Bank18	72	2.7	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	1.0741	0.8055
Bank19	150	2.7	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	2.2376	1.6782
Bank20	80	2.7	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	1.1934	0.8951
Bank21	80	2.7	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	1.1934	0.8951
Bank22	120	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	1.9890	1.4918
Bank23	900	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	14.9175	11.1881
Bank24	50	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.8288	0.6216
Bank25	70	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	1.1603	0.8702
Bank26	150	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	2.4863	1.8647
Bank27	70	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	1.1603	0.8702
Bank28	160	3.3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	2.9172	2.1879
Bank29	30	3.4	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.5636	0.4227
Bank30	30	3.4	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.5636	0.4227
Bank31	50	3.3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.9116	0.6837
Bank32	15	3.1	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.2569	0.1927
Bank33	30	2.8	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.4641	0.3481
Bank34	25	2.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.3453	0.2590
Bank35	10	2.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.1381	0.1036
Bank36	20	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.3315	0.2486
Bank37	30	3.3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.5470	0.4102
Bank38	15	2.6	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.2155	0.1616
Bank39	45	3.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.8702	0.6526
Bank40	30	3.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.5801	0.4351
Bank41	40	3.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.7735	0.5801
Bank42	50	4.1	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	1.1326	0.8495
Bank43	10	3.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.1934	0.1450
Bank44	450	2.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	6.2156	4.6617
Bank45	30	2.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.4144	0.3108
Bank46	35	2.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.4834	0.3626
Bank47	50	2.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.6906	0.5180
Bank48	30	2.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.4144	0.3108
Bank49	20	2.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.2763	0.2072
Bank50	100	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	1.6575	1.2431
Bank51	35	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.5801	0.4351
Bank52	40	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.6630	0.4973
Bank53	40	2.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.5525	0.4144
Bank54	20	2.8	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.3094	0.2321
Bank55	20	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.3315	0.2486
Bank56	30	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.4973	0.3729
Bank57	30	2.5	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.4144	0.3108
Bank58	30	2.8	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.4641	0.3481
Bank59	40	2.8	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.6188	0.4641
Bank60	50	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.8288	0.6216
Bank61	20	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.3315	0.2486
Bank62	50	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.8288	0.6216
Bank63	70	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	1.1603	0.8702
Bank64	65	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	1.0774	0.8080
Bank65	50	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.8288	0.6216
Bank66	15	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.2486	0.1865
Bank67	15	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.2486	0.1865
Bank68	10	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.1658	0.1243
Bank69	40	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.6630	0.4973
Bank70	100	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	1.6575	1.2431
Bank71	20	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.3315	0.2486
Bank72	15	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.2486	0.1865
Bank73	60	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.9945	0.7459
Bank74	125	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	2.0719	1.5539
Bank75	70	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	1.1603	0.8702
Bank76	15	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.2486	0.1865
Bank77	15	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.2486	0.1865
Bank78	20	3	2. Moderate	0.06 - 0.2	0.13	0.75	Silt Loam	0.0425	1	0.3315	0.2486

	1. Total load by subwatershed(s)												
Water-shed	Strm Bank	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
		lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
W3	Bank1	25.8	9.9	51.7	16.2	19.4	7.5	38.8	12.1	6.5	2.5	12.9	4.0
	Bank2	8.2	3.1	16.3	5.1	6.1	2.4	12.2	3.8	2.0	0.8	4.1	1.3
	Bank3	47.6	18.3	95.2	29.8	35.7	13.7	71.4	22.3	11.9	4.6	23.8	7.4
	Bank4	17.7	6.8	35.4	11.1	13.3	5.1	26.5	8.3	4.4	1.7	8.8	2.8
	Bank5	4.8	1.8	9.5	3.0	3.6	1.4	7.1	2.2	1.2	0.5	2.4	0.7
	Bank6	10.9	4.2	21.8	6.8	8.2	3.1	16.3	5.1	2.7	1.0	5.4	1.7
	Bank7	16.3	6.3	32.6	10.2	12.2	4.7	24.5	7.7	4.1	1.6	8.2	2.6
	Bank8	6.8	2.6	13.6	4.3	5.1	2.0	10.2	3.2	1.7	0.7	3.4	1.1
	Bank9	13.6	5.2	27.2	8.5	10.2	3.9	20.4	6.4	3.4	1.3	6.8	2.1
	Bank10	8.2	3.1	16.3	5.1	6.1	2.4	12.2	3.8	2.0	0.8	4.1	1.3
	Bank11	12.2	4.7	24.5	7.7	9.2	3.5	18.4	5.7	3.1	1.2	6.1	1.9
	Bank12	1.1	0.4	2.3	0.7	0.9	0.3	1.7	0.5	0.3	0.1	0.6	0.2
	Bank13	2.2	0.9	4.4	1.4	1.7	0.6	3.3	1.0	0.6	0.2	1.1	0.3
	Bank14	0.9	0.3	1.8	0.6	0.7	0.3	1.3	0.4	0.2	0.1	0.4	0.1
	Bank15	0.9	0.3	1.8	0.6	0.7	0.3	1.3	0.4	0.2	0.1	0.4	0.1
	Bank16	0.9	0.3	1.8	0.6	0.7	0.3	1.3	0.4	0.2	0.1	0.4	0.1
	Bank17	1.8	0.7	3.5	1.1	1.3	0.5	2.7	0.8	0.4	0.2	0.9	0.3
	Bank18	1.7	0.7	3.4	1.1	1.3	0.5	2.6	0.8	0.4	0.2	0.9	0.3
	Bank19	3.6	1.4	7.2	2.2	2.7	1.0	5.4	1.7	0.9	0.3	1.8	0.6
	Bank20	1.9	0.7	3.8	1.2	1.4	0.6	2.9	0.9	0.5	0.2	1.0	0.3
	Bank21	1.9	0.7	3.8	1.2	1.4	0.6	2.9	0.9	0.5	0.2	1.0	0.3
W2	Bank22	3.2	1.2	6.4	2.0	2.4	0.9	4.8	1.5	0.8	0.3	1.6	0.5
	Bank23	23.9	9.2	47.7	14.9	17.9	6.9	35.8	11.2	6.0	2.3	11.9	3.7
	Bank24	1.3	0.5	2.7	0.8	1.0	0.4	2.0	0.6	0.3	0.1	0.7	0.2
W1	Bank25	1.9	0.7	3.7	1.2	1.4	0.5	2.8	0.9	0.5	0.2	0.9	0.3
	Bank26	4.0	1.5	8.0	2.5	3.0	1.1	6.0	1.9	1.0	0.4	2.0	0.6
	Bank27	1.9	0.7	3.7	1.2	1.4	0.5	2.8	0.9	0.5	0.2	0.9	0.3
	Bank28	4.7	1.8	9.3	2.9	3.5	1.3	7.0	2.2	1.2	0.4	2.3	0.7
	Bank29	0.9	0.3	1.8	0.6	0.7	0.3	1.4	0.4	0.2	0.1	0.5	0.1
	Bank30	0.9	0.3	1.8	0.6	0.7	0.3	1.4	0.4	0.2	0.1	0.5	0.1
	Bank31	1.5	0.6	2.9	0.9	1.1	0.4	2.2	0.7	0.4	0.1	0.7	0.2
	Bank32	0.4	0.2	0.8	0.3	0.3	0.1	0.6	0.2	0.1	0.0	0.2	0.1
	Bank33	0.7	0.3	1.5	0.5	0.6	0.2	1.1	0.3	0.2	0.1	0.4	0.1
	Bank34	0.6	0.2	1.1	0.3	0.4	0.2	0.8	0.3	0.1	0.1	0.3	0.1
	Bank35	0.2	0.1	0.4	0.1	0.2	0.1	0.3	0.1	0.1	0.0	0.1	0.0
	Bank36	0.5	0.2	1.1	0.3	0.4	0.2	0.8	0.2	0.1	0.1	0.3	0.1
	Bank37	0.9	0.3	1.8	0.5	0.7	0.3	1.3	0.4	0.2	0.1	0.4	0.1
	Bank38	0.3	0.1	0.7	0.2	0.3	0.1	0.5	0.2	0.1	0.0	0.2	0.1
	Bank39	1.4	0.5	2.8	0.9	1.0	0.4	2.1	0.7	0.3	0.1	0.7	0.2
	Bank40	0.9	0.4	1.9	0.6	0.7	0.3	1.4	0.4	0.2	0.1	0.5	0.1
	Bank41	1.2	0.5	2.5	0.8	0.9	0.4	1.9	0.6	0.3	0.1	0.6	0.2
	Bank42	1.8	0.7	3.6	1.1	1.4	0.5	2.7	0.8	0.5	0.2	0.9	0.3
	Bank43	0.3	0.1	0.6	0.2	0.2	0.1	0.5	0.1	0.1	0.0	0.2	0.0
	Bank44	9.9	3.8	19.9	6.2	7.5	2.9	14.9	4.7	2.5	1.0	5.0	1.6
	Bank45	0.7	0.3	1.3	0.4	0.5	0.2	1.0	0.3	0.2	0.1	0.3	0.1
	Bank46	0.8	0.3	1.5	0.5	0.6	0.2	1.2	0.4	0.2	0.1	0.4	0.1
	Bank47	1.1	0.4	2.2	0.7	0.8	0.3	1.7	0.5	0.3	0.1	0.6	0.2
	Bank48	0.7	0.3	1.3	0.4	0.5	0.2	1.0	0.3	0.2	0.1	0.3	0.1
	Bank49	0.4	0.2	0.9	0.3	0.3	0.1	0.7	0.2	0.1	0.0	0.2	0.1
	Bank50	2.7	1.0	5.3	1.7	2.0	0.8	4.0	1.2	0.7	0.3	1.3	0.4
	Bank51	0.9	0.4	1.9	0.6	0.7	0.3	1.4	0.4	0.2	0.1	0.5	0.1
	Bank52	1.1	0.4	2.1	0.7	0.8	0.3	1.6	0.5	0.3	0.1	0.5	0.2
	Bank53	0.9	0.3	1.8	0.6	0.7	0.3	1.3	0.4	0.2	0.1	0.4	0.1
	Bank54	0.5	0.2	1.0	0.3	0.4	0.1	0.7	0.2	0.1	0.0	0.2	0.1
	Bank55	0.5	0.2	1.1	0.3	0.4	0.2	0.8	0.2	0.1	0.1	0.3	0.1
	Bank56	0.8	0.3	1.6	0.5	0.6	0.2	1.2	0.4	0.2	0.1	0.4	0.1
	Bank57	0.7	0.3	1.3	0.4	0.5	0.2	1.0	0.3	0.2	0.1	0.3	0.1
	Bank58	0.7	0.3	1.5	0.5	0.6	0.2	1.1	0.3	0.2	0.1	0.4	0.1
	Bank59	1.0	0.4	2.0	0.6	0.7	0.3	1.5	0.5	0.2	0.1	0.5	0.2
	Bank60	1.3	0.5	2.7	0.8	1.0	0.4	2.0	0.6	0.3	0.1	0.7	0.2
	Bank61	0.5	0.2	1.1	0.3	0.4	0.2	0.8	0.2	0.1	0.1	0.3	0.1
	Bank62	1.3	0.5	2.7	0.8	1.0	0.4	2.0	0.6	0.3	0.1	0.7	0.2
	Bank63	1.9	0.7	3.7	1.2	1.4	0.5	2.8	0.9	0.5	0.2	0.9	0.3
	Bank64	1.7	0.7	3.4	1.1	1.3	0.5	2.6	0.8	0.4	0.2	0.9	0.3
	Bank65	1.3	0.5	2.7	0.8	1.0	0.4	2.0	0.6	0.3	0.1	0.7	0.2
	Bank66	0.4	0.2	0.8	0.2	0.3	0.1	0.6	0.2	0.1	0.0	0.2	0.1
W2	Bank67	0.4	0.2	0.8	0.2	0.3	0.1	0.6	0.2	0.1	0.0	0.2	0.1
	Bank68	0.3	0.1	0.5	0.2	0.2	0.1	0.4	0.1	0.1	0.0	0.1	0.0
	Bank69	1.1	0.4	2.1	0.7	0.8	0.3	1.6	0.5	0.3	0.1	0.5	0.2
	Bank70	2.7	1.0	5.3	1.7	2.0	0.8	4.0	1.2	0.7	0.3	1.3	0.4
	Bank71	0.5	0.2	1.1	0.3	0.4	0.2	0.8	0.2	0.1	0.1	0.3	0.1
	Bank72	0.4	0.2	0.8	0.2	0.3	0.1	0.6	0.2	0.1	0.0	0.2	0.1
	Bank73	1.6	0.6	3.2	1.0	1.2	0.5	2.4	0.7	0.4	0.2	0.8	0.2
	Bank74	3.3	1.3	6.6	2.1	2.5	1.0	5.0	1.6	0.8	0.3	1.7	0.5
	Bank75	1.9	0.7	3.7	1.2	1.4	0.5	2.8	0.9	0.5	0.2	0.9	0.3
	Bank76	0.4	0.2	0.8	0.2	0.3	0.1	0.6	0.2	0.1	0.0	0.2	0.1
	Bank77	0.4	0.2	0.8	0.2	0.3	0.1	0.6	0.2	0.1	0.0	0.2	0.1
	Bank78	0.5	0.2	1.1	0.3	0.4	0.2	0.8	0.2	0.1	0.1	0.3	0.1
	Total	287.5	110.7	575.0	179.7	215.6	83.0	431.3	134.8	71.9	27.7	143.8	44.9

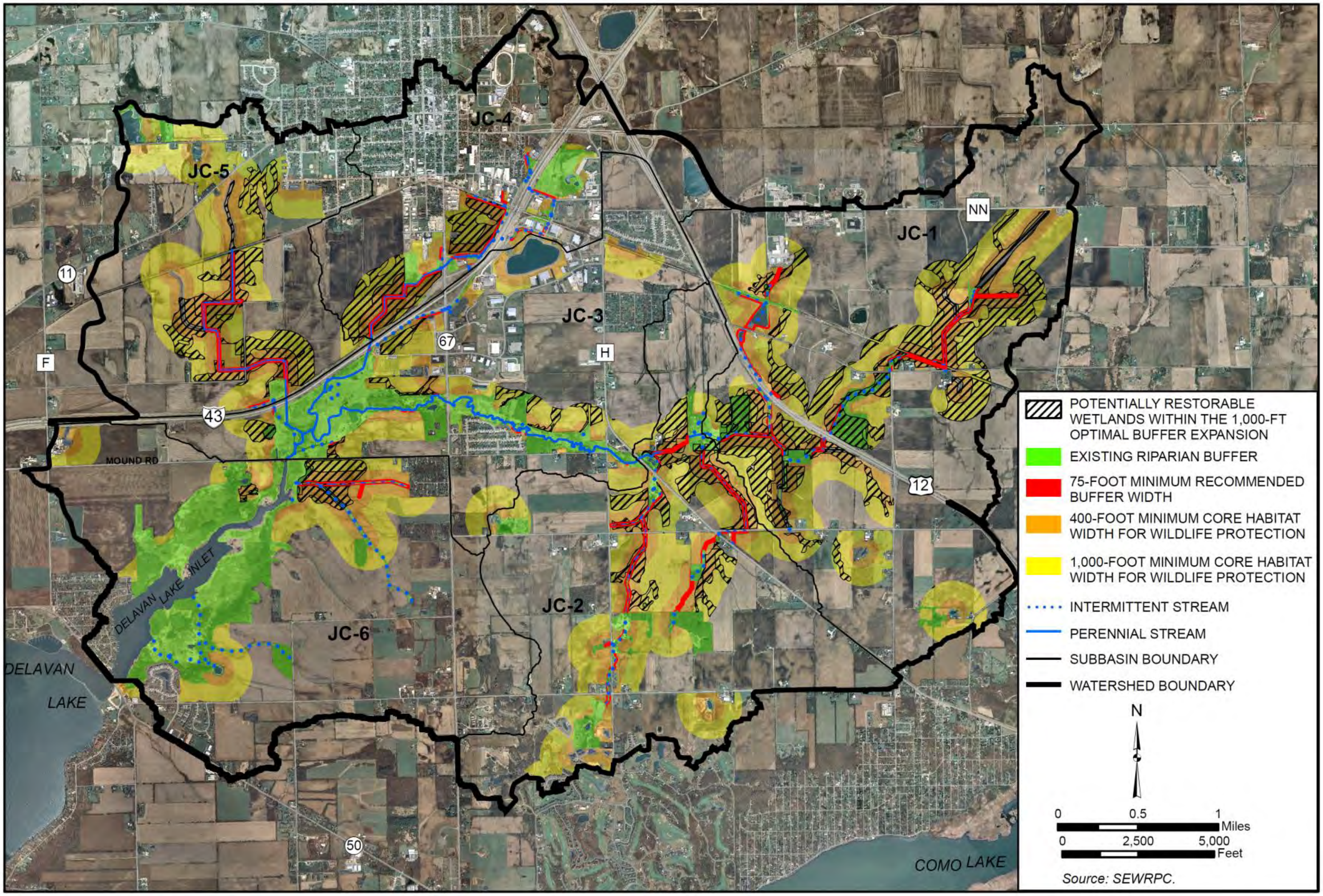
Map B-1

STEEP SLOPES, FEEDLOTS, AND EXISTING AND POTENTIAL GRASSED WATERWAY PROJECTS IDENTIFIED WITHIN THE JACKSON CREEK WATERSHED: 2015



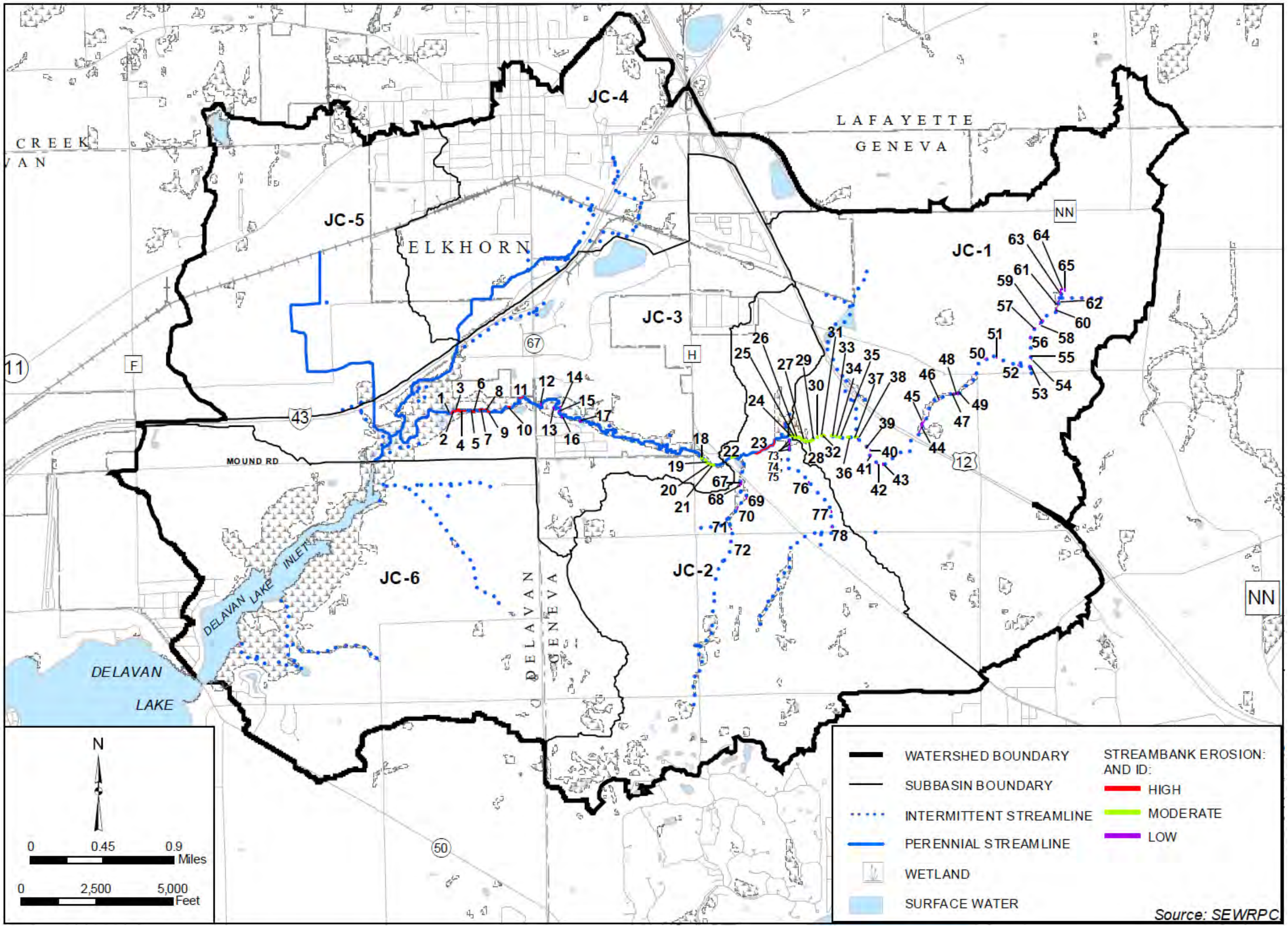
Map B-2

PROPOSED PRIORITY RIPARIAN BUFFER PROTECTION AREAS AND POTENTIALLY RESTORBALE WETLANDS WITHIN THE JACKSON CREEK WATERSHED: 2015



Map B-3

IDENTIFIED STREAMBANK EROSION SITES WITHIN JACKSON CREEK: 2012-2013



PRELIMINARY DRAFT

Appendix C

SEWRPC RIPARIAN BUFFER GUIDE NO. 1
"MANAGING THE WATER'S EDGE"

Managing the Water's Edge

Making Natural Connections

Problem Statement:

Despite significant research related to buffers, there remains no consensus as to what constitutes optimal riparian buffer design or proper buffer width for effective pollutant removal, water quality protection, prevention of channel erosion, provision of fish and wildlife habitat, enhancement of environmental corridors, augmentation of stream baseflow, and water temperature moderation.

Southeastern Wisconsin Regional Planning Commission

Our purpose in this document is to help protect and restore water quality, wildlife, recreational opportunities, and scenic beauty.

This material was prepared in part with funding from the U.S. Environmental Protection Agency Great Lakes National Program Office provided through CMAP, the Chicago Metropolitan Agency for Planning.

