# FROM FARM TO FLOW:

## COLLABORATIVE EFFORTS TO RESTORE MARATHON COUNTY'S SURFACE WATERS

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## Background

Marathon County's proposed ordinance updates represent the culmination of an intensive, collaborative, and data-driven effort to meaningfully improve water quality across the county. Over the course of more than eighteen months, Marathon County Conservation, Planning, and Zoning (CPZ) staff met monthly with the Environmental Resources Committee (ERC) to evaluate persistent water-resource challenges and identify actionable strategies that could truly "move the needle" in water quality. In mid-2024, CPZ introduced a key recommendation long supported by multiple county water-quality plans: adopting countywide winter manure-spreading restrictions for all farms, regardless of size, during the high-risk months of February and March.

The proposal sparked extensive public engagement, including nearly six months of vocal opposition from several sectors of the agricultural community. Rather than allowing disagreement to stall progress, the ERC embraced an opportunity for deeper collaboration by forming a farmer-led workgroup at the suggestion of the Marathon County Farm Bureau. This diverse team, comprised of CAFO operators, livestock-siting permitted farms, small dairies, crop and grain producers, Wisconsin DNR staff, Marathon County CPZ staff, Town Board representatives, Wisconsin Valley Improvement Company representatives, Farm Bureau members, and other partners, met over the following six months with a shared purpose: craft commonsense, science-supported solutions that balance agricultural realities with the urgent need to protect water resources.

What emerged from this process is both historic and inspiring. Marathon County's ordinance updates are the first of their kind in Wisconsin, built not through top-down regulation but through genuine collaboration, compromise, and mutual respect. They stand as proof that when stakeholders come to the table with open minds and a commitment to the common good, it *is* possible to develop policies that support farmers, safeguard natural resources, and advance long-term community wellbeing. This report documents that journey, the scientific basis for the changes, and the alignment of this ordinance with the many county, watershed, and statewide plans dedicated to protecting Marathon County's land and water for current and future generations.

## Executive Summary

Marathon County, Wisconsin has long been recognized as a leader in conservation, investing heavily in programs and cost-share initiatives that promote responsible land and water stewardship. Despite these efforts, surface water quality across the county continues to decline, and many local waterbodies remain impaired (Appendix B:1, C:1, C:2, C:3). Frequent algae blooms continually plague the Big Eau Pleine Reservoir (Appendix A:2, B:1) Current state-level agricultural prohibitions are insufficient to achieve the Wisconsin River Total Maximum Daily Load (TMDL) targets. To effectively protect and restore surface waters, Marathon County must adopt standards that go beyond existing state requirements through a strengthened local ordinance.

Over 93% of Marathon County drains into the Wisconsin River Basin, making the county a critical contributor to the overall health of this major waterway system. The Wisconsin River Basin TMDL (Appendix A:7), published in 2019, provides a comprehensive assessment of

nutrient sources and establishes phosphorus reduction goals needed to restore and maintain water quality. According to the TMDL, every watershed in Marathon County requires a phosphorus reduction between 63-85% to meet state standards. Across the full TMDL area, total baseline phosphorus loading from cropland was 840,831 pounds per year, with Marathon County alone contributing 238,937 pounds annually: approximately 28 percent of the total cropland phosphorus load in the basin (Appendix A:7).

This data highlights both the scale of the challenge, and the opportunity for local action. Eastern Clark County and Western Marathon County have some of the highest densities of dairy farms in the United States. Because of its geographic position and agricultural intensity, Marathon County has the ability to make a measurable difference in improving water quality across the entire Wisconsin River system (Appendix A:6). To achieve meaningful reductions in nutrient runoff and protect local waterways, Marathon County must take the next step in its long history of conservation leadership by strengthening its Animal Waste and Cropland Management Ordinance.

The following updates were the results of months of scientific research, collaboration, and compromises in Marathon County. These are proposed to improve surface water quality and align local practices with watershed goals:

1. Winter Spreading License Requirement (regardless of farm size)
    - Exemption: Landowners or operators with a current Nutrient Management Plan (NMP) on file with the Conservation, Planning, and Zoning (CPZ) Department will not require a license, as NMPs already follow state winter spreading guidelines.
    - License Requirement: For those without an NMP, a Winter Spreading License will be required for applying liquid manure on frozen soils. The license will be valid for four years.
2. Seasonal Spreading Limitations for Medium to Large Farms
    - Farms with 300–999 animal units (EPA definition of medium-sized farms) will be prohibited from spreading liquid animal waste in February and March, aligning with the existing restriction for large farms (1,000+ animal units).
    - Spreading may occur if weather conditions permit (no frozen or snow-covered ground), consistent with NR 243 in Wisconsin statutes.
    - Emergency exceptions may be approved by the CPZ Department.
3. 35-Foot Buffers Along Streams
    - A 35-foot vegetative buffer will be required along perennial and intermittent streams.
    - Existing natural buffers with sufficient vegetation to control erosion and runoff will meet this requirement.
    - This change ensures consistency with Marathon County Zoning Ordinance Chapter 22 (Shoreland Zoning) and allows for flexible, harvestable buffer options.

These proposed ordinance updates reflect Marathon County's continued commitment to proactive, science-based conservation. By adopting stronger local standards that build upon state regulations, the County can lead the way in reducing nutrient pollution, protecting surface waters, and sustaining clean water resources for future generations.

## Underlying Challenges

By the 1930s and 1940s, the importance of drainage had become a defining feature of agricultural development in Marathon County. The federal government, through New Deal conservation programs, actively encouraged settlement and farm expansion in central Wisconsin, promoting Marathon County as an area with "fertile" but underutilized land. Yet, as the 1942 Soil Conservation District report documented, the "failure to develop imperfectly drained land" emerged as the County's greatest agricultural limitation. This challenge led to the adoption of widespread soil and water management practices (including ditching, tiling, terracing, and land leveling) to make wet, glacially influenced soils more productive. By 1958, Marathon County had installed more than 130 miles of terraces, waterways, and surface drains, eventually expanding to over 1,000 miles of terraces and 350 miles of engineered waterways. These projects were supported by a growing conservation workforce, technical assistance from federal and state agencies, and a strong local belief that proper drainage was essential to agricultural prosperity.

Through the mid-20th century, drainage and soil conservation became deeply intertwined in Marathon County's agricultural identity. Drainage projects not only increased cropland productivity but also served as visible symbols of progress and stewardship. By the 1960s, Marathon County was recognized as a statewide leader in conservation, securing major funding for watershed improvement projects in the Upper and Lower Big Eau Pleine and Rib River basins. Although these programs succeeded in "reclaiming" thousands of acres of farmland, they also altered hydrology, increasing nutrient runoff into downstream systems such as the Big Eau Pleine Reservoir. Recurring fish kills, first noted in the 1940s and continuing into the 21st century, revealed the long-term environmental tradeoffs of extensive drainage and nutrient enrichment. The last major fish kill in 2009 destroyed approximately 80% of the Big Eau Pleine fishery (Appendix B:3). **Marathon County's history of a well-developed, extensive "drainage system," to quickly move water off the landscape, is one of the predominant reasons that increased agricultural standards are needed to protect water quality** (Appendix B:4).

## Current Landscape

According to the 2022 USDA Census of Agriculture, Marathon County is home to approximately 353 dairy farms with 65,598 animals, and 455 beef farms with 8,369 animals. This concentration of livestock reflects Marathon County's enduring role as a cornerstone of Wisconsin's dairy and beef industries, supporting extensive milk production, cheese processing, and agricultural exports. However, this level of agricultural intensity also brings significant environmental responsibilities. With roughly 65,000 dairy cows, each producing an estimated 28 gallons of manure per day, the county generates more than 664 million gallons of animal waste annually; all of which must be carefully managed and land-applied to prevent nutrient loss and water contamination. When combined with the additional load from human and industrial waste

applied to land, this underscores the importance of strong local nutrient management policies and sustainable conservation practices to protect Marathon County's surface waters and agricultural future.

## Current Conservation Efforts

Marathon County's Conservation, Planning, and Zoning (CPZ) Department continues to build upon the County's long history of environmental stewardship through a diverse portfolio of conservation programs, technical assistance, and partnerships. CPZ's experienced staff work closely with farmers, landowners, and partner organizations to implement practices that reduce nutrient runoff, protect surface waters, and promote sustainable agriculture. In 2024, Marathon County's conservation efforts directly resulted in an estimated 6,240 pounds of phosphorus reduction, and 4,955 tons of sediment loss prevention. These measurable outcomes were achieved through the implementation of nearly 5,000 acres of Nutrient Management Plans (NMPs), 1,580 acres of cover crops, 479 acres of no-till practices, and 150 farm compliance inspections, supported by roughly $500,000 in annual grant funding.

A central component of these efforts is the County's leadership in Nutrient Management Planning. With nearly 400 individual NMPs covering 183,602 acres, approximately 60% of all cropland in Marathon County is managed under a nutrient management plan, making it the fourth-highest county in Wisconsin for total acres and 17th highest by percentage. CPZ staff play a key role in advancing these plans through the North Central Region Nutrient Management Farmer Training Program, which has operated for 18 years in partnership with six counties and two technical colleges. This proactive, educational approach ensures farmers meet State Agricultural Performance Standards while improving efficiency and soil health.

Marathon County also demonstrates strong collaboration through its partnerships with local producer-led watershed groups. In the Big Eau Pleine Watershed, CPZ works closely with the Eau Pleine Partnership for Integrated Conservation (EPPIC): a producer-led group focused on outreach, education, and innovative conservation strategies. County staff serve as EPPIC's fiscal agent, coordinate reporting, and help organize field days and training events. EPPIC regularly collaborates with other watershed groups across the Wisconsin River Basin, sharing best practices for nutrient reduction and farm innovation. Marathon County's conservation network extends far beyond EPPIC, involving partnerships with organizations such as AgSource, BEPCO, The Nature Conservancy, Grassland 2.0 (UW–Madison), Marshfield Research Station, the USDA NRCS, Wisconsin DNR, DATCP, UW-Extension, Pheasants Forever, and the Wisconsin Farm Bureau, among many others.

CPZ also manages several targeted initiatives that strengthen local conservation outcomes. These include the Fenwood Pilot Program, an incentive-based approach promoting proactive phosphorus and soil loss reduction; expansion of the county grazing program to encourage perennial grass systems; ongoing surface water monitoring through DNR-funded phosphorus testing and the Water Action Volunteers Program; and promotion of Conservation Reserve Enhancement Program (CREP) enrollment to establish riparian buffers along streams and wetlands.

A wide breadth of regulatory and compliance programs ensure that vast acreage across the County are already under the purview of NR151 standards, and subject to routine inspections. Under the Livestock Facility Siting Ordinance, CPZ currently licenses 18 dairy herds (500–999 animal units), representing 16,163 animal units and 21,150 acres of cropland managed under existing NMPs. Staff conduct annual inspections to ensure compliance with state standards and assist farms transitioning to DNR Concentrated Animal Feeding Operation (CAFO) permits; eight operations have made this transition to date, with five additional farms transitioning to CAFO permits.

CPZ also administers Wisconsin's Farmland Preservation Program (FPP), which provides tax credits to landowners who maintain agricultural use while meeting all State Agricultural Performance Standards and Prohibitions. Currently, 264 landowners across 12 towns participate in the program, protecting over 58,000 acres of farmland (Appendix A:8).

Despite the significant conservation efforts by Marathon County farmers and CPZ staff, and the enactment of the cropland and pastureland soil erosion performance standard (i.e., soil erosion rate equal to, or less than, the "Tolerable" (T) rate), **soil erosion rates in the county have been trending upward over the past 25 years** (Appendix A:5). This has been determined and documented via CPZ conducting a biennial, county-wide soil erosion transect survey since 1999.

This increase in soil erosion is the result of cropping practices trending toward more annual and erodible crop types being grown (e.g., corn and soybean row crops versus perennial grass and legume full-width crops and pastures) and the increased frequency of (i.e., annual) tillage of the cropland soil to grow these annual row crops. **In 2024 (the most recent year of the soil erosion transect survey) 22.3% of fields exceeded the "Tolerable" (T) soil erosion performance standard (vs. 14.0% in 1999),** and the 2024 average soil erosion rate was 2.4 tons/acre/year (vs. 1.6 tons/acre/year in 1999) (Appendix A:1 and A:5).

This increase in cropland soil erosion leads to an increase in runoff of soil amendments applied to the cropland, such as animal waste. As Marathon County sees an increase in cash-grain and corn silage (intensive) rotations, it is imperative to have safeguards in place to prevent increased soil and nutrient runoff in to surface waters. This reasoning was one of the catalysts to the buffer requirement in our proposed ordinance changes, as the farmer workgroup recognized the clear data and plan recommendations, proving that a buffer along streams would go far in meeting water quality goals.

While Marathon County CPZ continues to be a state leader in conservation programming and conservation cost-share dollars distributed to producers, decades of data show that voluntary conservation programs will not be enough to meet the Wisconsin River TMDL(Appendix A:7) in Marathon County. Marathon County's Fenwood Creek Pilot Program (which has operated for six years using Multi-Discharger Variance Funds) has proved that incentive-based payments are the most effective and affordable cost-sharing option (decreasing approximately 1,800 pounds of phosphorus a year from the Fenwood Creek Watershed at $18/pound).

Marathon County staff has explored numerous avenues to secure large-scale, incentive-based conservation funding, including multiple bills introduced in the Wisconsin Legislature and several grant proposals exceeding $1,000,000. Despite these efforts, many opportunities have not yet materialized. Until the State of Wisconsin provides greater flexibility in cost-sharing

programs that would allow counties to implement initiatives similar to the successful Fenwood Creek Pilot Program, Marathon County recognizes that locally driven solutions are necessary to continue making progress toward Wisconsin River TMDL goals.

The proposed regulatory updates are designed to support all agricultural operations across the county, including those who participate in conservation programs as well as those who choose not to enroll or accept cost-share funding. By creating a consistent framework that applies fairly across all agricultural lands, Marathon County aims to strengthen water-quality protections while ensuring that every landowner and operator has a clear, equitable role in helping safeguard our shared natural resources.

## Cohesion with Relevant Studies

### WCR Region Winter Runoff Study; Mark Hazuga (Appendix D:3)

Winter runoff in agricultural watersheds can deliver large amounts of organic material, nutrients, and bacteria to flowages during snowmelt events, causing oxygen depletion beneath the ice and sometimes fish kills. The Big Eau Pleine Flowage experienced a fish kill in 2005 (Appendix B:3) when a mid-winter rain event washed manure-laden runoff into the system, triggering extremely high Biochemical Oxygen Demand (BOD) and widespread low dissolved oxygen. To understand these events, the Wisconsin DNR conducted a two-year study (2006–2007) monitoring the Big Eau Pleine watershed (dominated by dairy farming and 77% agricultural land use) alongside the minimally disturbed Spirit River watershed, which served as a reference (only 11% agriculture). Non-event conditions showed low BOD and low bacteria levels, but snowmelt events sharply increased BOD, phosphorus, and E. coli concentrations in tributaries and under-ice flowage waters.

Event sampling documented that winter and early-spring snowmelt delivered pulses of manure-derived pollutants, with BOD in the Big Eau Pleine River reaching 10–21 mg/L and E. coli as high as 2,400 colonies/100 mL—far higher than the Spirit River. Export analyses showed the Big Eau Pleine delivered **BOD at over four times** the rate of the Spirit River and **phosphorus at nearly eight times** the rate. In 2007, a three-day runoff period delivered an estimated **221,138 pounds of BOD**, a load equivalent to runoff from roughly 8,000 dairy cows losing only 20% of their stored winter manure. When compared to human wastewater, the Big Eau Pleine's three-day runoff delivered **14 times more BOD than the City of Wausau's raw sewage influent** over the same period, emphasizing the scale of winter manure runoff impacts.

The study concludes that winter spreading of manure across the Big Eau Pleine watershed is a major driver of elevated BOD, phosphorus, and bacteria during snowmelt, and that the timing of these events determines the severity of oxygen depletion under the ice. Early or mid-winter runoff events (such as in 2005) allow manure-derived BOD to exert long-lasting oxygen demand beneath the ice, increasing fish kill risk; late-season events tend to be less damaging because ice-out occurs sooner, allowing re-aeration. Although the two-year study documented clear pollutant delivery, total loads were likely underestimated because some high-discharge tributaries lacked streamflow data and many events could not be sampled throughout their full duration. Overall, the findings indicate that the land application of animal waste on frozen soils poses a substantial threat to the Big Eau Pleine Flowage's water quality and fish populations.

**Considerations for Mid and Late Winter Manure Applications; Discovery Farms (Appendix D:8)**

Discovery Farms' research demonstrates that the period of February and March represents the highest-risk window for nutrient loss from agricultural fields, primarily due to the presence of frozen soils, concrete frost, dense snowpack, and frequent freeze/thaw cycles. These conditions sharply limit the soil's capacity to absorb liquid manure, causing nutrients and organic material to remain on the surface until the next melt event. As the study shows, these **late-winter conditions generate phosphorus losses two to four times higher than those observed during early or mid-winter applications**, underscoring the disproportionate impact of manure spreading during the final months of winter. These observations are entirely consistent with Marathon County's documented history of manure runoff events, including several recent cases where fields spread in mid-to-late winter produced significant volumes of overland flow and delivered high concentrations of nutrients to waterways (Appendix B:5, B:2).

Discovery Farms further emphasizes that the risk associated with late-winter application is not merely a function of manure quantity but is driven by the hydrologic realities of frozen ground and surface runoff behavior. Their research shows that runoff during this period is governed almost entirely by snowmelt and rainfall on frozen soils (conditions that prevent nutrient infiltration and accelerate nutrient transport to streams). This mechanism aligns directly with the County's watershed data and the long-term trends described in this report, including the role of extensive drainage infrastructure that rapidly conveys meltwater and runoff to tributaries such as the Big Eau Pleine River, Fenwood Creek, and numerous unnamed channels. **The County's landscape, shaped by decades of conservation drainage and increasing row-crop intensity, magnifies the runoff pathways that Discovery Farms identifies as the primary drivers of late-winter nutrient transport (Appendix B:4).**

A significant point of cohesion is the importance of manure storage planning and field-by-field risk assessment. Discovery Farms recommends that farmers manage their storage capacity in the fall to avoid emergencies, or convenience-based winter applications and encourages producers to prioritize lower-risk fields when winter spreading is unavoidable. Marathon County's ordinance proposals translate these recommendations into practice by requiring either a comprehensive nutrient management plan or a winter spreading license that provides producers with SnapPlus-generated maps indicating field restrictions under frozen or snow-covered conditions. These regulatory tools compel the type of strategic planning, risk awareness, and responsible manure placement that Discovery Farms identifies as critical to reducing winter nutrient losses. In this way, the ordinance functions as a policy-level implementation mechanism for the storage management and field selection strategies outlined by Discovery Farms.

Finally, the quantitative trends described by Discovery Farms align closely with the phosphorus reduction estimates modeled for Marathon County farms in this report. Discovery Farms demonstrates that eliminating late-winter manure applications can dramatically reduce phosphorus losses, particularly in landscapes with high runoff potential. Marathon County's SnapPlus analyses of "Farms A and B" produced nearly identical findings, showing meaningful phosphorus reductions when winter applications were removed from their management schedules. When scaled across the dozens of farms operating between 300 and 999 animal units in the County, these reductions translate into thousands of pounds of phosphorus prevented from

entering surface waters (precisely the type of load reduction necessary to meet the Wisconsin River TMDL's 63–85% reduction targets).

Discovery Farms' research explains why late-winter manure spreading poses such an acute threat to water quality, while our ordinance provides the policy framework to prevent those conditions from recurring. By aligning local regulations with the hydrologic principles and timing-risk evidence identified by Discovery Farms, Marathon County is advancing a practical, data-driven approach to reducing phosphorus loss, enhancing storage planning, improving field-level decision making, and safeguarding surface waters during the most vulnerable period of the year.

**Considerations for Early Winter Applications of Manure; Discovery Farms (Appendix D:9)**

This Discovery Farms publication demonstrates that manure applications made earlier in the winter (generally October through December) pose lower phosphorus loss potential than those made later in the season because soils are not yet deeply frozen, snowpack is lighter or absent, and infiltration pathways are still at least partially functional. Under these early-winter conditions, nutrients have greater opportunity to bind to soil particles, reducing the likelihood that they will be mobilized during subsequent melt or rain events. These findings are consistent with Marathon County's modeling work showing significantly lower phosphorus export from farms when winter manure applications are minimized or shifted earlier in the season.

The study also emphasizes the importance of understanding field-specific characteristics when spreading during early winter, noting that areas with well-drained soils, flatter slopes, and minimal surface runoff pathways present lower environmental risk. These recommendations mirror the field risk considerations embedded within Marathon County's nutrient management plan requirements and the winter spreading license provisions. By requiring either an NMP or county-generated SnapPlus maps, identifying field restrictions under frozen or snow-covered conditions, the proposed ordinance ensures that producers follow the same risk-based field selection processes that Discovery Farms highlights as essential. In this way, our approach operationalizes the early-winter risk stratification framework that Discovery Farms promotes.

Another key point of cohesion is the shared recognition that even early-winter applications can become problematic when they occur immediately before rainfall or thaw events. Discovery Farms warns that manure applied within a short time window, particularly within one week of a runoff-producing event, can contribute substantially to nutrient loss regardless of season. This observation aligns with Marathon County's documented runoff events, several of which were triggered by rainfall on freshly applied manure, and supports the need for more structured planning around manure timing and field conditions. The ordinance's focus on promoting broader nutrient management planning and providing producers with explicit winter field-risk guidance directly reflects this emphasis on timing awareness and weather-based decision making.

Finally, Discovery Farms underscores that early-winter spreading should be viewed not as a preferred practice, but as an option that must be managed with careful oversight, storage planning, and field-level judgment. Marathon County's approach to ordinance updates echo this perspective, noting that while early-winter applications carry less risk than late-winter spreading, the overarching conservation priority is to reduce winter manure applications altogether

whenever possible. The County's analysis showing substantial phosphorus reductions from eliminating winter spreading at individual farms, and its broader conclusion that voluntary practices alone will not meet Wisconsin River TMDL requirements, reinforces Discovery Farms' position that early-winter spreading is only a comparatively safer option, not a comprehensive solution.

**Manure Applications on Frozen and/or Snow-Covered Ground; Discovery Farms (Appendix D:7)**

Proper timing of manure applications is especially critical for minimizing nutrient loss. Research by UW Discovery Farms shows that almost all winter runoff events in December and January (75%) are the result of a rain event on frozen or snow-covered ground. During February and March, warmer temperatures during the day lead to more frequent rain events than earlier in the winter. This publication shows that **later winter manure applications lead to phosphorus losses two to four times higher than early or no winter manure applications.**

Winter applications are particularly challenging due to frozen soil and snow cover, which prevent nutrients from bonding with the soil. Early winter (October–December) generally poses less risk than late winter (February–March), since conditions like concrete frost, ice crust, and dense snowpack are less developed earlier in the season.

Farmers should plan applications strategically to manage storage capacity and field risk. Those with sufficient storage should empty enough manure in fall to avoid emergency spreading later. Those with limited storage should prioritize riskier fields first. Understanding soil and weather conditions—such as avoiding spreading on frozen, crusted, or heavily snow-covered soils—helps prevent nutrient runoff. Applications should be timed to avoid imminent thaws or rain, and manure should be placed on flatter or internally drained fields when conditions are risky. Overall, reducing nutrient loss during winter spreading requires awareness of soil conditions, weather forecasts, and a well-prepared manure management plan.

**Nutrients and sediment in frozen-ground runoff from no-till fields receiving liquid-dairy and solid-beef manures; M.J. Komiskey, T.D. Stuntebeck, D.R. Frame, and F.W. Madison (Appendix D:6)**

The study by Komiskey et al. (2011) provides direct scientific support for Marathon County's proposed ordinance updates. Their research demonstrated that nutrient losses, particularly nitrogen and phosphorus, from both liquid dairy and solid beef manure are highly dependent on the timing of application, with late-winter applications on frozen or snow-covered ground resulting in disproportionately high losses. Applications within one week of runoff events were found to be especially problematic. Marathon County's ordinance responds directly to these findings by prohibiting manure spreading in February and March for medium and large-sized farms, and by requiring either a comprehensive Nutrient Management Plan or a winter spreading license that incorporates field-specific risk assessments. In this way, the ordinance translates Komiskey's empirical results into enforceable, practical regulations that reduce late-winter nutrient runoff, improve manure management planning, and support the county's broader phosphorus reduction and water quality goals.

**Steady-State Modeling Analysis of Big Eau Pleine Reservoir, Wisconsin River System; University of Wisconsin STOUT (Appendix D:1)**

The Big Eau Pleine Reservoir exhibits eutrophic to hypereutrophic conditions, with high phosphorus concentrations and frequent algal blooms (Appendix A:2, B:1). Between 2010 and 2013, a detailed monitoring study measured total phosphorus, chlorophyll a, and water clarity to inform Total Maximum Daily Load (TMDL) development. Samples were taken biweekly from four stations along the reservoir, complimented by gauged inflow and outflow data from tributaries such as the Big Eau Pleine River, Freeman Creek, and Fenwood Creek.

The findings showed a substantial phosphorus gradient (from 0.195 mg/L near the inflow, to 0.102 mg/L near the dam), indicating strong phosphorus retention (about 60%) within the reservoir. Average chlorophyll concentrations (~69 µg/L) and poor Secchi transparency (~0.7 m) reflected nutrient enrichment and algal dominance, corresponding to hypereutrophic conditions.

Empirical models were developed using the "Bathtub" software to simulate nutrient dynamics and predict water quality responses to phosphorus load reductions**. The models showed that external phosphorus inputs from tributaries accounted for most of the summer phosphorus levels**, with limited evidence of internal loading from sediments.

Current phosphorus loading to Big Eau Pleine Reservoir was reduced by 20% increments in Bathtub to examine predicted water quality responses to simulated future phosphorus loading reduction as a result of best management practices (BMP) implementation for TMDL development and goal-setting (Fig. 16 in Appendix D:1). **A 50% reduction in annual phosphorus loading coincided with a 40% decline in summer total phosphorus**. Under this same phosphorus loading reduction scenario, predicted summer chlorophyll concentrations declined by 54%. Predicted Secchi transparency increased by 27%.

**Modeling results indicated that reducing phosphorus inputs by 50% would yield significant ecological improvements.**

**Impact of Manure Application in Different Seasons on Phosphorus Loss in Runoff; Peter Vadas, Bill Jokela, and Laura Good (Appendix D:4)**

Phosphorus loss from agricultural lands remains a major environmental concern, especially where manure is surface-applied without incorporation. In northern states, including Wisconsin, winter manure spreading is common, but the combination of frozen soils and snowmelt runoff can lead to substantial phosphorus loss. Researchers from the USDA Agricultural Research Service (ARS) and the University of Wisconsin–Madison developed the SurPhos model, a process-based tool that simulates how manure phosphorus transforms and moves through the environment under different application and weather conditions.

Using SurPhos, the USDA scientists evaluated how manure application timing affects phosphorus loss across 108 site-years of runoff data from six Wisconsin monitoring locations. Simulations of liquid dairy manure applications across all days of the year revealed that phosphorus losses were minimal when manure was applied between March and October, but rose sharply with winter applications, especially at sites prone to high runoff. T**he highest P losses occurred with manure applied in January through March**. On average, winter applications

increased runoff phosphorus loss by 2.8 to 4.2 times compared to non-winter periods, and sites with high runoff potential lost up to seven times more phosphorus than low-runoff sites. They also found that shifting manure applications to fields with less runoff potential can reduce phosphorus losses by 3.4 to 7.5 times. These findings demonstrate that avoiding winter manure application (particularly in high-runoff areas), could substantially reduce phosphorus pollution risk, though annual variability in field runoff potential complicates management decisions.

**Strategies for Reducing Fish Kills in the Big Eau Pleine Reservoir (Appendix E:5)**

Our ordinance updates directly support the hydrologic and biogeochemical objectives outlined in *Strategies for Reducing Fish Kills in the Big Eau Pleine Reservoir*, which identifies late-winter organic loading and associated oxygen depletion as primary drivers of fish mortality events. The strategy highlights that elevated biological oxygen demand (BOD), high concentrations of particulate and dissolved phosphorus, and rapid runoff pulses during freeze/thaw transitions are the critical conditions leading to hypolimnetic oxygen drawdown in the Big Eau Pleine Reservoir.

By prohibiting manure application during February and March (months characterized by frozen soils, concrete frost, limited infiltration capacity, and high runoff coefficients), the ordinance substantially reduces the delivery of oxygen-demanding material and bioavailable phosphorus to tributaries such as the Big Eau Pleine River and Fenwood Creek.

The requirement for expanded nutrient management planning, improved winter-storage planning, and increased buffer implementation further reduces particulate transport, peak-flow nutrient spikes, and sediment-bound phosphorus loads.

Collectively, these regulatory shifts decrease the magnitude and frequency of late-winter nutrient pulses that have historically triggered fish kills by suppressing dissolved oxygen concentrations. In this way, the ordinance provides a direct implementation mechanism for achieving the water-quality conditions and load-reduction targets specified in the fish-kill mitigation strategy.

**<u>Scientific Data Supporting the Need for Local Ordinances above State Performance Standards</u>**

The transition to more row crop and corn silage acres has increased soil and nutrient losses. Many of these acres already meet current State requirements for nutrient management, tolerable soil loss, PI, and tillage setbacks, yet surface water quality continues to suffer.

According to Wisconsin River TMDL data, **Marathon County contributes 28% of agricultural phosphorus load to the system from 25% of cropland in the TMDL area.** Cropland is the largest contributor of phosphorus runoff in Marathon County, (Appendix A:3 and Appendix A:4). The data shows that critical phosphorus loading conditions from agriculture occur from March to June. Best management practices that are effective year-round at reducing phosphorus losses will need to be implemented, leading to a seasonal pattern in load reductions that is approximately proportional to the seasonal pattern of the baseline loading seen in TMDL data. Current State Performance Standards will not get the reductions that are required (Appendix A:7).

One localized example comes from Marathon County's Nine-Key Element HUC-12 Watershed: Fenwood Creek (Appendix D:2, E:2). This is a typical watershed found in western Marathon County's agriculture dominated area, and is frequently used in Marathon County for various water quality modeling efforts due to its appropriate representation of the full county. Modeling from the 9-Key Element Plan shows a weighted phosphorus index (PI) average (SnapPlus calculated) for cropland of 4.8, which is well below the State requirement of 6. Cropland is the single largest contributor of phosphorus runoff, when compared to all other agricultural sources. **These same trends are seen throughout Marathon County, with cropland being the single largest contributor of agricultural phosphorus runoff**. During the Fenwood Creek watershed inventory, other sources of potential phosphorus runoff were identified, and these accounted for less than 10% of total agricultural phosphorus runoff. Marathon County CPZ staff have used SnapPlus data, in conjunction with expertise from DNR staff Pat Oldenburg, to determine that in order for the Fenwood Creek Watershed to meet the Wisconsin River TMDL, all cropland would have to have a PI of less than 2.

The TMDL used SnapPlus modeling to estimate total phosphorus reduction targets for each watershed based on average slopes and dominant soil types. Because it uses average rather than critical conditions, these models show lower phosphorus losses than those accounting for steeper slopes or more vulnerable soils. **Overall, Marathon County data indicates that phosphorus reductions of 63–85% from cropland are needed to meet water quality standards (Appendix A:3).** However, the modeling does not include phosphorus losses from gullies or concentrated flow channels, which can greatly increase runoff and must be addressed first.

## Analysis of Estimated Phosphorus and Sediment Reductions from Ordinance Changes

Buffers:

Buffers are highly effective at reducing phosphorus and sediment runoff from cropland. Using SnapPlus modeling, Marathon County staff found that a 30-foot grass buffer could reduce phosphorus losses by 59–78% and sediment losses by 81–89% for both dairy and cash grain rotations (results confirmed by UW–Madison soil scientist and SnapPlus Administrator, Hava Blair).

The weighted average reduction for phosphorus was 3.5 lbs/acre and for sediment it was 2.9 tons/acre. Marathon County's analysis identified about 3,816 acres (1.3% of cropland) that should have buffers installed along streams. These areas typically have high water tables and soils too wet for productive cropping. Using the data above, 3816 acres x 3.5 lbs/acre = 13,356 lbs phosphorus/yr and 3816 acres x 2.9 tons/acre =11,066 tons soil/year in reductions. Keep in mind that the above calculations are using SnapPlus's standard 30-foot buffer on streams, and our calculations are truly conservative estimates. Many fields have several different soil complexes and this is why a weighted average was used to calculate sediment and phosphorus reductions. **A 35-ft vegetated buffer on every stream in Marathon County could plausibly stop on the order of over 30,000 pounds of phosphorus per year.**

While buffers are a valuable best management practice, they are just one of many best management practices needed to control runoff. Many crop fields also need to implement grassed

waterways, cover crops, and other agronomic practices to control runoff and increase water retention.

Winter Spreading Restrictions for Farms 300-999 Animal Units:

In Marathon County, 98% of farms with animal waste storage have nutrient management plans, representing nearly 80% of the county's cattle and manure production. Although most animal waste storage systems can hold waste for four months or more, large amounts of liquid animal waste are still applied in winter (mainly in February and March), leading to significant runoff. "The application of manure to frozen impermeable soils can increase the risk of manure nutrients and contaminants running off of fields during the spring thaw. The loss of nutrients to spring thaws means a loss of soil productivity for farmers in addition to potentially impacting local water bodies *(*Thompson et al., 1979*)*." (Appendix D:5)

These winter applications often occur for a variety of reasons such as preparing for spring fieldwork, taking advantage of frozen/accessible fields, increasing waste storage space for the coming year, or applying manure before road restrictions begin. "Until nutrient runoff from the surrounding lands is reduced, the Big Eau Pleine will continue to be challenged by winter anoxia and fish kills." (Appendix E:6)

Marathon County CPZ staff were involved with several complaints over the past six years that occurred with medium-sized farms (300-999 animal units) applying manure during mid-to-late winter that resulted in runoff. The farms have adequate animal waste storage for six months, but chose to winter-spread animal waste for convenience purposes. The most recent runoff event in January 2023 had an estimated 750,00 to 1,000,000 gallons of animal waste applied that ran off into nearby surface water.

For case study purposes, let's review two Marathon County farms ("Farm A" and "Farm B") that recently installed long-term animal waste storage. SnapPlus was used to model the phosphorus reductions by removing the actual winter applications that occurred, to determine the reduction in phosphorus. The animal waste applied was a solid, semi-solid, and/or liquid throughout winter months.

Farm A had about 200 milk cows and a mix of young stock. Winter manure applications were occurring from the milk cows on 126 acres. By removing winter spreading, the farm saw a phosphorus reduction of 300 pounds, or about 2.4 pounds/acre. For Farm A, this was averaged over two years of data.

Farm B had 220 milk cows and a mix of young stock. Winter manure applications were occurring on 200 acres. This farm was applying the majority of their manure as a liquid (700,000 gallons during winter months). By removing winter spreading, Farm B saw a phosphorus reduction of 388 pounds, or 1.9 pounds/acre.

The weighted average reduction from these two farms, is 2.1pounds of phosphorus per acre. If winter conditions occur for 4.5 months, or 135 days, this would be an average phosphorus reduction of 0.01555 lbs/phosphorus/acre/day.

Substantial reductions in winter nutrient losses can be achieved by establishing a manure-spreading prohibition for farms with 300 to 999 animal units during February and March, the period identified as the highest risk for runoff.

There are 18 livestock siting farms in Marathon County that have an average of 808 animals units, and 1175 acres/farm (1.45 acres/animal unit or 21,150 acres cropland total). A number of the livestock siting farms annually winter-apply liquid manure during the high-risk runoff period of February and March. In reviewing their nutrient management plans, these applications generally do not get documented correctly for season timing or application rates.

From using our department's data, there are an additional 22 to 42 farms that have 300 to 999 animals units in Marathon County. We have data for 23 of these farms with an average of 391 animal units/farm, and 778 acres/farm (1.99 acres/animal unit) or 17,885 acres cropland total. Again, a number of these farms annually-winter apply liquid manure during the high-risk runoff period of February and March. In reviewing their nutrient management plans, these applications generally do not get documented correctly for season timing or application rates.

Marathon County CPZ staff have observed variability throughout the years for the amount of liquid manure applied during winter. The reduction calculations below will look at a range of 10-50% of the acres for farms that have 300 to 999 animals, applying liquid manure during February and March:

- Total acres for these farms are: 21,150 acres (18 livestock siting farms) + 17,885 acres (23 farms) + 7,002 acres (estimated 9 additional farms x 778 acres/farm) = 46,037 acres.

- For calculations, we used 10% of 46,037 acres, (~4600 acres) and 50% of 46,037 acres (~23,000 acres).

- Using 0.01555 lbs phosphorus/acre/day (found in the above case study) x 60 days x 4,600 acres = ~4,290 lbs phosphorus/2-month period.

- For 23,000 acres x 0.01555 lbs/acre/day x 60 days = 21,460 lbs phosphorus/2-month period.

- Averaging 4,600 acres over 50 farms is about 92 acres per farm and 23,000 over 50 farms is about 460 acres per farm, that would have winter-applied liquid manure. **Marathon County CPZ's estimate of 4,290-21,460 lbs phosphorus/2-month period is based on the best data that is available, and is a conservative estimate.**

Winter Spreading License Requirement

The farmer workgroup that spent months meeting to come up with compromises for ordinance changes were in unity surrounding the need for greater adoption and implementation of nutrient management plans in Marathon County. A winter spreading license would not be required if a nutrient management plan is on file with the CPZ office. If farmers opt to get a winter spreading license instead of adopt a nutrient management plan, they will be given a set of winter spreading maps created through SnapPlus, depicting field restrictions and options for frozen soils.

While we are not able to model specific phosphorus or soil loss reductions portraying larger-scale nutrient management adoption, we are confident that our ordinance change is supported by

directives within the many water quality, watershed plans, and research studies that have been created surrounding Marathon County surface waters.

The *Marathon County Land & Water Resource Management Plan* (Appendix E:3) directly identifies increased NMP adoption as a core strategy for reducing nutrient losses, improving soil health, and safeguarding wellhead protection areas. Within this plan, NMPs are explicitly connected to the goal of enhancing groundwater quality by ensuring that manure applications are better timed, better placed, and better aligned with agronomic needs. The Marathon County Board also focuses on achieving action items laid out in the *2023-2024 Marathon County Strategic Plan*, such as protecting and enhancing the quality of groundwater and surface water (Appendix E:4).

Similarly, the *Strategic Plan for the Big Eau Pleine River Watershed and Reservoir* (Appendix E:1) underscores NMPs as a necessary component of the county's efforts to reduce phosphorus loading. The plan states that Marathon County and its partners "must provide producers with better strategies to minimize runoff," specifically naming NMPs alongside BMPs and manure-treatment technologies as tools required to curb chronic discharges and widespread nonpoint-source impacts. In this context, NMPs are seen not simply as compliance documents, but as central mechanisms for improving manure utilization, minimizing runoff risk, and meeting long-term water-quality goals.

The *Fenwood Creek Watershed Management Plan* (9-Key Element Plan*)* further reinforces the importance of nutrient management, even where it is not explicitly named (Appendix E:2). The plan's phosphorus-reduction targets (including lowering the watershed's average Phosphorus Index (PI) and reducing soil erosion), are objectives that inherently depend on robust and widespread NMP implementation. Achieving the watershed's 45% phosphorus-reduction goal requires field-level nutrient budgeting, erosion control practices, and seasonal manure-application planning: the very components of a properly developed NMP (Appendix E:2).

Even *Strategies for Reducing Fish Kills in the Big Eau Pleine Reservoir* (Appendix E:5), though focused on flow, oxygen levels, and late-winter nutrient pulses, aligns with the broader theme that improved manure-management planning is necessary to prevent high-risk runoff events. By addressing manure timing and field risk (functions governed within NMPs), the County advances the strategy's objectives through more consistent and science-based nutrient-application practices.

Taken together, these plans demonstrate a unified direction: **expanding NMP coverage is fundamental to achieving Marathon County's soil-health, groundwater-protection, and phosphorus-reduction goals.** By strengthening nutrient-management expectations across all agricultural operations, the proposed ordinance aligns directly with the strategic intent of every major planning document guiding the county's conservation work.

## Consistency with Existing Plans and Research: Side-by-Side Comparison Table

**Marathon County Land & Water Resource Management Plan (LWRMP)**

| Plan Goal | Corresponding Ordinance Recommendation / Supporting Data |
|---|---|
| **1.1 Reduce soil erosion** | Soil erosion increased from 1.6 → 2.4 tons/ac/yr (1999–2024). Ordinance requires **35-ft buffers** to filter sediment. |
| **1.2 Improve soil health** | Vadas Study (USDA) & Discovery Farms show late-winter manure causes 2.8–4.2× more P loss. **February–March spreading prohibition** improves soil function. |
| **2.1 Reduce agricultural runoff** | Hazaga (DNR): Winter runoff delivered **14×** sewage-strength BOD. Removing late-winter manure reduces high-risk runoff events. |
| **2.2 Implement TMDLs** | Marathon County contributes **238,937 lbs P/yr** to the Wisconsin River TMDL. Ordinance reduces P loading via seasonal limits + buffers. |
| **2.5 Improve lake/stream habitat** | Buffer modeling shows **59–78% P reduction**; aligns with habitat improvement goals. |
| **3. Protect groundwater** | 664M gallons manure/yr require careful timing; NMP-based permitting reduces contamination risk. |
| **4. Education & outreach** | CPZ, EPPIC, producer-led groups support farmer engagement as new rules take effect. |

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**Strategies For Reducing Fish Kills In The Big Eau Pleine Reservoir**

| Plan Goal | Corresponding Ordinance Recommendation / Supporting Data |
|---|---|
| Improve water quality & fishery | Hazaga (DNR) study: 3-day melt delivered BOD equal to **8,000 cows losing 20% of manure**. Feb–Mar prohibition targets these events. |
| Reduce manure-driven oxygen depletion | Ordinance removes late-winter manure inputs that create under-ice oxygen demand. |

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**Strategic Plan For The Big Eau Pleine River Watershed And Reservoir**

| Plan Goal | Corresponding Ordinance Recommendation / Supporting Data |
|---|---|
| Minimize winter surface spreading | Ordinance prohibits Feb–Mar liquid manure spreading for farms ≥300 AU. |
| Increase regulatory presence where chronic runoff persists | Documented runoff events (750k–1M gallons in 2023) justify increased ordinance authority. |
| Provide BMP training & tech support | Ongoing CPZ & EPPIC programs achieve this requirement. |

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**Marathon County Strategic Plan**

| Plan Objective | Ordinance Alignment |
|---|---|
| **5.2 Sound land-use decisions** | Ordinance modernizes protections in response to rising erosion & nutrient loading. |
| **6.3 Protect potable water** | Reduces P, BOD, and bacteria at the source rather than through costly treatment. |

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**Fenwood Creek Watershed Management Plan**

| Plan Goal | Corresponding Ordinance Recommendation / Supporting Data |
|---|---|
| 45% P reduction (5,080 lbs/yr) | Removing winter spreading reduces **4,290–21,460 lbs** P over 2 months. |
| Reduce PI 4.8 → 2.6 | Ordinance reduces PI through timing restrictions + buffers. |
| Reduce erosion 3.1 → 1.7 tons/ac/yr | Buffers modeled to reduce **11,066 tons/yr** sediment. |
| Address cropland as major P source | Ordinance directly targets high-risk cropland applications. |

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**Big Eau Pleine Dissolved Oxygen Modeling Technical Committee (2016)**

| | |
|---|---|
| **General Purpose:** Protect BEP fishery by preventing winter anoxia (oxygen depletion). | Our ordinance addresses the **largest controllable source of winter oxygen depletion—manure-driven nutrient and organic loading**—by restricting February–March spreading and strengthening manure management practices. |
| **Maintain reservoir water levels as high as practical entering winter** | Our report documents how **late-winter manure runoff increases sediment oxygen demand (SOD)** in the reservoir, accelerating DO depletion. Reducing nutrient loading aligns with this goal by decreasing SOD regardless of water level. |
| **Risk Factor: Heavy fall or spring precipitation washes nutrients/sediment into reservoir** | February–March manure spreading is often followed by **late-winter melt and rain events**, which your ordinance eliminates. This directly reduces the nutrient/sediment load that the DO model identifies as a high-risk factor. |
| **Recommend expanded year-round monitoring (summer/fall temperatures, algal blooms, P levels)** | Your report's data on **annual phosphorus loading, soil erosion, manure tonnage, and high-risk fields** provides a scientific basis for integrating summer/fall monitoring into manure-management decisions. |
| **Support measures reducing nutrient & organic loading to BEP** | This is the direct purpose of our ordinance. Late-winter manure restriction, NMP strengthening, and buffer requirements all **reduce the exact nutrient and organic loads** identified by the DO model as the drivers of winter anoxia. |
| **Address sediment-oxygen demand (SOD) as key driver of DO loss** | Our report documents **how manure runoff contributes high-BOD organic material** to BEP. Eliminating Feb–Mar manure spreading directly reduces SOD inputs, helping slow winter oxygen loss. |

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**Discovery Farms – Considerations For Mid And Late Winter Manure Applications**

| **Discovery Farms Findings & Recommendations** | **Corresponding Ordinance Recommendation / Supporting Data From Your Report** |
|---|---|
| **Late winter (Feb–Mar) is when most annual runoff occurs** | The ordinance **prohibits liquid manure spreading in February–March** for medium and large farms—directly aligning with research showing this is the highest-risk period for nutrient loss. |
| **Runoff risk spikes when manure is applied within one week of a runoff event** | The ordinance removes the need for manure application during late winter "panic spreading," preventing manure from being applied near thaw or rain events when P and N losses peak. |

| | |
|---|---|
| **Warming temps, rapid melts, intense sun = high runoff** | The winter spreading restrictions eliminate manure applications during the exact weather conditions Discovery Farms identifies as dangerous for runoff. |
| **Rain on frozen or snow-covered ground causes most early-winter runoff (75% of Dec–Jan events)** | The February–March restriction extends protection into the most problematic late-winter rain-on-snow conditions, reducing these documented high-runoff events. |
| **Concrete frost or ice crust prevents infiltration, increasing manure runoff risk** | The ordinance's prohibition on manure during late winter avoids manure placement on frozen or ice-covered soils—conditions Discovery Farms identifies as the *primary predictor* of manure loss. |
| **Vegetative cover reduces severity of frost, lowering runoff risk** | The ordinance's **35-foot buffer requirement** increases vegetative cover in riparian areas, directly reducing frost severity and improving infiltration. |
| **Saturated soil during thaw leads to high runoff and soil compaction** | Your ordinance ensures **most manure is not applied during thaw**, preventing both runoff and soil damage, consistent with Discovery Farms' guidance to avoid manure during saturated-soil periods. |
| **Spring (May–June) contributes significant runoff; soil moisture is a key factor** | Strengthened NMP planning in your ordinance encourages farmers to adjust spreading to soil conditions, reducing nutrient loss during wet spring periods. |
| **Farmers should empty storage earlier in winter to avoid Feb–Mar spreading** | The ordinance directly implements this recommendation by incentivizing storage planning and requiring farms to avoid late-winter spreading unless conditions are non-winter per NMP guidance. |
| **If forced to spread, farmers must identify low-risk fields** | The ordinance's **NMP-based winter spreading permit** reflects this guidance by requiring field-by-field risk analysis if spreading is necessary. |
| **Don't plan winter manure application in February—plan earlier** | The ordinance operationalizes this advice, prompting farmers to prepare months in advance so they are not forced to spread manure during unsafe conditions. |
| **A winter spreading plan should be in place to reduce nutrient loss** | The ordinance creates the regulatory framework ensuring **every farm has a workable winter contingency plan**, exactly as recommended by Discovery Farms. |

**Discovery Farms – Considerations for Early Winter Applications Of Manure**

| **Discovery Farms Findings & Recommendations (Early Winter 2014)** | **Corresponding Ordinance Recommendation / Supporting Data From Your Report** |
|---|---|
| **Timing of manure is critical to reducing nutrient loss** | The ordinance's seasonal restrictions and NMP-based planning are built to ensure manure is applied **only during low-risk windows**. |
| **Manure applied ≤ 1 week before a runoff event results in significantly increased N & P losses** | The ordinance removes the need for "emergency" late-winter spreading and ensures storage is managed proactively to avoid last-minute applications. |
| **Manure applied weeks or months before runoff reduces nutrient loss by 50–75%** | The February–March prohibition pushes applications back into lower-risk late fall/early winter months, where nutrient loss is dramatically reduced. |
| **Early winter (Oct–Dec) has lower risk due to less snow, less concrete frost, and fewer ice crusts** | Ordinance allows manure application during early winter *when conditions are safer*, while preventing spreading later when frost/ice risk increases. |
| **Late winter (Feb–Mar) greatly increases risk because of deep snowpack, concrete frost, and ice crusts** | The ordinance's **Feb–Mar spreading prohibition** directly reflects these findings, eliminating the highest-risk application period. |
| **Farmers with 3+ months of storage should empty storage early to avoid February/March spreading** | Ordinance incentivizes early pumping by prohibiting late-winter liquid manure spreading except under very specific low-risk conditions. |
| **Farms with limited storage should use early winter to spread on riskier fields and save low-risk fields for late winter** | The ordinance formalizes this by requiring **NMP-based winter spreading permits**, directing manure only to low-runoff-potential fields when necessary. |
| **Concrete frost prevents infiltration and greatly increases nutrient loss** | The ordinance restricts manure application during periods when concrete frost is most common, preventing manure from sitting atop impermeable frozen soil. |
| **Ice crust (formed when rain falls on cold soil) prevents manure-soil contact** | The manure-timing restrictions avoid applications during ice crust conditions, exactly matching Discovery Farms' identified risk factors. |
| **Snowpack depth and condition strongly affect manure loss risk** | The ordinance emphasizes avoiding manure application on **dense late-winter snowpack**, mirroring this guidance. |
| **Shallow, light early-winter snow is lower risk** | Ordinance allows early-winter application while conditions allow manure to melt through and bind to the soil. |
| **Dense late-winter snow or slush offers little soil contact and greatly increases P loss** | Ordinance prohibits manure application during late winter when such snowpack conditions dominate. |

| | |
|---|---|
| **Avoid spreading before melt events or winter rain** | The ordinance eliminates spreading during the time of year when **rain-on-snow events are most frequent** and most damaging. |
| **If manure must be applied during risky periods, choose flat, internally drained fields** | The NMP-based winter permit process mirrors this exactly—requiring targeted field selection based on slope, drainage, and soil conditions. |
| **Key to reducing nutrient loss: understand local conditions and have a winter spreading plan** | The ordinance requires farms to integrate a winter-spreading plan within their NMP, operationalizing this recommendation. |

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**Nutrients and sediment in frozen-ground runoff from no-till fields receiving liquid-dairy and solid-beef manures**

**Komiskey et al. (2011) Study Findings**

| **Findings and Recommendations** | **Corresponding Ordinance Recommendation / Supporting Data From Your Report** |
|---|---|
| Nutrient losses (N & P) are highly dependent on **timing of manure applications**, with **late-winter applications posing the greatest risk**. | Ordinance prohibits manure spreading in **February and March** for medium- and large-sized farms, directly targeting the highest-risk period. |
| Losses are especially severe when manure is applied **on frozen or snow-covered soils**, preventing nutrient infiltration and increasing runoff. | Ordinance requires either an **NMP or winter spreading license** that incorporates **field-specific risk assessments**, ensuring manure is applied only when soils can absorb nutrients. |
| Applications within **one week of runoff events** can lead to catastrophic nutrient loss. | Ordinance enforces **structured planning and timing awareness**, minimizing manure application before potential runoff events. |
| Field-specific management, including storage planning and identifying higher-risk fields, is critical to reducing nutrient losses. | Ordinance translates this into a **regulatory framework**, using SnapPlus maps and NMPs to guide field-level decisions and improve manure management practices. |
| Late-winter nutrient losses contribute significantly to surface water contamination and downstream environmental impacts. | Ordinance implements **practical, enforceable measures** to reduce late-winter phosphorus runoff, supporting the county's **phosphorus reduction targets, TMDL compliance, and fishery protection goals**. |

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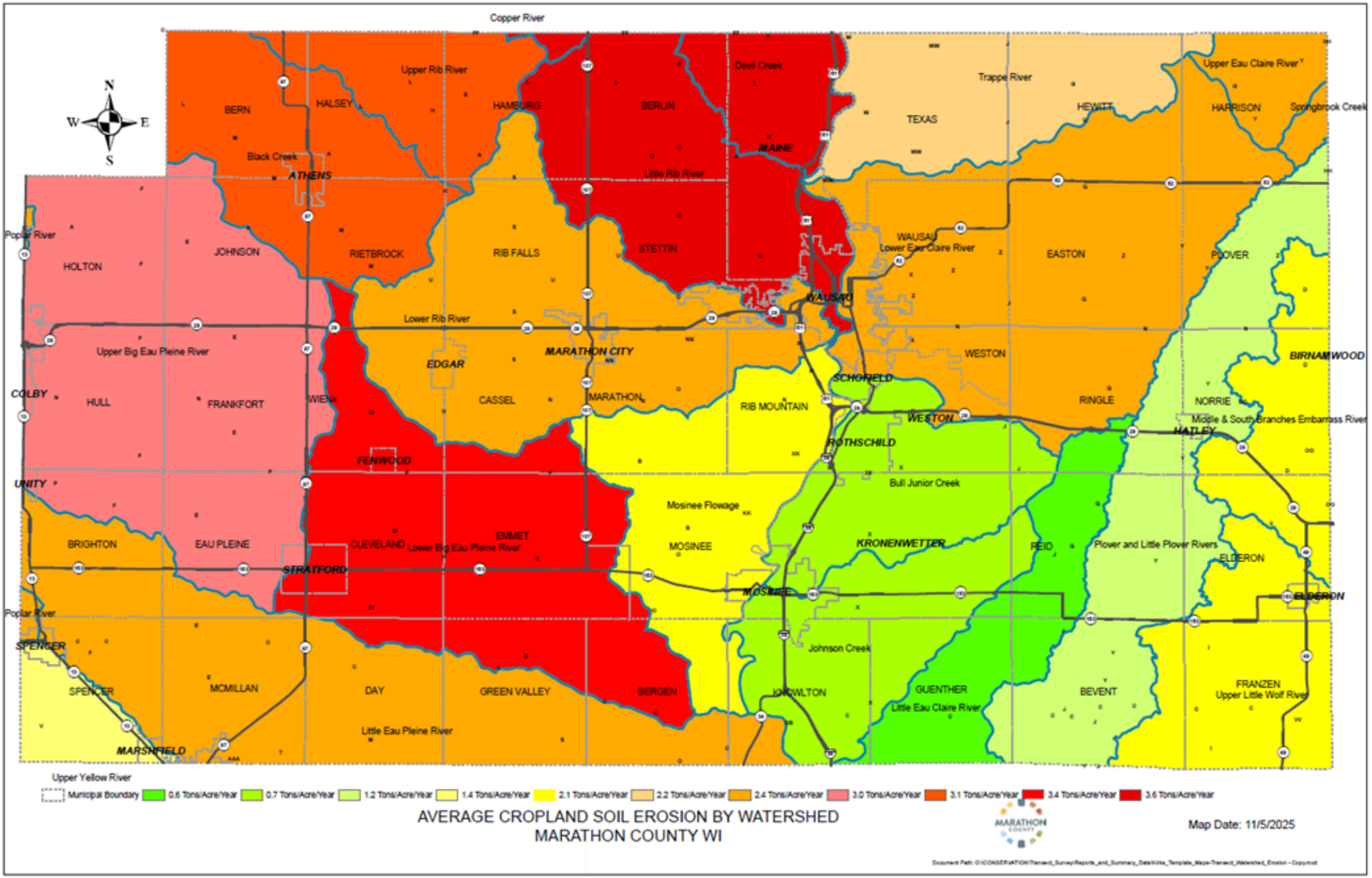
**Steady-State Modeling Analysis of Big Eau Pleine Reservoir, Wisconsin River System**

| Findings and Recommendations | Corresponding Ordinance Recommendation / Supporting Data From Your Report |
|---|---|
| The reservoir is **hypereutrophic** (TSI-P = 74) with extremely high phosphorus, chlorophyll, and low water clarity. | Ordinance aims to **reduce countywide phosphorus loading**, directly addressing the impaired status documented by the study. |
| Inflow TP averaged **0.269 mg/L**—very high for a reservoir—driven mainly by agricultural tributaries (BEP River, Freeman Creek, Fenwood Creek). | Ordinance targets the **largest controllable P source: agricultural runoff**, especially through winter spreading restrictions, NMP requirements, and field risk mapping. |
| The reservoir **retains ~60% of incoming phosphorus**, meaning phosphorus entering the system accumulates and worsens algae blooms over time. | Reducing watershed P inputs through the ordinance helps **slow the accumulation of legacy P**, improving long-term water quality. |
| Longitudinal P gradients show **highest concentrations in headwaters**, coinciding with zones receiving watershed runoff. | Ordinance's **performance-based field restrictions** (via NMPs, SnapPlus risk layers) prioritize high-risk fields typically closer to tributary flow paths. |
| Algal blooms frequently exceed **20 µg/L (89% of summers)** and **60 µg/L (41% of summers)**—indicating severe bloom issues. | Ordinance reduces nutrient input during the **highest-risk hydrologic windows (late winter/early spring)**, when runoff-driven bloom fueling typically begins. |
| Study models show a **50% P loading reduction** would decrease summer P by 41%, chlorophyll by 55%, and increase water clarity by 28%. | Ordinance components (winter spreading ban, NMP requirements, proper storage, field-by-field risk controls) are **exactly the types of BMPs needed to achieve TMDL-driven P reductions**. |
| Tributary inputs—not internal loading—were the **dominant P source**, meaning solutions must focus on the watershed, not the reservoir itself. | Ordinance's focus on **source reduction** (manure management, timing controls, storage requirements) is aligned with the study's conclusion that watershed actions are most effective. |
| High-flow years delivered the most P and triggered strong uptake/bloom responses—confirming **runoff events drive algal problems**. | Ordinance reduces manure spreading during seasonal runoff periods and requires **planning around hydrology** via NMPs and spreading licenses. |
| The BEP River contributed **84% of all measured P inputs**; smaller tributaries contributed much less. | Ordinance applies countywide but significantly benefits the **BEP basin**, which is the major driver of reservoir impairment. |

| | |
|---|---|
| Empirical models used in the study are the basis for setting **TMDL phosphorus reduction goals**. | Ordinance provides the **regulatory framework necessary for Marathon County to meet TMDL reduction targets** identified by these models. |

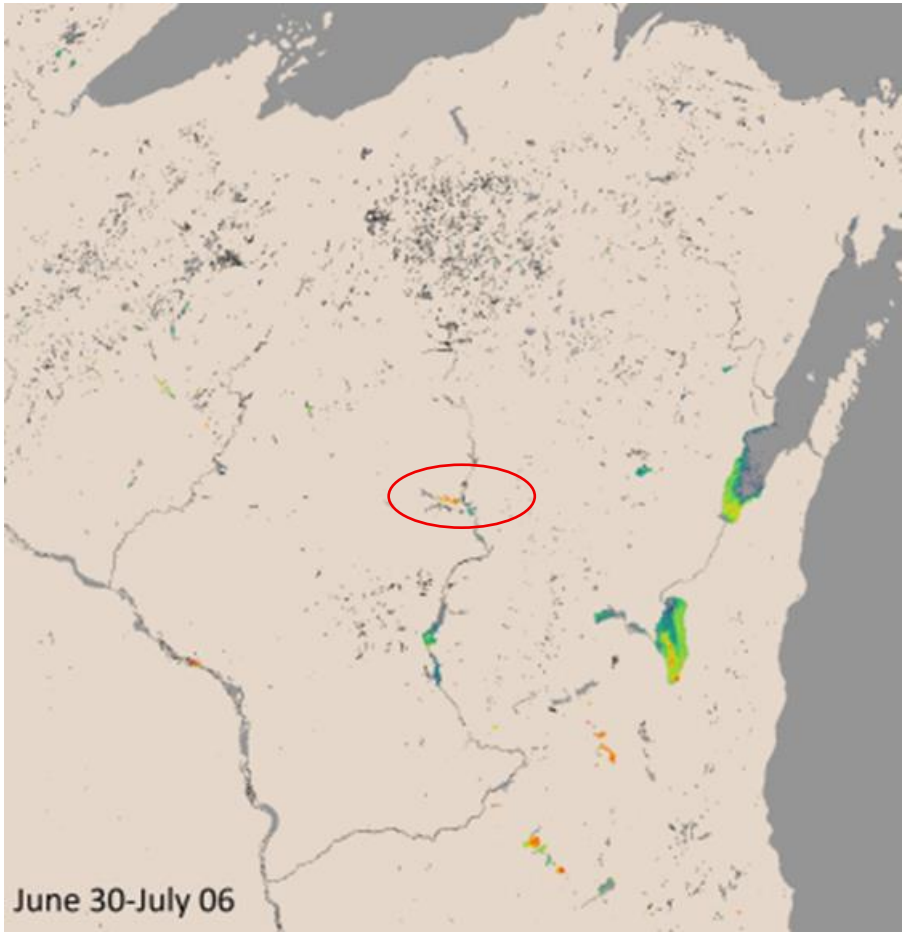
# Appendix A

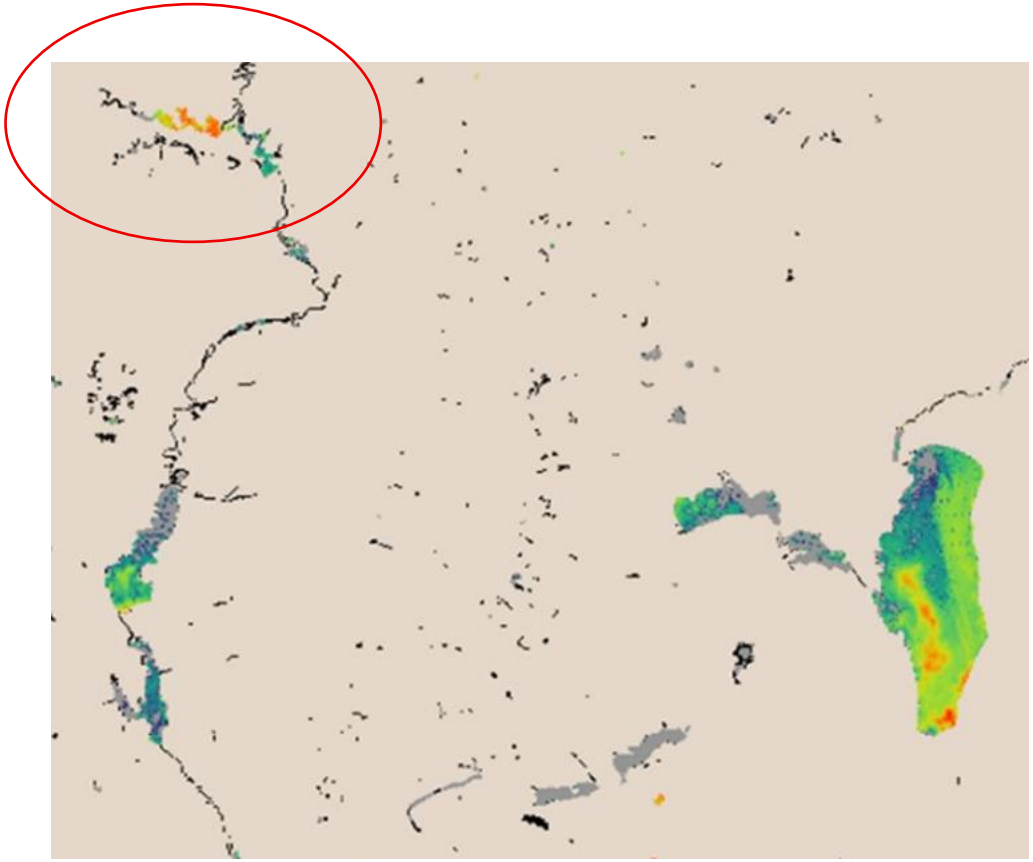
# Appendix A:1


Copper River
Upper Rib River
Devil Creek
Trappe River
Upper Eau Claire River
BERN
HALSEY
HAMBURG
BERLIN
TEXAS
HEWITT
HARRISON
Springbrook Creek
MAINE
Black Creek
ATHENS
Little Rib River
Poplar River
JOHNSON
RIETBROCK
RIB FALLS
STETTIN
WAUSAU
Lower Eau Claire River
EASTON
PLOVER
HOLTON
Lower Rib River
WAUSAU
Upper Big Eau Pleine River
EDGAR
MARATHON CITY
WESTON
BIRNAMWOOD
SCHOFIELD
COLBY
HULL
FRANKFORT
WIEN
CASSEL
MARATHON
RIB MOUNTAIN
RINGLE
NORRIE
WESTON
Middle & South Branches Embarrass River
HATLEY
ROTHSCHILD
FENWOOD
UNITY
Bull Junior Creek
Mosinee Flowage
BRIGHTON
EAU PLEINE
CLEVELAND
EMMET
Lower Big Eau Pleine River
MOSINEE
KRONENWETTER
REID
Plover and Little Plover Rivers
ELDERON
STRATFORD
MOSINEE
ELDERON
Poplar River
SPENCER
Johnson Creek
SPENCER
MCMILLAN
DAY
GREEN VALLEY
BERGEN
KNOWLTON
GUENTHER
BEVENT
FRANZEN
Upper Little Wolf River
Little Eau Pleine River
Little Eau Claire River
MARSHFIELD
Upper Yellow River
Municipal Boundary
0.6 Tons/Acre/Year
0.7 Tons/Acre/Year
1.2 Tons/Acre/Year
1.4 Tons/Acre/Year
2.1 Tons/Acre/Year
2.2 Tons/Acre/Year
2.4 Tons/Acre/Year
3.0 Tons/Acre/Year
3.1 Tons/Acre/Year
3.4 Tons/Acre/Year
3.6 Tons/Acre/Year
AVERAGE CROPLAND SOIL EROSION BY WATERSHED
MARATHON COUNTY WI
Map Date: 11/5/2025

# Appendix A:2

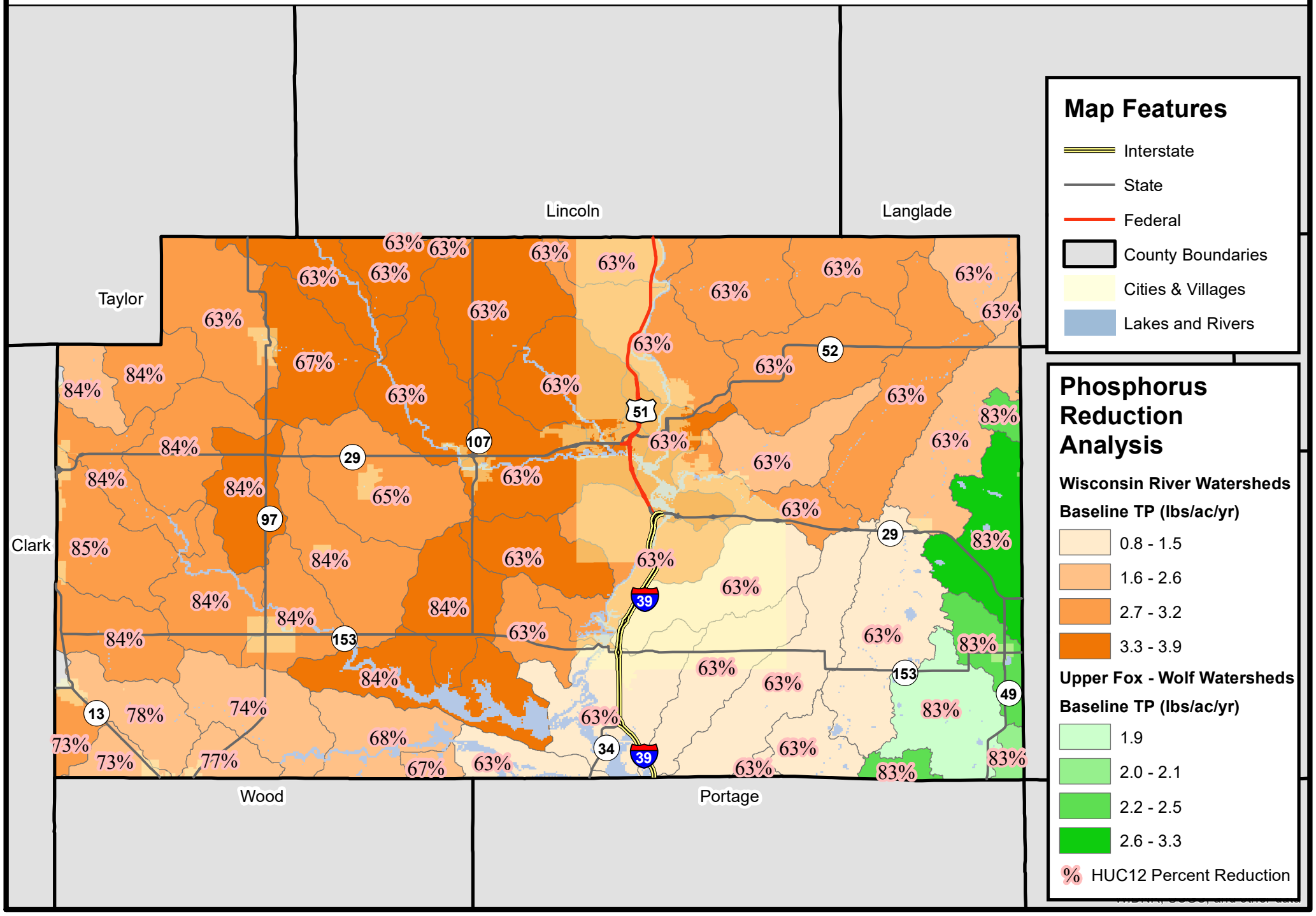
Satellite detected algal blooms.