Introduction

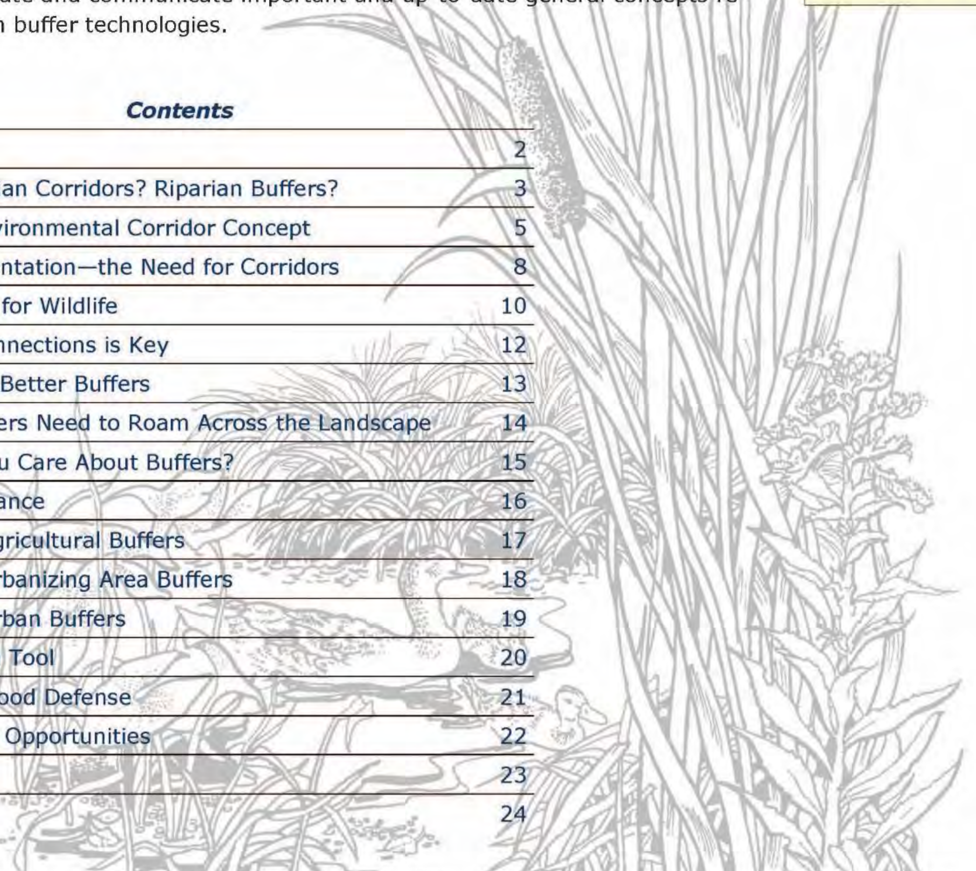
Perhaps no part of the landscape offers more variety and valuable functions than the natural areas bordering our streams and other waters.

These unique "riparian corridor" lands help filter pollutants from runoff, lessen downstream flooding, and maintain stream baseflows, among other benefits. Their rich ecological diversity also provides a variety of recreational opportunities and habitat for fish and wildlife. Regardless of how small a stream, lake, or wetland may be, adjacent corridor lands are important to those water features and to the environment.

Along many of our waters, the riparian corridors no longer fulfill their potential due to the encroachment of agriculture and urban development. This publication describes common problems encountered along streamside and other riparian corridors, and the many benefits realized when these areas are protected or improved. It also explains what landowners, local governments, and other decision-makers can do to capitalize on waterfront opportunities, and identifies some of the resources available for further information. While much of the research examined here focuses on stream corridors, the ideas presented also apply to areas bordering lakes, ponds, and wetlands throughout the southern Lake Michigan area and beyond. This document was developed as a means to facilitate and communicate important and up-to-date general concepts related to riparian buffer technologies.

Riparian corridors are unique ecosystems that are exceptionally rich in biodiversity

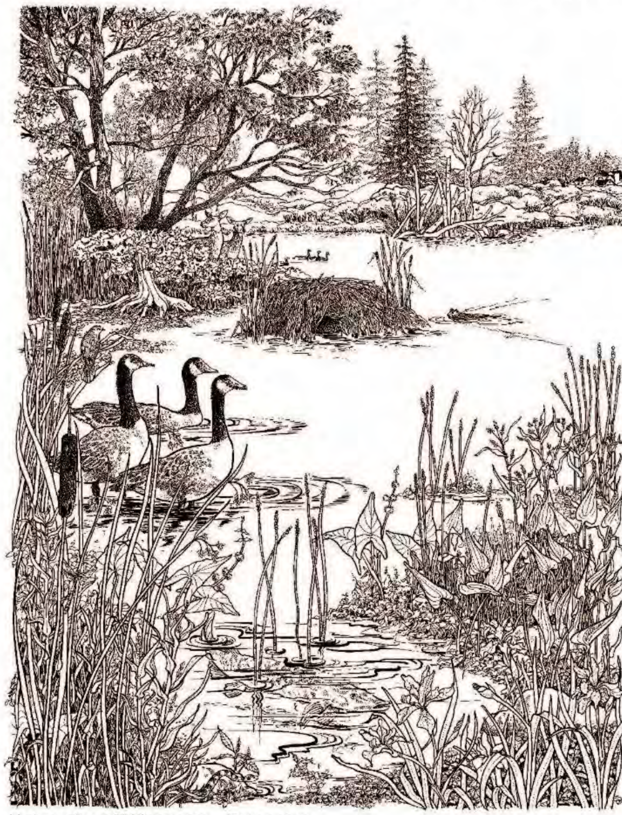
Contents



University of Wisconsin—Extension

What Are Riparian Corridors? Riparian Buffer Zones?

The word riparian comes from the Latin word *ripa*, which means bank. However, in this document we use riparian in a much broader sense and refer to land adjoining any water body including ponds, lakes, streams, and wetlands. This term has two additional distinct meanings that refer to 1) the "natural or relatively undisturbed" corridor lands adjacent to a water body inclusive of both wetland and upland flora and fauna and 2) a buffer zone or corridor lands in need of protection to "buffer" the effects of human impacts such as agriculture and residential development.



University of Wisconsin—Extension

The word buffer literally means something that cushions against the shock of something else (noun), or to lessen or cushion that shock (verb). Other useful definitions reveal that a buffer can be something that serves to separate features, or that is capable of neutralizing something, like filtering pollutants from stormwater runoff. Essentially, buffers and buffering help protect against adverse effects.

Riparian buffer zones function as core habitat as well as travel corridors for many wildlife species.

Riparian buffers are zones adjacent to waterbodies such as lakes, rivers, and wetlands that simultaneously protect water quality and wildlife, including both aquatic and terrestrial habitat. These zones minimize the impacts of human activities on the landscape and contribute to recreation, aesthetics, and quality of life. **This document summarizes how to maximize both water quality protection and conservation of aquatic and terrestrial wildlife populations using buffers.**

What Are Riparian Corridors? Riparian Buffer Zones?

Buffers **can** include a range of complex vegetation structure, soils, food sources, cover, and water features that offer a variety of habitats contributing to diversity and abundance of wildlife such as mammals, frogs, amphibians, insects, and birds. Buffers can consist of a variety of canopy layers and cover types including ephemeral (temporary-wet for only part of year) wetlands/seasonal ponds/spring pools, shallow marshes, deep marshes, wetland meadows, wetland mixed forests, grasslands, shrubs, forests, and/or prairies. Riparian zones are areas of transition between aquatic and terrestrial ecosystems, and they can potentially offer numerous benefits to wildlife and people such as pollution reduction and recreation.

In the water resources literature, riparian buffers are referred to in a number of different ways. Depending on the focus and the intended function of a buffer, or a buffer-related feature, buffers may be referred to as stream corridors, critical transition zones, riparian management areas, riparian management zones, floodplains, or green infrastructure.

It is important to note that within an agricultural context, the term buffer is used more generally to describe filtering best management practices most often at the water's edge. Other practices which can be interrelated may also sometimes be called buffers. These include grassed waterways, contour buffer strips, wind breaks, field border, shelterbelts, windbreaks, living snow fence, or filter strips. These practices may or may not be adjacent to a waterway as illustrated in the photo to the right. For example, a grassed waterway is designed to filter sediment and reduce erosion and may connect to a riparian buffer. These more limited-purpose practices may link to multipurpose buffers, but by themselves, they are not adequate to provide the multiple functions of a riparian buffer as defined here.

U.S. Department of Agriculture, Natural Resource Conservation Service, Ohio Office.

Beyond the Environmental Corridor Concept

The term "environmental corridors" (also known as "green infrastructure") refers to an interconnected green space network of natural areas and features, public lands, and other open spaces that provide natural resource value. Environmental corridor planning is a process that promotes a systematic and strategic approach to land conservation and encourages land use planning and practices that are good for both nature and people. It provides a framework to guide future growth, land development, and land conservation decisions in appropriate areas to protect both community and natural resource assets.

Environmental corridors are an essential planning tool for protecting the most important remaining natural resource features in Southeastern Wisconsin and elsewhere. Since development of the environmental corridor concept, there have been significant advancements in landscape ecology that have furthered understanding of the spatial and habitat needs of multiple groups of organisms. In addition, advancements in pollutant removal practices, stormwater control, and agriculture have increased our understanding of the effectiveness and limitations of environmental corridors. In protecting water quality and providing aquatic and terrestrial habitat, there is a need to better integrate new technologies through their application within riparian buffers.

SEWRPC has embraced and applied the environmental corridor concept developed by Philip Lewis (Professor Emeritus of Landscape Architecture at the University of Wisconsin-Madison) since 1966 with the publication of its first regional land use plan. Since then, SEWRPC has refined and detailed the mapping of environmental corridors, enabling the corridors to be incorporated directly into regional, county, and community plans and to be reflected in regulatory measures. The preservation of environmental corridors remains one of the most important recommendations of the regional plan. Corridor preservation has now been embraced by numerous county and local units of government as well as by State and Federal agencies. The environmental corridor concept conceived by Lewis has become an important part of the planning and development culture in Southeastern Wisconsin.

Beyond the Environmental Corridor Concept

Environmental corridors are divided into the following three categories.

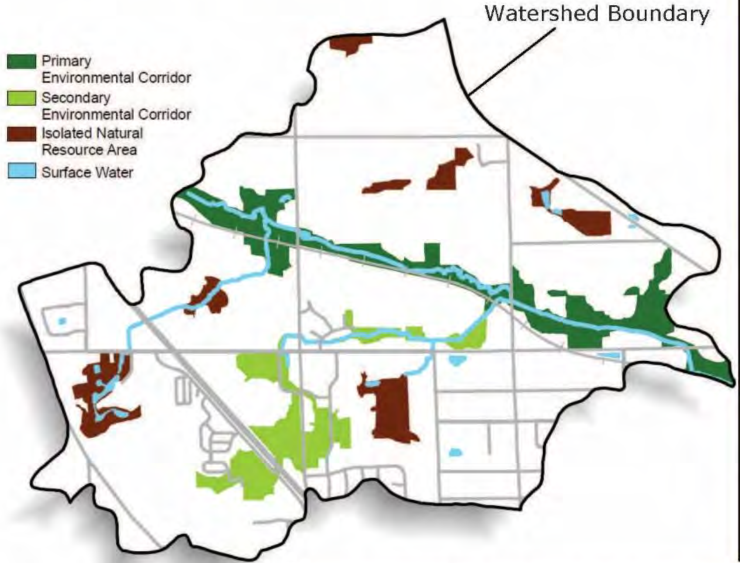
- **Primary environmental corridors** contain concentrations of our most significant natural resources. They are at least 400 acres in size, at least two miles long, and at least 200 feet wide.
- **Secondary environmental corridors** contain significant but smaller concentrations of natural resources. They are at least 100 acres in size and at least one mile long, unless serving to link primary corridors.
- **Isolated natural resource areas** contain significant remaining resources that are not connected to environmental corridors. They are at least five acres in size and at least 200 feet wide.

Key Features of Environmental Corridors

- Lakes, rivers, and streams
- Undeveloped shorelands and floodlands
- Wetlands
- Woodlands
- Prairie remnants
- Wildlife habitat
- Rugged terrain and steep slopes
- Unique landforms or geological formations
- Unfarmed poorly drained and organic soils
- Existing outdoor recreation sites
- Potential outdoor recreation sites
- Significant open spaces
- Historical sites and structures
- Outstanding scenic areas and vistas

Managing the Water's Edge

Beyond the Environmental Corridor Concept

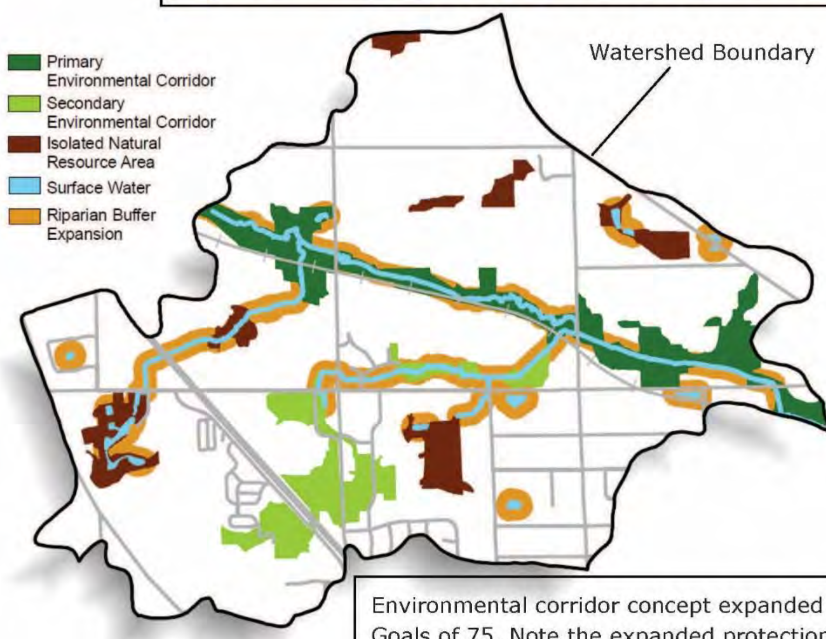


The Minimum Goals of **75** within a Watershed

75% minimum of total stream length should be naturally vegetated to protect the functional integrity of the water resources. (Environment Canada, How Much Habitat is Enough? A Framework for Guiding Habitat Rehabilitation in Great lakes Areas of Concern, Second Edition, 2004)

75 foot wide minimum riparian buffers from the top edge of each stream bank should be naturally vegetated to protect water quality and wildlife. (SEWRPC Planning Report No 50, A Regional Water Quality Management Plan for the Greater Milwaukee Watersheds, December 2007)

Example of how the environmental corridor concept is applied on the landscape. For more information see "Plan on It!" series **Environmental Corridors: Lifelines of the Natural Resource Base** at http://www.sewrpc.org/SEWRPC/LandUse/EnvironmentalCorridors.htm



Environmental corridor concept expanded to achieve the Goals of 75. Note the expanded protection in addition to the connection of other previously isolated areas.

Habitat Fragmentation—The Need for Corridors

Southeastern Wisconsin is a complex mosaic of agricultural and urban development. Agricultural lands originally dominated the landscape and remain a major land use. However, such lands continue to be converted to urban uses. Both of these dominant land uses fragment the landscape by creating islands or isolated pockets of wetland, woodland, and other natural lands available for wildlife preservation and recreation. By recognizing this fragmentation of the landscape, we can begin to mitigate these impacts.

New developments should incorporate water quality and wildlife enhancement or improvement objectives as design criteria by looking at the potential for creating linkages with adjoining lands and water features.

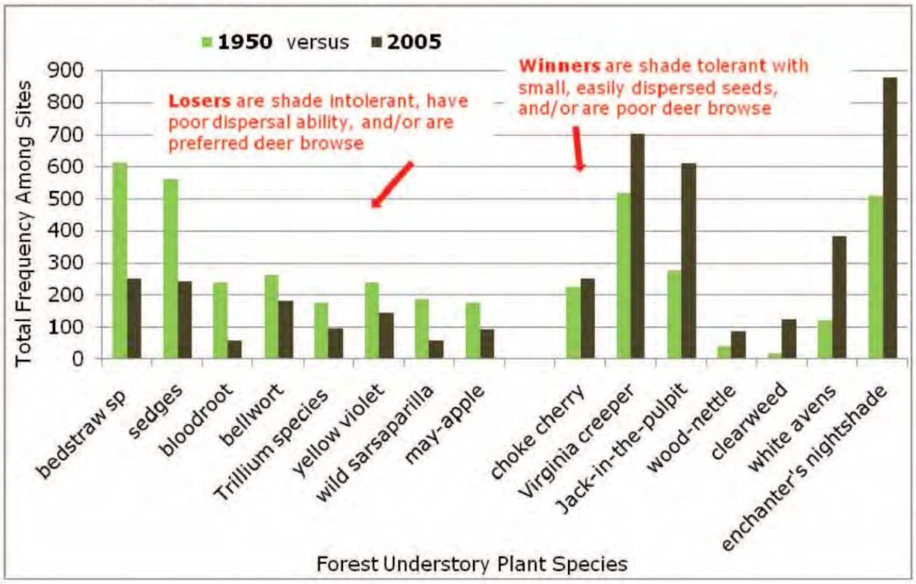
At the time of conversion of agricultural lands to urban uses, there are opportunities to re-create and expand riparian buffers and environmental corridors reconnecting uplands and waterways and restoring ecological integrity and scenic beauty locally and regionally. For example, placement of roads and other infrastructure across stream systems could be limited so as to maximize continuity of the riparian buffers. This can translate into significant cost savings in terms of reduced road maintenance, reduced salt application, and limited bridge or culvert maintenance and replacements. This simple practice not only saves the community significant amounts of money, but also improves and protects quality of life. Where necessary road crossings do occur, they can be designed to provide for safe fish and wildlife passage.


Overland travel routes for wildlife are often unavailable, discontinuous, or life endangering within the highly fragmented landscapes of Southeastern Wisconsin and elsewhere.

State Threatened Species: Blanding's turtle

Habitat Fragmentation—The Need for Corridors

Forest understory plant species abundance among stands throughout Southern Wisconsin



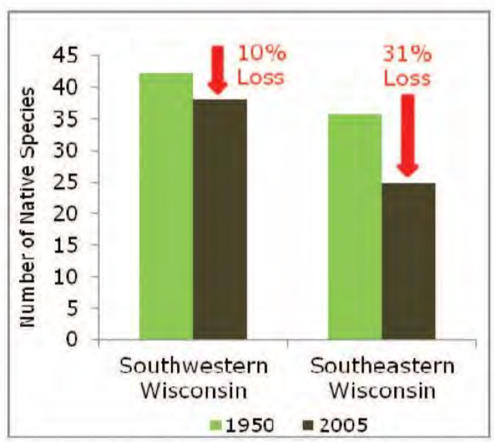
Forest fragmentation has led to significant plant species loss within Southern Wisconsin

(Adapted from David Rogers and others, 2008, Shifts in Southern Wisconsin Forest Canopy and Understory Richness, Composition, and Heterogeneity, Ecology, 89 (9): 2482-2492)

"...these results confirm the idea that large intact habitat patches and landscapes better sustain native species diversity. It also shows that people are a really important part of the system and their actions play an increasingly important role in shaping patterns of native species diversity and community composition. Put together, it is clear that one of the best and most cost effective actions we can take toward safeguarding native diversity of all types is to protect, enhance and create corridors that link patches of natural habitat."
Dr. David Rogers, Professor of Biology at the University of Wisconsin-Parkside

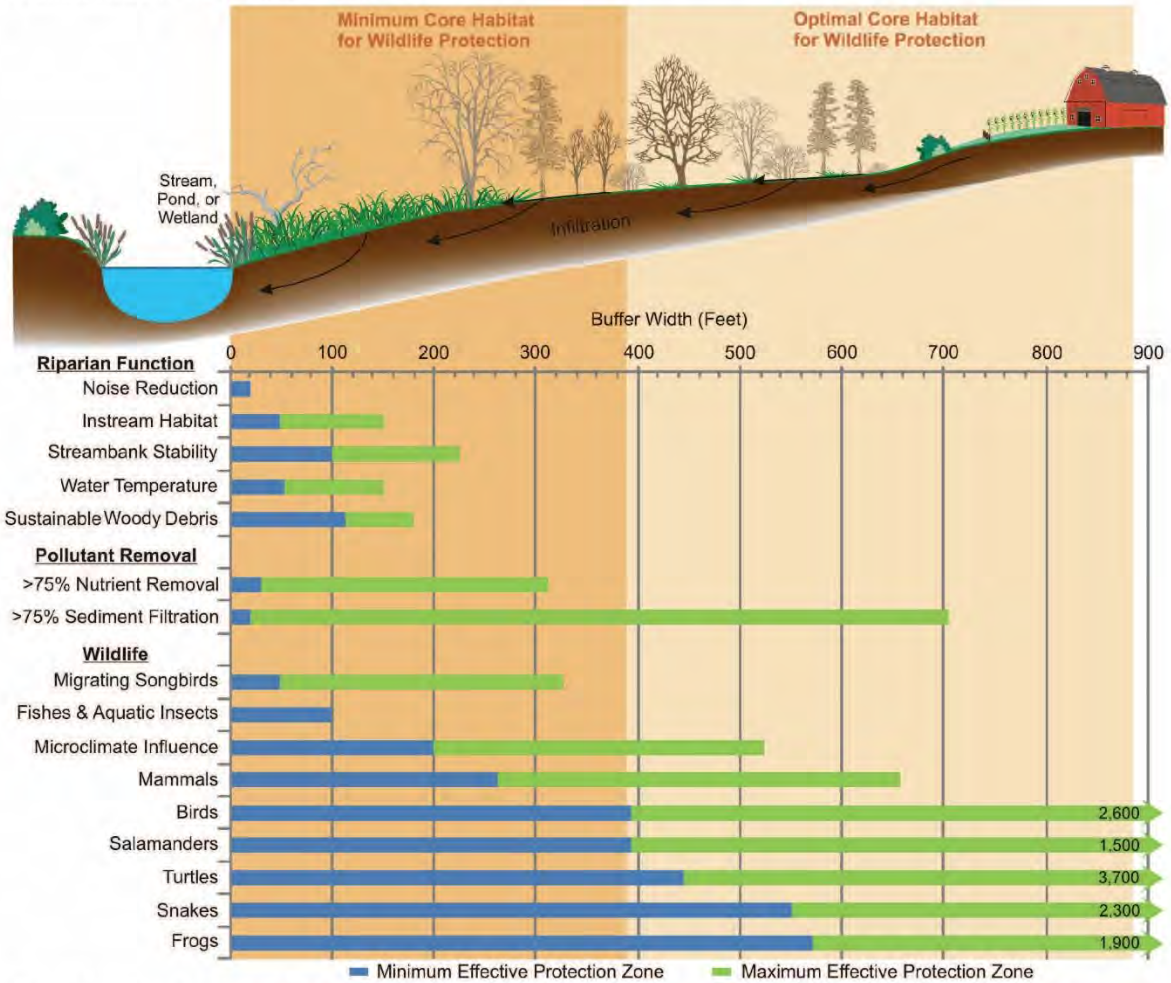
Since the 1950s, forests have increasingly become more fragmented by land development, both agricultural and urban, and associated roads and infrastructure, which have caused these forests to become isolated "islands of green" on the landscape. In particular, there has been significant loss of forest understory plant species over time (shrubs, grasses, and herbs covering the forest floor.) It is important to note that **these forests lost species diversity even when they were protected as parks or natural areas**.

One major factor responsible for this decline in forest plant diversity is that routes for native plants to re-colonize isolated forest islands are largely cut-off within fragmented landscapes. For example, the less fragmented landscapes in Southwestern Wisconsin lost fewer species than the more fragmented stands in Southeastern Wisconsin. In addition, the larger-sized forests and forests with greater connections to surrounding forest lands lost fewer species than smaller forests in fragmented landscapes.



Wider is Better for Wildlife

Why? Because buffer size is the engine that drives important natural functions like food availability and quality, access to water, habitat variety, protection from predators, reproductive or resting areas, corridors to safely move when necessary, and help in maintaining the health of species' gene pools to prevent isolation and perhaps extinction.



One riparian buffer size does not fit all conditions or needs. There are many riparian buffer functions and the ability to effectively fulfill those functions is largely dependent on width. Determining what buffer widths are needed should be based on what functions are desired as well as site conditions. For example, as shown above, water temperature protection generally does not require as wide a buffer as provision of habitat for wildlife. Based on the needs of wildlife species found in Wisconsin, the minimum core habitat buffer width is about 400 feet and the optimal width for sustaining the majority of wildlife species is about 900 feet. Hence, the value of large undisturbed parcels along waterways which are part of, and linked to, an environmental corridor system. The minimum effective buffer width distances are based on data reported in the scientific literature and the quality of available habitats within the context of those studies.

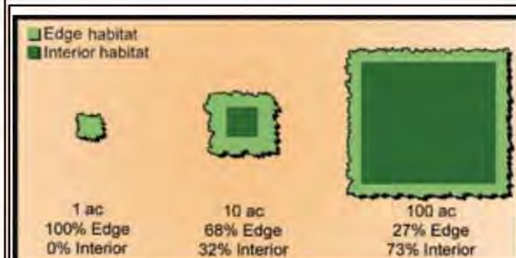
Wider is Better for Wildlife

Wildlife habitat needs change within and among species. **Minimum Core Habitat and Optimum Core Habitat distances were developed from numerous studies to help provide guidance for biologically meaningful buffers to conserve wildlife biodiversity.** These studies documented distances needed for a variety of biological (life history) needs to sustain healthy populations such as breeding, nesting, rearing young, foraging/feeding, perching (for birds), basking (for turtles), and overwintering/dormancy/hibernating. These life history needs require different types of habitat and distances from water, for example, one study found that Blanding's turtles needed approximately 60-foot-wide buffers for basking, 375 feet for overwintering, and up to 1,200 feet for nesting to bury their clutches of eggs. Some species of birds like the Blacked-capped chickadee or white breasted nuthatch only need about 50 feet of buffer, while others like the wood duck or great blue heron require 700-800 feet for nesting. Therefore, **understanding habitat needs for wildlife species is an important consideration in designing riparian buffers.**

Although *Ambystoma* salamanders require standing water for egg laying and juvenile development, most other times of the year they can be found more than 400 feet from water foraging for food.

Wisconsin Species	Mimimum Core Habitat (feet)	Optimum Core Habitat (feet)	Number of Studies
Frogs	571	1,043	9
Salamanders	394	705	14
Snakes	551	997	5
Turtles	446	889	27
Birds	394	787	45
Mammals	263	No data	11
Fishes and Aquatic Insects	100	No data	11
Mean	388	885	

This approach was adapted from *R.D. Semlitsch and J.R. Bodie, 2003, Biological Criteria for Buffer Zones around Wetlands and Riparian Habitats for Amphibian and Reptiles, Conservation Biology, 17(5):1219-1228.* These values are based upon studies examining species found in Wisconsin and represent mean linear distances extending outward from the edge of an aquatic habitat. The Minimum Core Habitat and Optimum Core Habitat reported values are based upon the mean minimum and mean maximum distances recorded, respectively. Due to a low number of studies for snake species, the recommended distances for snakes are based upon values reported by *Semlitsch and Bodie.*

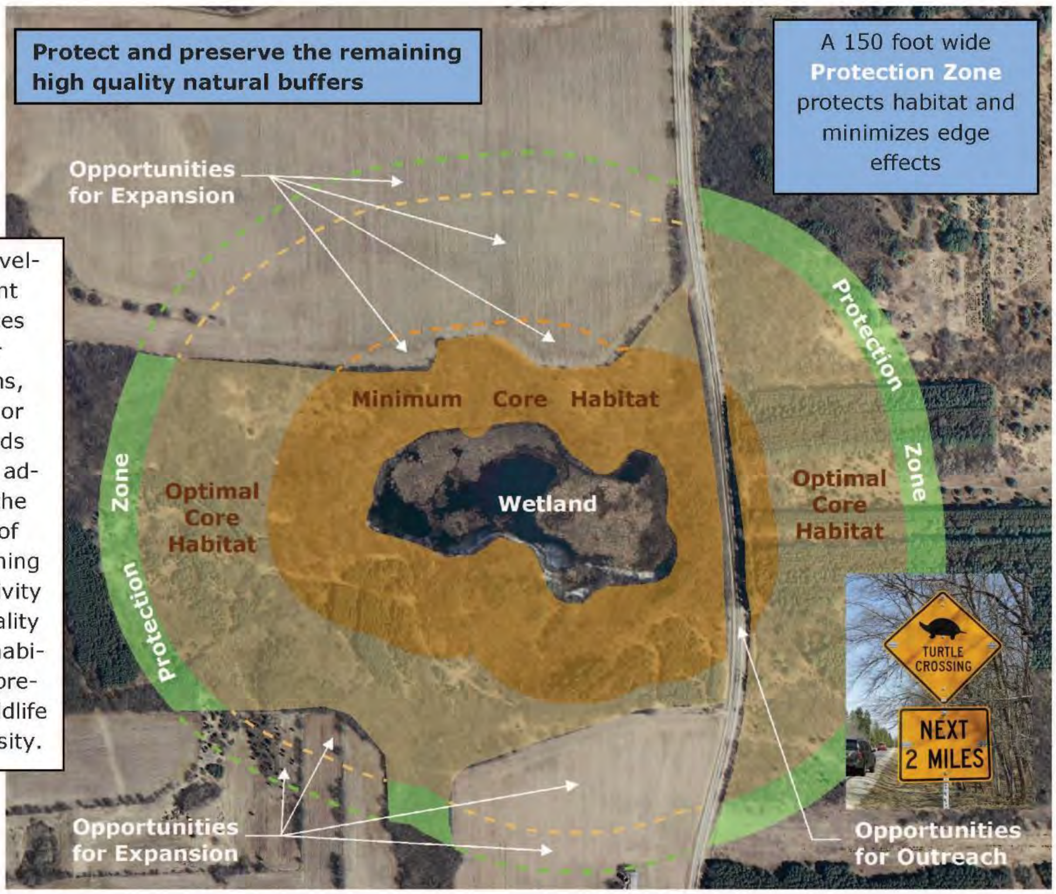


*"**Large patches typically conserve a greater variety and quality of habitats, resulting in higher species diversity and abundance.**" Larger patches contain greater amounts of interior habitat and less edge effects, which benefits interior species, by providing safety from parasitism, disease, and invasive species.*

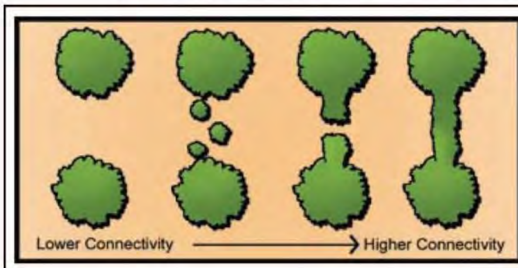
(Bentrup, G. 2008. Conservation buffers: design guidelines for buffers, corridors, and greenways. Gen. Tech. Rep. SRS-109. Asheville, NC: Department of Agriculture, Forest Service, Southern Research Station)

Maintaining Connections is Key

Like humans, all forms of wildlife require access to clean water. Emerging research has increasingly shown that, in addition to water, more and more species such as amphibians and reptiles cannot persist without landscape connectivity between quality wetland and upland habitats. Good connectivity to upland terrestrial habitats is essential for the persistence of healthy sustainable populations, because these areas provide vital feeding, overwintering, and nesting habitats found nowhere else. Therefore, both aquatic and terrestrial habitats are essential for the preservation of biodiversity and they should ideally be managed together as a unit.



Land development practices near streams, lakes, or wetlands need to address the issue of maintaining connectivity with quality upland habitats to preserve wildlife biodiversity.



Increasing connectivity among quality natural landscapes (wetlands, woodlands, prairies) can benefit biodiversity by providing access to other areas of habitat, increasing gene flow and population viability, enabling recolonization of patches, and providing habitat (Bentrup 2008).

Basic Rules to Better Buffers

There are opportunities to improve buffer functions to improve water quality and wildlife habitat, even in urban situations

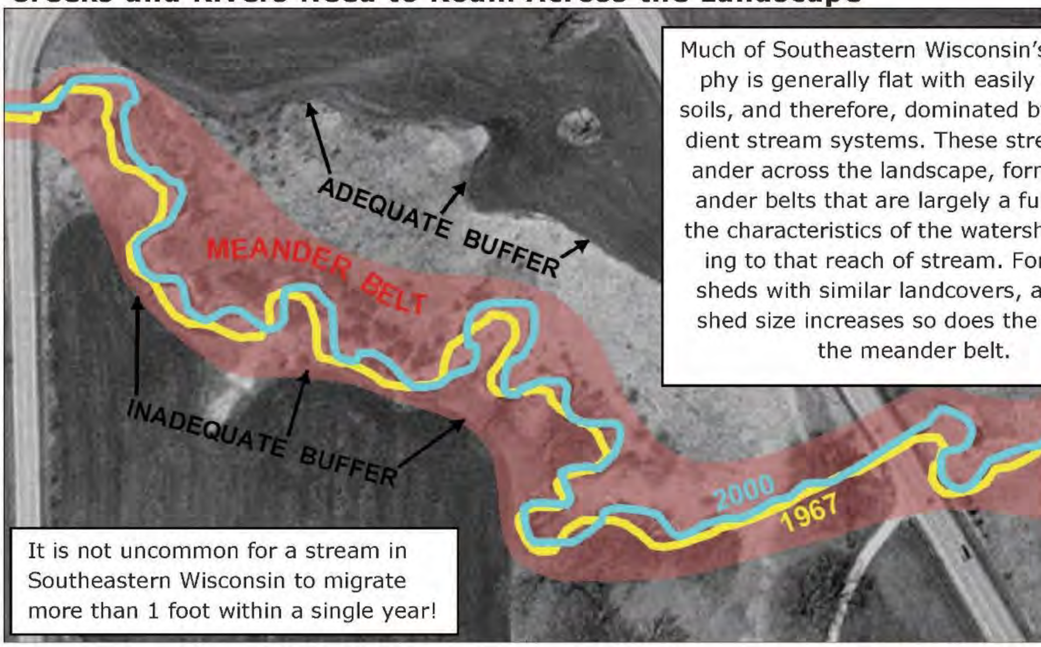
Protecting the integrity of native species in the region is an objective shared by many communities. The natural environment is an essential component of our existence and contributes to defining our communities and neighborhoods. Conservation design and open space development patterns in urbanizing areas and farm conservation programs in rural areas have begun to address the importance of maintaining and restoring riparian buffers and connectivity among corridors.

How wide should the buffer be? Unfortunately, there is no one-size-fits all buffer width adequate to protect water quality, wildlife habitat, and human needs. Therefore, the answer to this question depends upon the predetermined needs of the landowner and community objectives or goals. As riparian corridors become very wide, their pollutant removal (buffering) effectiveness may reach a point of diminishing returns compared to the investment involved. However, the prospects for species diversity in the corridor keep increasing with buffer width. For a number of reasons, 400- to 800-foot-wide buffers are not practical along all lakes, streams, and wetlands within Southeastern Wisconsin. Therefore, communities should develop guidelines that remain flexible to site-specific needs to achieve the most benefits for water resources and wildlife as is practical.

Key considerations to better buffers/corridors:

- Wider buffers are better than narrow buffers for water quality and wildlife functions
- Continuous corridors are better than fragmented corridors for wildlife
- Natural linkages should be maintained or restored
- Linkages should not stop at political boundaries
- Two or more corridor linkages are better than one
- Structurally diverse corridors (e.g., diverse plant structure or community types, upland and wetland complexes, soil types, topography, and surficial geology) are better than corridors with simple structures
- Both local and regional spatial and temporal scales should be considered in establishing buffers
- Corridors should be located along dispersal and migration routes
- Corridors should be located and expanded around rare, threatened, or endangered species
- Quality habitat should be provided in a buffer whenever possible
- Disturbance (e.g. excavation or clear cutting vegetation) of corridors should be minimized during adjacent land use development
- Native species diversity should be promoted through plantings and active management
- Non-native species invasions should be actively managed by applying practices to preserve native species
- Fragmentation of corridors should be reduced by limiting the number of crossings of a creek or river where appropriate
- Restoration or rehabilitation of hydrological function, streambank stability, instream habitat, and/or floodplain connectivity should be considered within corridors.
- Restoration or retrofitting of road and railway crossings promotes passage of aquatic organisms

Creeks and Rivers Need to Roam Across the Landscape



Much of Southeastern Wisconsin's topography is generally flat with easily erodible soils, and therefore, dominated by low gradient stream systems. These streams meander across the landscape, forming meander belts that are largely a function of the characteristics of the watershed draining to that reach of stream. For watersheds with similar landcovers, as watershed size increases so does the width of the meander belt.

It is not uncommon for a stream in Southeastern Wisconsin to migrate more than 1 foot within a single year!

Healthy streams naturally meander or migrate across a landscape over time. Streams are transport systems for water and sediment and are continually eroding and depositing sediments, which causes the stream to migrate. When the amount of sediment load coming into a stream is equal to what is being transported downstream—and stream widths, depths, and length remain consistent over time—it is common to refer to that stream as being in a state of **"dynamic equilibrium."** In other words the stream retains its physical dimensions (equilibrium), but those physical features are shifted, or migrate, over time (dynamic).

Room to Roam

Riparian buffer widths should take into account the amount of area that a stream needs to be able to self-adjust and maintain itself in a state of dynamic equilibrium. ... These are generally greater than any minimum width needed to protect for pollutant removal alone.

Streams are highly sensitive, and they respond to changes in the amounts of water and sediment draining to them, which are affected by changing land use conditions. For example, streams can respond to increased discharges of water by increased scour (erosion) of bed and banks that leads to an increase in stream width and depth—or "degradation." Conversely, streams can respond to increased sedimentation (deposition) that leads to a decrease in channel width and depth—or "aggradation."

Why Should You Care About Buffers?

Economic Benefits:

- Increased value of riparian property
- Reduced lawn mowing time and expense
- Increased shade to reduce building cooling costs
- Natural flood mitigation protection for structures or crops
- Pollution mitigation (reduced nutrient and contaminant loading)
- Increased infiltration and groundwater recharge
- Prevented loss of property (land or structures) through erosion
- Greater human and ecological health through biodiversity

Recreational Benefits:

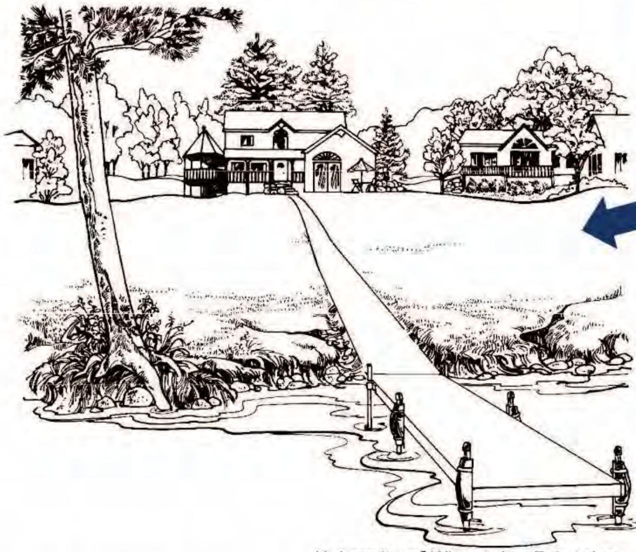
- Increased quality of the canoeing/kayaking experience
- Improved fishing and hunting quality by improving habitat
- Improved bird watching/wildlife viewing quality and opportunities
- Increased potential for expansion of trails for hiking and bicycling
- Opportunities made available for youth and others to locally reconnect with nature

Riparian buffers make sense and are profitable monetarily, recreationally, and aesthetically!

Social Benefits:

- Increased privacy
- Educational opportunities for outdoor awareness
- Improved quality of life at home and work
- Preserved open space/balanced character of a community
- Focal point for community pride and group activities
- Visual diversity
- Noise reduction

A Matter of Balance



University of Wisconsin—Extension

Although neatly trimmed grass lawns are popular, these offer limited benefits for water quality or wildlife habitat. A single house near a waterbody may not seem like a "big deal," but the cumulative effects of many houses can negatively impact streams, lakes, and wetlands.

All the lands within Southeastern Wisconsin ultimately flow into either the Mississippi River or the Great Lakes systems. The cumulative effects of agriculture and urban development in the absence of mitigative measures, ultimately affects water quality in those systems. Much of this development causes increases in water runoff from the land into wetlands, ponds, and streams. This runoff transports water, sediments, nutrients, and other pollutants into our waterways that can lead to a number of problems, including flooding that can cause crop loss or building damage; unsightly and/or toxic algae blooms; increased turbidity; damage to aquatic organisms from reduced dissolved oxygen, lethal temperatures, and/or concentrations of pollutants; and loss of habitat.

Riparian buffers are one of the most effective tools available for defending our waterways. Riparian buffers can be best thought of as forming a living, self-sustainable protective shield. This shield protects investments in the land and all things on it as well as our quality of life locally, regionally, and, ultimately, nationally. Combined with stormwater management, environmentally friendly yard care, effective wastewater treatment, conservation farming methods, and appropriate use of fertilizers and other agrichemicals, **riparian buffers complete the set of actions that we can take to minimize impacts to our shared water resources.**

Lakeshore buffers can take many forms, which require a balancing act between lake viewing, access, and scenic beauty. Lakeshore buffers can be integrated into a landscaping design that complements both the structural development and a lakeside lifestyle. Judicious placement of access ways and shoreline protection structures, and preservation or reestablishment of native vegetation, can enhance and sustain our use of the environment.

University of Wisconsin—Extension

Case Study—Agricultural Buffers

Agricultural nonpoint source pollution runoff continues to pose a threat to water quality and aquatic ecosystems within Wisconsin and elsewhere. In an effort to address this problem, the Wisconsin Buffer Initiative was formed with the goal of designing a buffer implementation program to achieve science-based, cost-effective, water quality improvements (report available online at http://www.soils.wisc.edu/extension/nonpoint/wbi.php).

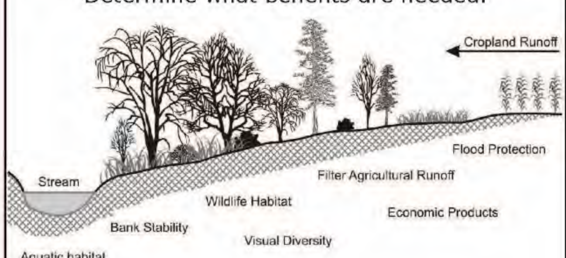
While it is true that riparian buffers alone may not always be able to reduce nutrient and sediment loading from agricultural lands, WBI researchers found that "...***riparian buffers are capable of reducing large percentages of the phosphorus and sediment that are currently being carried by Wisconsin streams. Even in watersheds with extremely high loads (top 10%), an average of about 70% of the sediment and phosphorus can be reduced through buffer implementation***." *(Diebel, M.J. and others, 2009, Landscape planning for agricultural nonpoint source pollution reduction III: Assessing Phosphorus and sediment reduction potential, Environmental Management, 43:69-83.).*

Challenge:
Buffers may take land out of cultivated crop production and require additional cost to install and maintain. Cost sharing, paid easements, and purchase of easements or development rights may sometimes be available to offset costs.

Benefits:
Buffers may offset costs by producing perennial crops such as hay, lumber, fiber, nuts, fruits, and berries. In addition, they provide visual diversity on the landscape, help maintain long-term crop productivity, and help support healthier fish populations for local enjoyment.

Federal and state natural resource agencies have long recognized the need to apply a wide range of Best Management Practices on agricultural lands to improve stream water quality. Although there are many tools available in the toolbox to reduce pollutant runoff from agricultural lands, such as crop rotations, nutrient and manure management, conservation tillage, and contour plowing, riparian buffers are one of the most effective tools to accomplish this task. Their multiple benefits and inter-connectedness from upstream to downstream make riparian buffers a choice with watershed-wide benefits.

Determine what benefits are needed.



The USDA in *Agroforestry Notes* (AF Note-4, January 1997) outlines a four step process for designing riparian buffers for Agricultural lands:

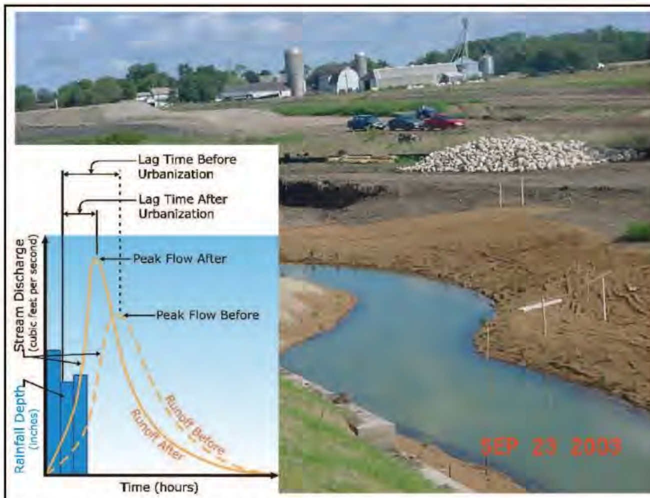
1-Determine what buffers functions are needed
2-Identify the best types of vegetation to provide the needed benefits
3-Determine the minimum acceptable buffer width to achieve desired benefits
4-Develop an installation and maintenance plan

Drain tiles can bypass infiltration and filtration of pollutants by providing a direct pathway to the water and "around" a buffer. This is important to consider in design of a buffer system which integrates with other agricultural practices.