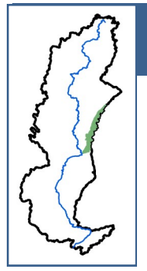



# Appendix A:3

# TMDL Baseline Phosphorus and Reductions
# Marathon County HUC12 Analysis



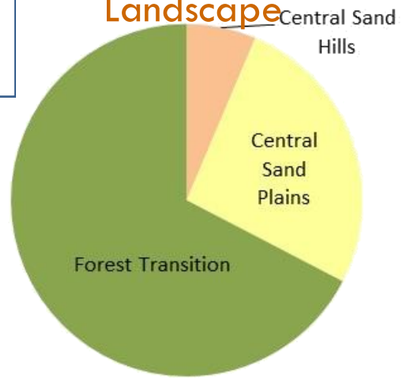
# Appendix A:4



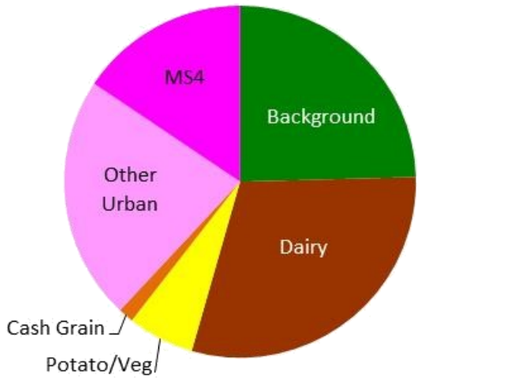
Ave. Annual Phosphorus Load = 6.0 tons | Langlade, Portage, Shawano and Wood Counties | 181.2 square miles |

# Plover River Watershed

## Ecological Landscape



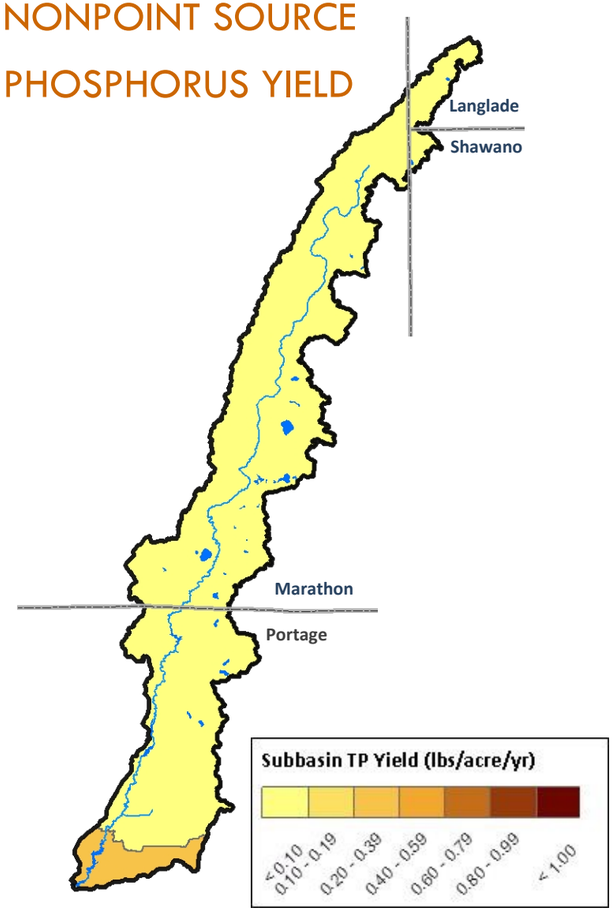

## Sources of Phosphorus



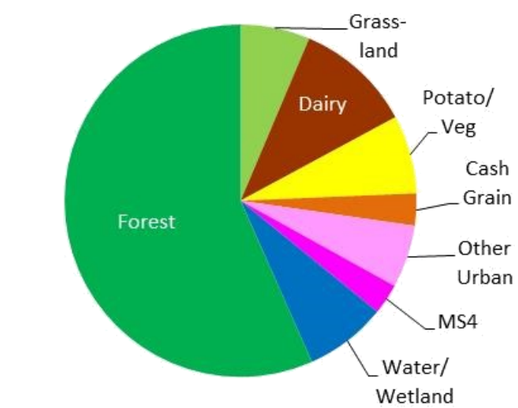

## IMPAIRED WATERS

## PHOSPHORUS POINT SOURCES

## NONPOINT SOURCE PHOSPHORUS YIELD




## Land Use




**Impaired Waters**

| Name | TP Standard (ug/L) | Subbasin/Reach ID |
|---|---|---|
| Lost Lake | 20 | 149 |

**Municipal WWTFs**

| Permittee | Permit No. | No. Outfalls | Map ID |
|---|---|---|---|
| Whiting | 0021636 | 1 | P-1 |

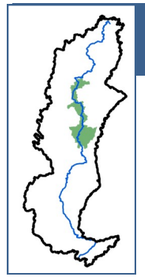
**Permitted MS4s**

*(Covered by WPDES Gen. Permit WI-S050075-2)*

| Permittee | Permit ID No. | Map ID |
|---|---|---|
| City of Stevens Point | 0031432 | P-2 |

**CAFOs**

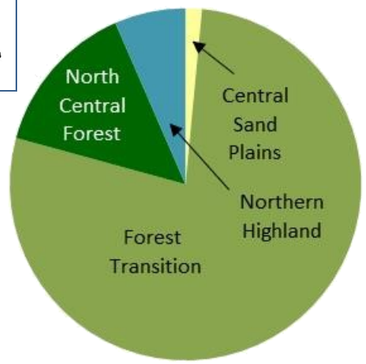
| Permittee | Permit No. | Map ID |
|---|---|---|
| Fischer Clark Dairy | 0065625 | P-3 |



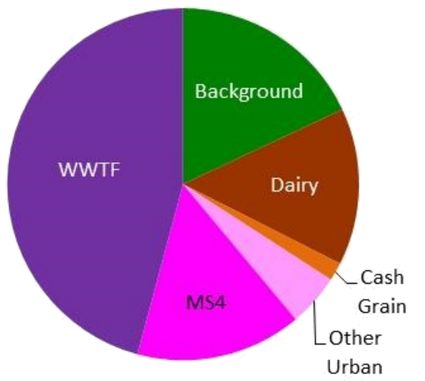
Ave. Annual Phosphorus Load = 65.3 tons | Lincoln, Marathon, and Portage County | 539.0 square miles |

# Upper Wisconsin River Corridor

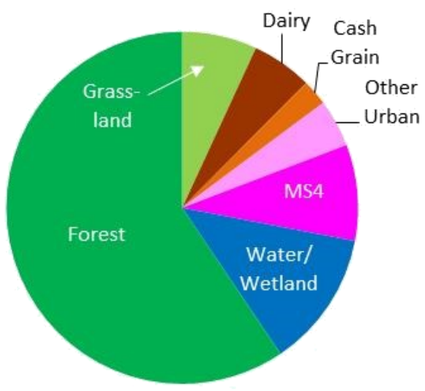
## Ecological




## Sources of Phosphorus




## Land Use




### Impaired Waters

| Name | TP Standard (ug/L) | Subbasin/Reach ID |
|---|---|---|
| Big Eau Pleine River | 75 | 86 |
| Little Eau Pleine River | 75 | 81 |
| Lake DuBay | 100 | 81 |

### Municipal WWTFs

| Permittee | Permit No. | No. Outfalls | Map ID |
|---|---|---|---|
| Brokaw | 0022136 | 1 | U-1 |
| Merrill | 0020150 | 1 | U-2 |
| Rib Mountain | 0035581 | 1 | U-3 |
| Tomahawk | 0021946 | 1 | U-4 |
| Wausau | 0025739 | 1 | U-5 |

### Permitted MS4s

*(Covered by WPDES Gen. Permit WI-S050075-2)*

| Permittee | Permit No. | Map ID |
|---|---|---|
| Kronenwetter, Village | 0031046 | U-14 |
| Merrill, City of | 0031427 | U-15 |
| Mosinee, City of | 0031050 | U-16 |
| Rib Mountain, Town | 0031053 | U-17 |
| Rothschild, Village | 0031055 | U-18 |
| Schofield, City of | 0031056 | U-19 |
| Wausau, City of | 0031058 | U-20 |
| Weston, Village | 0031060 | U-21 |

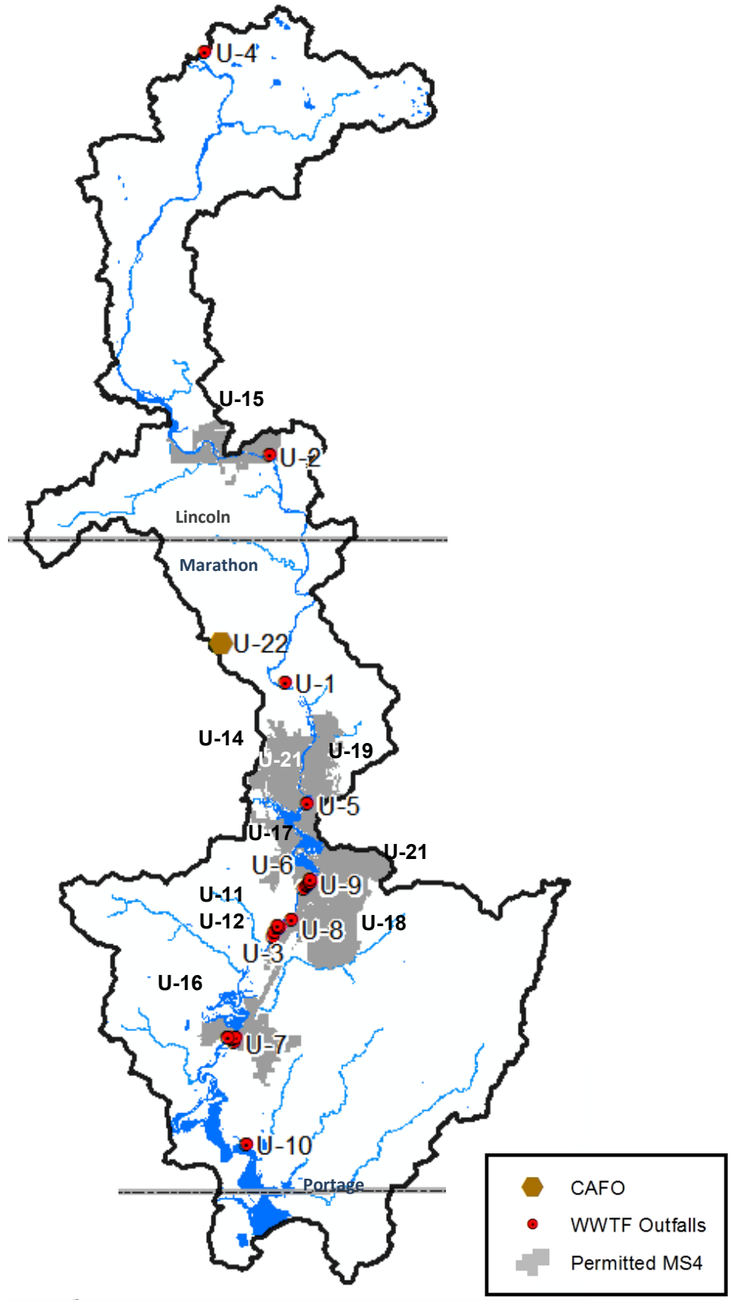
### Industrial WWTFs

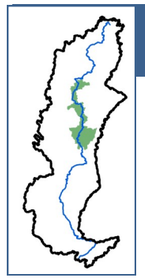
| Permittee | Permit No. | No. Outfalls | Map ID |
|---|---|---|---|
| Domtar Paper Inc. | 0026042 | 5 | U-6 |
| Expera Specialty Solutions LLC | 0003671 | 5 | U-7 |
| Foremost Farms USA Rothschild | 0003875 | 1 | U-8 |
| Lignotech USA Inc | 0003450 | 2 | U-9 |
| Mullins Cheese Inc | 0054127 | 1 | U-10 |
| Wisconsin Public Service Corp Weston 1 & 2 | 0003131 | 3 | U-12 |
| Wisconsin Public Service Corp Weston 3 & 4 | 0042765 | 4 | U-13 |

### CAFOs

| Permittee | Permit No. | Map ID |
|---|---|---|
| Van Der Geest Dairy Cattle, Inc. | 0059293 | U-22 |

## PHOSPHORUS POINT SOURCES

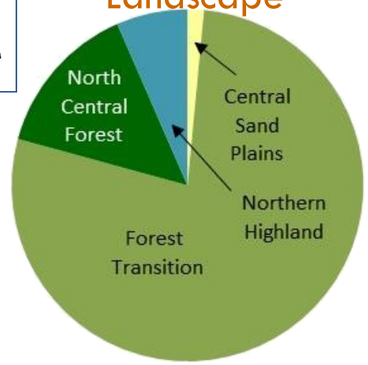




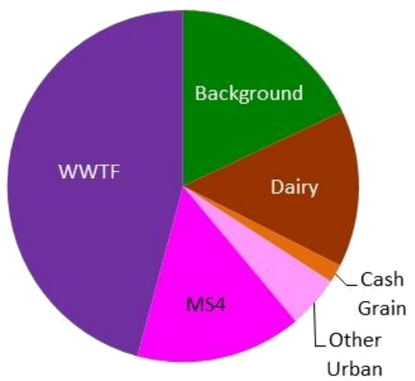
Ave. Annual Phosphorus Load = 65.3 tons | Lincoln, Marathon, and Portage County | 539.0 square miles |

# Upper Wisconsin River Corridor

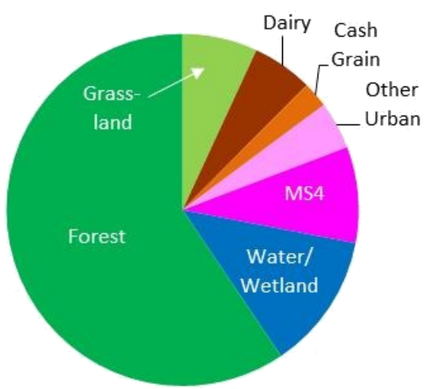
## Ecological Landscape



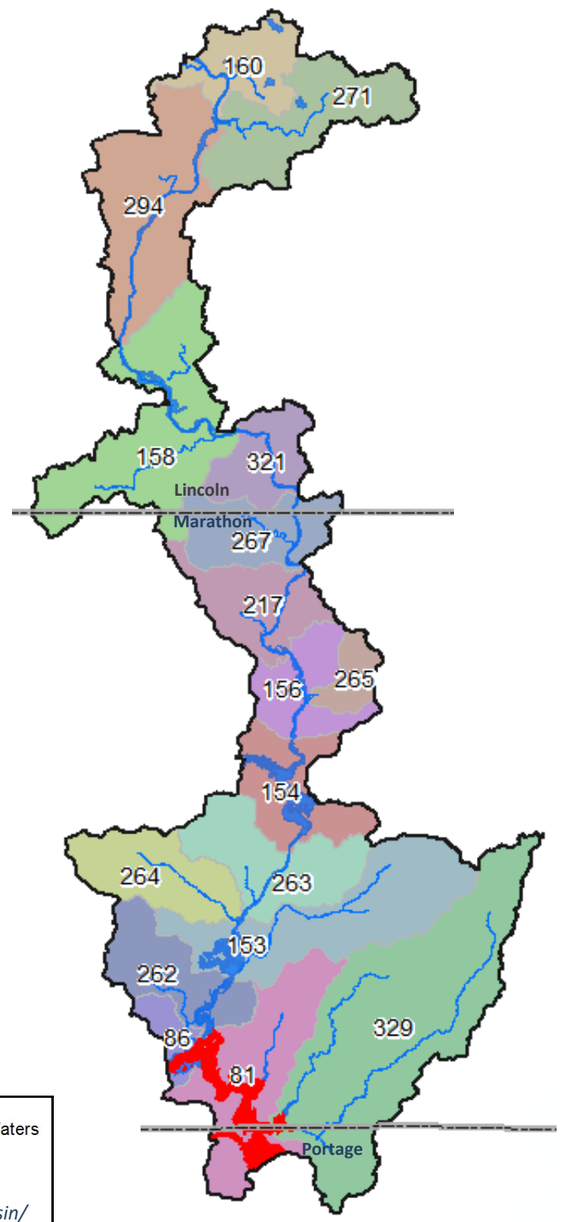

## Sources of Phosphorus




## Land Use




## IMPAIRED WATERS

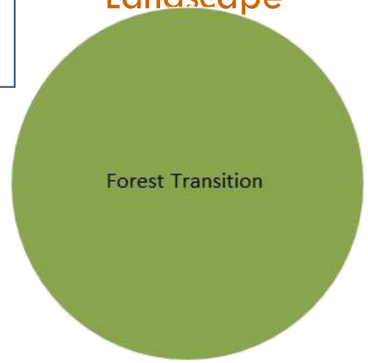



## PHOSPHORUS POINT SOURCES

Ave. Annual Phosphorus Load = 38.3 tons | Clark, Marathon, Portage and Wood Counties | 250.0 square miles |

# Little Eau Pleine River Watershed

## Ecological Landscape

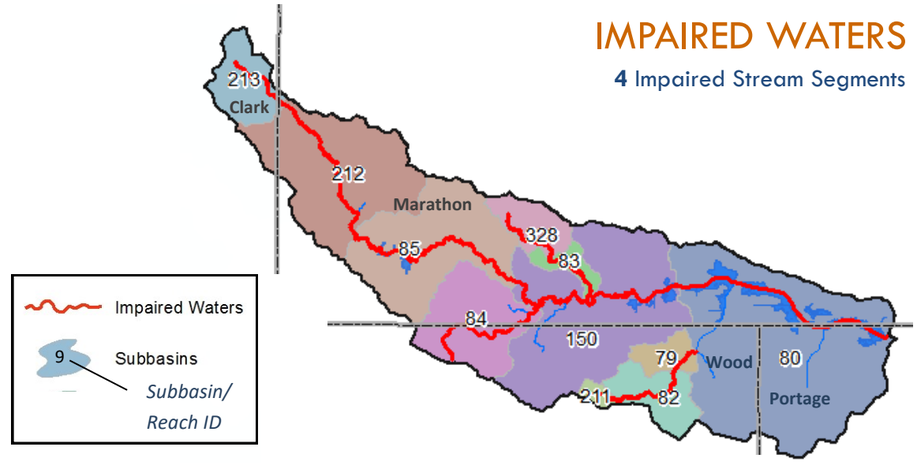



### Impaired Waters

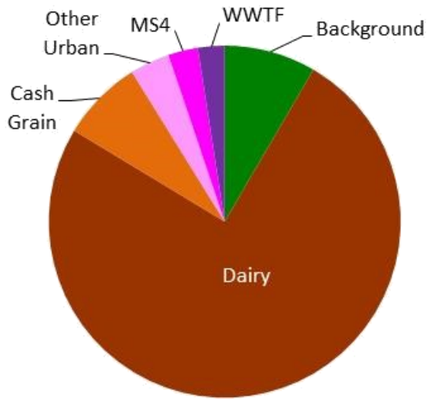
| Name | TP Standard (ug/L) | Subbasin/ Reach ID |
|---|---|---|
| Little Bear Creek | 75 | 79, 82, 211 |
| Little Eau Pleine River | 75 | 80, 85, 150, 212, 213 |
| Squaw Creek | 75 | 84 |
| Wild Creek | 75 | 83, 328 |

## IMPAIRED WATERS

**4** Impaired Stream Segments




## Sources of Phosphorus



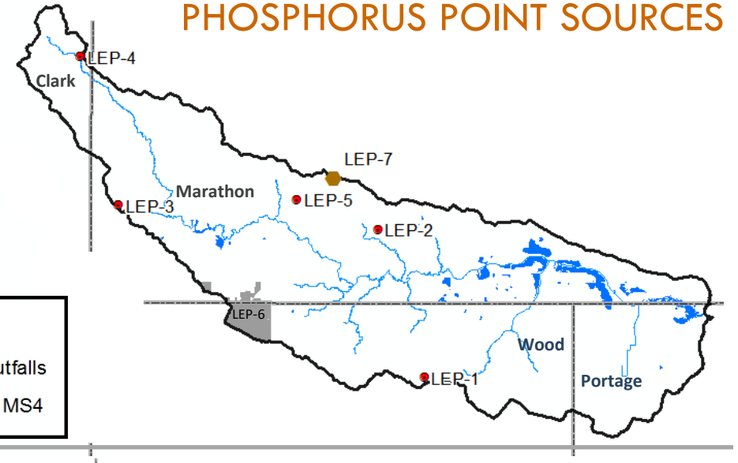

### Municipal WWTFs

| Permittee | Permit No. | No. Outfalls | Map ID |
|---|---|---|---|
| Auburndale | 0022411 | 1 | LEP-1 |
| Rozelleville | 0029076 | 1 | LEP-2 |
| Spencer | 0021521 | 1 | LEP-3 |
| Unity | 0060526 | 1 | LEP-4 |

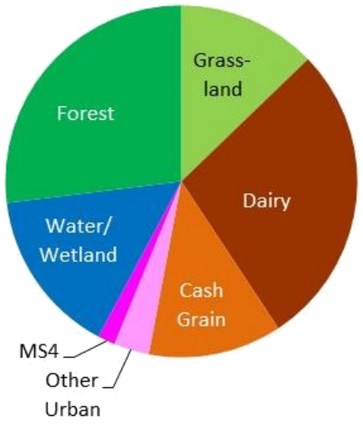
### Industrial WWTFs

| Permittee | Permit No. | No. Outfalls | Map ID |
|---|---|---|---|
| Mullins Cheese | 0053694 | 1 | LEP-5 |

## PHOSPHORUS POINT SOURCES




## Land Use




### Permitted MS4s

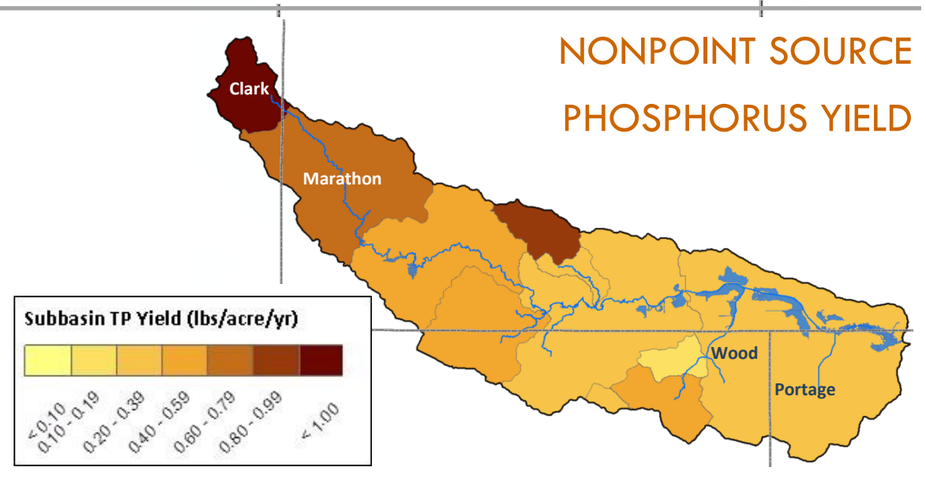
*(Covered by WPDES Gen. Permit WI-S050075-2)*

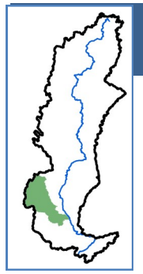
| Permittee | Permit No. | Map ID |
|---|---|---|
| City of Marshfield | 0031425 | LEP-6 |

### CAFOs

| Permittee | Permit No. | Map ID |
|---|---|---|
| Night Hawk Dairy LLC | 0065609 | LEP-7 |

## NONPOINT SOURCE PHOSPHORUS YIELD

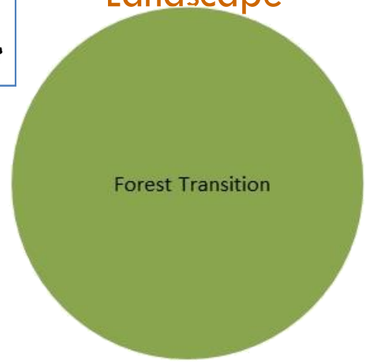




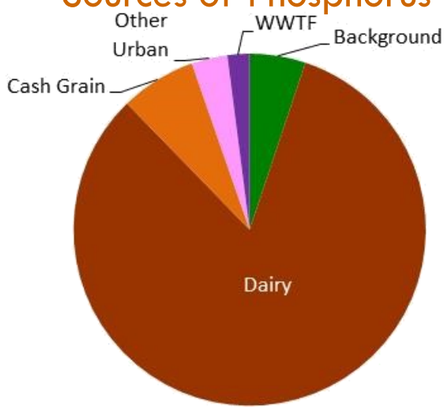
Ave. Annual Phosphorus Load = 69.8 tons | Clark, Marathon and Taylor Counties | 358.1 square miles |

# Big Eau Pleine River Watershed

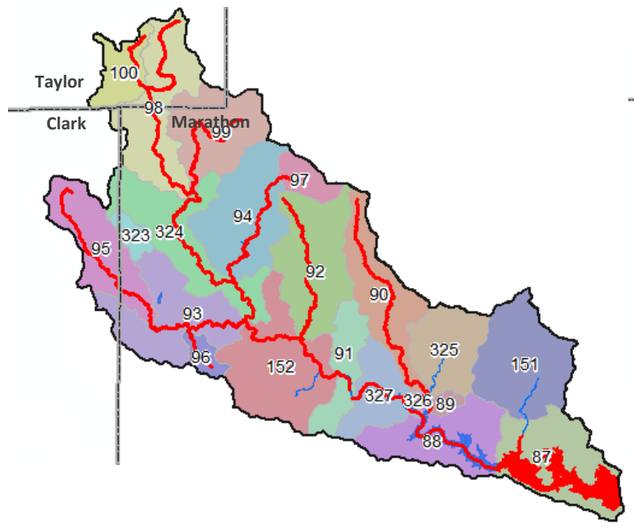
## Ecological Landscape



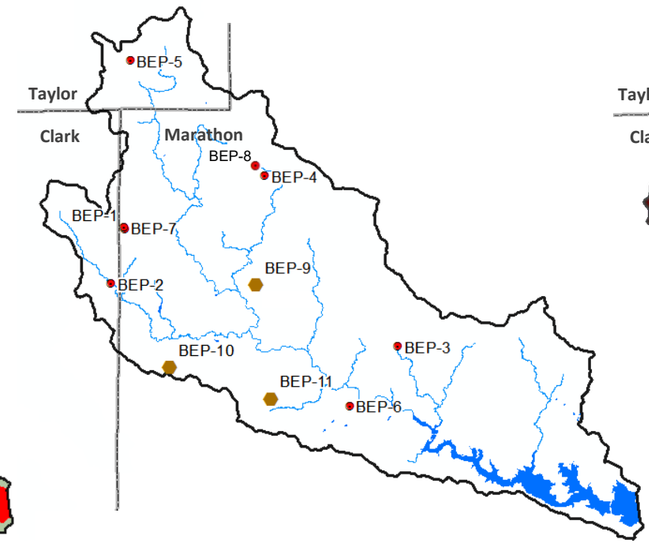

## Sources of Phosphorus



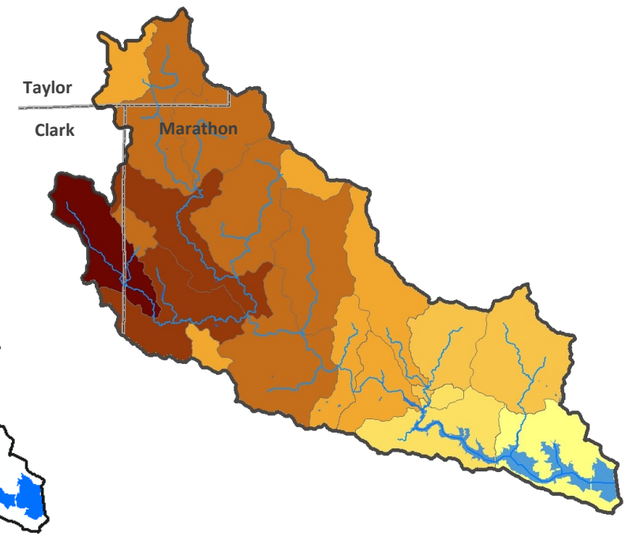

## IMPAIRED WATERS

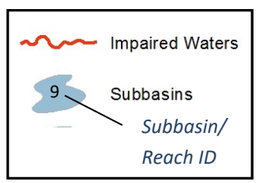


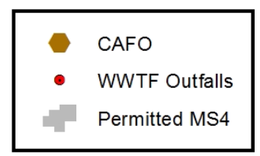

## PHOSPHORUS POINT SOURCES

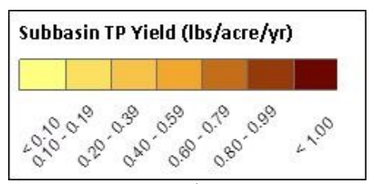



## NONPOINT SOURCE PHOSPHORUS YIELD

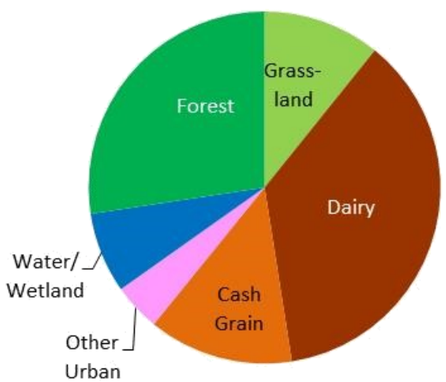



## Land Use




### Impaired Waters

| Name | TP Standard (ug/L) | Subbasin/ Reach ID | Name | TP Standard (ug/L) | Subbasin/ Reach ID |
|---|---|---|---|---|---|
| Big Eau Pleine River | 75 | 88, 91, 152, 324, 327 | Hamann Creek | 75 | 92 |
| Deer Creek | 75 | 98 | Raeder Creek | 75 | 96 |
| Dill Creek | 75 | 93, 95 | Randall Creek | 75 | 94, 97 |
| East Branch Big Eau Pleine River | 75 | 99 | West Br. Big Eau Pleine River | 75 | 98, 100 |
| Fenwood Creek | 75 | 89, 90, 326 | Big Eau Pleine Flowage | 30 | 87 |

### Municipal WWTFs

| Permittee | Permit No. | No. Outfalls | Map ID |
|---|---|---|---|
| Abbotsford | 0023141 | 1 | BEP-1 |
| Colby | 0023655 | 1 | BEP-2 |
| Fenwood | 0031411 | 1 | BEP-3 |
| Milan SD | 0031500 | 1 | BEP-4 |
| Stetsonville | 0060216 | 1 | BEP-5 |
| Stratford | 0025569 | 1 | BEP-6 |

### Industrial WWTFs

| Permittee | Permit No. | No. Outfalls | Map ID |
|---|---|---|---|
| Abbyland Foods | 0057436 | 1 | BEP-7 |
| Foremost Farms Milan | 0051815 | 1 | BEP-8 |

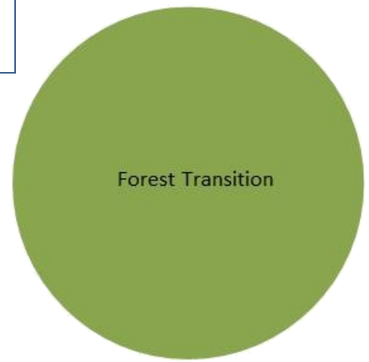
### CAFOs

| Permittee | Permit No. | Map ID |
|---|---|---|
| Heeg Brothers Dairy LLC | 0061841 | BEP-9 |
| Lynn Enterprises | 0062413 | BEP-10 |
| Maple Ridge Dairy | 0061832 | BEP-11 |

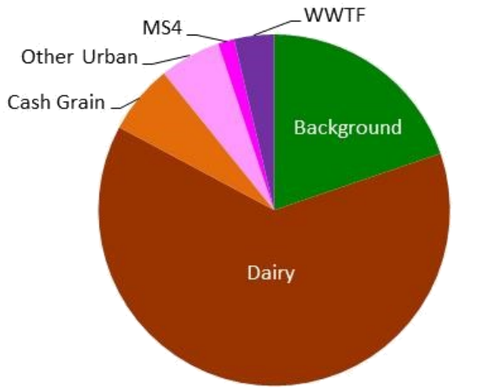
Ave. Annual Phosphorus Load = 52.2 tons | Langlade, Marathon and Taylor Counties | 488.2 square miles |

# Rib River Watershed

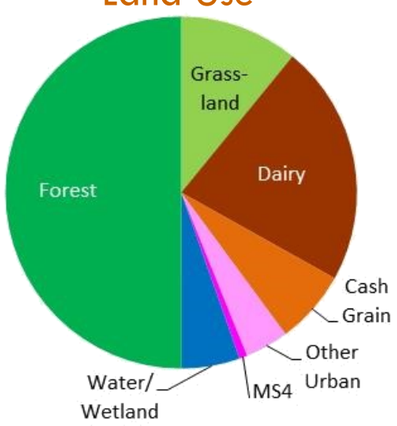
## Ecological




## Sources of Phosphorus




## Land Use




### Impaired Waters

| Name | TP Standard (ug/L) | Subbasin/ Reach ID |
|---|---|---|
| Big Rib River | 75 | 276 |
| Black Creek | 75 | 102, 104, 215 |
| Mink Creek | 75 | 276 |
| Scotch Creek | 75 | 101, 105, 106 |

### Municipal WWTFs

| Permittee | Permit No. | No. Outfalls | Map ID |
|---|---|---|---|
| Athens | 0022365 | 1 | R-1 |
| Edgar | 0021784 | 1 | R-2 |
| Marathon | 0020273 | 1 | R-3 |
| Rib Lake | 0029017 | 1 | R-4 |

### Permitted MS4s

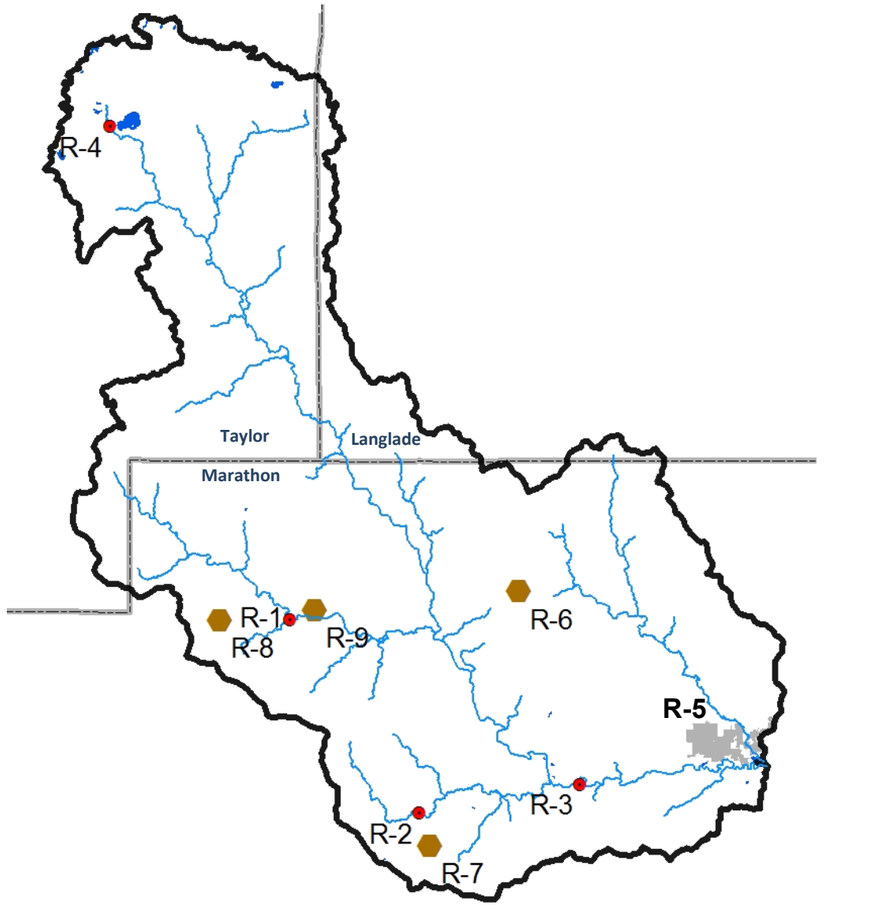
*(Covered by WPDES Gen. Permit WI-S050075-2)*

| Permittee | Permit ID No. | Map ID |
|---|---|---|
| City of Wausau | 0031058 | R-5 |

### CAFOs

| Permittee | Permit No. | Map ID |
|---|---|---|
| Double P Dairy LLC | 0062031 | R-6 |
| Kingdom Haven Dairy | 0062391 | R-7 |
| Miltrim Dairy | 0061638 | R-8 |
| Rausch Family Farms | 0062405 | R-9 |

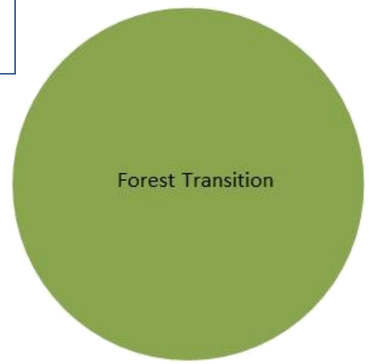
## PHOSPHORUS POINT SOURCES



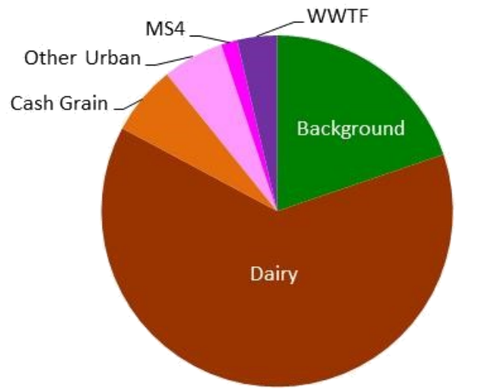
Ave. Annual Phosphorus Load = 52.2 tons | Langlade, Marathon, and Taylor Counties | 488.2 square miles |

# Rib River Watershed

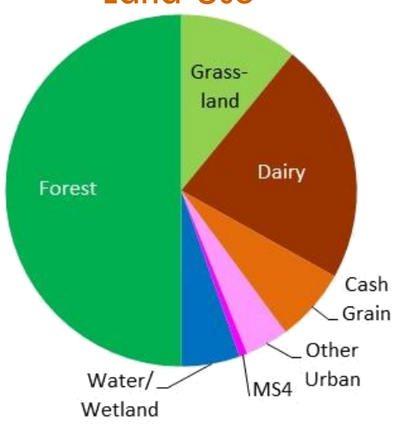
## Ecological




## Sources of Phosphorus

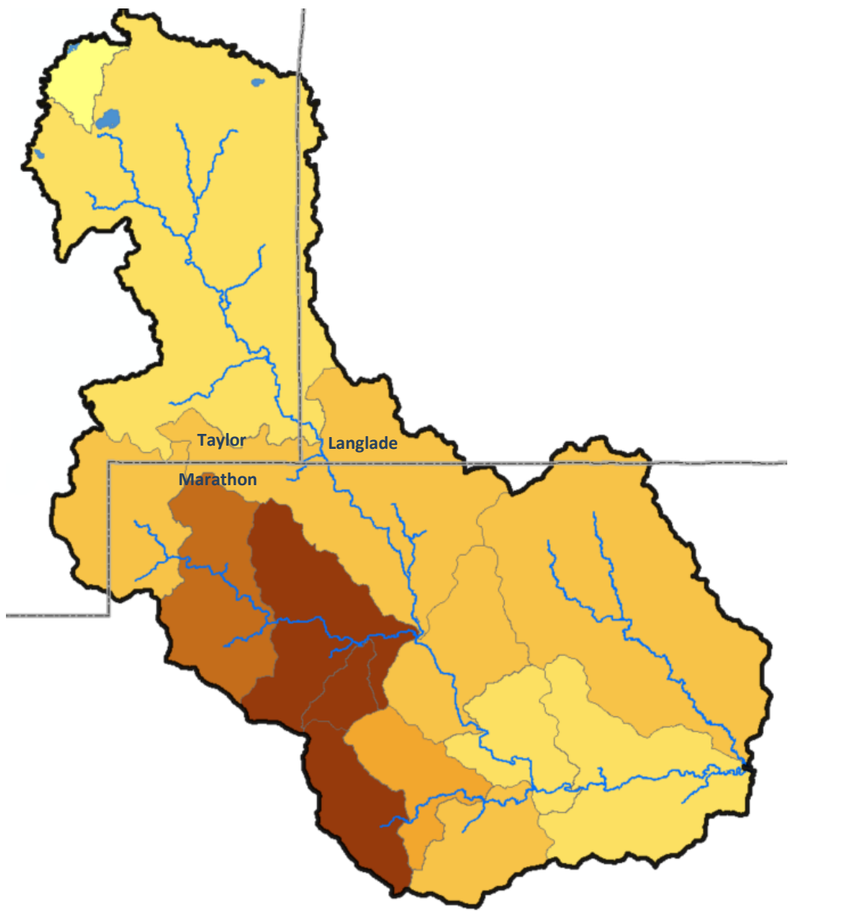


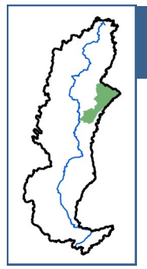

## Land Use




## IMPAIRED WATERS

## NONPOINT SOURCE PHOSPHORUS YIELD

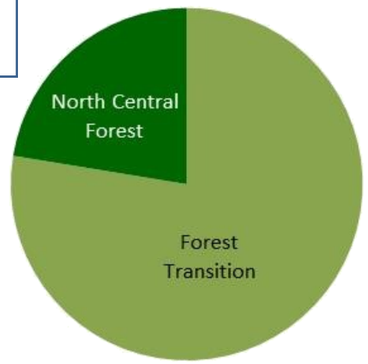




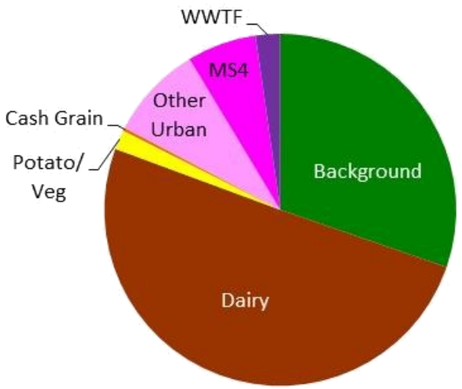
Ave. Annual Phosphorus Load = 25.4 tons | Langlade and Marathon Counties | 455.2 square miles |

# Eau Claire River Watershed

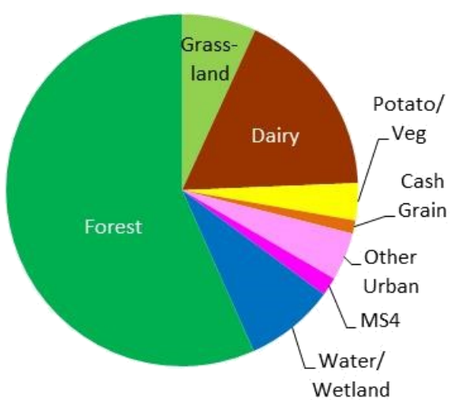
## Ecological




## Sources of Phosphorus




## Land Use




### Impaired Waters

| Name | TP Standard (ug/L) | Subbasin/ Reach ID |
|---|---|---|
| Spring Brook Creek | 75 | 107, 216 |
| West Branch Eau Claire River | 75 | 108 |

### Municipal WWTFs

| Permittee | Permit No. | No. Outfalls | Map ID |
|---|---|---|---|
| Antigo | 0022144 | 1 | EC-1 |

### Industrial WWTFs

| Permittee | Permit No. | No. Outfalls | Map ID |
|---|---|---|---|
| Sartori Company | 0032794 | 1 | EC-2 |

### Permitted MS4s

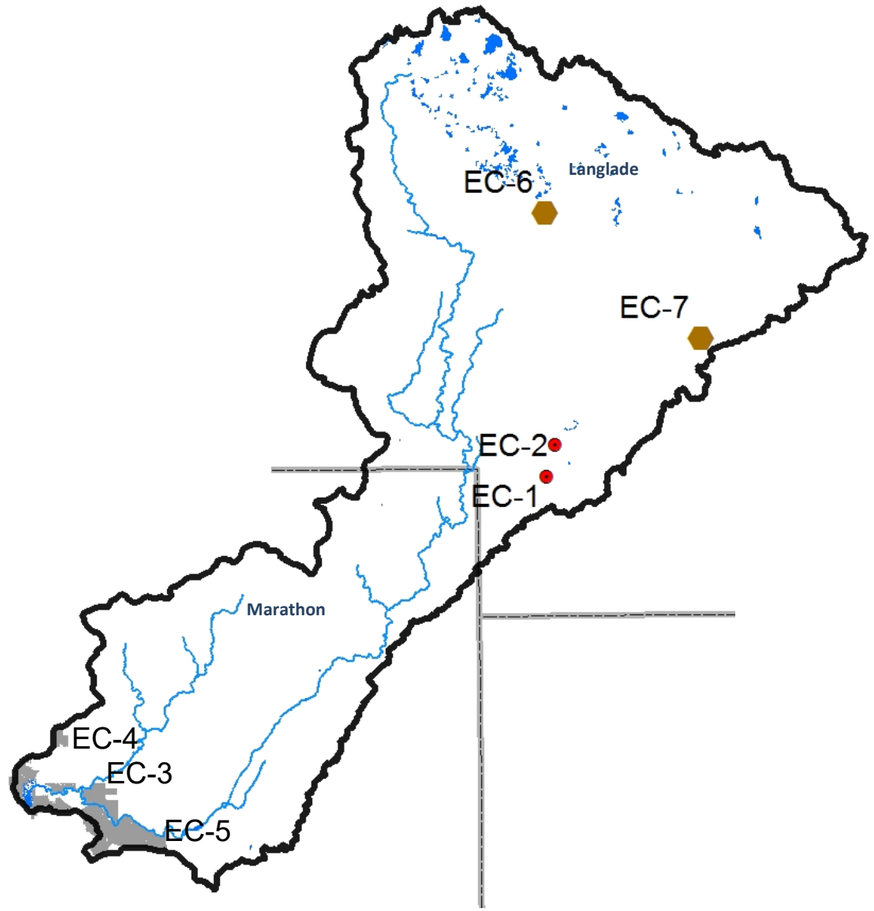
*(Covered by WPDES Gen. Permit WI-S050075-2)*

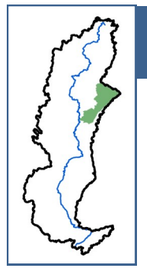
| Permittee | Permit ID No. | Map ID |
|---|---|---|
| City of Schofield | 0031056 | EC-3 |
| City of Wausau | 0031058 | EC-4 |
| City of Weston | 0031060 | EC-5 |

### CAFOs

| Permittee | Permit No. | Map ID |
|---|---|---|
| Nagel Dairy Farm LLC | 0063819 | EC-6 |
| Spring Breeze Dairy LLC | 0066281 | EC-7 |

## PHOSPHORUS POINT SOURCES

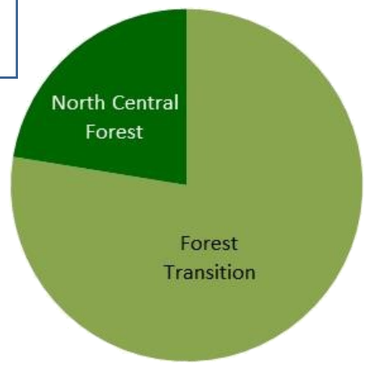




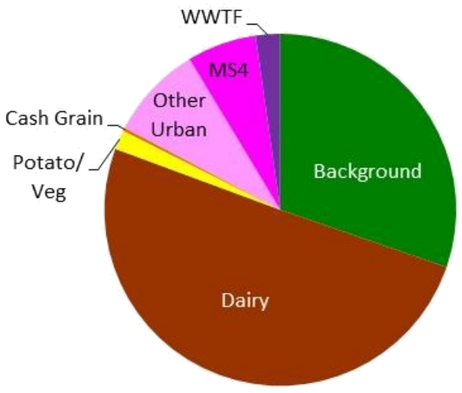
Ave. Annual Phosphorus Load = 25.4 tons | Langlade and Marathon Counties | 455.2 square miles |

# Eau Claire River Watershed

## Ecological




## Sources of Phosphorus

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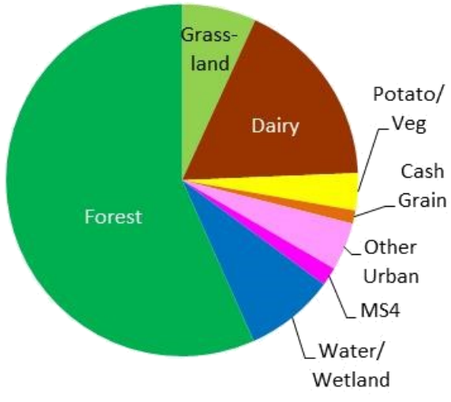
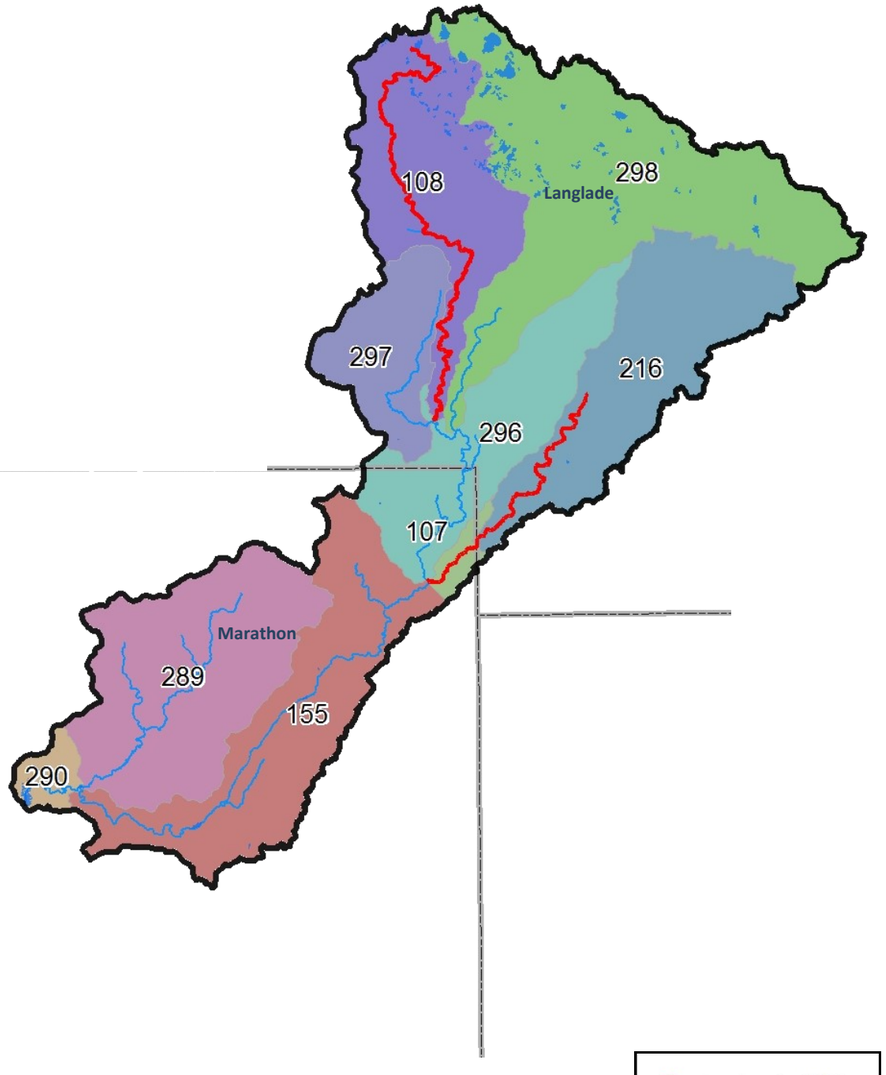
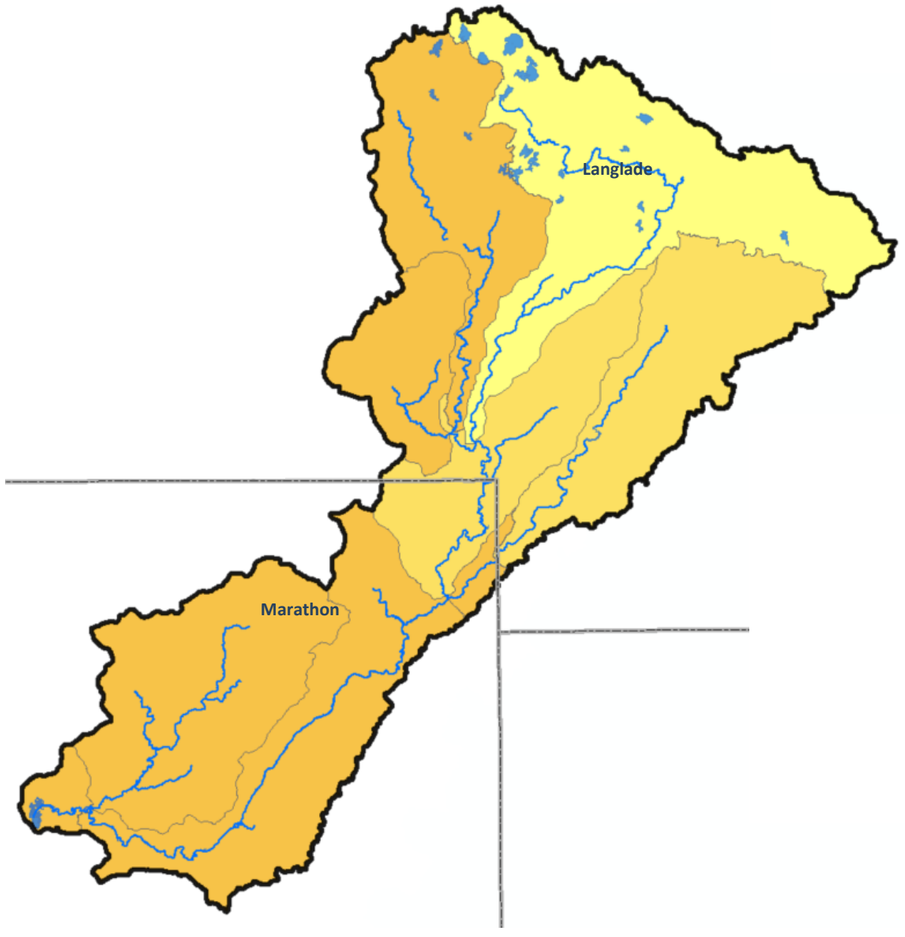



## IMPAIRED WATERS



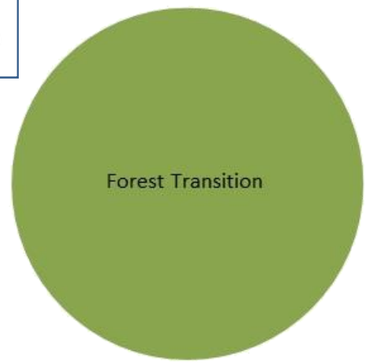

## NONPOINT SOURCE PHOSPHORUS YIELD



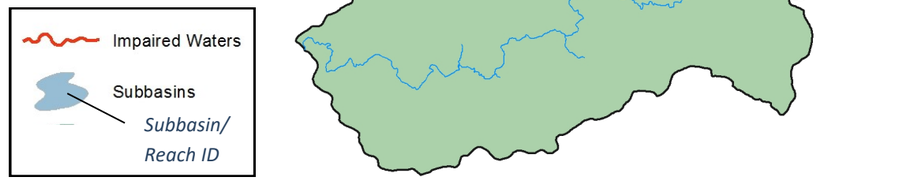
Ave. Annual Phosphorus Load = 7.6 tons | Langlade, Lincoln and Marathon Counties | 90.3 square miles |

# Trappe River Watershed

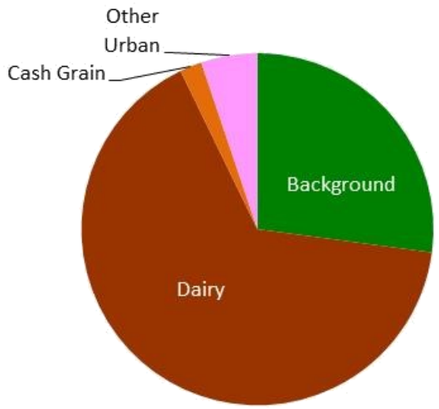
## Ecological



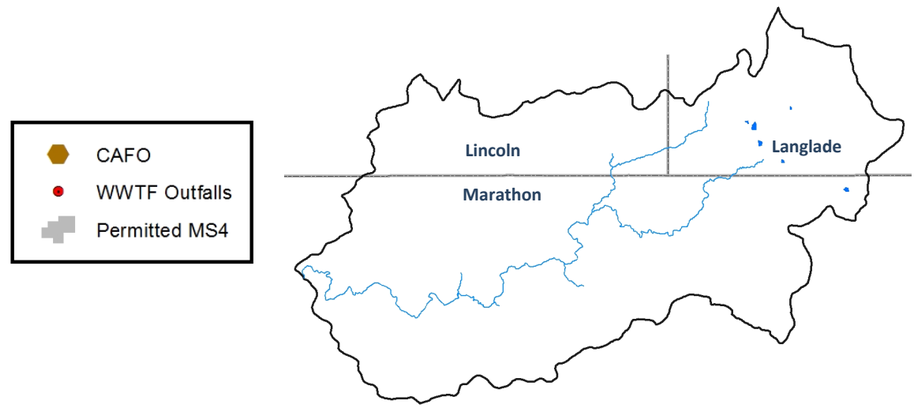

## IMPAIRED WATERS



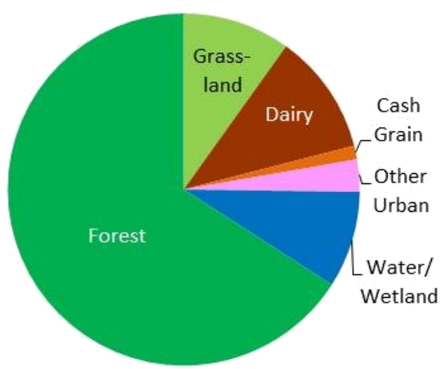

## Sources of Phosphorus



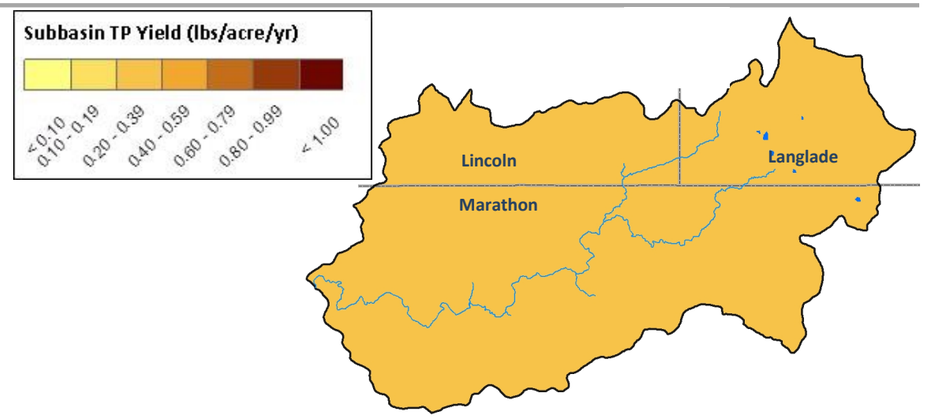

## PHOSPHORUS POINT SOURCES



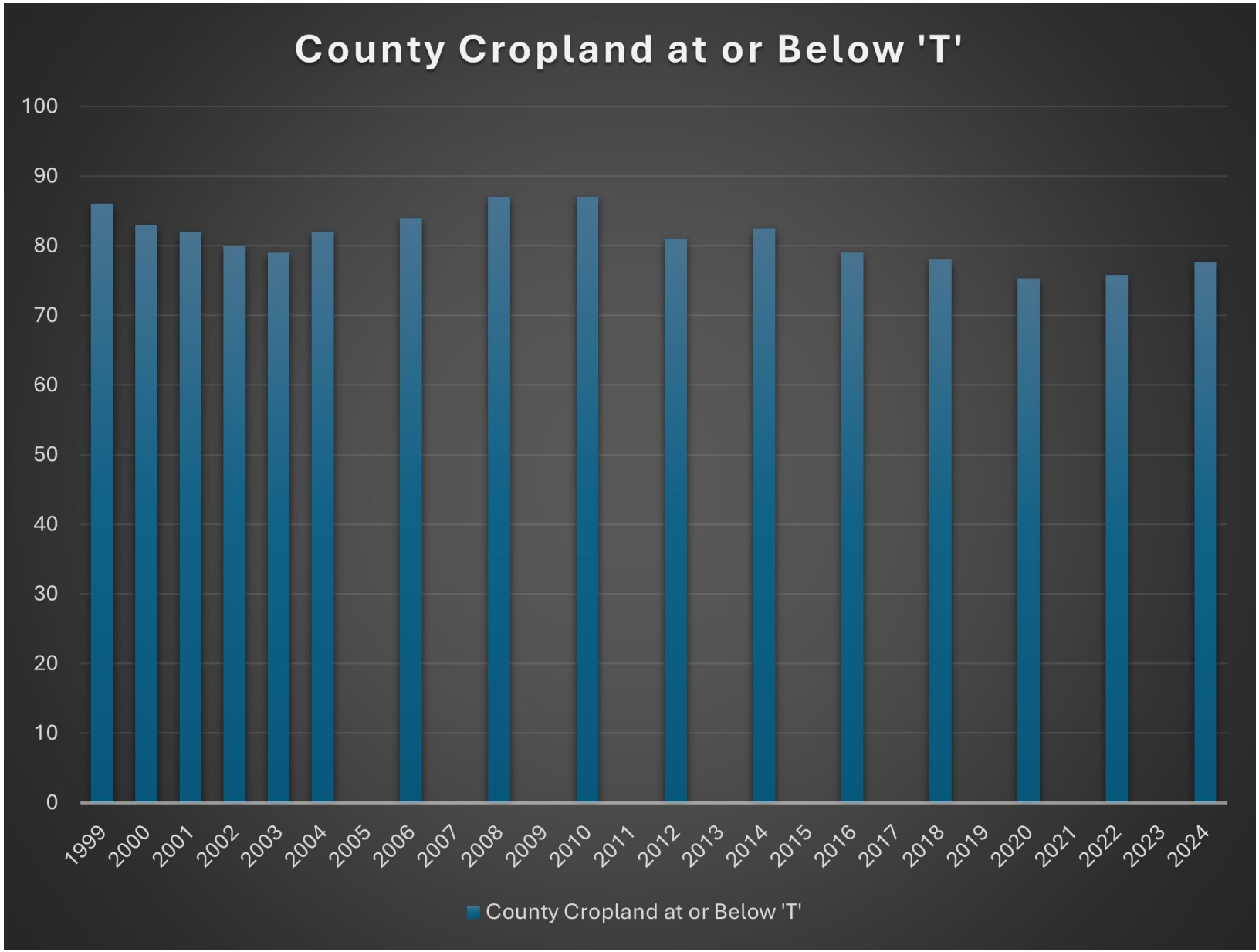

## Land Use

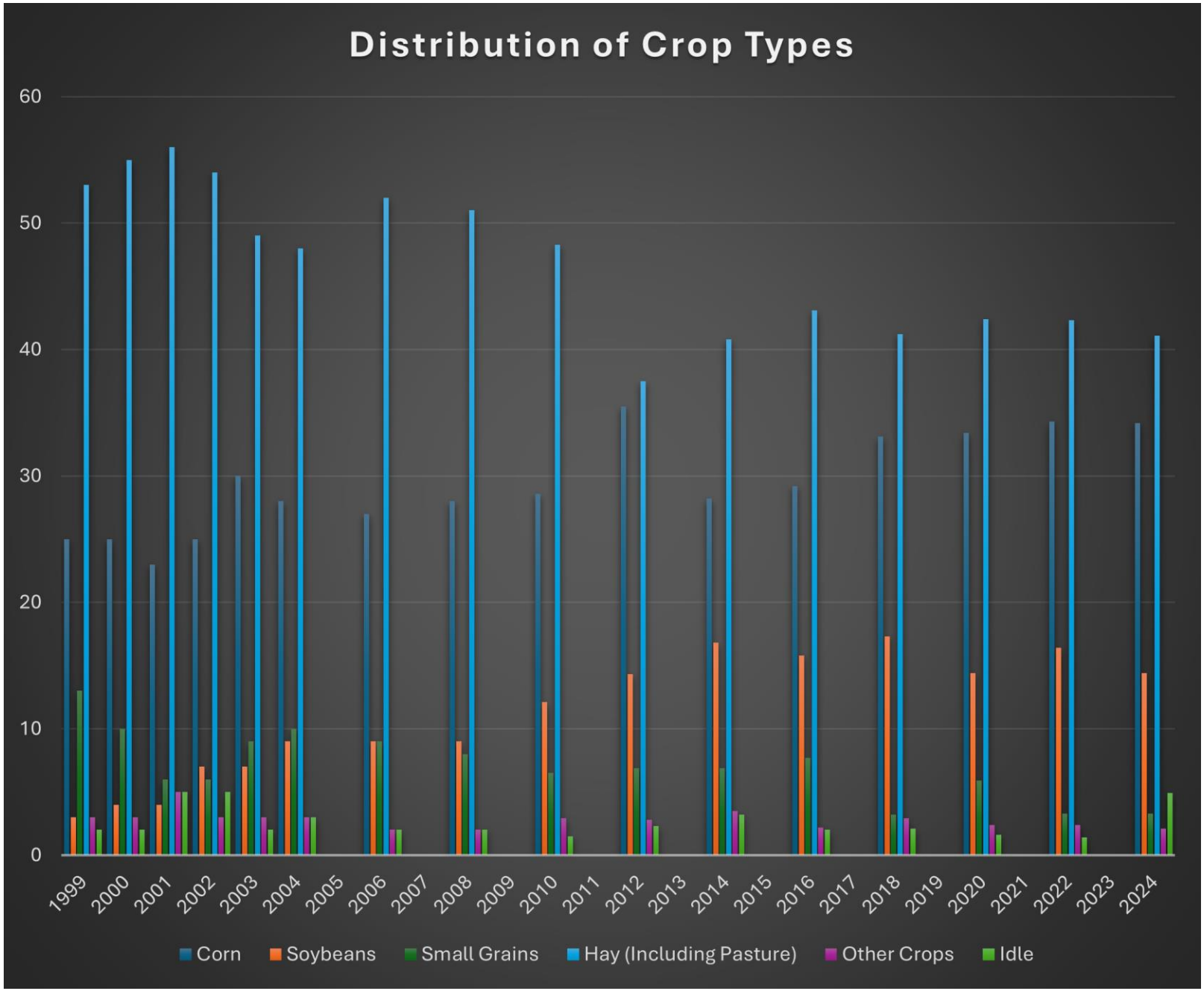


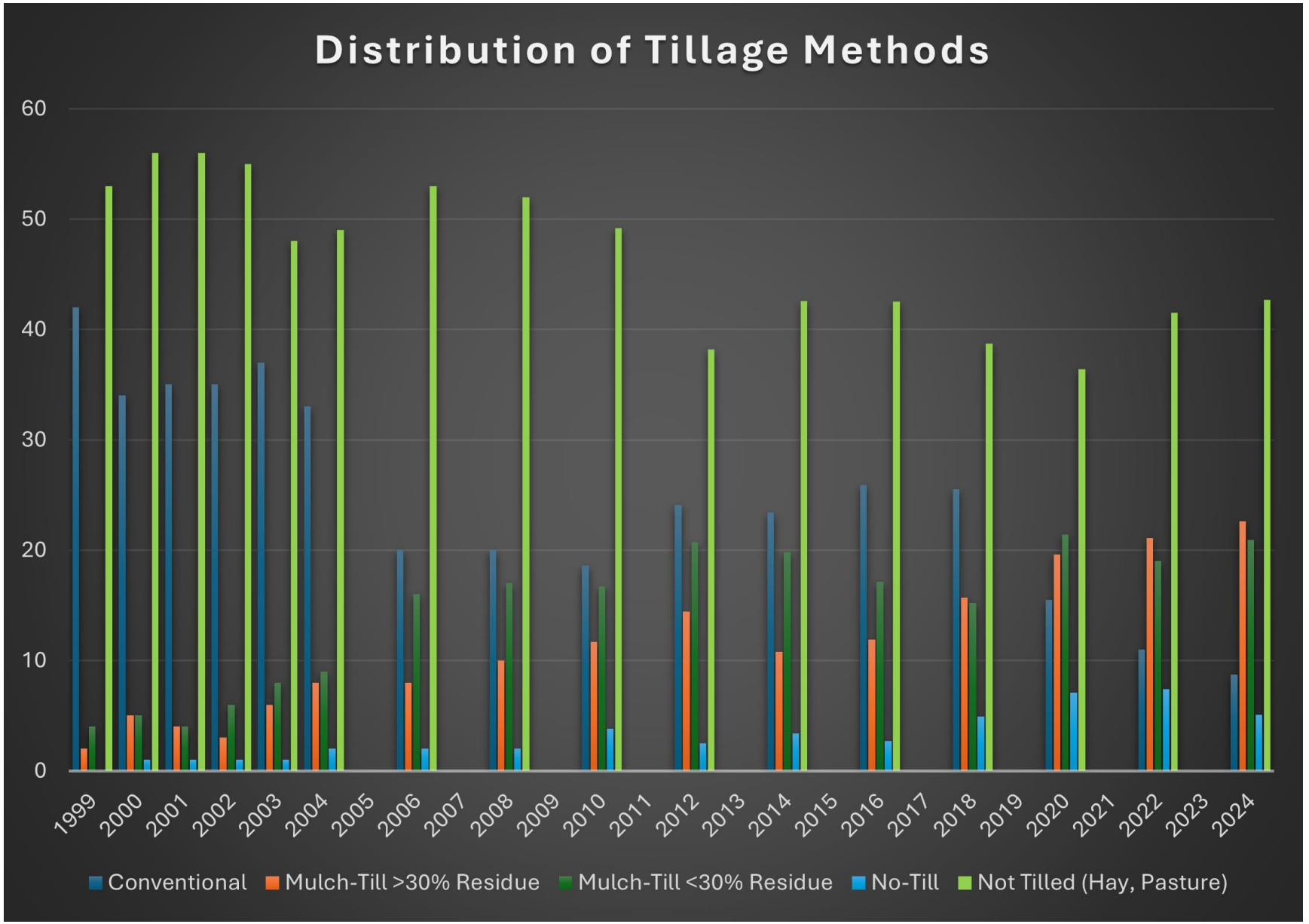

## NONPOINT SOURCE PHOSPHORUS YIELD

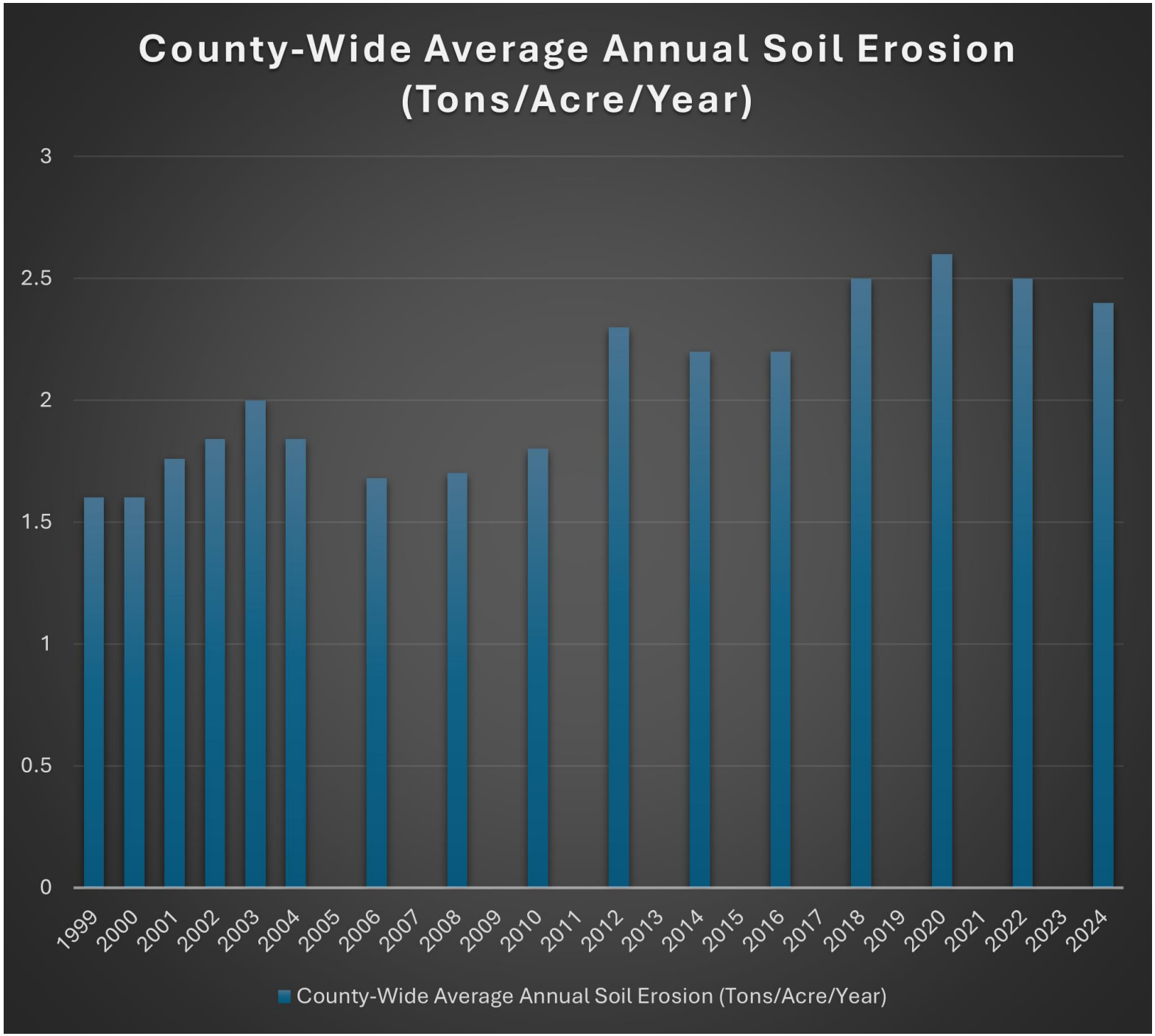


# Appendix A:5

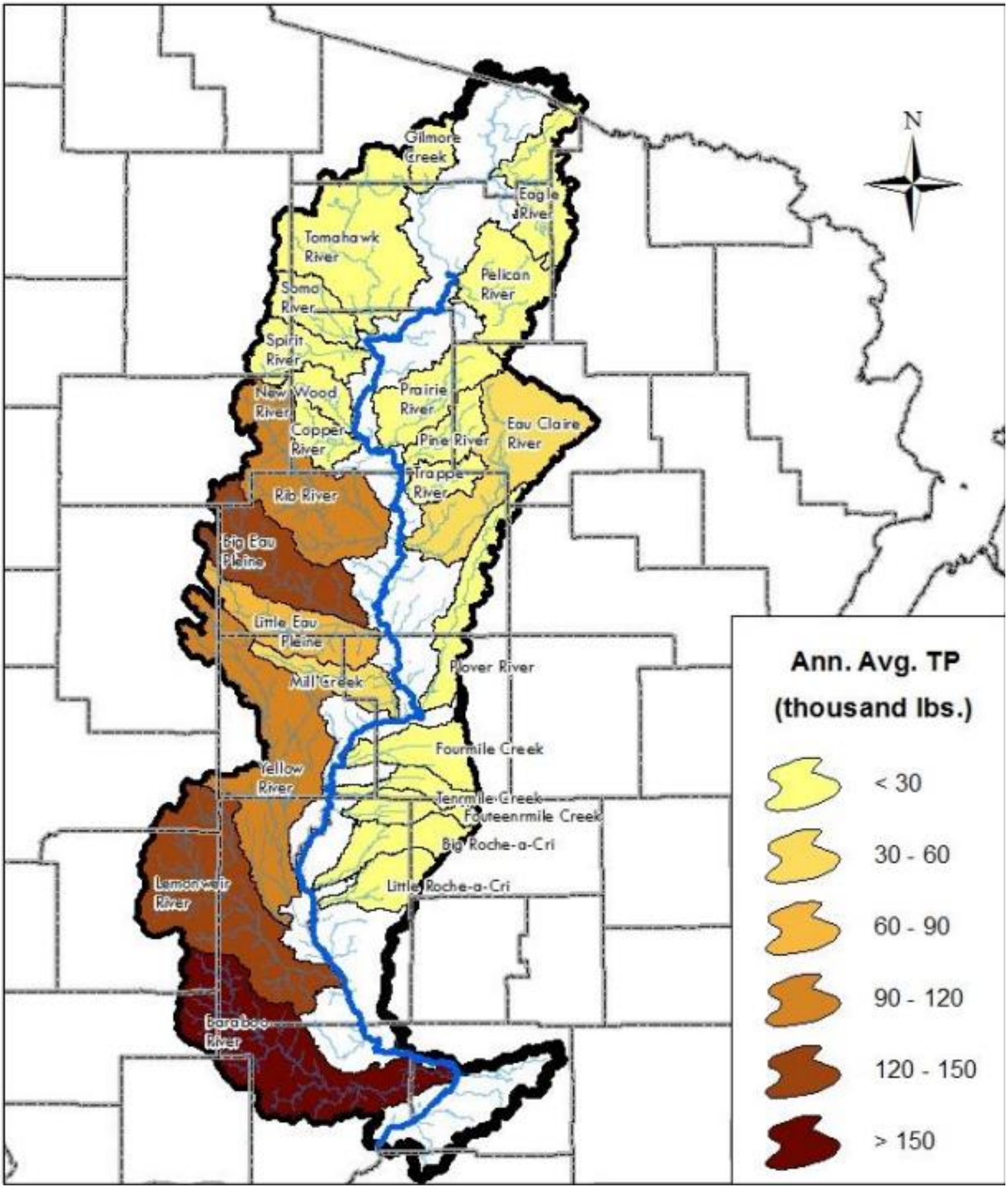

County Cropland at or Below 'T'
100
90
80
70
60
50
40
30
20
10
0
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
County Cropland at or Below 'T'


Distribution of Crop Types
60
50
40
30
20
10
0
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Corn
Soybeans
Small Grains
Hay (Including Pasture)
Other Crops
Idle

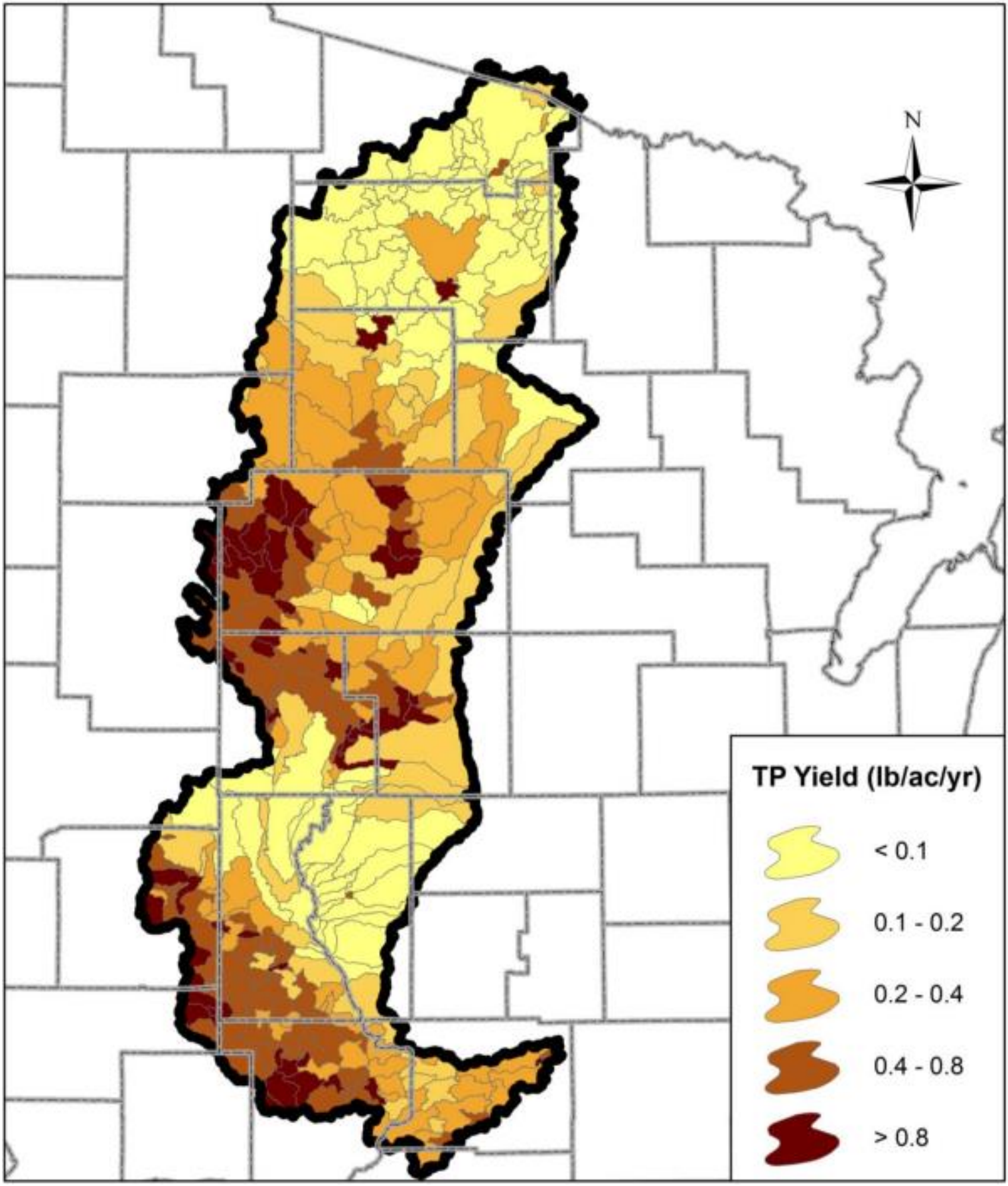

Distribution of Tillage Methods
60
50
40
30
20
10
0
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Conventional
Mulch-Till >30% Residue
Mulch-Till <30% Residue
No-Till
Not Tilled (Hay, Pasture)


County-Wide Average Annual Soil Erosion (Tons/Acre/Year)
3
2.5
2
1.5
1
0.5
0
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
County-Wide Average Annual Soil Erosion (Tons/Acre/Year)

# Appendix A:6




Total phosphorus delivered by major tributary watersheds.




Total phosphorus yields per subbasin.