Case Study—Urbanizing Area Buffers

When development occurs near a waterbody, the area in driveways, rooftops, sidewalks, and lawns increases, while native plants and undisturbed soils decrease. As a result, the ability of the shoreland area to perform its natural functions (flood control, pollutant removal, wildlife habitat, and aesthetic beauty) is decreased. In the absence of mitigating measures, one the consequences of urban development is an increase in the amount of stormwater, which runs off the land instead of infiltrating into the ground. Therefore, **urbanization impacts the watershed, not only by reducing groundwater recharge, but also by changing stream hydrology** through increased stormwater runoff volumes and peak flows. This means less water is available to sustain the baseflow regime. The urban environment also contains increased numbers of pollutants and generates greater pollutant concentrations and loads than any other land use. This reflects the higher density of the human population and associated activities, which demand measures to protect the urban water system.

Mitigation of urban impacts may be as simple as not mowing along a stream corridor or changing land management and yard care practices, or as complex as changing zoning ordinances or widening riparian corridors through buyouts.



Comparison of hydrographs before and after urbanization. Note the rapid runoff and greater peak streamflow tied to watershed development. (Adapted from Federal Interagency Stream Restoration Working Group (FISRWG), Stream Corridor Restoration: Principles, Processes, and Practices, October 1998)

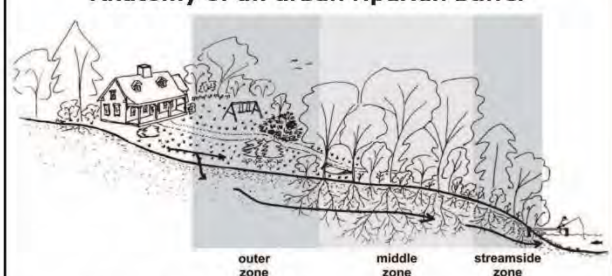
Challenge:

Urban development requires balancing flood protection, water quality protection, and the economic viability of the development.

Opportunities:

Buffers may offset costs by providing adequate space for providing long-term water quantity and water quality protection. In addition, they provide visual diversity on the landscape, wildlife habitat and connectedness, and help maintain property values.

Anatomy of an urban riparian buffer



The most effective urban buffers have three zones:

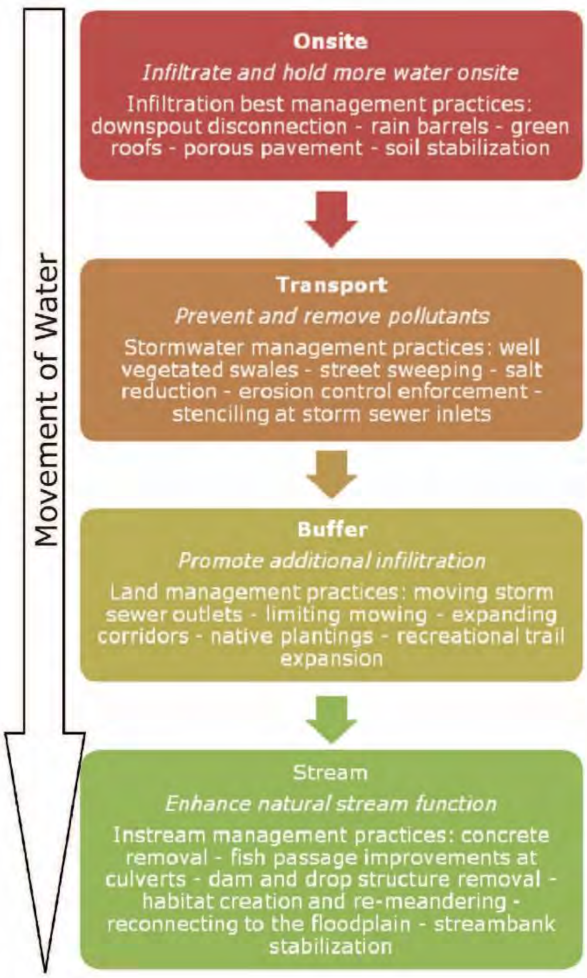
- **Outer Zone-**Transition area between the intact buffer and nearest permanent structure to capture sediment and absorb runoff.
- **Middle Zone-**Area from top of bank to edge of lawn that is composed of natural vegetation that provides wildlife habitat as well as improved filtration and infiltration of pollutants.
- **Streamside Zone-**Area from the water's edge to the top of the bank or uplands that provides critical connection between water, wetland, and upland habitats for wildlife as well as protect streams from bank erosion

(Fact sheet No. 6 Urban Buffer in the series Riparian Buffers for Northern New Jersey)

Case Study—Urban Buffers

Placement of riparian buffers in established urban areas is a challenge that requires new and innovative approaches. In these areas, historical development along water courses limits options and requires balancing flood management protection versus water quality and environmental protection needs. Consequently, some municipalities have begun to recognize the connections between these objectives and are introducing programs to remove flood-prone structures and culverts from the stream corridors and allow recreation of the stream, restoring floodplains, and improving both the quality of life and the environment.

In urban settings it may be necessary to limit pollution and water runoff before it reaches the buffer.



Challenge:
There are many potential constraints to establishing, expanding, and/or managing riparian buffers within an urban landscape. Two major constraints to establishment of urban buffers include:

1) **Limited or confined space to establish buffers** due to encroachment by structures such as buildings, roadways, and/or sewer infrastructure;
2) **Fragmentation of the landscape** by road and railway crossings of creeks and rivers that disrupt the linear connectedness of buffers, limiting their ability to provide quality wildlife habitat.

Much traditional stormwater infrastructure intercepts runoff and diverts it directly into creeks and rivers, bypassing any benefits of buffers to infiltrate or filter pollutants. This is important to consider in design of a buffer system for urban waterways, which begin in yards, curbsides, and construction sites, that are figuratively as close to streams as the nearest storm sewer inlet.

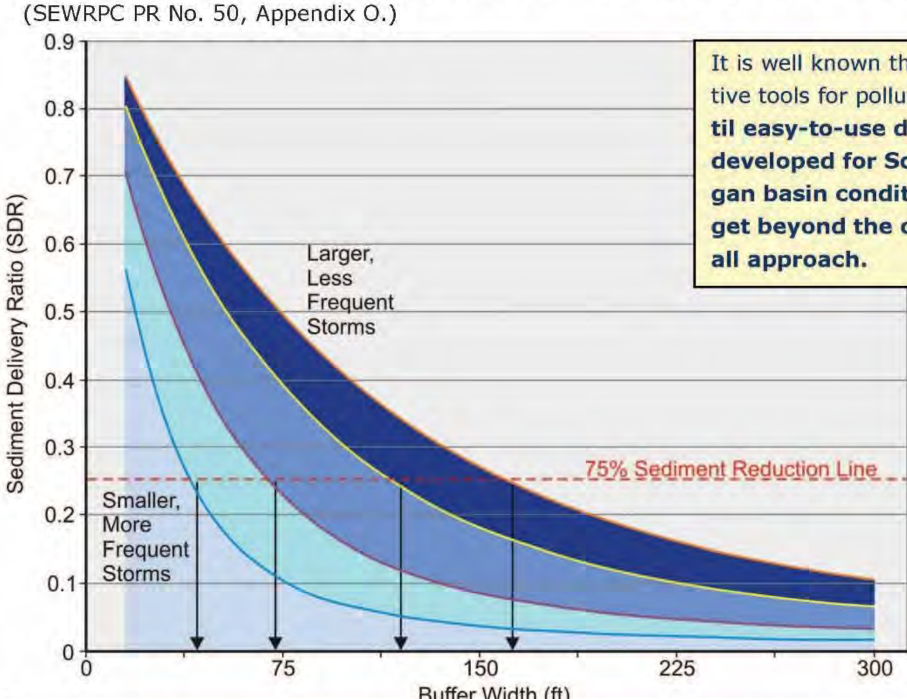
A Buffer Design Tool

Design aids are needed to help municipalities, property owners, and others take the "guesswork" out of determining adequate buffer widths for the purpose of water resource quality protection. While there are various complex mathematical models that can be used to estimate sediment and nutrient removal efficiencies, they are not easily applied by the people who need them including homeowners, farmers, businesses and developers.

To fill this gap, design aid tools are being developed using factors such as slope, soils, field length, incoming pollutant concentrations, and vegetation to allow the user to identify and test realistic buffer widths with respect to the desired percent pollutant load reduction and storm characteristics. By developing a set of relationships among factors that determine buffer effectiveness, the width of buffer needed to meet specific goals can be identified.

In the example below, 50-foot-wide buffers are necessary to achieve 75 % sediment removal during small, low intensity storms, while buffers more than 150 feet wide are necessary to achieve the same sediment reduction during more severe storms. Based on this information, decision-makers have the option of fitting a desired level of sediment removal into the context of their specific conditions. Under most conditions, a 75-foot width will provide a minimum level of protection for a variety of needs (SEWRPC PR No. 50, Appendix O.)

It is well known that buffers are effective tools for pollutant removal, but **until easy-to-use design aid tools are developed for Southern Lake Michigan basin conditions, we can never get beyond the current one size fits all approach.**



This generalized graph depicts an example of model output for an optimal buffer width to achieve a 75% sediment reduction for a range of soil and slope, vegetation, and storm conditions characteristic of North Carolina. *(Adapted from Muñoz-Carpena R., Parsons J.E.. 2005. VFSMOD-W: Vegetative Filter Strips Hydrology and Sediment Transport Modeling System v.2.x. Homestead, FL: University of Florida. http://carpena.ifas.ufl.edu/vfsmod/citations.shtml)*

Buffers Are A Good Defense

Today's natural resources are under threat. These threats are immediate as in the case of chemical accidents or manure spills, and chronic as in the case of stormwater pollution carrying everything from eroded soil, to fertilizer nutrients, to millions of drips from automobiles and other sources across the landscape. Non-native species have invaded, and continue to invade, key ecosystems and have caused the loss of native species and degradation of their habitats to the detriment of our use of important resources.

> ***"Riparian ecosystems are naturally resilient,*** *provide linear habitat connectivity, link aquatic and terrestrial ecosystems, and create thermal refugia for wildlife: all characteristics that can contribute to ecological adaptation to climate change."*
>
> *(N. E. Seavy and others, Why Climate Change Makes Riparian Restoration More Important Than Ever: Recommendations for Practice and Research, 2009, Ecological Restoration 27(3):330-338)*

A more subtle, but growing, concern is the case of stresses on the environment resulting from climate change. Buffers present an opportunity for natural systems to adapt to such changes by providing the space to implement protective measures while also serving human needs. **Because riparian buffers maintain an important part of the landscape in a natural condition, they offer opportunities for communities to adjust to our changing world.**

Well-managed riparian buffers are a good defense against these threats. In combination with environmental corridors, buffers maintain a sustainable reserve and diversity of habitats, plant and animal populations, and genetic diversity of organisms, all of which contribute to the long-term preservation of the landscape. Where they are of sufficient size and connectivity, riparian buffers act as reservoirs of resources that resist the changes that could lead to loss of species.

Refuge or protection from increased water temperatures as provided by natural buffers is important for the preservation of native cold-water, cool-water, and warm-water fishes and their associated communities.

Managing the Water's Edge

Buffers Provide Opportunities

River, lake, and wetland systems and their associated riparian lands form an important element of the natural resource base, create opportunities for recreation, and contribute to attractive and well-balanced communities. These resources can provide an essential avenue for relief of stress among the population and improve quality of life in both urban and rural areas. Such uses also sustain industries associated with outfitting and supporting recreational and other uses of the natural environment, providing economic opportunities. Increasing access and assuring safe use of these areas enhances public awareness and commitment to natural resources. Research has shown that property values are higher adjoining riparian corridors, and that such natural features are among the most appreciated and well-supported parts of the landscape for protection.

We demand a lot from our riparian buffers!

Sustaining this range of uses requires our commitment to protect and maintain them.

Summary

The following guidance suggestions highlight key points to improve riparian corridor management and create a more sustainable environment.

Riparian corridors or buffers along our waters may contain varied features, but all are best preserved or designed to perform multiple important functions.

Care about buffers because of their many benefits. Riparian buffers make sense and are profitable monetarily, recreationally, aesthetically, as well as environmentally.

Enhance the environmental corridor concept. Environmental corridors are special resources which deserve protection. They serve many key riparian corridor functions, but in some cases, could also benefit from additional buffering.

Avoid habitat fragmentation of riparian corridors. It is important to preserve and link key resource areas, making natural connections and avoiding habitat gaps.

Employ the adage "wider is better" for buffer protection. While relatively narrow riparian buffers may be effective as filters for certain pollutants, that water quality function along with infiltration of precipitation and runoff and the provision of habitat for a host of species will be improved by expanding buffer width where feasible.

Allow creeks and rivers room to roam across the landscape. Streams are dynamic and should be buffered adequately to allow for natural movement over time while avoiding problems associated with such movement.

Consider and evaluate buffers as a matter of balance. Riparian buffers are a living, self-sustainable shield that can help balance active use of water and adjoining resources with environmental protection.

Agricultural buffers can provide many benefits. Riparian buffers in agricultural settings generally work well, are cost-effective, and can provide multiple benefits, including possibly serving as areas to raise certain crops.

Urban buffers should be preserved and properly managed. Though often space-constrained and fragmented, urban buffers are important remnants of the natural system. Opportunities to establish or expand buffers should be considered, where feasible, complemented by good stormwater management, landscaping, and local ordinances, including erosion controls.

A buffer design tool is needed and should be developed. Southeastern Wisconsin and the Southern Lake Michigan Basin would benefit from development of a specific design tool to address the water quality function of buffers. Such a tool would improve on the currently available general guidance on dimensions and species composition.

Buffers are a good defense. Combined with environmental corridors, riparian buffers offer a good line of defense against changes which can negatively impact natural resources and the landscape.

Managing the Water's Edge

MORE TO COME

Future editions in a riparian buffer planning series are being explored with the intent of focusing on key elements of this critical land and water interface. Topics may include:

- Information sharing and development of ordinances to integrate riparian buffers into existing land management plans and programs
- Integration of stormwater management practices and riparian buffer best management practices
- Application of buffers within highly constrained urban corridors with and without brownfield development
- Installation of buffers within rural or agricultural lands being converted to urban uses
- Utilization of buffers in agricultural areas and associated drainage systems
- Integration of riparian buffers into environmental corridors to support resources preservation, recreation and aesthetic uses
- Preservation of stream courses and drainageways to minimize maintenance and promote protection of infrastructure
- Guidance for retrofitting, replacement, or removal of infrastructure such as dams and road crossings, to balance transportation, recreation, aesthetic, property value, and environmental considerations.
- Protection of groundwater recharge and discharge areas
- Protection of high quality, sensitive coastal areas, including preservation of recreational potential

MORE INFORMATION

This booklet can be found at http://www.sewrpc.org/RBMG-no1 . Please visit the website for more information, periodic updates, and a list of complementary publications.

* * *

This publication may be printed without permission but please give credit to the Southeastern Wisconsin Regional Planning Commission for all uses,
W239 N1812 Rockwood Drive, Waukesha, WI, 53187-1607
262-547-6721.

KENOSHA·MILWAUKEE·OZAUKEE·RACINE·WALWORTH·WASHINGTON·WAUKESHA
SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Staff Acknowledgements:

Principal Author: Tom Slawski, PhD, Principal Planner

Michael Hahn, P.E., P.H., Chief Environmental Engineer
Laura Kletti, P.E., Principal Engineer
Gary Korb, Regional Planning Educator, UW-Extension/SEWRPC
Ed Schmidt, GIS Planning Specialist
Mike Scott, GIS Application Specialist
Sara Teske, Research Analyst
Jeff Thornton, PhD, Principal Planner

www.sewrpc.org

May 7, 2010

PRINTED ON RECYCLED PAPER

Appendix D

JACKSON CREEK POTENTIALLY RESTORABLE WETLAND EVALUATION

Step 1. Information to Help Determine Appropriate Restoration Targets

A. **Pre-settlement vegetation -** Pre-settlement vegetation is mapped as wetland, prairie, oak savanna, and oak forest, with wetland, prairie, and oak savanna being the primary community types. Thus, pre-settlement wetlands in the Jackson Creek watershed likely contained prairie elements, particularly wetlands that were not seasonally inundated for prolonged periods.

B. **1937 Aerial imagery -** Agricultural land use was already extensive in 1937. Trees occurred primarily on uplands and were almost exclusively oaks. Stands generally ranged from oak woodland to oak savanna in terms of canopy coverage (~10-90%). Woody vegetation appears to have been insignificant in non-farmed wetlands. An example showing part of the project area is given below. The darkest patches are oak savanna and woodland. The smooth, uniform appearance of the wetlands indicates that woody vegetation was an insignificant component of the community at the time.

C. **Rare species records and inventories of natural communities -** Inventories, most recently between 1993 and 2005, from the Elkhorn RR Prairie remnant (SEWRPC CSH), Marsh Road RR Prairie remnant (SEWRPC NA-3), Jackson Creek Wetlands (SEWRPC NA-3), and Lake Lawn Wetland Complex (SEWRPC NA-3) are most relevant (see locations in Map I-8 in Chapter I of this report). Natural communities in these areas include prairies ranging wet-mesic to dry-mesic prairie, sedge fen, cattail-bulrush-burreed shallow marsh, tussock sedge meadow, Midwest cattail deep marsh, and dogwood-mixed willow shrub meadow. One state threatened and one state special concern species are known from these sites, with many other rare prairie species present. While small, the Elkhorn RR Prairie is by far the richest, with over 100 native species. The Lake Lawn Wetland Complex is the least diverse, with 41 native species.

Step 2. Appropriate Restoration Targets

All potentially restorable wetlands in the project area should be restored to open, herbaceous plant communities. However, the exact nature of the appropriate community in any given location depends upon the hydrologic regime in place upon the cessation of agricultural practices, removal of tile, and any earth moving activities that may occur. Small elevation gradients (< 1') can separate different wetland plant communities. Low areas that are inundated or saturated to the surface consistently only early in the growing season and that typically experience some degree of drying out by late summer should be restored using wet-mesic prairie species (Table 1). Restoration of slightly wetter areas should utilize sedge meadow species (Table 2) where flooding may occur in spring or after heavy summer rains, but the water table is generally just below the surface. Areas that are flooded for most of the growing season should be restored to shallow marsh (Table 3). In some areas, deep marsh may be an appropriate restoration target, but most presently farmed lands in the project area would be too wet to farm, if they were historically deep marsh. In all cases, the overarching goal should be to establish plant communities dominated by perennial, native species. Wet-mesic prairies can contain hundreds of native plant species, but a reasonable goal for restoration should be the establishment of at least 30 native species per acre. Establishing communities dominated by native sedge meadow species (e.g. tussock sedge) and shallow marsh species is a reasonable goal for sedge meadows and shallow marshes respectively.

Table D-1

A PARTIAL LIST OF SPECIES THAT ARE OFTEN EITHER CO-DOMINANT OR ABUNDANT IN WET-MESIC PRAIRIES WITHIN SOUTHEASTERN WISCONSIN

Latin Name	Common Name	Vegetation Type
Andropogon gerardii	Big bluestem	Grass
Calamagrostis canadensis	Canada blue-joint	Grass
Carex buxbaumii	Buxbaum's sedge	Sedge
Carex pellita	Broad-leafed wooly sedge	Sedge
Desmodium canadense	Showy tick-trefoil	Forb
Elymus canadensis	Canada wild rye	Grass
Liatris pycnostachya	Prairie blazingstar	Forb
Muhlenbergia racemosa	Prairie muhly	Grass
Pycnanthemum virginianum	Mountain mint	Forb
Silphium terebinthinaceum	Prairie dock	Forb
Spartina pectinata	Sloughgrass	Grass
Symphyotrichum novae-angliae	New England aster	Forb

Source: SEWRPC.

Table D-2

A PARTIAL LIST OF SPECIES THAT ARE OFTEN EITHER CO-DOMINANT OR ABUNDANT IN SEDGE MEADOWS. WITHIN SOUTHEASTERN WISCONSIN

Latin Name	Common Name	Vegetation Type
Asclepias incarnata	Marsh milkweed	Forb
Calamagrostis canadensis	Canada blue-joint	Grass
Carex aquatilis	Long-bracted tussock sedge	Sedge
Carex stipata	Awlfruit sedge	Sedge
Carex stricta	Tussock sedge	Sedge
Cicuta maculata	Water hemlock	Forb
Eutrochium maculatum	Spotted Joe-Pye weed	Forb
Impatiens capensis	Jewelweed	Forb
Iris virginica	Blue flag iris	Forb
Juncus dudleyi	Common rush	Rush
Stachys tenuifolia	Smooth hedge-nettle	Forb
Symphyotrichum puniceum (syn. S. lucidulum and S. firmum)	Marsh aster	Forb

Source: SEWRPC.

Table D-3

A PARTIAL LIST OF SPECIES THAT ARE OFTEN EITHER CO-DOMINANT OR ABUNDANT IN SHALLOW MARSHES. WITHIN SOUTHEASTERN WISCONSIN

Latin Name	Common Name	Vegetation Type
Carex atherodes	Slough sedge	Sedge
Carex lacustris	Lake sedge	Sedge
Eleocharis palustris	Spike rush	Sedge
Glyceria grandis	Giant manna grass	Grass
Juncus torreyi	Torrey's rush	Rush
Leersia oryzoides	Rice cut-grass	Grass
Sagittaria latifolia	Arrowhead	Forb
Schoenoplectus fluviatilis	River bulrush	Sedge
Schoenoplectus tabernaemontani	Soft-stem bulrush	Sedge
Sparganium eurycarpum	Bur-reed	Forb
Stachys tenuifolia	Smooth hedge-nettle	Forb
Typha latifolia	Broad-leaved cattail	Forb

Source: SEWRPC.

Areas restored that are outside of wetlands should be restored to prairie or bur-oak savanna, with dry-mesic prairie and savanna on slopes greater than ~5% and mesic prairie on level ground adjacent to wetlands. The benefits of restoring these community types adjacent to wetlands are that they would minimize disturbances near the wetland edge that would otherwise promote the establishment and spread of invasive species, reduce the amount of sediment and surface-runoff entering wetlands from surrounding uplands after heavy rain events (sediment and nutrients carried by runoff also promote invasive species), and sunny upland habitats adjacent to wetlands bolster the wildlife value of wetlands. For instance, many turtles and snakes require upland habitat adjacent to wetlands for nesting.

Step 3. Prioritizing sites

Consider, at least qualitatively, the below factors in order to maximize potential for successfully establishing native-dominated communities and conserving existing native plant communities.

A. **Parcel size -** Large and/or adjacent parcels should be priorities, because restored areas that maximize interior versus perimeter will be the easiest to manage and experience less pressure from invasive species.