# Appendix A:7

# Total Maximum Daily Loads for Total Phosphorus in the Wisconsin River Basin

## Final U.S. EPA Approved Report

**04/26/2019**

Including Adams, Clark, Columbia, Dane, Forest, Jackson, Juneau, Langlade, Lincoln, Marathon, Monroe, Oneida, Portage, Price, Richland, Sauk, Shawano, Taylor, Vernon, Vilas, Waushara, and Wood Counties, Wisconsin


**Prepared For:**
U.S. Environmental Protection Agency
Region 5
77 W. Jackson Blvd.
Chicago, IL 60604

**Prepared By:**
WI Department of Natural Resources
101 S. Webster St
PO Box 7921
Madison, WI 53707-7921

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# Total Maximum Daily Loads for Total Phosphorus in the Wisconsin River Basin

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Appendix Q Public Hearing Comments (August 20 through September 19, 2018 comment period)
Appendix R Response to Public Hearing Comments (August 20 through September 19, 2018 comment period)

## List of Acronyms and Terms

| | |
|---|---|
| 303(d) List | List of Impaired Waters |
| AM | Wisconsin's Watershed Adaptive Management Option |
| BMPs | Best Management Practices |
| CAFO | Concentrated Animal Feeding Operation |
| CREP | Conservation Reserve Enhancement Program |
| CRP | Conservation Reserve Program |
| DATCP | Department of Agriculture, Trade, and Consumer Protection |
| DO | Dissolved Oxygen |
| FAL | Fish and Aquatic Life |
| FSA | Farm Service Agency |
| LA | Load Allocation |
| LAL | Limited Aquatic Life |
| LCD | Land Conservation Department |
| LFF | Limited Forage Fish |
| LWRM | Land and Water Resources Management |
| mL | milliliters |
| MOS | Margin of Safety |
| MS4 | Municipal Separate Storm Sewer System |
| NCCW | Noncontact Cooling Water |
| NOD | Notice of Discharge |
| NPS Program | Nonpoint Source Pollution Abatement Program |
| NRCS | Natural Resources Conservation Service |
| PI | Phosphorus Index |
| POTW | Publicly Owned Treatment Works |
| RC | Reserve Capacity |
| WinSLAMM | Source Loading and Management Model |
| SWAT | Soil and Water Assessment Tool |

| | |
|---|---|
| TBEL | Technology-Based Effluent Limit |
| TMDL | Total Maximum Daily Load |
| TP | Total Phosphorus |
| TRM | Targeted Runoff Management |
| TSS | Total Suspended Solids |
| US EPA | United States Environmental Protection Agency |
| USGS | United States Geological Survey |
| WDNR | Wisconsin Department of Natural Resources |
| WisCALM | Wisconsin Consolidated Assessment and Listing Methodology |
| WisDOT | Wisconsin Department of Transportation |
| WLA | Wasteload Allocation |
| WPDES | Wisconsin Pollutant Discharge Elimination System |
| WQBEL | Water Quality-Based Effluent Limit |
| WQT | Water Quality Trading |
| WVIC | Wisconsin Valley Improvement Company |
| WWSF | Warm Water Sport Fish |
| WWTF | Wastewater Treatment Facility |

# 1 INTRODUCTION

## 1.1 Federal TMDL Program

Section 303(d) of the Federal Clean Water Act (CWA) requires each state to identify impaired waters within its boundaries; impaired waters are those not meeting water quality standards for any given pollutant applicable to the water's designated uses. Section 303(d) further requires that states develop a Total Maximum Daily Load (TMDL) for all pollutants violating or causing violation of applicable water quality standards for each impaired water body.

A TMDL is the maximum amount of pollutant that a water body is capable of assimilating while continuing to meet the existing water quality standards. In April of 1991, the United States Environmental Protection Agency (EPA) Office of Water's Assessment and Protection Division published "Guidance for Water Quality-based Decisions: The Total Maximum Daily Load (TMDL) Process." In July 1992, EPA published the final "Water Quality Planning and Management Regulation" (40 CFR Part 130). Together, these documents describe the roles and responsibilities of EPA and the states in meeting the requirements of Section 303(d) of the Federal Clean Water Act (CWA) as amended by the Water Quality Act of 1987, Public Law 100-4.

FIGURE 1. TMDL PROJECT AREA

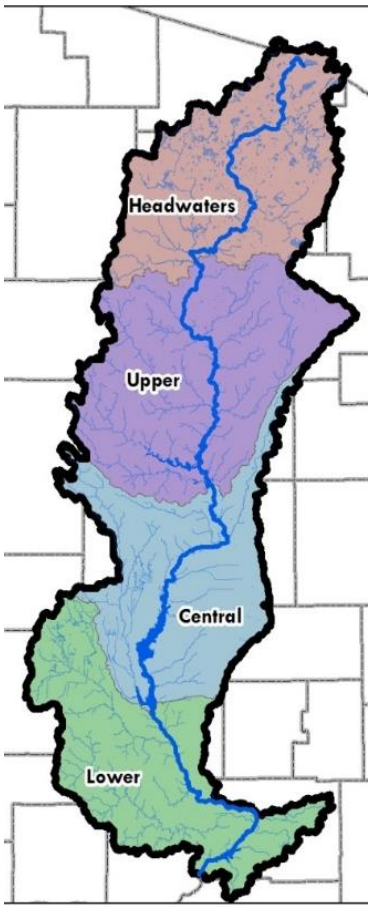


FIGURE 2. PROJECT AREA REGIONS

Under a TMDL, pollutant allocations are set at the levels necessary to meet the applicable standards for all point and nonpoint sources causing impairment, with consideration given to seasonal variations and margin of safety. TMDLs provide the framework that allows states to establish and implement pollution control and management plans, with the goal indicated in Section 101(a)(2) of the CWA: "water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water, wherever attainable"

## 1.2 Wisconsin River TMDL Project

The Wisconsin River TMDL project area encompasses the Wisconsin River Basin from the Lake Wisconsin dam near Prairie Du Sac, WI to the basin's headwaters in Vilas, County, WI (Figure 1). The TMDL project area encompasses 9,156 square miles, including all or portions of the following 22 counties: Adams, Clark, Columbia, Dane, Forest, Jackson, Juneau, Langlade, Lincoln, Marathon, Monroe, Oneida, Portage, Price, Richland, Sauk, Shawano, Taylor, Vernon, Vilas, Waushara, and Wood. Twenty-four major tributaries, and additional smaller ones, drain into the main stem of the river (see **Figure 3A** in Section 1.3) The river system includes 25 hydroelectric dams on the main stem of the river and 21 tributary storage reservoirs that regulate flow on the river's main stem. Summary information by tributary is illustrated in **Appendix A**.

Because of the size of the project area, many of the map figures of the project area included in this report are divided into four regions – the lower, central, upper and headwaters project areas; these figure regions are illustrated in Figure 2. The lower region includes the tributaries that drain to the Wisconsin River below Castle Rock and Petenwell reservoirs and extends to the outlet of Lake Wisconsin. The Central region spans the area downstream of the Lake DuBay dam to the

area upstream of, and including, Castle Rock Lake. The Upper region spans the area that drains to Lake DuBay up to the point where the Spirit River Reservoir discharges into the Wisconsin River. The Headwaters region includes everything upstream of the Upper region, where the Spirit River Reservoir discharges into the river.

Many lakes, rivers, and streams in the Wisconsin River Basin are impaired by excessive phosphorus. These impairments lead to nuisance algae growth, oxygen depletion, water clarity problems and reduced submerged aquatic vegetation in lakes, excessive beds of submerged aquatic vegetation in streams, and degraded habitat. They also adversely affect fish and other aquatic life, recreation, and navigation. This document establishes a framework for addressing these impairments, through the development of TMDLs for total phosphorus (TP).

## 1.3 Problem Statement

Phosphorus, an essential nutrient for plant growth, is problematic for aquatic ecosystems when present in large amounts because it fertilizes the growth of excessive algae blooms and other plant growth in aquatic systems. Algal blooms, particularly those that form surface scums, are unsightly and can have unpleasant odors, making recreational use of the water body unpleasant, affecting the quality of life of the people who live and work nearby. Algae blooms that include toxic blue-green algae or cyanobacteria can be harmful to fish and pose health risks to humans. When algal blooms die, the decomposition of the organic matter depletes the supply of dissolved oxygen in the water and depending on the severity of a low dissolved oxygen event, fish kills can occur. Overabundant growth of aquatic plants can also lead to many other undesirable consequences. For example, mats of filamentous algae and duckweed can block sunlight from penetrating the water, choking out beneficial submerged aquatic vegetation. Large areas of excessive vegetative growth can inhibit use of the water for fishing, boating, and swimming. These environmental impacts have negative economic impacts to local communities and the state.

Water bodies can also be impaired by excess sediment loading. Sediment that is suspended in the water scatters and absorbs sunlight, reducing the amount of light that reaches submerged aquatic vegetation, which reduces its photosynthetic rate and growth. Bottom-rooted aquatic plants (called macrophytes) produce life-giving oxygen, provide food and habitat for fish and other aquatic life, stabilize bottom sediments, protect shorelines from erosion, and take up nutrients that would otherwise contribute to nuisance algae growth. As photosynthetic rates decrease, less oxygen is released into the water by the plants. If light is completely blocked from bottom dwelling plants, the plants will stop producing oxygen and will die. As the plants are decomposed, bacteria will use up even more oxygen from the water. Reduced water clarity can also have direct impacts on aquatic fauna, including fish, waterfowl, frogs, turtles, and insects. Suspended sediments interfere with the ability of fish and waterfowl to see and catch food and can clog the gills of fish and invertebrates, making it difficult for them to breathe. When sediments settle to the bottom of a river, they can smother the eggs of fish and aquatic insects, as well as suffocate newly hatched insect larvae. Settling sediments can also fill in spaces between rocks, which could have been used by aquatic organisms for homes. Excess sediments can also cause an increase in surface water temperature because the sediment particles absorb heat from sunlight. This can cause dissolved oxygen levels to fall even farther (warmer waters hold less dissolved oxygen), and further harm aquatic life.

In addition to its direct effects, sediment may also carry nutrients, heavy metals and other pollutants into water bodies. A large proportion of the phosphorus that moves from land to water is attached to sediment particles. In general, this means that managing sediment sources can help manage phosphorus sources (Sharpley et al., 1990).

Through monitoring and assessment, the Wisconsin Department of Natural Resources (WDNR) has identified all or part of 73 streams, covering 120 individual segments/assessment units in the Wisconsin River Basin, as impaired due to phosphorus pollution, and has listed these on the state's 2016 303(d) Impaired Waters List.

The Department has also identified nine lakes in the project area as impaired due to phosphorus that will be addressed by this TMDL. Phosphorus impaired rivers and streams addressed by this TMDL are listed in Table 1. Total phosphorus impaired river and stream segments. Rivers and streams impaired by sediment and TSS are listed in Table 2. Sediment/total suspended solids impaired river and stream segments. Lakes and reservoirs impaired by phosphorus and addressed by this TMDL are listed in Table 3. Phosphorus impaired lakes addressed by TMDL. These impairments are illustrated in Figure 3 through Figure 6. This information is also shown by tributary basin in **Appendix A**.

The analysis method employed in this TMDL divided the Wisconsin River Basin into smaller subbasins. Each of these subbasins, approximately the size of a 12-digit federal hydrologic unit code (HUC-12) watershed, has an allocated load for phosphorus based on the phosphorus criteria for the waterbodies in that subbasin and to address more stringent downstream water quality criteria. The delineation of these subbasins often directly corresponds with the spatial extent of impaired river and stream segments or the contributory drainage areas of impaired lakes; however, subbasins were also delineated for waterbodies not listed as impaired. Thus, allocations were assigned to subbasins with listed and unlisted waterbodies. The resulting system of subbasin allocations provide protection ensuring that allocated loads meet promulgated water quality criteria for all waterbodies within the subbasin as well as downstream waterbodies. If future monitoring determines that additional river or stream segments within a subbasin are impaired, these impaired segments can be added to Wisconsin's future 303(d) Impaired Waters Lists under Category 5B: impaired waters with an approved TMDL or restoration plan.

There are some lakes in the Wisconsin River Basin that are not explicitly addressed by the TMDL. These lakes are listed as impaired for reasons possibly related to excessive phosphorus, even though phosphorus is not specifically identified as the pollutant causing their impairment. These lakes are listed and discussed in **Appendix B**. These lakes and reservoirs will require further evaluation to determine if the allocations listed in **Appendix J** will be sufficient to achieve water quality standards for the lakes or if more detailed studies, site-specific restoration plans, adoption of site-specific criteria (SSC), or other measures will be needed to achieve water quality goals. Most of these lakes are in the headwaters of the Wisconsin River where there are limited agricultural nonpoint sources of phosphorus and very few point sources. While implementation of the phosphorus allocations assigned in the TMDL are likely to result in water quality improvements, additional evaluation of phosphorus sources beyond the scope and scale of this TMDL, such as failing septic systems and stabilization and restoration of shore land buffers, are all potential avenues that will need to be explored in lake specific management plans.

This report identifies the TMDLs, load allocations, and recommended management actions that will help restore water quality in the Wisconsin River Basin for phosphorus impaired waterways. Sediment and TSS impaired streams and rivers have not been assigned explicit allocations and are therefore not explicitly addressed in this TMDL.

The sediment and TSS impaired segments listed in Table 2. Sediment/total suspended solids impaired river and stream segments are impaired due to nonpoint sources of sediment and TSS; there are not permitted point sources upstream of or discharging directly to these segments that cause or contribute to the sediment and TSS impairments. It is reasonable to expect that TMDL implementation actions that reduce TP to acceptable levels will also reduce TSS loads. Based on the lack of numeric sediment and TSS criteria for streams and rivers it is recommended that the segments listed in Table 2. Sediment/total suspended solids impaired river and stream segments rely on a combination of nonpoint phosphorus reductions along with the development of 9-Key Element Plans to reduce nonpoint sediment and TSS loads to an extent sufficient to achieve designated fish and other aquatic life uses.

Table 1. Total phosphorus impaired river and stream segments

| Waterbody | Start Mile | End Mile | Counties | Assessment Unit | WBIC | Pollutants | Impairments[1] | Phosphorus Criteria[2] (µg/L) | Fish & Aquatic Life Designated Use *(proposed DU, if different)*[3] | TMDL Subbasin(s) | Figure Region | Tributary Watershed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Baraboo River | 0 | 28.16 | Sauk, Columbia | 944741 | 1271100 | Total Phosphorus | Water Quality Use Restrictions | 100 | Default FAL | 4, 137, 179, | Lower | Baraboo |
| Baraboo River | 28.16 | 60.23 | Sauk | 944788 | 1271100 | Total Phosphorus | Impairment Unknown | 100 | Default FAL | 5, 179, 180, 184, 231 | Lower | Baraboo |
| Baraboo River | 60.23 | 86.79 | Juneau, Sauk | 944844 | 1271100 | Total Phosphorus | Impairment Unknown | 100 | Default FAL | 184-187, 227 | Lower | Baraboo |
| Baraboo River | 86.79 | 101.29 | Juneau | 944915 | 1271100 | Total Phosphorus | Impairment Unknown | 100 | Default FAL | 187,274 | Lower | Baraboo |
| Baraboo River | 101.35 | 106.16 | Juneau | 13023 | 1271100 | Total Phosphorus | Impairment Unknown | 100 | Default FAL* | 27 | Lower | Baraboo |
| Baraboo River | 108.6 | 118.93 | Monroe | 12978 | 1271100 | Total Phosphorus | Impairment Unknown | 100 | Cold | 28, 189 | Lower | Baraboo |
| Bear Creek | 0 | 13.95 | Juneau, Monroe | 13102 | 1311600 | Total Phosphorus | Degraded Biological Community | 75 | Default FAL | 51, 52 | Lower | Lemonweir |
| Bear Creek | 0 | 11.7 | Portage, Wood | 12317 | 139870 | Total Phosphorus | Water Quality Use Restrictions | 75 | Default FAL | 78 | Central | Mill |
| Beaver Creek | 0 | 4 | Wood | 12237 | 1372300 | Total Phosphorus | Water Quality Use Restrictions | 75 | Default FAL | 307 | Central | Yellow |
| Beaver Creek | 4 | 6.21 | Wood | 5735909 | 1372300 | Total Phosphorus | Water Quality Use Restrictions | 75 | Default FAL | 307 | Central | Yellow |
| Beaver Creek | 0 | 4 | Juneau, Monroe | 18435 | 1314000 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 53 | Lower | Lemonweir |
| Big Eau Pleine River | 0 | 16.6 | Marathon | 12398 | 1427200 | Total Phosphorus | Low DO | 75 | WWSF | 87, 88 | Upper | Big Eau Pleine |
| Big Eau Pleine River | 16.61 | 21.84 | Marathon | 12399 | 1427200 | Total Phosphorus | Low DO | 75 | WWSF | 327 | Upper | Big Eau Pleine |
| Big Eau Pleine River | 22.34 | 45.64 | Marathon | 886772 | 1427200 | Total Phosphorus | Low DO | 75 | WWSF | 91, 152, 324 | Upper | Big Eau Pleine |
| Big Rib River | 44.8 | 49.91 | Taylor | 886912 | 1451800 | Total Phosphorus | Impairment Unknown | 75 | Cold | 276 | Upper | Rib |
| Big Rib River | 49.91 | 55.13 | Taylor | 1443175 | 1451800 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 276 | Upper | Rib |
| Black Creek | 0 | 14.65 | Marathon | 12474 | 1458200 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 102, 215 | Upper | Rib |
| Black Creek | 14.65 | 19.64 | Marathon | 12475 | 1458200 | Total Phosphorus | Impairment Unknown | 75 | Cold | 104 | Upper | Rib |
| Brewer Creek | 0 | 6.7 | Juneau | 18447 | 1305000 | Total Phosphorus | Degraded Biological Community, Impairment Unknown | 75 | Cold | 43, 44 | Lower | Lemonweir |

1 Water Quality Use Restrictions = TP criteria were "overwhelmingly" exceeded (1.5 times the criteria for lakes and 2 times the criteria for rivers/streams); Degraded Biological Community = In addition to TP exceedance biological impairment was shown (poor macroinvertebrate and/or fish Index of Biological Integrity (IBI) scores); Impairment Unknown = TP exceeded criteria but no biological impairment was shown (either no biological data or all IBIs were fair – excellent); Low DO = Low dissolved oxygen

2 Phosphorus criteria (µg/L): The waterbody's applicable phosphorus criterion under s. NR 102.06, Wis. Admin. Code.

3 Fish & Aquatic Life Designated Use Status: This column indicates the waterbody's current Fish & Aquatic Life (FAL) Designated Use (DU) subcategory. If the DU has an asterisk behind it, that indicates that the waterbody was classified as Trout Class III before 1980, and may or may not be proposed as Cold in future DU revisions. Acronyms within this column are as follows: FAL=Fish & Aquatic Life; LFF=Limited Forage Fish; LAL=Limited Aquatic Life; WWSF=Warmwater Sport Fish; default FAL = Default Fish & Aquatic Life

Table 1. Total phosphorus impaired river and stream segments

| Waterbody | Start Mile | End Mile | Counties | Assessment Unit | WBIC | Pollutants | Impairments[1] | Phosphorus Criteria[2] (µg/L) | Fish & Aquatic Life Designated Use *(proposed DU, if different)*[3] | TMDL Subbasin(s) | Figure Region | Tributary Watershed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brewer Creek | 6.7 | 8.78 | Juneau | 13069 | 1305000 | Total Phosphorus | Impairment Unknown | 75 | Cold | 44 | Lower | Lemonweir |
| Cat Creek | 0 | 2 | Wood | 12232 | 1370700 | Total Phosphorus | Water Quality Use Restrictions | 75 | Default FAL | 65 | Central | Yellow |
| Cazenovia Branch | 0 | 0.66 | Richland, Sauk | 13010 | 1283100 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 310 | Lower | Baraboo |
| Cleaver Creek | 0 | 5 | Juneau | 13031 | 1292500 | Total Phosphorus | Water Quality Use Restrictions | 75 | Default FAL | 26 | Lower | Baraboo |
| Copper Creek | 0 | 6 | Sauk | 12999 | 1278400 | Total Phosphorus | Degraded Biological Community | 75 | Default FAL | 8 | Lower | Baraboo |
| Council Creek | 0 | 3.58 | Monroe | 13110 | 1341600 | Total Phosphorus | Degraded Biological Community | 75 | Default FAL | 55 | Lower | Lemonweir |
| Crossman Creek | 0 | 6.43 | Juneau, Sauk | 13019 | 1286700 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 17 | Lower | Baraboo |
| Crossman Creek | 6.42 | 12.01 | Juneau | 13020 | 1286700 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 19 | Lower | Baraboo |
| Dawes Creek | 0 | 7.75 | Wood | 12226 | 1367400 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 62 | Central | Yellow |
| Deer Creek | 0 | 7.15 | Taylor | 12414 | 1433400 | Total Phosphorus | Water Quality Use Restrictions | 75 | Default FAL | 98 | Upper | Big Eau Pleine |
| Dell Creek | 1.84 | 7.56 | Sauk | 18439 | 1295200 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 31 | Lower | Lower WI |
| Dell Creek | 7.55 | 15.82 | Sauk | 13045 | 1295200 | Total Phosphorus | Impairment Unknown | 75 | Cold | 32 | Lower | Lower WI |
| Dell Creek | 15.82 | 19.25 | Sauk | 6897810 | 1295200 | Total Phosphorus | Impairment Unknown | 75 | Cold | 32 | Lower | Lower WI |
| Dell Creek | 19.25 | 23.35 | Juneau | 946824 | 1295200 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 33 | Lower | Lower WI |
| Dill Creek | 0 | 8 | Marathon | 12402 | 1430700 | Total Phosphorus | Water Quality Use Restrictions | 75 | Default FAL | 93 | Upper | Big Eau Pleine |
| Dill Creek | 8 | 20 | Clark, Marathon | 12403 | 1430700 | Total Phosphorus | Water Quality Use Restrictions | 75 | LFF | 95 | Upper | Big Eau Pleine |
| Duck Creek | 0 | 12 | Columbia | 13523 | 1266300 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 3 | Lower | Lower WI |
| E Br Big Eau Pleine River | 0 | 11 | Marathon | 12411 | 1432300 | Total Phosphorus | Water Quality Use Restrictions | 75 | Default FAL | 99 | Upper | Big Eau Pleine |
| East Br Big Creek | 0 | 7 | Juneau, Sauk | 13006 | 1280500 | Total Phosphorus | Degraded Biological Community | 75 | Default FAL | 15 | Lower | Baraboo |
| Fenwood Creek | 0 | 1.5 | Marathon | 12393 | 1428700 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 89, 326 | Upper | Big Eau Pleine |
| Fenwood Creek | 1.5 | 17 | Marathon | 12394 | 1428700 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 90 | Upper | Big Eau Pleine |
| Hamann Creek | 0 | 10 | Marathon | 18334 | 1429900 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 92 | Upper | Big Eau Pleine |

Table 1. Total phosphorus impaired river and stream segments

| Waterbody | Start Mile | End Mile | Counties | Assessment Unit | WBIC | Pollutants | Impairments[1] | Phosphorus Criteria[2] (µg/L) | Fish & Aquatic Life Designated Use *(proposed DU, if different)*[3] | TMDL Subbasin(s) | Figure Region | Tributary Watershed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay Creek | 0 | 5.42 | Sauk | 13001 | 1279000 | Total Phosphorus | Degraded Biological Community | 75 | Cold | 9 | Lower | Baraboo |
| Hemlock Creek | 0 | 28.1 | Wood | 12224 | 1366300 | Total Phosphorus | Degraded Biological Community, Impairment Unknown | 75 | Default FAL/LFF for section from Vesper Dam to Dawes Creek. | 62, 201 | Central | Yellow |
| Hills Creek | 0 | 10 | Juneau, Vernon | 18434 | 1288800 | Total Phosphorus | Degraded Biological Community | 75 | Default FAL | 21 | Lower | Baraboo |
| Hulbert Creek | 0 | 1.55 | Sauk | 13050 | 1298500 | Total Phosphorus | Impairment Unknown | 75 | Cold | 243 | Lower | Lower WI |
| Lemonweir River | 0 | 25.8 | Juneau | 13059 | 1301700 | Total Phosphorus | Impairment Unknown | 100 | Default FAL | 36, 244, 245 | Lower | Lemonweir |
| Lemonweir River | 25.8 | 30.64 | Juneau | 13060 | 1301700 | Total Phosphorus | Impairment Unknown | 100 | Default FAL | 45 | Lower | Lemonweir |
| Lemonweir River | 30.64 | 55.88 | Juneau, Monroe | 201397 | 1301700 | Total Phosphorus | Impairment Unknown | 100 | Default FAL | 195, 197, 306 | Lower | Lemonweir |
| Little Baraboo River | 0 | 11.93 | Richland, Sauk | 13007 | 1282500 | Total Phosphorus | Degraded Biological Community | 75 | Default FAL | 14, 301 | Lower | Baraboo |
| Little Bear Creek | 0 | 1.5 | Wood | 12359 | 1416900 | Total Phosphorus | Degraded Biological Community, Impairment Unknown | 75 | Default FAL | 79 | Upper | Little Eau Pleine |
| Little Bear Creek | 1.5 | 8 | Wood | 12360 | 1416900 | Total Phosphorus | Impairment Unknown | 75 | Default FAL with portions listed as LFF and LAL in NR. 104 | 82, 211 | Upper | Little Eau Pleine |
| Little Eau Pleine River | 0 | 28.6 | Marathon, Portage | 12354 | 1412600 | Total Phosphorus | Degraded Biological Community | 75 | Default FAL | 80, 150 | Upper | Little Eau Pleine |
| Little Eau Pleine River | 28.6 | 57 | Clark, Marathon | 12355 | 1412600 | Total Phosphorus | Water Quality Use Restrictions | 75 | Default FAL | 85, 212, 213 | Upper | Little Eau Pleine |
| Little Hemlock Creek | 0 | 10.39 | Wood | 12225 | 1367100 | Total Phosphorus | Water Quality Use Restrictions | 75 | Default FAL | 62 | Central | Yellow |
| Little Hoten Creek | 0 | 2.23 | Juneau | 13100 | 1307000 | Total Phosphorus | Impairment Unknown | 75 | Cold | 48 | Lower | Lemonweir |
| Little Hoton Creek | 2.23 | 3.93 | Juneau | 1442012 | 1307000 | Total Phosphorus | Impairment Unknown | 75 | Cold | 48 | Lower | Lemonweir |
| Little Lemonweir River | 0 | 4.62 | Juneau | 18456 | 1306100 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 47 | Lower | Lemonweir |
| Little Lemonweir River | 4.62 | 12.36 | Juneau | 948033 | 1306100 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 47, 48, 196 | Lower | Lemonweir |
| Little Lemonweir River | 12.36 | 22.86 | Juneau, Monroe | 948058 | 1306100 | Total Phosphorus | Impairment Unknown | 75 | Cold | 49 | Lower | Lemonweir |
| Little Lemonweir River | 22.86 | 24.81 | Monroe | 948085 | 1306100 | Total Phosphorus | Impairment Unknown | 75 | Cold | 50 | Lower | Lemonweir |
| Lyndon Creek | 0 | 6 | Juneau | 13054 | 1300700 | Total Phosphorus | Impairment Unknown | 75 | Default FAL* | 34, 192 | Lower | Lower WI |

Table 1. Total phosphorus impaired river and stream segments

| Waterbody | Start Mile | End Mile | Counties | Assessment Unit | WBIC | Pollutants | Impairments[1] | Phosphorus Criteria[2] (µg/L) | Fish & Aquatic Life Designated Use *(proposed DU, if different)*[3] | TMDL Subbasin(s) | Figure Region | Tributary Watershed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lyndon Creek | 6 | 8.73 | Juneau | 13055 | 1300700 | Total Phosphorus | Impairment Unknown | 75 | Default FAL* | 35 | Lower | Lower WI |
| Mill Creek | 0 | 16.01 | Portage | 12318 | 1398600 | Total Phosphorus | Low DO | 75 | Default FAL | 78, 146 | Central | Mill |
| Mill Creek | 16.01 | 32.82 | Wood, Portage | 12319 | 1398600 | Total Phosphorus | Low DO | 75 | Default FAL | 207, 332 | Central | Mill |
| Mill Creek | 5.81 | 8.24 | Monroe | 18452 | 1326700 | Total Phosphorus | Impairment Unknown | 75 | Cold | 58, 305 | Lower | Lemonweir |
| Mink Creek | 0 | 5.78 | Taylor | 12498 | 1463300 | Total Phosphorus | Impairment Unknown | 75 | Cold | 276 | Upper | Rib |
| Narrows Creek | 0 | 23 | Sauk | 12996 | 1276400 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 7, 181, 183 | Lower | Baraboo |
| North Br Duck Creek | 0 | 20.6 | Columbia | 13526 | 1267500 | Total Phosphorus | Water Quality Use Restrictions | 75 | Default FAL | 2, 177 | Lower | Lower WI |
| Onemile Creek | 0 | 0.69 | Juneau | 18445 | 1303400 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 38 | Lower | Lemonweir |
| Onemile Creek | 0.7 | 3.6 | Juneau | 13063 | 1303400 | Total Phosphorus | Impairment Unknown | 75 | Default FAL* | 39 | Lower | Lemonweir |
| Onemile Creek | 3.6 | 5.99 | Juneau | 947890 | 1303400 | Total Phosphorus | Impairment Unknown | 75 | Cold | 40 | Lower | Lemonweir |
| Onemile Creek | 5.99 | 7.23 | Juneau | 1517524 | 1303400 | Total Phosphorus | Impairment Unknown | 75 | Cold | 41 | Lower | Lemonweir |
| Onemile Creek | 7.23 | 13 | Juneau | 947914 | 1303400 | Total Phosphorus | Impairment Unknown | 75 | Cold | 42 | Lower | Lemonweir |
| Plum Creek | 0 | 8 | Sauk | 13021 | 1287700 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 18 | Lower | Baraboo |
| Puff Creek | 0 | 7.72 | Wood | 12236 | 1371500 | Total Phosphorus | Degraded Biological Community | 75 | Default FAL | 307 | Central | Yellow |
| Raeder Creek | 0 | 3 | Marathon | 18335 | 1430800 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 96 | Upper | Big Eau Pleine |
| Randall Creek | 9 | 10 | Marathon | 12407 | 1431800 | Total Phosphorus | Water Quality Use Restrictions | 75 | Default FAL | 97 | Upper | Big Eau Pleine |
| Randall Creek | 0 | 9 | Marathon | 18336 | 1431800 | Total Phosphorus | Water Quality Use Restrictions | 75 | Default FAL? | 94 | Upper | Big Eau Pleine |
| Rocky Creek | 0 | 12.22 | Wood | 12233 | 1370800 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 66 | Central | Yellow |
| Scotch Creek | 0 | 3.8 | Marathon | 12460 | 1455600 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 101 | Upper | Rib |
| Scotch Creek | 3.8 | 10 | Marathon | 18354 | 1455600 | Total Phosphorus | Impairment Unknown | 75 | LFF | 106 | Upper | Rib |
| Scotch Creek | 10 | 18 | Marathon | 12461 | 1455600 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 105 | Upper | Rib |
| Seeley Creek | 0 | 13.12 | Sauk | 12990 | 1275300 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 6 | Lower | Baraboo |

Table 1. Total phosphorus impaired river and stream segments

| Waterbody | Start Mile | End Mile | Counties | Assessment Unit | WBIC | Pollutants | Impairments[1] | Phosphorus Criteria[2] (µg/L) | Fish & Aquatic Life Designated Use *(proposed DU, if different)*[3] | TMDL Subbasin(s) | Figure Region | Tributary Watershed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sevenmile Creek | 0 | 15 | Juneau | 13061 | 1302400 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 37 | Lower | Lemonweir |
| Seymour Creek | 0 | 2.63 | Juneau | 13024 | 1291400 | Total Phosphorus | Impairment Unknown | 75 | Default FAL* | 23 | Lower | Baraboo |
| Seymour Creek | 2.63 | 6.48 | Juneau, Vernon | 946527 | 1291400 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 24 | Lower | Baraboo |
| Seymour Creek | 6.48 | 11.49 | Monroe, Vernon | 946550 | 1291400 | Total Phosphorus | Impairment Unknown | 75 | Default FAL* | 25 | Lower | Baraboo |
| Silver Creek | 0 | 4.4 | Sauk | 13004 | 1280000 | Total Phosphorus | Low DO, Degraded Habitat | 75 | Default FAL | 12 | Lower | Baraboo |
| South Br Creek (S Br Baraboo) | 0 | 1.25 | Vernon | 13029 | 1289800 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 22 | Lower | Baraboo |
| South Fork Lemonweir River | 6.21 | 12.2 | Monroe | 888023 | 1338500 | Total Phosphorus | Low DO, Degraded Biological Community | 75 | Default FAL | 54 | Lower | Lemonweir |
| South Fork Lemonweir River | 13.28 | 22.03 | Monroe | 3870704 | 1338500 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 56, 57 | Lower | Lemonweir |
| Spring Brook Creek | 0 | 10.27 | Langlade, Marathon | 12431 | 1440800 | Total Phosphorus | Degraded Biological Community | 75 | Default FAL (Cold) | 107, 216 | Upper | Eau Claire |
| Spring Brook Creek | 10.26 | 12.65 | Langlade | 12432 | 1440800 | Total Phosphorus | Low DO | 75 | Default FAL | 216 | Upper | Eau Claire |
| Squaw Creek | 0 | 9 | Marathon, Wood | 12363 | 1420700 | Total Phosphorus | Impairment Unknown | 75 | LFF (FAL) | 84 | Upper | Little Eau Pleine |
| Tributary to the South Branch of Yellow River | 0 | 1.07 | Clark | 1516846 | 1372800 | Total Phosphorus | Water Quality Use Restrictions | 75 | LAL (FAL) | 71 | Central | Yellow |
| Twin Creek | 0 | 9 | Sauk | 18426 | 1279400 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 11 | Lower | Baraboo |
| Unnamed Creek | 5 | 7.91 | Wood | 5533601 | 1371200 | Total Phosphorus | Water Quality Use Restrictions | 75 | Default FAL | 72 | Central | Yellow |
| Unnamed Creek (T23N,R3E,S10,SESW,72) | 0 | 3 | Wood | 12234 | 1371200 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 67, 72 | Central | Yellow |
| Unnamed Creek (T23N,R3E,S10,SESW,72) | 3 | 5 | Wood | 12235 | 1371200 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 72, 313 | Central | Yellow |
| Unnamed Stream | 0 | 1.94 | Wood | 3987535 | 5016277 | Total Phosphorus | Degraded Biological Community | 75 | Default FAL | 67 | Central | Yellow |
| Unnamed Stream | 0 | 2.33 | Clark | 3987619 | 5015142 | Total Phosphorus | Degraded Biological Community | 75 | Default FAL | 70 | Central | Yellow |
| Unnamed Trib to Yellow River | 0 | 1.25 | Wood | 4699046 | 1372500 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 68 | Central | Yellow |
| Unnamed Trib to Yellow River | 0 | 0.84 | Clark | 5533738 | 1374000 | Total Phosphorus | Water Quality Use Restrictions | 75 | Default FAL | 275 | Central | Yellow |
| W Br Eau Claire River | 2.01 | 32.01 | Langlade | 1496996 | 1445700 | Total Phosphorus | Degraded Biological Community | 75 | Cold | 108 | Upper | Eau Claire |
| W Branch Big Eau Pleine River | 0 | 8.7 | Marathon, Taylor | 12412 | 1432700 | Total Phosphorus | Water Quality Use Restrictions | 75 | LFF | 98 | Upper | Big Eau Pleine |

Table 1. Total phosphorus impaired river and stream segments

| Waterbody | Start Mile | End Mile | Counties | Assessment Unit | WBIC | Pollutants | Impairments[1] | Phosphorus Criteria[2] (µg/L) | Fish & Aquatic Life Designated Use *(proposed DU, if different)*[3] | TMDL Subbasin(s) | Figure Region | Tributary Watershed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W Branch Big Eau Pleine River | 8.7 | 12 | Taylor | 12413 | 1432700 | Total Phosphorus | Degraded Biological Community | 75 | Default FAL | 100 | Upper | Big Eau Pleine |
| West Br Baraboo River | 0 | 7.24 | Juneau, Vernon | 13026 | 1288400 | Total Phosphorus | Low DO | 75 | Default FAL | 20, 138, 188 | Lower | Baraboo |
| West Br Big Creek | 0 | 8 | Juneau, Sauk | 18427 | 1281200 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 13, 16 | Lower | Baraboo |
| Wild Creek | 0 | 10 | Marathon | 12361 | 1420400 | Total Phosphorus | Water Quality Use Restrictions | 75 | FAL | 83, 328 | Upper | Little Eau Pleine |
| Wisconsin River (At Castle Rock Lake) | 158.68 | 173.27 | Adams/Juneau | 885667 | 1179900 | Total Phosphorus | Low DO | 40 | WWSF | 59 | Central | Central WI |
| Wisconsin River (At Petenwell Lake) | 173.27 | 187.81 | Adams/Juneau | 885864 | 1179900 | Total Phosphorus | Eutrophication, Degraded Biological Community | 40 | WWSF | 74 | Central | Central WI |
| Yellow River | 39.1 | 50.01 | Clark, Juneau, Wood | 12205 | 1352800 | Total Phosphorus | Water Quality Use Restrictions | 75 | FAL Warmwater | 61, 140 | Central | Yellow |
| Yellow River | 0 | 8.43 | Juneau | 12230 | 1352800 | Total Phosphorus | Degraded Biological Community | 75 | Default FAL | 60, 199 | Central | Yellow |
| Yellow River | 8.43 | 39.1 | Juneau, Wood | 5541128 | 1352800 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 61,199 | Central | Yellow |
| Yellow River | 53.01 | 57.3 | Wood | 5541350 | 1352800 | Total Phosphorus | Water Quality Use Restrictions | 75 | FAL Warmwater | 64, 200 | Central | Yellow |
| Yellow River | 57.3 | 74.48 | Wood | 5541396 | 1352800 | Total Phosphorus | Water Quality Use Restrictions | 75 | FAL Warmwater | 250, 307 | Central | Yellow |
| Yellow River | 74.48 | 83.08 | Clark, Wood | 5541476 | 1352800 | Total Phosphorus | Water Quality Use Restrictions | 75 | FAL Warmwater | 275 | Central | Yellow |
| Yellow River | 83.08 | 97.59 | Clark | 5541562 | 1352800 | Total Phosphorus | Water Quality Use Restrictions | 75 | FAL Warmwater | 275 | Central | Yellow |
| Yellow River-E. Branch | 0 | 8.78 | Marathon, Wood | 12239 | 1373200 | Total Phosphorus | Impairment Unknown | 75 | Default FAL | 275 | Central | Yellow |
| Yellow River-S. Branch | 0 | 18 | Clark, Wood | 12238 | 1372600 | Total Phosphorus | Degraded Biological Community | 75 | Default FAL | 69, 71 | Central | Yellow |

Table 2. Sediment/total suspended solids impaired river and stream segments

| Waterbody [1] | Start Mile | End Mile | Counties | Assessment Unit | WBIC | Pollutants | Impairments | Phosphorus Criteria (µg/L) | Fish & Aquatic Life Designated Use *(proposed DU, if different)* | TMDL Subbasin(s) | Figure Region | Tributary Watershed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Babb Creek | 0 | 6.42 | Sauk | 13003 | 1279100 | Sediment/Total Suspended Solids | Degraded Habitat | 75 | Default FAL | 10 | Lower | Baraboo |
| Crossman Creek | 0 | 6.43 | Juneau, Sauk | 13019 | 1286700 | Sediment/Total Suspended Solids | Degraded Habitat, Turbidity | 75 | Default FAL | 17 | Lower | Baraboo |
| Silver Creek | 0 | 4.4 | Sauk | 13004 | 1280000 | Sediment/Total Suspended Solids | Low DO, Degraded Habitat | 75 | Default FAL (LAL) | 12 | Lower | Baraboo |
| West Br Baraboo River | 0 | 7.24 | Juneau, Vernon | 13026 | 1288400 | Sediment/Total Suspended Solids | Low DO | 75 | Default FAL | 20, 138, 188 | Lower | Baraboo |

[1] As described in Section 1.3, the sediment/TSS impaired river and stream segments listed have not been assigned allocations for sediment/TSS and are not explicitly addressed in this TMDL study. Sediment/total suspended solids impaired river and stream segments will be addressed by relying on a combination of nonpoint sediment/total suspended solids that are anticipated to accompany needed phosphorus reductions along with the development of 9-Key Element Plans specifically drafted to target and reduce nonpoint sediment and TSS loads to an extent sufficient to achieve designated fish and other aquatic life uses.

Table 3. Phosphorus impaired lakes addressed by TMDL

| Waterbody | Size (Acres) | Counties | Assessment Unit | WBIC | Pollutants | Impairments | Classification | Phosphorus Criteria (µg/L) | Fish & Aquatic Life Designated Use | Recreational Use | TMDL Subbasin | Figure Region | Tributary Watershed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Big Eau Pleine Reservoir | 4,909 | Marathon | 352690 | 1427400 | Total Phosphorus | Low DO, Eutrophication, Excess Algal Growth | Reservoir Deep Lowland | 30 | Default FAL | Full body contact | 87 | Upper | Big Eau Pleine |
| Castle Rock Reservoir | 12,386 | Adams, Juneau | 424081 | 1345700 | Total Phosphorus | Eutrophication, Water Quality Use Restrictions | Reservoir Shallow Lowland | 40 | Default FAL | Full body contact | 59 | Central | Central WI |
| Petenwell Reservoir | 23,001 | Adams, Juneau | 424132 | 1377100 | Total Phosphorus | Low DO, Water Quality Use Restrictions | Reservoir Shallow Lowland | 40 | Default FAL | Full body contact | 74 | Central | Central WI |
| Kawaguesaga Lake | 700 | Oneida | 128163 | 1542300 | Total Phosphorus | Impairment Unknown | Two-Story | 15 | Default FAL | Full body contact | 135 | Headwaters | Tomahawk |
| Minocqua Lake | 1,339 | Oneida | 128227 | 1542400 | Total Phosphorus | Impairment Unknown | Two-Story | 15 | Default FAL | Full body contact | 134 | Headwaters | Tomahawk |
| Redstone Lake | 612 | Sauk | 13542 | 1280400 | Total Phosphorus | Excess Algal Growth | Reservoir Deep Lowland | 30 | Default FAL | Full body contact | 13 | Lower | Baraboo |
| Lake DuBay [1] | 4,045 | Marathon, Portage | 3900358 | 1412200 | Total Phosphorus | Excess Algal Growth | Reservoir Shallow Lowland | 100 | Default FAL | Full body contact | 81 | Upper | Upper WI |
| Lake Delton | 249 | Columbia | 13546 | 1295400 | Total Phosphorus | Eutrophication, Water Quality Use Restrictions, Excess Algal Growth | Reservoir | 40 | Default FAL | Full body contact | 30 | Lower | Lower WI |
| Lake Wisconsin [2] | 7,197 | Sauk, Columbia | 13500 | 1260600 | Total Phosphorus | Low DO, Eutrophication, Recreational Restrictions - Blue Green Algae | Impounded Flowing Water | 100 | Default FAL | Full body contact | 1 | Lower | Lower WI |

[1] While the 100 µg/L TP criterion for Lake DuBay of is not sufficient to remove the impairment of excessive algal growth (monitoring data indicates that the lake averages 90 µg/L and is still impaired), the TMDL analysis shows that resulting loads from the attainment of water quality criteria for Big Eau Pleine (criteria of 30 µg/L) coupled with reductions needed to meet downstream reservoirs will result in a phosphorus concertation for Lake DuBay sufficient to address the impairment of excessive algal growth (see Appendix C for details). Lake DuBay is predicted to have a summer mean concentration of 37 µg/L under the TMDL allocations and 45 µg/L under the site-specific allocations proposed in Appendix K.

[2] The current TP criterion for Lake Wisconsin is not adequate to address the listed impairments; however, the allocations found in Appendix K corresponding with a SSC of 47 µg/L, as discussed in Appendix C, addresses the impairments.

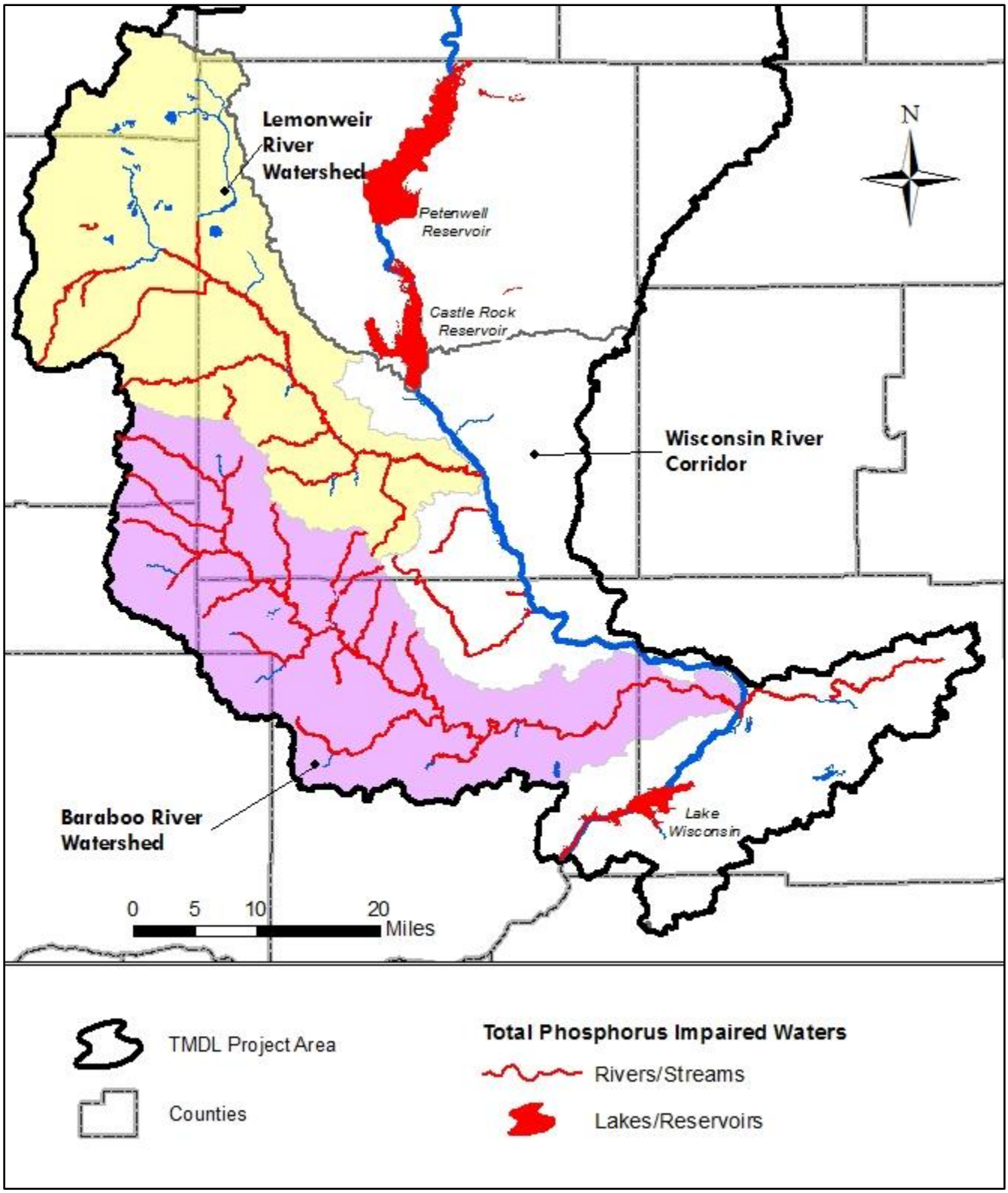


**FIGURE 3. TOTAL PHOSPHORUS IMPAIRED WATERS: LOWER REGION**

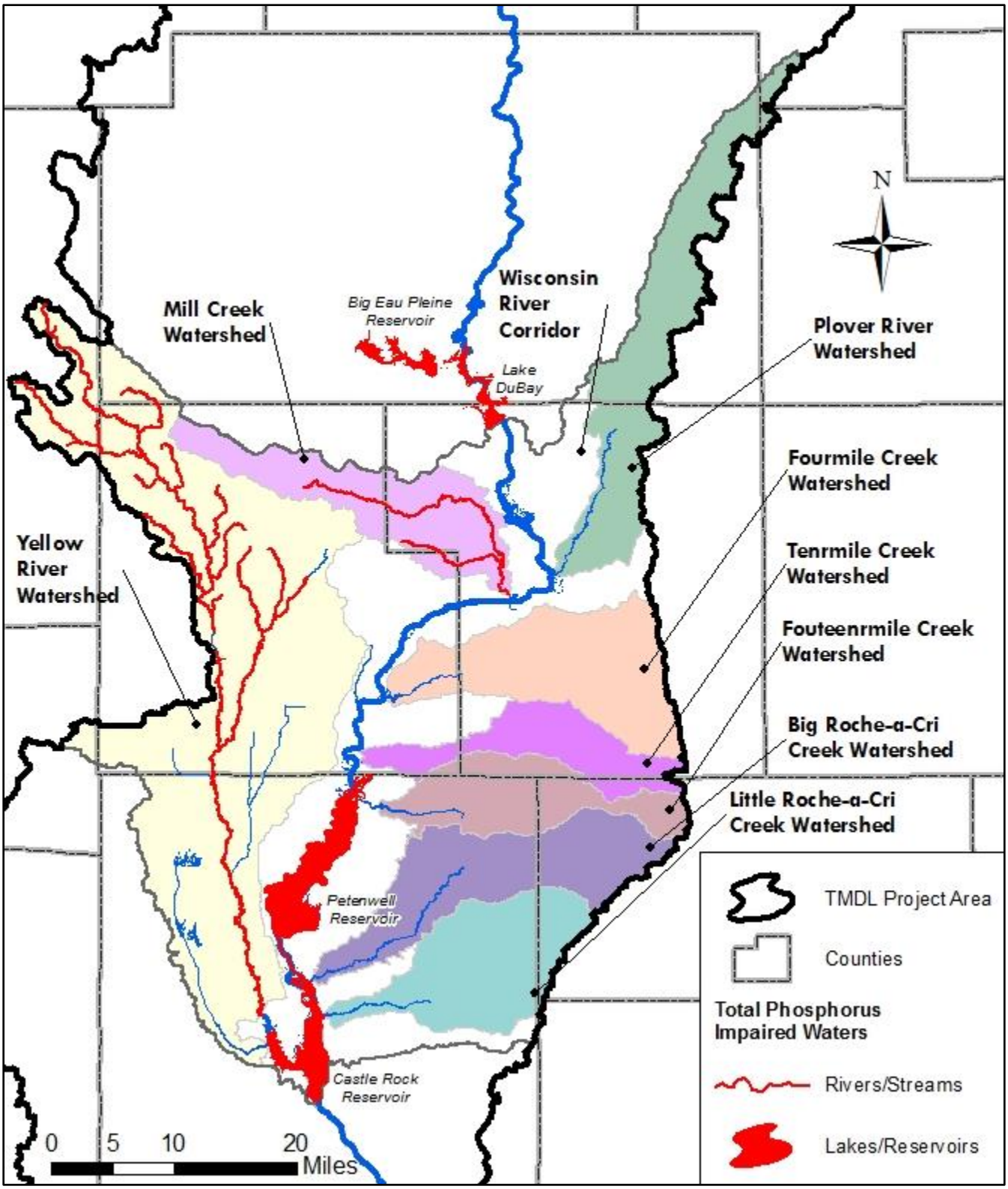


FIGURE 4. TOTAL PHOSPHORUS IMPAIRED WATERS: CENTRAL REGION

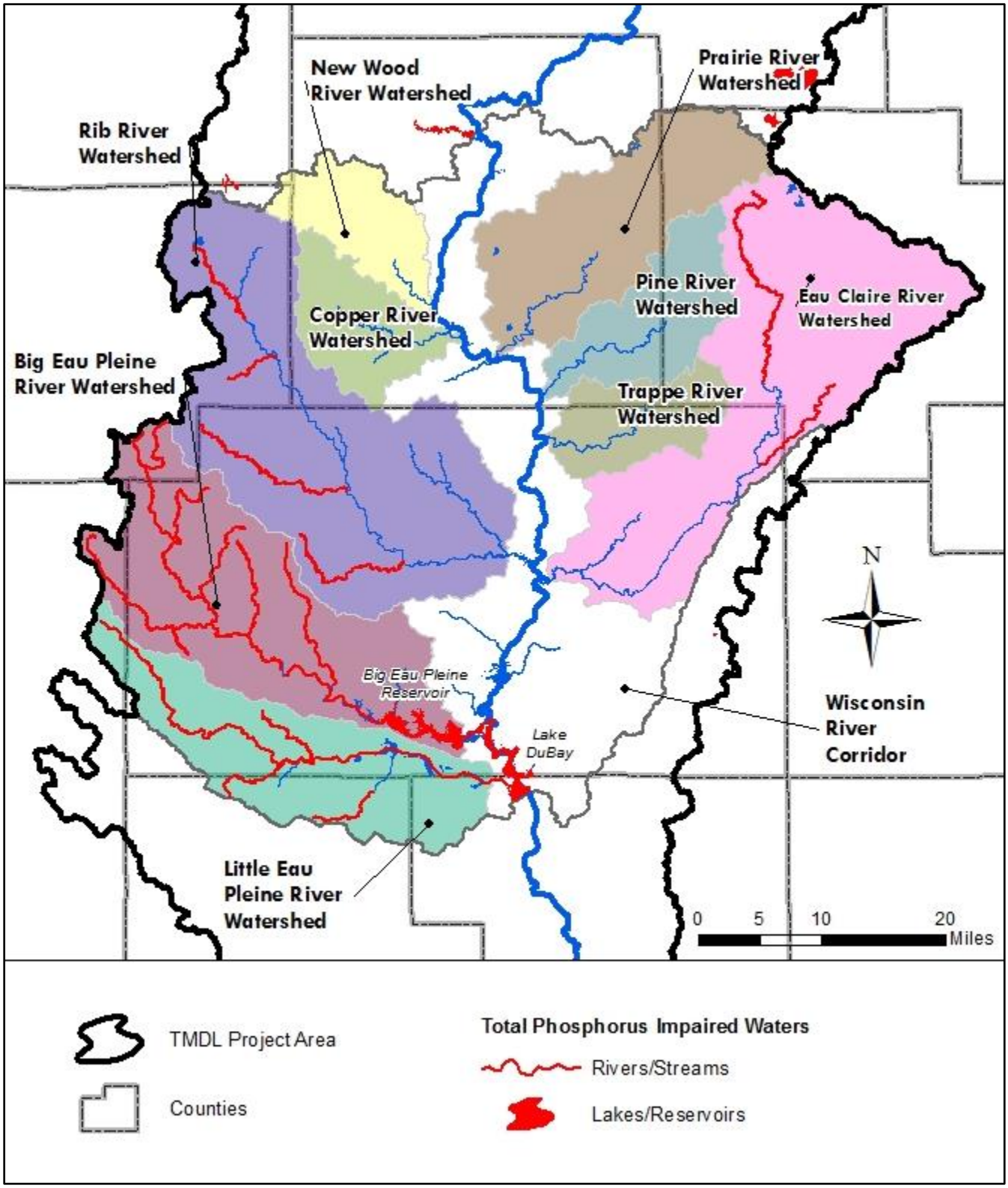


**FIGURE 5. TOTAL PHOSPHORUS IMPAIRED WATERS: UPPER REGION**

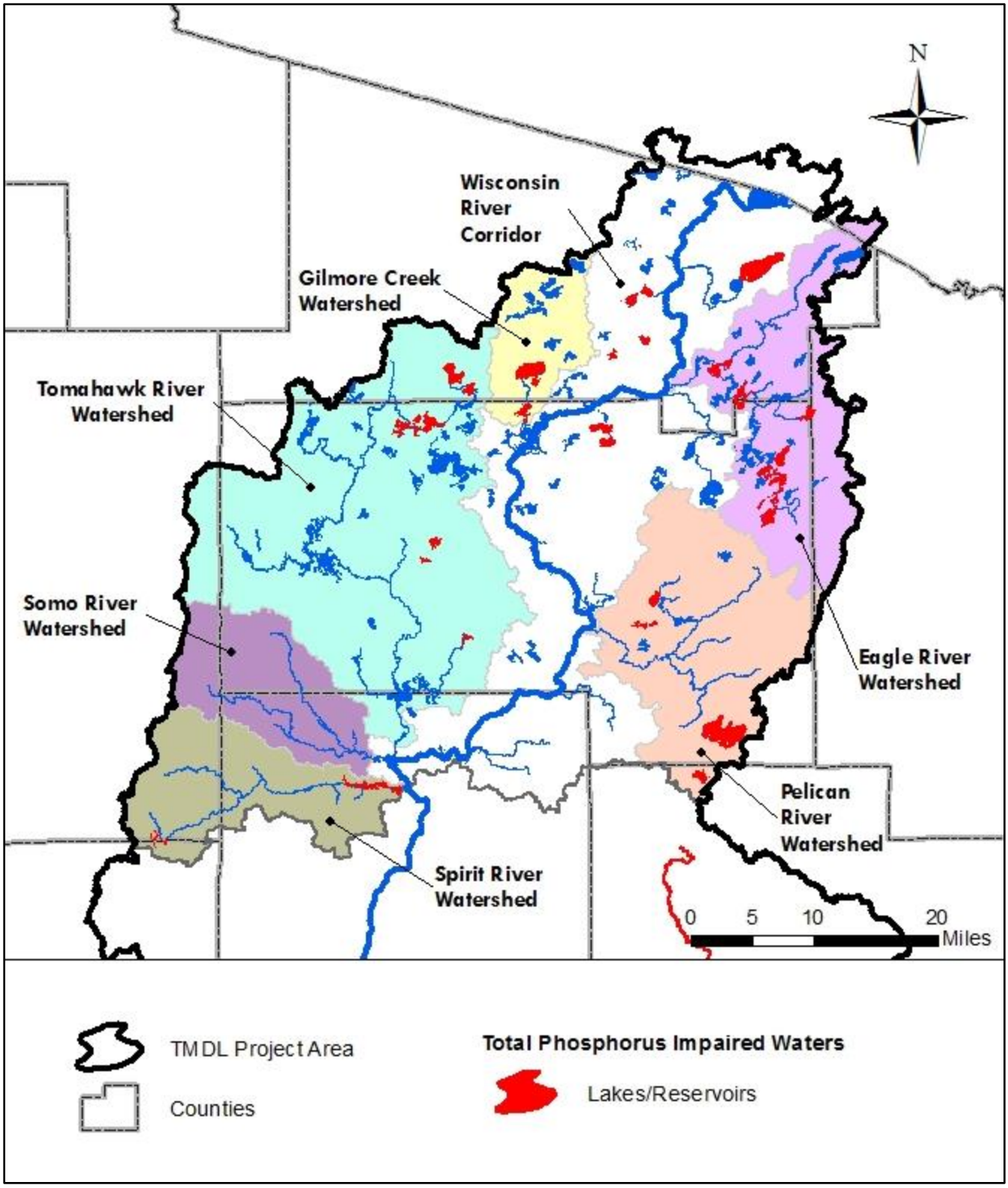


**FIGURE 6. TOTAL PHOSPHORUS IMPAIRED WATERS: HEADWATERS REGION**

## 1.4 Narrative Water Quality Criteria

All waters of the State of Wisconsin are subject to the following narrative water quality standard, as defined in s. NR 102.04(1), Wis. Adm. Code:

> "To preserve and enhance the quality of waters, standards are established to govern water management decisions. Practices attributable to municipal, industrial, 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 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 waters of the states, (c) 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."

Excessive phosphorus loading causes algal blooms in the Wisconsin River Basin, which may be characterized as floating scum, producing a green color, a strong odor and an unsightly condition. Sometimes these algal blooms contain toxins which limit recreational uses of the water bodies. Because of the low dissolved oxygen and degraded habitat impairments caused by TP, many designated fish and aquatic life uses are not supported in the waters of the Wisconsin River Basin.

## 1.5 Numeric Water Quality Criteria

To address the effects of excessive phosphorus, WDNR established numeric criteria for total phosphorus in surface waters in 2010 (s. NR 102.06, Wis. Adm. Code). These numeric criteria (Table 4. Wisconsin numeric phosphorus criteria) are based on relationships between phosphorus and designated uses of surface waters, which are summarized in the Wisconsin Phosphorus Water Quality Standards Criteria: Technical Support Document (December 2010).

Table 4. Wisconsin numeric phosphorus criteria

| | | |
|---|---|---|
| **Flowing Waters**[4] | Rivers | 100 µg/L |
| | Streams | 75 µg/L |
| **Reservoirs** | Stratified Reservoirs, Hydraulic residence time ≥ 14 days | 30 µg/L |
| | Non-stratified Reservoirs, Hydraulic residence time ≥ 14 days | 40 µg/L |
| **Lakes** | Stratified, two-story fishery lakes | 15 µg/L |
| | Stratified seepage lakes | 20 µg/L |
| | Stratified drainage lakes | 30 µg/L |
| | Non-stratified lakes | 40 µg/L |

µg/L = microgram per liter

Administrative code also specifies that a "…site-specific criterion may be adopted in place of the generally applicable criteria where site-specific data and analysis using scientifically defensible methods and sound scientific rationale demonstrate a different criterion is protective of the designated use of the specific surface water segment or waterbody" (s. NR 102.06(7), Wis. Adm. Code). In the process of developing this TMDL, WDNR evaluated relationships between TP and recreational uses of impaired waters. These analyses indicate

[4] Rivers and streams impounded by dams with hydraulic residence time < 14 days are classified as impounded flowing waters and given applicable river/stream criteria.

that site-specific criteria (SSC) may be appropriate for Petenwell, Castle Rock, and Lake Wisconsin (Table 5, see details of analysis in **Appendix C**). The potential for an SSC was also evaluated for Lake Du Bay but is not recommended at this time (see **Appendix C**).

Because these recommended SSCs have not yet been promulgated and a TMDL must be based on promulgated narrative or numeric criteria, this TMDL contains two sets of TP allocations: one set for the current criteria located in **Appendix J** and another set for the recommended SSC located in **Appendix K**. Sections 5.6, 6.3, 6.4, and 7.6 provide additional discussion concerning the allocations and proposed implementation of the SSC-based allocations should the SSC become promulgated.

Table 5. Recommended site-specific phosphorus criteria

| Waterbody Name | Waterbody Type | Default TP Criterion | Potential Site-Specific TP Criterion |
|---|---|---|---|
| Petenwell Reservoir | Non-stratified Reservoir | 40 µg/L | 53 µg/L |
| Castle Rock Reservoir | Non-stratified Reservoir | 40 µg/L | 55 µg/L |
| Lake Wisconsin | Impounded Flowing Water | 100 µg/L | 47 µg/L |

Revisions to other administrative codes supporting P criteria implementation went into effect concurrently with changes to ch. NR 102, Wis. Adm. Code. Chapter NR 217, Wis. Adm. Code, was revised to include procedures for translating numeric phosphorus criteria into water quality-based effluent limits (WQBELs) and incorporating those limits into Wisconsin Pollutant Discharge Elimination System (WPDES) permits. Chapter NR 151, Wis. Adm. Code revisions that went into effect concurrently with the changes to ch. NR 102, Wis. Adm. Code included new phosphorus index (P-Index) performance standards addressing phosphorus from agricultural lands.

## 1.6 Designated Uses

All waters of the state have the following designated uses: fish and aquatic life; recreation; wildlife; and public health and welfare. Additionally, there are five subcategories of the fish and aquatic life use, which reflect differences in the potential aquatic communities present in water bodies. These aquatic life communities may be adversely impacted by phosphorus and sediment. Section NR 102.04(3), Wis. Adm. Code, defines these use subcategories as follows:

### 1.6.1 Fish and Other Aquatic Life Uses

The department shall classify all surface waters into one of the fish and other aquatic life subcategories described in this subsection. Only those use subcategories identified in paragraphs (a) to (c) shall be considered suitable for the protection and propagation of a balanced fish and other aquatic life community as provided in the federal water pollution control act amendments of 1972, P.L. 92-500; 33 USC 1251 et. seq. TP criteria do not differ among these subcategories.

a) *Cold water communities*. This subcategory includes surface waters capable of supporting a community of cold water fish and aquatic life or serving as a spawning area for cold water fish species. This subcategory includes, but is not restricted to, surface waters identified as trout water by the department of natural resources (Wisconsin Trout Streams, publication 6-3600 (80)).
b) *Warm water sport fish communities*. This subcategory includes surface waters capable of supporting a community of warm water sport fish or serving as a spawning area for warm water sport fish.
c) *Warm water forage fish communities*. This subcategory includes surface waters capable of supporting an abundant diverse community of forage fish and other aquatic life.

d) *Limited forage fish communities.* (Intermediate surface waters). This subcategory includes surface waters of limited capacity and naturally poor water quality or habitat. These surface waters are capable of supporting only a limited community of forage fish and other aquatic life.
e) *Limited aquatic life.* (Marginal surface waters). This subcategory includes surface waters of severely limited capacity and naturally poor water quality or habitat. These surface waters are capable of supporting only a limited community of aquatic life."

Most of the impaired water bodies in the Wisconsin River Basin are classified as warm water sport fish communities or warm water forage fish communities, and a few are classified as cold water communities. Table 1, Table 2, and Table 3 contain these designations for each impaired water body.

### 1.6.2 Recreational Uses

All surface waters shall be suitable for supporting recreational use. A sanitary survey or evaluation, or both to assure protection from fecal contamination, is the chief criterion for determining the suitability of a water for recreational use. Recreational use of surface waters may also be impaired by excessive algae blooms, consistent with the narrative standard in s. NR 102.04(1), Wis. Adm. Code (see Section 1.4). Algae blooms can affect recreational use of surface waters by causing an unsightly appearance and disagreeable odor, and by producing substances that are toxic to humans and animals. Because numeric criteria for algae blooms do not exist, Wisconsin's Consolidated Assessment and Listing Methodology (WisCALM, http://dnr.wi.gov/topic/surfacewater/assessments.html) describes methods for assessing this type of recreational water quality impairment. Recreational algal impairment thresholds apply to lakes, reservoirs, and large rivers. Chlorophyll-a concentration is used to assess algal impairment. Chlorophyll-a in deep lakes and reservoirs shall not exceed 20 µg/L more than 5% of the July 15 – Sept 15 period. Chlorophyll-a in shallow lakes and reservoirs and large rivers shall not exceed 20 µg/L more than 30% of the July 15 – Sept 15 period.

# 2 WATERSHED CHARACTERISTICS

Wisconsin's namesake river, the Wisconsin River. is an important recreational, industrial, and natural resource to the State of Wisconsin. From its headwaters in Lac Vieux Desert in Vilas County to the outlet of Lake Wisconsin at Prairie du Sac Dam in Columbia County, the Wisconsin River travels 335 river miles flowing through diverse landscapes.

The Wisconsin River watershed extends approximately 42 square miles into the state of Michigan. Tribal lands are also present in the Wisconsin River watershed. Phosphorus loading from these land areas have been identified, but no reductions are required due to their not being part of the state's jurisdiction. Also, in most cases these lands are not developed and consist of forest and wetland land cover and there are no point source discharges present. The extent of tribal lands is depicted in Table 6 and Figure 8.

Agriculture is the predominant land use in many parts of the basin. The extent of agricultural areas in the basin is illustrated in Figure 7. The dominant type of agriculture varies from mixed dairy and cash cropping (continuous corn/corn–soybean rotations) in the lower and upper basins, to potatoes, vegetables and cranberries in the central

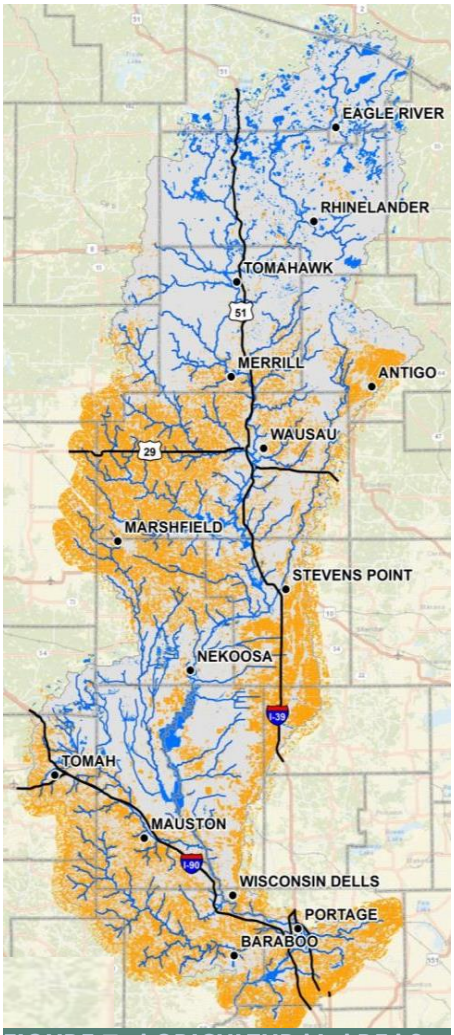


FIGURE 7. AGRICULTURAL AREAS

basin, and limited agriculture in the headwaters basin. Detailed maps of agricultural land use and land management throughout the project area are included in Section 3.2 of **Appendix D.**

Table 6. Tribal lands

| Tribe | TMDL Subbasin | Area (acres) |
|---|---|---|
| Lac du Flambeau | 300 | 8476.2 |
| Ho-Chunk Nation | 199 | 511.8 |
| Ho-Chunk Nation | 1 | 307.4 |
| Ho-Chunk Nation | 62 | 254.9 |
| Ho-Chunk Nation | 303 | 244.3 |
| Ho-Chunk Nation | 250 | 211.0 |
| Ho-Chunk Nation | 304 | 181.8 |
| Ho-Chunk Nation | 306 | 159.4 |
| Ho-Chunk Nation | 191 | 118.4 |
| Ho-Chunk Nation | 311 | 78.0 |
| Ho-Chunk Nation | 245 | 51.5 |
| Ho-Chunk Nation | 243 | 49.6 |
| Ho-Chunk Nation | 141 | 40.8 |
| Ho-Chunk Nation | 329 | 40.1 |
| Ho-Chunk Nation | 16 | 38.0 |
| Ho-Chunk Nation | 32 | 34.1 |
| Ho-Chunk Nation | 51 | 32.4 |
| Ho-Chunk Nation | 190 | 30.8 |
| Ho-Chunk Nation | 31 | 28.8 |
| Ho-Chunk Nation | 63 | 27.0 |
| Ho-Chunk Nation | 52 | 10.0 |
| Ho-Chunk Nation | 38 | 6.0 |
| Ho-Chunk Nation | 37 | 1.7 |
| Ho-Chunk Nation | 202 | 0.3 |

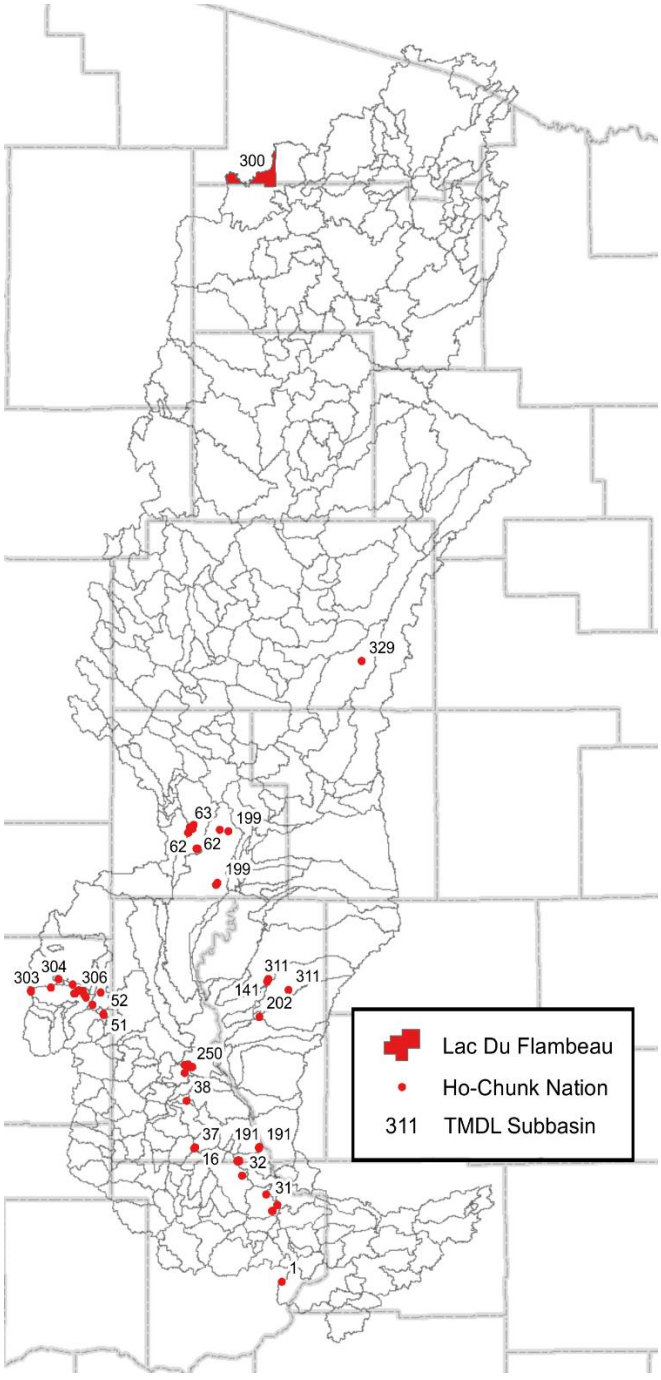


FIGURE 8. TRIBAL LANDS

The State of the Lower Wisconsin River Basin Report (WDNR, 2002), The State of the Central Wisconsin River Basin Report (WDNR, 2002) and The Headwaters State of the Basin Report (WDNR, 2002) provide additional details on characteristics of the basin's watershed, including geography, geology, soils, meteorology, groundwater, and ecological and cultural resources.

## 2.1 Ecological Landscapes

The TMDL watershed spans six distinct ecological landscapes (WDNR 2012). The Western Coulee and Ridges in the southwest, the Central Sand Plains and Central Sand Hills in the central and southeast portion of the project area, the North Central Forest and Northern Highlands in the northern portion of the project area, and Forest Transition in the tension zone between the agricultural and forested landscapes (Figure 9). Each of these regions is described in more detail in the subsections below.

### 2.1.1 Western Coulees and Ridges.

The southwest portion of the project area, including portions of Columbia, Monroe, Richland, Sauk, and Vernon counties, lies within the Western Coulees and Ridges ecological landscape. More commonly referred to as the "driftless area", this area is characterized by the absence of glacial material or "drift" left during the most recent glaciation and is comprised of steep sided valleys and ridges with loess–capped plateaus, deeply dissected by high-gradient streams. This area is mostly underlain by Paleozoic sandstones and dolomites of Cambrian and Ordovician age and covered by windblown loess of varying thicknesses. In contrast to the more recently glaciated areas of the state, this area has few lakes and a greater density of streams.

Land cover in this area is predominantly comprised of forest and agriculture, with lesser amounts of grassland; wetlands are rare and occur mostly in river valleys. Primary forest cover is oak-hickory, while maple-basswood forests are common in areas not burned frequently before Euro-American settlement.

With a mean growing season of 145 days, a mean annual temperature of 43.7°F, and mean annual precipitation of 32.6 inches, the climate of this ecoregion is favorable for agriculture. However, steep slopes limit intensive agricultural uses to broad ridge tops and parts of valleys above floodplains.

Livestock and dairy farming is common in this area and have had a major impact on stream quality. The Cities of Baraboo and Reedsburg are located within this region of the TMDL project area.

### 2.1.2 Central Sand Plains

The Central Sand Plains gets its name from the large, flat expanse of lacustrine and outwash sand deposited during the most recent glaciation. The Central Sand Plains are underlain by Late Cambrian sandstone containing strata of dolomite and shale.

The mean growing season in the Central Sand Plains is 135 days, the mean annual temperature is 43.8°F, and the mean annual precipitation is 32.8 inches. The shorter growing season, occasional freezing temperatures during summer, sandy soils, and abundance of wetlands limits agriculture in this ecological landscape west of the Wisconsin River. Agriculture is more prevalent east of the Wisconsin River, with an emphasis on cool

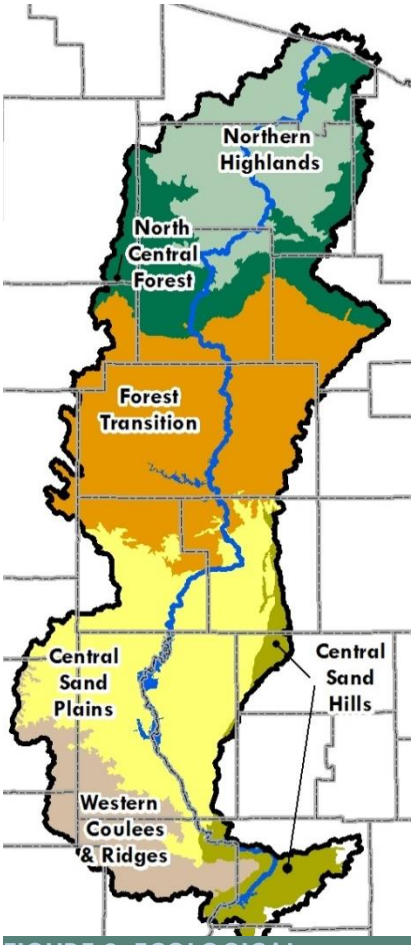


FIGURE 9. ECOLOGICAL LANDSCAPES

season crops such as potatoes, vegetable crops, and early maturing corn. Center pivot irrigation is common here because of the sandy soils and shallow aquifer.