B. **Within-parcel ecological considerations -** Initial restoration of wet-mesic prairie might be less costly than the restoration of sedge meadow or marsh, because more prairie species can be successfully established from seed versus transplants. Thus, areas with hydrology appropriate for wet-mesic area might be priorities. However, invasive species management issues in wet-mesic prairies will likely increase their long-term management costs relative to wetter community types, which tend to support fewer invasive species that also happen to be easier to control (see discussion under "Invasive Species"). However, parcels that can offer greater habitat complexity (i.e. marsh, sedge meadow, wet-mesic prairie, and even uplands) rather than just one community type have the potential to support more species and more ecological functions. In any case, candidate parcels should be surveyed for invasive species, so that likely future actions and costs for invasive species management can be determined, at least on a relative basis among candidate parcels. Those parcels where the boundary between planned restoration activities and invasive species (e.g. reed canary grass) are minimized should be much preferred.

C. **High-quality existing natural communities -** Within the project area the Elkhorn RR Prairie (SEWRPC CSH) and Jackson Creek Wetlands (SEWRPC NA-3) are the most valuable natural features in terms of their numbers of rare species and overall species richness. The Jackson Creek Wetlands also contain elements of calcareous fen vegetation. Between these two natural areas, it would be most feasible to acquire agricultural lands adjacent to the Jackson Creek Wetlands. The Jackson Creek Wetlands already buffer Jackson Creek from adjacent agricultural and residential lands, but the existing richness and uniqueness of these wetlands merits that they themselves be buffered against run-off from adjacent lands. Effective buffering would require the restoration of uplands adjacent to the Jackson Creek Wetlands and other adjoining wetlands. The Lake Lawn Wetlands (NA-3) would also benefit from the restoration of an adjacent upland buffer, but this area, though relatively large, retains less of its natural character and supports far fewer species than the Jackson Creek Wetlands.

Step 4. Implementation of Restoration and Management Process

A. **Prairie and Sedge Meadow and Marsh Restoration** - What follows is a brief summary of the applicable restoration process. The Minnesota Board of Soil and Water Resources and the Minnesota Department of Transportation have produced an excellent, detailed restoration guide for wetlands[1].

[1] http://www.shootingstarnativeseed.com/documents/BWSR-wetland-guide.pdf

Ensure that no herbicide with residual activity (e.g. atrazine) has been used for at least one year on agricultural lands. Ideally, cultivated land is farmed through the growing season that precedes restoration planting in order to prevent the proliferation of weeds. Restoration may then be attempted with seed broadcast on to bare, agricultural land. Seeding should occur from mid-November through December, or otherwise over shallow snow or bare ground before February 15. This is because many species require a cool, moist period prior to germination, and many wetland species will even germinate in the cool weather of early spring, which gives them a good head start. Seeding at the appropriate time may be risky in areas that are likely to be inundated early in the spring, because this may lift seed and carry it away. In such locations, plugs and/or pre-vegetated mats may be planted instead. Many of these species spread extensively by rhizomes, so planting plugs spaced a foot or two apart can achieve native plant coverage rather quickly. Plugs can be planted when the soil is moist and expected to remain so, and pre-vegetated mats can be staked into standing water, but planting in autumn should occur early enough that adequate root development can occur to prevent frost heave. The annual weeds that grow in fallow farm fields have the potential to kill native seedlings by robbing them of light. If soils are firm enough to allow it, areas that develop closed canopies of annual weeds should be mowed to a height of 8" as needed to prevent native seedling mortality. This is time sensitive, and an implementation plan should be in place before it is needed. Mowing is best performed by a sickle mower, which lays down cut material in an even layer that quickly dries and deteriorates. Rotary mowers tend to leave clumps that can smother seedlings, but mowing with a rotary mower is still preferred to not mowing vigorous annual weeds.

B. **Invasive Species -** Wetland plant communities are extremely vulnerable to invasive species, because water can disperse the seeds or vegetative parts of invasive plants, and because nutrients and sediments that are funneled from surrounding agricultural and developed lands diminish the relative competitive abilities of both existing and establishing native wetland vegetation. Even if native species are sown or transplanted into former agricultural lands, the end result is likely to be large areas dominated by reed canary grass (*Phalaris arundinacea*) or other invasive species unless plans are in place to detect and control invasive species from the beginning. Once an area becomes dominated by reed canary grass, reversal of the situation is costly in terms of cost and effort. Invasion is also promoted by disturbance, so control efforts that create disturbance and negatively impact desired vegetation can be counter-productive. Especially troublesome wetland invasive plants aside from reed canary grass in SE Wisconsin include giant reed (*Phalaris australis* subsp. *australis*), giant manna grass (*Glyceria maxima*), hairy willow-Herb (*Epilobium hirsutum*), and purple loosestrife (*Lythrum salicaria*).

C. **Other Long-Term Management** – Prescribed burns will be important for the long term maintenance of wet-mesic prairie and the drier portions of sedge meadows. Without fire, these areas will be invaded by shrubs and trees, including both common buckthorn (*Rhamnus cathartica*) and glossy buckthorn (*Frangula alnus*). Fire should be prescribed as soon after restoration as a fire will carry through the vegetation and thereafter at 2-5 year intervals.

Appendix E

SOIL QUALITY INDICATORS: PHYSICAL, CHEMICAL, AND BIOLOGICAL INDICATORS FOR SOIL QUALITY ASSESSMENT AND MANAGEMENT

USDA Natural Resources Conservation Service

Indicator	Test	Function
?	?	?

Soil Quality Indicators

Physical, Chemical, and Biological Indicators for Soil Quality Assessment and Management

A series of information sheets for physical, chemical, and biological indicators is available to help conservationists and soil scientists with soil quality assessment. Use this guide to learn more about selecting appropriate soil quality indicators to assess specific soil functions. Visit http://go.usa.gov/zUAH for more information and to download copies of the information sheets.

What is soil quality?

Concise definitions for soil quality include "fitness for use" and "the capacity of a soil to function." Combining these, soil quality is the ability of a soil to perform the functions necessary for its intended use.

Soil functions include:

- sustaining biological **D**iversity, activity, and productivity
- regulating **W**ater and solute flow
- **F**iltering, buffering, degrading organic and inorganic materials
- storing and cycling **N**utrients and carbon
- providing physical **S**tability and support

TIP: *The* ***Function*** *icon at the top right corner of each information sheet uses* ***D, W, F, N, or S*** *to show the function(s) that is most affected by the subject indicator.*

How is soil quality measured?

The quality of a soil, or its capacity to function, is evaluated using ***inherent*** and ***dynamic*** soil properties. These properties serve as ***indicators*** of soil function because it is difficult to measure function directly and observations may be subjective.

Inherent, or use-invariant, soil properties change very little or not at all with management. Inherent soil properties form over thousands of years and result primarily from the soil forming factors: climate, topography, parent material, biota, and time. Examples of inherent properties are soil texture, type of clay, depth to bedrock, and drainage class.

Dynamic, or management dependent, soil properties are affected by human management and natural disturbances over the human time scale, i.e., decades to centuries. Significant changes in dynamic soil properties can occur in a single year or growing season. There are many dynamic soil properties, several of which are the subjects of this information sheet series.

Soil indicators are often divided into **P**hysical, **C**hemical and **B**iological categories depending on how they affect soil function. However, these categories are not always clearly defined since a soil property or indicator can affect multiple soil functions or categories.

TIP: *The* ***Indicator*** *icon at the top right corner of each information sheet uses* ***P, C, or B*** *to show the category in which the indicator best fits.*

Depending on the indicator and the method used to evaluate it, properties are assessed in the **F**ield, **L**aboratory, or even an **O**ffice when no special equipment is required.

TIP: *The* ***Test*** *icon at the top right corner of each information sheet uses* ***F, L, or O*** *to show where indicator assessment takes place for the method highlighted on the information sheet.*

Selecting soil quality indicators

A soil function – indicator matrix (fig. 1) can be used to select appropriate indicators for assessing a particular soil function. Additionally, if an indicator is already being measured, the matrix reveals the indicator's relationship to other soil functions, thus maximizing the usefulness of the collected data.

Each indicator listed in the matrix below is linked to its accompanying information sheet. The information sheets:

- define and describe the indicator
- relate the indicator to soil function
- discuss inherent and dynamic factors influencing it
- suggest management practices to improve soil function
- provide a reference for an assessment method

Figure 1. Soil function – indicator matrix: when a direct relationship exists between the function and indicator, increasing reliability and ease of use of the associated assessment method is shown with increasing stars.

	Soil Function				
Soil Quality Indicator	**Sustain biological diversity, activity, and productivity "D"**	**Regulate and partition water and solute flow "W"**	**Filter, buffer, degrade, detoxify organic and inorganic materials "F"**	**Store and cycle nutrients and carbon "N"**	**Physical stability and support for plants and structures associated with human habitation "S"**
Aggregate Stability [a,c,f]	★★	★★	—	★★	★★½
Available Water Capacity [a,g]	★★★	★★½	—	★★	—
Bulk Density [a,h]	★★½	★★★	—	★	★★★
Earthworms [b,d]	★★★	—	★★★	★★★	★★★
Infiltration [b,e,i]	—	★★	★	—	—
Particulate Organic Matter [a,c]	★★★	★★★	★★★	★★★	★★★
Potentially Mineralizable Nitrogen [a,c]	★★★	—	—	★★★	—
Reactive Carbon [a]	★★	★	★★★	★★	★★
Slaking [b,e,i,j]	★	★★½	—	—	—
Soil Crusts [b,d]	—	★★½	—	—	—
Soil Electrical Conductivity [b]	—	★★★	—	—	—
Soil Enzymes [a]	★★★	—	—	★★★	—
Soil Nitrate [b]	★	★	—	—	—
Soil pH [b,d]	★★	★★★	★★★	★★★	—
Soil Respiration [a,b,c]	★★★	—	★	★★★	★★
Soil Structure and Macropores [b,d]	★½	★½	★	★	★★
Total Organic Carbon [a]	★★★	★★★	★★★	★★★	★★★

[a] laboratory/office method
[b] field method
[c] time consuming
[d] simple visual observation
[e] variability requires large sample number
[f] perhaps the most informative physical indicator
[g] important for drought prone areas
[h] important for weight to volume conversions, small sampling errors result in significant interpretation problems
[i] effective educational method
[j] qualitative

Appendix F

JACKSON CREEK CROSS-SECTION AND POINT FEATURE DATA DESCRIPTION OF FIELD MEASUREMENTS AND LOCATIONS: SUMMER 2012-2013

CROSS-SECTION DATA

STREAM BANK CHARACTERISTICS

Bankfull Width: The stream channel that is formed by the dominant discharge, also referred to as the active channel, which meanders across the floodplain as it forms pools and riffles. Defined by the discharge that occurs when water just begins to leave the channel and spread onto the floodplain.

Bank Height: Height of the bank from the streambed to the top edge of the lateral scour line as shown in Figure F-1.

Undercut Depth: A bank that has had its toe of slope, or base, cut away by the water action creating overhangs in the stream as shown in Figure F-1.

Slope: Ratio of horizontal distance divided by the vertical height of the streambank as shown in Figure F-2.

Instream habitat characteristics

Width: The width of the existing water surface measured at a right angle to the direction of flow from shore to shore.

Maximum Depth: The vertical height of the water column from the existing water surface level to the lowest point of the streambed.

Habitat Type: An aquatic unit, consisting of an aggregation of habitats having equivalent structure, function, and responses to disturbance. Pool, riffle, and run habitat types were observed in the Jackson Creek watershed.

- A pool is that area of the water column that has slow water velocity and is usually deeper than a riffle or run (Figure F-3). Pools usually form around bends or around large-scale obstructions that laterally constrict the channel or cause a sharp drop in the water surface profile.
- Riffles are portions of the water column where water velocity is fast, stream depths are relatively shallow, and the water surface gradient is relatively steep (Figure F-4).
- A run is that area of the water column that does not form distinguishable pools or riffles, but has a rapid nonturbulent flow. A run is usually too deep to be a riffle and has flow velocities too fast to be a pool.

Figure F-1

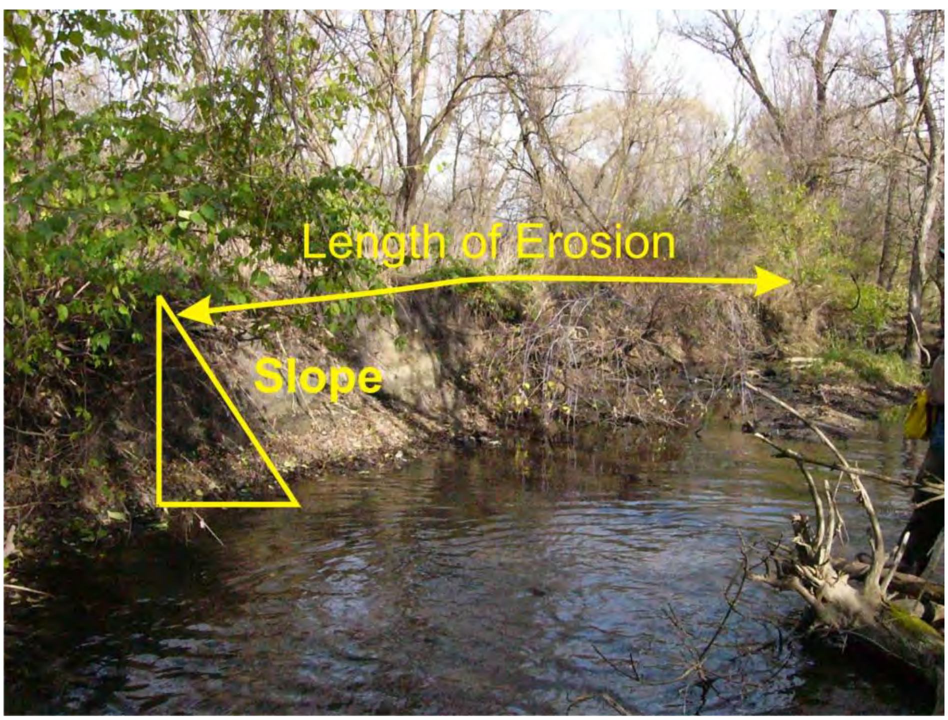
EXAMPLE OF BANK HEIGHT AND UNDERCUT DEPTH MEASURED AT AN ACTIVELY ERODING SITE

NOTE: These photos were not taken within the Jackson Creek watershed and are for illustrative purposes only.

Source: SEWRPC.

Figure F-2

EXAMPLE OF LENGTH OF EROSION AND BANK SLOPE MEASURED AT AN ACTIVELY ERODING SITE



NOTE: This photo was not taken within the Jackson Creek watershed and is for illustrative purposes only.

Source: SEWRPC.

Figure F-3

TYPICAL DEEP WATER/LOW VELOCITY POOL HABITATS IN THE JACKSON CREEK WATERSHED: 2013

Source: SEWRPC.

Figure F-4

TYPICAL SHALLOW WATER/HIGH VELOCITY RIFFLE HABITATS IN THE JACKSON CREEK WATERSHED: 2013

Source: SEWRPC.

Substrates: Refers to the materials that make up the streambed. Substrate composition in the streams of the Jackson Creek watershed was determined visually by recording the dominant substrate types within the transect. The following categories of substrate type were used.

- Bedrock: Solid rock forming a continuous surface.
- Boulder: Rocks with a diameter of 10 to 20 inches.
- Cobble: Rocks with a diameter of 2.5 to 10 inches.
- Gravel: Rocks with a diameter of 0.07 to 2.5 inches.
- Sand: Inorganic particles smaller than gravel, but coarser than silt with a diameter of 0.002 to 0.07 inch.
- Silt: Fine inorganic particles, typically dark brown in color. Feels greasy and muddy in hands. The material is loose and does not retain shape when compacted into a ball and will not support a person's weight when it makes up the stream bottom. Silt particles have a diameter of less than 0.0001 inch.
- Peat: A fibrous mass of organic matter in various stages of decomposition, generally dark brown to black in color and of spongy consistency.
- Clay: Very fine, inorganic, dark brown or gray particles. Individual particles are barely visible or not visible to the unaided eye. The particles feel gummy and sticky and slippery underfoot. Clay particles retain shape when compacted and partially or completely support a person's weight when they comprise the stream bottom. Clay particles have a diameter of less than 0.0001 inch.

Sediment Depth: The depth of fine sediments (usually silt) that overlay or comprise the streambed. Sediment depth is an indicator of sediment deposition and was measured to the nearest 0.5 inch.

Woody Debris: Large pieces or aggregations of smaller pieces of wood (e.g., logs, large tree branches, root tangles) located in, or in contact with, the water surface.
Cover: This can be one, or any combination, of characteristics that include undercut banks, overhanging vegetation, water velocities, logs or woody debris, deep pools, boulders and other substrates, aquatic macrophytes, and algae that provide 1) protection from predators, 2) feeding areas, 3) spawning habitat, or 4) some other benefit such as shading.

POINT FEATURE DATA

Beaver Dam: A collection of large or small pieces of wood (e.g., logs and tree branches) creating a barrier or dam-like structure within the stream system, often resulting in a beaver pond upstream.

Crossing: A structure (e.g., bridge or culvert) that crosses over is lying within the stream channel.

Drain Tile: A subsurface drainage system (plastic or metal corrugated pipe) that allows excess water from agricultural and urban lands to discharge into a drainage ditch, stream or wetland.

Pool: A single maximum depth is recorded within a pool habitat (See Habitat Type above and Figure F-3).

Riffle: A single maximum depth is recorded within a riffle habitat (See Habitat Type above and Figure F-4).

Stormwater Outlet: Any culvert or drainage system that allows for excess storm water to discharge into a certain location.

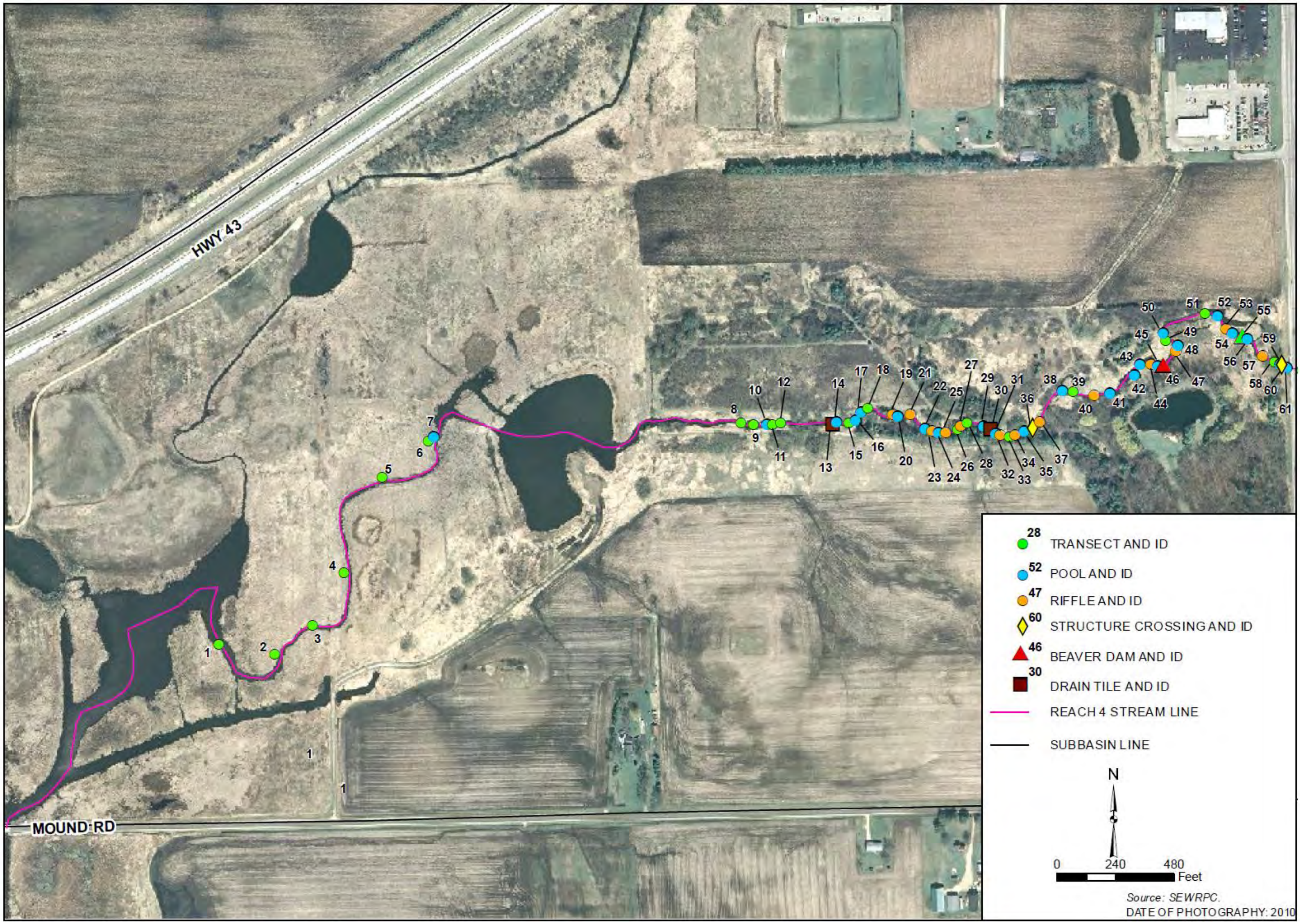
Trash: Identify and describe trash or any debris that is within or adjacent to the stream channel.

Woody debris Jam: Identify and describe the extent of the obstruction in the channel (See description above).