### 2.1.3 Central Sand Hills

Along the southeast and central-east edge of the project area is a narrow sliver of the ecological landscape Central Sand Hills, including portions of Columbia, Dane, Adams, Portage, Waushara and Waupaca counties. The Central Sand Hills are covered in glacial deposits including a mix of moraines, drumlins, till plains, outwash features, and lake plains originating from the most recent glaciation. Glacial sediment in this area is typically 50 to 100 feet thick and underlain by Cambrian sandstone bedrock. Soils are primarily sands in the northwestern portion and sandy loam tills in the southeast.

The climate of Central Sand Hills is similar to the Central Sand Plains and Western Coulees and Ridges and is thus suitable for agricultural use.

This ecological landscape area supports a mix of agriculture - primarily cropland, dairy operations, and woodland. Most of the original vegetation has been cleared with forested areas remaining only on steeper end moraines and poorly drained depressions. Many wetlands have been drained and used for agriculture here. Irregular till plains, end moraines, kettles, and drumlins are common, and wetlands are found throughout the region, especially along end morainal ridges. There are fewer lakes here than in ecoregions to the north, but considerably more than in the driftless area to the west.

### 2.1.4 Forest Transition

The Forest Transition ecological landscape supports both northern forests and agricultural areas. Within the TMDL project area, this includes all of Marathon County and portions of Wood, Portage, Langlade, Lincoln, Clark and Taylor Counties. The central portion of the Forest Transition lies primarily on glacial till plain underlain Precambrian volcanic or metamorphic bedrock, or Cambrian sandstones with inclusions of dolomite and shale. Soils are predominantly non-calcareous, moderately well-drained sandy loams derived from glacial till, but there is considerable diversity in the range of soil attributes. The area includes sandy soils formed in outwash as well as organic soils and loam and silt loam soils on moraines.

The average growing season is 133 days, average annual temperature is 41.9°F and annual average precipitation is 32.6 inches. Land cover is predominantly forest and agriculture with lesser amounts of grassland/pasture and wetlands. There is an adequate growing season and enough precipitation to support agricultural activity. Corn, small grains, and pastures are common land uses in many parts of this ecological landscape. However, growing conditions in the Forest Transition are not as favorable for row crop agriculture as in southern Wisconsin.

Within this area, Wood, Portage, and Marathon counties have greater than half their population living in metropolitan areas, mostly on or near the Wisconsin River.

### 2.1.5 North Central Forest

Forests cover approximately 75% of the North Central Forest ecological landscape. Mesic northern hardwood forest dominant, made up of sugar maple, basswood, and red maple, with some stands containing scattered hemlock, yellow birch, and/or eastern white pine pockets. The aspen-birch forest type group is also common. Forested and non-forested wetland communities are common and widespread. The landscape is characterized by 5 to 100-foot-thick glacial deposits, including end and ground moraines, kettle depressions and pitted outwash, underlain by igneous and metamorphic bedrock. Organic soils (peats and mucks) are common in poorly drained lowlands. Within the project area, this landscape includes portions of Forest, Lincoln, Langlade, Oneida, Vilas and Price Counties.

The mean growing season is 115 days, and the mean annual precipitation is 32.3 inches. The mean annual temperature is 40.3°F and summer temperatures can be cold or freezing at night in low-lying areas of the region, thereby limiting agricultural land use.

### 2.1.6 Northern Highlands

The ecological landscape of Wisconsin River Basin Headwaters is primarily the Northern Highlands. This area is characterized by a globally significant concentration of glacial lakes and small connecting streams, rare aquatic species and extensive wetlands. Land cover is predominantly forest - including the state's greatest acreage of dry-mesic eastern white pine-red pine forests, wetlands, and lakes. There is a small amount of grassland and urban area, and limited agriculture.

The Northern Highlands are underlain by igneous and metamorphic rock, generally covered by deposits of glacial drift from 5 feet to over 100 feet in depth. Most soils are sands and gravels, some with a loamy mantle. The climate is typical of northern Wisconsin, with a mean growing season of 122 days, mean annual temperature of 39.5 °F, and mean annual precipitation of 31.6 inches. The tourism-oriented cities of Minocqua, Tomahawk and Eagle River are all located here.

## 2.2 Hydrology and Water Resources

The Wisconsin River itself is only one component of the complex hydrologic network of water resources within the project area. The following sections of the report describe the various categories of waterways addressed by the TMDL, and their numeric phosphorus criteria.

### 2.2.1 Wisconsin River Main Stem

The Wisconsin River originates at Lac Vieux Desert and from there to the Rhinelander Dam a numeric phosphorus criterion of 75 µg/L applies to the free-flowing portions of the river. Water quality is excellent, and portions of the upper river are classified as Outstanding and Exceptional Resource Waters in ch. NR 102, Wis. Adm. Code. Downstream of the Rhinelander Dam, a numeric phosphorus criterion of 100 µg/L applies. For much of its length, the free-flowing portions of the Wisconsin River are well below the phosphorus criteria.

### 2.2.2 Wisconsin River Tributary Streams

The numeric phosphorus criteria of all major tributary streams in the TMDL project area except two, is 75 µg/L. The two exceptions are the Baraboo and Lemonweir Rivers, which like the Wisconsin River main stem, have numeric phosphorus criteria of 100 µg/L. Due to differences in watershed characteristics and land use, tributary streams west of the main stem generally have higher phosphorus concentrations and deliver higher pollutant loads into the Wisconsin River than those east of the main stem.

### 2.2.3 Lakes and Reservoirs

As described in an earlier section of the report, the Wisconsin River system consists of 25 hydroelectric dams on the Wisconsin River. Upstream of these dams are impoundments that are highly valued economic, social, recreation, and ecological resources. In addition, there are 21 storage impoundments on the river and its tributaries to regulate flow for hydropower generation. These storage impoundments range from smaller raised natural lakes in the headwater's region to large reservoirs over 6,000 acres. The sensitivity of these impoundments to elevated phosphorus concentrations depends on their hydraulic residence time. Residence time is defined as the length of time that water remains within the reservoir before continuing downstream. Waterbodies with longer residence times are more sensitive to excessive phosphorus concentrations due to the longer time available for water to warm and grow algae. In Wisconsin, reservoirs with a summer residence time of 14 days or greater have a numeric phosphorus criterion of 30 or 40 µg/L. Reservoirs with a residence time of less than 14 days have the numeric phosphorus criterion that applies to the primary stream or river

entering the impounded water, i.e., 75 or 100 µg/L. The following subsections of this report describe the lakes and reservoirs addressed by this TMDL.

#### 2.2.3.1 PETENWELL AND CASTLE ROCK RESERVOIRS

Petenwell and Castle Rock are located at the downstream section of the central portion of the Wisconsin River main stem; they are the second and fifth largest inland lakes in the state of Wisconsin, respectively. These reservoirs were developed for hydroelectric power generation. Because both are unstratified reservoirs with a residence time greater than 14 days, both have numeric water quality criteria for total phosphorus of 40 µg/L, though as stated in Section 1.5, the department is recommending SSC for both reservoirs. Petenwell is 23,173 acres with a maximum depth of 44 feet. Castle Rock is 12,981 acres with a maximum depth of 36 feet. A comprehensive management plan was developed for these reservoirs in 1996 (WDNR, 1996), which provides a summary of their impaired beneficial uses and recommends measures to mitigate the problems. Based on information in the management plan, impaired beneficial uses to Petenwell and Castle Rock include: impaired recreation, impaired aesthetics, undesirable blue-green algae blooms, some toxic algae, dioxin, mercury and PCB contaminated fish and sediments; degradation of desirable phytoplankton, zooplankton, bottom-dwelling organisms (benthos) and fish and wildlife communities because of poor water quality and lack of established rooted aquatic plants; low dissolved oxygen; and fish (carp) kills on the Petenwell Reservoir. This TMDL will address impairments related to excessive phosphorus and sediment, however it will not address dioxin, mercury and PCB contaminated fish and sediments.

#### 2.2.3.2 THE BIG EAU PLEINE RESERVOIR

The Big Eau Pleine Reservoir is a 6,348-acre storage reservoir on the Big Eau Pleine River, a tributary stream that discharges into the Wisconsin River at Lake DuBay in Marathon County. It has a maximum depth of 46 feet. Fish include musky, smallmouth bass, northern pike and walleye. The lake's water clarity is very low. Large fish kills due to low dissolved oxygen during the winter have occurred in the past and are an ongoing concern. Because the Big Eau Pleine is a stratified reservoir with a residence time of more than 14 days, its numeric water quality criteria for total phosphorus is 30 µg/L.

#### 2.2.3.3 LAKE DU BAY

Lake DuBay is a 4,649-acre hydroelectric reservoir on the Wisconsin River, in Marathon and Portage Counties. It has a maximum depth of 30 feet. Fish include musky, smallmouth bass, northern pike and walleye. The lake's water clarity is low. Because Lake DuBay has a residence time of less than 14 days, its numeric water quality criteria for total phosphorus is 100 µg/L.

#### 2.2.3.4 LAKE WISCONSIN

Lake Wisconsin is a 7,197-acre hydroelectric reservoir on the Wisconsin River in Columbia and Sauk Counties. It has a maximum depth of 24 feet. The water is brown and moderately fertile. Largemouth bass, panfish, catfish and walleye are most common in the fishery. Other species contributing to the catch are musky, northern pike and lake sturgeon. Because Lake Wisconsin has a residence time of less than 14 days, its numeric water quality criteria for total phosphorus is 100 µg/L.

#### 2.2.3.5 LAKE REDSTONE

Lake Redstone is a 605-acre reservoir on Big Creek in Sauk County. It was created in the 1970's for real estate interests. It has a maximum depth of 36 feet. The lake reflects the extensive agricultural watershed it drains with heavy, late summer algal blooms. Fish include musky, panfish, largemouth bass, northern pike and walleye. Because Lake Redstone is a stratified reservoir with a residence time of more than 14 days, its numeric water quality criteria for total phosphorus is 30 µg/L.

#### 2.2.3.6 KAWAGUESAGA AND MINOCQUA LAKES

Kawaguesaga and Minocqua Lakes are the lower most lakes in a complex chain of lakes in Oneida County. Water levels of both lakes are controlled by the dam at the outlet of Kawaguesaga Lake (Tomahawk River). These are raised natural lakes where the dam only increases lake levels by about 4 feet. Kawaguesaga Lake is 700 acres with a maximum depth of 44 feet. Minocqua Lake is 1,339 acres with a maximum depth of 61 feet. Fish include musky, panfish, largemouth bass, smallmouth bass, northern pike, walleye and cisco. A key element of these lakes is that they support a cisco fishery in the lower strata of the lake. This requires that these lakes attain and maintain dissolved oxygen in the hypolimnion, the lowest layer in these stratified lakes. The numeric water quality criterion for total phosphorus is 15 µg/L.

#### 2.2.3.7 LAKE DELTON

Lake Delton is a 249-acre reservoir on Dell Creek, in Sauk County. It was created in the 1920's as part of a resort development. It has an average depth of 12 feet. Fish include panfish, largemouth bass, northern pike, walleye and catfish. Because Lake Delton is an unstratified reservoir with a residence time of more than 14 days, its numeric water quality criteria for total phosphorus is 40 µg/L.

# 3 MONITORING

Extensive water quality and flow monitoring was conducted in support of TMDL development. In fact, the Wisconsin River TMDL monitoring program is among the most comprehensive watershed monitoring efforts ever undertaken in the state. It included four years of flow and water quality monitoring in the rivers, streams and lakes of the Wisconsin River Basin. The purpose of this comprehensive, long-term, large-scale monitoring effort was to gain an understanding of water quality conditions within the basin and to provide calibration and validation datasets for use in the development of watershed and reservoir response models.

The four years (2009-2013) of Wisconsin River Basin monitoring data included main stem, tributary and reservoir monitoring sites, as described in the following sections, and illustrated in Figure 10 through Figure 14. Full technical documentation of the TMDL Water Quality monitoring effort is summarized in **Appendix D**.

## 3.1 Wisconsin River Main Stem and Tributary Monitoring

Stream flow, phosphorus concentration and other water quality constituents, such as nitrogen and suspended solids, were measured year-round at thirteen sites along the main stem of the river, providing information about how much phosphorus is carried from north to south by the main stem. Stream flow was measured either at 15-minute intervals or hourly, and water quality constituents were measured every two weeks. Field parameters such as temperature, dissolved oxygen, pH, transparency and conductivity were measured concurrently with other water quality constituents. Sites on the Wisconsin River at Merrill, Biron and Wisconsin Dells and the Baraboo River near Baraboo are part of Wisconsin's Long-Term Trends Rivers monitoring network and have been routinely monitored over several decades.

Continuous temperature data was collected at the Nekoosa, Petenwell, and Castle Rock dams and on Tenmile Creek, Big Roche a Cri Creek, and the Yellow River. As on the main stem sites, water flow, phosphorus, other water quality constituents and field parameters were measured year-round at 19 sites on tributaries flowing into the main stem of the river, providing information about how much phosphorus each tributary watershed contributes to the main stem of the river. Results of main stem and tributary total phosphorus monitoring are illustrated on Figure 10 and Figure 11, respectively

## 3.2 Reservoir Monitoring

Chlorophyll, phosphorus, other water quality constituents, and field parameters were measured semi-monthly from April – October at 20 sites on the five major reservoirs. Additionally, hourly flow data at the Petenwell and Castle Rock dams was provided by the Wisconsin River Power Company. At the reservoir sites, field

parameters were measured in profile, at one-meter depth intervals from the water's surface to the bottom of the lake. Thermistor strings were placed at multiple sites on Castle Rock and Petenwell to continuously monitor changes in thermal mixing of the reservoirs over the course of the summer. Algae samples were collected at multiple sites to identify the major algal species present and to estimate the number of algae present. The location and results of reservoir total phosphorus monitoring are illustrated in Figure 12 through Figure 14.

## 3.3 Additional Phosphorus Evaluation Sites

Phosphorus concentrations were measured monthly at 98 additional sites between May and October 2012 to provide an additional validation dataset independent from the main stem, tributary and reservoir monitoring sites just described. A subset of these sites received additional follow-up monitoring in 2013 and 2014 to determine phosphorus criteria attainment status. In addition, multiple water bodies were monitored through the Citizen Lake Monitoring Network, Wisconsin Valley Improvement Company Trophic Status Monitoring and other lake and stream monitoring projects.

## 3.4 Sediment Monitoring

The phosphorus concentration and phosphorus release rates in reservoir sediment, under various conditions, was measured in multiple locations in Castle Rock, Petenwell and Big Eau Pleine Reservoirs and Lake DuBay. Appendix E contains complete documentation regarding methods and results of sediment monitoring measurements.

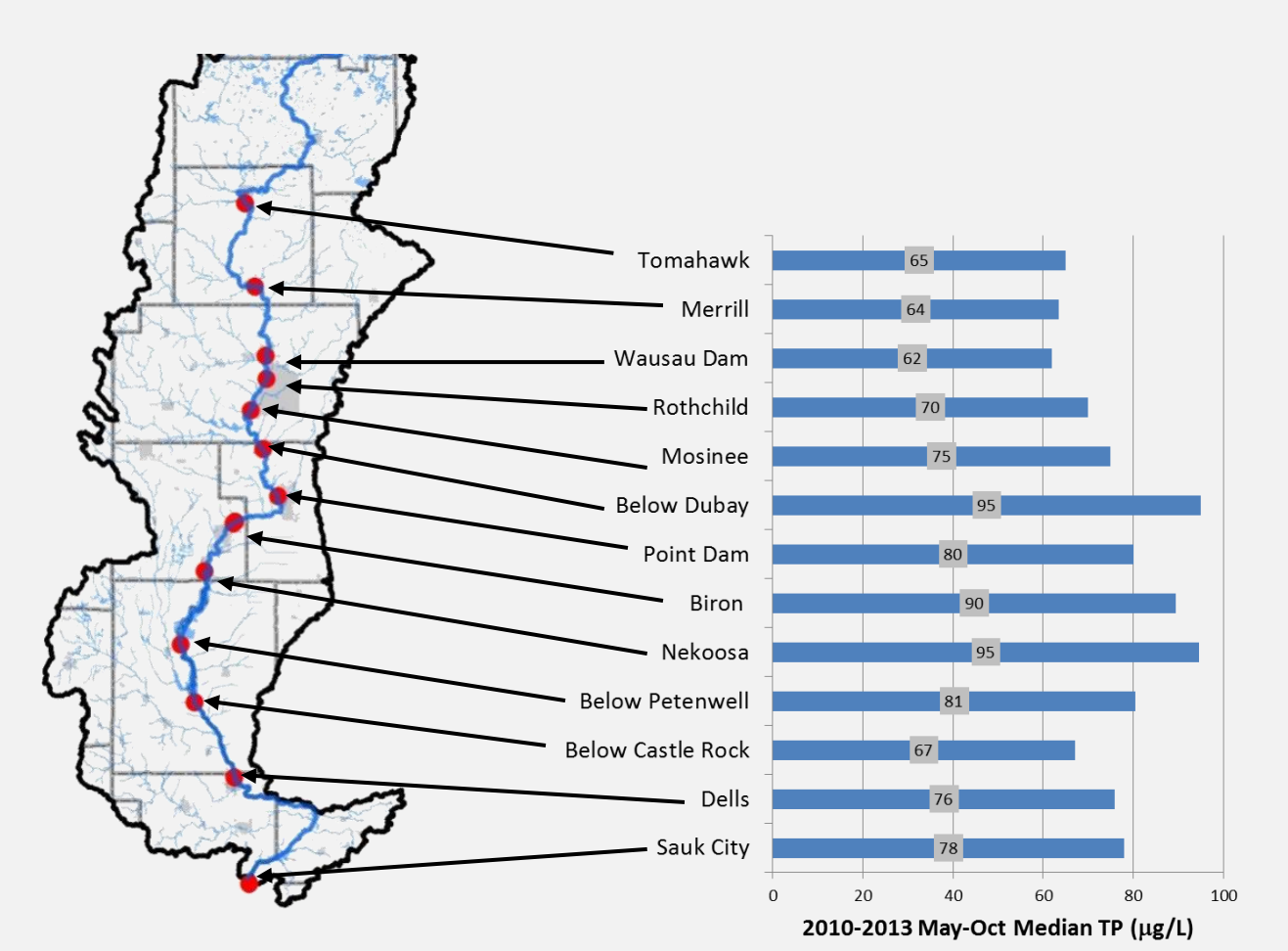


FIGURE 10. MAIN STEM MONITORING: MEDIAN TOTAL PHOSPHORUS

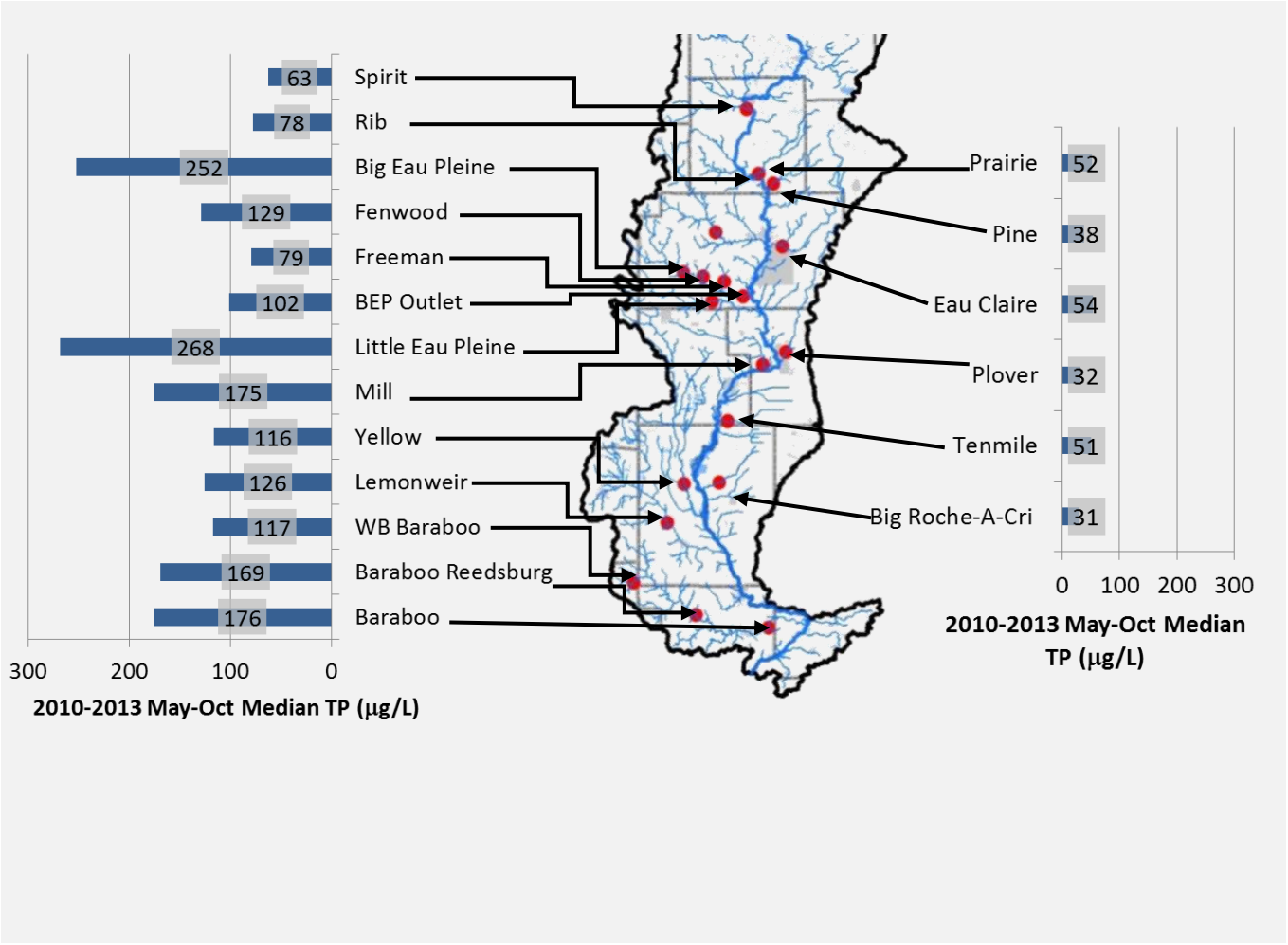


FIGURE 11. TRIBUTARY MONITORING: MEDIAN TOTAL PHOSPHORUS

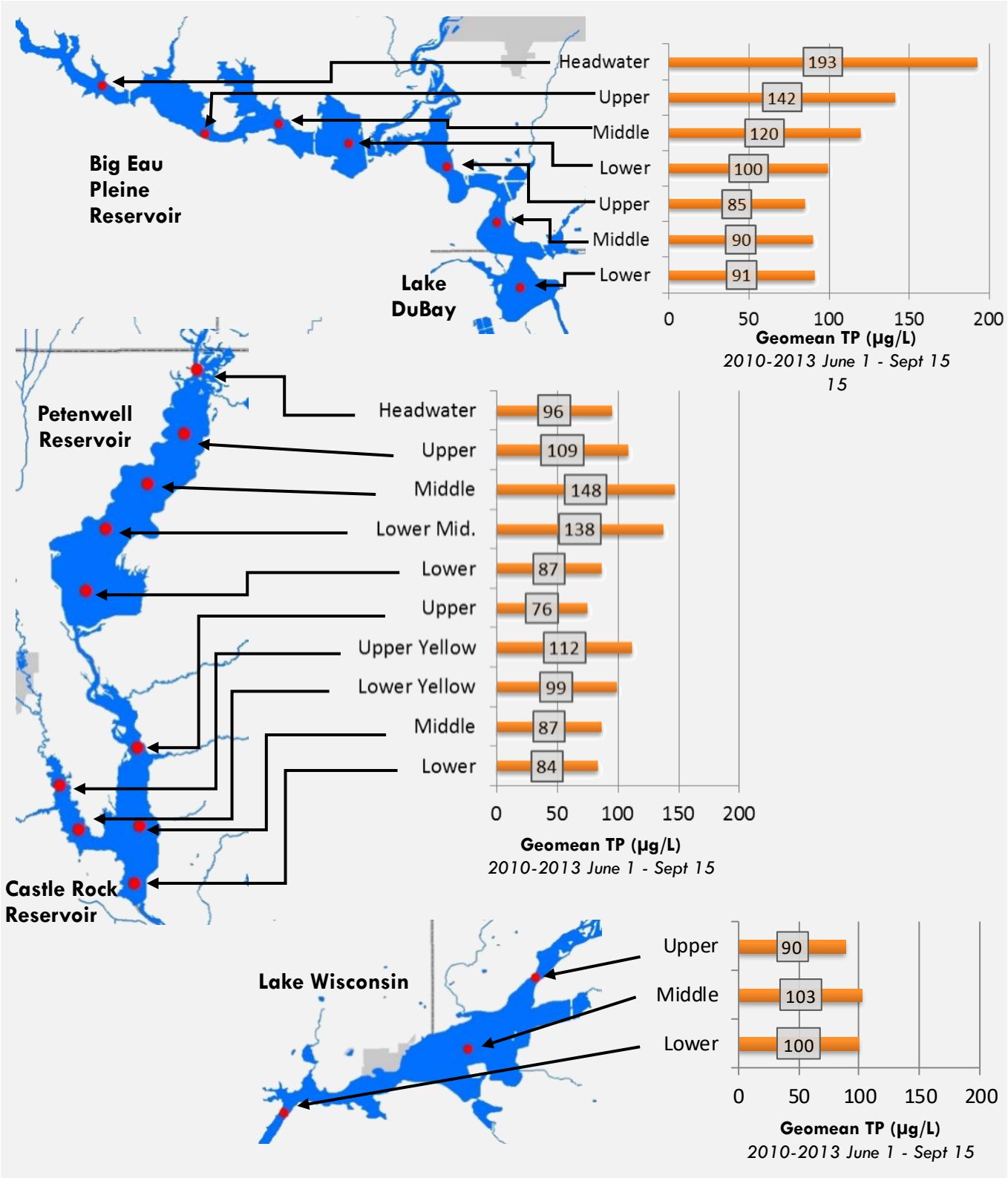


FIGURE 12. RESERVOIR MONITORING: GEOMEAN TOTAL PHOSPHORUS

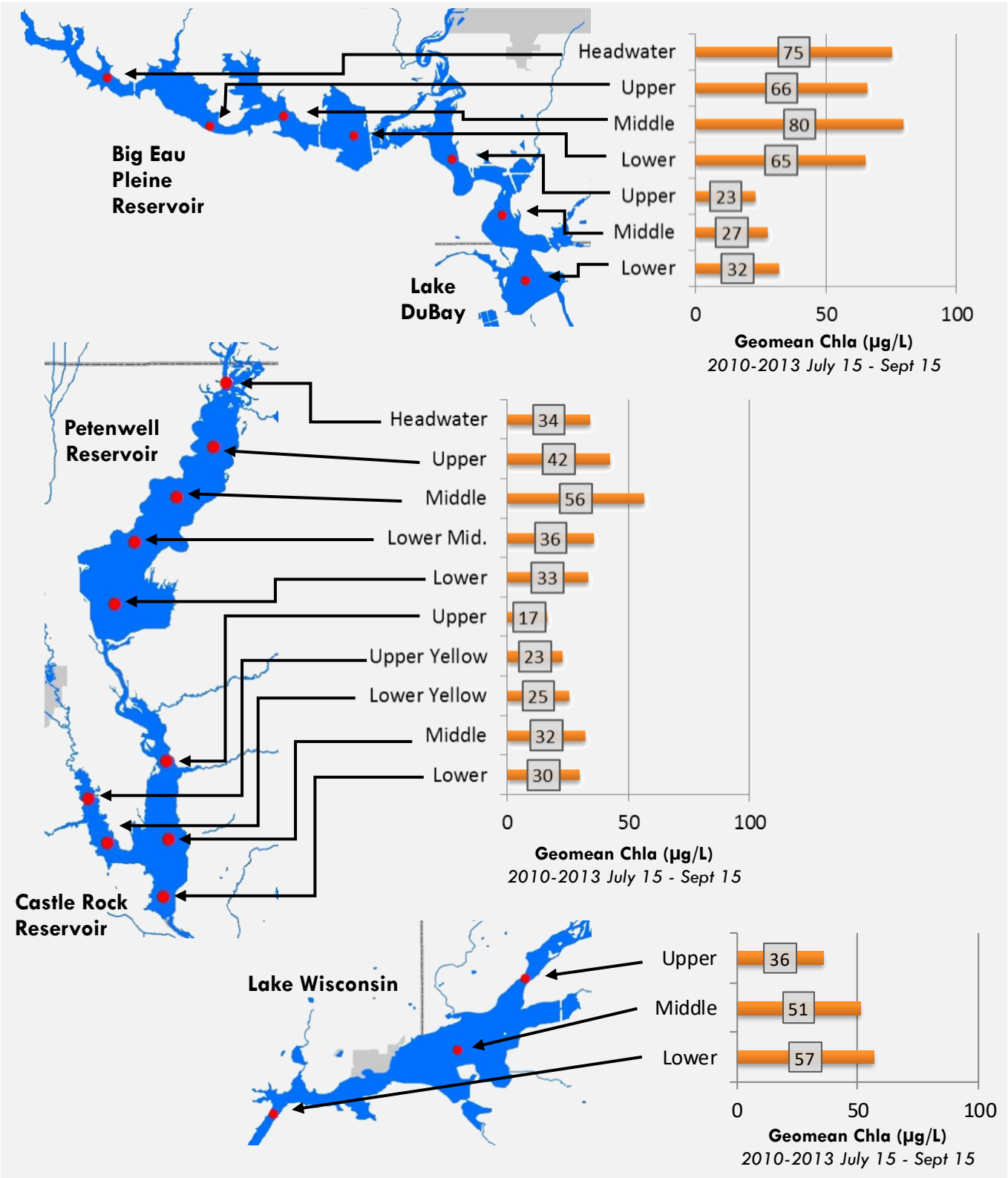


FIGURE 13. RESERVOIR MONITORING: GEOMEAN CHLOROPHYLL-A

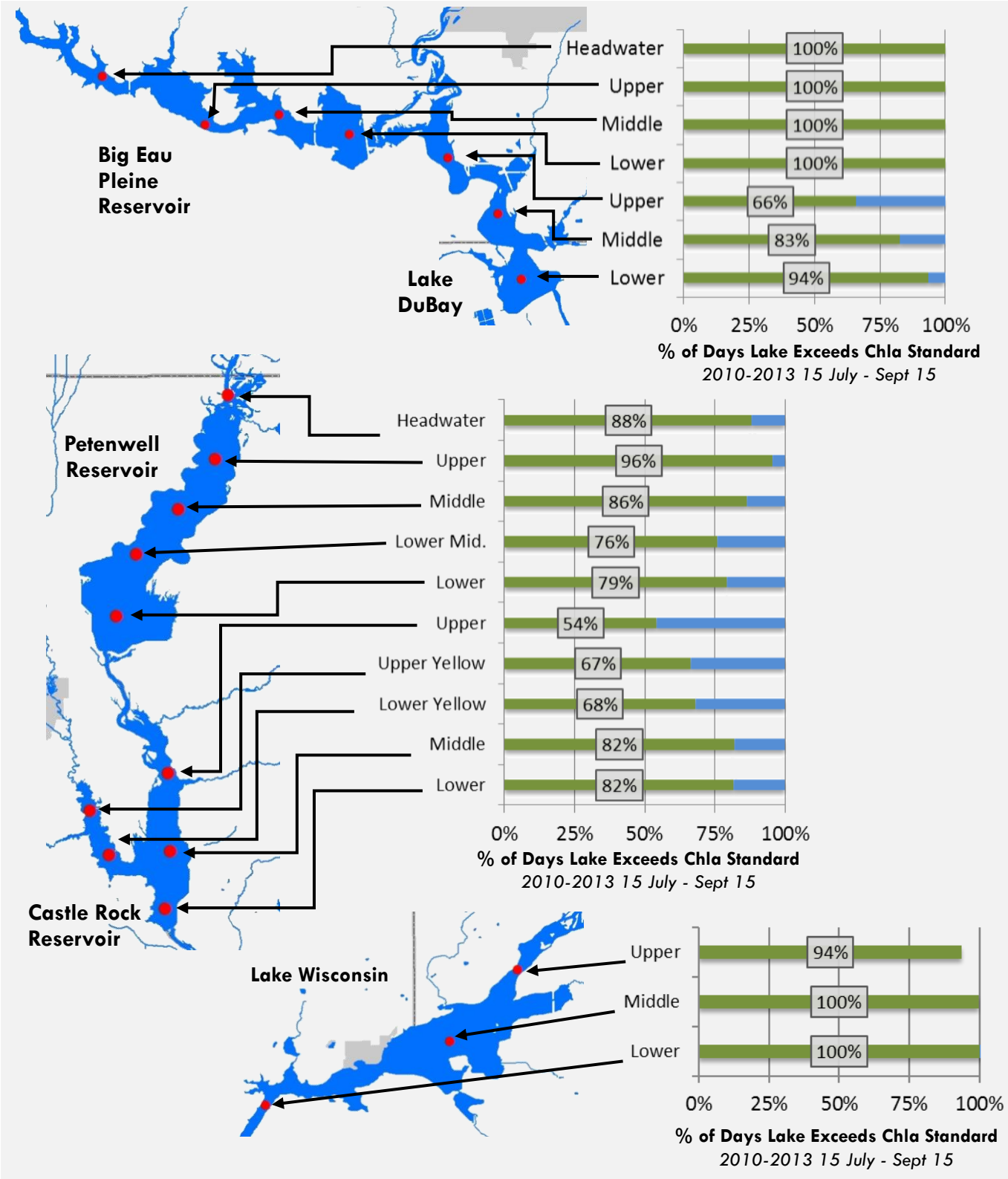


FIGURE 14. RESERVOIR MONITORING: GEOMEAN CHLOROPHYLL-A, EXCEEDANCE FREQUENCY

# 4 SOURCE ASSESSMENT

Sources of phosphorus loading in the Wisconsin River TMDL project area include discharges from regulated municipal and industrial wastewater discharges, agricultural runoff, urban runoff (both regulated and non-regulated), and natural runoff (e.g., forests and wetlands). To develop and calibrate the models used in this analysis, information about current or "existing" nonpoint, urban, and wastewater discharges were used. To develop the TMDL, "baseline" conditions were determined and generally reflect current regulatory conditions.

## 4.1 Phosphorus Sources

There are two general types of water pollution sources: point source and nonpoint source. The Clean Water Act defines a point source of pollution as any discrete conveyance that discharges polluted material, such as a pipe or ditch that discharges treated effluent from a municipal and industrial WWTFs into a river. Nonpoint sources of pollution include sources that do not meet the definition of a point source, such as runoff from agricultural lands and background sources such as forest and wetlands. This section provides a general description of point and nonpoint sources of phosphorus and provides further discussion of how loads from each source were quantified through the TMDL development.

### 4.1.1 Point Sources

Point sources of phosphorus are regulated under the Wisconsin Pollutant Discharge Elimination System (WPDES) program. Point sources are regulated either through an individual permit or a general permit. Point sources include:

#### 4.1.1.1 PUBLICLY OWNED TREATMENT WORKS

The term Publicly Owned Treatment Works (POTWs) refers to a sewage treatment plant that is owned and operated by a government entity, typically a city, town, or other local government. POTWs receive domestic and industrial wastewater via sewer systems; treat the wastewater to reduce or remove solid and chemical contaminants; and typically discharge treated effluent to surface waters. Raw sewage contains elevated levels of biological oxygen demand, bacteria, suspended solids and phosphorus. These levels are reduced during treatment to meet WPDES permit limits but are often still present in the discharge. Discharges from POTWs are regulated through individual permits.

#### 4.1.1.2 INDUSTRIAL FACILITIES

As part of their manufacturing process, many industrial facilities generate wastewater that may contain elevated levels of biological oxygen demand, bacteria, suspended solids and phosphorus. This wastewater may be discharged to a POTW or be treated by the industry to meet WPDES permit limits and discharged directly into a nearby surface water. Conversely, wastewater from other industrial processes may only contain trace levels of these substances and can meet WPDES permit limits without treatment prior to discharge. The most common examples of discharges of this nature are non-contact cooling water (NCCW) and permeate from reverse osmosis systems. Discharges from industrial facilities may be regulated either through individual or general permits depending on the nature of the discharge.

In some instances, industrial facilities discharge NCCW which contains elevated levels of phosphorus. Some facilities, including municipal water supply systems, add phosphates (orthophosphate or phosphate-based additives) for corrosion control and to reduce lead/copper from leaching into the water. Many NCCW facilities rely on municipal water for cooling so phosphorus added by the municipality gets passed through the NCCW discharge. The standard additive for corrosion resistance is orthophosphate; however, multiple municipal facilities utilize sodium silicate.

#### 4.1.1.3 REGULATED STORMWATER

As described here, stormwater refers to runoff that is generated from surfaces that have been affected by human development (e.g., parking lots, roads, lawns, exposed soils). These surfaces typically accumulate solid particles (dust, small rocks, plant matter, etc.) that are carried into waterbodies with stormwater. Some of these solid particles, such as soil or plant matter, also contain phosphorus. Other sources of elevated phosphorus in stormwater can include lawn fertilizers and pet waste.

Even though stormwater is driven by precipitation and fits the description of nonpoint source pollution, certain stormwater discharges to surface water are regulated under the WPDES program and are therefore considered point sources. Stormwater drainage systems (ditches, curbs, gutters, storm sewers, etc.) that are publicly-owned and do not connect with a wastewater collection system are termed Municipal Separate Storm Sewer Systems (MS4s). Most MS4s that are located in a federally designated Urbanized Area and serve populations of 10,000 or more are required to have a WPDES permit to discharge stormwater into surface waters. WPDES permits are also required for stormwater discharge from some construction sites and industrial sites. A Transportation Separate Storm Sewer System (TS4) permit has been developed and was signed on June 30, 2018 covering Wisconsin Department of Transportation administered facilities within permitted MS4s.

Regulated stormwater also extends, through either general or individual permits, to the impervious surfaces of industrial facilities and land development activities. Development activities are usually covered through general permits that cover both the construction activities and post-construction stormwater management. Construction activities often disturb the soil and without sufficient erosion control and sedimentation practices can be source of both sediment and phosphorus. Once stabilized, developed sites can often be a continued source of phosphorus as runoff from rain and melting snow washes away pollutants from rooftops, driveways, lawns, streets, parking lots, and storage yards. Unlike sanitary sewers which collect wastewater from homes and businesses and convey it to a wastewater treatment plant, most stormwater does not go to a wastewater treatment plant but rather relies on treatment and management practices such as rain gardens, swales, infiltration practices, wet ponds, street sweeping and bioretention systems.

#### 4.1.1.4 REGULATED CONCENTRATED ANIMAL FEEDING OPERATIONS

A Concentrated Animal Feeding Operation (CAFO) is an agricultural operation that raises 1,000 or more farmed animals in confined areas. Wastewater that is generated by CAFOs is high in suspended solids and phosphorus from animal sewage and other animal production operations. Because of the potential water quality impacts from CAFOs, animal feeding operations with 1,000 animal units or more are required to have a WPDES CAFO permit. These permits are designed to ensure that operations use proper planning, construction, and manure management to protect water quality from adverse impacts.

WPDES permits for CAFO facilities cover the production area, ancillary storage areas, and storage areas. CAFOs must comply with all WPDES permit conditions which include the livestock performance standards and prohibitions in ch. NR 151 Wis. Admin. Code, Wis. Admin. Code. Manure from CAFO operations used for agronomic purposes in the watershed through surface land spreading or injection is considered a nonpoint source.

### 4.1.2 Nonpoint Sources

Nonpoint sources of pollution include any sources that do not meet the definition of a point source. Nonpoint source pollution is typically driven by watershed runoff, or the movement of water over the land surface and through the ground into waterbodies, though other types of nonpoint source pollution exist. Nonpoint sources were simulated and aggregated into three categories for the calculation of allocations. These categories include background sources such as forest and wetlands, agricultural sources including dairy rotations, cash-crops, and non-regulated urban which is comprised of urban land uses that are not covered with a permit.

The aggregation was done to correspond with the different implementation mechanisms available to each source and to differentiate between the pollutant loading characteristics of the sources. Agricultural allocations do not differentiate between different cropping rotations because of the transient nature of some rotations; however, Appendix N provides agricultural targets that can aid in implementation of load allocation reductions. The following paragraphs describe nonpoint sources of phosphorus in more detail:

#### 4.1.2.1 AGRICULTURAL RUNOFF

High levels of sediment and phosphorus in agricultural runoff can occur because of several factors. Chemical fertilizer and/or animal manure contains phosphorus, a critical plant nutrient, and are often applied to cropland to support crop growth. The phosphorus in chemical fertilizer and manure often becomes bound to soil particles. Because agricultural lands typically have lower vegetative cover than natural areas, they are prone to erosion during runoff events. Erosion from cropland not only carries sediment into nearby surface waters but also carries phosphorus from fertilizer and manure that is attached to soil particles. Alternatively, on cropland with phosphorus saturated soils or recent fertilizer/manure applications, phosphorus can become dissolved in surface or subsurface runoff and wash into nearby waterbodies. The transport of dissolved phosphorus in subsurface agricultural runoff is accelerated on fields with tile drainage systems, which act as a conduit between subsurface water and adjacent drainage channels.

CAFOs with over 1,000 animal units are regulated under the WPDES program. Smaller animal feeding operations that are not regulated may also contribute phosphorus and sediment to adjacent waters because of leakage of animal sewage from covered facilities and from sediment erosion or wash off of manure from outdoor feedlots, barnyards, and grazing areas.

#### 4.1.2.2 NON-REGULATED URBAN RUNOFF

Developed areas are significant sources of phosphorus and sediment. Loading magnitudes typically increase with greater intensity of development. For example, runoff from areas with a high proportion of impervious surfaces tends to have high sediment and phosphorus concentrations because any dust, plant debris, pet/wildlife waste, or other material deposited on the surface is carried into nearby waters without being filtered through soil. Roads, driveways, rooftops, parking lots, and other paved areas in cities, suburban, and rural areas therefore all act as phosphorus and sediment sources. Other unpaved areas with disturbed soils (gravel or dirt roads, trails, paths, construction sites, etc.) also contribute high levels of sediment and attached phosphorus to surface waters. Vegetated spaces such as lawns, golf courses, and parks typically have lower phosphorus and sediment loading than impervious areas since soil particles are held in place by plant roots and precipitation can infiltrate the soil. However, loading from these areas is generally still higher than undisturbed natural lands because of lower canopy densities and a minimal plant litter layer. Phosphorus loads can be particularly high from vegetated developed lands when plant fertilizers are applied.

Septic systems may be an additional source of phosphorus in developed areas. Septic systems are used to dispose domestic sewage in regions that lack a centralized sanitary sewer system. Septic systems are underground systems that function by receiving domestic sewage in a holding tank that allows solids to settle out of suspension and for an initial breakdown of organic material. Liquid sewage exits the tank into a drain field. The drain field is typically two to five feet below the soil surface in the unsaturated zone and is comprised of multiple rows of perforated pipes. As the liquid sewage percolates through the soil, phosphorus is reduced as it binds to soil particles before reaching groundwater.

A fully functioning septic system should result in the retention of nearly all the phosphorus discharged in liquid sewage. However, excess phosphorus loading to waterbodies from septic systems can occur when sewage pools on the land surface and is transported in runoff during precipitation events; when sewage is not adequately treated by soil before reaching groundwater; and when liquid sewage "short-circuits" groundwater and is instead routed to a nearby waterbody with minimal soil contact time. These issues can be significant with aging or improperly sited septic systems or with extreme rainfall events.

The WPDES program regulates stormwater discharges from permitted MS4s, construction sites, and industrial sites. The Wisconsin River Basin contains many additional acres of urban, suburban, and developed rural areas that are not covered by WPDES stormwater permits. Runoff and pollutant loading from these areas is referred to as "non-regulated urban" or "non-permitted urban" throughout this report.

#### 4.1.2.3 BACKGROUND SOURCES

Phosphorus is a naturally occurring compound that is present in rocks, plant material, soils, and wildlife waste. Phosphorus loading is therefore expected from undisturbed forests, wetlands, and other natural areas. However, these areas contribute significantly lower loads per unit area than agricultural and developed lands since runoff volumes and phosphorus concentrations are reduced with a more extensive plant canopy, leaf litter layer, and soil infiltration and percolation. These same factors also reduce soil erosion and sediment loading from undeveloped vegetated lands.

An additional background source of phosphorus and sediment loading to waterbodies is atmospheric deposition. Dust and plant material in the atmosphere can be deposited in waterbodies from the wind during dry periods or carried by precipitation. In developed watersheds, this typically represents a small fraction of phosphorus and sediment loading.

#### 4.1.2.4 STREAM CHANNELS AND LAKESHORES

Under natural conditions, stream channels exist in dynamic equilibrium, with balanced erosion and deposition. Channel morphology (width, depth, slope, etc.) is in a stable state that is only altered with an extreme flow event or major disturbance to the landscape. In watersheds with urban or agricultural development, the equilibrium between channel erosion and deposition has been disrupted due to altered streamflow and sediment loading patterns or artificial channel modifications. Because of these changes, the stream channel adjusts through transitional phases that can persist for years to centuries before again reaching a stable form. Channel downcutting and widening are two channel evolution phases that result in bed and bank erosion and contribute sediment and attached phosphorus to downstream waters. Conversely, when excess sediment enters a stream from the watershed or upstream reaches, the aggradation phase occurs, with sediment settling out of the water and the channel becoming increasingly shallow.

Like stream channels, lakeshores typically exist in a similar state of equilibrium under natural conditions, with significant erosion only occurring with extreme water level changes or major disturbances to the landscape. Accelerated lakeshore erosion can occur when human activity removes trees and other deep-rooted vegetation from the nearshore area, when water levels are artificially manipulated, and/or with high wave action from boaters.

#### 4.1.2.5 LAKE AND RESERVOIR INTERNAL SOURCES

An additional category of nonpoint source loading in lakes and reservoirs is the release of phosphorus from sources that are internal to the lake. When phosphorus enters a lake from external sources (e.g., runoff or point source discharges), it cycles between inorganic and organic forms in the water column and bottom sediment. The season net release of phosphorus from bottom sediments into the water column can be significant in lakes where several years of high external phosphorus loading have left a legacy of stored phosphorus. Release of phosphorus from bottom sediments can occur through a variety of processes, including aerobic and anaerobic decomposition of organic sediments, release of iron-bound phosphorus under anoxic conditions, simple diffusion due to sediment-water column concentration differences, or resuspension of phosphorus-laden sediment through wind and other disturbances.

It is important to note that bottom sediments should not be considered an independent source of phosphorus to a lake. A fundamental coupling exists between loading of phosphorus from external sources and loading from bottom sediment. The magnitude of phosphorus loading from bottom sediment is largely determined by the amount held in storage in the lake due to historical external phosphorus loading.

## 4.2 Spatial Framework

The Wisconsin River TMDL project area was subdivided (Figure 15 through Figure 18) for the purpose of assessing pollutant load generation and receiving water loading capacity, and for the development of load allocations. Specifically, the TMDL project area was subdivided by first identifying "hydrologic break points" in the basin according to the criteria listed in Table 7, and then delineating the upstream reach and subbasin area draining to each point.

Table 7. Criteria for siting hydrologic break points

| | |
|---|---|
| ✓ Locations where water quantity and quality were measured during the model period for use in model calibration. | ✓ Locations where local water quality does not meet numeric water quality criteria (i.e., impaired reaches). |
| ✓ Locations where there are major hydrologic transitions, such as the confluence of two large streams | ✓ Locations where there are significant changes in land use or land cover. |
| ✓ Locations where there is a change in the numeric water quality criterion, such as where a stream or river flows into an impoundment, or a stream flows into a river. | ✓ At point source outfalls – except where streamflow does not significantly change between the outfall location and the next downstream breakpoint. |

A total of 337 breakpoints were identified and the corresponding TMDL subbasins and TMDL reaches were delineated using each breakpoint as a pour point. The resulting average subbasin size is 26 $mi^2$. This is smaller than the average HUC-12 watershed (32 $mi^2$), which is the scale at which TMDL nonpoint implementation strategies are typically planned.

Within each subbasin is a single "reach" which can be either a stream or an impoundment. The loads generated from each subbasin are delivered to the reach and propagate downstream through the drainage system.

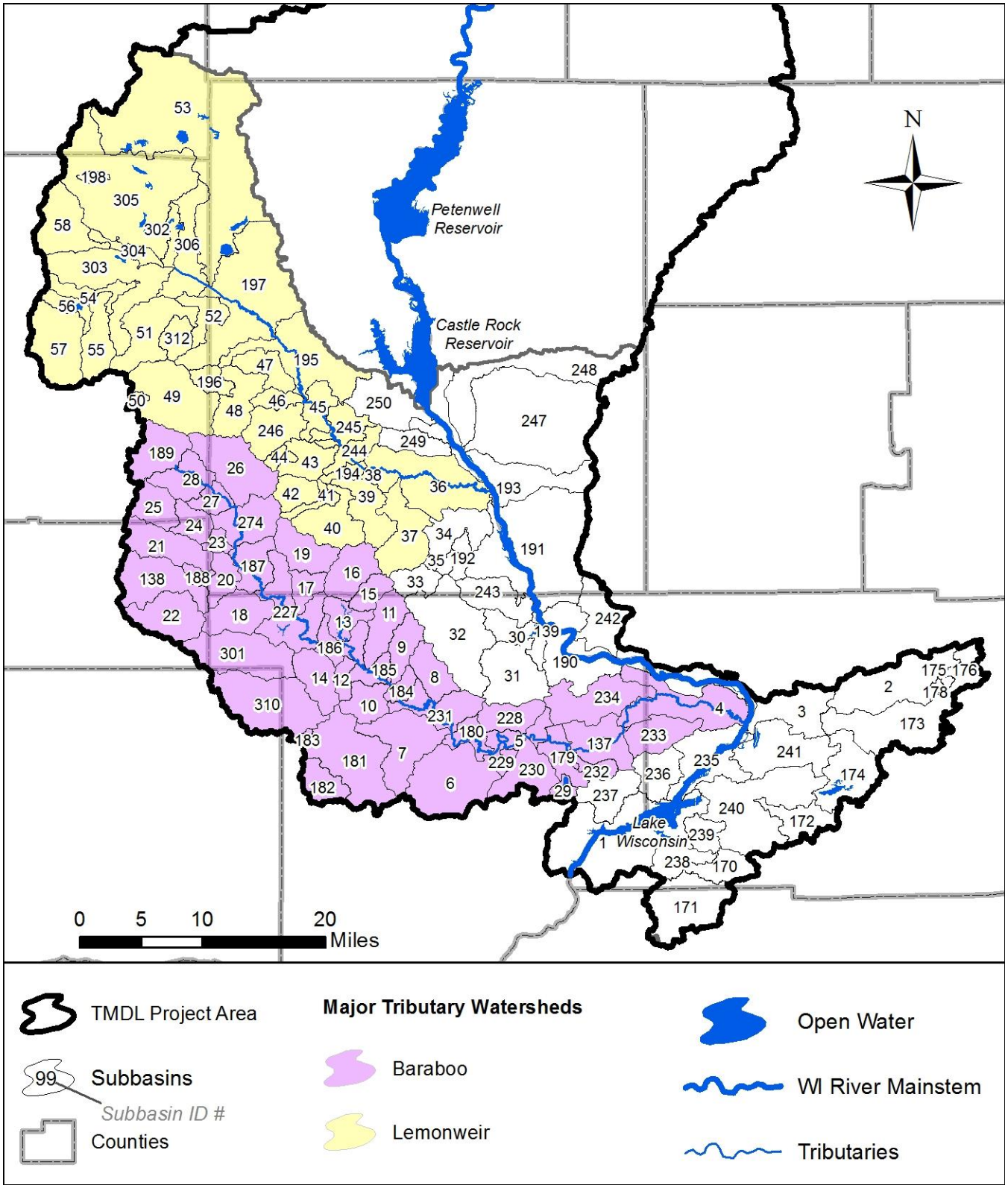


FIGURE 15. TMDL SUBBASINS: LOWER REGION

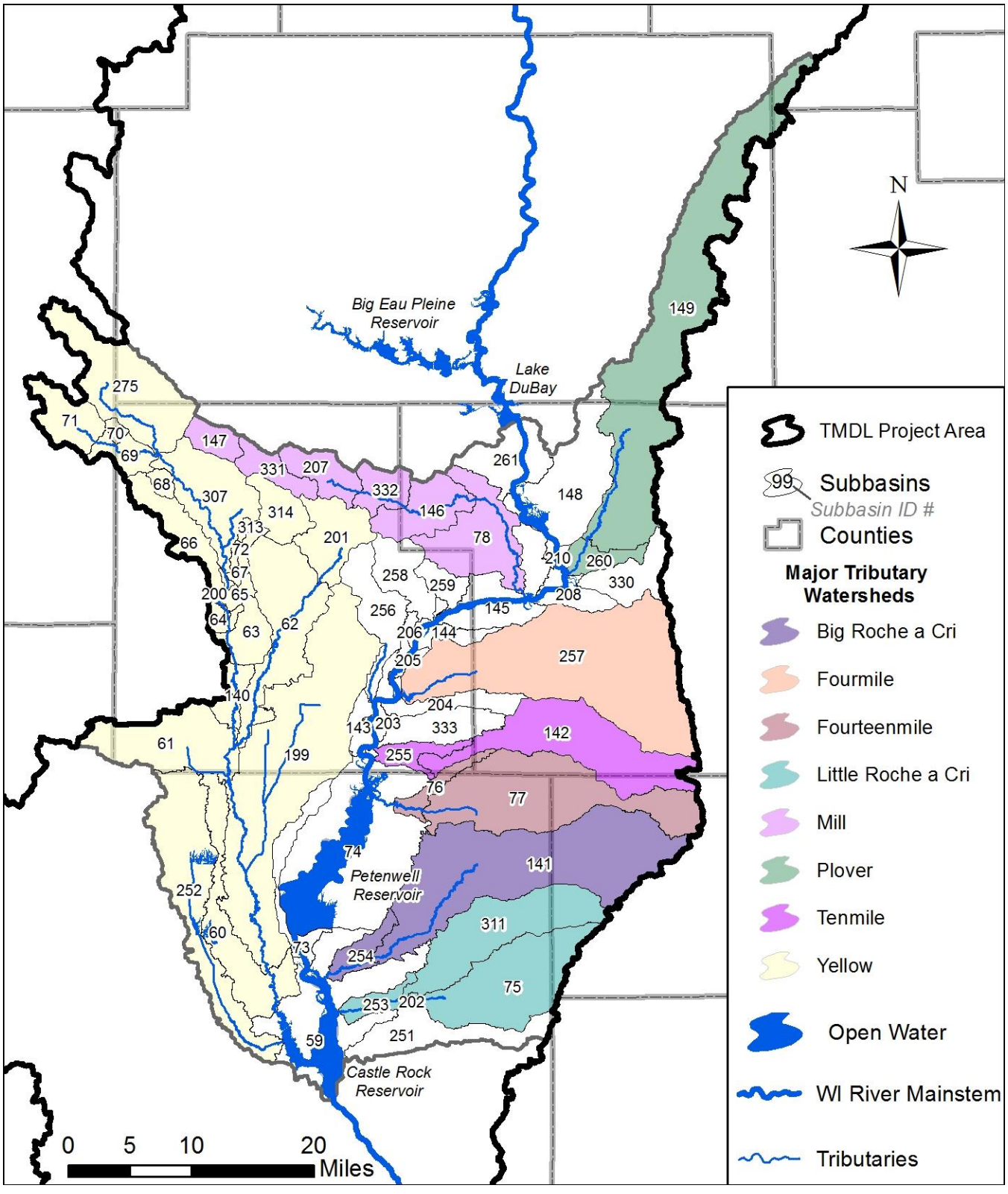


FIGURE 16. TMDL SUBBASINS: CENTRAL REGION

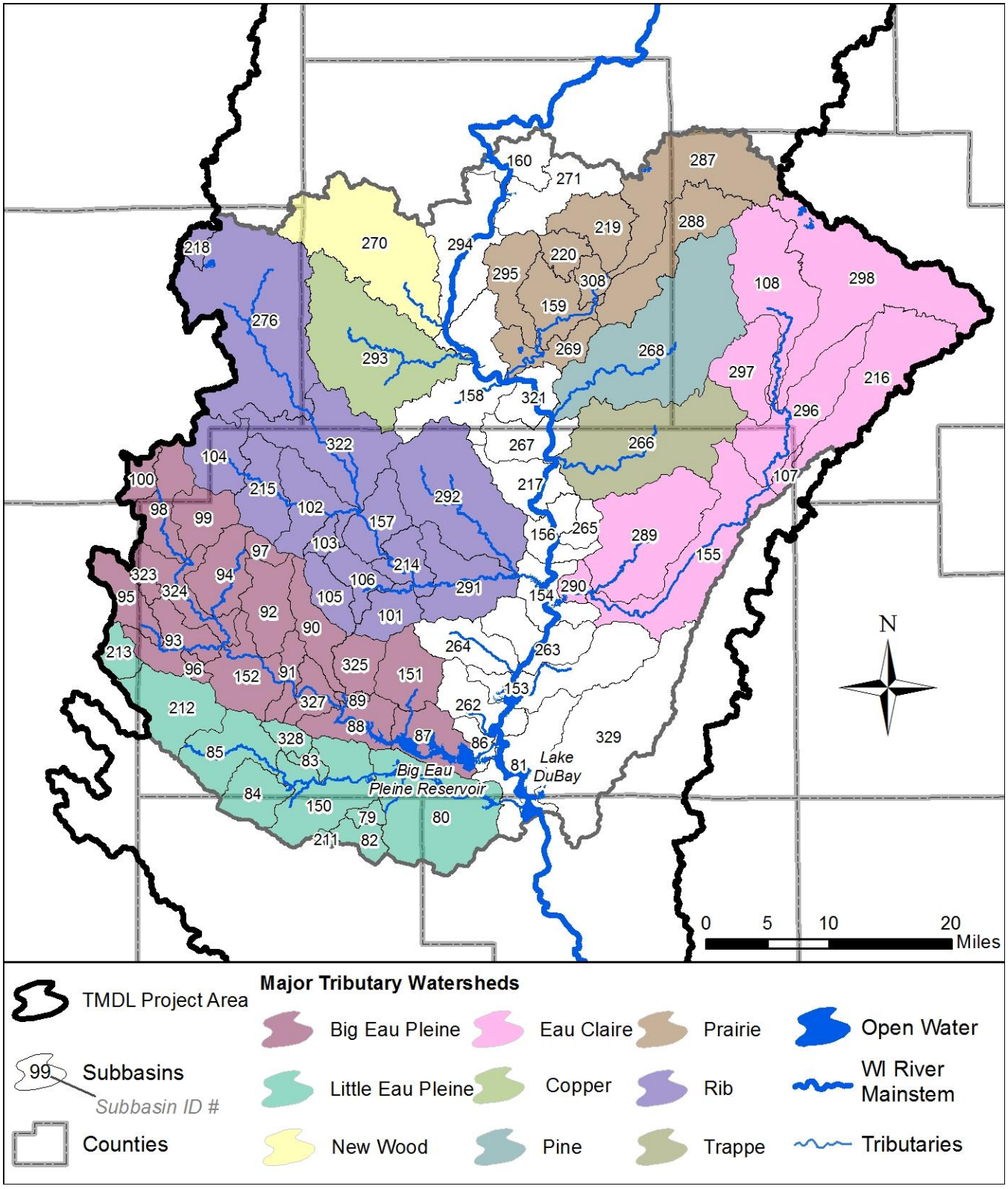


FIGURE 17. TMDL SUBBASINS: UPPER REGION

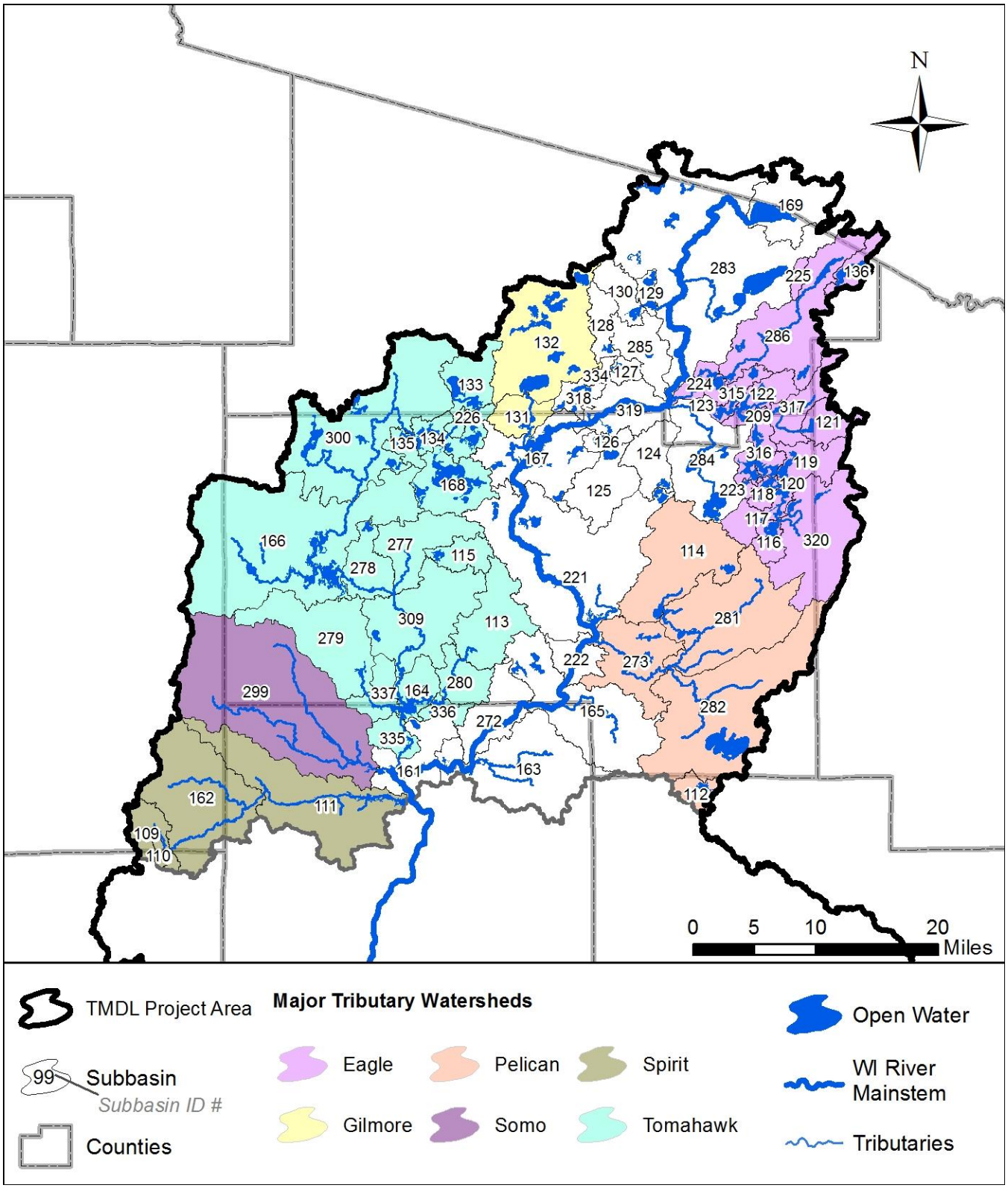


FIGURE 18. TMDL SUBBASINS: HEADWATERS REGION

## 4.3 Analysis Framework

### 4.3.1 Water Quality Model Selection

Because the Wisconsin River Basin is a large and diverse system, several different models, each with a special purpose, were used for calculating baseline pollutant loads (Table 8).

Table 8. Descriptions of models used to determine baseline pollutant loads

| Model | Primary Inputs | Purpose |
|---|---|---|
| **FLUXMASTER** | Measured daily streamflow and TSS and TP concentration samples. | Estimating site-specific monthly TP/TSS loads for model calibration. |
| **WinSLAMM** | Measured daily precipitation, soils, and land use. | Generation of urban daily TP/TSS loads to feed into SWAT. |
| **SWAT** | Measured daily climate variables, land use, soils, and topography. | Estimate daily nonpoint source TP/TSS loads, integrate point source and urban loads, and calibrated to FLUXMASTER loads. |
| **Routing sub-model** | Monthly land-based TSS/TP loads estimated by SWAT and WinSLAMM. | Account for monthly in-stream storage and resuspension of TP, while also correcting biases in SWAT-calibrated TSS and TP loads. |

#### 4.3.1.1 FLUXMASTER

FLUXMASTER is an empirical model that was used to estimate site-specific pollutant loads. To fit a FLUXMASTER model, concentration samples are taken intermittently (e.g., bi-weekly) and for those days when a sample was taken, the concentration is paired with daily average streamflow to estimate a load on that day which are then fitted in a regression to provide daily load estimates. The predictor variables in the regression are streamflow, day of the year, and decimal year. FLUXMASTER is standard software developed and used by the United States Geological Survey (USGS) for predicting loads. These loads can then be used to calibrate a watershed loading model such as SWAT or HSPF (Hydrological Simulation Program – FORTRAN).

#### 4.3.1.2 WINSLAMM

Urban loads (both permitted and non-permitted) were quantified using the WinSLAMM (Source Loading and Management Model for Windows) model. The State of Wisconsin has codified the WinSLAMM model as one of the official software packages for assessing urban runoff compliance and was therefore chosen for this TMDL to remain consistent with Wisconsin rules. WinSLAMM is a mechanistic model that estimates daily runoff and pollutant loading based on precipitation, soil type, and land use. The resulting runoff and pollutant loads were later integrated into the overall watershed SWAT (Soil and Water Assessment Tool) model (urban area footprints were cut from the watershed model to avoid double counting).

The WinSLAMM (Version 10.0) model was used to simulate TSS and TP loads from urban areas in the TMDL project area (Figure 19 and Table 9). WinSLAMM was selected because of its ability to model pollutant loads generated by small storm events. Also, it allows the user to define more categories of urban types (e.g., paved parking lots, roofs, etc.), and loadings from many of these categories have been well validated in the field. A full description of the urban area modeling methodology using WinSLAMM is documented in **Appendix D**.

In urban areas drained by a network of curb and gutters and storm sewers, the drainage area has been altered from its natural topography. For this reason, within permitted MS4s the urban model area draining to each TMDL reach was delineated according to outfall locations and outfall watershed mapping rather than the subbasin boundaries described in Section 4.2.

Within the TMDL project area, the extent of the urban model was delineated to include the following:

1) Cities and villages, excluding the following:
   a) Large, contiguous non-urbanized, undeveloped areas
   b) Undeveloped floodplain islands, and areas mapped as open water
2) Urbanized areas[5] within townships that have a permitted Municipal Separate Storm Sewer System (MS4)
3) State Department of Transportation right-of-way located within an urbanized area, and county transportation right-of-way located within an urbanized area of a county that has a permitted MS4

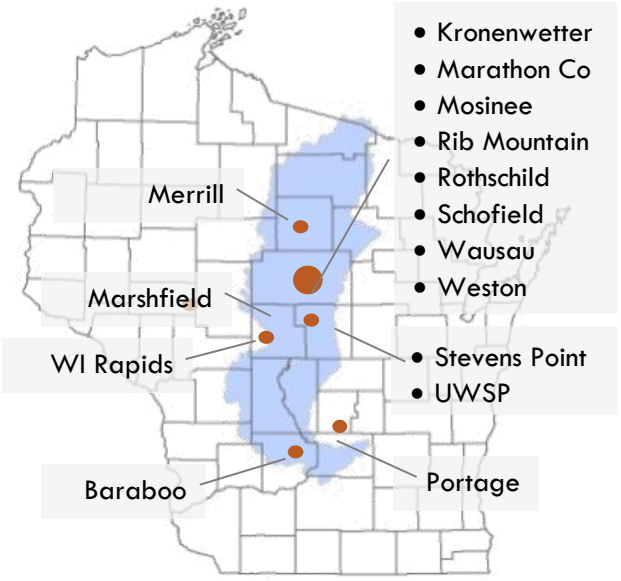


FIGURE 19. LOCATIONS OF PERMITTED MS4S

Table 9. List of permitted MS4s

| Permittee | County | Permittee | County | Permittee | County |
|---|---|---|---|---|---|
| **C. of Baraboo** | Sauk | **C. of Schofield** | Marathon | **C. of Wausau** | Marathon |
| **C. of Marshfield** | Wood/Marathon | **V. of Kronenwetter** | Marathon | **T. of Rib Mountain** | Marathon |
| **C. of Merrill** | Lincoln | **Co. of Marathon** | Marathon | **C. of Stevens Point** | Portage |
| **C. of Portage** | Columbia | **V. of Rothschild** | Marathon | **UW-Stevens Point** | Portage |
| **C. of Mosinee** | Marathon | **V. of Weston** | Marathon | **C. of Wisconsin Rapids** | Wood |

#### 4.3.1.3 SWAT

The SWAT model was the primary model used to simulate and calibrate watershed pollutant loading (Sections 3 and 4 of **Appendix D**). The SWAT model is a physically based model that simulates stream flow, sediment loss, and nutrient exports (Neitsch et al., 2002a). Agricultural, natural, and developed areas located outside of city and village limits, such as roads and rural subdivisions, were modeled in SWAT. Urban loads estimated by WinSLAMM and point source loads were integrated into the SWAT model. The SWAT model was calibrated at several locations using site-specific loads calculated by FLUXMASTER.

SWAT was selected because it maintains open-source model code and an easy-to-use interface. It has a history of successful implementation throughout Wisconsin and has successfully been used to evaluate agriculturally dominant watersheds for sediment and nutrient TMDLs (Cadmus, 2011; Cadmus, 2012).

Another reason for selecting SWAT was because SWAT has tools for simulating complex agriculture operations. The agricultural landscape throughout the basin is heterogeneous, ranging from dairy farming in the north central region, potato/vegetable cropping in the Central Sands region, and corn/soybean cropping in the southern region. Furthermore, there is diversity in tillage and fertilizer usage within each farming operation type, creating a diverse landscape of agricultural management. The accurate representation of

[5] "Urbanized area" is defined herein as an area classified as urbanized by the 2010 Decennial Census. For the purpose of this document "urbanized area" and "urban model area" are not the same.

agriculture was particularly important to the development of the Wisconsin River Basin SWAT model. Preliminary assessments of the monitoring data collected showed that agricultural regions of the basin deliver a significant fraction of the overall phosphorus and sediment loads, and therefore a significant effort was undertaken to inventory agricultural sources.

The SWAT model was developed to simulate field-based agricultural phosphorus losses, such as phosphorus in manure that runs off a fertilized field or phosphorus loss resulting from particles bound to sediment during soil erosion events. However, the SWAT model does not explicitly account for other agricultural sources such as feed lots, dairy production facilities, or erosion from streambanks that have high concentrations of soil phosphorus from the deposition of past agricultural runoff. Phosphorus loss from these other agricultural sources are implicitly lumped with field-based phosphorus loss estimates during the calibration phase of model development. In other words, when field-based agricultural phosphorus loss estimates are summed at the watershed scale, and then calibrated to match in-stream TP loads, all sources are accounted for in the watershed, even though some are not explicitly defined in the SWAT model.

Use of the SWAT model provided the opportunity to distinguish between land cover and land management in the model. The term "land cover" generally refers to maps of broad classifications of land use, such as "forest", "wetlands", or "agriculture"; whereas, the term "land management" generally refers to specific practices within a land use classification (e.g., "solid manure fertilization" for agricultural land use classes). A more holistic representation of activities within a watershed can be achieved when land cover and land management are merged together. When together, the two provide both the spatial representation of land use (i.e., "land cover"), and the temporal aspect of activities within each land cover category (i.e., "land management"), so land use can therefore be described through both space and time. The innovative method used to spatially and temporally define land cover and land management within agricultural areas throughout the basin is summarized in Figure 20. Full documentation of the land cover and land management definition process and its results are detailed and mapped in Section 3.2 of **Appendix D**.

A complete inventory was conducted that compiled all individually permitted wastewater facilities that discharge to surface waters within the basin. This inventory is required for simulating conditions for the SWAT modeling period of 2002–2013. The inventory process involved querying existing WDNR databases, verifying with Regional WDNR staff, and developing methods to consistently account for gaps in data to accurately estimate existing discharge rates. The methodology used to compile this data is described further in Section 3.7 of Appendix D.

Monitored loads from dischargers and estimated urban loads from WinSLAMM were integrated with the SWAT simulation. With all sources combined, the SWAT model was calibrated to fit site-specific loads calculated by FLUXMASTER. Details of the SWAT model calibration results are described in Section 5 of **Appendix D.**

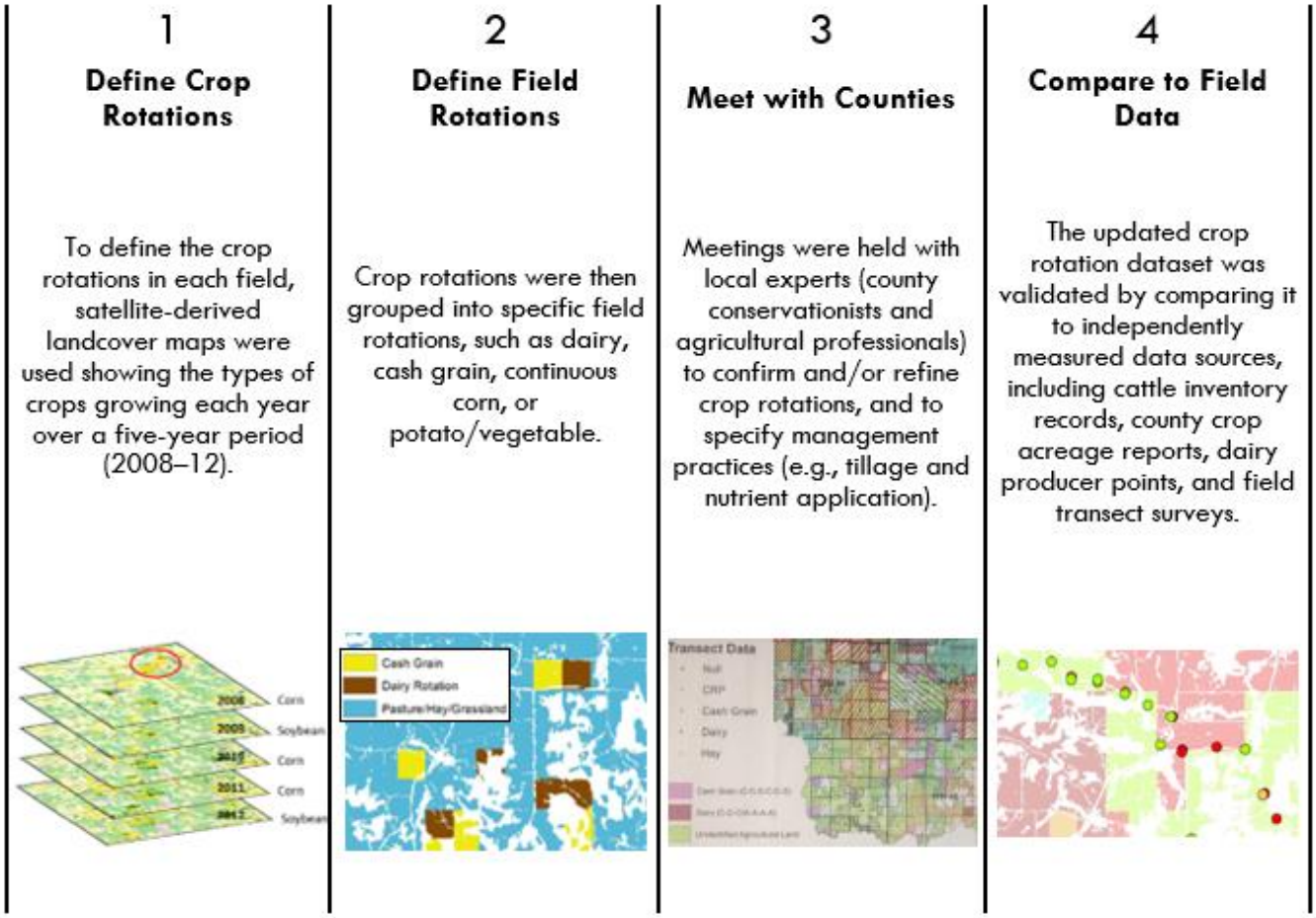


**FIGURE 20. DEFINING LAND COVER AND LAND MANAGEMENT IN AGRICULTURAL AREAS**

#### 4.3.1.4 TRIBUTARY ROUTING SUB-MODEL

A custom empirical model was developed to address three concerns with the SWAT model:

1 Estimates of loads from SWAT hydrologic response units (HRUs) can be thought of as the loads that are exported from fields rather than the loads that are ultimately delivered downstream. Therefore, HRU loads are nearly always larger than delivered loads, unless the SWAT model is configured such that reaches in the model act as sources (i.e. internal loading).
2 The calibrated SWAT model was not able to capture some seasonal fluctuations in TP loading, which probably results from transient storage and release of phosphorus from stream sediments.
3 The calibrated SWAT model still had residual bias after calibration.