The transect and point feature data within the Jackson Creek watershed are shown on Maps F-1 through F-5 below. Table F-1 below lists the data and measurements collected at each transect along with a description detailing how each measurement is taken as well as description of the point features mapped. Note that all of this data, site locations, and associated shape files are available on a CD in the inside back cover of this report or available to download from the SEWRPC website at http://www.sewrpc.org/SEWRPC/DataResources.htm

Map F-1

JACKSON CREEK WATERSHED STREAM INVENTORY LOCATION MAP: 2012-2013

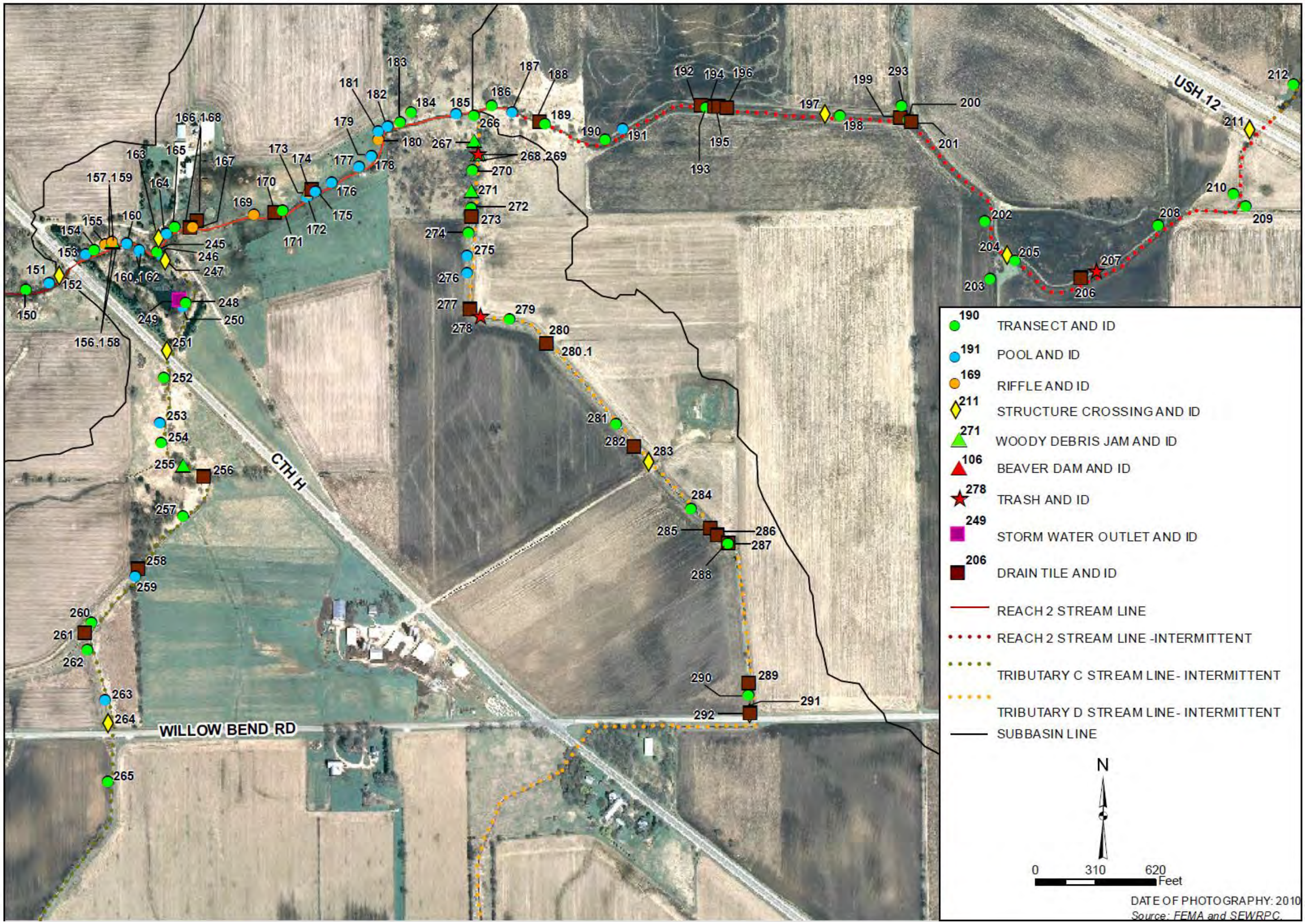


Map F-2

JACKSON CREEK WATERSHED STREAM INVENTORY LOCATION MAP: 2012-2013

Map F-3

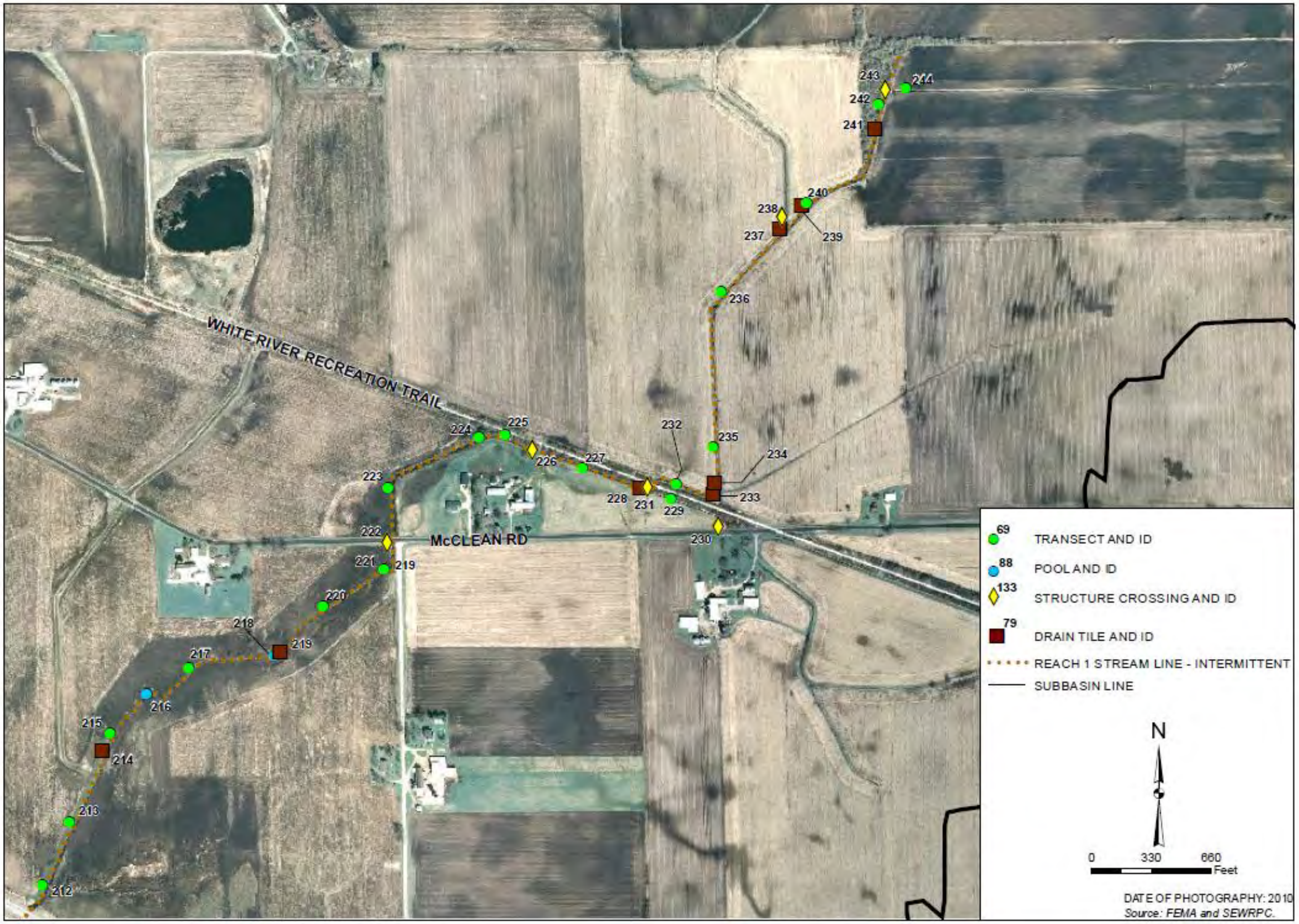
JACKSON CREEK WATERSHED STREAM INVENTORY LOCATION MAP: 2012-2013



PRELIMINARY DRAFT

Map F-4

JACKSON CREEK WATERSHED STREAM INVENTORY LOCATION MAP: 2012-2013



Map F-5

JACKSON CREEK WATERSHED STREAM INVENTORY LOCATION MAP: 2012-2013

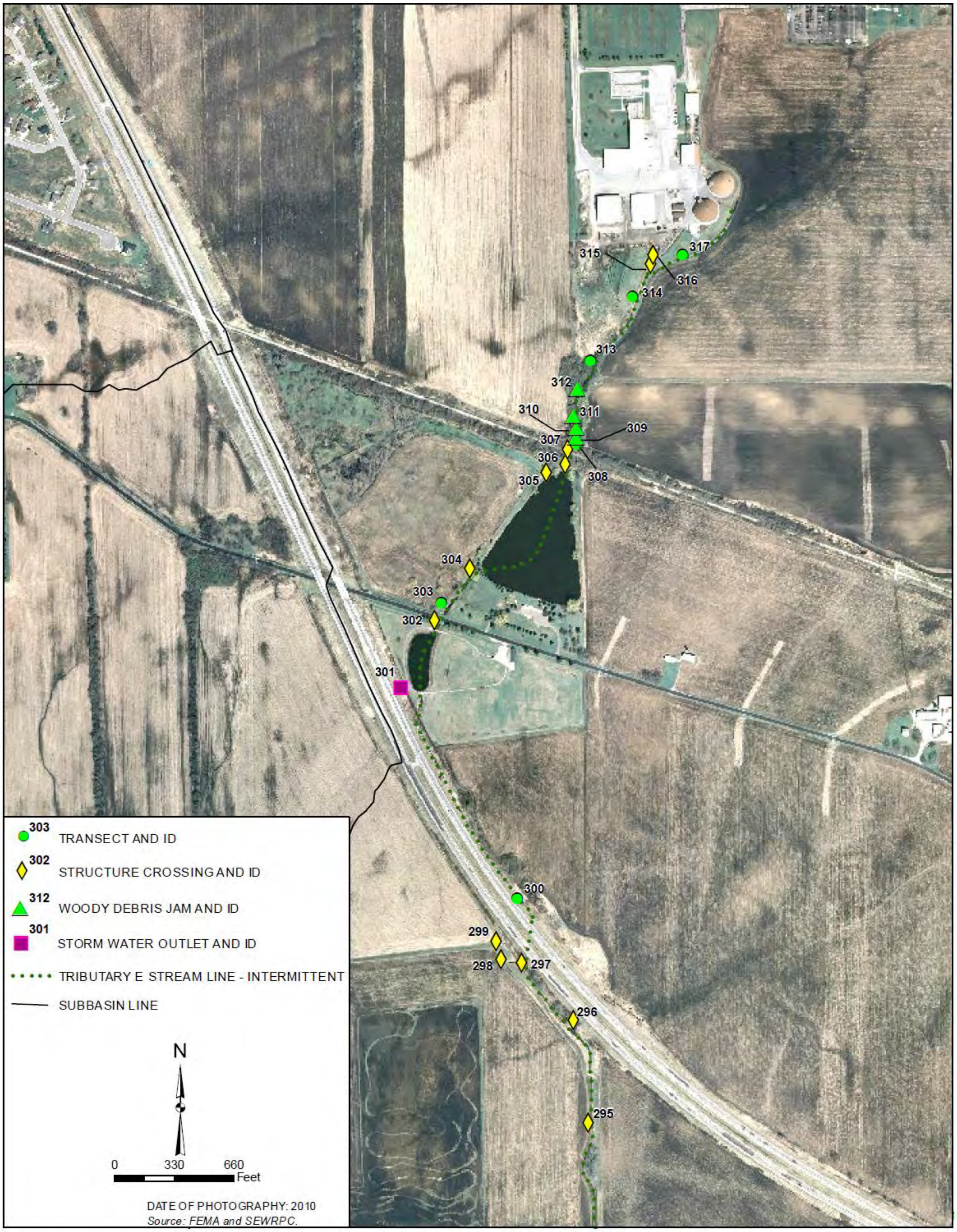


Table F-1

TRANSECT AND POINT FEATURE DATA DESCRIPTIONS COLLECTED AS PART OF THE JACKSON CREEK STREAM INVENTORY CONDUCTED BY SEWRPC STAFF: 2012-2013 (SEE MAPS F1-F5)

Parameters	Measurement/Data Description
Transect Features	
Class	Each point surveyed was assorted into a *class*, such as Cross-Section Crossing, Drain Tile, Stormwater Outlet, Pool, Riffle, Trash and Woody Debris Jam, Drain Tile, Debris Jam, Beaver Dam, Stream Crossing, Trash and Stormwater Outlet.
MaxWater_Riff_Pool_combined	Includes the maximum water depths measured at surveyed cross-sections, pools and riffle habitat locations, riffle locations and pool locations.
AppdxMap_ID	Map identification number on Appendix Stream Inventory Map __.
Wat_WID	*Wetted (water) stream width* or low flow channel width at the time of the survey at stream cross-sections.
Incised_H	*Incised Height* ***was*** collected at stream cross-sections where the stream channel is substantially disconnected from its floodplain. This is a vertical measurement from middle of streambed to the height of the lowest bank.
Incised_W	*Incised Width was* collected at cross-sections where the stream is substantially disconnected from its floodplain. This is a horizontal measurement from top of lowest bank height to the opposite bank.
Bank_Wid	*Bankfull Width*. The measurement of the channel width that occurs when water just begins to leave the channel and spread onto the floodplain.
LB_SLOPE	*Left Bank Slope.* The left bank ratio of horizontal distance divided by the vertical height of the streambank. This measurement was taken at stream cross-sections.
RB_SLOPE	*Right Bank Slope.* The right bank ratio of horizontal distance divided by the vertical height of the streambank. This measurement was taken at stream cross-sections.
BF_avg_Depth_ft_	*Average Bankfull Depth (ft.).* The average depth measured at the bankfull discharge, or where water would flow out from the banks. Bankfull depths were measured at three to five points evenly spaced across a surveyed cross-section.
BF_max_Depth_ft_	*Maximum Bankfull Depth (ft.).* The maximum depth measured at the bankfull discharge, or where water would flow out from the banks. Bankfull depths were measured at three to five points evenly spaced across a surveyed cross-section.
Water_avg_Depth_ft_	*Average Water Depth (ft.).* The average water depth across the stream channel measured at stream cross-sections. Water depths were measured at three to five points evenly spaced across a surveyed cross-section
Sed_avg	*Average Sediment Depth (ft.)* The average depth of sediment measured across the stream at surveyed cross-sections.
Sed_max	*Maximum Sediment Depth (ft.)* The maximum depth of sediment measured across the stream at surveyed cross-sections.
LBUndct_Max	*Maximum Left Bank Undercut (ft.)* Undercut banks occur when the toe of the bank is eroded away, leaving just the top of the bank overhanging the stream. This measures the deepest undercut point on the left bank of a surveyed cross section.
LBUndct_Avg	*Average Left Bank Undercut (ft.)* Undercut banks occur when the toe of the bank is eroded away, leaving just the top of the bank overhanging the stream. This measurement is the average depth of the undercutting on the left bank.
RBUndct_Max	*Maximum Right Bank Undercut (ft.)* Undercut banks occur when the toe of the bank is eroded away, leaving just the top of the bank overhanging the stream. This measures the deepest undercut point on the right bank of a surveyed cross section.
RBUndct_Avg	*Average Right Bank Undercut (ft.)* Undercut banks occur when the toe of the bank is eroded away, leaving just the top of the bank overhanging the stream. This measurement is the average depth of the undercutting on the right bank.
Silt_Per	*Percent Silt.* The percentage of streambed substrates at a surveyed cross-section that are made up of silt.
Sand_Per	*Percent Sand.* The percentage of streambed substrates at a surveyed cross-section that are made up of sand.
Gravel_Per	*Percent Gravel.* The percentage of streambed substrates at a surveyed cross-section that are made up of gravel.
Cobble_Per	*Percent Cobble.* The percentage of streambed substrates at a surveyed cross-section that are made up of cobbles.

Boulder_Per	*Percent Boulder.* The percentage of streambed substrates at a surveyed cross-section that are made up of boulders.
Bedrock_Per	*Percent Bedrock.* The percentage of streambed substrates at a surveyed cross-section that are made up of bedrock.
Clay_Per	*Percent Clay.* The percentage of streambed substrates at a surveyed cross-section that are made up of clay.
HABITAT	Type of stream habitat at surveyed stream cross-sections (pool, riffle, or run).
VELOCITY	An observation taken at stream cross-sections of how fast (slow, moderate, fast) the water is flowing in the stream.
CANOPY	Portion of the stream at a surveyed stream cross-section that is shaded by overhanging trees, shrubs, or grasses. **0-** unshaded; **1-** partially shaded; **2-** halfway shaded; **3-** mostly shaded.
AMT_COV	*Amount of instream fish cover.* The percent of stream containing some form of fish cover at a surveyed cross-section. **0** indicating none or 0 percent instream cover; **1-** less than 25 percent instream cover; **2-** 25 to 75 percent instream cover; **3-** greater than 75 percent instream cover.
WOOD_DEB	*Woody Debris.* The percent of stream that contains woody debris at a surveyed cross-section. **0** indicating none or 0 percent of stream containing woody debris; **1-** less than 25 percent; **2-** 25 to75 percent; **3-** greater than 75 percent of woody debris.
AQ_PLA	*Aquatic Plants.* The percent stream that contains aquatic plants at a surveyed cross-section. . **0** indicating none or 0 percent of aquatic vegetation; **1-** less than 25 percent; **2-** 25 to75 percent; **3-** greater than 75 percent of aquatic plants.
ALGAE	Percent of stream that contains algae at a surveyed stream cross-section. **0** indicating none or 0 percent of stream contains algae; **1-** less than 25 percent; **2-** 25 to75 percent; **3-** greater than 75 percent of algae.
VEG_CVR	*Vegetative Cover.* Indicates that overhanging vegetation fish cover was present at the surveyed cross-section.
PLT_CVR	*Aquatic Plant Cover.* Indicates that aquatic plant fish cover was present at the surveyed cross-section.
ALG_CVR	*Algae Cover.* Indicates that algae fish cover was present at the surveyed cross-section.
WOOD_CVR	*Woody Debris Cover.* Indicates that woody debris fish cover was present at the surveyed cross-section.
ROOT_CVR	*Root Cover.* Indicates that root cover was present at the surveyed cross-section.
BOULD_CVR	*Boulder Cover.* Indicates that boulder cover was present at the surveyed cross-section.
LB_Shape	*Left Bank Shape.* Left bank angle measured at surveyed stream cross-sections. **1-** 90 degree bank angle; **2**- 45 to 90 degree bank angle; **3**- less than 45 degree bank angle
RB_Shape	*Right Bank Shape.* Right bank angle measured at surveyed stream cross-sections. **1-** 90 degree bank angle; **2-** 45 to 90 degree bank angle; **3-** less than 45 degree bank angle
Point Features	
Beaver Dam	Indicates that a beaver dam was identified during the instream field survey. Beaver dam height and upstream impounded water are measured.
Crossing	*A structure*, either a bridge or culvert crossing, identified along with its measurements during the instream field survey.
Drain Tile	A drain tile identified within the stream system. Measurements taken include diameter and material of drain tile (metal or plastic), left or right bank and whether or not it was actively draining.
Pool	A *substantial pool* or deep point within the water column identified. Water depth and width are measured.
Riffle	Portions of the water column where water velocity is fast, stream depths are relatively shallow, and the water surface gradient is relatively steep. Measurements include riffle width, depth and length.
Stormwater Outlet	Stormwater drainage systems identified. Includes stormwater pond outlets or drainage ditch culverts. Culvert diameter, location, and culvert material are noted.
Trash	Any tire(s), large pieces of metal, or plastic material identified within the streambed that would need to be removed. Description and location of the trash is noted during the field survey.
Woody Debris Jam	Large pieces or aggregations of smaller pieces of wood (e.g., logs, large tree branches, root tangles) located in, or in contact with, the water surface often resulting in water backup or interfering with stream flow. General description of the woody debris jam is noted, such as size, impoundment of water and any impacts it is creating within the stream system.

Source: SEWRPC.

Appendix G

CHANNEL-FORMING DISCHARGES FACT SHEET

THE OHIO STATE UNIVERSITY EXTENSION

FACT SHEET

Agriculture and Natural Resources

AEX-445-03

Channel-Forming Discharges

Andy Ward, Jessica L. D'Ambrosio, and Jonathan Witter
The Ohio State University Department of Food, Agricultural, and Biological Engineering
and the Ohio NEMO Program

What Is Channel-Forming Discharge?

Have you ever wondered why a stream is located where it is, is bigger or smaller than another stream, why it is crooked, or why some streams are wide and shallow while others are narrow and deep? The answers to these questions enable us to understand the origin and evolution of a stream system, which will help us to develop ways to protect, enhance, or sustain these complex and fragile ecosystems. Streams are constantly changing and, like any physical system, trying to create balance between all of the factors acting on them. The balance of constantly changing factors is called *dynamic equilibrium*. Two primary influences on the equilibrium of a stream system are the quantity and movement of both water and sediment. We call the movement of water or sediment *discharge*. The quantity and movement of both water and sediment tend to balance each other within the confines of the stream channel and this is what, ultimately, gives the stream bed and banks their shape or form. We also can call this movement *channel-forming discharge*. The purpose of this fact sheet is to provide an explanation of channel-forming discharges, their importance to stream systems, and how they can be determined.

Factors That Give Stream Channels Shape

A natural stream running through the middle of a valley will have a main channel and a connected *active floodplain*—land closest to the channel that is flooded often (Figure 1). The channel carries water and sediment discharges through the system that is related to a specific, predictable amount of flow called the *bankfull discharge* or *effective discharge*. When the discharge is higher than the channel can hold within its banks, the extra water and sediment spills out over the banks and onto the floodplain. The active floodplain, if connected to the channel, helps to decrease the speed at which water is flowing and helps to maintain dynamic equilibrium so that the bed and banks are not washed away during a big storm event.

Copyright © 2008, The Ohio State University

Figure 1. A small urban stream with a connected active floodplain containing less than the bankfull discharge; note the distinct shape and size of both stream banks. B: The same stream with a bankfull, or channel-forming discharge, after a rainstorm.

If we understand the balance between water and sediment discharges—or *fluvial processes*—we can begin to predict what happens to the stream when these factors are out of balance (Figure 2). For example, if higher water flow is not able to spill out onto the floodplain, it may be picking up sediment from the bed and banks. This is called *degradation* and can cause erosion and *scour* (Figure 2A, C). On the other hand, if water containing a lot of sediment is flowing very slowly because of a dam installed downstream, the heavier sediment particles will drop out of the water flow and deposit on the bed and banks. This is called *aggradation,* which is a build up of material (Figure 2B, D).

The *bankfull discharge* is often related to the amount of water flowing in a stream that fills the main channel and begins to spill onto the active floodplain[1, 2]. Bankfull discharge is a range of flows (volume per unit time) that is most important in forming a channel, floodplains (benches), and banks. When we talk about *bankfull discharge,* we also talk about the collection and/or analysis of data relating to the channel shape and size, or *dimension*[3, 4].

The term *effective discharge* is the amount of water (again, volume per unit time) that transports the most sediment over the long term[2]. When we talk about effective discharge we also talk about the collection and/or analysis of data related to the type and amount of sediment in that flow of water. This moving sediment is called the *suspended* and/or *bedload sediment*[5]. Often, the terms *bankfull* and *effective discharge* are considered to be synonymous. For example, Leopold[6] stated that bankfull discharge is "considered to be the channel-forming or effective discharge". Powell and others[7] found that, for large rivers in Ohio, the bankfull and effective discharge were often similar.