The custom empirical model was calibrated to fit streamflow, TP, and TSS loads at tributary sites using seasonality and lag coefficients that minimize the root mean square error and percent bias of delivered loads.

Currently 67% of the phosphorus entering the Big Eau Pleine is retained. Because of this high rate of retention, an empirical model based on the BATHTUB modeling was used to describe phosphorus retention in the Big Eau Pleine. See Sections 5.10–5.13 of **Appendix D** for more details regarding additional modeling efforts beyond the primary SWAT model.

#### 4.3.1.5 MAIN-STEM ROUTING SUB-MODEL

As described in Section 4.3.1.4, transport of total phosphorus (TP) through tributaries was estimated by SWAT model calibration, followed by application of a tributary routing sub-model. Because the SWAT model was not calibrated to main stem Wisconsin River stations downstream of Merrill, a separate method was needed to estimate transport on the main stem. This section addresses the question: what fraction of tributary TP loads are delivered to points downstream? The time scale of the analysis is the average annual load over the 2010-13 period when the highest frequency monitoring occurred.

Because TP load estimates are tightly tied to flow records, the quality of the flow records at main stem stations was first evaluated. There are twelve stations with daily streamflow on the main stem between Merrill and Muscoda. Four of these stations are operated by the USGS and are considered to be the most accurate. The other stations are operated by hydroelectric companies, most of which report data to the Wisconsin Valley Improvement Corporation (WVIC). The data from most of these stations is of unknown quality. First, a linear regression between mean discharge and drainage area was fit for the four USGS gages (Figure 21). Then, the "sum of tributaries" flow for each station was calculated by summing measured flows where available and SWAT modeled flows on ungaged tributaries. Of the WVIC stations, three (Stevens Point, Wisconsin Rapids, and Nekoosa) are closely aligned to the USGS gage regression and slightly below the sum of tributaries estimates. Mean flows at the other four WVIC stations (Wausau, DuBay, Petenwell, and Castle Rock) are significantly lower than predicted by the USGS gage regression and sum of tributaries estimates. Flow at the Prairie du Sac dam, which is operated by Alliant Energy, is significantly higher than predicted by the USGS gage regression and sum of tributaries estimate. Based on this evaluation, TP load estimates at the USGS gages and the three WVIC stations where flows align with the USGS regression should be considered most accurate.

Next, the measured average annual TP load at the Wisconsin Dells station (500 tons) was compared to the sum of gaged tributary loads where available, SWAT-estimated loads for ungaged areas, and direct discharges to the main stem (686 tons) (

Table 10), giving a net TP retention of 27% (73% delivery). To distribute this TP retention through the main stem, delivery fractions (maximum=1) for reservoir reaches were calculated to match the pattern in measured TP load, particularly at stations with apparently unbiased flow estimates. For example, all of the retention observed between Merrill and Rothschild was assumed to happen between Wausau and Rothschild because that reach contains Lake Wausau and the TP load estimate at Rothschild is assumed to be more accurate than at Wausau. TP delivery through Lake DuBay was estimated at Stevens Point rather than at the Lake DuBay dam because flow at DuBay appears to be underestimated. TP delivery through Petenwell and Castle Rock was estimated by matching the observed TP load at Wisconsin Dells while assuming 100% delivery between Castle Rock and Wisconsin Dells and balancing the differences between measured and predicted loads at the Petenwell and Castle Rock dams. Even with 100% delivery, the sum of TP loads between Wisconsin Dells and Prairie du Sac (Lake Wisconsin) is underestimated, though this discrepancy is probably due to the overestimate of flow at Prairie du Sac. Overall, this process of distributing TP retention through the main stem Wisconsin River produces a pattern that closely matches the observed pattern and is consistent with expectations that retention should be generally proportional to water residence time (Figure 22).

Table 10. Average annual (2010–2013) discharge, total phosphorus (TP) load, and estimated TP delivery fractions for main stem WI river monitoring stations

| Station ID | Station Name | Drainage Area ($mi^2$) | TP Delivery Fraction | Measured Discharge (cfs) | Sum of Tributary Discharge (cfs) | Measured TP Load (tons) | Sum of Tributary TP Load (tons) | Sum of Tributary TP Load with Delivery (tons) |
|---|---|---|---|---|---|---|---|---|
| **353068** | Merrill | 2,760 | | 2,205 | | 137 | | |
| **373007** | Wausau | 3,060 | 1 | 2,159 | 2,460 | 142 | 163 | 163 |
| **10031102** | Rothschild | 4,020 | 0.945 | 3,281 | 3,277 | 248 | 262 | 248 |
| **10014652** | DuBay | 4,900 | 0.880 | 3,758 | 4,182 | 346 | 403 | 342 |
| **503059** | Stevens Point | 4,990 | 1 | 4,122 | 4,254 | 349 | 410 | 349 |
| **723002** | Wisconsin Rapids | 5,380 | 1 | 4,416 | 4,637 | 379 | 466 | 405 |
| **723259** | Nekoosa | 5,665 | 1 | 4,661 | 4,941 | 475 | 517 | 456 |
| **293130** | Petenwell | 5,970 | 0.815 | 4,606 | 5,215 | 364 | 530 | 382 |
| **10017791** | Castle Rock | 7,060 | 0.913 | 5,469 | 6,116 | 388 | 593 | 407 |
| **573052** | Wisconsin Dells | 8,000 | 1 | 6,726 | 6,972 | 500 | 686 | 500 |
| **10029830** | Prairie du Sac | 9,180 | 1 | 8,512 | 7,985 | 679 | 830 | 644 |
| **223282** | Muscoda | 10,400 | | 8,959 | | | | |

### 4.3.2 Model Simulation Period

The chosen model simulation period was the years 2002 to 2013. The project was funded in 2009 and intensive monitoring began in 2010 and ended in 2013 which established the end of the simulation period. The beginning of the simulation period was largely determined by typical patterns of agriculture. An average crop rotation cycle is about six years—to span a range of weather conditions, two crop rotation cycles results in a total of 12 years and 12 years prior to 2013 is 2002.

The range of weather conditions between 2002 and 2013 was shown to be representative of the historical average. For three of the long-term trend sites within the basin (Wisconsin River at Merrill, Wisconsin Rapids, and Wisconsin Dells), the streamflow regime in the model simulation period was compared to the streamflow regime between the years of 1980 and 2014.

Streamflow regimes were compared by overlaying plots of streamflow quantiles for the simulation period and the historical period, and visually affirming that the distributions of streamflows overlapped.

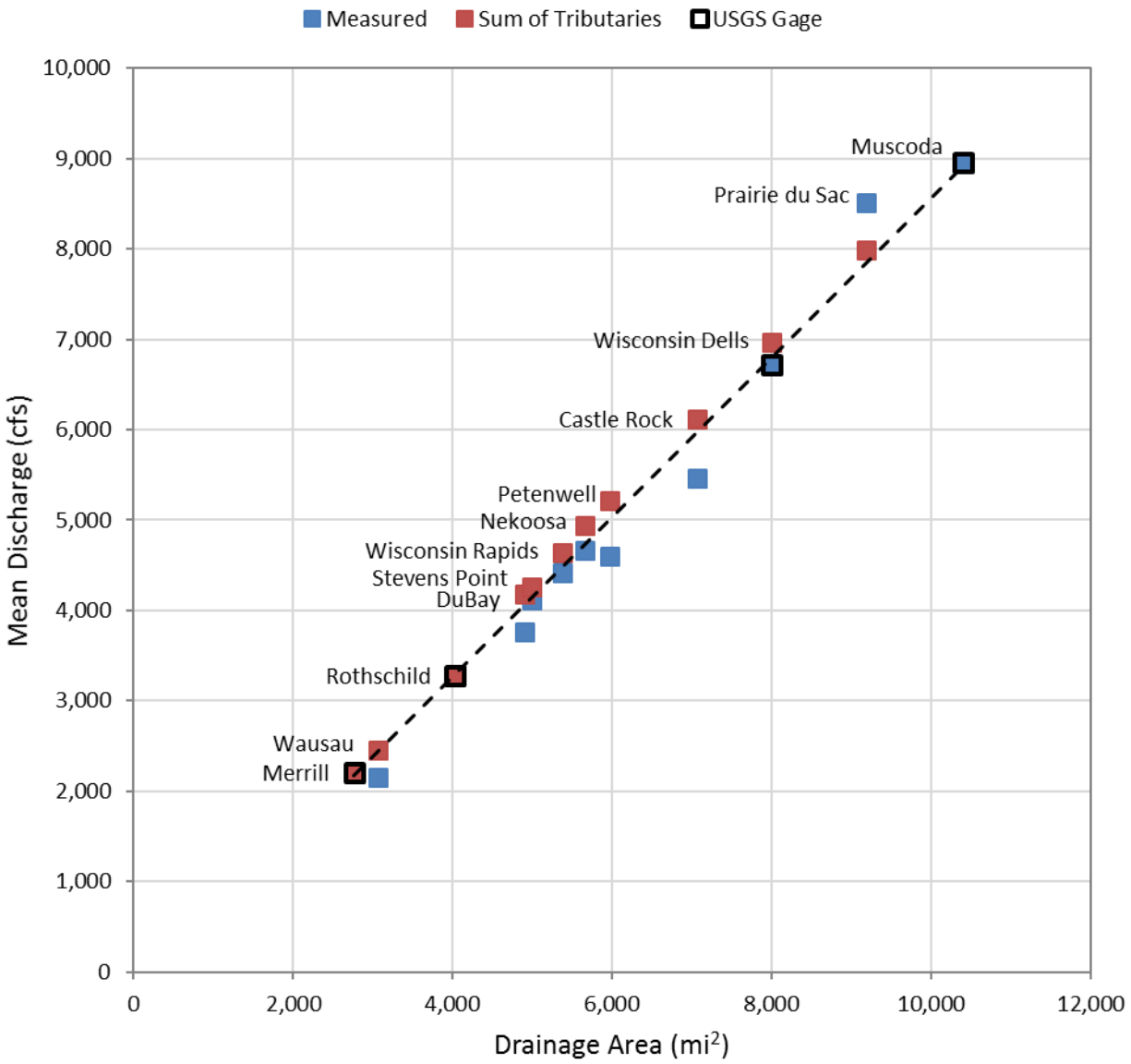


**FIGURE 21. DISCHARGE ON THE WI RIVER BETWEEN MERRILL AND PRAIRIE DU SAC**

Note: The sum of tributary flows is a combination of measured flows where available, and SWAT modeled flows on ungaged tributaries. The dashed line is a linear regression on the USGS gages only.

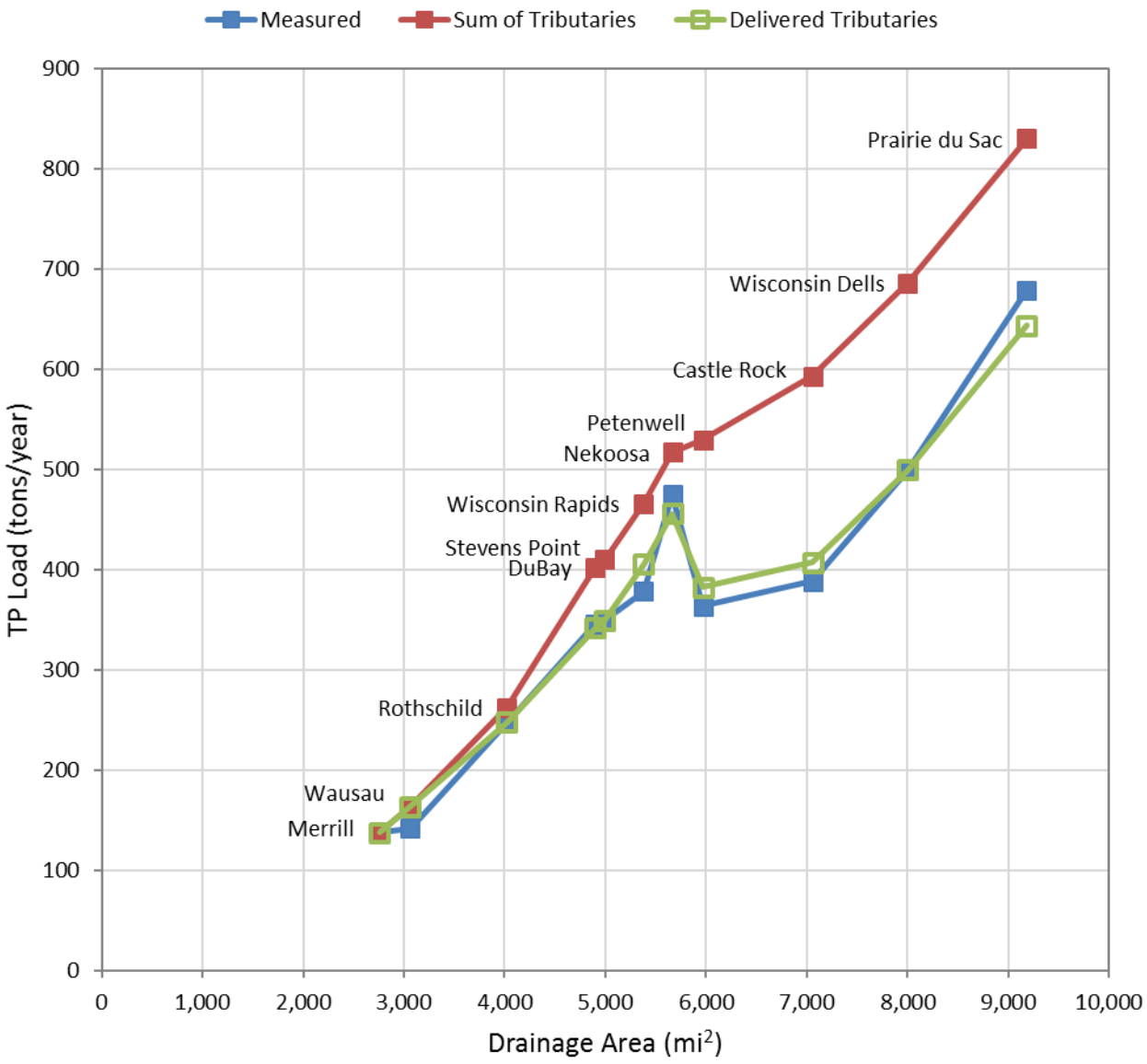


**FIGURE 22. TP LOAD ON THE WI RIVER BETWEEN MERRILL AND PRAIRIE DU SAC**

Note: The sum of tributary loads is a combination of measured loads where available, and SWAT modeled loads on ungaged tributaries. Delivered tributary loads were calculated by applying the delivery fractions in

Table 10.

### 4.3.3 Calibration Results

For assessing model fit, well established guidelines in the scientific literature were followed. Moriasi et al. (2007) has been cited nearly 2,775 times (August 2016, www.scholar.google.com) because it establishes numeric benchmarks for model performance that are adaptable to most SWAT (and other hydrologic models, empirical and mechanistic) applications. The numeric criteria were calculated using two objective functions: 1) percent bias (PBIAS), and 2) Nash-Sutcliffe efficiency (NSE). Benchmarks were met for streamflow, TSS, and TP for all sites with the exception of TSS for the Baraboo River at Reedsburg and Mill Creek[6] (Table 11 and Table 12).

Table 11. Watershed model performance benchmarks for a monthly time step

| Performance Rating | NSE | PBIAS (%) | | |
|---|---|---|---|---|
| | | Streamflow | Sediment | N, P |
| Very good | 0.75 < NSE ≤ 1.00 | PBIAS < ±10 | PBIAS < ±15 | PBIAS < ±25 |
| Good | 0.65 < NSE ≤ 0.75 | ±10 ≤ PBIAS < ±15 | ±15 ≤ PBIAS < ±30 | ±25 ≤ PBIAS < ±40 |
| Satisfactory | 0.50 < NSE ≤ 0.65 | ±15 ≤ PBIAS < ±25 | ±30 ≤ PBIAS < ±55 | ±40 ≤ PBIAS < ±70 |
| Unsatisfactory | NSE ≤ 0.50 | PBIAS ≥ ±25 | PBIAS ≥ ±55 | PBIAS ≥ 70 |

### 4.3.4 Existing Conditions Model Results

The average annual phosphorus load delivered by each major tributary watershed into the Wisconsin River, as calculated by the SWAT model for "existing" conditions, is illustrated in Figure 23 and the phosphorus yield for each subbasin is illustrated in Figure 24. The relative percentages of each phosphorus source type and total magnitude of the phosphorus load at the outlet of each tributary watershed are illustrated in the tributary watershed figures in **Appendix A**. The relative magnitude of the "existing" total phosphorus load at various points along the main stem of the Wisconsin River is illustrated in Figure 25. Model results are presented in much greater detail in Section 6 of **Appendix D**.

6 Systematic biases in monthly nonpoint TP estimates in the watershed model were corrected using non-linear empirical models, however the Mill Creek monitoring station had insufficient data for fitting the monthly model. Mill Creek biases were corrected after the final watershed model was complete by proportionally reducing upstream nonpoint annual average TP loads until the estimated annual average total TP load estimate from the watershed model equaled the site-specific annual average TP load estimate at the County Hwy PP monitoring station.

Table 12. Final fit statistics of streamflow, total suspended solids (TSS), and total phosphorus (TP) after bias correction

| Station Name | Streamflow | | | TSS | | | TP | | |
|---|---|---|---|---|---|---|---|---|---|
| | n | NSE | PBIAS | n | NSE | PBIAS | n | NSE | PBIAS |
| Baraboo River at Main Street, Reedsburg, WI | 144 | 0.8 | 0 | 24 | -0.16 | 66.8 | 24 | 0.58 | 24.7 |
| Baraboo River near Baraboo, WI | 144 | 0.86 | 0 | 120 | 0.81 | 0 | 132 | 0.89 | 0 |
| Big Eau Pleine River at Stratford, WI | 144 | 0.77 | 0 | | | | 96 | 0.45 | 0.2 |
| Big Rib River at Rib Falls, WI | 51 | 0.82 | 0 | | | | 36 | 0.79 | 0 |
| Big Roche a Cri Creek at Hwy 21 | 44 | 0.79 | 0 | 36 | 0.15 | 0.4 | 36 | 0.8 | 0 |
| Eau Claire River at Kelly, WI | 144 | 0.7 | 0 | 36 | 0.8 | 9.5 | 48 | 0.85 | 0 |
| Fenwood Creek at Bradley, WI | 51 | 0.65 | 0 | | | | 48 | 0.36 | 0 |
| Freeman Creek at Halder, WI | 51 | 0.71 | 0 | | | | 48 | 0.69 | 0 |
| Lemonweir at New Lisbon | 44 | 0.88 | 0 | 36 | 0.78 | 0 | 36 | 0.76 | 0 |
| Little Eau Pleine River near Rozellville, WI | 45 | 0.71 | 0.7 | 36 | 0.47 | 4.8 | 36 | 0.8 | 0.5 |
| Mill Creek at County Hwy PP | 45 | 0.78 | 10 | 36 | 0.52 | 66.5 | 36 | 0.79 | 30.4* |
| Pine River at Center Avenue near Merrill, WI | 45 | 0.75 | 0 | | | | 36 | 0.82 | 0 |
| Plover River at Hwy 10/66 | 45 | 0.65 | 0 | 36 | 0.87 | 0 | 36 | 0.9 | -0.4 |
| Prairie River near Merrill, WI | 144 | 0.63 | -9.5 | 48 | 0.34 | -40.4 | 48 | 0.69 | -16.6 |
| Spirit River at Spirit Falls | 144 | 0.64 | 10.4 | | | | 24 | 0.41 | -25.7 |
| Ten Mile Creek near Nekoosa | 144 | 0.85 | 0 | 48 | 0.69 | 0 | 48 | 0.92 | 0 |
| West Branch of Baraboo River at Hillsboro, WI | 144 | 0.7 | 17.3 | | | | | | |
| Wisconsin River at Castle Rock Dam | 144 | 0.69 | 17.2 | | | | | | |
| Wisconsin River at Lake DuBay Dam | 144 | 0.77 | 14.5 | | | | 60 | 0.41 | 14.9* |
| Wisconsin River at Merrill, WI | 144 | 0.7 | 0 | 132 | 0.76 | 0.2 | 132 | 0.7 | 0 |
| Wisconsin River at Nekoosa Dam | 144 | 0.78 | 8 | | | | 60 | 0.54 | 12.1* |
| Wisconsin River at Petenwell Dam | 144 | 0.68 | 19.9 | | | | | | |
| Wisconsin River at Rothschild, WI | 144 | 0.78 | -1.1 | | | | 36 | 0.81 | 5.6 |
| Wisconsin River at Stevens Point Dam | 144 | 0.79 | 2.4 | | | | 60 | 0.35 | 18.8* |
| Wisconsin River at Wisconsin Dells | 144 | 0.78 | 6.6 | | | | | | |
| Wisconsin River at Wisconsin Rapids | 144 | 0.77 | 7 | | | | | | |
| Wisconsin River below Prairie du Sac Dam | 69 | 0.85 | -0.2 | | | | | | |
| Yellow River at Babcock | 144 | 0.81 | 0.9 | 24 | 0.59 | 5.6 | 24 | 0.64 | 0.4 |
| Yellow River at Hwy 21 | 44 | 0.83 | 0 | 36 | 0.1 | -1.3 | 36 | 0.56 | -2 |

*Rather than correcting the bias using the monthly-scale tributary or main-stem sub-models, TP load estimates at these locations were corrected on an annual average basis after completion of the watershed model.

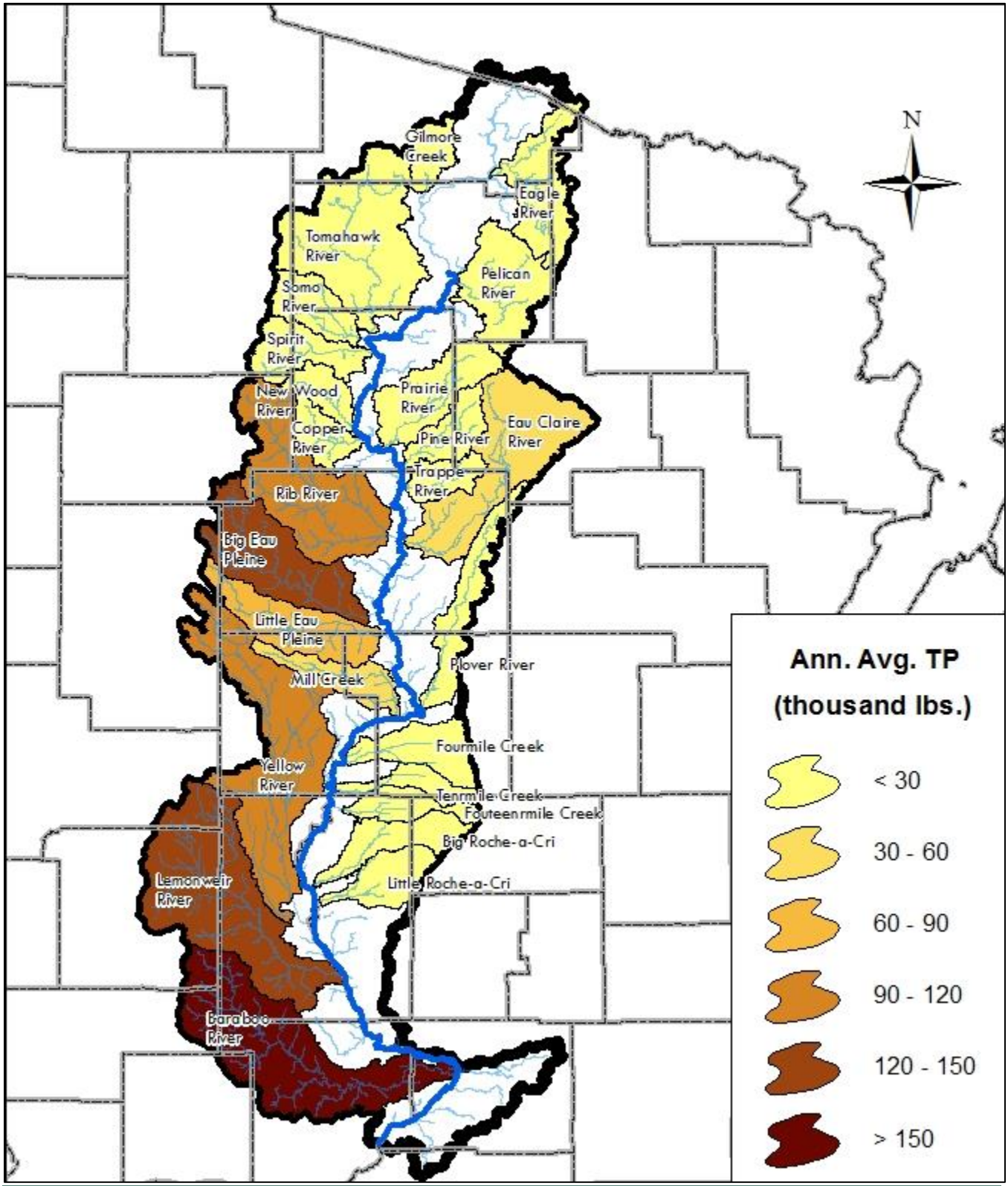


**FIGURE 23. TP LOAD DELIVERED BY MAJOR TRIBUTARY WATERSHEDS**

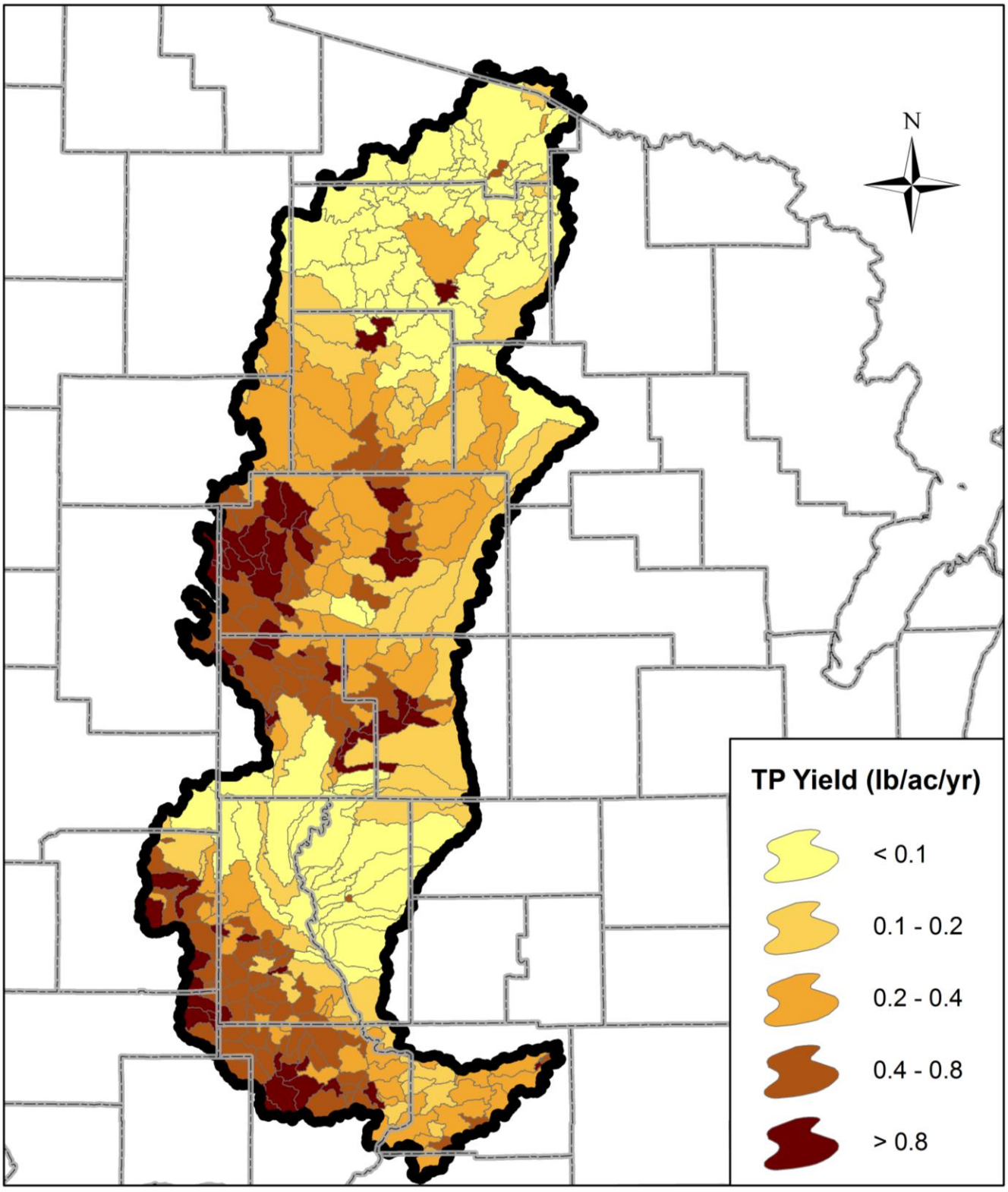


FIGURE 24. TP YIELDS PER SUBBASIN

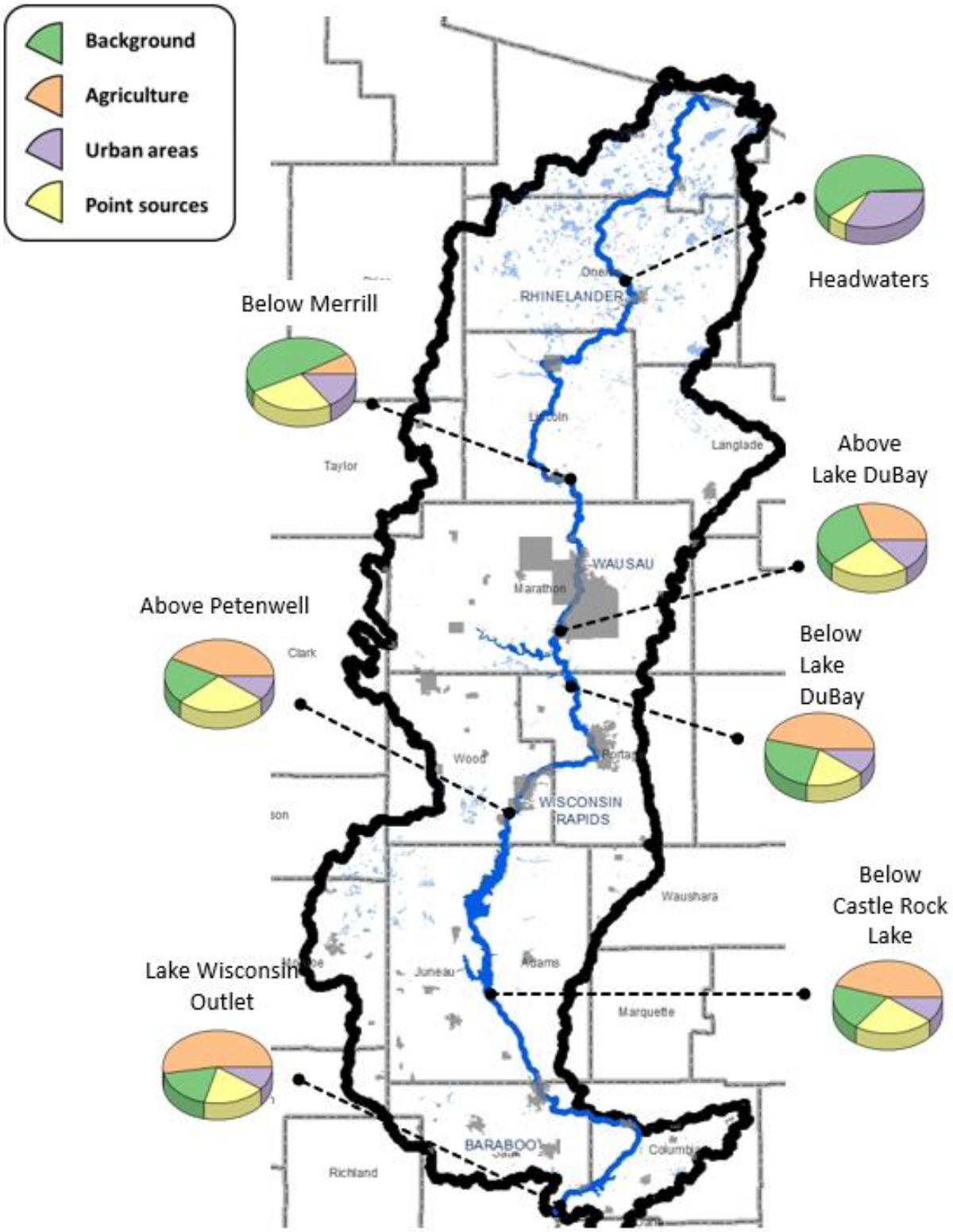


FIGURE 25. SOURCES OF TP LOADS

## 4.4 Analysis of Baseline Phosphorus and Sediment Loading

### 4.4.1 Nonpoint Source Loading

Baseline flow and phosphorus loads from nonpoint sources were generated in the SWAT model. Natural or background sources of loads from forest, grassland, wetlands, and other natural areas were estimated from forest, grassland, and wetland land covers in the SWAT model. Baseline agricultural loads were calculated from the crop land cover areas including dairy, cash grain and potato and vegetable rotations in the SWAT model. Baseline loads for non-permitted urban areas were calculated from the non-background and non-agricultural land covers outside of permitted MS4 municipal boundaries as determined both in SWAT and in WinSLAMM. Specifically, developed areas within the municipal limits of cities and villages not covered by an MS4 WPDES permit were simulated with the WinSLAMM model. Developed areas located outside of city and village limits, such as roads and rural subdivisions, were modeled as developed areas in SWAT. Details regarding the modeling conditions used to determine baseline loads from background, agricultural, and non-permitted urban loads can be found in the SWAT model report (Sections 3 and 4 of **Appendix D**).

Baseline phosphorus loads for background, agricultural, and non-permitted urban sources are shown in **Table F-1** of **Appendix F**.

### 4.4.2 Point Source Loading

Methods for determining the baseline flows and loads for individual and general permittees are described in the following sections.

#### 4.4.2.1 INDIVIDUAL PERMITS

The phosphorus baseline loads for municipal and industrial wastewater discharges covered by an individual WPDES permit with specified limits were based on the concentration limit and design flow (annual average design flow for POTWs; highest average annual flow over five years (2012-2016) for industrial dischargers). If a permitted limit did not exist, measured data from the facility was used in place of the concentration limit to determine the baseline load. To be representative of the ch. NR 217, Wis. Adm. Code, technology-based effluent limit (TBEL) for phosphorus, all wastewater point source baseline TP concentrations were set to an effluent limit of 1.0 mg/L unless the individual permittee's actual discharge was naturally low in phosphorus (e.g., noncontact cooling water without additives, reverse osmosis permeate), in which case the baseline load was based on actual discharge data.

Some discharges are intermittent or seasonal, and specific permit conditions vary on a case-by-case determination. Typical operation of seasonal discharges is to take advantage of higher seasonal flows; however, for some discharges such as from food processors, discharge is based on production times corresponding with harvests. The TMDL was developed to account for these variations and evaluated timing of discharges when assigning allocations.

During TMDL development, noncontact cooling water (NCCW) discharges were evaluated for the purposes of determining whether WLAs for phosphorus were needed to meet TMDL goals. Elevated phosphorus concentrations may be present in NCCW discharges where city water is the main source, due to the use of additives to control lead in municipal water supplies. Phosphorus WQBELs that are imposed because of this TMDL, or according to s. NR 217.13, Wis. Adm. Code, do not intend to suggest that additives in finished drinking water are not needed or should not be used. In the case of lead, additives are often needed to ensure healthy and safe drinking water. However, alternatives may need to be explored to reduce phosphorus inputs into receiving waters.

For facilities with individual permits that use groundwater or a public water supply for cooling water purposes, design flows and discharge concentrations were used to determine individual WLAs. For pass

through systems (i.e., facilities with surface water intake structures) where phosphorus is not added, and the water is withdrawn from and discharged to the same or downstream waterbody, the baseline condition for the allocation process utilized actual discharge flows with TP concentrations set to zero to reflect that no net addition of phosphorus is occurring. This would result in an allocation of zero but allow the facility to discharge the pass-through phosphorus load.

Baseline flows and loads for individual permittees are listed in **Table F-2** of **Appendix F** and facility locations are shown in Figure 26 through Figure 29 (map numbers in the table correspond to point labels in the figures).

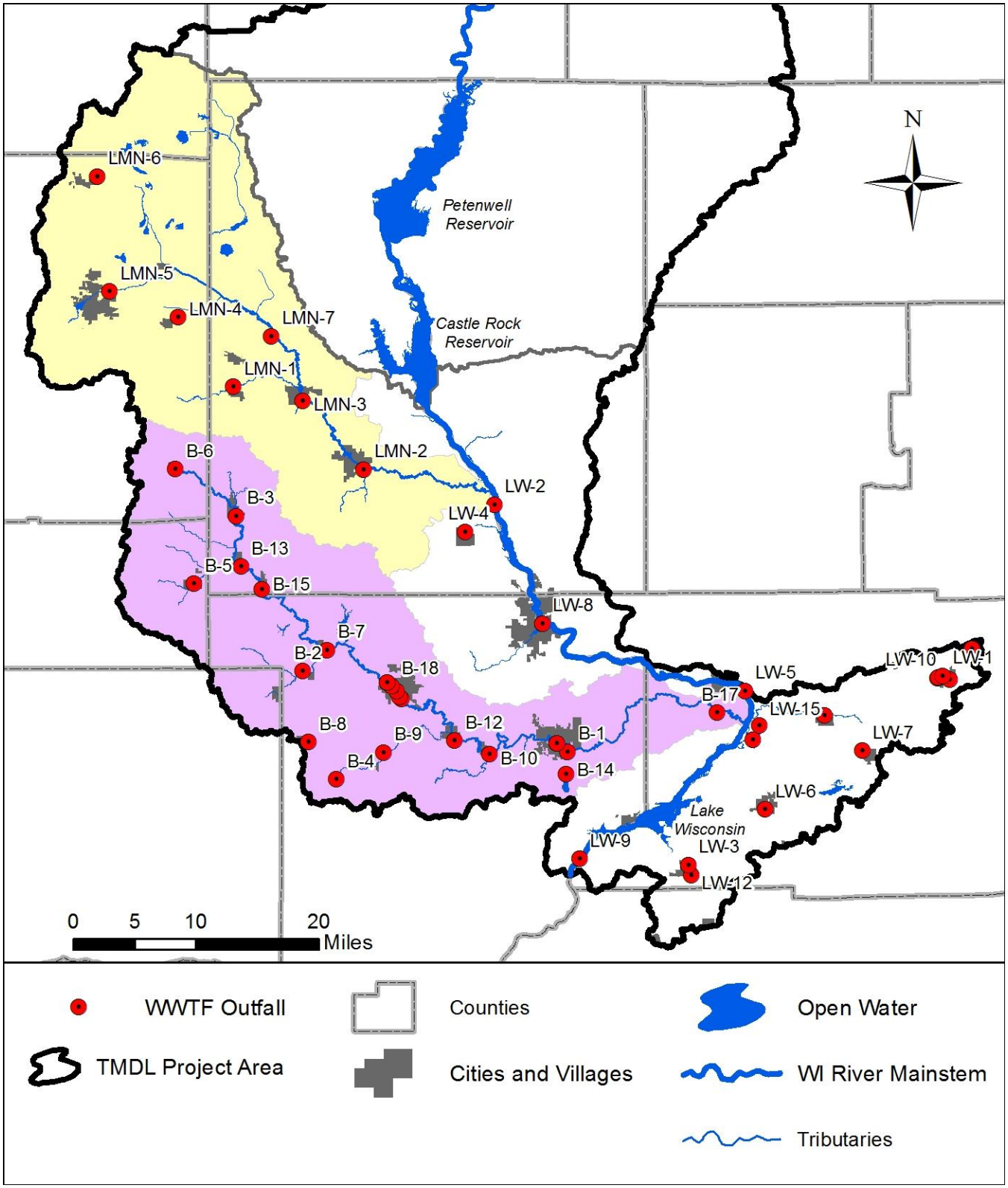


FIGURE 26. LOCATIONS OF WASTEWATER TREATMENT FACILITIES: LOWER REGION

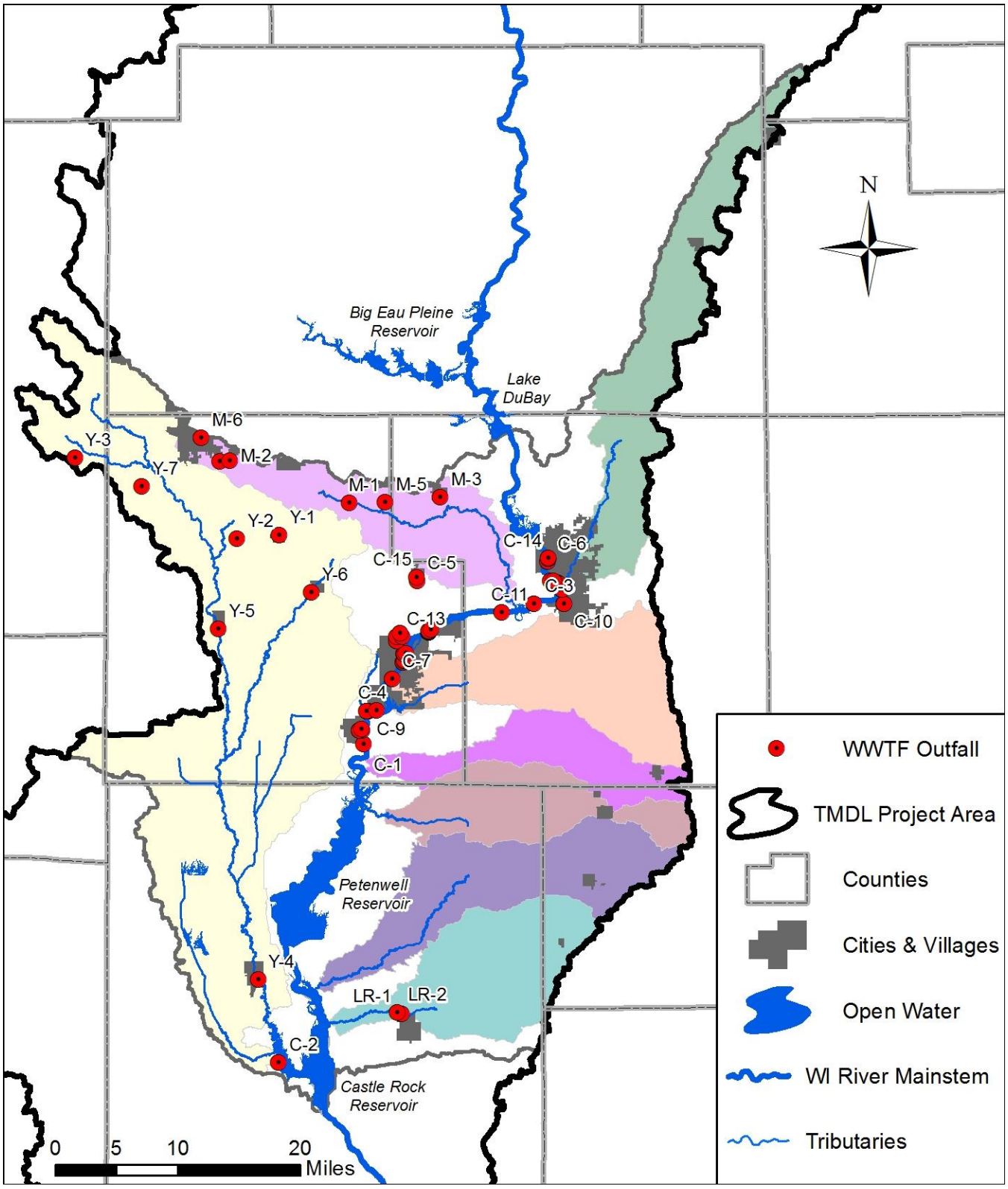


FIGURE 27. LOCATIONS OF WASTEWATER TREATMENT FACILITIES: CENTRAL REGION

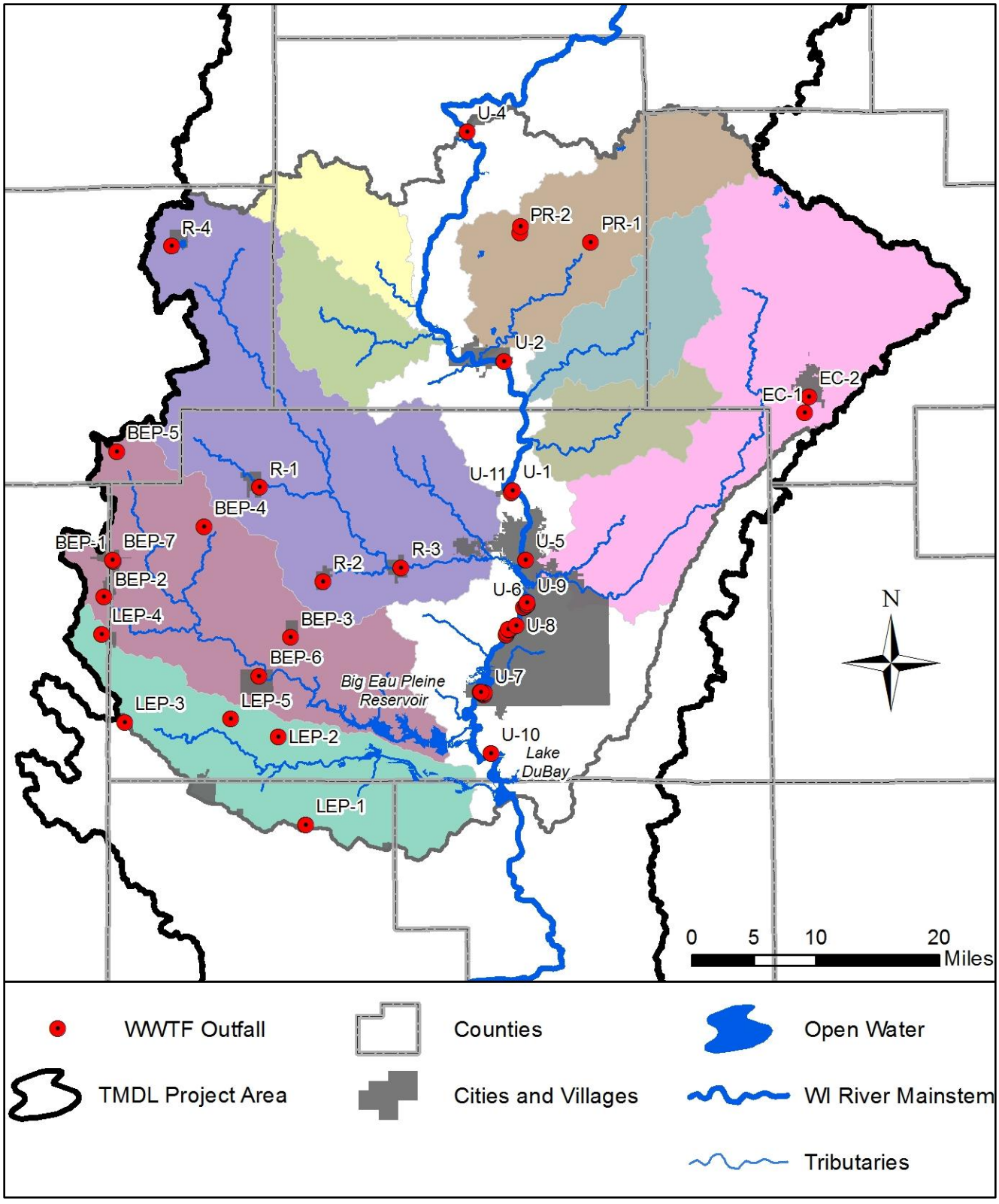


FIGURE 28. LOCATIONS OF WASTEWATER TREATMENT FACILITIES: UPPER REGION

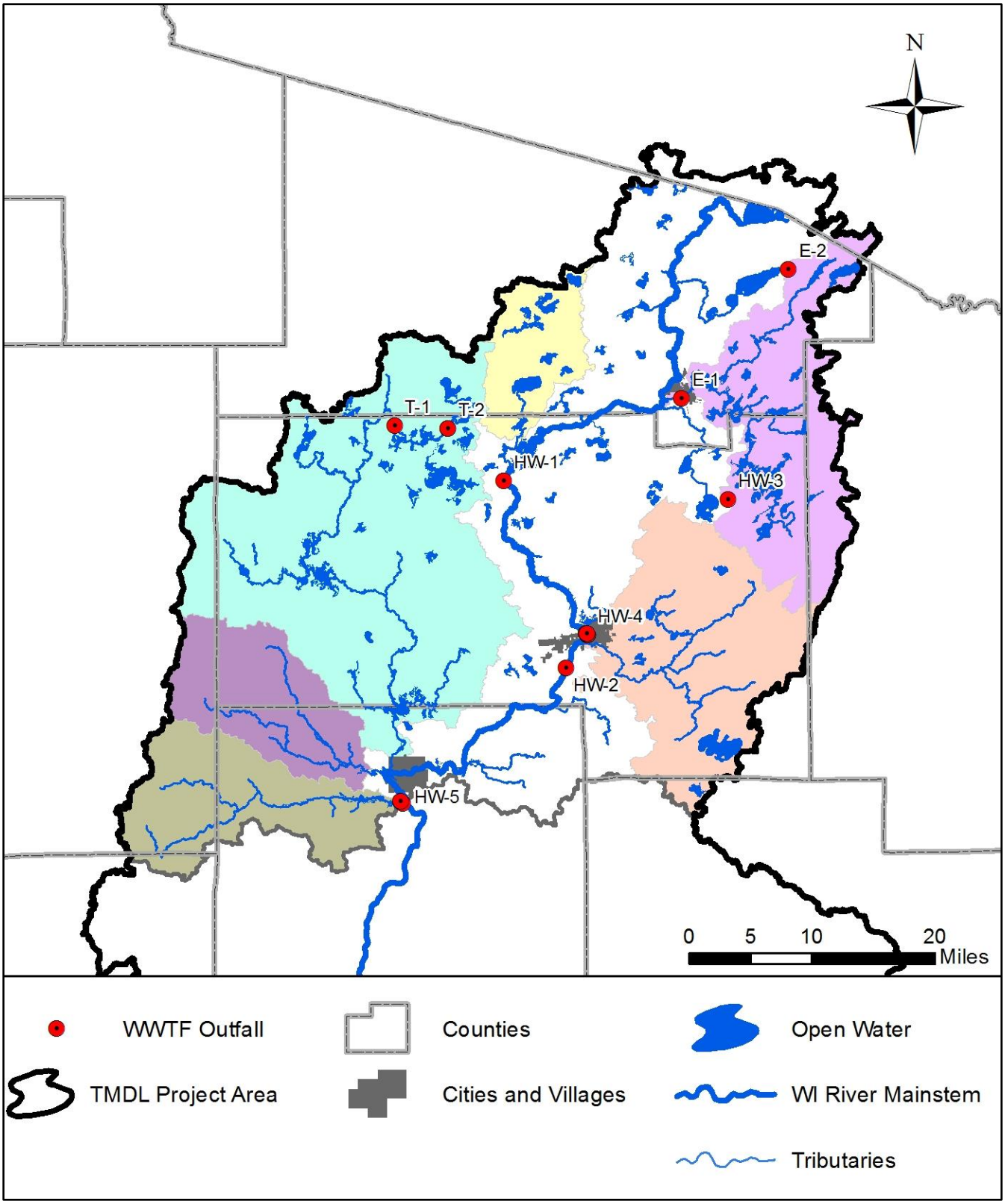


FIGURE 29. LOCATIONS OF WASTEWATER TREATMENT FACILITIES: HEADWATERS REGION

#### 4.4.2.2 GENERAL PERMITS

WDNR authorizes the discharge of stormwater and wastewater from industrial facilities, CAFOs, and construction sites under a set of general WPDES permits. Unlike individual WPDES permits, general permits are not written to reflect site-specific conditions of a single discharger, but rather are issued to cover multiple dischargers that have similar operations and types of discharges. Each general permit can have different requirements for monitoring, inspection frequency, and plan development. Stormwater general permits cover discharges from industrial and construction sites (see https://dnr.wi.gov/topic/stormwater/). Concentrated Animal Feeding Operations general permits are issued to large dairies with 1,000 to 5,720 animal units (see https://dnr.wi.gov/topic/AgBusiness/CAFO/PermitTypes.html). Wastewater general permits cover multiple categories, including: NCCW, nonmetallic mining (quarries), car washes, swimming pools, and other discharges (see https://dnr.wi.gov/topic/wastewater/generalpermits.html for a full list of Wastewater general permits).

Baseline phosphorus loads for general permittees located within an MS4 boundary were included in the MS4 baseline load. Baseline phosphorus loads for general permittees located outside of MS4 areas were included as 10% of the non-permitted urban baseline load for TP by subbasin. The assumption of 10% was based on the number and typical types of facilities present within the watersheds and best professional judgment of the TMDL Development Team.

#### 4.4.2.3 MUNICPAL SEPARATE STORM SEWER SYSTEMS (MS4S)

There are 15 permitted MS4s within the TMDL area (see Table 9 in Section 4.3.1.2). Baseline MS4 TP and TSS loads were determined from the WinSLAMM modeling described in Section 4.3.1.2 and detailed in Section 4.4 of **Appendix D**. The WinSLAMM results used in the existing conditions SWAT model were adjusted for baseline conditions to reflect the ch. NR 216 Wis. Admin. Code 20% TSS reduction requirement and corresponding 15% reduction in TP. The corresponding 15% TP reduction is calculated in WinSLAMM by applying BMPs to obtain the 20% TSS reduction. The reduction relationship between TP and TSS is not 1:1 because of the partitioning between phosphorus attached to sediment and the soluble phosphorus in the urban runoff.

Because of the large spatial expanse of the Wisconsin River Basin, each modeled MS4 area utilized different rainfall files to best represent local conditions. Therefore, unique monthly flows and loads were generated for each MS4 to determine baseline conditions.

Figure 30 through Figure 32 shows the locations and boundaries of each permitted MS4. Table 13 lists the area of each MS4 within SWAT subbasins and serves as a legend to Figure 30 through Figure 32 by listing an ID code that can be referenced to each map. MS4 baseline values are shown in **Appendix F**, **Table F-3**. Although included in the table, Marathon County and University of Wisconsin-Stevens Point are both covered by a WPDES MS4 permit but will not receive individual allocations. Instead, they are accounted for in the portions of each city, village, or town MS4 that they discharge to or lie within. However, these regulated MS4s that are not given specific allocations will still be expected to achieve the applicable identified reductions within their portion of their jurisdictional area. Please refer to the MS4 TMDL Implementation Guidance for details; "TMDL Guidance for MS4 Permits: Planning, Implementation, and Modeling Guidance". The guidance and addendums can be found at https://dnr.wi.gov/topic/stormwater/standards/ms4_modeling.html

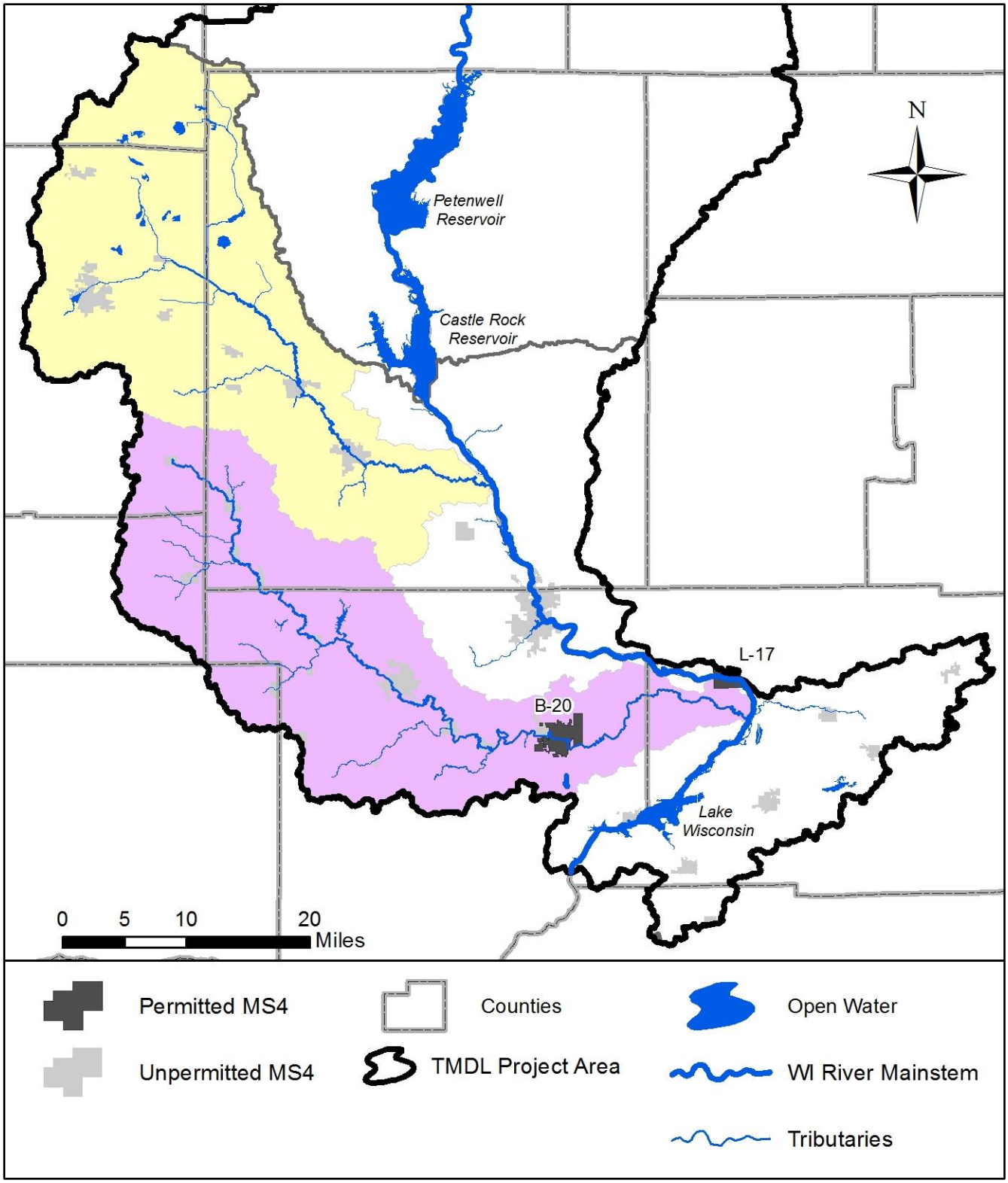


FIGURE 30. LOCATIONS OF PERMITTED MS4S: LOWER REGION

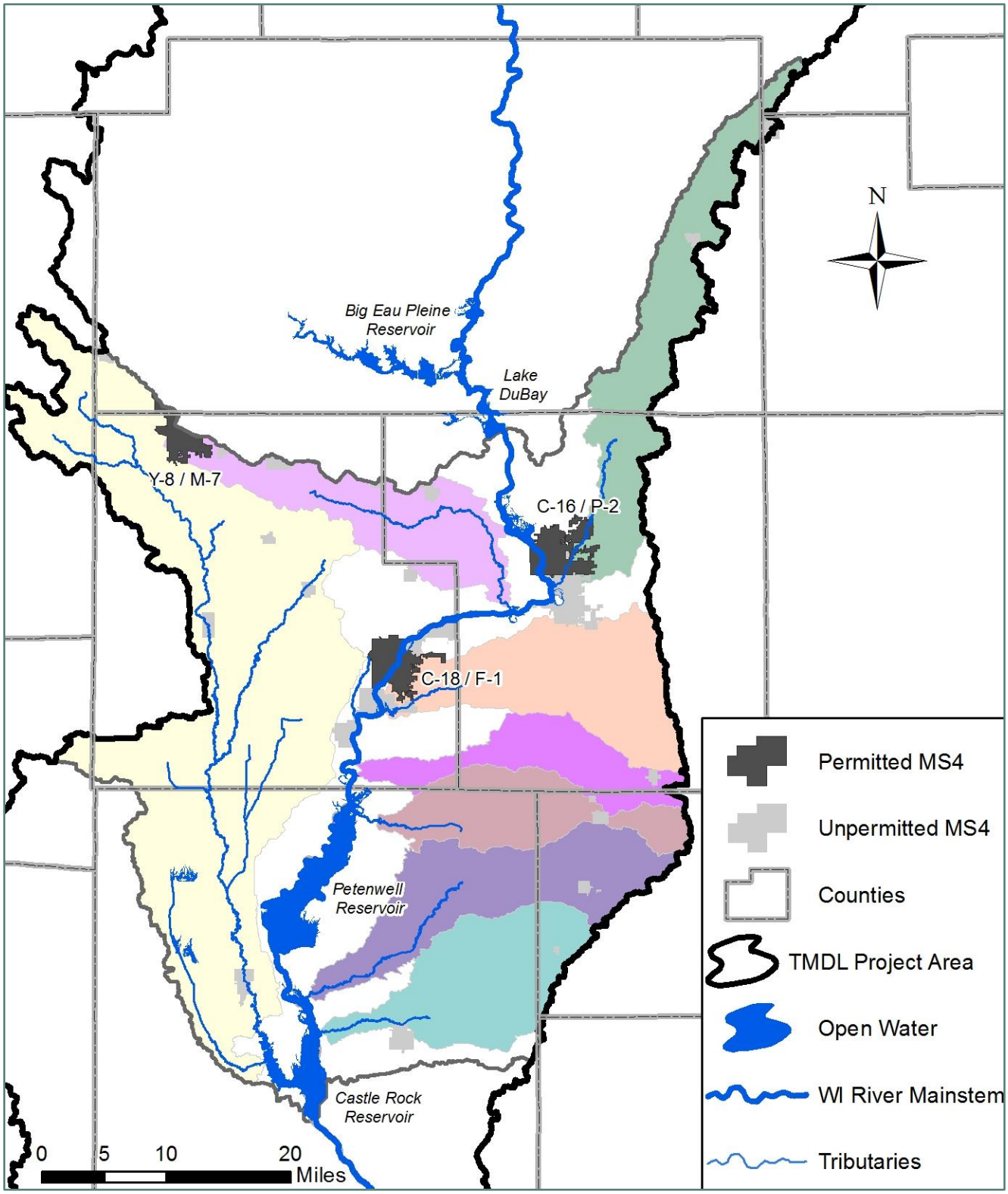


FIGURE 31. LOCATIONS OF PERMITTED MS4S: CENTRAL REGION

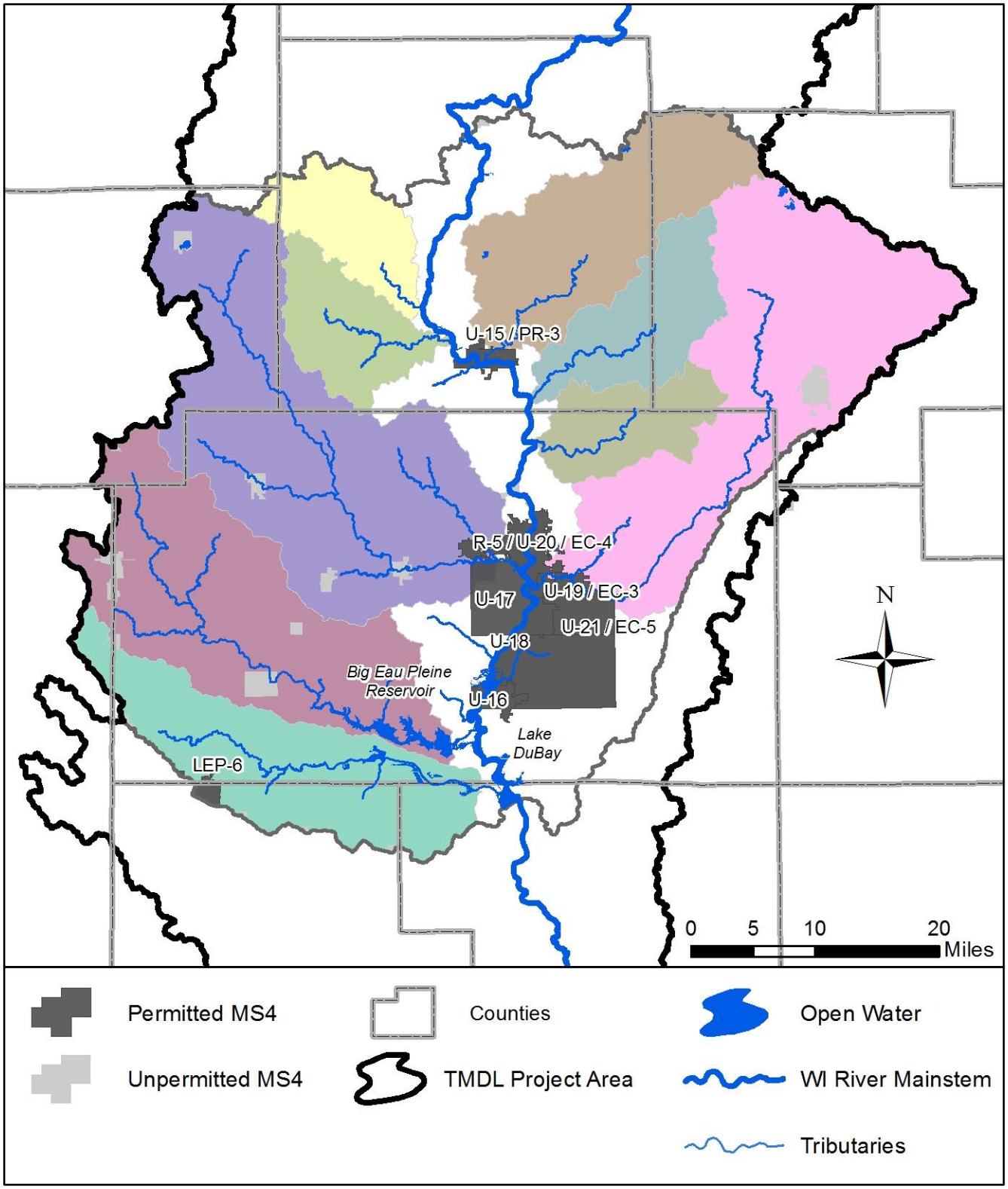


FIGURE 32. LOCATIONS OF PERMITTED MS4S: UPPER REGION

## Table 13. Permitted MS4 area by TMDL subbasin

| Municipality | TMDL Subbasin | Area (acres) | Figure | Major Trib. Watershed | Map ID |
|---|---|---|---|---|---|
| Baraboo | 5 | 546.6 | Lower | Baraboo | B-20 |
| Baraboo | 137 | 390.9 | Lower | Baraboo | B-20 |
| Baraboo | 179 | 2,671.7 | Lower | Baraboo | B-20 |
| Baraboo | 230 | 119.3 | Lower | Baraboo | B-20 |
| Baraboo | 234 | 2.6 | Lower | Baraboo | B-20 |
| Kronenwetter | 81 | 41.1 | Upper | WI River Upper | U-14 |
| Kronenwetter | 153 | 1,061.2 | Upper | WI River Upper | U-14 |
| Kronenwetter | 263 | 2,412.5 | Upper | WI River Upper | U-14 |
| Marathon County | NA | NA | Upper | WI River Upper | NA |
| Marshfield | 84 | 2,358.7 | Upper | Little Eau Pleine | LEP-6 |
| Marshfield | 85 | 186.1 | Upper | Little Eau Pleine | LEP-6 |
| Marshfield | 147[1] | 4,004.0 | Central | Mill | M-7 |
| Marshfield | 275 | 1,709.0 | Central | Yellow | Y-8 |
| Marshfield | 307 | 290.7 | Central | Yellow | Y-8 |
| Merrill | 158 | 2,343.4 | Upper | WI River Upper | U-15 |
| Merrill | 269 | 620.7 | Upper | Prairie | PR-3 |
| Merrill | 321 | 1,621.4 | Upper | WI River Upper | U-15 |
| Mosinee | 81 | 1,184.7 | Upper | WI River Upper | U-16 |
| Mosinee | 153 | 1,512.7 | Upper | WI River Upper | U-16 |
| Mosinee | 262 | 1,149.8 | Upper | WI River Upper | U-16 |
| Portage | 190 | 578.7 | Lower | WI River Lower | L-17 |
| Rib Mountain | 154 | 2,311.8 | Upper | WI River Upper | U-17 |
| Rib Mountain | 263 | 127.8 | Upper | WI River Upper | U-17 |
| Rothschild | 154 | 820.5 | Upper | WI River Upper | U-18 |
| Rothschild | 263 | 3,246.0 | Upper | WI River Upper | U-18 |
| Schofield | 154 | 603.7 | Upper | WI River Upper | U-19 |
| Schofield | 290 | 432.0 | Upper | Eau Claire | EC-3 |
| Stevens Point | 145 | 234.4 | Central | WI River Central | C -16 |
| Stevens Point | 148 | 1,466.4 | Central | WI River Central | C -16 |
| Stevens Point | 149 | 1,359.4 | Central | Plover | P-2 |
| Stevens Point | 210 | 4,310.0 | Central | WI River Central | C -16 |
| Stevens Point | 260 | 1,904.9 | Central | Plover | P-2 |
| Wausau | 154 | 4,114.1 | Upper | WI River Upper | U-20 |
| Wausau | 156 | 3,792.9 | Upper | WI River Upper | U-20 |
| Wausau | 265 | 608.8 | Upper | WI River Upper | U-20 |
| Wausau | 290 | 687.8 | Upper | Eau Claire | EC-4 |
| Wausau | 291 | 1,321.4 | Upper | Rib | R-5 |
| Wausau | 292 | 690.7 | Upper | Rib | R-5 |
| Weston | 153 | 19.4 | Upper | WI River Upper | U-21 |
| Weston | 154 | 2,367.5 | Upper | WI River Upper | U-21 |
| Weston | 155 | 3,135.7 | Upper | Eau Claire | EC-5 |

| Municipality | TMDL Subbasin | Area (acres) | Figure | Major Trib. Watershed | Map ID |
|---|---|---|---|---|---|
| Weston | 263 | 934.2 | Upper | WI River Upper | U-21 |
| Weston | 289 | 234.0 | Upper | Eau Claire | EC-5 |
| Weston | 290 | 476.0 | Upper | Eau Claire | EC-5 |
| Wisconsin Rapids | 144 | 1,260.2 | Central | WI River Central | C-18 |
| Wisconsin Rapids | 204 | 159.4 | Central | WI River Central | C-18 |
| Wisconsin Rapids | 205 | 3,496.0 | Central | WI River Central | C-18 |
| Wisconsin Rapids | 206 | 1,050.9 | Central | WI River Central | C-18 |
| Wisconsin Rapids | 256 | 995.4 | Central | WI River Central | C-18 |
| Wisconsin Rapids | 257 | 1,381.3 | Central | Fourmile | F-1 |
| UW-Stevens Point | 210 | ND | Central | WI River Central | C-17 |

1. Note: Subbasin 147 has been combined with subbasin 331.

Detailed maps of the permitted MS4 areas included in the TMDL are provided in **Appendix G**.

#### 4.4.2.4 CONCENTRATED ANIMAL FEEDING OPERATIONS

Concentrated Animal Feeding Operations (CAFOs) are operations defined and regulated under the WPDES program. There are 26 regulated CAFOs in the Basin (Table 14 and Figure 34 through Figure 36).

WPDES permits for CAFO facilities cover the production area, ancillary storage areas, storage areas, and land application areas. Any runoff from CAFO land application activities is considered a nonpoint source and is covered in the TMDL through the load allocation. CAFOs must comply with all WPDES permit conditions which include the livestock performance standards and prohibitions in ch. NR 151, Wis. Admin. Code. Specific WPDES permit conditions for the production area specify that CAFOs may not discharge manure or process wastewater pollutants to navigable waters from the production area, including approved manure stacking sites, unless all the following apply:

- Precipitation causes an overflow of manure or process wastewater from a containment or storage structure.
- The containment or storage structure is properly designed, constructed and maintained to contain all manure and process wastewater from the operation, including the runoff and the direct precipitation from a 25-year, 24-hour rainfall event for this location.
- The production area is operated in accordance with the inspection, maintenance and record keeping requirements in s. NR 243.19, Wis. Admin. Code.
- The discharge complies with surface water quality standards.

For ancillary service and storage area, CAFOs may discharge contaminated stormwater to waters of the state provided the discharges comply with groundwater and surface water quality standards. The permittee shall take preventive maintenance actions and conduct periodic visual inspections to minimize the discharge of pollutants from these areas to surface waters. For CAFO outdoor vegetated areas, the permittee shall also implement the following practices:

- Manage stocking densities, implement management systems and manage feed sources to ensure that sufficient vegetative cover is maintained over the entire area at all times.
- Prohibit direct access of livestock or poultry to surface waters or wetlands located in or adjacent to the area unless approved by the Department.

Manure from CAFO operations used for agronomic purposes through surface land spreading or injection is considered a nonpoint source for purposes of a TMDL. Manure spreading is included implicitly in the SWAT model.

## Table 14. List of CAFOs

| Facility Name | Permit ID | TMDL Reach | Figure | Major Tributary Watershed | Map Number* |
|---|---|---|---|---|---|
| Burr Oak Heifers LLC | 0061824 | 75 | Central | Little Roche a Cri | LR-3 |
| Central Sands Dairy LLC | 0063533 | 73 | Central | WI River Central | C-18 |
| Chapman Brothers Farms | 0062774 | 57 | Lower | Lemonweir | LMN-8 |
| Destiny Farms LLC | 0064343 | 68 | Central | Yellow | Y-9 |
| Dietsche Dairy LLC | 0059277 | 275 | Central | Yellow | Y-10 |
| Double P Dairy LLC | 0062031 | 292 | Upper | Rib | R-6 |
| Elusive Hill Dairy | 0062022 | 275 | Central | Yellow | Y-11 |
| Fischer Clark Dairy | 0065625 | 149 | Central | Plover | P-3 |
| Golden Sands Dairy LLC | 0064980 | 255 | Central | Tenmile | TM-1 |
| Heeg Farm | 0061841 | 324 | Upper | Big Eau Pleine | BEP-9 |
| Hillsprairie Dairy/Mitchell F | 0062634 | 21 | Upper | Baraboo | B-21 |
| Kingdom Haven Dairy | 0062391 | 106 | Upper | Rib | R-7 |
| Kinnamon Ridge Dairy LLC | 0065129 | 12 | Lower | Baraboo | B-22 |
| Lynn Enterprises | 0062413 | 93 | Upper | Big Eau Pleine | BEP-10 |
| Maple Ridge Dairy | 0061832 | 152 | Upper | Big Eau Pleine | BEP-11 |
| Miltrim Dairy | 0061638 | 215 | Upper | Rib | R-8 |
| Nagel Dairy Farm LLC | 0063819 | 298 | Upper | Eau Claire | EC-6 |
| New Chester Dairy LLC | 0064696 | 247 | Lower | WI River Lower | LW-15 |
| Night Hawk Dairy LLC | 0065609 | 328 | Upper | Little Eau Pleine | LEP-7 |
| Norm-E-Lane | 0059421 | 70 | Central | Yellow | Y-12 |
| Ocooch Dairy | 0065081 | 22 | Lower | Baraboo | B-23 |
| Rausch Family Farms | 0062405 | 102 | Upper | Rib | R-9 |
| Richfield Dairy | 0064815 | 75 | Central | Little Roche a Cri | LR-4 |
| Spring Breeze Dairy LLC | 0058777 | 216 | Upper | Eau Claire | EC-7 |
| Tri Star Dairy, Inc. | 0062111 | 207 | Central | Mill | M-8 |
| Van Der Geest Dairy Cattle, Inc. | 0059293 | 217 | Upper | WI River Upper | U-23 |

**map numbers correspond to point labels in Figure 34 through Figure 36.*

## 4.5 Seasonality

Nonpoint source pollution loads are not evenly distributed over time. There are certain times of the year when TSS and TP yields can be 1–2 orders of magnitude greater than others (Figure 33 and **Appendix D.6** for observed and simulated loads over time at each calibration site). Agricultural nonpoint loads tend to be the lowest in winter months during snow cover. Runoff tends to be highest in early spring (usually beginning in March) when snow begins melting, and with runoff, simulated TSS and TP yields are greater. This pattern is particularly evident in March and April. For many dairy operations, the SWAT model simulates solid manure applications once monthly between January and April, and simulated TP yields tend to be the greatest when snow mixed with manure begins to melt. Summer months also yield higher TSS and TP than winter months due to more intense rain events and greater precipitation overall, however plant cover and reduced fertilization result in less pollutant yield than in spring months. Simulated TP yields in October are slightly higher due to some agricultural operations in the model programmed to fertilize at that time.

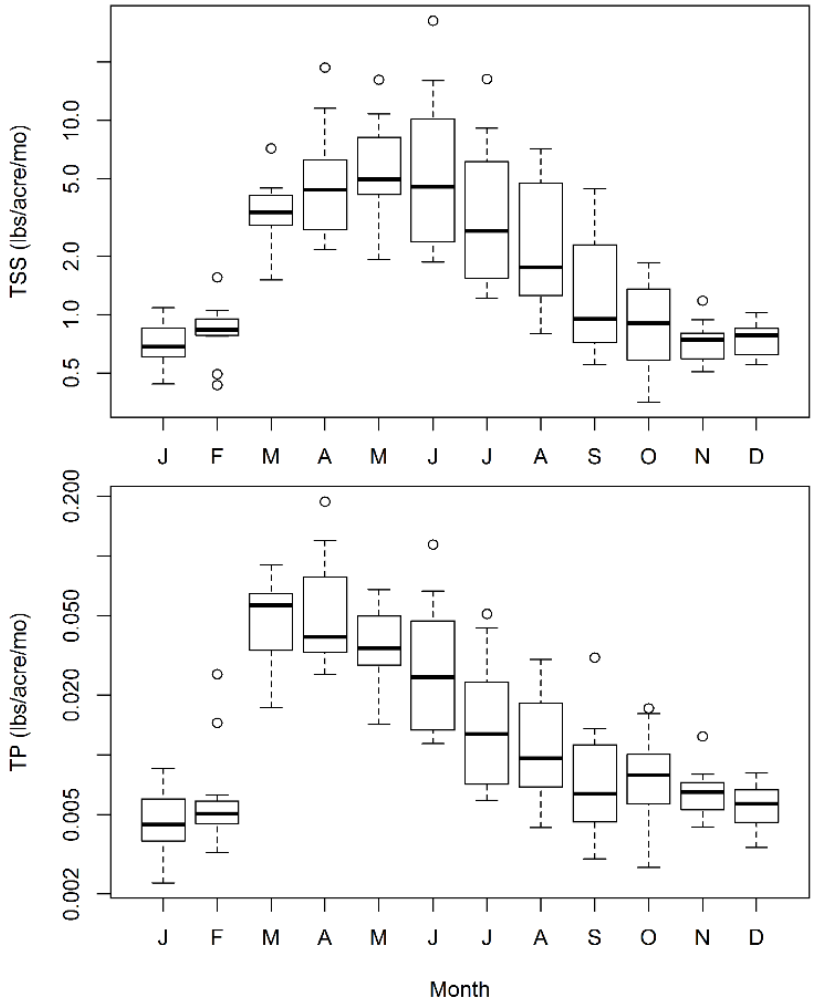


**FIGURE 33. BOXPLOTS SHOWING INTRA-ANNUAL POLLUTANT VARIABILITY**

Some of the TP that is loaded to surface waters outside of the growing season, particularly during March and April, is retained and affects those waters during the growing season. Therefore, the reductions required to meet the TP loading capacity must be distributed throughout the year, in approximate proportion to the seasonal pattern of the baseline loading, in order to meet the assumptions of the methods used to calculate loading capacity (see Section 5 for details).

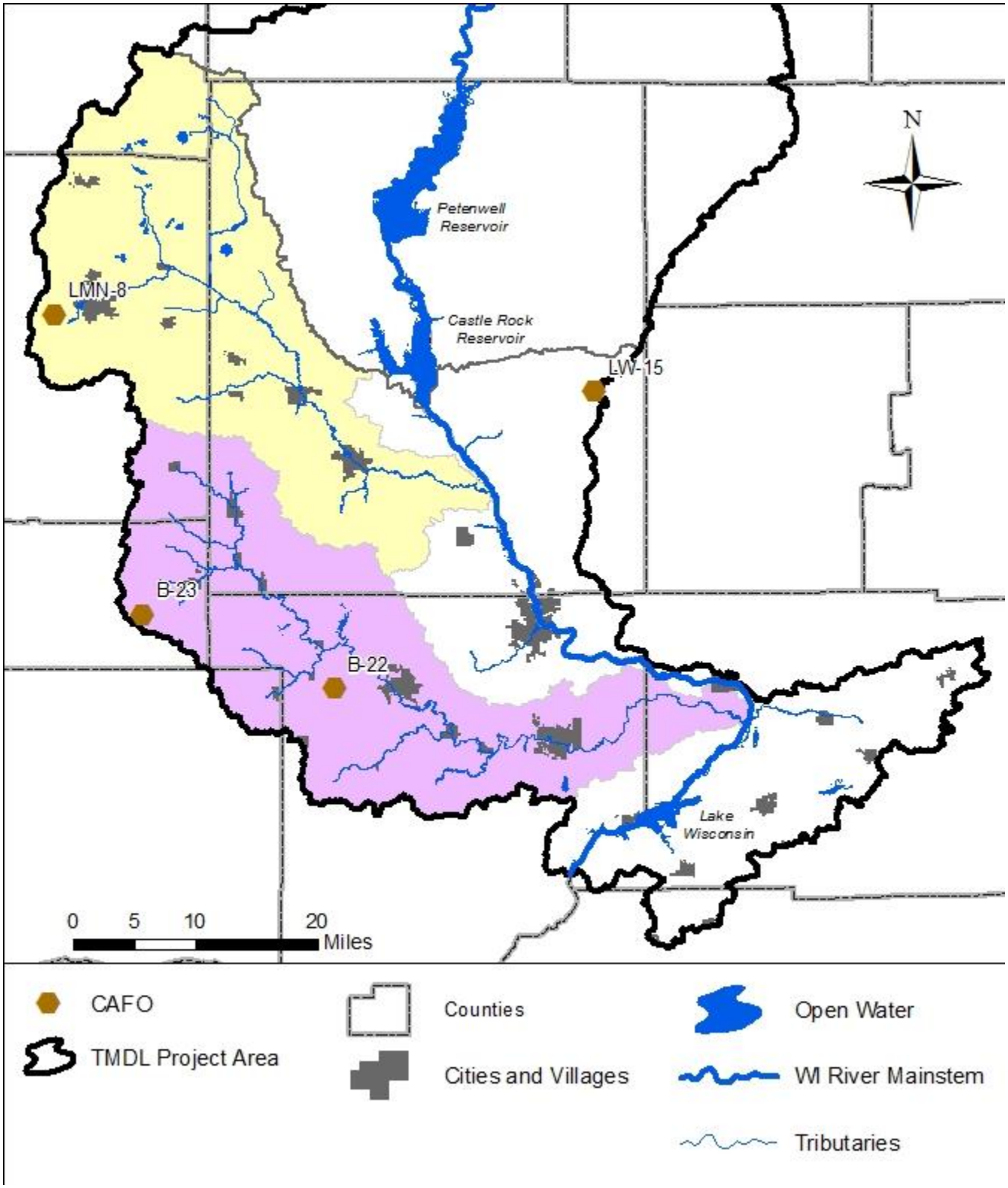


FIGURE 34 LOCATIONS OF CAFOS: LOWER REGION

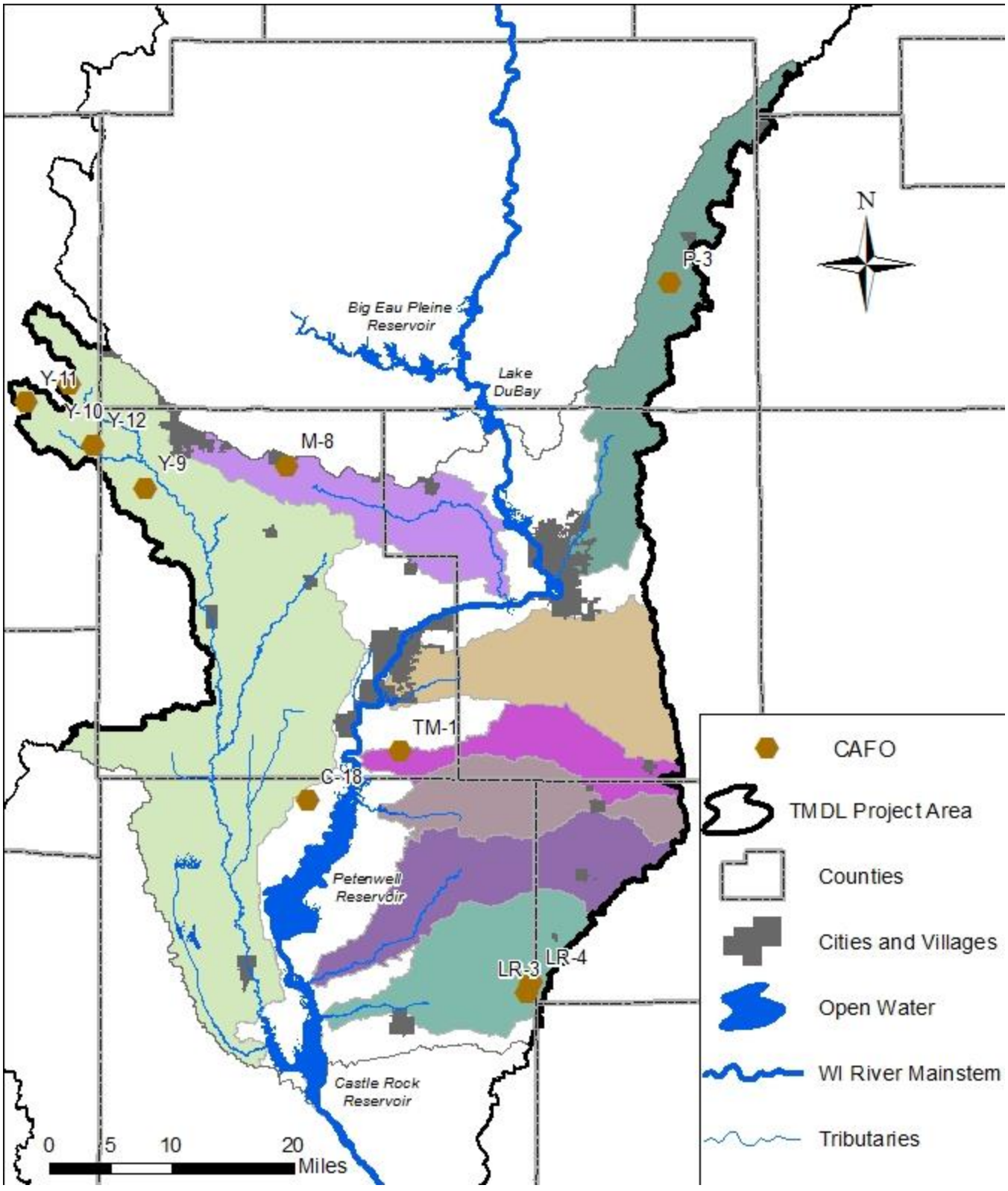


FIGURE 35. LOCATIONS OF CAFOS: CENTRAL REGION

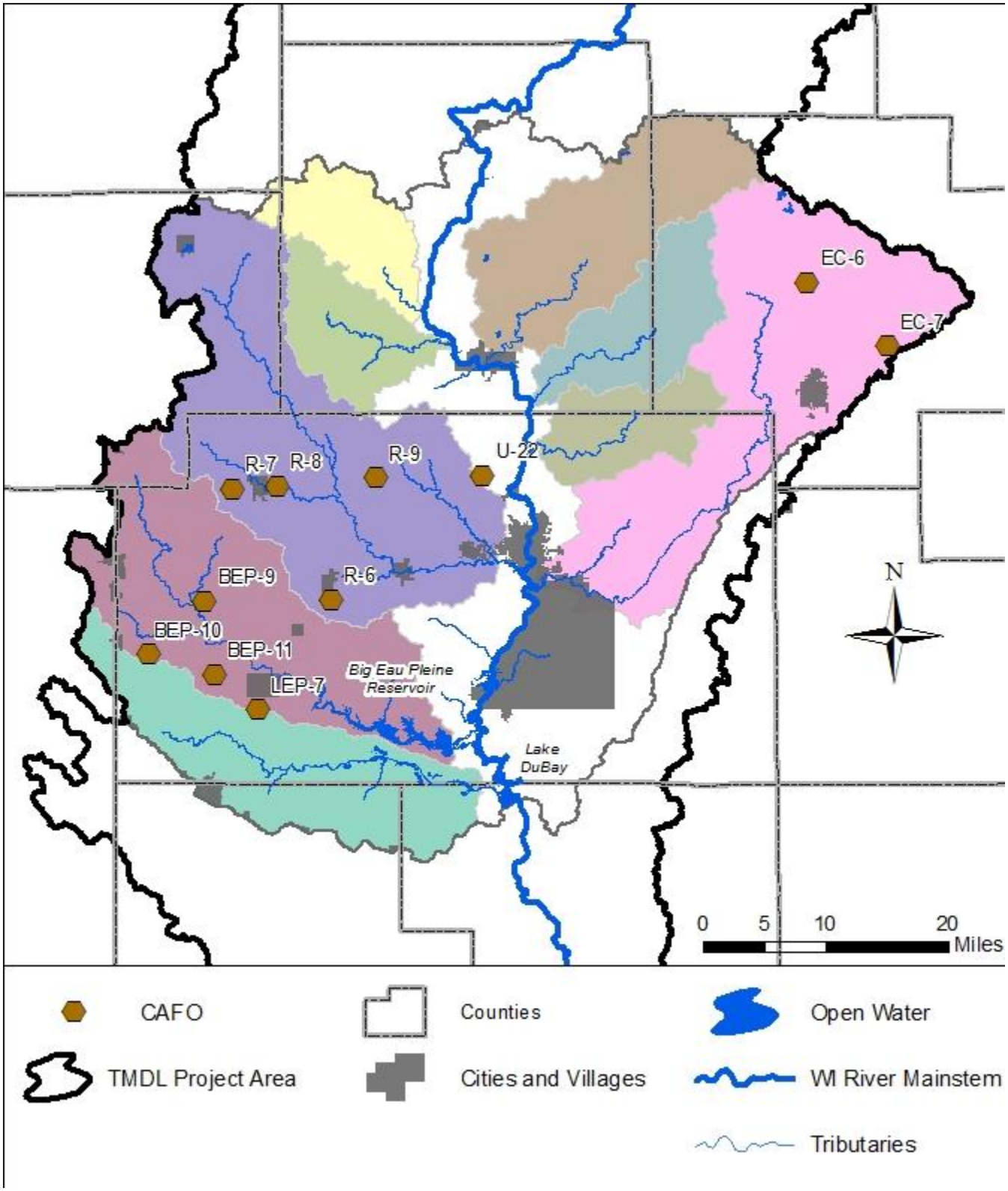


FIGURE 36. LOCATIONS OF CAFOS: UPPER REGION

# 5 POLLUTANT LOADING CAPACITY

Pollutant loading capacity is defined as the amount of a pollutant that a water body can assimilate and still meet water quality standards. By definition, a TMDL is a daily loading capacity; however, loading capacities can also be calculated for time periods other than daily, if the effects of a pollutant manifest themselves over longer periods. This section describes how the pollutant loading capacities for river and stream reaches as well as the basin reservoirs were determined.

## 5.1 Linking Pollutant Loading to Concentration

Wisconsin's stream/river total phosphorus criteria are assessed as growing-season (May - October) median (GSM) concentrations. Although the SWAT model was run with a daily time step, predicted daily TP concentrations are not as accurate as monthly or annual flow-weighted mean (FWM) values. To establish annual TP loads that will meet these criteria, a method is required to translate GSM concentrations to flow-weighted mean concentrations. FWM is higher than GSM in streams where TP concentration increases with discharge and where there is little seasonal variation. In contrast, GSM may be higher than FWM in streams where TP exhibits a strong seasonal pattern that peaks in summer and is independent of discharge. We assume that the FWM/GSM ratio for a given tributary will remain constant as TP concentrations change because the underlying hydrologic drivers of the ratio will not change very much. The FWM/GSM ratio for a tributary can be used to estimate the TP loading that will meet TP criteria – they do not change the criteria themselves.

The FWM/GSM ratio was estimated for each tributary monitoring station from monitoring data. For each station, the FWM was calculated from measured daily flow and daily loads estimated by the Fluxmaster model (Section 4.3.1.1and Section 5.2.3 of **Appendix D**). GSMs were estimated from monitoring data adjusted to control for the influence of antecedent precipitation on TP concentration (WDNR PhosMER model). PhosMER was chosen to estimate GSM rather than Fluxmaster because WDNR intends to use it to assess future TP monitoring data where flow may not be monitored. Ratios for ungaged tributaries were either calculated from SWAT-derived FWM and PhosMER-derived GSM or from a nearby gaged tributary station with similar watershed characteristics (**Figure 24**). Subbasins that drain directly to the main stem Wisconsin River were assigned the ratio for the Wisconsin River at Merrill because ratios at all downstream stations were very similar.

FWM/GSM ratios at tributary monitoring stations ranged from 0.86 (Little Eau Pleine River) to 2.44 (Freeman Creek) with a median of 1.27 (Table 15). The lowest ratios are in parts of the basin (including the main stem Wisconsin River) that contain many impoundments that likely dampen hydrologic response. The highest ratios are in parts of the basin with clay soils and flashy hydrology. There was no relationship between FWM/GSM ratios and the distribution of TP sources, but even if there were, the assumption that the ratio will remain constant as concentrations decrease would still be valid because load allocations to each source are proportional to baseline loads. In addition, because allocations for most of the basin are driven by downstream reservoirs, load reductions for most tributaries are beyond what is needed to meet the stream loading capacities derived from the FWM/GSM ratios.

Because the FWM concentration is calculated from year-round data, this method for linking loading to concentration assumes that TP loading reductions will occur year-round. Some of the TP that enters surface waters in a given month is retained in stream and lake bottom sediments, and later remobilized through a variety of biogeochemical and hydrologic processes. Therefore, even though TP assessments only use data from the growing season (May-Oct) in streams and summer (Jun-Sep) in lakes, TP load reductions will be required outside of this period. For point sources, the validity of this assumption is supported by the year-round application of permit limits. For nonpoint sources, it relies on the assumption that practices that reduce TP loading will be implemented and effective year-round, and that the seasonal pattern in the resulting load reductions will be approximately proportional to the seasonal pattern of the baseline loading.

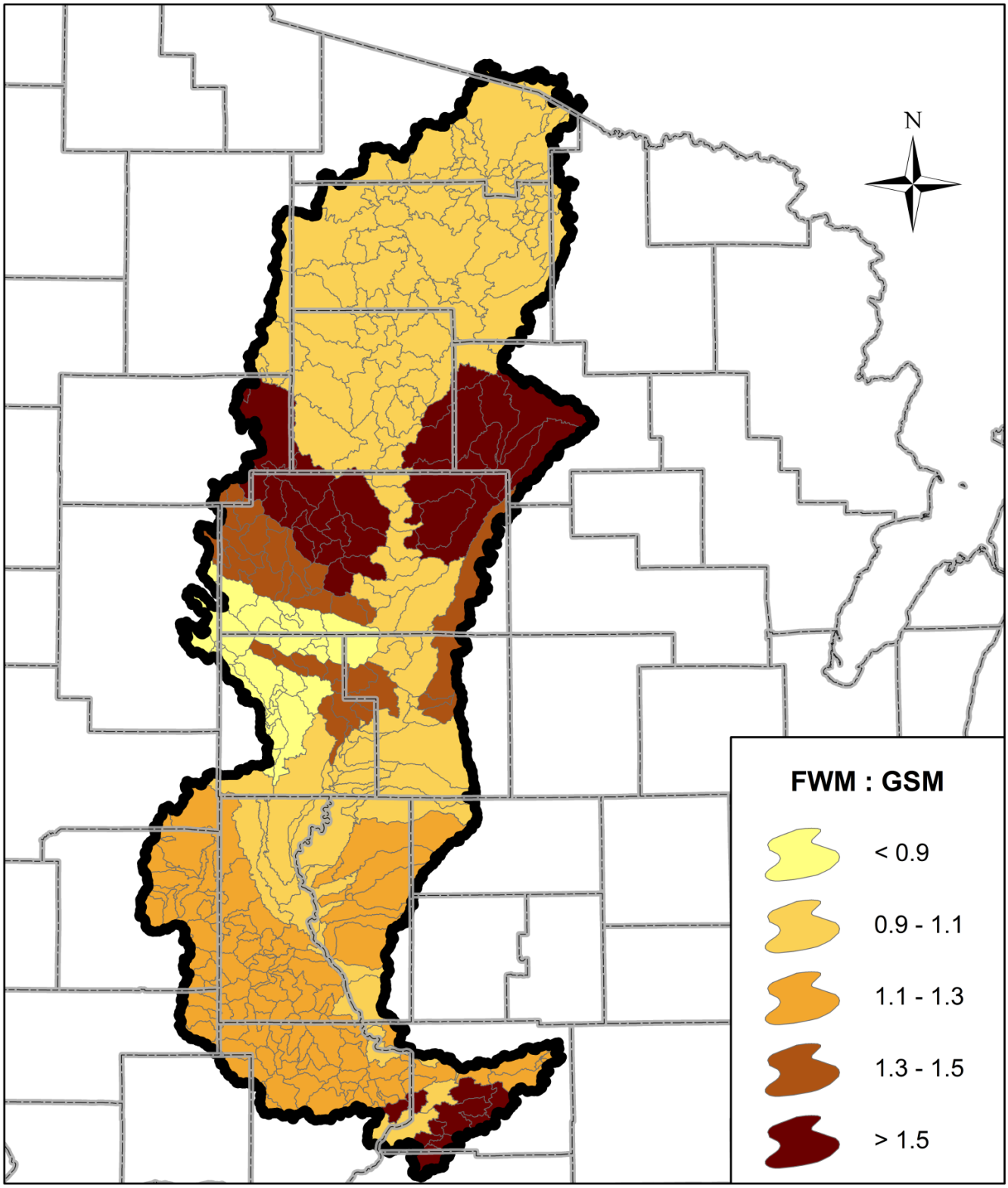


FIGURE 37. FLOW-WEIGHTED MEAN, GROWING-SEASON MEDIAN RATIO

Table 15. WI river tributary monitoring stations used to convert from annual flow-weighted mean (FWM) to growing-season median (GSM) total phosphorus concentration

| Subbasin | Station ID | Station Name | FWM | GSM | FWM / GSM |
|---|---|---|---|---|---|
| **150** | 10031106 | Little Eau Pleine River at Smokey Hill Rd | 0.248 | 0.29 | 0.86 |
| **140** | 723128 | Yellow River at STH 54 | 0.212 | 0.244 | 0.87 |
| **329** | 373375 | Johnson Creek at CTH C | 0.055 | 0.059 | 0.92 |
| **158** | 353068 | Wisconsin River - Below Merrill Dam | 0.06 | 0.062 | 0.96 |
| **199** | 10031103 | Yellow River downstream STH 21 | 0.114 | 0.115 | 0.99 |
| **142** | 10012667 | Tenmile Creek at Rangeline Rd | 0.053 | 0.049 | 1.09 |
| **141** | 10030199 | Big Roche a Cri Creek at STH 21 | 0.033 | 0.028 | 1.18 |
| **195** | 293156 | Lemonweir River at New Lisbon | 0.147 | 0.12 | 1.22 |
| **137** | 573051 | Baraboo River at CTH X | 0.231 | 0.182 | 1.27 |
| **3** | 10029202 | Duck Creek at Duck Creek Road | 0.126 | 0.099 | 1.27 |
| **152** | 373325 | Big Eau Pleine River at STH 97 | 0.361 | 0.275 | 1.31 |
| **326** | 373366 | Fenwood Creek at Hwy 153 | 0.162 | 0.117 | 1.38 |
| **149** | 503130 | Plover River - Hwy 10 | 0.042 | 0.029 | 1.43 |
| **78** | 10012666 | Mill Creek at CTH PP bridge | 0.262 | 0.178 | 1.48 |
| **157** | 10018128 | Big Rib River - Access | 0.131 | 0.073 | 1.8 |
| **238** | 10011031 | Lodi-Spring Creek at Cty J | 0.139 | 0.076 | 1.84 |
| **155** | 373183 | Eau Claire River at Ross Ave At Kelly | 0.098 | 0.052 | 1.87 |
| **268** | 353109 | Pine River at Center Rd | 0.069 | 0.034 | 2.05 |
| **151** | 373411 | Freeman Creek at Sugar Bush Rd | 0.15 | 0.061 | 2.44 |

## 5.2 Critical Conditions

Wisconsin's phosphorus criteria are assessed during the growing season (May-Oct) in streams and the summer (Jun-Sep) in lakes. These periods may be considered critical response conditions because it is when the biological response to phosphorus is strongest. However, the critical phosphorus loading conditions occur from March to June. As described in Section 5.1, this means that practices that reduce TP loading will need to be implemented and effective year-round, leading to a seasonal pattern in load reductions that is approximately proportional to the seasonal pattern of the baseline loading.

## 5.3 Rivers and Streams

Phosphorus loading capacity was calculated for headwater stream reaches as Qmean · TPcrit / (FWM/GSM), where Qmean is the mean annual flow, TPcrit is the total phosphorus criterion (75 µg/L for headwater streams), and FWM/GSM is the conversion factor described in Section 5.1. Phosphorus loading capacity was calculated for non-headwater stream reaches using the headwater equation and then subtracting the loading capacity of all upstream reaches. Loading capacities for each stream reach are reported in **Appendix J** using the current criteria and **Appendix K** using the proposed SSC for Lakes Petenwell, Castle Rock, and Wisconsin.

## 5.4 Lakes and Reservoirs

Phosphorus loading capacity for each impaired lake and reservoir was calculated with one of two models described in detail in **Appendix H** and **Appendix I.**

Phosphorus loading capacity for Castle Rock and Petenwell Reservoirs was calculated with a custom model based on a paper by Jensen et al. (2006). The Jensen model is an empirical mass balance model that uses daily inflows of water and TP and reservoir water temperature as inputs. The change in TP concentration in the reservoir is modeled as a difference between input and output, the sedimentation of TP is deducted, and the release of TP from the sediment is added. Separate Jensen models were developed for Petenwell Reservoir, the main body of Castle Rock Reservoir, and the Yellow River arm of Castle Rock Reservoir. The models simulate daily TP concentrations over the 2010-2013 monitoring period. Once calibrated (see **Appendix H** for details), the TP loading capacity for each reservoir (Table 16) was calculated by reducing the inflow TP concentration by a fixed percentage on every day of the year until the summer (June-Sept) mean TP concentration met the criterion (40 µg/L).

Loading capacity for Big Eau Pleine Reservoir, Lake DuBay, and Lake Wisconsin was calculated with the BATHTUB model (Walker, 1999). Like the Jensen model, BATHTUB is an empirical mass balance model that uses inflows of water and P as inputs. Unlike the Jensen model, BATHTUB uses average annual inputs and therefore estimates steady state reservoir conditions. Separate BATHTUB models were developed for each water body and are described in detail in the reports in **Appendix I.** The TP loading capacity for each water body was calculated by reducing the annual TP load until the predicted summer TP concentration met applicable criterion (Table 16).

Table 16. Summary of current loading and loading capacity for total phosphorus (TP) in WI River Basin impaired lakes and reservoirs

| Water Body | 2010-13 Inflow TP Load (tons/yr) | Inflow TP Loading Capacity (tons/yr) | TP Load Reduction[7] | TP Retention[8] | 2010-13 Summer TP Conc (µg/L) | TP Criterion (µg/L) |
|---|---|---|---|---|---|---|
| Petenwell Lake | 472 | 175 | 63% | 18.5% | 109 | 40 |
| Castle Rock Lake (Main Body) | 362 | 184 | 49% | 8.7% | 79 | 40 |
| Castle Rock Lake (Yellow River Arm) | 65 | 26 | 60% | | 101 | 40 |
| Big Eau Pleine Reservoir | 95 | 15 | 84% | 42% | 123 | 30 |
| Lake DuBay | 344 | NA | NA | 12% | 90 | 100 |
| Lake Wisconsin | 640 | NA | NA | NA | 97 | 100 |
| Lake Delton | 8.1 | 3.7 | 54% | 20% | 73 | 40 |
| Lake Redstone | 3.9 | 1.3 | 67% | 0% | 57 | 30 |
| Minocqua Lake | 1.4 | 1.1 | 17% | 0% | 17 | 15 |
| Kawaguesaga Lake | 1.2 | 1.0 | 15% | 0% | 18 | 15 |

[7] Percent reductions in this table are from the current load, which is different from reductions from baseline, which is how reductions are expressed in the allocation tables.
[8] Percent of TP load that is retained when inflow equals loading capacity.

## 5.5 Allowable Watershed Loads

The allowable annual load for TP was determined for each TMDL reach using the critical conditions described above. Daily loads were calculated by dividing the annual load by 365.25 days per year and rounding up to three significant digits. Loading capacities for each reach are reported in Appendix J using the current criteria and Appendix K using the proposed SSC for Lakes Petenwell, Castle Rock, and Wisconsin. While TMDLs must be expressed as daily loading rates, ecosystem responses to phosphorus inputs occur at longer timescales and are largely decoupled from short-term fluctuations in phosphorus loading. The approach of using longer-term averages for implementation of the TMDL is consistent with how Wisconsin's phosphorus criteria were developed.

## 5.6 Site-Specific Criteria and Load Capacity Analysis

The loading capacity for the Wisconsin River Basin has been calculated under two scenarios, one based on the current promulgated criteria and a second under a SSC scenario. The SSC scenario is based on the proposed SSC for Lakes Petenwell, Castle Rock, and Wisconsin. The current default criteria and the proposed SSC are listed in Table 5 in Section 1.5.

The calculation for the loading capacity under the proposed SSC followed the same process outlined above. In both scenarios, load capacity was calculated for headwater stream reaches, and non-headwater stream reaches, and the lakes and reservoirs. The only difference in the calculations was the loading capacity under the SSC analysis utilized the proposed SSC target concentrations in calculating the loading capacity.

# 6 POLLUTANT LOAD ALLOCATIONS

The objective of a TMDL is to allocate loads among pollutant sources so that appropriate control measures can be implemented and water quality standards achieved. Wasteload allocations (WLAs) are assigned to point source discharges regulated by WPDES permits and nonpoint source loads are assigned load allocations (LAs), which include both anthropogenic and natural background sources of a given pollutant.

The load allocation is the portion of the waterbody's total loading capacity attributed to existing and future nonpoint sources, including natural background sources. The wasteload allocation is the portion of the waterbody's total loading capacity that is allocated to point sources (for example, municipal or industrial wastewater facilities).

TMDLs must also include a margin of safety (MOS) to account for the uncertainty in predicting how well pollutant reduction will result in meeting water quality standards, and account for seasonal variations. A reserve load capacity (RC) may be included in a TMDL to account for future discharges, changes in discharges, and other sources not defined through the TMDL study.

This TMDL includes two sets of pollutant load allocations, one based on the current promulgated criteria and a second under the proposed SSC for Lakes Petenwell, Castle Rock, and Wisconsin. The current criteria and the proposed SSC are listed in Table 5 in Section 1.4. Both sets of allocations are set to meet the loading capacity under each of the two scenarios. The process used in the allocation process is the same under both scenarios; just the loading capacities changed for Lakes Petenwell, Castle Rock, and Wisconsin. The proposed process for implementing the allocations, specifically the wasteload allocations associated with WPDES permits, is discussed in Section 7.6; however, it is important to note that until the proposed SSC are adopted by rule and approved by USEPA only the allocations in **Appendix J** can be implemented in WPDES permits.

## 6.1 TMDL Equation

A TMDL is expressed as the sum of all individual WLAs for point source loads, LAs for nonpoint source loads, and an appropriate MOS, which takes into account uncertainty:

$$TMDL = \Sigma WLA + \Sigma LA + MOS + RC$$

$\Sigma WLA$ is the sum of wasteload allocations (point sources), $\Sigma LA$ is the sum of load allocations (nonpoint sources), MOS is the margin of safety, and RC is the reserve capacity.

## 6.2 Load Allocation Approach

Load and wasteload allocations were developed for the following source types:

| Load allocations: | Wasteload allocations: |
|---|---|
| • Background sources (woodland, wetland, and natural areas) | • Individual WPDES permittees (WW, MS4, CAFO) |
| • Agricultural sources | • General WPDES permittees (WW, stormwater, CAFO) |
| • Non-permitted urban areas (NPUs) | |

The phosphorus load allocation approach involves several steps:

1. Determining baseline loadings from all sources
2. Determining the reductions needed to meet local water quality criteria
3. Determining the reserve capacity allocation
4. Determining the reductions needed to meet downstream reservoir criteria

5. Checking the point source concentrations and adjusting, if needed

The specifics of determining the baseline loadings for each source type are described in the following sections. Allocations for background and general permits were set equal to each of their baseline loads. Before allocating loads to other source types, the background load and a load assigned to general permits were subtracted from the total allowable reach load to set aside the loads that cannot likely be reduced further; the remaining load is considered "controllable".

The allocation process depends on whether the baseline reach load is greater than or less than the allowable reach load and whether the reach contains a reservoir with a criterion that is different than the incoming reach criterion. Each case is presented below, and visualized in **Figure 25**, **Figure 26**, and **Figure 27**.

Case 1: Reach baseline load above reach allowable load

Using the reach allowable load, the background and general permit loads are first subtracted. The reserve capacity is set to 5% of the remaining controllable load. If a downstream reservoir requires additional reductions, the reserve capacity and the remaining source loads are reduced proportionally by the necessary amount resulting in the reserve capacity remaining 5% of the final controllable load.

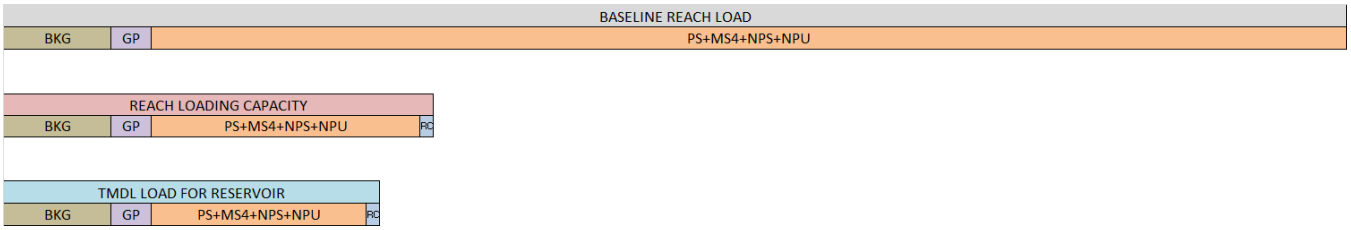


**FIGURE 38. ALLOCATION APPROACH WHEN BASELINE LOAD IS ABOVE ALLOWABLE LOAD**

Case 2: Reach baseline load below reach allowable load

Since the baseline reach load is less than the reach allowable load, no load reductions are required to meet local water quality criteria. The reserve capacity is set to 5% of the reach controllable load (point source, MS4, NPS, NPU, & RC) and added to the baseline reach load. If a downstream reservoir requires reductions, the reserve capacity and the remaining source loads are reduced proportionally by the necessary amount resulting in the reserve capacity remaining 5% of the final controllable load.

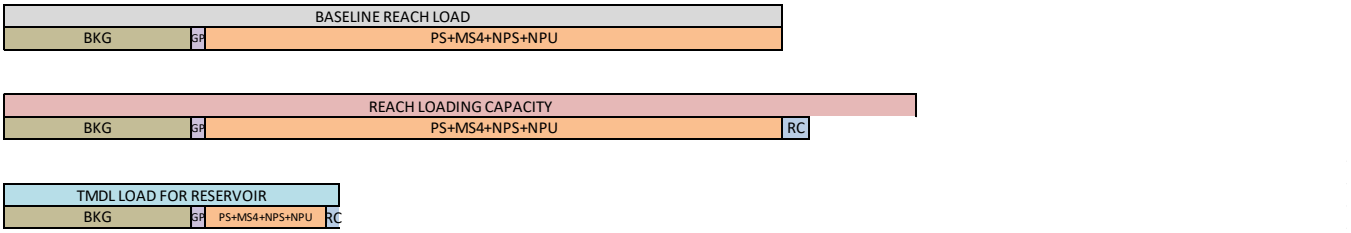


**FIGURE 39. ALLOCATION APPROACH WHEN BASELINE LOAD IS BELOW ALLOWABLE LOAD**

Case 3: Reach contains reservoir

Reductions from the baseline reach load for subbasins containing reservoirs are made to the controllable load as necessary. The reserve capacity is then set at 5% of the reduced controllable load and subtracted from the remaining controllable load.

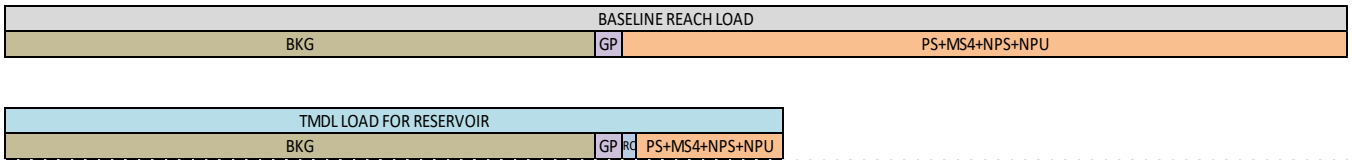


**FIGURE 40. ALLOCATION APPROACH FOR REACH WITH A RESERVOIR**

In general, loads are reduced by reach from upstream to downstream based on the local reach allowable load. At the reservoirs, the incoming load is calculated and compared to the allowable reservoir load, determined from modeling as described in Section 5.4. The difference is the amount of reduction that needs to come from all upstream subbasins. In an iterative process, the controllable load of each upstream reach is incrementally reduced until the total required amount of reduction to the reservoir is achieved. Reaches with reductions for local criteria that exceed the percent reduction for the downstream reservoir are not further reduced.

In reservoir reaches, a fraction of the inflowing pollutant load may be retained. The fraction of pollutant that is retained was estimated from the BATHTUB and Jensen reservoir models (see Section 5.4) and is assumed to remain constant as the inflowing load is reduced. The reach calculations then continue downstream to the outlet of the basin.

The fraction of the controllable load that is allocated to each source category is equal to its fraction of the baseline load as calculated over the 12-year model simulation period. These fractions were calculated separately for each reach. This method assigns responsibility for attaining water quality targets in proportion to each source's current contribution to the excess load.

A final check is done to determine if any of the permitted wastewater facilities have received an allocation that puts their effluent concentration below the local water quality criterion. If their reductions are due to downstream reservoirs, the following applies:

If the facility's baseline concentration is greater than the local criterion and the initial TMDL concentration is less than the local criterion, the load is recalculated so the final TMDL concentration is equal to the local reach criterion. If the facility's baseline concentration is less than the local criterion and the initial TMDL concentration is less than the baseline concentration, the load is recalculated so the final TMDL concentration equal to their baseline concentration. The resulting differences in load reductions are then subtracted from all other reaches upstream of the same reservoir. Allocations are then rebalanced so that reserve capacity is 5% of the allocable controllable load and each source's allocation is proportional to its baseline contribution.

Allocations must not exceed established regulations. CAFO wasteload allocations are set to zero because CAFOs must comply with all authorized discharge and overflow requirements described in the State of Wisconsin's NPDES CAFO General Permit. In accordance with the CAFO General Permit, overflow events from CAFOs are allowable due to precipitation related overflows from CAFO storage structures which are properly designed, constructed, operated and maintained in accordance with CAFO permits. Discharges from such overflows are allowable only if they do not cause or contribute to a violation of water quality standards.

Allocations were calculated separately for each source or source type in each TMDL reach on an annual basis. The phosphorus allocations by reach and source type are presented in Appendix J. Baseline loads were presented in **Appendix F**.

To address the possibility of SSCs being developed for Lakes Petenwell, Castle Rock, and Wisconsin, allocations were also calculated based on the SSC allowable loads and are shown in **Appendix K**.

## 6.3 Load Allocations

### 6.3.1 Background Sources

Baseline background loads (forest, grassland, and wetlands,) were determined from the SWAT model results. Allocations for background sources are equal to the baseline background load for that TMDL reach (no load reduction from baseline). Details regarding the modeling conditions used to determine baseline loads from background sources can be found in the SWAT model report (Sections 3 and 4 of **Appendix D**).

### 6.3.2 Agricultural Sources

Baseline agricultural phosphorus loads were calculated from the cropland cover areas including dairy, cash grain and potato and vegetable rotations based on existing management conditions used in the SWAT calibrated model (i.e. baseline loads were set equal to existing loads). Details regarding the modeling conditions used to determine baseline loads from agricultural lands can be found in the SWAT model report (Sections 3 and 4 of **Appendix D**). Agricultural sources received allocations proportional to their contribution to the total controllable baseline phosphorus load for each reach over the 12-year model period.

Total annual phosphorus load allocations for agricultural sources can be found in **Table J-1** of **Appendix J**. Total annual phosphorus load allocations for agricultural sources based on the proposed SSCs for Lakes Petenwell, Castle Rock, and Wisconsin, are shown in **Table K-1** of **Appendix K**. The load allocations are also presented based on the percent reduction from baseline in **Tables J-5** and **K-5**. The percent reduction is expressed in three ways; as the percent reduction needed to protect local water quality, the percent reduction necessary to meet downstream water quality criteria such as those for Lakes Petenwell, Castle Rock, and Wisconsin, and the total percent reduction. The total percent reduction represents what is needed to meet both local and downstream water quality criteria.

### 6.3.3 Non-Permitted Urban Sources

Baseline phosphorus loads for non-permitted urban areas were calculated from the non-background and non-agricultural land covers outside of a permitted MS4 municipal boundary as determined both in SWAT and in WinSLAMM. Non-permitted urban sources received allocations proportional to their contribution to the total controllable baseline load for each reach over the 12-year model period. Details regarding the modeling conditions used to determine baseline loads from non-permitted urban areas can be found in the SWAT model report (Sections 3 and 4 of Appendix D).

Total annual phosphorus load allocations for non-permitted urban areas can be found in **Table J-1** of **Appendix J**. Total annual phosphorus load allocations for non-permitted urban areas based on the proposed SSCs for Lakes Petenwell, Castle Rock, and Wisconsin, are shown in **Table K-1** of **Appendix K**.

The load allocations are also presented based on the percent reduction from baseline in **Tables J-5** and **K-5**. The percent reduction is expressed in three ways; as the percent reduction needed to protect local water quality, the percent reduction necessary to meet downstream water quality criteria such as those for Lakes Petenwell, Castle Rock, and Wisconsin, and the total percent reduction. The total percent reduction represents what is needed to meet both local and downstream water quality criteria.

## 6.4 Wasteload Allocation

### 6.4.1 Permitted Municipal and Industrial Wastewater Discharges

The phosphorus baseline loads for municipal and industrial wastewater discharges covered by an individual WPDES permit with specified limits are discussed in Section 4.4.2.1. In generally, individually permitted wastewater dischargers received allocations proportional to their baseline load. Exceptions to this rule were made to low-strength discharges which discharged at concentrations less than the local water quality criterion. The WLA contained in this TMDL will be expressed in permits as a mass limit. In many cases, discharges will also receive a concentration limit for TP, based on the TBEL requirements in Subchapter II of NR 217, Wis. Adm. Code.

Annual total phosphorus wasteload allocations by permitted point source are shown in **Table J-3** in **Appendix J**. Wasteload allocations set to address the proposed SSCs for Lakes Petenwell, Castle Rock, and Wisconsin, are shown in **Table K-3** of **Appendix K**. **Tables J-3** and **K-3** both present wasteload allocations broken out by the total wasteload allocation for the facility, the wasteload allocation assigned to the facility needed to meet local water quality in the reach the facility discharges into, and the wasteload allocation required to meet downstream water quality in Lakes Petenwell, Castle Rock, and Wisconsin. WDNR has broken out the allocations in this manner to help facilitate water quality trading, since the geographic extent in which trades can occur is based on the point of standards application as outlined in the "Guidance for Implementing Water Quality Trading in WPDES Permits". A copy of the guidance can be found at: https://dnr.wi.gov/topic/SurfaceWater/WaterQualityTrading.html or by searching for "water quality trading" at http://dnr.wi.gov/.

Section 40 CFR 122.45 (d), s. NR 212.76 (4), and s. NR 205.065 (7), Wis. Adm. Code, specifies that unless impracticable, permit effluent limits must be expressed as weekly and monthly averages for publicly owned treatment works and as daily maximums and monthly averages for all other continuous discharges. A continuous discharge is a discharge which occurs without interruption throughout the operating hours of the facility, except for infrequent shutdowns for maintenance, process changes, or other similar activities (40 CFR § 122.2).

The Department has demonstrated the impracticability of expressing WQBELs for TP as specified in 40 CFR § 122.45 (d). The impracticability demonstration indicates that WQBELs for TP shall be expressed as a monthly average, if the TP WQBEL is equivalent to a concentration value greater than 0.3 mg/l, and as a six-month average and a monthly average limit of 3 times the six-month average, if the TP WQBEL is equivalent to a concentration value less than 0.3 mg/l.

For non-continuous discharges, methods for converting WLAs into permit limits should be determined on a case-by-case basis. For example, some discharges do not occur continuously and often vary from year to year, depending on weather conditions or production processes. In these cases, it may be appropriate to express limits by season or as a total annual amount. In many cases, using shorter term limits (daily, monthly) might have the effect of unduly limiting operational flexibility and, since TMDLs are required to be protective of critical conditions, a seasonal or annual limit would be consistent with the TMDL and protective of water quality.

Discharges covered by individual permits that have surface water intake structures are allowed to pass through the phosphorus that is present due to the water supply but are expected to remove any excess that is added or concentrated in their discharge to meet their wasteload allocation.

There are a limited number of discharges in the basin that discharge to large wetland complexes or other non-contributing areas which may not impact downstream surface waters. As wetlands and other limited aquatic life waters do not have phosphorus criteria (see s. NR 102.06(6), Wis. Admin. Code), discharges to

these types of systems have a point of standards compliance downstream of their outfall and the wasteload allocation is designed to be protective of this and all downstream locations. In such instances, the Department may consider phosphorus losses prior to the point of standards compliance as part determining whether permit limitations are consistent with the TMDL wasteload allocation.

### 6.4.2 General Permits

WDNR authorizes the discharge of stormwater and wastewater from industrial facilities, CAFOs, and construction sites under a set of general WPDES permits. Unlike individual WPDES permits, general permits are not written to reflect site-specific conditions of a single discharger, but rather are issued to cover multiple dischargers that have similar operations and types of discharges. Stormwater general permits cover discharges from industrial and construction sites (see https://dnr.wi.gov/topic/stormwater/). CAFO general permits are issued to large dairies with 1,000 to 5,720 animal units (see https://dnr.wi.gov/topic/AgBusiness/CAFO/PermitTypes.html). Wastewater general permits cover multiple categories, including: NCCW, nonmetallic mining (quarries), car washes, swimming pools, and other discharges (see https://dnr.wi.gov/topic/wastewater/generalpermits.html for a full list of Wastewater general permits).

Wasteload allocations for general permittees located within an MS4 boundary were included in the MS4 WLA. WLAs for general permittees located outside of MS4 areas were allocated as 10% of the non-permitted urban baseline load for TP. This general permit load was set aside from the loading capacity with no reduction from the baseline described in Section 4.4.2.2.

Many NCCW discharges in this TMDL area are covered by a general permit (WI-0044938). Similar conditions are assumed for these facilities as for those with individual permits. That is, for facilities that use water from a public water supply, it is assumed that phosphorus will be present in the NCCW if added by the water supply. Discharges covered by general permits that have surface water intake structures are assumed to have no net addition. Similar to individual permit holders, general permittees are allowed to pass through the phosphorus that is present due to the water supply but are expected to remove any excess that is added or concentrated in their discharge.

NCCW facilities covered under the general permit and located in watersheds with approved TMDLs are required to submit quarterly monitoring results for P and TSS. These monitoring results will be used to track the total mass allocation used by NCCW facilities in each watershed. If through the increased monitoring and tracking it is determined that sufficient allocation has not been set aside for NCCW facilities, facilities may be switched to individual permits with discharge requirements placed in the permit sufficient to meet TMDL allocations and/or reserve capacity may be used to increase the WLA for general permits, where necessary.

### 6.4.3 Permitted Municipal Separate Storm Sewer Systems

As described in Section 4.4.2.3, there are 15 permitted MS4s within the basin that will receive wasteload allocations under this TMDL project. Baseline MS4 TP and TSS loads were determined from the WinSLAMM modeling described in Section 4.3.1.2 and detailed in Section 4.4 of **Appendix D**. The WinSLAMM results used in the existing conditions SWAT model were adjusted for baseline conditions to reflect the 20% TSS reduction requirement and corresponding 15% reduction in TP. The corresponding 15% TP reduction is calculated in SLAMM by applying BMPs to obtain the 20% TSS reduction. The reduction relationship is not 1:1 because of the portioning between phosphorus attached to sediment and soluble phosphorus.

The permitted area is determined by the US Census Bureau's mapped Urbanized Area, adjacent developed areas, or areas that are connected or will connect to other municipal separate storm sewer systems regulated under subch. I of NR 216, Wis. Adm. Code. Because of the large spatial expanse of the Wisconsin River Basin, each modeled MS4 area utilized a different rainfall file to best represent local conditions. Therefore, unique monthly flows and loads were generated for each MS4 to determine baseline conditions.

MS4 permittees received allocations proportional to their contribution to the total baseline load for each TMDL reach to which they discharge. There may be MS4s in the basin that have already implemented practices that achieve an annual average TSS reductions of greater than 20% or TP reduction of greater than 15%. While these individual modeled results have not been included in the TMDL analysis, these above-baseline condition reductions will be credited towards meeting water quality targets established in the WPDES permits regulating these municipalities.

Marathon County and University of Wisconsin-Stevens Point are both covered by a WPDES MS4 permit but will not receive individual allocations. Instead, their allocations are lumped into the portions of each city, village, or town MS4 that they discharge to or lie within. This is because at the current level of analysis, it was not possible to break-out blended and nested MS4 systems. As part of the implementation planning process, permittees are required to map out their MS4 systems. Once completed, allocations can be partitioned based on area; however, once implemented this simplifies to Marathon County and University of Wisconsin-Stevens Point receiving the same percent reduction assigned to the city, village, or town MS4 that portions of their MS4 discharge to or lie within. Refer to the MS4 TMDL Implementation Guidance for details on how the allocation is partition and the percent reduction is used to implement the TMDL allocations; "TMDL Guidance for MS4 Permits: Planning, Implementation, and Modeling Guidance". The guidance and addendums can be found at: https://dnr.wi.gov/topic/stormwater/standards/ms4_modeling.html

Stormwater discharge from Wisconsin Department of Transportation (WisDOT) land areas are not currently covered by a WPDES permit; however, a WPDES permit is being developed. This permit, referred to as the TS4 permit, along with the conditions of a memorandum of understanding with WDNR will be used to implement the TMDL requirements for WisDOT discharges. A section of the MS4 permit is dedicated to the implementation of the TMDL requiring WisDOT to comply with the TMDL allocation set forth in this TMDL.

The specific TS4 allocation is included in the allocation for each MS4 with WisDOT area. At the time the watershed modeling was conducted for this TMDL, sufficient detail did not exist to partition out the TS4 allocation and assign an explicit allocation. Please refer to the MS4 TMDL Implementation Guidance for details on how to partition the allocation; "TMDL Guidance for MS4 Permits: Planning, Implementation, and Modeling Guidance". The guidance and addendums can be found at: https://dnr.wi.gov/topic/stormwater/standards/ms4_modeling.html

Annual total phosphorus wasteload allocations by MS4 and reach are shown in Table J-4 in Appendix J. Total annual phosphorus wasteload allocations by MS4 and reach based on the proposed SSCs for Lakes Petenwell, Castle Rock, and Wisconsin, are shown in Table K-4 of Appendix K.

The percent reduction from baseline that would apply to each MS4 are broken out by reach in Tables J-5 and K-5. The percent reduction is expressed in three ways; as the percent reduction needed to protect local water quality, the percent reduction necessary to meet downstream water quality criteria such as those for Lakes Petenwell, Castle Rock, and Wisconsin, and the total percent reduction. The total percent reduction represents what is needed to meet both local and downstream water quality criteria. Guidance related to applying the percent reduction to implement the TMDL can be found in the MS4 TMDL Implementation Guidance: "TMDL Guidance for MS4 Permits: Planning, Implementation, and Modeling Guidance". The guidance and addendums can be found at: https://dnr.wi.gov/topic/stormwater/standards/ms4_modeling.html

### 6.4.4 Concentrated Animal Feeding Operations

Baseline CAFO loads were set to zero as discharges from CAFO production areas must be consistent with WPDES permit requirements. Likewise, CAFOs received a wasteload allocation of zero. Land spreading loads associated with CAFO operations are included in the nonpoint source allocations.

## 6.5 Margin of Safety

A margin of safety (MOS) is included in the TMDL to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality. The MOS can be implicit using conservative assumptions in the analysis or explicit by allocating a portion of the loading directly to a MOS. The MOS in this TMDL is implicit and is based on one conservative assumptions and one aspect of the allocation process.

First, the fraction of the TP load from background (forest and wetland) sources may be over-estimated. The TP concentration assigned to groundwater in the SWAT model is really an estimate of background stream TP (Robertson et al. 2006). An unknown fraction of background stream TP is derived from land surface processes, so assigning this concentration entirely to groundwater means that background TP loads are likely overestimated. Therefore, if controllable TP loads are reduced by their allocated amounts, the net TP load may be lower than needed to meet TP criteria.

Second, the loading capacity of Petenwell and Castle Rock Reservoirs requires load reductions from most tributaries beyond what is needed to meet local stream criteria. The difference between these two levels of loading capacity is an MOS for tributary water quality. Across the entire basin, approximately half of the required load reduction is attributable to a downstream reservoir (**Tables J-5** and **K-5).**

An additional explicit MOS was determined to be unnecessary because understanding of the relationship between TP loading and water quality response is excellent in the Wisconsin River Basin. First, the amount of monitoring data collected to support the TMDL development was unprecedented in Wisconsin, including the number of stations, period of record, and sampling frequency. Second, the initial bias in modeled pollutant loads was corrected with the tributary routing model. Third, the main stem routing analysis found a consistent relationship between measured main stem TP loads and the sum of measured and modeled tributary loads, further validating the tributary modeling and bias correction. And fourth, the recommended site-specific TP criteria for Petenwell and Castle Rock Flowages, and Lake Wisconsin are based on strong empirical relationships between TP and Chlorophyll-a, the designated use indicator. In summary, there are multiple lines of evidence that the loading capacity estimates are accurate and will result in the attainment of designated uses in the Wisconsin River Basin.

## 6.6 Reserve Capacity

A reserve capacity (RC) was included in the TMDL allocations to account for future discharges, changes in current discharger loading, and other sources not defined through TMDL development. Reserve capacity is intended to provide wasteload allocation for new or expanding industrial, CAFO, or municipal WPDES individual permit holders. RC may be applied to general permittees if it is determined, through analysis of discharge monitoring data, that the amount set aside for GPs is not enough to cover the actual discharge amount. The reserve capacity is not intended to be applied to MS4s.

For TP, the natural background load and general permitted baseline loads were subtracted from the total allowable load for each TMDL reach, and then the RC was set as 5% of the remaining controllable load. This provides adequate reserve capacity for potential new or expanding dischargers in headwater sections of the basin. In addition, reserve capacity accumulates from contributing reaches moving down through the basin making more available for dischargers located on larger downstream rivers. This approach affords dischargers greater flexibility in where they can locate or expand, minimizes impacts on existing dischargers, and is consistent with the observed practice of larger dischargers locating on larger bodies of water.

Baseline loads from municipal wastewater treatment plants were calculated using the design flow of the facility, which is based on a 20-year design life; therefore, the allocations for these point sources should account for future growth in many communities.

If a permittee wishes to commence a new discharge or expand an existing discharge of a pollutant covered by the TMDL and within the area covered by the TMDL, the permittee must submit a written notice of interest for reserve capacity along with a demonstration of need to WDNR. Interested dischargers will not be given a portion of the reserve capacity unless they can demonstrate a need for a new or increased wasteload allocation. Examples of point sources in need of WLA would include those that are a new discharge or those that are significantly expanding their current discharge and would be unable to meet current WLAs despite optimal operation and maintenance of their treatment facility.

A demonstration of need should include an evaluation of conservation measures, recycling measures, and other pollution minimization measures. New dischargers must evaluate current available treatment technologies and expanding dischargers should evaluate optimization of their existing treatment system and evaluation of alternative treatment technologies. In addition to evaluation of treatment options, an expanding discharger must demonstrate that the request for reserve capacity is due to increasing productions levels or industrial, commercial, or residential growth in the community.

If the department determines that a new or expanding discharger qualifies for reserve capacity, the reserve capacity, if available, will be distributed using the procedures outline below:

New Discharger: For a new discharger, calculate the water quality based effluent limit (WQBEL) per ch. NR 217, Wis. Adm. Code, for phosphorus. If the discharger can meet the resulting limit with available technology than the limit is translated into a mass and this mass becomes the amount of reserve capacity allocated to the discharger. If the discharger is unable to meet the limit with available technology than more reserve capacity, up to a maximum cap, can be allocated to the discharger. The maximum cap is calculated based on the facility's flow and the highest concentration for a similar type facility and treatment system.

Determination of the wasteload allocation available to a new discharge will depend on the type and condition of the immediate receiving water. Limitations for new discharges to Outstanding Resource Waters shall be based on s. NR 207.03(3), Wis. Adm. Code. Limitations for new discharges to Exceptional Resource Waters which are not needed to prevent or correct either an existing surface or groundwater contamination situation, or a public health problem shall be based on s. NR 207.03(4)(b), Wis. Adm. Code. For all other situations involving new discharges, the following procedures apply to determine the appropriate mass allocation:

a) Determine the mass of reserve capacity that is available in the given reach.

b) Calculate the water quality based effluent limit (WQBEL) per s. NR 217.13(2)(a) and the associated mass limit per s. NR 217.14(3), Wis. Adm. Code. Calculation should be based on current upstream water quality and for purposes of this calculation any other discharges within the given reach may be ignored.

c) Calculate the mass load associated with the baseline condition for the class of the new discharger. Then apply the TMDL reductions, consistent with the applicable reach, to the baseline condition to determine the resultant mass. Baseline conditions, consisting of concentration and flows, are set for different classes of dischargers and are summarized in Section 4.4.2.1.

d) Set the wasteload allocation equal to the most restrictive of the values determined by the above methods.

For a new discharge directly to a lake or reservoir, use the following procedure to determine the appropriate mass allocation:

a) Determine the amount of reserve capacity that is available for the lake or reservoir. This can include unassigned reserve capacity from contributory reaches located upstream of the lake or reservoir.

b) Calculate the WQBEL per s. 217.13(3) and associated mass limit per s. NR 217.14(3), Wis. Adm. Code.

c) Set the wasteload allocation equal to the more restrictive of the values determined by the above methods.

Expanding Discharger: For an expanding discharger, reserve capacity will be allocated to cover the increased mass attributed to the facility expansion, measured as the increase in flow over the flow assumed in the TMDL baseline (see Section 4.4.2.1), minus any reductions that can be realized through optimization or economically viable treatment technologies.

If a new or expanding discharger requires more mass than what was allocated through reserve capacity the difference between the mass discharged and their allocation can be made up through an offset such as water quality trading. If there is not sufficient reserve capacity available, the discharge must be offset or the TMDL can be re-evaluated to determine if more assimilative capacity has become available since the original analysis.

Reserve capacity should be taken equally from all reaches upstream and in which the discharger is located. As additional demands are placed on available reserve capacity, it may become necessary to shift the location that previously assigned reserve capacity was taken, provided the total loading capacity for each reach is maintained. WDNR will maintain a database system to track assigned reserve capacity. Once reserve capacity reaches levels that it is no longer usable, the TMDL will need to be re-evaluated to see if additional assimilative capacity has become available since the original TMDL analysis due to changes in flow or implementation of the reductions prescribed in the TMDL.

Reserve capacity is not required for new or expanding permitted MS4s. For new or expanding permitted MS4s, the mass associated with the load allocation for the nonpermitted, undeveloped, or agricultural land, that is now part of the permitted MS4, is transferred to the wasteload allocation with a percent reduction in pollutant load assigned to the new or expanding permitted MS4 area consistent with the reductions stipulated in the TMDL for the reachshed. Refer to "TMDL Guidance for MS4 Permits: Planning, Implementation, and Modeling Guidance" and corresponding addendums for process details. The MS4 guidance and addendums can be found at https://dnr.wi.gov/topic/stormwater/standards/ms4_modeling.html.

For CAFOs, the TMDL assigns the production area a wasteload allocation of zero; however, reserve capacity is available to cover a new or expanding continuous or intermittent surface water discharge resulting from a manure treatment system. If reserve capacity is not available, the mass resulting from a treatment system discharge must be offset through water quality trading. This offset can be generated through reductions in pollutant loads associated with modifications in manure applications to fields resulting from the treatment system or changes in the CAFO's operation. Fields receiving manure from the CAFO are covered by the nonpoint load allocation.

WDNR will use the information provided by the permittee to determine if reserve capacity is available and then issue, reissue, or modify a WPDES permit to implement a new WLA based on application of reserve capacity. The new WLA will be used as the basis for effluent limits in the WPDES permit. EPA will be notified if a new or increased WLA is developed.

Pursuant to 40 CFR § 122.41(g) and s. NR 205.07(1)(c), Wis. Adm. Code, a WPDES permit does not convey any property rights of any sort nor any exclusive privilege. All proposed reserve capacity assignments are subject to WDNR review and approval and must be consistent with applicable regulations. Reserve capacity decisions and related permit determinations are subject to public notice and participation procedures as well

as opportunities for challenge at the time of permit modification, revocation and reissuance, or reissuance under Chapter 283, Wis. Stats.

## 6.7 Seasonal Variation

The method for linking TP criteria to loading capacity is based on their existing relationship and the assumption that the frequency distribution and seasonal pattern of a reduced TP load will be similar to the current conditions. For nonpoint sources, this means that changes in land management will need to be effective throughout the year. While this may not be true for any single practice, it is anticipated that a broad suite of practices will be used, and that the collective effects of these practices at the watershed scale will meet this assumption. Discharges from point sources have much less seasonal variation, and it is expected that any required reductions will be approximately uniformly distributed seasonally.

# 7 TMDL IMPLEMENTATION

## 7.1 Implementation Planning

The next step following approval of the TMDL is to develop an implementation plan that specifically describes how the TMDL goals can be achieved, over time. WDNR has hired a TMDL Project Manager to deal specifically with implementation of the TMDL. Implementation planning will build on past planning and implementation of practices to control or reduce nutrient and sediment pollutants in the Wisconsin River Basin. The implementation planning process will develop strategies to most effectively utilize existing federal, state, and county-based programs to achieve wasteload and load allocations outlined in the TMDL. This TMDL will be implemented through enforcement of existing regulations, financial incentives, and various local, state, and federal water pollution control programs. The plan will build upon knowledge gained in recent planning efforts, some of which are discussed in more detail below.

Effective implementation of the load allocations in the TMDL requires addressing both environmental conditions and the choices people make that impact the environment. Because nonpoint source pollution control relies heavily on the voluntary actions of citizens, applying best practices to those problems will require establishing trusting relationships with the public and at the right scale so that water quality goals are achievable and measurable. The pollution problems that remain require new solution strategies that encourage and support collaboration, citizenship, transparency, and accountability at all levels of government (LimnoTech 2013). As part of this effort, WDNR has developed a framework for communicating agricultural load allocation by translating watershed models to field-scale models that are well understood by the agricultural community, ultimately putting the TMDL tools in the hands of producers to enhance their ability to estimate the downstream benefits of best management practices on their own fields (see **Appendix N** for TP targets for agricultural producers, and methods that can be used to aid with planning water quality trading agreements that result in meeting these TP targets). Required by the Clean Water Act, reasonable assurances provide a level of confidence that the wasteload allocations and load allocations in TMDLs will be implemented. This TMDL will be implemented through enforcement of existing regulations, financial incentives, and various local, state, and federal water pollution control programs. The following subsections describe some of the activities, programs, requirements, and institutional arrangements that will provide reasonable assurance that this TMDL will be implemented and that the water quality goals will be achieved.

## 7.2 Reasonable Assurances for Point Sources

WDNR regulates point sources through the WPDES permit program. Individual permits are issued to municipal and industrial wastewater discharges. General permits are issued to some classes of industries or activities that are similar in nature, such as NCCW and certain stormwater discharges. Once the TMDL WLAs have been state and federally approved, reissued permits must contain conditions consistent with the wasteload allocations. Individual permits issued to municipal and industrial wastewater discharges will include discharge limits consistent with the approved wasteload allocations. Dischargers with general WPDES permits will be evaluated to determine if additional requirements are necessary to ensure that discharges remain consistent with TMDL goals. This could include issuing individual WPDES permits to facilities that currently hold general permits.

WDNR regulates stormwater discharges from certain MS4s, industries, and construction sites under WPDES permits issued pursuant to ch. NR 216, Wis. Adm. Code. WDNR also established developed urban area, construction site, and post-construction performance standards under ch. NR 151, Wis. Adm. Code, which are implemented through stormwater MS4 and construction site permits. Once the TMDL WLAs have been state and federally approved, WDNR will incorporate permit conditions into stormwater permits consistent with the TMDL WLAs. Existing programs that detect and eliminate illicit discharges will continue to be implemented by municipalities. WPDES permit conditions already require monitoring and elimination of discovered discharges.

WDNR will monitor and enforce CAFO permit requirements so that CAFOs are operated and maintained to prevent discharges as required by their WPDES permit.

## 7.3 Reasonable Assurances for Nonpoint Sources

To attain the TMDL reduction goals, management measures must be implemented and maintained over time to control phosphorus and sediment loadings from nonpoint sources of pollution. Wisconsin's Nonpoint Source Pollution Abatement Program (NPS Program), described in the state's Nonpoint Source Program Management Plan (WDNR, 2015), outlines a variety of financial, technical, educational, and enforcement programs, which support implementation of management measures to address nonpoint source pollution. WDNR and the Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) coordinate statewide implementation of the NPS Program. The NPS Program includes core activities and programs, which are a high priority and the focus of WDNR and DATCP's efforts to address NPS pollution; these programs include those described in the following sections.

### 7.3.1 Statewide Agricultural Performance Standards & Prohibitions

WDNR is a leader in the development of regulatory authority to prevent and control nonpoint source pollution. Chapter NR 151, Wis. Adm. Code, establishes runoff management performance standards and prohibitions for agricultural and non-agricultural facilities and practices. These standards are intended to be minimum standards of performance necessary to achieve water quality standards, as described in Chapter 281.16. Implementing the performance standards and prohibitions on a statewide basis is a high priority for the NPS Program and requires having adequate WDNR staff and financial resources in order to meet the NR 151 implementation and enforcement procedures (NR 151.09 and 151.095). In particular, the implementation and enforcement of agricultural performance standards and manure management prohibitions, listed below, throughout the TMDL area will be critical to achieve the necessary nonpoint source load reductions. Such effort will require having adequate amounts of cost share funding to cover the cost for meeting TMDL NPS reductions.

- **Tillage setback:** A setback of 5 feet from the top of a channel of a waterbody for the purpose of maintaining stream bank integrity and avoiding soil deposits into state waters. Tillage setbacks greater than 5 feet but no more than 20 feet may be required if necessary to meet the standard. Harvesting of self-sustaining vegetation within the tillage setback is allowed.
- **Phosphorus Index (PI):** A limit on the amount of phosphorus that may run off croplands and pastures as measured by a phosphorus index with a maximum of 6, averaged over an eight-year accounting period, and a PI cap of 12 for any individual year.
- **Process wastewater handling**: a prohibition against significant discharge of process wastewater from milk houses, feedlots, and other similar sources.
- **Meeting TMDLs:** A standard that requires crop and livestock producers to reduce discharges if necessary to meet a load allocation specified in an approved Total Maximum Daily Load (TMDL) by implementing targeted performance standards specified for the TMDL area using best management practices specified in ch. ATCP 50, Wis. Adm. Code. If a more stringent or additional performance standard is necessary to meet water quality standards, it must be promulgated by rule before compliance is required. Before promulgating targeted performance standards to implement a TMDL, the department must determine, using modeling or monitoring, that a specific waterbody or area will not attain water quality standards or groundwater standards after substantial implementation of the existing ch. NR 151, Wis. Admin. Code performance standards and prohibitions.
- **Sheet, rill and wind erosion:** All cropped fields shall meet the tolerable (T) soil erosion rate established for that soil. This provision also applies to pastures.

- **Manure storage facilities:** All new, substantially altered, or abandoned manure storage facilities shall be constructed, maintained or abandoned in accordance with accepted standards, which includes a margin of safety. Failing and leaking existing facilities posing an imminent threat to public health or fish and aquatic life or violate groundwater standards shall be upgraded or replaced.

- **Clean water diversions:** Runoff from agricultural buildings and fields shall be diverted away from contacting feedlots, manure storage areas and barnyards located within water quality management areas (300 feet from a stream or 1,000 feet from a lake or areas susceptible to groundwater contamination).

- **Nutrient management:** Agricultural operations applying nutrients to agricultural fields shall do so according to a nutrient management plan (Each nutrient management plan must be designed to limit or reduce the discharge of nutrients to waters of the state for the purpose of complying with state water quality standards and groundwater standards. In addition, for croplands in watersheds that contain impaired surface waters, a plan must be designed to manage soil nutrient concentrations so as to maintain or reduce delivery of nutrients contributing to the impairment of impaired surface waters. ATCP 50.04 c additional requirements for all nutrient management plans. This standard does not apply to applications of industrial waste, municipal sludge or septage regulated under other WDNR programs provided the material is not commingled with manure prior to application.

- **Manure management prohibitions:**

    - no overflow of manure storage facilities
    - no unconfined manure piles in a water quality management area
    - no direct runoff from feedlots or stored manure into state waters
    - no unlimited livestock access to waters of the state in locations where high concentrations of animals prevent the maintenance of adequate or self-sustaining sod cover

WDNR, DATCP, and the county Land Conservation Departments (LCDs) will work with landowners to implement agricultural and non-agricultural performance standards and manure management prohibitions to address sediment and nutrient loadings in the TMDL area.

Some landowners voluntarily install BMPs to help improve water quality and comply with the performance standards. Cost-sharing funds, provided via state or federal funds, may or may not be available for many of these BMPs. Wisconsin statutes, and the NR 151 implementation and enforcement procedures of s. NR 151.09 and 151.095 Wis. Admin. Code, require that farmers must be offered at least 70% cost-sharing funds for BMP installation before they can be required to comply with the agricultural performance standards and prohibitions. If cost-share money is offered, those in violation of the standards are obligated to comply with the rule. The amount of cost sharing funds available for use by LCD's, DATCP and WDNR will require implementing the performance standards and prohibitions throughout the TMDL area over time. DATCP's Farmland Preservation Program requires that any agricultural land enrolled in the program must be determined to be in compliance with the performance standards by no later than 2020 to continue receive tax credits associated with the program.

### 7.3.2 County Agricultural Performance Standards & Prohibitions

Towns and counties may adopt ordinances to require permits for manure storage structures and regulate the spreading of the manure and wastes from these facilities. The DATCP oversees these local regulations under state statute Chapter 92. DATCP's administrative rule ATCP 50 spells out standards for manure storage ordinances, which may include the annual submission of a nutrient management plan that complies with s. ATCP 50.04 (3) Wis. Admin Code. Local governments must submit these ordinances to DATCP for review, but DATCP approval is not required. All counties with significant agricultural activity have adopted manure storage ordinances (Figure 41). The requirements associated with these ordinances varies by county.

Counties and towns may also require additional conservation practices on farm, however an offer of cost-sharing must be provided. DATCP and WDNR must approve any local regulations that exceed state agricultural performance standards.

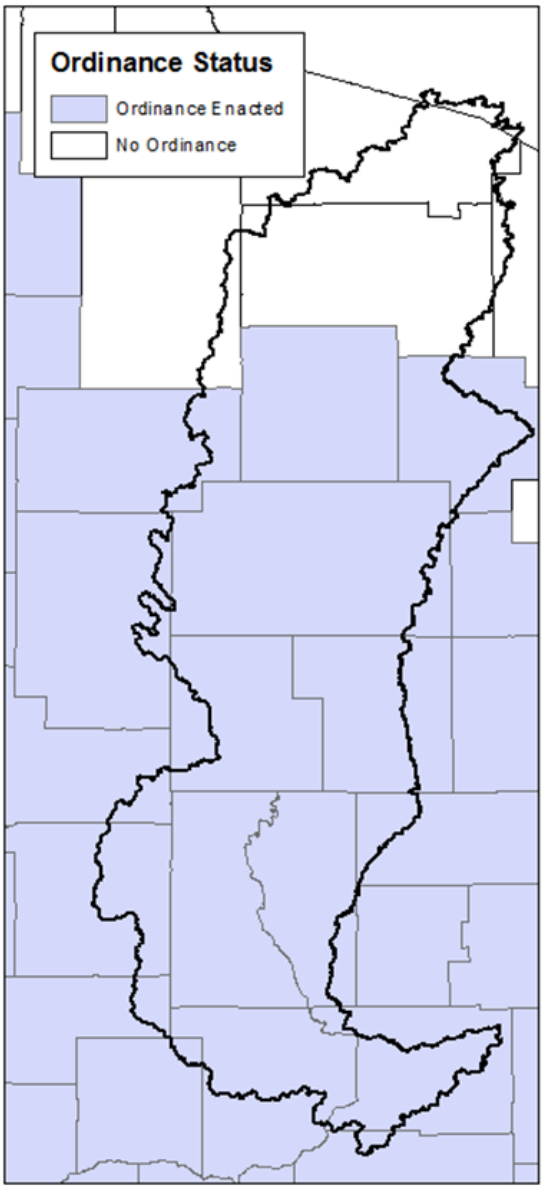


**FIGURE 41. COUNTIES WITH MANURE STORAGE ORDINANCES**

### 7.3.3 WDNR Cost Sharing Grant Programs

The counties and other local units of government in the TMDL area may apply for grants from WDNR to control NPS pollution and, over time, meet the TMDL load allocation. The WDNR supports NPS pollution abatement by administering and providing cost-sharing grants to fund BMPs through various grant programs, including, but not limited to:

- The Targeted Runoff Management (TRM) Grant Program
- The Notice of Discharge (NOD) Grant Program
- The Urban Nonpoint Source & Storm Water Management Grant Program
- The Lake Planning Grant Program
- The Lake Protection Grant Program
- The River Planning & Protection Grant Program

Many of the counties and municipalities in the TMDL area have a track record of participating in these NPS-related grant programs.

### 7.3.4 Targeted Runoff Management (TRM) Grant Program

#### 7.3.4.1 TRM GRANT PROGRAM OVERVIEW

Targeted Runoff Management (TRM) grants are provided by the WDNR to control nonpoint source pollution from both urban and agricultural sites. A combination of state General Purpose Revenue, state Bond Revenue, and federal Section 319 Grant funds is used to support TRM grants. The grants are available to local units of government (typically counties) and targeted at high-priority resource problems. TRM grants can fund the design and construction of agricultural and urban BMPs. Some examples of eligible BMPs include livestock waste management practices, some cropland protection, and streambank protection projects. These and other practices eligible for funding are listed in s. NR 154.04, Wis. Adm. Code.

Revisions to ch. NR 153, Wis. Adm. Code, (http://legis.wisconsin.gov/rsb/code/nr/nr153.pdf) which governs the program, took effect on January 1, 2011, and modified the grant criteria and procedures, increasing the state's ability to support performance standards implementation and TMDL implementation. Since the calendar year 2012 grant cycle, projects may be awarded in four categories:

| | TMDL | Non-TMDL |
|---|---|---|
| **Small Scale** | • Implements a TMDL<br>• Agricultural or urban focus | • Implements NR 151 performance standards<br>• Agricultural or urban focus |
| **Large Scale** | • Implements a TMDL<br>• Agricultural focus only | • Implements NR 151 performance standards<br>• Agricultural focus only |

Section 281.65(4c), Wis. Stats., defines additional priorities for Targeted Runoff Management Projects as follows:

- Projects must be targeted to an area based on any of the following:
    - Need for compliance with established performance standards.
    - Existence of impaired waters.
    - Existence of outstanding or exceptional resource waters.
    - Existence of threats to public health.
    - Existence of an animal feeding operation receiving a Notice of Discharge.
    - Other water quality concerns of national or statewide importance.
- Projects are consistent with priorities identified by WDNR on a watershed or other geographic basis.
- Projects are consistent with approved county land and water resource management plans.

The maximum cost-share rate available to TRM grant recipients is up to 70% of eligible costs (maximum of 90% in cases of economic hardship), with the total of state funding not to exceed established grant caps. TRM grants may not be used to fund projects to control pollution regulated under Wisconsin law as a point source. Grant application materials are available on the WDNR web site at: http://dnr.wi.gov/aid/targetedrunoff.html.