The term *bankfull* causes some confusion in some artificial, or constructed, channels such as agricultural ditches because the size of the ditch is unrelated to *fluvial processes*, or the size that nature would form naturally. In streams that are *entrenched* or *incised*, or too deep (this is common in urban and many rural settings), the bankfull stage is lower than the top of the bank and is identified as a bench, change in bank material and vegetation, the top of point bars, or a scour line. By taking measurements of the stream, we can predict the size and shape of the stream, or its *bankfull geometry*, when it is in equilibrium.

The force that flowing water exerts on the bed and banks of a stream channel is called *shear stress*. Shear stress is typically used to describe scouring or degrading of the bed and banks. Except on bends, it is related to the depth of flow of the water and the slope of the channel bed. The deeper the water, or the steeper the slope of the bed, the greater the force. For every place in a stream there will be some combination of water depth and bed slope that will cause the bed or banks to scour. A simple but approximate way of estimating when scour will occur is to use Andy's

Copyright © 2008, The Ohio State University

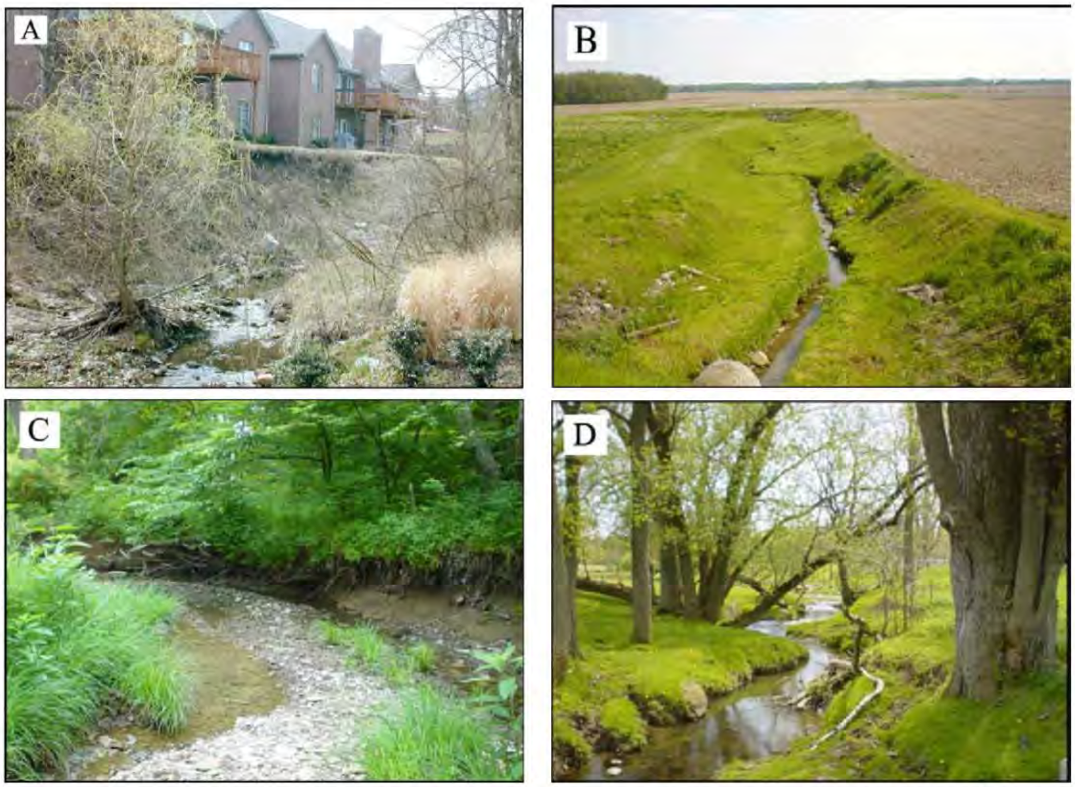


Figure 2. A: A deeply incised stream that is out of equilibrium due to urbanization. B: An agricultural ditch was built too wide and has naturally started forming a new floodplain and is changing its form to regain equilibrium. C: Aggradation of sediment, called a flat point bar, on the left is occurring to regain equilibrium; the point bar will continue to build up until it is at the same level as the connected active floodplain on the left side of the picture. D: An incised rural stream that has become unattached from its active floodplain, the pasture on either side of the trees.

Rule, which states, "if the depth of flow is 1 foot and the bed slope is 1% then the average size bed material that will start to move will be 1 inch." If you use those particular units, multiplying depth and slope will give you the approximate sediment diameter. For example, if the depth of flow in the channel is 4 feet and the bed slope is 0.5% then the average size bed material (called the d_{50}) that will move with the flow of water will be 2 inches (4 *multiplied by* 0.5).

For many streams that are in equilibrium we will find, by using Andy's Rule, that the average bed material size is related to the average bankfull depth and the bed slope. The method is not exact and in some cases the shear stress is better related to other factors. If there is no relationship between bankfull depth, bed slope, and bed material size, it might be an indication that the stream is not in equilibrium. In a straight section of a stream (called a *reach*) average shear stresses on the banks are about 80% of those on the bed. On the outside of a bend, the shear stresses on the banks might be several times larger than those on the bed. This is the main reason why banks erode and streams shift their position.

What Data Do I Need To Determine Channel-Forming Discharges?

Obtaining highly detailed stream data, also called *surveying*, can be a time consuming and difficult activity, particularly in large rivers. Fortunately, useful guidelines for smaller, shallower streams—also

Copyright © 2008, The Ohio State University

called *wadeable*—are available[8]. For each *reach*, data are collected over a stream length equal to at least 20 times the channel width so that the survey includes at least two bends in the channel. Channel width and depth measurements depend on an ability to correctly measure the location of the *bankfull elevation*. Signs of *bankfull elevation* in a stream can be found at the back of point bars, significant breaks in slope, benches, changes in vegetation, or at the top of the bank. Determining the bankfull elevation is not an easy thing to do and requires a lot of practice and good observation skills (Figure 3).

One channel width and depth measurements are taken at the *bankfull elevation,* data can be plotted on a graph (using a basic spreadsheet program like Microsoft Excel) and related to watershed size—or *drainage area*—for the channel. The relationship is indicated with a trend line, and an equation for predicting each component is generated. When many of these measurements from different locations are plotted on the same graph for the same watershed over a range of drainage areas, these relationships are called *regional curves* (Figure 4). To illustrate this idea we will use data for the Scioto River near Higby, Ohio, which has a drainage area at this location of 5,131 square miles. The measured bankfull width is 567 feet, the measured mean bankfull depth is 12.1 feet, and the bankfull cross-sectional area (width multiplied by depth) is 6,880 square feet. Using the regional curve for the Scioto River shown in Figure 4, the predicted (calculated using the equations on the graph) bankfull width is 475 feet, the predicted mean bankfull depth is 14.1 feet, and the bankfull cross-sectional area is 6,710 square feet. It is not uncommon for estimates obtained from a regional curve and measured values to vary by 50% or more, so regional curves should be used with caution.

Determining the Bankfull Discharge

Discharge in a channel can be calculated by knowing just a few pieces of information. This is illustrated in the following sequence of equations. Discharge is calculated by knowing the cross-sectional area of the stream and the average velocity of the flowing water:

$$q = va$$

This is also called the *equation of continuity*, where q is the discharge (ft^3/sec), a is the cross-sectional area of the stream (ft^2) and v is the average velocity of flowing water (ft/sec). Bankfull velocities for low gradient channels (<2% bed slope) will usually be between 2 and 5 ft/s. At the Higby gage the bankfull velocity is about 4 ft/s. To determine the average velocity, v, you must know the slope, S, of the bed (ft/ft), the hydraulic radius, R, of the channel (ft) and something called a Manning's roughness coefficient, n. This velocity calculation is called *Manning's equation*:

$$v = \frac{1.5}{n} R^{2/3} S^{1/2}$$

Figure 3. A: Measuring bankfull features in an urban stream. B: Bankfull flow in the same stream with water depths and currents that make taking measurements unsafe.

Copyright © 2008, The Ohio State University

Manning's n is an indicator of how much resistance to flow a channel bed has and can be found in a hydrology textbook estimated from other equations[9,10]. Most channels in Ohio will have a Manning's n value of 0.025 to 0.05. To calculate the hydraulic radius of the channel, R, you need to know P, the wetted perimeter (ft) of the channel cross-section (see Figure 5):

$$R = \frac{a}{P}$$

Determining the Effective Discharge

Effective discharge is related to the sediment transport rate (Figure 6). Low discharges—or smaller flow rates—associated with small storm events transport a small amount of sediment, and high discharges—or larger flow rates—associated with large storm events transport a very high amount of sediment (Figure 6A). However, the largest storm events producing the largest discharge flow rates do not happen very often so the total sediment load carried over many years is very small (Figure 6B). Small storm events producing smaller discharge flow rates happen very often so the total amount of sediment carried is large (Figure 6B). When the frequency of a discharge event is multiplied by the rate at which sediment is transported for that frequency, we obtain Figure 6C, which is a measure of the total sediment load carried for that particular discharge. Therefore, in Figure 6C, the *effective discharge* rate, which carries the most sediment over time, is around 17,000 cubic feet per second (cfs) and is carrying 100,000 tons of sediment per year.

This approach for determining the amount of sediment moving through a system—also called *geomorphic work*—is known as the Wolman-Miller model[11]. The reason the data do not all fall on the trend line in Figure 6A is because there are seasonal and annual changes in land use that affect a stream system. For example, a large storm producing a lot of

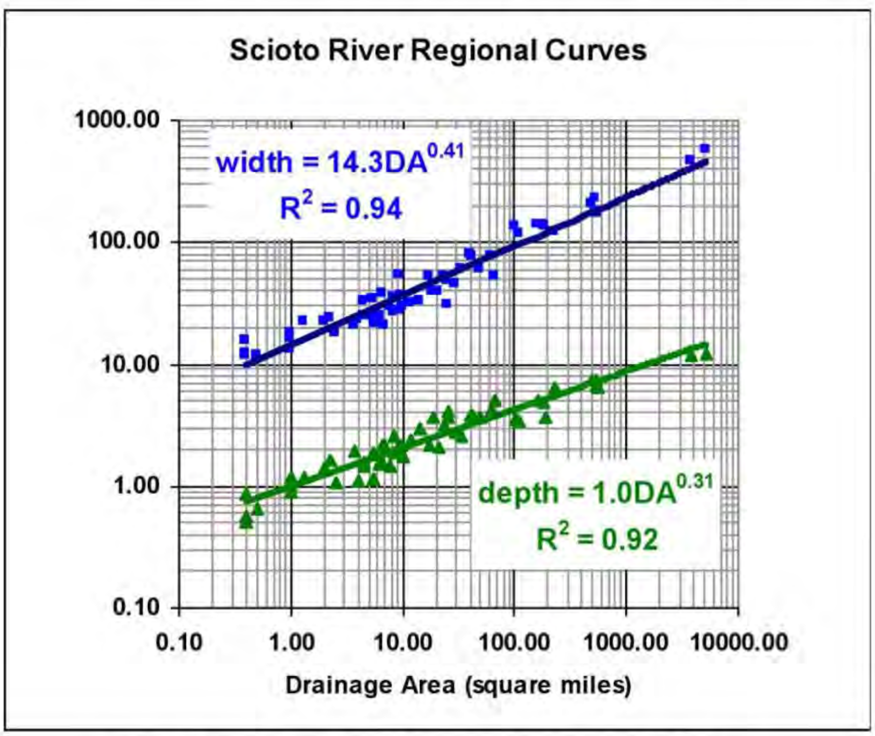


Figure 4. Regional curve for the Scioto River watershed near Higby, Ohio.

Copyright © 2008, The Ohio State University

runoff during frozen conditions might contain little sediment while a much smaller storm producing runoff might contain high sediment loads from a recently plowed field or land disturbed by a development project.

How Often Do We Get Channel-Forming Discharges?

It is difficult to determine exactly how many times each year a channel-forming discharge will occur on a particular stream reach because we usually do not have detailed enough data to make those predictions. Based on an analysis of annual discharge data for humid and semi-humid regions, the channel-forming discharge generally may occur or be exceeded several times a year. The return period is the likelihood a storm event will occur or be exceeded. For example, the 10-year recurrence interval storm event has a 10% chance of occurring in any given year. In Ohio's streams, *bankfull discharge* may be associated with a return period that is less than the 1-year recurrence interval event[7]. However there are many streams where it is in the 1 to 2 year range, and some streams where the recurrence interval approaches 5 years. Information on the recurrence interval of channel-forming discharges should only be used as one piece of evidence in determining the bankfull characteristics of a channel.

Figure 7 shows recurrence interval information for discharges on the Scioto River near Higby, Ohio. Using the data in Figure 7, for an *effective discharge* of 17,000 cfs the regression lines predict RIs of 0.45 and 0.92 years. For an *effective discharge* of 26,000 cfs the two lines provide RIs of 1.1 and 1.3 years. Because of the limitations of data available or methods developed to analyze them, we advise caution in interpreting discharge and recurrence interval data. To illustrate this using the data for the Scioto River near Higby, Ohio, there are on average more than 24 days a year with discharges exceeding 17,000 cfs. Yet, in 1954 there were no daily discharges larger than 17,000 cfs while in 1996 there were 10 events, lasting a total of 73 days, which exceeded 17,000 cfs. As a general guideline, it should be expected that, for most streams and rivers in Ohio, flows exceeding the channel forming discharge would occur at least a few times annually.

What About Discharges That Are Not Channel-Forming?

A question that we might ask is, why do smaller or larger discharges than the *effective discharge* not form channels, banks, benches, and bars that are different than those associated with the stream channel? The answer to this question is not simple. There probably

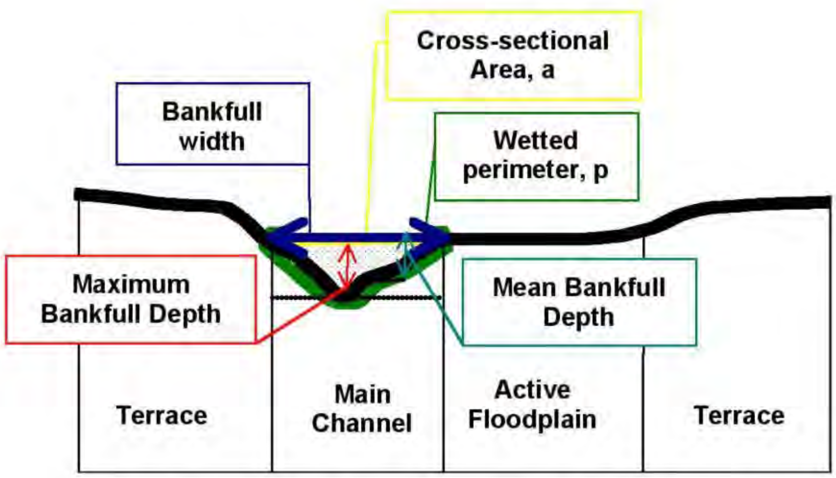


Figure 5. Cross-section of a channel with an active floodplain and terraces.

Copyright © 2008, The Ohio State University

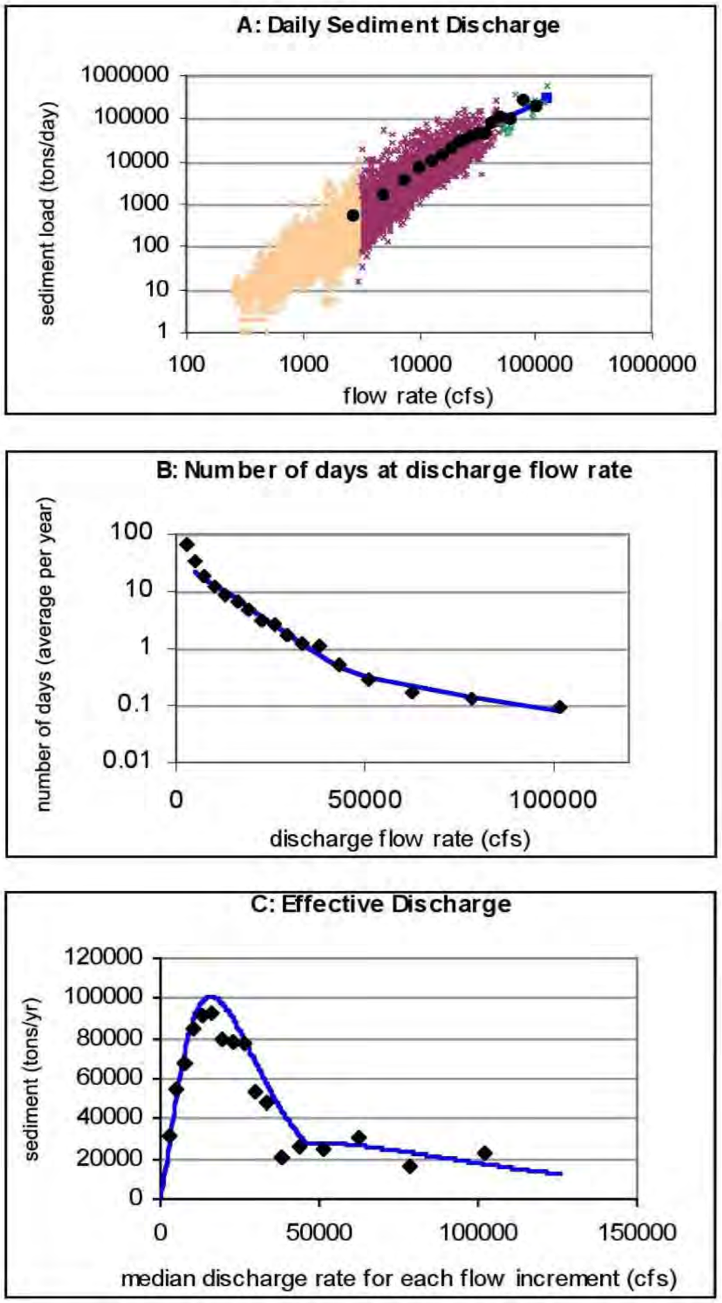


Figure 6. Illustration for Scioto River, Ohio, explaining that effective discharge carries the largest total seidment load. A: Plot of measured discharge and sediment data. B: Frequency of different median discharge rates. C: Plot of sediment load versus median discharge—the peak sediment load occurs at the effective discharge value.

Copyright © 2008, The Ohio State University

is a wide range of discharges that have the potential to shape a river channel. For example, we have found in Northwest Ohio discharges associated with high subsurface drainage flows form a low bench in most agricultural drainage ditches. Why are similar features not formed in natural rivers or other ditches? First, very low discharges are ineffective in moving sediment and can only transport very fine material such as clay. If fine clays are not available, there will be little or no sediment transport. Second, the ability of these low discharges to scour the bed and banks of a channel also is very low. Third, if beds, banks, and benches are to be formed as primary features of the system, then there must be a way to effectively stabilize the deposited sediments so they do not eventually wash downstream. In the case of many agricultural ditches, vegetation provides stabilization and it grows very quickly on these features.

In a natural channel we might think of discharges lower than the effective discharge either: (1) being too small to scour and/or transporting sufficient sediment to create permanent features; or (2) occurring too frequently to allow the deposited materials to stabilize. Perhaps harder to understand and visualize is why discharges larger than the *effective discharge* do not scour and wash away the banks, benches, and bars. In places along a river system, extreme storm events might cause bank instability problems, but on average, most channel and floodplain features that are in dynamic equilibrium have relatively stable banks and beds. Once balanced, they do not *aggrade* (build up due to sediment deposits) or *degrade* (downcut due to scour) because discharges larger than the effective discharge spread out across the floodplain, have low velocities when they flow across these features, and in the main channel have similar forces on the bed and banks to those produced by the *effective discharge*.

Why Is My Channel the Shape It Is?

We have seen that the size of a channel is related to the forces on the bed and banks, the size of the bed and bank material, the discharge that carries the most sediment over a long period of time, the bed slope, and the depth of flow associated with the channel-forming discharge. So, why are channels not the same shape?

In a pasture, where there are clay soils that are stabilized by dense grass roots, we might find a narrow but deep channel. In a woodland, where there are clay/loam soils and large sparse tree roots that anchor the soil, we might find a wide and shallow channel. The constant degrading and aggrading of stream beds and banks leads to bends forming in the channel and the channel, if not constrained by valley walls, to moving

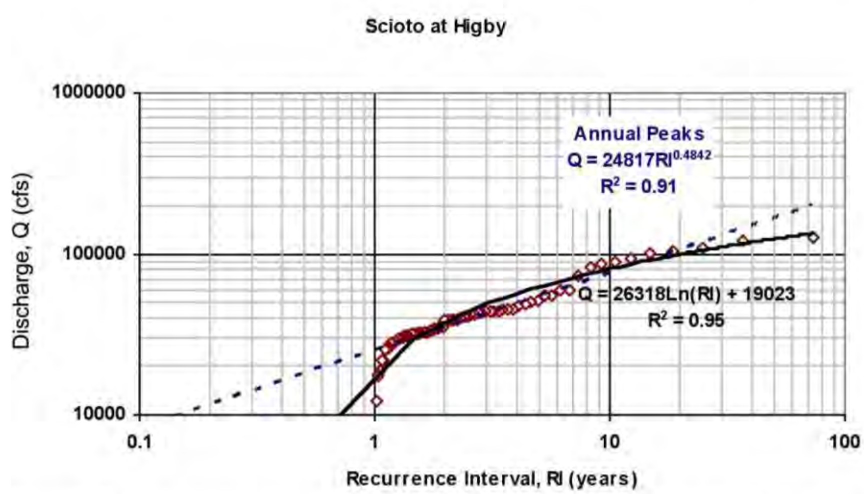


Figure 7. Discharge versus recurrence interval relationships at the Higby, Ohio USGS stream gage.

Copyright © 2008, The Ohio State University

through a valley over time. This is mainly related to the resistance of the beds and banks to scour and the stability of the banks. Some materials will scour more easily than others. For example, if a channel bed has degraded to bedrock (this can be thought of as its foundation) it will have trouble getting deeper. To maintain dynamic equilibrium, the banks will scour and the channel will widen. In other cases, vegetation on the banks will help to stabilize the bank materials and it might be easier for the bed to scour than the banks. If we understand the balance between water and sediment discharges—or *fluvial processes*—we can begin to predict what happens to the stream when these factors are out of balance.

Acknowledgments

This publication was produced in cooperation with the Ohio Department of Natural Resources Division of Soil and Water Conservation, The Ohio State University Department of Food, Agricultural, and Biological Engineering, and the Ohio NEMO Program with funding from the Ohio Environmental Protection Agency as part of a larger Section 319 Nonpoint Source Program grant. The authors express their appreciation to the reviewers of this project and to Heather Murphy Gates, Associate Editor (Communications and Technology, The Ohio State University), for editorial and graphic production.

References

[1]Wolman, M. G., & Leopold, L. B. (1957). *River flood plains: Some observations on their formation* (United States Geological Survey Professional Paper 282-C). Washington, DC: US Government Printing Office.