### 7.3.4.2 TRM GRANT PROJECTS IN THE TMDL PROJECT AREA

Since 2005, 29 TRM grants have funded the construction and implementation of agricultural best management in the TMDL project area. Over $3.7 million dollars in TRM grant awards have gone towards funding over $5.3 million in agricultural management practices, including construction of manure facilities storage, barnyard runoff control practices and implementation of other ch. NR 151, Wis. Admin. Code runoff management standards. A complete list of TRM grant projects funded since 2005 are listed in **Table L-1**, Agricultural Runoff Management Grant Projects in WI River TMDL project area. Urban Runoff management grant projects in the basin during this same timeframe are listed in **Table L-2**.

One recent notable TRM grant awarded in the project area was the $805,385.00 award received by Marathon County for Fenwood Creek Watersheds, the most significant P loading HUC-12 within the Big Eau Pleine Watershed; the Big Eau Pleine itself is the highest loading tributary upstream of Petenwell Reservoir. This grant award spans Jan. 1, 2016 to Dec. 31, 2018 and includes funding for both cropping ($25,373) and structural BMP's ($739,935), as well as local assistance ($39,825). As a condition of the grant, Marathon County has developed a 9-key element watershed plan for Fenwood Creek (HUC-12) watershed to meet or make progress towards the Wisconsin River TMDL water quality reduction goal requirements for this watershed.

## 7.3.5 Notice of Discharge (NOD) Grants Program

### 7.3.5.1 NOD PROGRAM OVERVIEW

Notice of Discharge (NOD) Project Grants, also governed by ch. NR 153, Wis. Adm. Code, are provided by WDNR and DATCP to local units of government (typically counties). A combination of state General Purpose Revenue, state Bond Revenue, and federal Section 319 Grant funds are used to support NOD grants. The purpose of these grants is to provide cost sharing to farmers who are required to install agricultural best management practices to comply with Notice of Discharge requirements. Notices of Discharge are issued by the WDNR under ch. NR 243 Wis. Adm. Code (Animal Feeding Operations - http://legis.wisconsin.gov/rsb/code/nr/nr243.pdf), to small and medium animal feeding operations that pose environmental threats to state water resources. The project funds can be used to address an outstanding NOD or an NOD developed concurrently with the grant award.

Both state agencies work cooperatively to administer funds set aside to make NOD grant awards. Although the criteria for using agency funds vary between the two agencies, WDNR and DATCP have jointly developed a single grant application that can be used to apply for funding from either agency. The two agencies jointly review the project applications and coordinate funding to assure the most cost-effective use of the available state funds. Funding decisions must consider the different statutory and other administrative requirements each agency operates under. Grant application materials are available on the WDNR web site at: http://dnr.wi.gov/Aid/NOD.html.

### 7.3.5.2 NOD GRANT PROJECTS IN THE TMDL PROJECT AREA

Since 2005, 14 NOD grants have funded the construction and implementation of agricultural best management in the TMDL project area. Over $2.1 million dollars in NOD grant awards have gone towards funding over $3.0 million in agricultural management practices, including construction manure facilities storage, barnyard runoff control practices and implementation of other ch. NR 151, Wis. Admin. Code runoff management standards. A complete list of NOD grant projects funded since 2005 are included in **Table L-1** of **Appendix L**, Agricultural Runoff Management Grant Projects in WI River TMDL project area.

Currently there are six livestock facilities located within the project area have been determined to be in violation of state agricultural performance standard and/or manure management prohibition requirements. As a result, these facilities have received NOD grants to install and implement BMP's to meet NR 151 agricultural performance standard and manure management prohibitions.

## 7.3.6 Lake Management Planning Grants

The WDNR provides grants to eligible parties to collect and analyze information needed to protect and restore lakes and their watersheds and develop lake management plans. Section 281.68, Wis. Stats., and ch. NR 190, Wis. Adm. Code, provide the framework and guidance for WDNR's Lake Management Planning Grant Program. Grant awards may fund up to 66% of the cost of a lake planning project. Grant awards cannot exceed $25,000 per grant for large-scale projects.

Eligible planning projects include:

- Gathering and analysis of physical, chemical, and biological information on lakes.
- Describing present and potential land uses within lake watersheds and on shorelines.
- Reviewing jurisdictional boundaries and evaluating ordinances that relate to zoning, sanitation, or pollution control or surface use.

- Assessments of fish, aquatic life, wildlife, and their habitats. Gathering and analyzing information from lake property owners, community residents, and lake users.
- Developing, evaluating, publishing, and distributing alternative courses of action and recommendations in a lake management plan.

Grants can also be used to investigate pollution sources, including nonpoint sources, followed by incorporation into the lake management plan of strategies to address those sources. Investigation can involve many types of assessment, including determining if the water quality of the lake is impaired. A plan approved by WDNR for a lake impaired by NPS pollution should incorporate the U.S. EPA's "Nine Key Elements" for watershed-based plans.
Grant application materials are available on the WDNR web site at:
http://dnr.wi.gov/Aid/SurfaceWater.html.

## 7.3.7 Lake and River Protection Grants

### 7.3.7.1 LAKE PROTECTION GRANT PROGRAM OVERVIEW

The WDNR provides grants to eligible parties for lake protection grants. Sections 281.69 and 281.71, Wis. Stats., and ch. NR 191, Wis. Adm. Code, provide the framework and guidance for the Lake Protection Grant Program. Grant awards may fund up to 75 percent of project costs (maximum grant amount $200,000).

Eligible projects include:

- Purchase of land or conservation easements that will significantly contribute to the protection or improvement of the natural ecosystem and water quality of a lake.
- Restoration of wetlands and shorelands (including Healthy Lakes best practices) that will protect a lake's water quality or its natural ecosystem (these grants are limited to $100,000). Special wetland incentive grants of up to $10,000 are eligible for 100 percent state funding if the project is identified in the sponsor's comprehensive land use plan.
- Development of local regulations or ordinances to protect lakes and the education activities necessary for them to be implemented (these grants are limited to $50,000)
- Lake management plan implementation projects recommended in a plan and approved by WDNR. These projects may include watershed management BMPs, in-lake restoration activities, diagnostic feasibility studies, or any other projects that will protect or improve lakes. Sponsors must submit a copy of their lake management plan and the recommendation(s) it wants to fund for WDNR approval at least two months in advance of the February 1 deadline. Plans must have been officially adopted by the sponsor and made available for public comment prior to submittal. The WDNR will review the plan and advise the sponsor on the project's eligibility and development of a lake protection grant application for its implementation.

Grant application materials are available on the WDNR web site at:
http://dnr.wi.gov/Aid/SurfaceWater.html.

### 7.3.7.2 RIVER GRANT PROGRAM OVERVIEW

The WDNR provides grants to eligible parties for river protection grants. Chapter 195, Wis. Adm. Code, provides the framework and guidance for the River Protection Grant Program. This program provides assistance for planning and management to local organizations that are interested in helping to manage and protect rivers, particularly where resources and organizational capabilities may be limited.

River Planning Grants up to $10,000 are available for:

Developing the capacity of river management organizations,

- Collecting information on riverine ecosystems,
- River system assessment and planning,
- Increasing local understanding of the causes of river problems

River Management Grants up to $50,000 are available for:

- Land/easement acquisition,
- Development of local regulations or ordinances that will protect or improve the water quality of a river or its natural ecosystem,
- Installation of practices to control nonpoint sources of pollution,
- River restoration projects including dam removal, restoration of in-stream or shoreland habitat,
- An activity that is approved by the WDNR and that is needed to implement a recommendation made because of a river plan to protect or improve the water quality of a river or its natural ecosystem,
- Education, planning and design activities necessary for the implementation of a management project.

The state share of both grants is 75% of the total project costs, not to exceed the maximum grant amount. Grant application materials are available on the WDNR web site at: http://dnr.wi.gov/Aid/SurfaceWater.html.

#### 7.3.7.3 LAKE & RIVER PLANNING & PROTECTION GRANTS IN THE TMDL PROJECT AREA

Since 2005, over $2.0 million in lake and river planning projects and nearly $3.0 million in lake protection grants have funded over $7.8 million in lake and river planning and projects in the TMDL project area. A complete list of Lake and River Planning and Protection grant projects funded and undertaken in the basin since 2005 are listed in **Tables G-3** and **G4**, Lake and River Planning and Protection Grants Projects in WI River TMDL project area.

### 7.3.8 DATCP Soil and Water Resource Management Program

DATCP oversees and supports county conservation programs that implement the state performance standards and prohibitions and conservation practices. DATCP's Soil and Water Resource Management (SWRM) Program requires counties to develop Land and Water Resource Management (LWRM) Plans to identify conservation needs. Each county Land and Water Conservation Department in the TMDL area developed an approved plan for addressing soil and water conservation concerns in its respective county.

County LWRM plans advance land and water conservation and prevent NPS pollution by:

- Inventorying water quality and soil erosion conditions in the county.
- Identifying relevant state and local regulations, and any inconsistencies between them.
- Setting water quality goals in consultation with the WDNR.
- Identifying key water quality and soil erosion problems, and practices to address those problems.
- Identifying priority farm areas using a range of criteria (e.g., impaired waters, manure management, high nutrient applications).
- Identifying strategies to promote voluntary compliance with statewide performance standards and prohibitions, including information, cost-sharing, and technical assistance.

- Identifying enforcement procedures, including notice and appeal procedures.
- Including a multi-year work plan to achieve soil and water conservation objectives.

Counties must receive DATCP's approval of their plans to receive state cost-sharing grants for BMP installation and these plans must be updated at least every 10 years. The schedule for County LWRM plan updates for counties within the TMDL area is provided in Table 17. DATCP is also responsible for providing local assistance grant funding for county conservation staff implementing NPS control programs included in the LWRM plans. This includes local staff support for DATCP and WDNR programs. In CY 2016 alone, DATCP awarded $1,118,912 in grants to counties in the TMDL area for local assistance and BMP implementation.

Table 17. County Land and Water Plan update schedule

| County | Next LWRM Plan Update | County | Next LWRM Plan Update | County | Next LWRM Plan Update | County | Next LWRM Plan Update |
|---|---|---|---|---|---|---|---|
| Adams | 2025 | Juneau | 2018 | Portage | 2019 | Vernon | 2019 |
| Clark | 2019 | Langlade | 2019 | Price | 2019 | Vilas | 2025 |
| Columbia | 2020 | Lincoln | 2026 | Richland | 2022 | Waushara | 2019 |
| Dane | 2018 | Marathon | 2020 | Sauk | 2028 | Wood | 2019 |
| Forest | 2016 | Monroe | 2018 | Shawano | 2026 | | |
| Jackson | 2017 | Oneida | 2019 | Taylor | 2018 | | |

The Wisconsin River TMDL provides County Land and Water Conservation Departments with the data necessary to more effectively identify and prioritize pollutant sources so that strategies can be developed and applied to reduce pollutant loads in the TMDL area over time.

### 7.3.9 DATCP Producer Led Watershed Protection Grant Program

To improve the quality of Wisconsin's waterways, DATCP developed and launched the first Producer Led Watershed Protection Grants Program in 2016. The new grant program included in the 2015-17 Wisconsin state budget, was designed to give financial support to farmers willing to lead conservation efforts in their own watersheds.

In the first-round of 2016 grants, $242,550 was awarded to 14 groups of innovative farmers to work with resource conservation agencies and organizations to address soil and water issues tailored to their local conditions. Included in this first round of awards was a $20,000 award to the Farmers of Mill Creek for Water quality improvement and public outreach in Mill Creek. Specifically, through this project, the Farmers of Mill Creek Watershed Council will work with Portage County UW-Extension to perform cover crop research regarding effects on soil moisture and temperature, as well as research on agricultural drains to improve water management. The group will also offer incentives for planting cover crops and focus on outreach to farmers through educational field days. Mill Creek is the fourth highest TP loading tributary watershed upstream of Petenwell Reservoir.

### 7.3.10 Federal Programs

Numerous federal programs are also being implemented in the TMDL area and are expected to be an important source of funds for future projects designed to control phosphorus and sediment loadings in the Wisconsin River TMDL Basin. A few of the federal programs include:

- **Environmental Quality Incentive Program (EQIP).** EQIP is a federal cost-share program administered by the Natural Resources Conservation Service (NRCS) that provides farmers with technical and financial assistance. Farmers receive flat rate payments for installing and implementing runoff management practices. Projects include terraces, waterways, diversions, and contour strips to manage agricultural waste, promote stream buffers, and control erosion on agricultural lands.
- **Conservation Reserve Program (CRP).** CRP is a voluntary program available to agricultural producers to help them safeguard environmentally sensitive land. Producers enrolled in CRP plant long-term, resource conserving covers to improve the quality of water, control soil erosion, and enhance wildlife habitat. In return, the Farm Service Agency (FSA) provides participants with rental payments and cost-share assistance.
- **Conservation Reserve Enhancement Program (CREP).** CREP provides annual rental payments up to 15 years for taking cropland adjacent to surface water and sinkholes out of production. A strip of land adjacent to the stream must be planted and maintained in vegetative cover consisting of certain mixtures of tree, shrub, forbs, and/or grass species. Cost-sharing incentives and technical assistance are provided for planting and maintenance of the vegetative strips. Landowners also receive an upfront, lump sum payment for enrolling in the program, with the amount of payment dependent on whether they enroll in the program for 15 years or permanently.
- **Regional Conservation Partnership Program** (**RCPP**) promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners. NRCS provides assistance to producers through partnership agreements and through program contracts or easement agreements RCPP combines the authorities of four former conservation programs – the Agricultural Water Enhancement Program, the Chesapeake Bay Watershed Program, the Cooperative Conservation Partnership Initiative and the Great Lakes Basin Program. Assistance is delivered in accordance with the rules of EQIP, CSP, ACEP and HFRP; and in certain areas the Watershed Operations and Flood Prevention Program.

#### 7.3.10.1 FEDERAL GRANTS IN THE WI RIVER TMDL PROJECT AREA

In early 2015, Sauk and Juneau Counties which comprise the majority of the Baraboo River Watershed, one of the highest TP loading tributary watersheds in the project area, received an RCPP grant focused on improving water quality within the Baraboo River Watershed through the promotion and installation of soil and water conservation practices. The primary resource concern addressed through the Baraboo River Watershed RCPP is Water Quality Degradation, specifically high phosphorus and sediment levels being contributed to surface waters within the watershed. After receiving this grant, Sauk Co. used the EVAAL model to prioritize the farms most vulnerable to erosion for BMP implementation.

### 7.3.11 Water Quality Trading & Adaptive Management

Water Quality Trading (WQT) and Adaptive Management (AM) may be used by eligible municipal and industrial wastewater dischargers to demonstrate compliance with TMDL WLAs. Both compliance options provide a unique watershed-based opportunity to reduce pollutant loading to streams, rivers, and lakes through point and nonpoint source collaboration. AM and WQT may also provide a new source of funding for local assistance and implementation of management measures to address nonpoint source pollution and improve water quality. The WDNR web site provides more details about water quality trading at: http://dnr.wi.gov/topic/SurfaceWater/WaterQualityTrading.html and adaptive management at:

http://dnr.wi.gov/topic/SurfaceWater/AdaptiveManagement.html. Wasteload allocations have also been broken down into the amount needed for the reach to meet local water quality requirements and the amount needed to meet downstream water quality criteria for Lakes Petenwell, Castle Rock, and Wisconsin.

### 7.3.12 Phosphorus Multi Discharger Variance (MDV)

The statewide multi-discharger variance (MDV) for phosphorus (s. 283.16, Wis. Stat.) extends the timeline for wastewater dischargers that must comply with low-level phosphorus limits. In exchange, point sources commit to step-wise reductions of phosphorus in their effluent as well as helping to address nonpoint sources of phosphorus from farm fields, cities or natural areas to implement projects designed to improve water quality.

Wisconsin's phosphorus MDV was approved by EPA on February 6, 2017. MDV implementation guidance (https://dnr.wi.gov/topic/surfacewater/phosphorus/variance/) is available to provide details about MDV eligibility and programmatic requirements. If a facility meets the eligibility requirements and requests and gets approval for the MDV, the WPDES permit will be modified or reissued with the following requirements:

1. *Reductions of effluent phosphorus:* Point sources are required to reduce their phosphorus load each permit term of MDV coverage.
2. *Implement a watershed project:* Point sources must implement one of the following watershed project options to help reduce nonpoint source of phosphorus pollution:
    a. Implement a watershed project directly;
    b. Work with a third party to implement a watershed project; or
    c. Make payments to a county (or counties) to be used for nonpoint source pollution control activities.

### 7.3.13 Healthy Soil, Healthy Water Partnership

WDNR staff had a "behind the scenes" role in establishing a partnership between water quality advocates and producers in the Wisconsin River Basin. The approach used was to identify and develop relationships with individuals in the agricultural community representative of the various types of agriculture in the basin, who are also well connected and respected among their peers; in many cases these were individuals with leadership roles in their respective agricultural organizations.

Among these individuals were further identified likely "innovators" and/or early adopters of conservation practices. Through relationships with these individuals, areas of overlap between producer interests and water quality goals were investigated. Understanding these areas of overlap helped to find common ground and develop a strategy for promoting phosphorus reductions from agricultural operations that focused on healthy soil – which includes cover crops and no-till practices.

The first effort towards this end was a Healthy Soil, Healthy Water workshop for producers in the basin to learn and share stories about no-till and cover crop practices. The workshop featured a nationally known soil health expert as well as local producers who have already implemented no-till and cover crops practices, who shared their experiences about what works and what doesn't in their specific location. Over 65 producers participated in the workshop. A unique feature of this approach was that participation in the workshop was achieved by extending a personal invitation to producers in the region from someone each producer already knew. Once the group agreed on a set of shared goals and commitments, it worked to highlight practices and share information with peers through informal conversations and more formal events such as farm tours, workshops, etc.

The Healthy Soil, Healthy Water partnership's next step is to invite agronomists and the producers they work with to participate in a workshop as a group, so producers and agronomists that work with similar operation types and in similar physical settings can learn together about the local and operation-specific information

they need to implement no till and cover crops, and provide each other with post-workshop peer support and reinforcement.

## 7.4 Post-Implementation Monitoring

A post-implementation monitoring effort will determine the effectiveness of the implementation activities associated with the TMDL. WDNR will monitor the tributaries of the Wisconsin River Basin based on the rate of management practices installed and tracked through the implementation of the TMDL, including sites where WDNR, DATCP, and NRCS grants are aimed at mitigating phosphorus and sediment loading. Monitoring will occur as staff and fiscal resources allow until it is deemed that stream quality has responded to the point where it is meeting its codified designated uses and applicable water quality standards.

In addition, the streams of the TMDL area may be monitored on a rotational basis as part of WDNR's statewide water quality monitoring strategy to assess current conditions and trends in overall stream quality. That monitoring consists of collecting data to support a myriad of metrics contained in WDNR's baseline protocol for wadeable streams, such as the IBI, the HBI, a habitat assessment tool, and several water quality parameters determined on a site by site basis.

WDNR will work in partnership with local citizen monitoring groups to support monitoring efforts which often provide a wealth of data to supplement WDNR data. All other quality-assured available data in the basin will be considered when looking at the effectiveness of the implementation activities associated with the TMDL.

## 7.5 Statewide Tracking Database

Tracking the implementation of nonpoint source (NPS) pollution reduction practices on the landscape is an important but often challenging component of TMDL implementation tracking and assessment. These challenges become even greater in the context of point source permit programs that require NPS partnerships such as adaptive management, water quality trading and the multi-discharger variance. A database system for efficiently and effectively tracking implementation of nonpoint source pollution implementation practices is currently under development by the WDNR. The system will include a web-based portal, allowing externals to easily and efficiently submit information via a GIS-based application for submitting, visualizing and tracking spatial data.

## 7.6 Implementation of Current TMDL Allocations and SSC Based Allocations

As discussed throughout the report, two sets of allocations are included in this TMDL. The allocations in **Appendix J** are based on the current promulgated water quality criteria and the allocations in **Appendix K** are based on the proposed SSC for Lakes Petenwell, Castle Rock, and Wisconsin. Implementation of the allocations contained in **Appendix K** can only occur after the SSC have been adopted by rule per s. NR 102.06(7), Wis. Adm. Code, and approved by USEPA. It is crucial to note that the SSC allocations contained in **Appendix K** only apply to the proposed SSC presented in Table 5 in Section 1.5. If SCC values other than those proposed in Table 5, Section 1.5, are adopted by rule and approved by USEPA, then the allocations in **Appendix K** cannot be used and a new set of allocations will need to be calculated and documented in a revised version of the TMDL. This revised TMDL would need to go through the public approval process outlined in ch. NR 212.77, Wis. Adm. Code, and be re-submitted for USEPA for review and approval.

The SSC allocations presented in **Appendix K** must be approved under two separate actions: 1) state and USEPA approval of the TMDL, and 2) state promulgation and USEPA approval of the SSC listed in Table 5 in Section 1.5. After all of this has occurred, WDNR will notify USEPA and stakeholders that adoption of the SSC has occurred and submit the necessary documentation to USEPA to confirm that the SSC-based wasteload

allocations will be implemented in future WPDES permits. From that point forward, SSC WLAs would be implemented in WPDES permits via permit modification or reissuance.

Implementation of the load allocations contained in **Appendix J and K** are both implemented through ch. NR 151, Wis. Adm. Code. Implementation of the load allocations contained in **Appendix J and K** that exceed the current performance standards in subchs. III and IV of ch. NR 151, Wis. Adm. Code, is voluntary unless adopted through ch. NR 151.005, Wis. Adm. Code.

The Wisconsin River Basin TMDL expresses wasteload allocations for TP as maximum annual loads (pounds per year) and maximum daily loads (pounds per day), which equal the maximum annual loads divided by the number of days in the year. As described in the "TMDL Implementation Guidance for Wastewater Permits" (available on-line at http://dnr.wi.gov/topic/tmdls/implementation.html), total phosphorus WQBELs for wastewater discharges covered by the WRB TMDL should be derived in a similar manner as methods used for Lower Fox River TMDL discharges. That is, consistent with the impracticability demonstration, TP limits should be expressed as a monthly average when wasteload allocations equate to a TP effluent concentration greater than 0.3 mg/L, and as a six-month average and monthly average equal to 3 times the six-month average when WLAs equate to a TP effluent concentration equal to or less than 0.3 mg/L.

The Wisconsin River TMDL establishes TP wasteload allocations to reduce the loading in the entire watershed including WLAs to meet water quality standards for tributaries to the Wisconsin River. Therefore, WLA-based WQBELs are protective of immediate receiving waters and limit calculators will not need to include TP WQBELs derived according to s. NR 217.13, Wis. Adm. Code.

Since wasteload allocations are expressed as annual loads (lbs/yr), permits with TMDL-derived monthly average permit limits should require the permittee to calculate and report rolling 12-month sums of total monthly loads for TP. Rolling 12-month sums can be compared directly to the annual wasteload allocation.

The above guidance for expressing TMDL wasteload allocations as permit limits is based on USEPA's statistical method for deriving water quality-based effluent limits as presented in 5.4 and 5.5 of the Technical Support Document for Water Quality-based Toxics Control (EPA/505/2-90-001; https://www3.epa.gov/npdes/pubs/owm0264.pdf).

# 8 PUBLIC PARTICIPATION

USEPA expects full and meaningful public participation in the TMDL development process, and TMDL regulations require that each State/Tribe must provide opportunities for public review consistent with its own continuing planning process (40 CFR §130.7(c)(1)(ii)). EPA is required to publish a notice seeking public comment when it establishes a TMDL (40 CFR §130.7(d)(2)).

WDNR believes that public outreach and meaningful stakeholder engagement throughout the TMDL development, TMDL implementation planning, and TMDL implementation process results in better outcomes and overall TMDL success. With this in mind, the WDNR has provided many ways for stakeholders to learn about the Wisconsin River TMDL and provide input in the TMDL development process, as described in the following subsections.

## 8.1 Wisconsin River Symposium

For five years spanning 2011 to 2015, the WDNR in collaboration with UW-Stevens Point Center for Watershed Science and other partners, organized and hosted an annual Wisconsin River symposium, a full day event centrally located within the basin at the University of Wisconsin-Stevens Point. Each symposium provided updates on Wisconsin TMDL development, including monitoring and modeling. The annual symposium also provided a venue for stakeholders to learn about issues, events and opportunities for involvement in the TMDL project area, as well as a forum for discussion about issues among stakeholders. The WDNR provided the majority of funding for each symposium, as well as substantial staff time towards planning and presenting at the event. Each year, the symposium was announced via email, and via postcards mailed directly to known stakeholders including municipal wastewater and industrial facilities, county land and water conservation department staff, state agency staff, tribal representatives, engineering consultants, business owners, citizen watershed groups and individual citizens. Symposium information, including registration, was posted online, and shared through phone calls and word of mouth. Approximately 150 people attended the symposium each year. Agendas and presentations from each year's symposium can be found online at: http://dnr.wi.gov/topic/TMDLs/WisconsinRiver/symposium.html.

## 8.2 Invited Presentations at Stakeholder Sponsored Meeting

Wisconsin River TMDL Project team members are frequently invited to make public presentations about the TMDL at the regular meetings of various organizations. Between 2012 and 2016, Wisconsin River TMDL project team members provided presentations at meetings of the following organizations: Petenwell and Castle Rock Stewards, Lake Wausau Associations, Lake Wisconsin Citizens Group, Big Eau Pleine Citizen Organization Conference, National Conference for Air and Stream Improvement (NCASI), Wisconsin River Discharger Group (WRDG), Wisconsin Paper Council, Wisconsin Government Affairs Seminar, American Society of Civil Engineers, Wisconsin Lakes Convention, Wisconsin River Industrial Discharger Group (WRIDA), Famers of Mill Creek Watershed Council, Wood County CEED Committee, North Central Wisconsin Stormwater Coalition, North Central Wisconsin Regional Planning Commission, Wisconsin Potato and Vegetable Growers (WPVGA) Annual Conference. In addition, TMDL project team members have had face-to-face meetings/discussion about the TMDL with most of the groups previously listed in this paragraph, as well as the following additional groups: Professional Dairy Producers of Wisconsin, Wisconsin Farm Bureau Federation; Wisconsin Farmers Union; Dairy Business Association (DBA); Wisconsin Agricultural Center for Excellence; Dairy Grazing Apprenticeship; Women Food and Agriculture Network; Coloma Farms/DATCP Board President; and Land Conservation, CPZ and/or NRCS staff in all the following Counties: Adams, Columbia, Juneau, Lincoln, Marathon, Portage, Sauk, and Wood.

## 8.3 Technical Meetings & Webinars

At various points during TMDL development WDNR provided opportunities for technical stakeholders to come together, virtually or in person, to discuss and ask questions about TMDL data, modeling approaches, and various technical issues. In November 2013, the TMDL Development Team organized and hosted two full-day meetings (11/6 and 11/13) with technical stakeholders to present, discuss, and accept feedback on the technical details of the proposed TMDL modeling scope and approach. A detailed technical scope of work was made available externally for review one month prior to these meetings (10/4). During the meetings, WDNR modeling staff and technical partners made detailed presentations about each component of the technical modeling scope, as well as monitoring results. Sixty-seven (67) technical stakeholders attended and participated in the meetings. The aforementioned technical scope, technical presentations, and meeting agendas are available online at http://dnr.wi.gov/topic/TMDLs/WisconsinRiver/techapproach.html and http://dnr.wi.gov/topic/TMDLs/WisconsinRiver/techmtg.html.

Additional webinars presented by the Wisconsin River TMDL team, include the list below:

- On April 20, 2016 WDNR hosted a technical presentation by EPA contractor LimnoTech Inc. on the development and results of CE-QUAL-W2 model of Castle Rock and Petenwell Reservoirs.
- On September 7, 2016 WDNR in partnership with UW-Extension hosted and presented a technical TMDL webinar on the topic of model integration and allocation methodology. Nearly seventy (70) individuals watched the webinar live and many more watched the recording, which is available online http://dnr.wi.gov/topic/TMDLs/WisconsinRiver/presentations.html.
- On November 17, 2016 WDNR hosted and presented a technical TMDL webinar on reservoir modeling updates. Thirty (30) individuals watched the webinar live and many more later watched the recording, which is available online http://dnr.wi.gov/topic/TMDLs/WisconsinRiver/presentations.html.

## 8.4 Draft TMDL Model Review

In addition to the previously mentioned technical meetings and webinars, WDNR staff in collaboration with TMDL technical stakeholders, developed a process for external review of draft TMDL models by interested technical stakeholders, throughout the TMDL development process. This process provided external stakeholders with the ability to access draft models and basic accompanying documentation at set points during the TMDL process. Each time draft models were shared, a formal opportunity to ask questions about the model was provided, via conference call or Skype meeting. WDNR then responded in writing to all comments and questions received within 21 days each time models were made available. The availability of draft models for review was announced via the Wisconsin River TMDL GovDelivery email subscription list; GovDelivery announcements contained a link that allowed recipients to download draft models. Table 18 summarizes the dates and information shared as part of this process.

Table 18. Draft TMDL products accessible for external review during development

| Draft Product | Product Type | Date Accessible for Review | Email Recipients | No. of Unique Opens | Date of WDNR Response to Comments |
|---|---|---|---|---|---|
| SWAT Model Subbasins | Spatial Data | 01/16/2015 | 531 | 134 | 02/25/2015 |
| Topographic Slope | | | | | |
| Wetlands/ Internally Drained Areas | | | | | |
| Climate | | | | | |
| Groundwater | | | | | |
| Baseflow phosphorus | | | | | |
| Land Cover/Management | | | | | |
| Urban model reach-shed delineation | | | | | |
| SWAT Model Development | Report | | | | |
| Wastewater Facility Summary | Excel Table | | | | |
| Scripts used to develop SWAT model input layers | Data Proc. Scripts | | | | |
| Wastewater Baseline | Excel Table | 08/13/2015 | 915 | 234 | 09/23/2015 |
| Urban Model | Draft Model | | | | |
| Lake Wisconsin Bathtub | Draft Model | | | | |
| Lake DuBay Bathtub | Draft Model | | | | |
| Calibrated SWAT Model | Draft Model | 10/02/2015 | 963 | 228 | 11/13//2015 |
| Model Analysis & Preparation of CE-QUAL-W2 modeling of Caste Rock and Petenwell Reservoirs | Technical Memo | | | | |
| CE-QUAL-W2 lake response models of Petenwell and Castle Rock Reservoirs | Draft Model | 04/21/2016 | 1258 | 291 | -- |
| Lake DuBay Bathtub Model | Draft Model | | | | |
| Calibrated SWAT Model Summary Results | Model Results | 05/04/2016 | 1265 | 279 | -- |

## 8.5 Other Stakeholder Meetings & Webinars

WDNR together with UW-Extension also organized and hosted meetings and presented webinars for general stakeholder audiences. In January 2015, WDNR, together with UW-Extension hosted a workshop to discuss the important role of agricultural stakeholders and partnerships in efforts to improve water quality in the Wisconsin River basin. Fifty-two (52) stakeholders attended and participated in the meeting. On September 11, 2013 WDNR in partnership with UW-Extension hosted and presented a Wisconsin River TMDL overview

webinar. In July 2013 WDNR produced and posted online a webinar covering the land use and land management inventory and model input layers development used to develop the TMDL SWAT model. Both of these webinars are available online on at the web address included in the previous section.

## 8.6 Wisconsin River TMDL GovDelivery Email Subscription List

On August 27, 2014 WDNR launched a Wisconsin River TMDL GovDelivery email subscription list (Table 19). The Wisconsin River GovDelivery list is used to communicate project updates, announce opportunities for technical review and input, events, and distribute the project newsletter. At its inception, the GovDelivery list invitation was sent to 288 individuals on existing Wisconsin River TMDL email lists. A link was added to the Wisconsin River TMDL website that allowed anyone to subscribe or unsubscribe at any time. By February of the following year (2015), the number of subscribers had more than doubled, reaching 622. By the end of 2015 the number of subscribers had exceeded 1,000. As of this writing, there are over 1,900 subscribers. The increase in the number of receipts through GovDelivery reflects the growing interest in the project as it progressed.

Table 19. Wisconsin River TMDL GovDelivery list bulletins

| Bulletin Subject | Sent Date | No. Recipients |
|---|---|---|
| Welcome to Wisconsin River TMDL Subscription Service | 08/27/2014 | 288 |
| Wisconsin River TMDL Quarterly Newsletter | 11/13/2014 | 417 |
| Opportunities for Wisconsin River TMDL Technical Stakeholder Input | 12/17/2014 | 476 |
| Schedule for Upcoming Release of Draft TMDL Models | 01/08/2015 | 528 |
| Save the Date - 2015 WI River Symposium is March 19! | 01/09/2015 | 529 |
| Wisconsin River TMDL Draft Models Now Accessible | 01/16/2015 | 539 |
| Register for WI River Symposium & Submit Draft Model Comments | 02/03/2015 | 574 |
| Wisconsin River Basin Quarterly Newsletter, Issue 2 | 02/09/2015 | 589 |
| Response to Comments on Draft WR TMDL Models | 02/25/2015 | 622 |
| WI River TMDL Quarterly Newsletter - May 2015 | 05/11/2015 | 782 |
| Schedule for Upcoming Release of Draft TMDL Model Data | 08/05/2015 | 905 |
| Update on Upcoming Release of Draft TMDL Model Data | 08/11/2015 | 915 |
| Wisconsin River TMDL Draft Data/Models Now Accessible | 08/13/2015 | 915 |
| WI River TMDL Quarterly Newsletter - August 2015 | 08/19/2015 | 921 |
| WR TMDL "E-chat" - RSVP due TODAY | 08/24/2015 | 926 |
| Response to Comments on Wisconsin River TMDL Draft Data/Models | 09/23/2015 | 958 |
| Upcoming Release of Draft WR TMDL Models | 09/29/2015 | 959 |
| Wisconsin River TMDL Draft Models Now Accessible | 10/02/2015 | 963 |
| WR TMDL "E-chat" - RSVP due TODAY | 10/12/2015 | 972 |
| WI River TMDL Quarterly Newsletter, Nov 2015 | 11/19/2015 | |
| Response to Comments on Draft Calibrated WR TMDL SWAT Model | 11/13/2015 | |
| April 20 Presentation of Castle Rock & Petenwell Response Models | 04/01/2016 | 1228 |
| Draft WI River TMDL Models Now Available | 04/21/2016 | 1258 |
| WI River TMDL draft SWAT Model Summary Results | 05/02/2016 | 1265 |
| Response to Comments on Draft Calibrated Reservoir Models | 06/01/2016 | 1298 |
| Register Now for WI River TMDL Model Integration & Allocation Methods Webinar | 08/30/2016 | 1402 |
| Upcoming WI River TMDL Webinar – Clarifications | 09/01/2016 | 1399 |
| WI River TMDL Model Update – Nov 17 Webinar | 10/27/2016 | 1438 |
| Press Release and GOV Delivery Notification of Webinar on draft TMDL Report and Allocations | 02/07/2018 | 1,979 |
| Webinar on Draft TMDL Report and Allocations | 02/21/2018 | |

## 8.7 Draft TMDL Allocations and Draft TMDL Review

The WDNR conducted a webinar on February 2, 2018 to provide the public with an overview of the TMDL analysis and explain how to access the report and allocations. The webinar was also recorded and made available on the WDNR website, http://dnr.wi.gov (search Wisconsin River Basin TMDL)

The webinar kicked off a series of informational meetings to provide an even more detailed explanation of the TMDL analysis, allocations and any needed reductions, implementation and compliance options, and to provide opportunities for additional stakeholder input. Presentation material was the same at all locations and times. Total attendance for the five meetings was 111.

- March 5, 2018, 1-4 p.m., at the Quality Inn located in Rhinelander
- March 6, 2018, 10 a.m.-noon and 4-6 p.m., at the Portage County Courthouse Annex Building
- March 14, 2018, 10 a.m.-noon and 4-6 p.m., at the Portage Public Library

The copy of the presentation slides can be found on the WDNR website, http://dnr.wi.gov. Stakeholder input from these listening sessions as well as written comments received during the February 21 through April 23, 2018 comment period were incorporated into the final draft of the TMDL plan. The WDNR received 63 comments. A summary of the comments and responses can be found in Appendix P.

## 8.8 Public Informational Hearing

Per s. NR 212.77 Wis. Admin. Code, a public informational hearing and minimum 30-day comment period were conducted. The public hearing occurred on August 22, 2018 and was accompanied by the official 30-day comment period. Comments were accepted from August 20 to close of business on September 19, 2018.

The notice was sent out as an official WDNR press release hitting all news outlets, distributed through the Wisconsin River Basin TMDL Govdelivery distribution list, distributed through the WDNR permit distribution list, and posted on the WDNR website and public hearings calendar. A copy of the official public notice is included below.

The public hearing was attended by 36 stakeholders. Four verbal comments were submitted into the record and are summarized below. Written comments received during the comment period are included in Appendix Q. These comments are grouped by category with written responses in Appendix R. The most significant changes that occurred as the result of public informational hearing involved a re-examination of the values provided in Appendix N and a subsequent re-calculation of the values to address bias and correct programming errors. Additional explanation is included in Appendix N.

During the public informational hearing, four stakeholders provided verbal comments. Three of the verbal comments were accompanied by written submittals and are summarized in Appendix R. Below is a summary of the verbal comments:

> Mr. Rich Boden representing the Village of Plover and the Wisconsin River Discharger Group: As summarized in the written comments; Mr. Boden expressed concern over the lack of implementation tools available for nonpoint sources. The implementation tools and funding available for nonpoint sources is inadequate to meet water quality standards. Mr. Boden also expressed concern over the lack of a phased implementation for point sources; again, the point sources have short compliance periods while nonpoint has no regulatory driver.
>
> *Note: See written comments 4, 5, 25, 34, 35, 36, 37, 42, 43, 44, 45, 46, and 52 in Appendix R.*

Mr. Andy Kurtz representing the Village of Marathon City: As summarized in written comments, Mr. Kurtz expressed concern over the lack of cost sharing and funding support for nonpoint sources. For the Big Rib River, point sources represent less than 1% of the load while nonpoint sources represent over 99% of the load. While the MDV helps provide nonpoint funding; it is still lacking and there is not sufficient flexibility in the point source implementation and variance programs. The barriers in water quality trading, including high trade ratios, the credit threshold, serve as an impediment to generating phosphorus credits. Interim credits are only available and do not provide sufficient relief for point sources.

*Note: See written comments 3 and 54 in Appendix R.*

Mr. Mark Saemish representing the City of Elroy Wastewater: Believes that the TMDL is putting the cart before the horse and that the TMDL is not good enough because we have been under the gun to get it done. Specifically, we should be looking at this like Dane County's dredging of sediment to address legacy phosphorus. Most of the phosphorus is legacy phosphorus and reductions to point sources will not improve water quality unless the legacy phosphorus is addressed. This is a nonpoint issue and not a point source issue. Over 1,300 facilities have applied for economic variances because of the stringent phosphorus limits imposed on point sources. The phosphorus rules and criteria were imposed by EPA; what happened to state sovereignty? Stand-up to EPA.

Ms. Falon French representing River Alliance of Wisconsin: Voiced support for the TMDL; however, voiced concerns about nonpoint implementation and the lack of funding and support to implement nonpoint reductions. Ms. Falon encouraged the DNR to think creatively in utilizing and adapting phosphorus compliance tools to make compliance with wastewater permit limits easier. Voiced support for the SSC process.

*Note: See written comments 2, 22, 23, and 33 in Appendix R.*

**STATE OF WISCONSIN DEPARTMENT OF NATURAL RESOURCES**
**PUBLIC NOTICE OF INFORMATIONAL HEARING FOR THE WISCONSIN RIVER BASIN TOTAL MAXIMUM DAILY LOAD STUDY**

The Wisconsin Department of Natural Resources is conducting a public informational hearing on August 22, 2018 to receive comments on the "Total Maximum Daily Loads for Total Phosphorus in the Wisconsin River Basin" (TMDL Study). The TMDL Study covers the Wisconsin River Basin north of Lake Wisconsin encompassing or touching portions of 21 counties. US EPA, under the Clean Water Act, requires that waters not meeting water quality standards be listed as impaired and have TMDL or equivalent restoration plans developed. This TMDL Study quantifies the different sources of pollution, provide allocations, and prescribe reductions, if needed.

The public informational hearing will be held on August 22, 2018 from 2:00 to 4:00 pm at the Portage County Courthouse Annex Building (1462 Strongs Avenue, Stevens Point, WI 54481-2947).

**Contact**: Kevin Kirsch, DNRWisconsinRiverTMDL@wisconsin.gov

A copy of the public hearing version of the TMDL Study and supporting material will be posted on the website ( https://dnr.wi.gov/topic/tmdls/wisconsinriver/ ) on August 20th, 2018.

The public hearing version of the TMDL Study incorporates input and comments received during the March listening sessions and comment period. The public informational hearing on August 22nd will include a presentation outlining the modifications made.

Written comments will be accepted through September 19th, 2018. Written comments can be submitted via e-mail: DNRWisconsinRiverTMDL@wisconsin.gov

Or mail:
Wisconsin Department of Natural Resources Attn: Kevin Kirsch
101 S. Webster Street PO Box 7921 Madison, WI 53707-7921

Oral comments, received during the public hearing, and written comments received prior to the close of the comment period will be considered prior to making a final approval and submittal of the TMDL Study to EPA. Written and oral comments carry the same weight. A summary with response to comments shall be included in the final TMDL Study report.

Reasonable accommodation, including the provision of informational material in an alternative format, will be provided for qualified individuals with disabilities upon request.

# # #

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# Appendices

**Appendix A Tributary Information and Charts**

**Appendix B Lakes Requiring Additional Evaluation**

**Appendix C Site-Specific Criteria Analysis**

**Appendix D Watershed Modeling Documentation**

**Appendix E Sediment Monitoring**

**Appendix F Baseline Load**

**Appendix G MS4 Detail Maps**

**Appendix H Total Phosphorus Loading Capacity of Petenwell and Castle Rock Flowages**

**Appendix I BATHTUB and Empirical Lake Models**

**Appendix J Allocations**

**Appendix K Proposed Site-Specific Criteria Allocations**

**Appendix L Watershed Implementation Activities**

**Appendix M CE-QUAL-W2 Reservoir Model**

**Appendix N Agricultural Targets**

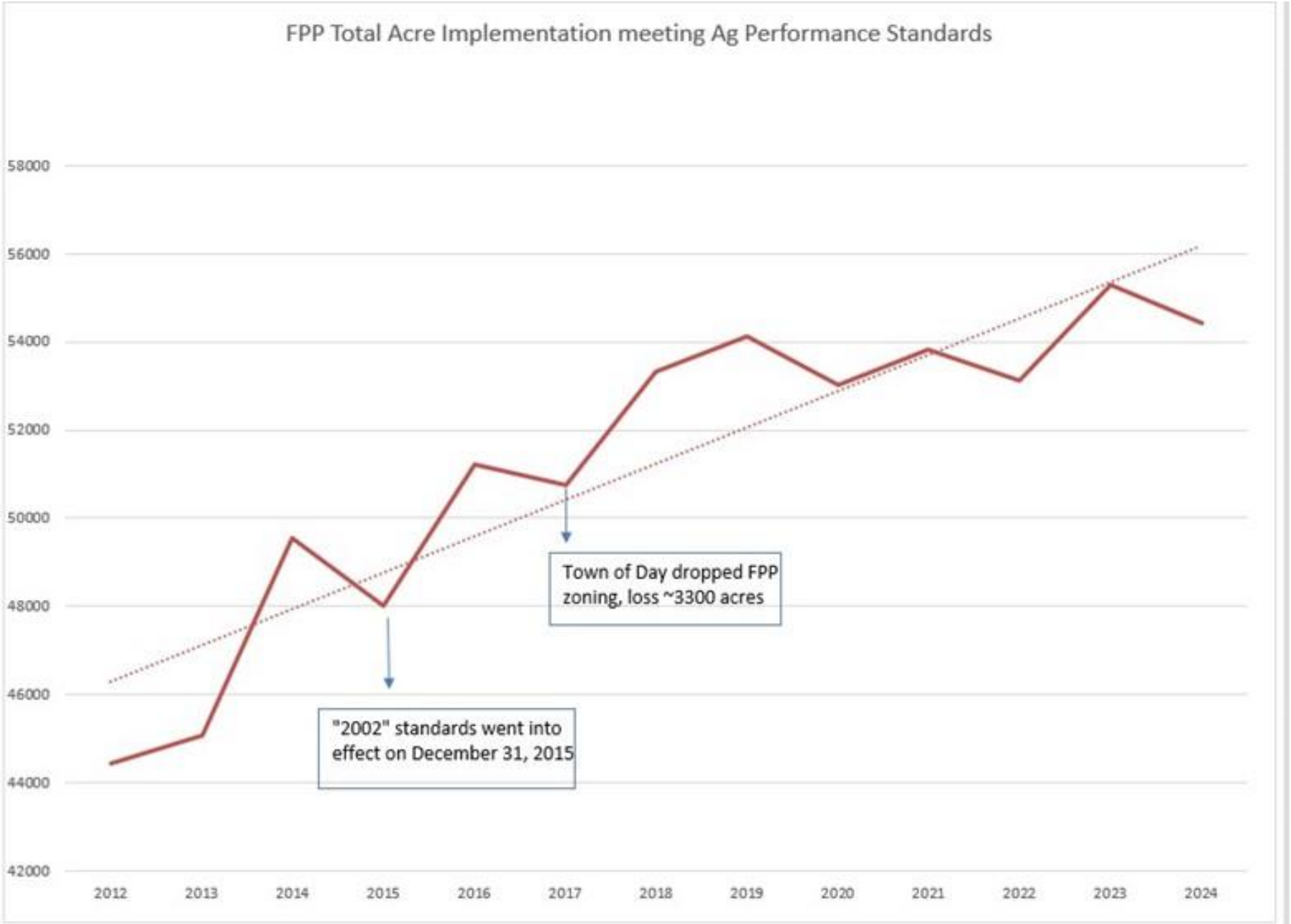
**Appendix O Trading and Adaptive Management Information**

**Appendix P Response to Preliminary Comments (February 21 to April 23, 2018 Comment Period)**

**Appendix Q Public Hearing Comments (August 20 through September 19, 2018 comment period)**

**Appendix R Response to Public Hearing Comments (August 20 through September 19, 2018 comment period)**

# Appendix A:8


FPP Total Acre Implementation meeting Ag Performance Standards
58000
56000
54000
52000
50000
48000
46000
44000
42000
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Town of Day dropped FPP zoning, loss ~3300 acres
"2002" standards went into effect on December 31, 2015

# Appendix B

# Appendix B:1

Photos of an algal bloom on the Big Eau Pleine Reservoir in August, 2024.

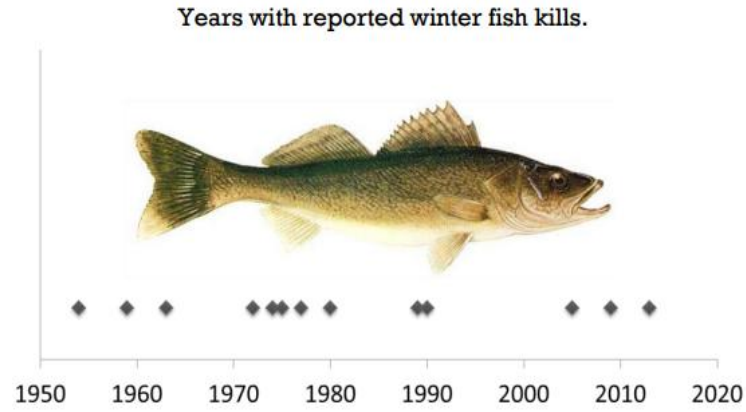
Photos of an algal bloom on the Big Eau Pleine Reservoir in August, 2024.

# Appendix B:2

Historic aerial photos from late 1990s showing winter manure runoff.

# Appendix B:3

2009 Big Eau Pleine Reservoir Fish Kill Photos and table of historic fish kills




Note: The fish kills in 1989, 1990, and 2005 were considered small.

# Appendix B:4

Historic air photos of extensive drainage systems installed in wetlands to form Marathon County agricultural lands.

# Appendix B:5

Fenwood Creek Watershed, Marathon County manure runoff photos.

# Appendix C

# Appendix C:1

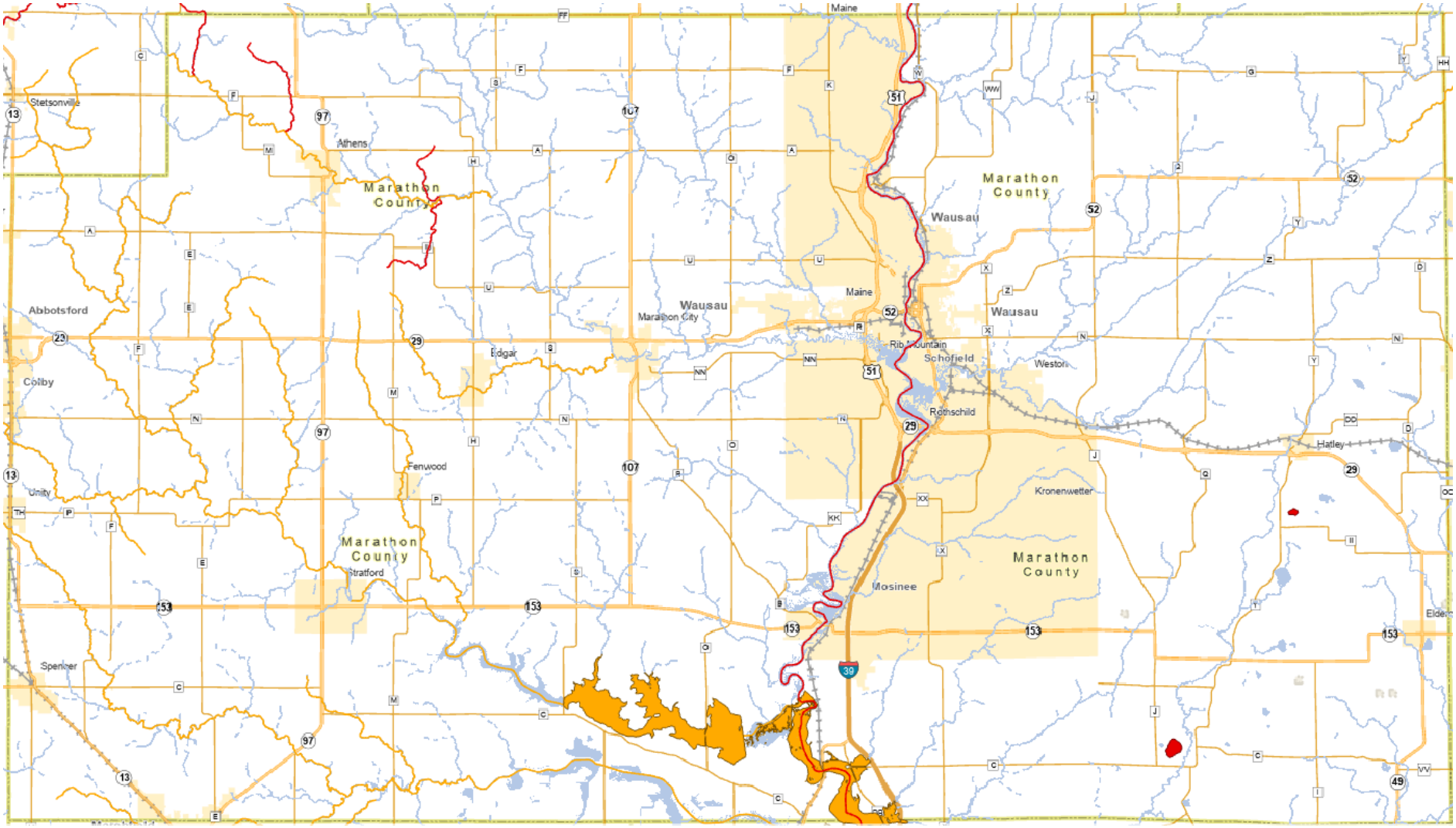



Image 2: 303(d) Phosphorus-Impaired Streams and Rivers and Waters in Restoration (WIRL) of Marathon County (2025)

# Appendix C:2

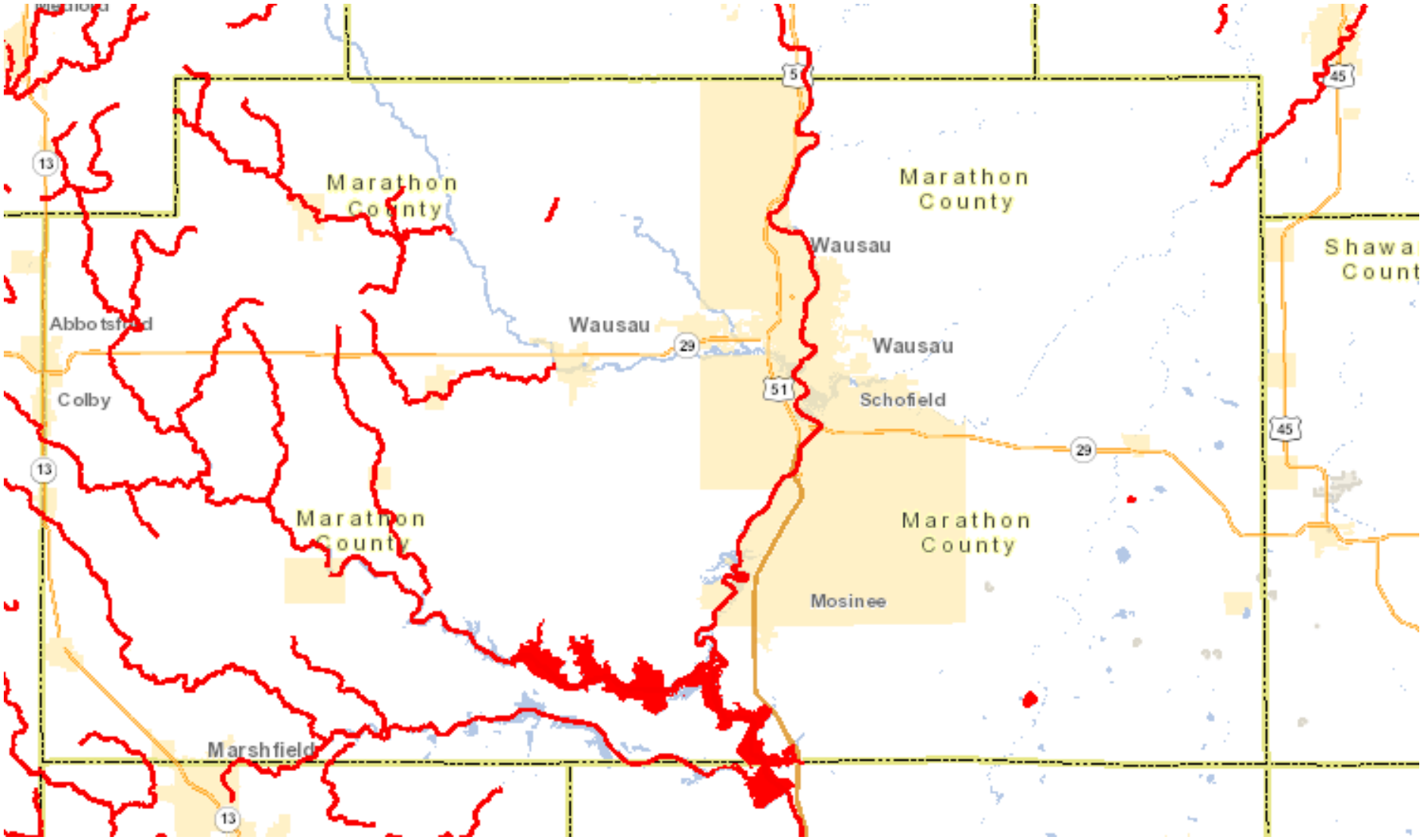
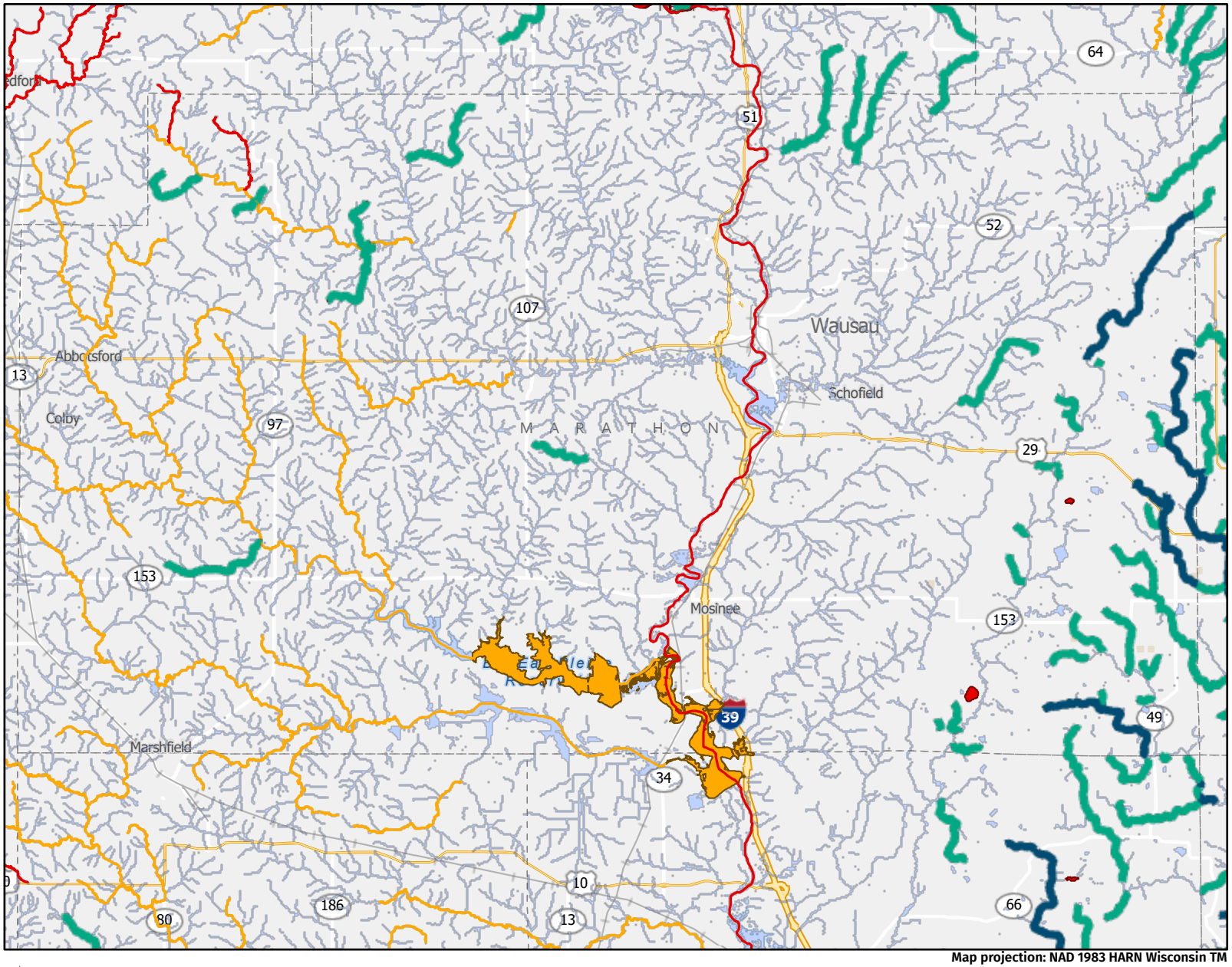



Image 1: 303(d) Phosphorus-Impaired Streams and Rivers of Marathon County (2025)

# Appendix C:3

WISCONSIN DEPARTMENT OF NATURAL RESOURCES




**Legend:** (some map layers may not be displayed)

Outstanding and Exceptional Streams

- Exceptional
- Outstanding
- IWL - River Stream Beach Shore
- IWL - Lake Reservoir Impoundment Wetland
- WIRL - River Stream Beach Shore
- WIRL - Lake Reservoir Impoundment
- Rivers and Streams
- Intermittent Streams
- Open Water

**Notes:**

**Map projection: NAD 1983 HARN Wisconsin TM**

N

Map: 0 30,000 60,000 Feet
0 9,350 18,700 Meters

Service Layer Credits:
DNR Basic Feature Vector Tile Layer WTM: , Clean Water Act Standards & Uses: WI Dept. of Natural Resources, Water Quality, Surface Water (Cached): WiDNR, USGS, and other data

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# Appendix D

# Appendix D:1

# *Steady-State Modeling Analysis of Big Eau Pleine Reservoir, Wisconsin River System*

21 November, 2016

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# EXECUTIVE SUMMARY

Big Eau Pleine Reservoir, located near Mosinee, WI, currently exhibits eutrophic to hypereutrophic conditions (Carlson TSI-Phosphorus = 74). A monitoring program was conducted between 2010 and 2013 on the reservoir to examine seasonal total phosphorus (P), chlorophyll, and Secchi transparency dynamics in relation to tributary P loading for Total Maximum Daily Load (TMDL) development. Gauged tributary flow and P inputs included the Big Eau Pleine River at Stratford, Freeman Creek at Halder, and Fenwood Creek at Bradley, WI. The gauged discharge was the Big Eau Pleine River below Big Eau Pleine Dam. Four stations were established along the longitudinal axis of the reservoir for water sampling purposes. Stations were located in the headwater region, upper middle, lower middle portion, and near the dam. Surface samples were collected biweekly between April and October for total P and chlorophyll analysis. A near-bottom samples was also collected for total P analysis. Secchi transparency was determined biweekly using a 20-cm alternating black and white disk.

Mean annual inflow over the 2010-13 period was 10.22 $m^3/s$ (± 1.61 standard error, SE), resulting in a moderately high mean annual residence time of 177 d (± 43 SE). Annual flow-weighted total P in the inflow and outflow were 0.269 mg/L and 0.102 mg/L, respectively, indicating substantial P retention. Longitudinal total P concentration gradients developed between the headwater and dam stations during the summer; the grand mean total P over 2010-13 declined from ~ 0.195 mg/L at the headwater station to 0.102 mg/L at the dam station. The reservoir-wide, area-weighted, grand mean (i.e., over 2010-13) total P was ~ 0.133 mg/L. The area-weighted grand mean chlorophyll concentration was high at ~ 69 µg/L and summer mean concentrations tended to decline from the headwater to the dam station. The area-weighted grand mean Secchi transparency was low at ~ 0.7 m. The area-weighted Carlson trophic state index (TSI, Carlson 1977) for P (TSI-P) was high at 74 and indicative of hypereutrophic conditions. The TSI based on chlorophyll (TSI-CHLA) was slightly lower at 71 and TSI based on Secchi transparency (TSI-SD) was 65.

Budgetary analysis of P loads suggested substantial P retention of loads to Big Eau Pleine Reservoir, as ~ 60% of the P input was retained. Overall, the P empirical model (Canfield and Bachmann 1981) closely predicted the observed area-weighted mean summer total P concentration. However, the model over predicted mean total P at the headwater station. Tributary P inputs entirely accounted for the summer total P budget, suggesting that internal P loading and entrainment to surface waters for algal uptake was a minor component of the P budget. The chlorophyll model (Jones and Bachmann 1976) over predicted observed means necessitating adjustment of the calibration coefficient. This pattern suggested that a portion of the total P was inorganic and not associated with algal biomass. After calibration, both the chlorophyll and Secchi transparency (based on chlorophyll concentration and nonalgal turbidity) models closely approximated observed summer grand means. A 50% reduction in P loading coincided with a 41% decline in summer total P from a predicted ~0.140 mg/L to 0.083 mg/L. Under this same P loading reduction scenario, summer chlorophyll concentrations declined by 55% from a predicted ~ 76 µg/L to ~35 µg/L. Predicted Secchi transparency increased by ~28% from 0.7 m to 0.9 m. Under current P loading conditions, chlorophyll blooms exceeding 20 µg/L and 60 µg/L occurred an estimated 89% and 41% of the time during the summer period, respectively. Using the same scenario, a 50% P loading reduction resulted in a predicted decline in the summer bloom frequency of chlorophyll exceeding 20 µg/L and 60 µg/L to 60% and 14% of the time during the summer period, respectively. Empirical steady-state models developed for Big Eau Pleine Reservoir will be used in conjunction with other decision-support tools to develop a TMDL based on predicted reservoir water quality responses to P loading reduction.

# OBJECTIVES

The objectives of this investigation were to examine summer limnological conditions in Big Eau Pleine Reservoir between 2010 and 2013 and project future conditions under phosphorus loading reduction scenarios using a steady-state empirical modeling approach.

# METHODS

Flow and total phosphorus (P) loadings from the Big Eau Pleine River and Freeman and Fenwood Creeks (Table 1) were combined with seasonal (April – September to early October) surface water chemistry information from four stations in Big Eau Pleine Reservoir (Table 2, Fig. 1) to construct a steady-state empirical model (Bathtub Version 6.14, Walker 1996) to forecast the response of limnological variables (total P, chlorophyll, and Secchi transparency) to future P loading reduction. Since the annual theoretical water residence time was moderate to long (range = 0.36 y to 0.84 y), an annual averaging period was used for steady-state empirical modeling analysis. Gauged hydraulic inputs included the Big Eau Pleine River at Stratford (Station ID 373325), Freeman Creek at Halder (Station ID 373411), and Fenwood Creek at Bradley, WI (Station ID 373366, Table 1). The gauged hydraulic discharge from the reservoir was the Big Eau Pleine River at Big Eau Pleine Dam (Station ID 10030620, Table 1). Monthly hydraulic flow ($m^3/s$) and total P loadings (kg/y) determined by the US Geological Survey (Madison, WI) were converted to mean flow (expressed as $hm^3/y$) and total P concentration (expressed as µg/L) over the 2010-13 period of study as input to the model. Additional hydrologic input to the model included ungauged local runoff to the reservoir from the surrounding subwatershed that was estimated using the Soil and Water Assessment Tool (SWAT) and daily precipitation records over the study period obtained from the Wisconsin State Climatology Office (Madison, WI). For the Big Eau Pleine

River and discharge from Big Eau Pleine Dam, the coefficient of variation (CV-mean) was estimated from mean January through December flows and total P concentrations between the years 2002 and 2013 reported by the US Geological Survey (Dale M. Robertson, U.S. Geological Survey, Madison, WI, unpublished data). Freeman and Fenwood Creek CV-means were estimated for the period 2010-13. The CV-mean was calculated as the standard error of the grand mean (i.e., 2002 through 2013 for the Big Eau Pleine River at Stratford and Big Eau Pleine Dam and 2010 through 2013 for Freeman and Fenwood Creek) divided by the grand mean of each constituent. This CV-mean was used for error analysis in Bathtub as recommended in Walker (1996).

Biweekly measurements of Secchi transparency and surface concentrations of chlorophyll and total P, collected in Big Eau Pleine Reservoir during the summer periods of 2010 through 2013, were averaged to estimate a mean concentration for each station segment during each year. June through September was used as the averaging period. Chemical analyses of water samples were conducted by the Wisconsin State Laboratory of Hygiene using standard methodological approaches. For in-lake morphometric inputs to the empirical model, the pool was divided into the 4 segments (i.e., headwater, upper middle, lower middle, and dam segments) corresponding to the locations of sampling stations (Table 2). The upper middle station was added in 2011.

The computer software program Bathtub was used to examine P loading reduction scenarios (Walker 1996). Bathtub is a windows-based software program that provides a suite of equations for predicting lake seasonal averages of total P, chlorophyll, and Secchi transparency. Grand means for total P, chlorophyll, and Secchi transparency over the summer 2010-13 period were used as input into the model. The coefficient of variation for total P, chlorophyll, and Secchi transparency of the grand mean (CV-mean) was calculated as the standard error of the grand mean divided by the grand mean of each constituent. This CV-mean was used for error analysis in Bathtub as recommended in Walker (1996).

# RESULTS AND DISCUSSION

## *Tributary Hydrology and Loading*

Mean annual inflow was highest and similar in 2010, 2011, and 2013 at ~ 12.0 $m^3/s$ and lowest in 2012 at 5.4 $m^3/s$ (Fig. 2). The annual theoretical water residence time ranged between 130 d and 136 d during the higher flow years and was 305 d during the lower flow year of 2012 (Fig. 2). Annual total P concentration of the inflow to Big Eau Pleine Reservoir, representing a flow-weighted concentration for the combined Big Eau Pleine River, Freeman Creek, Fenwood Creek, and estimated local subwatershed runoff ranged between 0.206 mg/L in 2012 and 0.345 mg/L in 2010, following a trend similar to that of annual gauged inflow (Fig. 2). The higher annual total P concentration in 2010 versus other higher flow years may have reflected seasonal differences in the timing of precipitation. For instance, monthly P loading was unusually high during September, 2010, compared to other years (not shown). Annual total P loading followed the same inter-annual trend. It was lowest in 2012 in conjunction with lower mean annual flow and greatest in 2010, 2011, and 2013.

## *Reservoir Limnological Trends*

In contrast to P loading, mean total P concentrations were relatively constant among years at all stations in Big Eau Pleine Reservoir (Fig. 3). In addition, they were lower than the measured inflow total P, particularly during the higher flow and P loading years of 2010, 2012, and 2013 (Fig. 3). This pattern indicated considerable P retention in the reservoir. Total P concentration gradients developed between the headwaters and dam during periods of elevated total P loading from the Big Eau Pleine River, suggesting advective transport of P loads and deposition along the longitudinal axis (Fig. 4-7). Total P was also elevated in the headwaters during periods of lower inflow, as in late July, 2012 (Fig. 6). This pattern coincided with the development of a chlorophyll maximum,

suggesting incorporation of P into algal biomass. The source of this P may have been internal P loading from sediment versus watershed P loading since flows were low during this period. Alternatively, wind-driven resuspension and mixing in the headwaters could have accounted for some of the total P concentration increase in late July. Overall, grand mean total P concentrations declined from 0.269 mg/L in the combined inflow to 0.195 mg/L at the headwater station and 0.102 mg/L at the dam station (Fig. 8). Mean measured P retention over the 4-year period was 61% (Table 3).

Near-bottom concentrations of total P often exceeded surface total P at all stations during the 2010-13 period (Fig. 9-12). Vertical concentration differences tended to coincide with bottom anoxia, indicating internal P loading under anaerobic conditions (Fig. 13 and 14). Vertical concentration differences were generally greatest at the deeper dam station location (Fig. 13). In addition, seasonal and longitudinal variations in bottom water dissolved oxygen were dynamic, but did not coincide with, for instance, variations in flow (Fig. 14). Instead, bottom water patterns may have been more influenced by hydropower dam operations and withdrawal from intermediate depths which would promote interflow and underflow currents that could alter residence time distribution in the vertical water column and constituent concentration.

Mean summer chlorophyll concentrations were relatively high, ranging between 55 µg/L and 89 µg/L, and tended to decrease slightly from the headwater to the dam station (Fig. 3 and 8). Concentrations also varied longitudinally and seasonally. Usually, chlorophyll was lowest in concentration during May and increased to peaks thereafter (Fig. 9-12). In addition, blooms tended to develop shortly after periods of elevated P loading, as in August, 2010, early and late July, 2011, and early July, 2013. Concentrations also declined during periods of high inflow, as in July of 2010 and 2011 and June, 2013, suggesting potential algal cell discharge or dilution as a result of decreased residence time. Chlorophyll concentrations were high (> 120 µg/L) during a period of relatively low inflow and high residence time between June and early August, 2012 and 2013 (Fig. 6 and 7).

Although there were seasonal periods when Secchi transparency slightly exceeded 1.0 m (Fig. 9-12), these instances occurred primarily in May when chlorophyll concentrations were low. Summer means were generally lower throughout the study period (Fig. 3), ranging between 0.4 m and 0.9 m. Longitudinal variations in grand mean Secchi transparencies were also minor but tended to increase from headwaters to dam (headwater station = 0.5 m ± 0.08 SE; upper middle station = 0.67 m ± 0.04 SE; lower middle station = 0.65 m ± 0.04 SE; dam station = 0.77 m ± 0.09 SE; Fig. 8).

Grand mean summer Carlson Tropic State Index (TSI) values were greatest for total P at ~ 71 to 80 (Fig. 8), indicative of hypereutrophic conditions. Grand mean TSI was slightly lower for chlorophyll (~ 71 to 74) and Secchi transparency (~64 to 69) compared to total P (Fig. 8). Higher total P TSI suggested that a portion of the total P was inorganic P (i.e., perhaps associated with watershed P) and not incorporated into algal biomass.

### *Steady-State Empirical Modelling*

The mean (2010-13) annual hydraulic and total P balance for measured inputs and outputs to Big Eau Pleine Reservoir are shown in Table 3. Measured mean annual P loading to the reservoir was much greater than P discharge resulting in retention of ~ 61% of the P income. The Big Eau Pleine River at Stratford, WI, overwhelmingly dominated mean annual gauged P inputs to the reservoir (Table 3). Mean flow and P loading represented 59% and 84% of the gauged mean inputs, respectively. The mean flow-weighted total P concentration was high at 0.381 mg/L. In addition, soluble reactive P represented ~ 68% of the total P at a mean flow-weighted concentration of 0.261 mg/L (U.S. Geological Survey unpublished data). Although Freeman and Fenwood Creeks represented only 14% of the gauged mean summer inflow, the mean summer flow-weighted total P concentrations were also high at 0.109 and 0.182 mg/L, respectively. Mean soluble reactive P represented 31% and 52% of the total P composition for Freeman and Fenwood Creeks, respectively. However, mean total P loading from these creek inputs represented only 8% of the measured total P load to the system. Ungauged P

inputs, estimated from SWAT output, accounted for ~ 7% of the total P input. A portion of the annual total P discharge from Big Eau Pleine Reservoir was soluble reactive P (U.S. Geological Survey unpublished data). The mean flow-weighted soluble reactive P concentration over the 2010-13 period was 0.029 mg/L, representing ~ 25% of the total P concentration in the discharge. Since withdrawal depths are below the lake surface, relatively high soluble reactive P probably reflected combined sources from riverine advective interflows and entrainment of internal P loads.

The Canfield-Bachmann (1981) empirical model (option 8; Bathtub) was chosen to predict summer mean lake total P (Table 4). Because the Jones and Bachman (1976) chlorophyll-total P regression relationship was developed from and extensive northern lake data set, it was chosen for mean summer chlorophyll prediction. Finally, the default Secchi transparency model developed from relationships between chlorophyll and turbidity in reservoirs was chosen to estimate mean summer Secchi depth.

Observed versus predicted summer means of total P, chlorophyll, and Secchi transparency over the 2010-13 period are shown in Figure 15 and Table 5. Overall, the P empirical model (Canfield-Bachmann) closely predicted the observed area-weighted mean summer total P concentration in Big Eau Pleine Reservoir (Table 5). For individual segments, the model over predicted the mean total P concentration of the headwater station but closely approximated the concentration at other stations (Fig. 15). Reasons for the headwater station discrepancy are not known.

The uncalibrated chlorophyll model tended to over predict the observed area-weighted mean summer chlorophyll concentration (Fig. 15). However, standard error bars overlapped and means were not significantly different given errors in the observed chlorophyll versus the model (Walker 1996). In addition to potential error, over prediction of mean summer chlorophyll based on chlorophyll-total P regression relationships could have been related to a portion of the total P pool that was not incorporated as algal biomass. For instance, some of the total P could have been inorganic particulate P in the form of clays and colloidal metal oxyhydroxides versus

algal biomass in the form of organic P. Adjustment to the observed summer mean chlorophyll concentration resulted in a calibration coefficient of ~0.65. Since the Secchi transparency model uses summer mean chlorophyll as an input variable, predicted summer mean Secchi transparency slightly underestimated the observed mean without calibration adjustment of the chlorophyll model (Fig. 15). Chlorophyll calibration resulted in improved prediction of Secchi transparency.

### *Phosphorus Loading Reduction*

Current P loading to Big Eau Pleine Reservoir was reduced by 10% increments in Bathtub to examine predicted water quality responses to simulated future P loading reduction due to best management practices (BMP) implementation for TMDL development and goal-setting (Fig. 16). A 50% reduction in annual P loading coincided with a 41% decline in summer total P from a predicted ~0.140 mg/L (i.e., slightly higher than the observed mean total P of 0.133 mg/L). to 0.083 mg/L. Under this same P loading reduction scenario, predicted summer chlorophyll concentrations declined by 55% from ~ 76 µg/L to ~35 µg/L. Predicted Secchi transparency increased by 28% from 0.7 m to 0.9 m.