[2]Wolman, M. G., & Miller, J. P. (1960). Magnitude and frequency of forces in geomorphic processes. *Journal of Geology, 68,* 54–74.

[3]Rosgen, D. L. (1994). A classification of natural rivers. *Catena, 22,* 169–199.

[4]Johnson, P. A., & Heil, T. M. (1996). Uncertainty in estimating bankfull conditions. *Journal of the American Water Resources Association, 32*(6), 1283–1291.

[5]Emmett, W. W., & Wolman, M. G. (2001). Effective discharge and gravel-bed rivers. *Earth Surface Processes and Landforms, 26,* 1369–1380.

[6]Leopold, L. B. (1994). *A view of the river.* Cambridge: Harvard University Press.

[7]Powell, G. E., Mecklenburg, D., & Ward, A. D. (2006). Evaluating channel-forming discharges: A study of large rivers in Ohio. *Transactions of the American Society of Agricultural and Biological Engineering, 49*(1), 35–46.

[8]Harrelson, C. C., Rawlins, C. L., & Potyondy, J. P. (1994). Stream channel reference sites: An illustrated guide to field technique. General technical report RM 245, US Dept. of Agriculture Forest Service Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

[9]Newbury, R., & Gaboury, M. (1993). Exploration and rehabilitation of hydraulic habitats in streams using principles of fluvial behaviour. *Freshwater Biology, 29*(2), 195–210.

[10]Ward, A. D., & Trimble, S. T. (2004). *Environmental hydrology* (2nd ed.). Boca Raton: CRC Press, Inc.

[11]Andrews, E. D., & Nankervis, J. M. (1995). Effective discharge and the design of channel maintenance flows for gravel-bed rivers. In Costa, J. E., Miller, A. J., Potter, K. W., & Wilcock, P. R. (Eds.), *Natural and anthropogenic influences in fluvial geomorphology: AGU monograph series no. 89* (pp. 151–164). Washington, DC: American Geophysical Union.

EMPOWERMENT THROUGH EDUCATION

Visit Ohio State University Extension's web site "Ohioline" at: http://ohioline.osu.edu

Ohio State University Extension embraces human diversity and is committed to ensuring that all research and related educational programs are available to clientele on a nondiscriminatory basis without regard to race, color, religion, sex, age, national origin, sexual orientation, gender identity or expression, disability, or veteran status. This statement is in accordance with United States Civil Rights Laws and the USDA.

Keith L. Smith, Ph.D., Associate Vice President for Agricultural Administration and Director, Ohio State University Extension

TDD No. 800-589-8292 (Ohio only) or 614-292-1868

Copyright © 2008, The Ohio State University

Appendix H

THE ST. CROIX/RED CEDAR RIVER BASIN FARMER-LED WATERSHED COUNCIL PROJECT

The St. Croix/Red Cedar River Basin Farmer-Led Watershed Council Project:

Utilizing Performance-Based Farmer-Led Watershed Councils to Reduce Phosphorus Runoff, Improve Water Quality and Enhance Agricultural Productivity

Project objectives: To improve water quality in the Red Cedar and St. Croix River basins through reduced phosphorus and sediment loading; to increase farmer knowledge about, and engagement with, water quality issues, including the adoption of conservation practices; to develop leadership around water quality among farmers in the selected sub-watersheds; and to develop a unique collaborative model of water quality improvement through farmer engagement that can be replicated in watersheds throughout the Upper Mississippi River Basin and nationwide.

Project approach: Phosphorus (P) pollution reductions and the expansion of farm conservation activities will occur by way of an innovative, farmer-directed conservation incentives program. Four Farmer-Led Watershed Councils are up and running in Pierce, Polk, St. Croix and Dunn Counties. Each council receives an annual pool of funding ($17,000 in 2014, provided by the Minneapolis-based McKnight Foundation), with which they can design a conservation incentives program that achieves water-quality goals. The farmers themselves determine the best paths to conservation success within their watershed, and recruit and encourage other farmers to participate. County Land Conservation Department staff and University of Wisconsin-Extension staff work closely with the farmer councils to provide technical assistance, facilitation, resource information and education, as well as monitor the project's outcomes.

BACKGROUND

The St. Croix and Red Cedar River Basins, situated in west central Wisconsin, each contain several impaired waterways. The two basins include fourteen total maximum daily load (TMDL) projects The land base in these basins is predominantly agricultural. Farming systems that create excess nutrient and sediment run-off are a primary source of pollution. According to the U.S. Geological Survey, agriculture sources contribute more than seventy percent of the nitrogen (N) and phosphorus (P) pollution to the Gulf of Mexico via the Mississippi Basin.[1] Because these basins drain into the Mississippi River, strategies to decrease agriculture's contribution to nutrient and sediment pollution would have a significant impact on improving water quality in the Upper Mississippi River Basin (UMRB) and further downstream.

There have been many attempts to reduce P and other nonpoint source (NPS) pollutants within these basins, with mixed results. Strategies to-date have largely focused on the development of technical tools for assessment and improvements. However, those strategies have missed the

Project partners:

- Dunn County Land Conservation Division
- Pierce County Land and Water Conservation Department
- Polk County Land and Water Resources Department
- St. Croix County Land and Water Conservation Department
- UW-Extension
- Wisconsin DNR
- Wisconsin Farmers Union

"... agriculture sources contribute more than seventy percent of the nitrogen (N) and phosphorus (P) pollution to the Gulf of Mexico via the Mississippi Basin."

May 2014

human social factors – farmers internalizing the need for better water quality, and making long-term coordinated management decisions based on that internalization – necessary for the widespread diffusion of those tools and sustainable water quality improvements.[2]

The U.S. Environmental Protection Agency recognizes the importance of citizen participation in successful long-term NPS strategies.[3] The lack of progress in meeting NPS reduction goals in the affected basins reinforces the need for innovations to better engage farmers in environmental management. In Iowa, a Farmer-Led Watershed Council model that combines performance-based environmental management with farmer leadership and civic engagement has resulted in significant improvements in the Soil Conditioning Index (SCI) and Phosphorus Index (P index), and has reduced nitrogen use and sediment delivery, all due to participants' management changes.[4] This successful innovation, which has been replicated in several sub-watersheds in northeast Iowa with similar success, serves as the model for our project.

"The lack of progress in meeting NPS reduction goals in the affected basins reinforces the need for innovations to better engage farmers in environmental management."

These Iowa successes have occurred in relatively small watersheds of USGS Hydrological Unit Code (HUC) 12 or similar scale. Farmer councils were developed in each watershed. Iowa State Extension provided technical and financial resources to allow the farmers to determine the best conservation mechanisms for improved water quality. In each watershed, farmers developed a set of performance-based incentives that they encouraged all farmers within the watershed to adopt. The co-development of farmer leadership alongside strong technical support and facilitation has led to wide participation within the watersheds, increased adoption of conservation practices, and long-term commitment to these management strategies by farmers. The projects are all ongoing.

Our project, made up of four pilot sub-watersheds ranging from about 7,000 to 33,000 acres in the St. Croix and Red Cedar River basins, shares the approach with Iowa. Because of existing conservation partnerships developed over years, we have a significant opportunity to observe the effectiveness of this innovation across watersheds, as we are leveraging the technical and financial resources of county, state and non-governmental partners. This is a unique opportunity to improve UMRB water quality and to further develop and promote a model for farmer engagement that can be spread to other watersheds nationwide.

INNOVATIONS

We consider this project innovative for the following reasons:

1. Farmers decide the best paths to water quality and conservation goals, and then conservation partners provide them with the technical resources to get there.

2. The partnership is combining technical conservation practices with civic engagement and farmer-leadership development strategies at a watershed level.

3. The project involves leveraging multi-level and multi-location collaboration, including county conservation departments, university Extension, the WI Department of Natural Resources and non-governmental organizations.

METHODS

The project is based on a model of civic engagement that develops knowledge and creates leadership and action on water quality by farmers. Farmer-Led Watershed Councils now exist in four target sub-watersheds in Pierce, Polk, St. Croix and Dunn Counties. These sub-watersheds were selected because they have both high P-loads as well as a critical number of farmers receptive to leading projects which educate and involve their local farm community in soil conservation and phosphorus runoff reductions.

One of the key innovations of this project is the leading role farmers will play, a strategy based on the successful participatory models of resident-led watershed projects developed by Iowa State Extension and others. The project coordinator (employed by University of Wisconsin-Extension) and the county conservationists will provide technical support, education and facilitation to the farmer councils, as well as a small pool of money, but will not dictate to farmers the best course of action to achieve water quality goals. The councils will decide how best to approach the task of water quality improvement in their watershed. They will have the freedom to select which conservation practices to incentivize, to create monitoring and evaluation plans, and to devise outreach strategies that are tailored to the particulars of their watersheds. In this way, farmers in the councils will become not only conservation leaders within their watersheds, but also strong advocates for the adoption of conservation practices and resources in their farm communities. This type of participatory approach has achieved sustained reductions in P and other water pollutants.

This project combines the considerable strengths of the partners with current watershed management TMDL goals in a groundbreaking collaborative. Conceptually, it draws from research and resources on civic engagement from the University of Minnesota, Iowa State University's sociological work on farmer-led, performance-based watershed projects, and the concept of landscape disproportionality analysis from the University of Wisconsin.[5] Project partners have created a local- and county-led watershed management implementation project partnership within the Red Cedar and St. Croix River (WI portion) Basins. Because of the reach of the many partners involved in this collaboration, it anticipates an increasing adoption of both the participatory model as well as the conservation practices themselves beyond the pilot watersheds and throughout the river basins.

Specifically, our methods are as follows:

Objective 1: Developing farmer-led councils in four pilot watersheds. The project coordinator from UW-Extension and staff from the Land Conservation Department offices in each of the four counties that contain the watersheds are working closely to facilitate and develop the farmer-led councils. Farmer councils have been meeting regularly since February 2013.

Project Personnel

DUNN COUNTY:

Dan Prestebak, Conservationist; Amanda Hanson, Conservation Planner

PIERCE COUNTY:

Rod Webb, Conservationist

POLK COUNTY:

Tim Ritten, Conservationist; Eric Wojchik, Conservation Planner

ST. CROIX COUNTY:

Bob Heise, Conservationist; Kyle Kulow, Conservation Planner

UW-EXTENSION:

Julia Olmstead, Outreach Specialist/ Project Coordinator; Paul Kivlin, Nutrient Management Specialist

Objective 2: Phosphorus-loading inventories in each watershed. To measure our progress, as well as for the farmer council to target the biggest P contributors, county conservation staff and UW-Extension nutrient management specialists will work with farmers to do P indexing on as many fields as possible within the watershed. The P Index assigns a number – 0, 1, 2, 4, 8 or 16 – to each of the conditions which can affect phosphorus losses, where 0 is the lowest P loss potential and 16 is the highest P loss potential. This is completed according to the probability of P loss from the site. Council members will take the lead to encourage non-participating or hesitant farmers to get involved.

Objective 3: Measurable reductions in phosphorus runoff. Several of the incentives we suggest to the farmer councils will result in P pollution reductions, including improved manure management, grass waterways, cover crops and grid sampling for precision agriculture methods. We will be able to track these reductions via annual P index assessments as well as by leveraging already existing edge-of-field water monitoring sites that are located in each watershed. We will also encourage farmers to target conservation activities to the heaviest contributors to P loading within the watersheds.

Objective 4: Increased adoption of conservation practices by farmers within the watershed. The farmer councils will determine which conservation practices are most useful and attractive to farmers within the watershed. They will create an incentives program before the start of the growing season, which will offer small amounts of compensation for farmers to adopt conservation practices. Farmers will be able to choose from a suite of incentive options the council has put together, which can include, but is not limited to: cover crop trials, corn stalk nitrate testing, nutrient management planning, manure spreader calibration, grass waterways, phosphorus indexing, grid sampling and bioreactors. A key component of the project model is the leadership taken by farmers in influencing each other. The council farmers will play a lead role in encouraging other farmers to become involved, using field days, mailings to other farmers, and one-on-one conversations.

Funding:

Staffing time: WI DNR provides funding for the project coordinator's position via UW-Extension, and supports ¼ staff time in each county LCD via a Lakes Grant (this is matched by the county for ½ FTE toward project).

Conservation incentives: The McKnight Foundation (a private, Minneapolis-based foundation) has provided a two-year grant of $100,000 total for the councils.

[1] Alexander, Richard B., Richard A. Smith, Gregory E. Schwarz, Elizabeth W. Boyer, Jacqueline V. Nolan and John W. Brakebill. 2008. "Differences in Phosphorus and Nitrogen Delivery to the Gulf of Mexico from the Mississippi River Basin." *Environmental Science & Technology* 42(3):822-830

[2] Morton, Lois Wright and Chich Yuan Weng. 2009. "Getting to Better Water Quality Outcomes: The Promise and Challenge of the Citizen Effect." *Agriculture and Human Values* 26(1):83-94

[3] U.S. EPA. 2008. *Handbook for Developing Watershed Plans to Restore and Protect Our Waters.* USEPA. Office of Water Nonpoint Source Control Branch. EPA 841-B-050005

[4] Morton, Lois Wright and Jean McGuire. 2011. "Getting to Performance-Based Outcomes at the Watershed Level" in *Pathways for Getting to Better Water Quality: The Citizen Effect* edited by L.L.W. Morton and S.S. Brown. New York: Springer.

[5] Nowak, Pete, Sarah Bowen, and Perry E. Cabot. 2006. "Disproportionality as a Framework for Linking Social and Biophysical Systems." *Society and Natural Resources* 19:153-173

An EEO/AA employer, University of Wisconsin Extension provides equal opportunities in employment and programming, including Title IX and American with Disabilities (ADA) requirements. Hearing Impaired Relay: 711

Farmer-Led WATERSHED COUNCIL

For More Information:

Julia Olmstead, UW-Extension Watershed Project Coordinator
UW-River Falls, 123i RDI Building, River Falls, WI 54022
julia.olmstead@ces.uwex.edu 715-531-8869

Graphic design by Jeffrey J. Strobel, UW-Extension Environmental Resources Center

Appendix I

WHAT IS THE DELAVAN LAKE WATERSHED INITIATIVE NETWORK?

What is the Delavan Lake Watershed Initiative Network?

The Delavan Lake WIN is a new approach to protecting and improving the entire Delavan Lake watershed that *complements* and *coordinates* the great things that many groups are doing for the Lake. The Watershed Network is a coalition of lake groups, municipalities, non-profit organizations, government agencies, and local citizens working together on targeted projects to enhance and expand on work already in progress.

The Delavan Lake WIN:

- ~ Maximizes efficient action, by coordinating lake and watershed workplans, and then putting those plans into action to protect and preserve area waters.
- ~ Maximizes financial efficiency, by spreading costs across multiple partners and leveraging cooperation to raise additional funds.
- ~ Maximizes the health of Delavan Lake by concentrating not only on the lake, but on the health and quality of all the waters that feed it. This "watershed" approach has seen great success by networks such as the Rock River Coalition, and the Root-Pike WIN.
- ~ Maximizes community by bringing diverse interests together and building trust and a spirit of cooperation to work for safe, clean water across the Delavan Lake Watershed.

What is the revenue supporting the DL WIN

The DL WIN has funding that comes in three forms: grants, contracts and in-kind. The revenue below represents total revenue (not counting in-kind) from November 2009 through January 2012.

FUNDING SOURCE	AMOUNT	TYPE
DLSD	231,000	Contract
WDNR Planning Grant	10,000	Grant
US Dept. of Agriculture Mississippi River Basin Initiative	283,500	Grant

The Wisconsin DNR grant required a match, which has been met using in-kind matching funds. In-kind funds come from donated goods and services. The DL WIN has been rich in in-kind assets due to commitments by DL WIN participants, resulting in over $30,000 of in-kind goods and services. The initial DL WIN implementation was strongly supported by in-kind donations by coalition participants.

In the case of the Mississippi River Basin Initiative grant, the Walworth County Land Use and Resource Management Department committed $42,000 of in-kind staff time and resources to support the project. The total of $72,000 of committed in-kind staff time from DL WIN participants is not reported in the funding chart above.

How have the DL WIN funds been utilized?

In our first year we focused on building the coalition of partners who are the Delavan Lake Watershed Initiative and prioritizing the work to be done. This included:

- building relationships with people in the community,
- inviting key stakeholders to be part of our working groups and committee meetings,

- inventorying existing lake and watershed plans to determine what needs to be done,
- identifying existing resources within the community that are working to improve the Delavan Lake watershed and where there are gaps,
- applying for additional funding to address gaps.

Once we established this community network and understood where the biggest challenges are in the watershed, we were able to seek funding that fit our needs. We inventoried the water quality threats to Delavan Lake, prioritized projects that will achieve the most water quality improvements, and met with watershed landowners to implement projects. With continued support we will be able to install more watershed projects that will improve the health of Delavan Lake.

The US Dept. of Agriculture Mississippi River Basin Initiative awarded the Network a grant for $283,500 of funding in the form of agricultural improvement projects in the watershed. This is new money brought into the community. These funds are paid directly to local farmers and help cover the cost of the improvement projects. With technical assistance from the Walworth County's resource management staff and the local Natural Resource Conservation Service staff, Delavan Lake WIN has completed 8 projects in less than two years to improve water quality, and will be completing another 5 projects in 2012.

The Mississippi River Basin Initiative Grant project has resulted in the installation of best management practices on 2,111 acres of land within the Delavan Lake watershed to date, with an additional approximately 500 acres being added in 2012. The projects include activities such as installation of streamside filter strips, grassed waterways, implementing conservation tillage, and reduction of phosphorus applications to farm fields.

DL WIN ACTIVITIES - November 2009 through January 2012

Start-Up

Completed advertising, screening, hiring staff

Oriented and trained staff

Developed DL WIN administrative functions, framework and procedures

Implementation of DL WIN

Created outreach activities/materials to build coalition

Expanded Lake & Watershed Plan Development & Equipment

Identified Education/Outreach Program strategies & Website goals

Developed and customized a GIS Database for Watershed project planning

Designed and launched DL WIN Education Website www.delavanlakewin.org

Grant Seeking

Researched and wrote grants

Administered grants, wrote reports, reviewed plans and field checked projects

WDNR River Protection Project - Currently

Identifying conditions affecting water quality of Jackson Creek

Developing and promoting a citizen advisory panel

Providing site specific project solutions to improve water quality entering Delavan Lake

Watershed Projects that Delavan Lake WIN Has Installed To Date:

2 Grassed Waterways Grass waterway channels were constructed as smooth, shallow channels and then planted to sod- forming grasses. The waterways carry runoff water from the field and the grass prevents the water from washing soil down eroded gullies. The vegetation also traps some sediment washed from cropland, and absorb some chemicals and nutrients in the runoff water.

No Till Management This practice is being implemented for 3 years on 288 acres and manages the amount and distribution of crop and other plant residue on the soil surface year round and provides the least amount of soil-disturbing activities during planting operations. This results in less soil loss and less water pollution.

Phosphorus Management This project utilizes grid or zone sampling on 590 acres to determine where phosphorus is not needed in a crop field, thereby reducing excess phosphorus being washed into streams and lakes. This practice will be followed for 3 years.

Cover Crops Cover crops protect fields from wind and water erosion during winter and spring by establishing a growing crop during a time when the soil is usually exposed to erosive forces. This project results in more water seeping into the ground and less polluted water running off the field.

Streamside Filter Strip These permanent areas of vegetation are used to intercept or trap field sediment, pesticides and other potential pollutants before they reach a body of water. 1.6 acres of cropland along a tributary of Jackson Creek has been retired from production and planted as a filter strip.

2 Grass Waterways & Diversion Channel Projects These projects consist of a channel constructed across the slope to collect and divert runoff water. The diversion empties into a new grass waterway that traps and absorbs some of the pollution.

Watershed Projects that Delavan Lake WIN will Complete in 2012:

Terraces These earthen structures intercept runoff water on moderate to steep slopes. They transform long slopes into a series of shorter slopes, reducing the rate of runoff and allowing soil particles to settle out. The resulting cleaner water is then carried off the field in a non-erosive manner.

Pasture Management This project maintains vigorous grass covering and eliminates bare ground and mud from repeated trampling of cattle, thereby reducing phosphorus and sediment amounts in nearby streams.

2 Grassed Waterway Projects These projects will benefit approximately 200 more acres by reducing sediment loss to nearby waterways, and improving the clarity of the water runoff.

Manure Storage Structure This project allows for the storage and safe stockpiling of manure until conditions are environmentally safe for spreading. Less manure is applied during snowmelt conditions and rainy seasons resulting in fewer pollutants reaching the lake. *Additional funding requested to complete this project.

Watershed Education & Outreach Event A community awareness day on April 25th at Delavan Community Park designed to educate people about the importance of the watershed and how individual actions can improve the quality of Lake water. Free resources and experts promote watershed education and action.

Why do we need the Delavan Lake WIN?

The Delavan Lake watershed is not static; it is constantly changing as new development is put into place and as new activities occur in and around the Lake. This constant state of change requires an equally flexible range of interventions to protect and preserve it.

The Delavan Lake WIN takes advantage of the relative strengths of each of the Network's partners and minimizes the direct costs incurred by any one of them. *In this way, incremental management measures can be implemented so as to minimize costs to any single agency or organization and minimize the overall cost of needing to undertake large scale actions such as were done in the 1990s.*

In Delavan Lake itself, the $2.4+ million dollar investment in 3 dredging projects since 2006 has rectified a portion of the deposition of sediments that has been ongoing for decades, and the presence of the Mound Road wetland system will minimize the rate at which sediments are deposited in the Inlet in future. Dredging projects are not the final solution and will need to be maintained and possibly repeated again in the future.

By serving as a clearing house for information, the Delavan Lake WIN can assist all parties in maintaining the improvements that have been achieved and by minimizing the costs of such maintenance by taking advantage of the participation of numerous local, state, and federal agencies and organizations. Through directed outreach, the Watershed Network can assist communities across the watershed to understand their connection to the Lake, and how best to play their part in maintaining the achievements of the Town of Delavan and DLSD in restoring and rehabilitating Delavan Lake.

The right initiative - let's keep it going!

The initiative of the DLSD, Town of Delavan, and Kettle Moraine Land Trust to create the Delavan Lake WIN has created a framework within which numerous public agencies and private organizations are willing to come together to pool their knowledge, resources, and relative strengths. As a result the investment in the Delavan Lake community since 2009 clearly fills a need shared amongst all participants - to maximize impact and minimize individual investments in a time of tight budgets and limited resources.

By coordinating the actions of the participants in the Delavan Lake watershed, the DL WIN has not only managed to "hold the line" in terms of local investment requirements, but also has leveraged outside investment in the watershed at a rate of 1:1.5. This is a significant achievement.

Further information can be found at: www.delavanlakewin.org