Predicted bloom frequency (i.e., percentage of the summer that chlorophyll exceeds a certain concentration) response to P loading reduction is shown in Figure 17 for various summer mean chlorophyll concentrations. Under current P loading conditions, chlorophyll blooms exceeding 20 µg/L and 60 µg/L occurred an estimated 89% and 41% of the time during the summer period, respectively. A 50% P loading reduction would result in a predicted decline in the summer bloom frequency of chlorophyll exceeding 20 µg/L and 60 µg/L to 60% and 14% of the time during the summer period, respectively. Thus, empirical models suggested that predicted reservoir trophic state indicator variables (total P, chlorophyll, and chlorophyll concentration bloom frequency) were responsive to P loading reduction.

# REFERENCES

Carlson RE. 1977. A trophic state index for Lakes. Limnol Oceanogr 22:361-369.

Walker WW. 1996. Simplified procedures for eutrophication assessment and prediction: User manual. Instruction Report W-96-2, September, 1996, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, USA.

Table 1. Gauged inflow-outflow stations used in the Big Eau Pleine Reservoir empirical steady-state model.

| Station ID | Gauged Inflow |
|---|---|
| 373325 | Big Eau Pleine River at Stratford |
| 373411 | Freeman Creek at Halder |
| 373366 | Fenwood Creek at Bradley |
| | **Gauged outflow** |
| 10030620 | Big Eau Pleine River at Big Eau Pleine Dam |

Table 2. Water quality sampling station locations in Big Eau Pleine Reservoir.

| Station ID | Name | Surface area ($km^2$) | Mean depth (m) | Segment length (km) |
|---|---|---|---|---|
| 373137 | Headwaters | 4.53 | 5.22 | 16.1 |
| 373136 | Upper middle | 5.07 | 5.08 | 6.4 |
| 10007758 | Lower middle | 4.34 | 6.64 | 4.8 |
| 373135 | Dam | 9.16 | 5.5 | 3.2 |

Table 3. A comparison of mean (2010-13) annual flow and total phosphorus (P) inputs to and discharge from Big Eau Pleine Reservoir.

| Component | Flow | | Total P | | |
|---|---|---|---|---|---|
| | ($m^3/s$) | (% contribution) | (mg/L) | (kg/y) | (% contribution) |
| **Inputs** | | | | | |
| Big Eau Pleine River | 6.1 | 59 | 0.381 | 72,805 | 84 |
| Freeman Creek | 0.7 | 6 | 0.109 | 2,241 | 3 |
| Fenwood Creek | 0.8 | 8 | 0.182 | 4,574 | 5 |
| Ungauged inputs[1] | 2.1 | 20 | 0.098 | 6,376 | 7 |
| Precipitation | 0.6 | 6 | 0.03 | 693 | 1 |
| Total | 10.2 | 100 | 0.285 | 86,689 | 100 |
| **Outputs** | | | | | |
| Big Eau Pleine Dam | 9.2 | | 0.115 | 33,805 | |
| Evaporation | 0.6 | | | | |
| Total | 9.8 | | 0.102 | 33,805 | |
| **Balance** | 0.4 | | | 52,884 | |
| | 96% | | | 61% | |

[1]Representing local subwatershed inputs estimated from the Soil and Water Assessment Tool (SWAT)

Table 4. Algorithms used for Bathtub (Walker 1996) phosphorus loading reduction modeling of Big Eau Pleine Reservoir.

| Variable | Model |
|---|---|
| Phosphorus | Canfield and Bachmann (1981) |
| Chlorophyll | Jones and Bachmann (1976) |
| Secchi Transparency | versus Chlorophyll & Turbidity |

Table 5. Predicted versus observed reservoir-wide area-weighted mean concentrations of total phosphorus (P), chlorophyll, and Secchi transparency. Predicted chlorophyll represents the value after calibration. CV = coefficient of variation.

| Variable | Predicted | CV | Observed | CV |
|---|---|---|---|---|
| Total P (mg/L) | 140 | 0.26 | 133 | 0.05 |
| Chlorophyll (ug/L) | 76 | 0.44 | 69.4 | 0.09 |
| Secchi Transparency (m) | 0.7 | 0.24 | 0.7 | 0.06 |

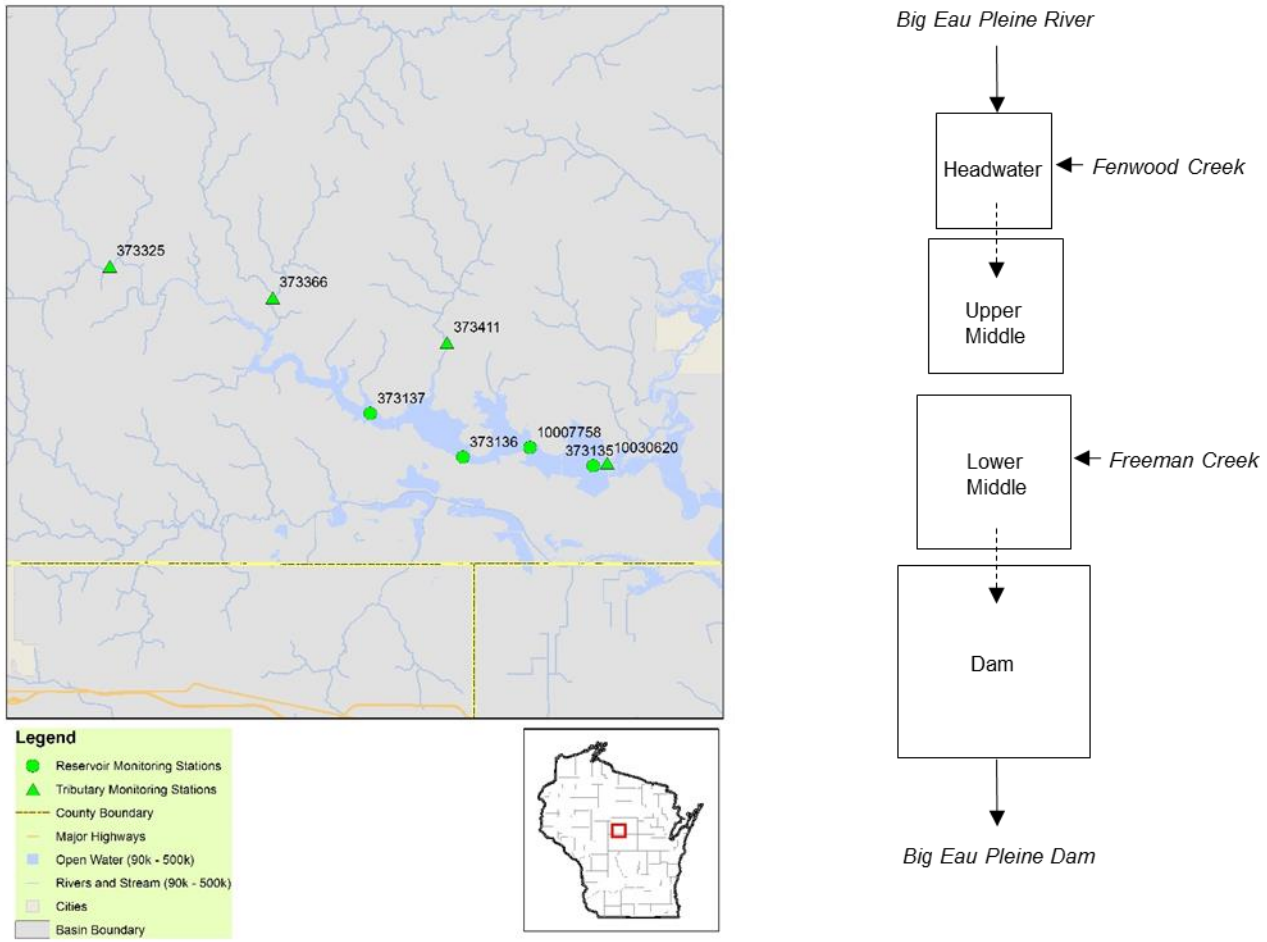


Figure 1. Water sampling station locations (left) and Bathtub conceptualization.

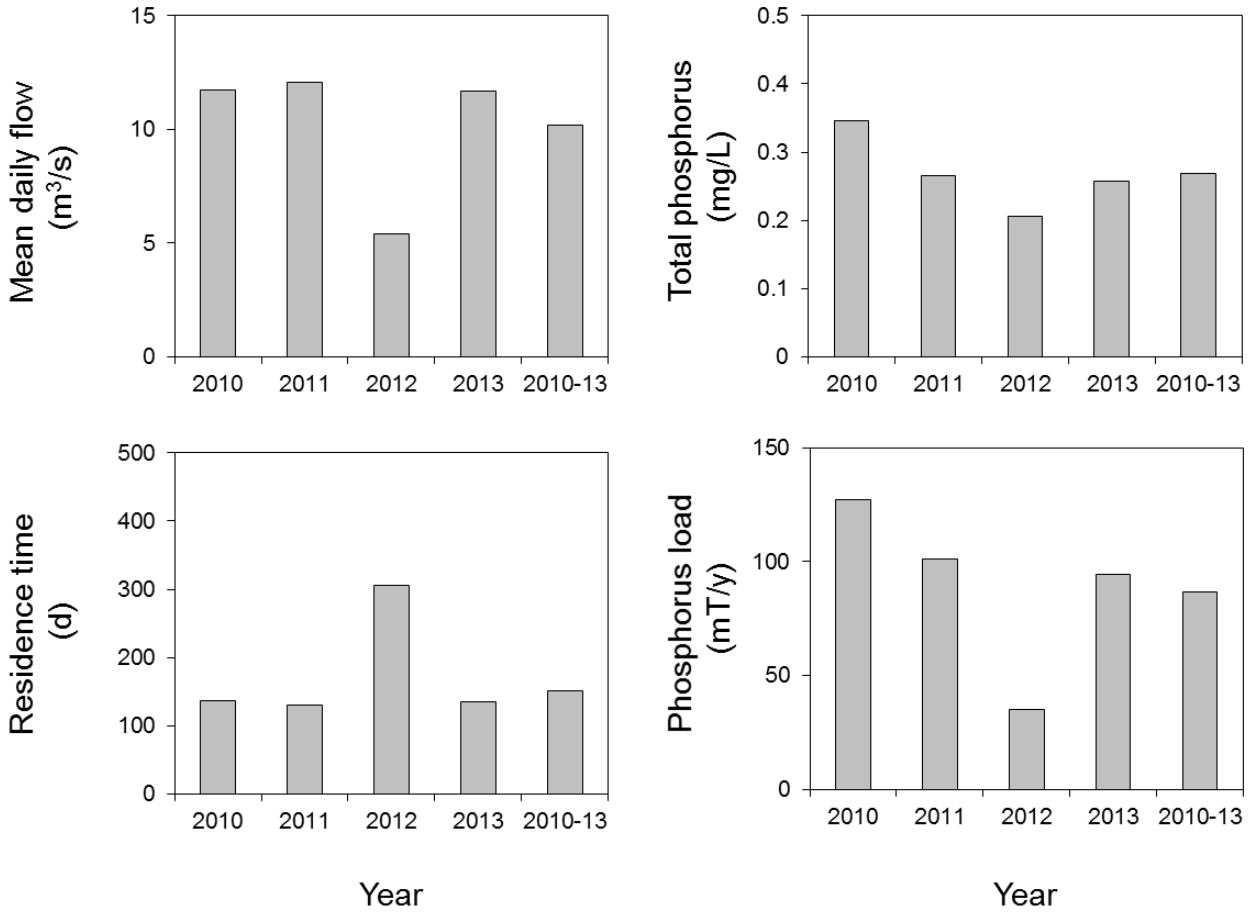


Figure 2. Annual gauged mean daily flow into Big Eau Pleine Reservoir (upper left panel), theoretical water residence time (lower left panel), flow-weighted total phosphorus concentration of the inflow (upper right panel), and total phosphorus load (lower right panel) during 2010 - 2013. The grand mean for each variable was estimated as the mean of the individual summer means.

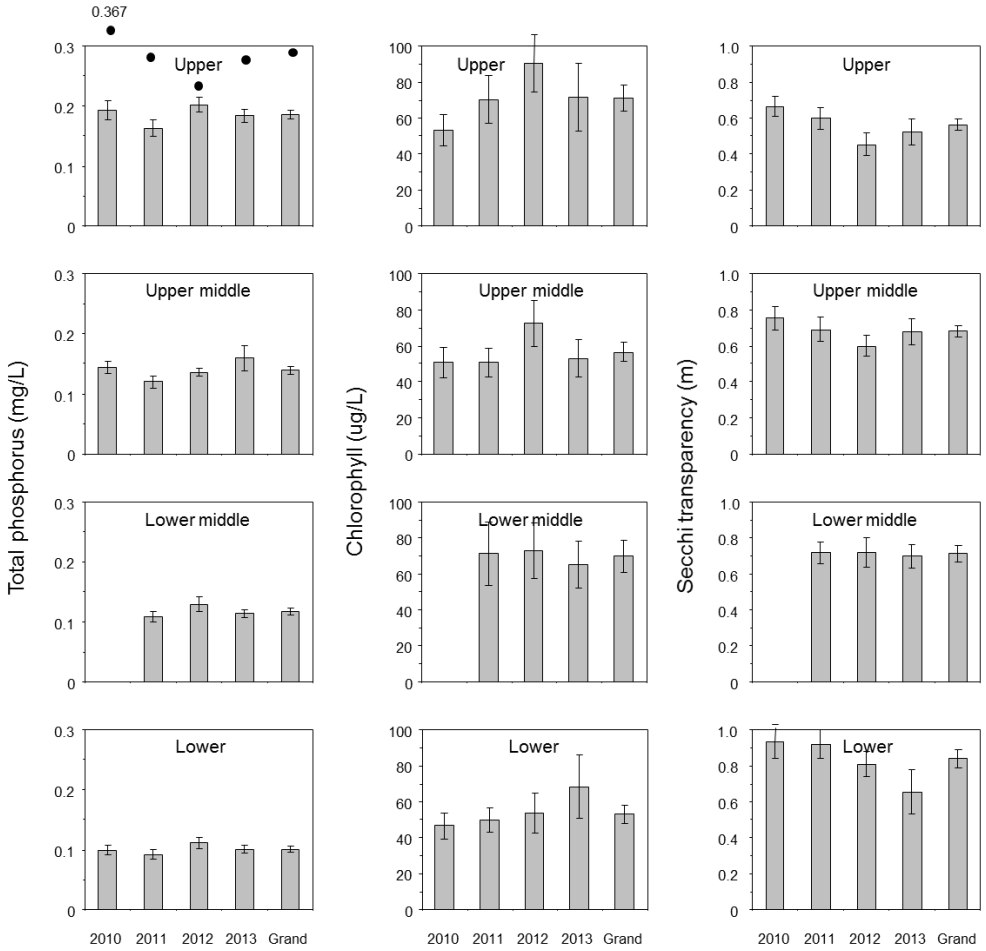


Figure 3. Summer (June – September) mean concentrations of total phosphorus (left panels), chlorophyll (middle panels), and Secchi transparency (right panels) during 2010 - 2013. The black circles denote the gauged annual inflow total phosphorus concentration (including estimated precipitation). The grand mean for each variable was estimated as the mean of the individual summer means. Vertical lines represent ± 1 standard error.

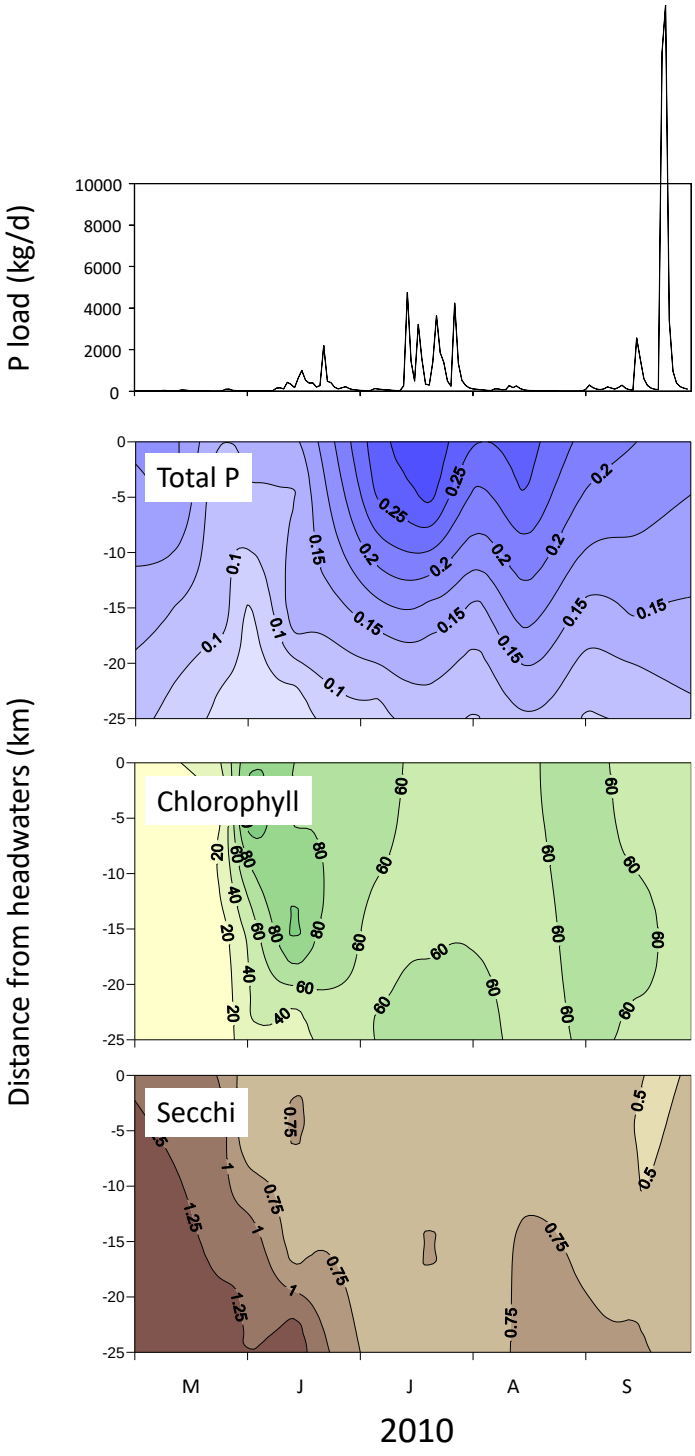


Figure 4. Summer phosphorus (P) loading from the Big Eau Pleine River (upper panel) versus seasonal and longitudinal variations in surface total phosphorus (P), chlorophyll, and Secchi transparency in 2010.

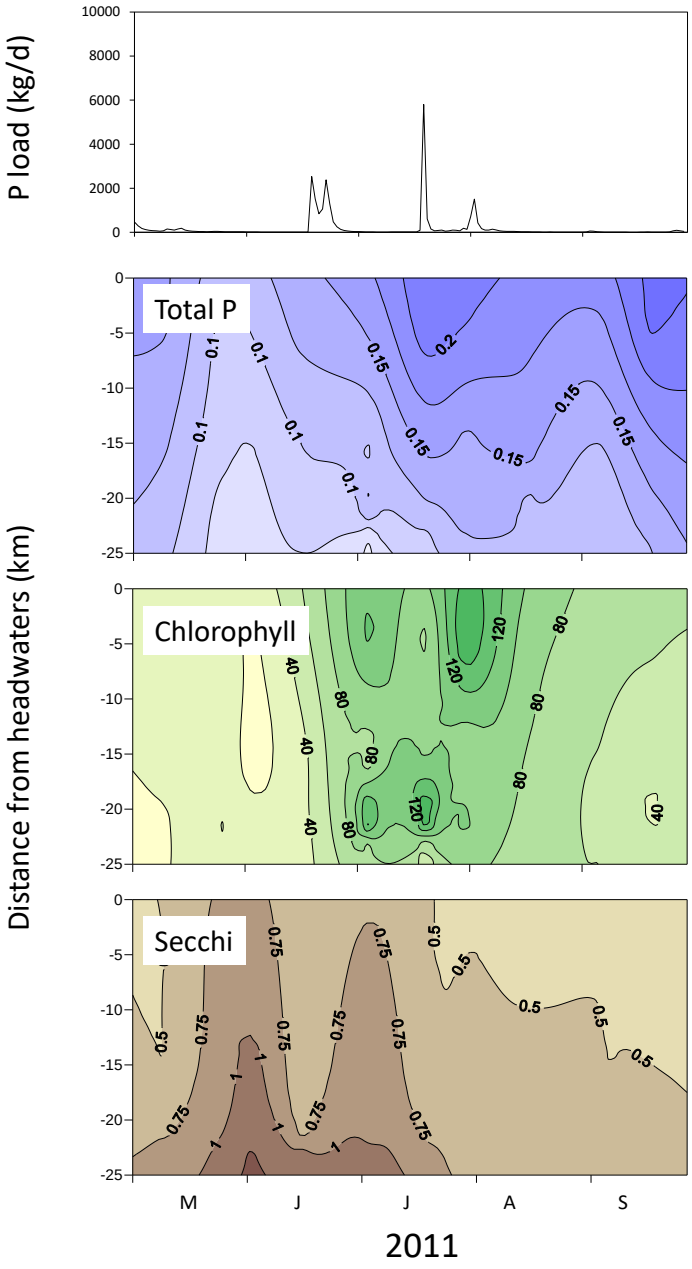


Figure 5. Summer phosphorus (P) loading from the Big Eau Pleine River (upper panel) versus seasonal and longitudinal variations in surface total phosphorus (P), chlorophyll, and Secchi transparency in 2011.

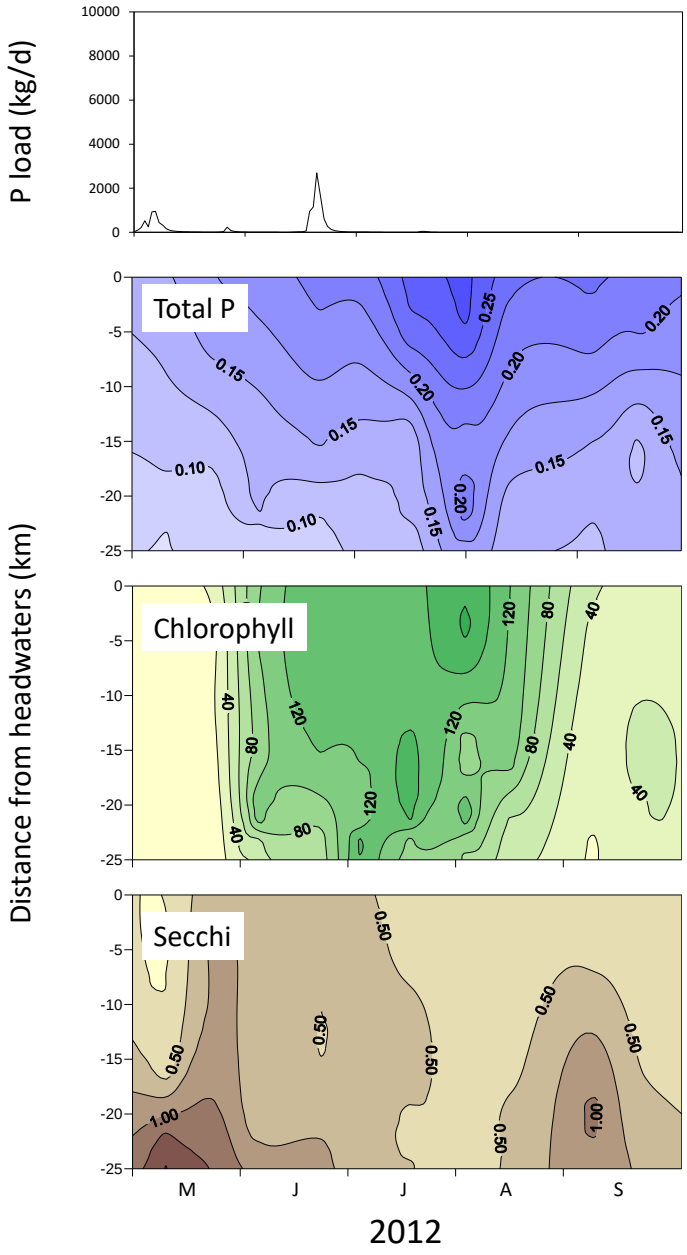


Figure 6. Summer phosphorus (P) loading from the Big Eau Pleine River (upper panel) versus seasonal and longitudinal variations in surface total phosphorus (P), chlorophyll, and Secchi transparency in 2012.

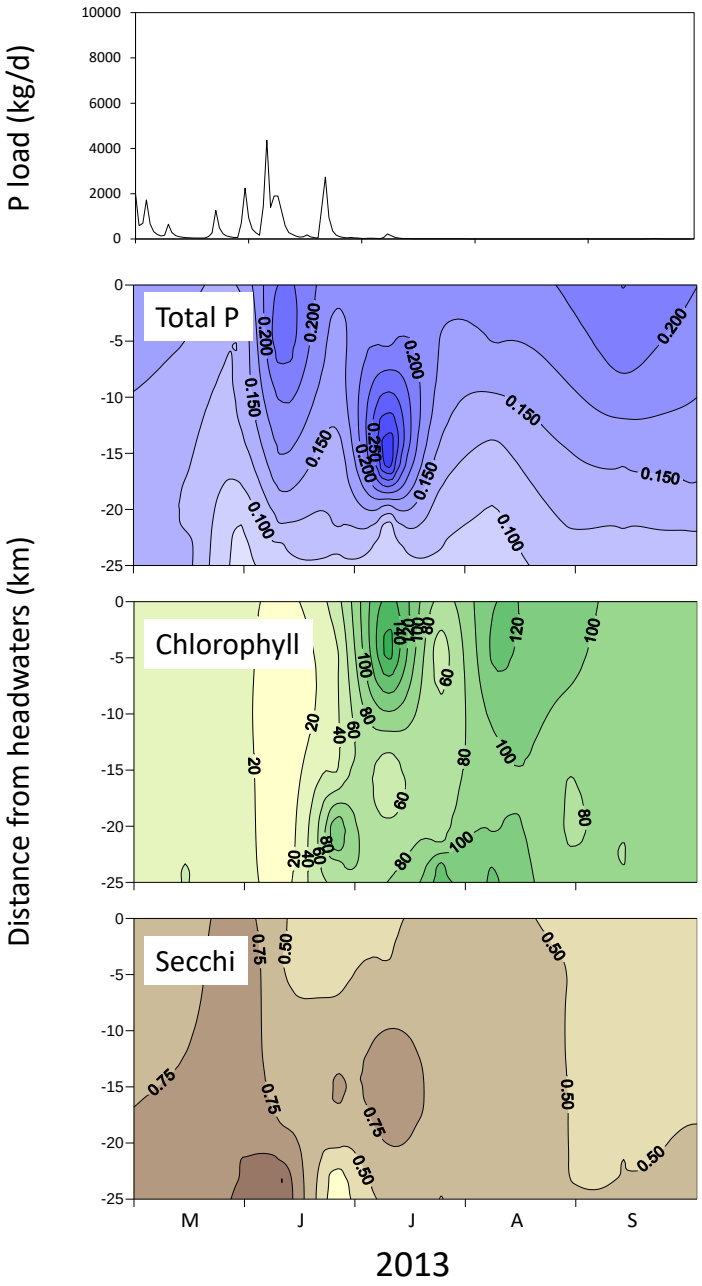


Figure 7. Summer phosphorus (P) loading from the Big Eau Pleine River (upper panel) versus seasonal and longitudinal variations in surface total phosphorus (P), chlorophyll, and Secchi transparency in 2013.

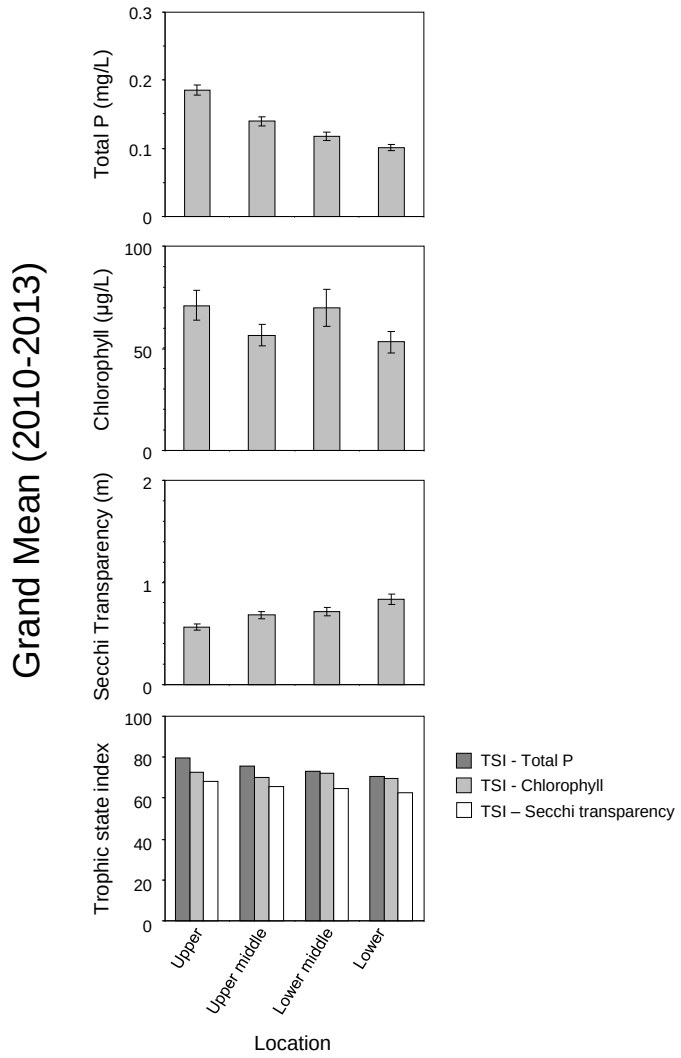


Figure 8. Variations in grand mean summer (June – September) total phosphorus (P, upper panel), chlorophyll (upper middle panel), Secchi transparency (lower middle panel), and Carlson trophic state indices (TSI) for the headwater, upper middle, lower middle, and dam stations in Big Eau Pleine Reservoir. Vertical lines represent ± 1 standard error of the grand mean.

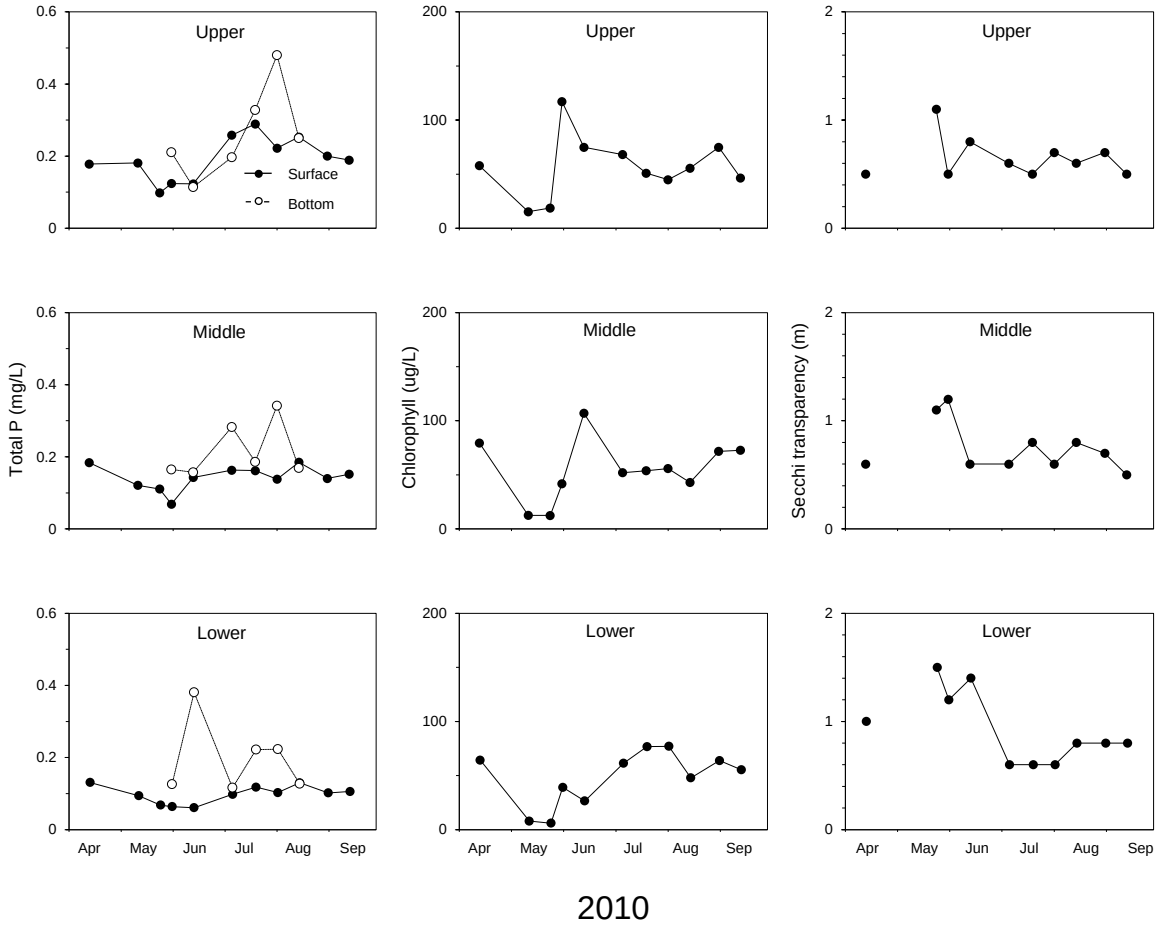


Figure 9. Seasonal variations in surface and near-bottom concentrations of total phosphorus (P, left panels), chlorophyll (middle panels), and Secchi transparency (right panels) for the headwater, lower middle, and dam stations during 2010.

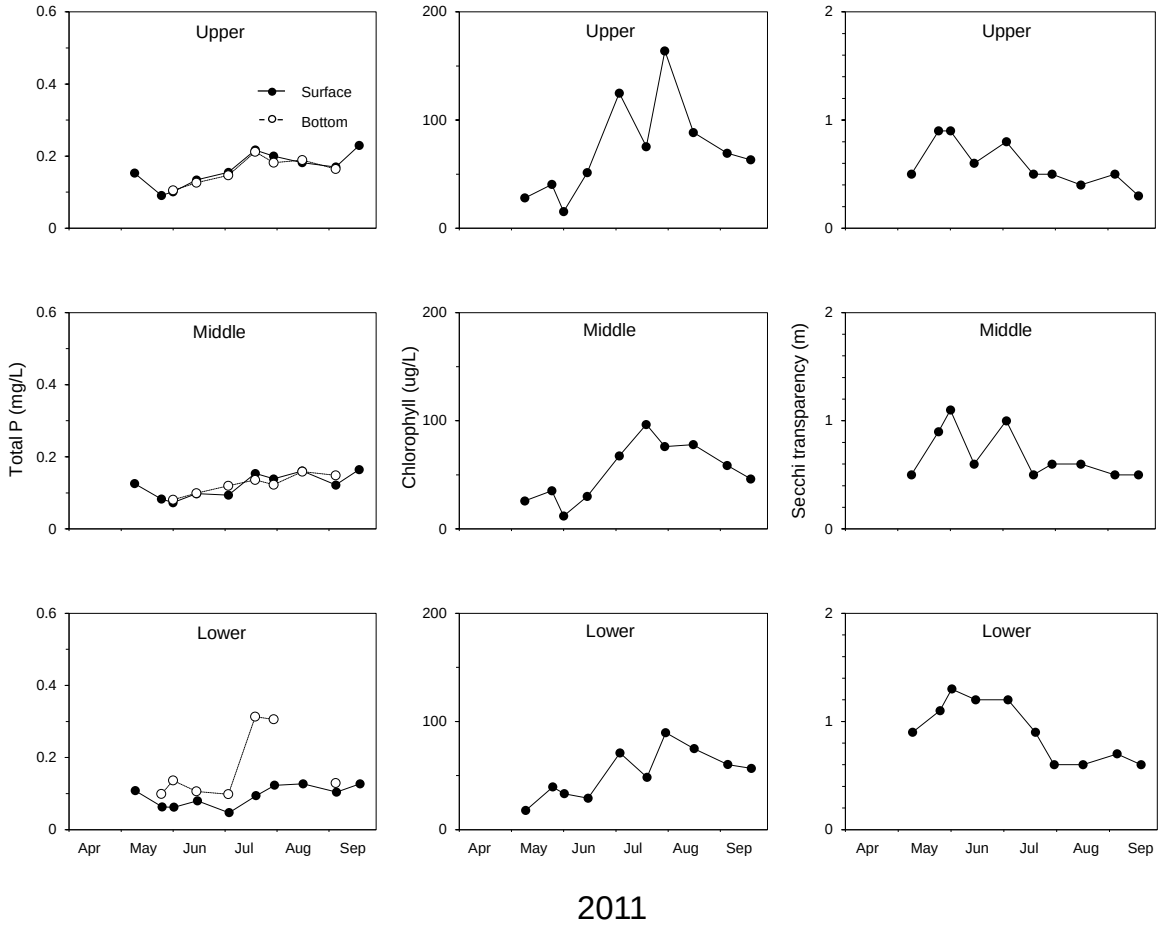


Figure 10. Seasonal variations in surface and near-bottom concentrations of total phosphorus (P, left panels), chlorophyll (middle panels), and Secchi transparency (right panels) for the headwater, lower middle, and dam stations during 2011.

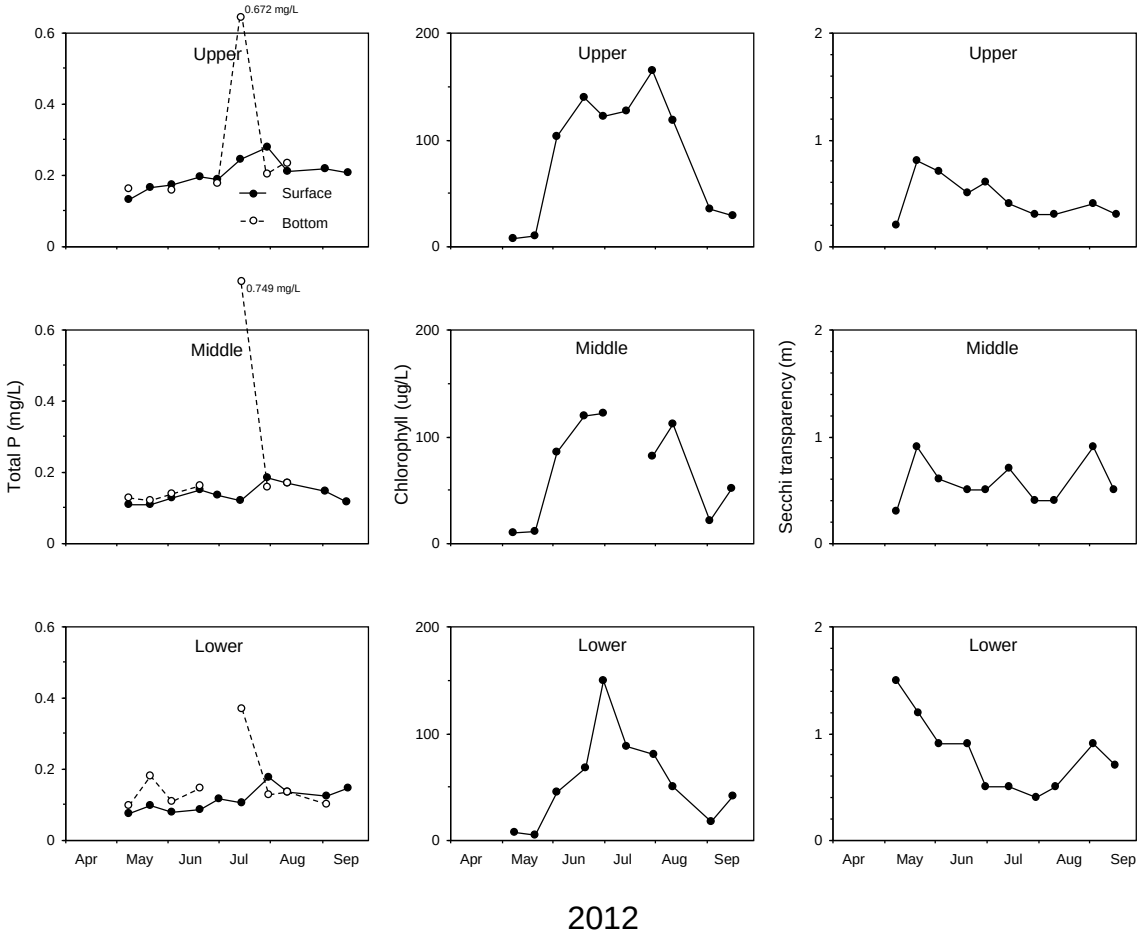


Figure 11. Seasonal variations in surface and near-bottom concentrations of total phosphorus (P, left panels), chlorophyll (middle panels), and Secchi transparency (right panels) for the headwater, middle, and dam stations during 2012.

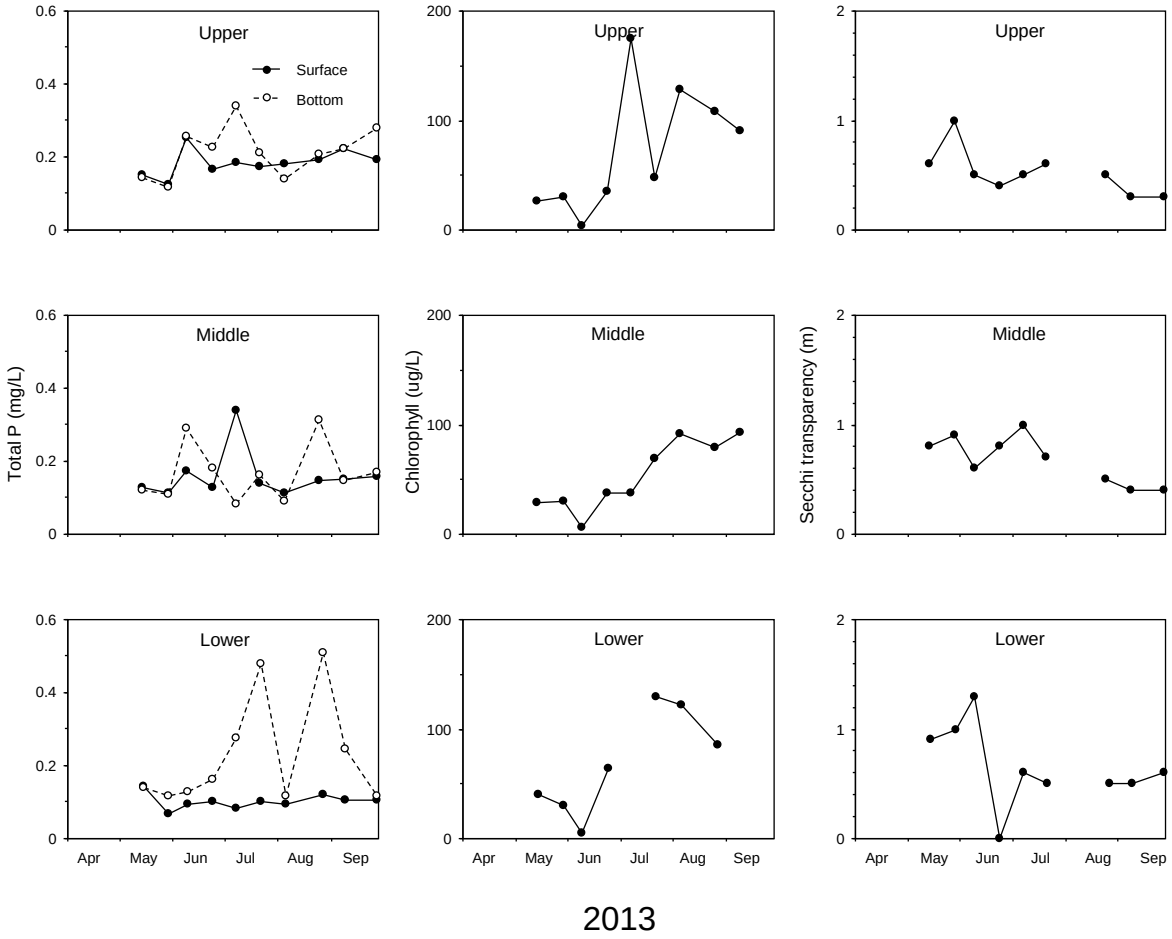


Figure 12. Seasonal variations in surface and near-bottom concentrations of total phosphorus (P, left panels), chlorophyll (middle panels), and Secchi transparency (right panels) for the headwater, middle, and dam stations during 2013.

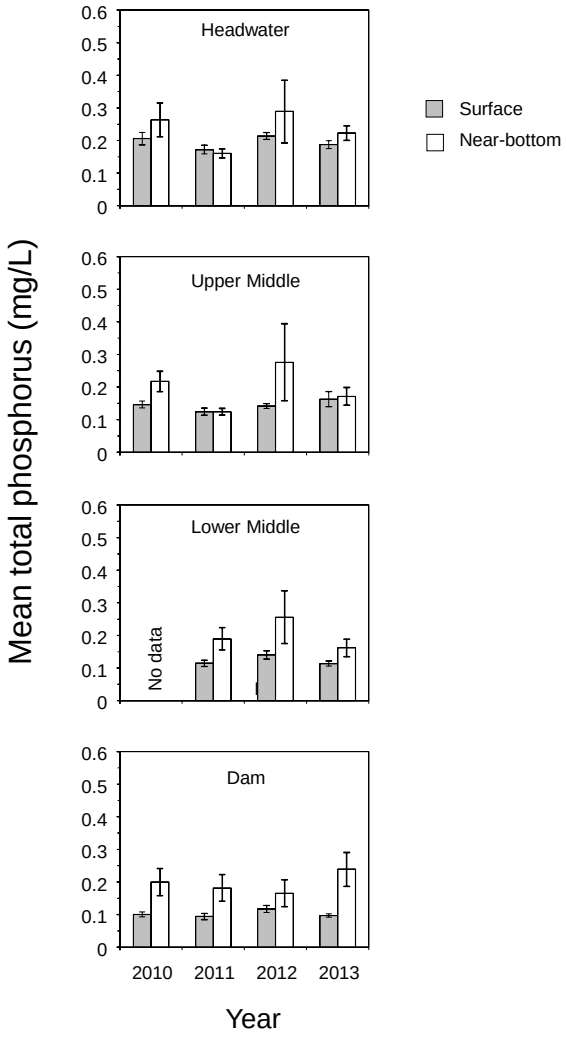


Figure 13. Variations in mean summer (June – September) surface and near -bottom total phosphorus concentrations at the headwater, upper middle, lower middle, and dam stations in Big Eau Pleine Reservoir. Vertical bars denote ± 1 standard error.

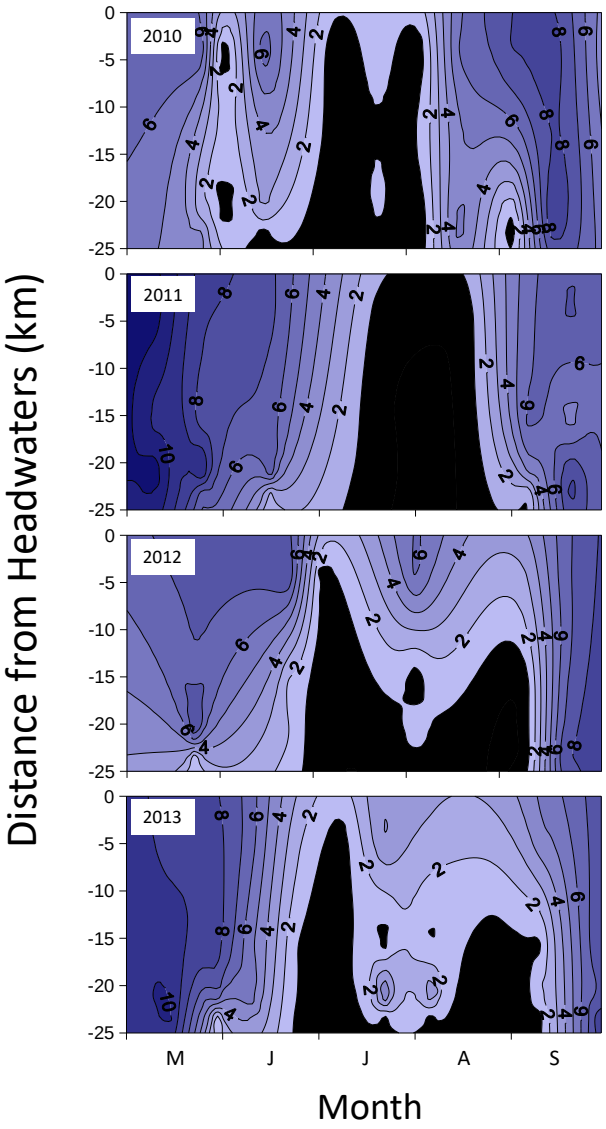


Figure 14. Seasonal and longitudinal variations in near-bottom concentrations of dissolved oxygen during 2010-2013. Black area indicate anoxic conditions (i.e., dissolved oxygen < 1 mg/L).

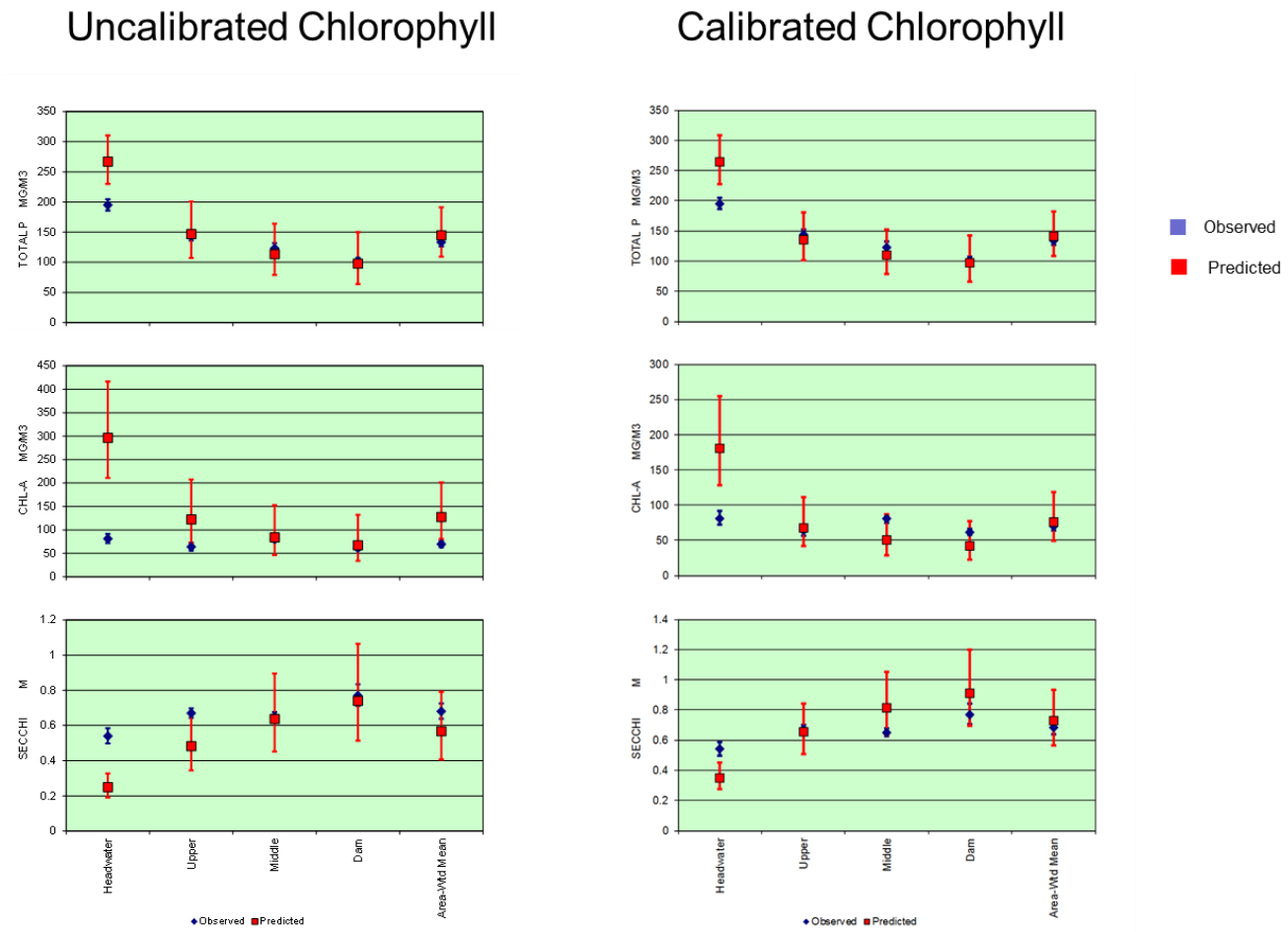


Figure 15. A comparison of mean (± 1 standard error) observed versus predicted area-weighted total phosphorus, chlorophyll, and Secchi transparency. Left panels show model output for the uncalibrated chlorophyll model while the right panels show the calibrated chlorophyll model output.

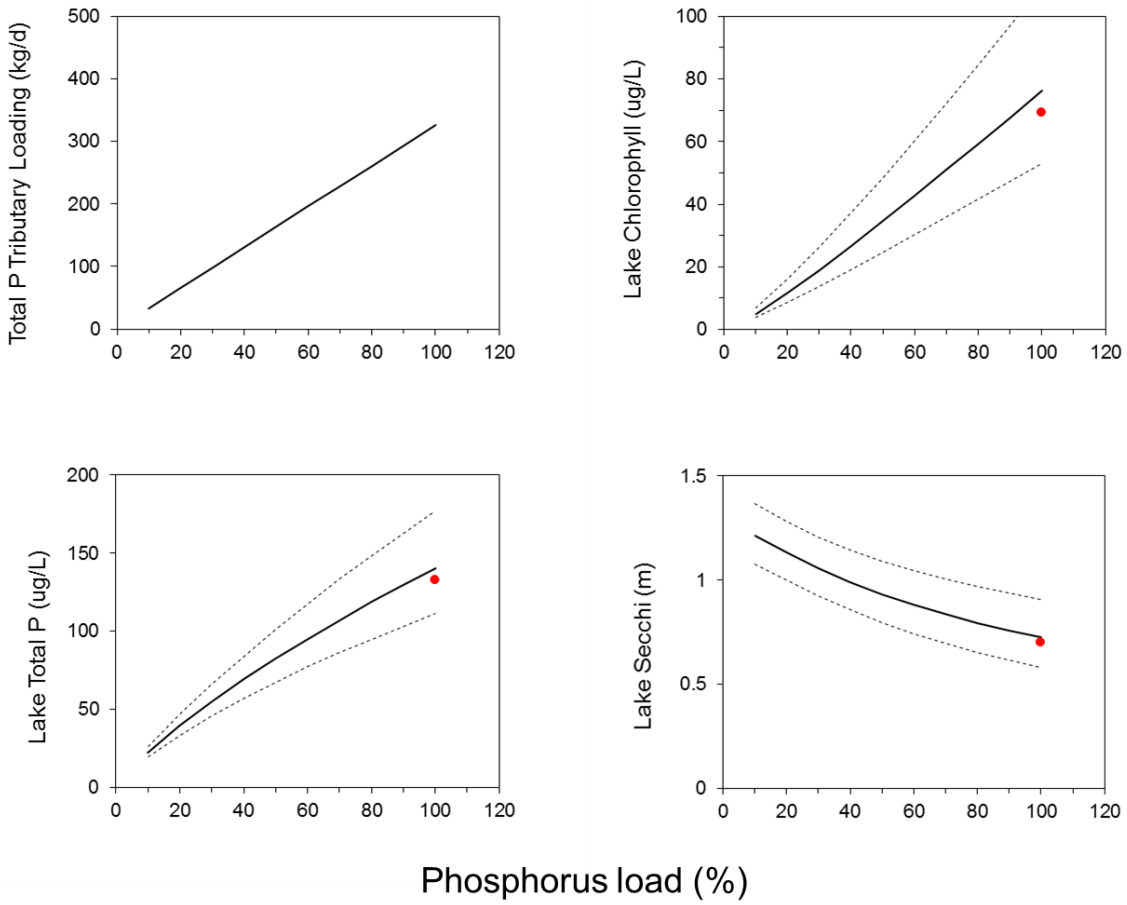


Figure 16. Bathtub (Walker 1996) model output of predicted changes in total phosphorus (P), chlorophyll, and Secchi transparency in Big Eau Pleine Reservoir as a function of reducing current mean 2010-13 mean summer P loading by 20% increments (black lines). Dotted lines denote 95% confidence intervals. Red circles represent current measured mean summer values. 100% P load represents current loading conditions.

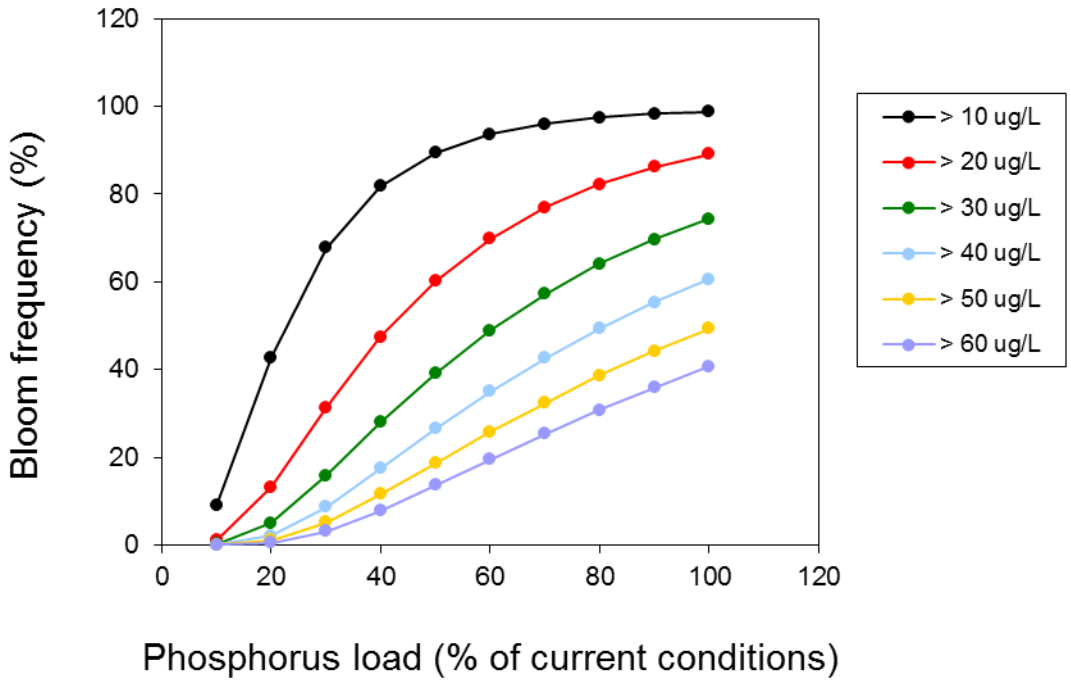


Figure 17. Bathtub (Walker 1996) model output of predicted changes in algal bloom frequency (as chlorophyll) as a function of reducing current mean 2010-13 mean summer P loading by 20% increments. 100% P load represents current loading conditions.

# APPENDICES

Appendix 1a. Big Eau Pleine summer (June-September to early October) means and standard errors (SE) for the headwater station.

| Statistic | Total P (Surface) | Total P (Bottom) | Chlorophyll | SRP | Secchi |
|---|---|---|---|---|---|
| | (mg/L) | (mg/L) | (ug/L) | (mg/L) | (m) |
| **2010-13** | | | | | |
| Mean[1] | 0.195 | 0.228 | 81.2 | 0.038 | 0.54 |
| SE | 0.007 | 0.023 | 7.8 | 0.006 | 0.03 |
| **2010** | | | | | |
| Mean | 0.206 | 0.263 | 60.6 | 0.072 | 0.63 |
| SE | 0.019 | 0.052 | 9.5 | 0.017 | 0.04 |
| **2011** | | | | | |
| Mean | 0.172 | 0.161 | 78.5 | 0.020 | 0.58 |
| SE | 0.014 | 0.014 | 14.5 | 0.004 | 0.06 |
| **2012** | | | | | |
| Mean | 0.213 | 0.289 | 108.3 | 0.027 | 0.44 |
| SE | 0.011 | 0.096 | 15.5 | 0.005 | 0.05 |
| **2013** | | | | | |
| Mean | 0.187 | 0.222 | 77.1 | 0.036 | 0.51 |
| SE | 0.012 | 0.023 | 20.5 | 0.014 | 0.08 |

[1]Represents the mean of all values measured between June-September to early October over 2010-13.

Appendix 1b. Big Eau Pleine summer (June-September to early October) means and standard errors (SE) for the upper middle station.

| Statistic | Total P (Surface) | Total P (Bottom) | Chlorophyll | SRP | Secchi |
|---|---|---|---|---|---|
| | (mg/L) | (mg/L) | (ug/L) | (mg/L) | (m) |
| **2010-13** | | | | | |
| Mean[1] | 0.144 | 0.188 | 63.4 | 0.018 | 0.67 |
| SE | 0.007 | 0.025 | 5.5 | 0.004 | 0.04 |
| **2010** | | | | | |
| Mean | 0.146 | 0.217 | 56.1 | 0.032 | 0.73 |
| SE | 0.011 | 0.031 | 9.1 | 0.011 | 0.07 |
| **2011** | | | | | |
| Mean | 0.124 | 0.124 | 55.3 | 0.010 | 0.69 |
| SE | 0.011 | 0.010 | 9.1 | 0.002 | 0.08 |
| **2012** | | | | | |
| Mean | 0.142 | 0.276 | 88.2 | 0.013 | 0.60 |
| SE | 0.008 | 0.118 | 12.7 | 0.005 | 0.07 |
| **2013** | | | | | |
| Mean | 0.163 | 0.171 | 55.9 | 0.018 | 0.66 |
| SE | 0.023 | 0.027 | 11.3 | 0.009 | 0.08 |

[1]Represents the mean of all values measured between June-September to early October over 2010-13.

Appendix 1c. Big Eau Pleine summer (June-September to early October) means and standard errors (SE) for the lower middle station.

| Statistic | Total P (Surface) | Total P (Bottom) | Chlorophyll | SRP | Secchi |
|---|---|---|---|---|---|
| | (mg/L) | (mg/L) | (ug/L) | (mg/L) | (m) |
| **2010-13** | | | | | |
| Mean[1] | 0.122 | 0.197 | 80.4 | 0.009 | 0.65 |
| SE | 0.006 | 0.027 | 9.6 | 0.003 | 0.04 |
| **2010** | | | | | |
| Mean | | | No Data | | |
| SE | | | | | |
| **2011** | | | | | |
| Mean | 0.114 | 0.190 | 81.9 | 0.006 | 0.69 |
| SE | 0.010 | 0.034 | 20.2 | 0.002 | 0.07 |
| **2012** | | | | | |
| Mean | 0.140 | 0.256 | 89.3 | 0.013 | 0.60 |
| SE | 0.013 | 0.081 | 16.7 | 0.007 | 0.08 |
| **2013** | | | | | |
| Mean | 0.114 | 0.162 | 70.0 | 0.008 | 0.68 |
| SE | 0.008 | 0.027 | 14.0 | 0.004 | 0.07 |

[1]Represents the mean of all values measured between June-September to early October over 2010-13.

Appendix 1d. Big Eau Pleine summer (June-September to early October) means and standard errors (SE) for the dam station.

| Statistic | Total P (Surface) | Total P (Bottom) | Chlorophyll | SRP | Secchi |
|---|---|---|---|---|---|
| | (mg/L) | (mg/L) | (ug/L) | (mg/L) | (m) |
| **2010-13** | | | | | |
| Mean[1] | 0.102 | 0.201 | 60.3 | 0.007 | 0.77 |
| SE | 0.004 | 0.023 | 5.5 | 0.002 | 0.05 |
| **2010** | | | | | |
| Mean | 0.100 | 0.199 | 53.3 | 0.008 | 0.87 |
| SE | 0.008 | 0.041 | 6.1 | 0.004 | 0.09 |
| **2011** | | | | | |
| Mean | 0.094 | 0.181 | 54.8 | 0.005 | 0.90 |
| SE | 0.010 | 0.041 | 7.2 | 0.001 | 0.10 |
| **2012** | | | | | |
| Mean | 0.117 | 0.165 | 64.6 | 0.008 | 0.69 |
| SE | 0.011 | 0.041 | 12.9 | 0.004 | 0.07 |
| **2013** | | | | | |
| Mean | 0.097 | 0.239 | 72.8 | 0.008 | 0.63 |
| SE | 0.005 | 0.052 | 20.2 | 0.004 | 0.14 |

[1]Represents the mean of all values measured between June-September to early October over 2010-13.

# *Steady-State Modeling Analysis of Lake Dubay, Wisconsin River System*

21 November, 2016

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# EXECUTIVE SUMMARY

Lake Dubay is a run-of-the-river hydropower reservoir on the Wisconsin River near Mosinee, WI, that currently exhibits eutrophic to hypereutrophic conditions (Carlson TSI = 62 to 69). A monitoring program was conducted between 2010 and 2013 on the reservoir to examine seasonal total phosphorus (P), chlorophyll, and Secchi transparency dynamics in relation to tributary P loading for Total Maximum Daily Load (TMDL) development. Gauged tributary flow and P inputs included the Wisconsin River at Chuck's Landing, the Big Eau Pleine River below Big Eau Pleine Reservoir, and the Little Eau Pleine River near Rozellville. The gauged discharge was the Wisconsin River below Lake Dubay Dam. Three stations were established along the longitudinal axis of the reservoir for water sampling purposes. Surface samples were collected biweekly between April and October for total P and chlorophyll analysis. A near-bottom samples was also collected for total P analysis. Secchi transparency was determined biweekly using a 20-cm alternating black and white disk.

Mean daily summer measured inflow was moderate over the 2010-13 period at 126 $m^3/s$ (± 25 standard error, SE), resulting in a low mean summer residence time of 6.6 d (±1.6 SE). Summer flow-weighted total P representing the gauged inflow and outflow was 0.107 mg/L and 0.108 mg/L, respectively, suggesting rapid flushing of P loads through the reservoir and advective dominance of total P concentrations in the reservoir. Longitudinal variation in summer mean total P concentration between the headwater and dam stations was minimal and the area-weighted grand mean (i.e., over 2010-13) total P was ~ 0.089 mg/L, similar to but slightly lower than inflow-outflow concentrations. The area-weighted grand mean chlorophyll concentration was moderate at ~ 25 µg/L and summer mean concentrations tended to increase from the headwater to the dam station. The area-weighted grand mean Secchi transparency was low at ~ 0.7 m. The Carlson trophic state index (TSI, Carlson 1977) for P (TSI-P) was high at 69 (indicative of hypereutrophic conditions). The TSI based on chlorophyll (TSI-CHLA) was slightly lower at 62 and TSI based on Secchi transparency (TSI-SD) was 66.

Budgetary analysis of summer flow and P loads indicated an approximate balance between inflow and outflow, suggesting minor P retention during the summer. Overall, the P empirical model (Vollenweider) closely predicted the observed area-weight mean summer total P concentration in Lake Dubay. Tributary P inputs entirely accounted for the summer total P budget, suggesting that internal P loading was negligible. The chlorophyll (chlorophyll:total P regression model for reservoirs; Walker 1996) and Secchi transparency (Based on chlorophyll and nonalgal turbidity) models also closely approximated observed summer grand means. Because Lake Dubay was dominated by advection, low residence time, and little apparent P retention (i.e., deposition), predicted summer total P concentration reductions coincided closely with tributary P load and concentration reductions. For instance, a 50% reduction in P loading coincided with a 50% decline in summer total P from ~0.089 mg/L to 0.046 mg/L. Under this same P loading reduction scenario, predicted summer chlorophyll concentrations declined by 50% from ~ 25 µg/L to ~13 µg/L. Predicted Secchi transparency increased by ~10% from 0.65 m to 0.7 m. Under current P loading conditions, chlorophyll blooms exceeding 20 µg/L and 60 µg/L occurred an estimated 53% and 5% of the time during the summer period, respectively. Using the same scenario, a 50% P loading reduction resulted in a predicted decline in the summer bloom frequency of chlorophyll exceeding 20 µg/L and 60 µg/L to 15% and <1% of the time during the summer period, respectively. Empirical steady-state models developed for Lake Dubay will be used in conjunction with other decision-support tools to develop a TMDL based on predicted reservoir water quality responses to P loading reduction.

# OBJECTIVES

The objectives of this investigation were to examine summer limnological conditions in Lake Dubay between 2010 and 2013 and project future conditions under phosphorus loading reduction scenarios using a steady-state empirical modeling approach.

# METHODS

Flow and total phosphorus (P) loadings from the Wisconsin, Big Eau Pleine, and Little Eau Pleine Rivers (Table 1) were combined with seasonal (April – September to early October) surface water chemistry information from three stations in Lake Dubay (Table 2, Fig. 1) to construct a steady-state empirical model (Bathtub Version 6.14; Walker 1996) to forecast the response of limnological variables (total P, chlorophyll, and Secchi transparency) to future P loading reduction. Since the annual theoretical water residence time was relatively low (range = 5.6 d to 10.8 d), a June through September (122 d) averaging period was used for steady-state empirical modeling analysis. Gauged hydraulic inputs included the Wisconsin River at Chuck's Landing (Station ID 10029678), The Big Eau Pleine River at Big Eau Pleine Dam (Station ID 10030620), and the Little Eau Pleine River near Rosellville (Station ID 10031106, Table 1). The gauged hydraulic discharge from Lake Dubay was the Wisconsin River at Lake Dubay Dam (Station ID 10014652, Table 1). Monthly hydraulic flow ($m^3/s$) and total P loadings (kg/month) determined by the US Geological Survey (Madison, WI) were converted to mean flow (expressed as $hm^3/y$) and total P concentration (expressed as µg/L) over the summer averaging period as input to the model. Additional hydrologic input to the model included ungauged local runoff to the reservoir from the surrounding subwatershed that was estimated using the Soil and Water Assessment Tool (SWAT) and daily precipitation records over the study period obtained from the Wisconsin State Climatology Office (Madison, WI). The coefficient of variation (CV-mean) was estimated from mean June through September flows and total P concentrations between the years 2002 and 2013

reported by the US Geological Survey. The CV-mean was calculated as the standard error of the grand mean (n = 12; i.e., JUN-SEP 2002 through 2013) divided by the grand mean of each constituent. This CV-mean was used for error analysis in Bathtub as recommended in Walker (1996). A 12-year average for flow, total P concentration, and total P loading between 2002 and 2013 was estimated from reports and data provided by the US Geological Survey (Dale M. Robertson, U.S. Geological Survey, Madison, WI, unpublished data).

Biweekly measurements of Secchi transparency and surface concentrations of chlorophyll and total P, collected in Lake Dubay during the summer periods of 2010 through 2013, were averaged to estimate a mean concentration for each station segment during each year. June through September was used as the averaging period. Chemical analyses of water samples were conducted by the Wisconsin State Laboratory of Hygiene and the University of Wisconsin – Stevens Water using standard methodological approaches. For in-lake morphometric inputs to the empirical model, the pool was divided into the 3 segments (i.e., headwater, middle, and dam segments) corresponding to the locations of sampling stations (Table 2).

The computer software program Bathtub was used to examine P loading reduction scenarios (Walker 1996). Bathtub is a windows-based software program that provides a suite of equations for predicting lake seasonal averages of total P, chlorophyll, and Secchi transparency. Grand means for total P, chlorophyll, and Secchi transparency over the summer 2010-13 period were used as input into the model. The coefficient of variation for total P, chlorophyll, and Secchi transparency of the grand mean (CV-mean) was calculated as the standard error of the grand mean divided by the grand mean of each constituent. This CV-mean was used for error analysis in Bathtub as recommended in Walker (1996).

# RESULTS AND DISCUSSION

### *Tributary Hydrology and Loading*

Mean daily summer inflow was highest in 2010 at 185 $m^3/s$ and lowest at 64 $m^3/s$ in 2012 (Fig. 2). Mean daily summer flow during the summers of 2011 and 2013 were slightly above the 12-year summer average. The summer theoretical water residence time exhibited the opposite pattern. It was very low during the high flow summer of 2010 at less than 4 d and greater than 11 d during the low-flow summer of 2012. The grand mean residence time over the 4-year study period was slightly lower at ~ 6.6 d compared to the 12-y average summer theoretical residence time.

Summer total P of the gauged inflow to Lake Dubay, representing a flow-weighted concentration for the combined Wisconsin, Big Eau Pleine, Little Eau Pleine Rivers, and estimated local subwatershed runoff ranged between 0.100 mg/L in 2012 and 0.111 mg/L in 2010, following a trend similar to that of mean daily summer inflow (Fig. 2). In general, the summer total P concentration was above the 12-y average in 2010 and slightly below the 12-y average in 2012. Summer total P loading followed the same inter-annual trend. It was greatest in 2010 and 2 times higher than the 12-y average. In contrast, summer total P loading was lowest in 2012 and approximately half of the 12-y average. Summer total P loading during the summers of 2011 and 2013 were slightly above the 12-year average.

### *Reservoir Limnological Trends*

Because summer theoretical water residence time was relatively low, even during the lower inflow period of 2012, Lake Dubay mean summer total P concentrations were only slightly lower than the measured inflow total P (Fig. 3). In addition, mean summer total P concentrations exhibited minor variation as a function of in-lake station or distance from

the dam (Fig. 4). This pattern suggested that limnological patterns in the lake were largely dominated by riverine influences along its longitudinal axis. By contrast, longitudinal concentration gradients from headwaters to the dam can typically develop in larger reservoirs as a function of widening morphometry, decreasing flow velocity, and deposition of loads (Thornton et al. 1990). Mean summer concentrations sometimes increased very slightly from headwaters to the dam, as in 2010 (i.e., 0.095 mg/L at the headwater stations and 0.100 mg/L at the dam station) and 2011 (i.e., 0.078 mg/L at the headwater stations and 0.096 mg/L at the dam station, Fig. 3). In all cases, however, summer total P concentration differences were minimal between stations as indicated by grand mean trends over the study period (Fig. 4).

Variations between surface and near-bottom concentrations of total P were small throughout the study period, suggesting that internal P loading from bottom sediments likely played a negligible role in P dynamics in Lake Dubay (Fig. 5-8). There were some periods of elevated near bottom total P concentration with respect to the surface at all stations; but these concentration differences were minor and could be attributable to other mechanisms such as resuspension caused by river current shear stress or river density underflows. For instance, total P concentrations were slightly higher near bottom compared to the surface in June and July of 2010, particularly at the dam station (Fig. 5). Similar vertical differences occurred at all stations during other summers (Fig. 6-8). Overall, differences in mean summer surface versus near-bottom total P concentrations were very minor over the study period (Fig. 9).

Dissolved oxygen concentrations near the sediment-water interface generally exceeded 2 mg/L throughout the summer months at all stations (Fig. 10), indicating oxidized and aerobic conditions near the sediment-water interface that potentially suppressed diffusive P flux from sediment (i.e., internal P loading). However, there were instances of near-bottom anoxia (i.e., DO < 1.0 mg/L) throughout the study period that may have driven some anaerobic P release from sediment. While potential anaerobic diffusive P flux could have occurred from sediment during these periods, its impact on the lake P budget appeared to be negligible compared to watershed P loading (see below).

Mean summer chlorophyll concentrations ranged between 16 µg/L and 35 µg/L and tended to increase slightly from the headwater to the dam station (Fig. 3 and 4). Interestingly, means were lowest during the lower flow summer of 2012 compared to other summers. Although there were seasonal periods when Secchi transparency slightly exceeded 1.0 m (Fig. 5-8), summer means were generally lower throughout the study period (Fig. 3 and 4), ranging between 0.5 and 0.9 m. Longitudinal variations in grand mean Secchi transparencies were also minor (headwater station = 0.6 m ± 0.03 SE; middle station = 0.7 m ± 0.04 SE; dam station = 0.7 m ± 0.04 SE; Fig. 4).

Grand mean summer Carlson Tropic State Index (TSI) values were greatest for total P at ~ 69 (Fig. 4), indicative of hypereutrophic conditions. Grand mean TSI was slightly lower for chlorophyll (~ 62) and Secchi transparency (~66) compared to total P (Fig. 4). This pattern may have been related to relatively low residence time which could promote some algal biomass export if cellular doubling times are greater than residence time in the lake.

Other variables of interest are shown in Appendix 1. The grand mean total P composition was dominated by particulate P, most likely incorporated into algal biomass. Soluble reactive P was generally low and ranged from not detectable to 0.028 µg/L. The grand mean soluble reactive P concentration ranged between 0.016 mg/L (middle station) to 0.019 mg/L (dam station), accounting for~ 20% of the total P composition. Particulate N accounted for ~82% of the total N composition. Dissolved inorganic N was dominated by $NO_x$ at a grand mean of 0.185 mg/L. The grand mean $NH_x$ concentration was low at 0.045 mg/L and represented only 5% of the total N composition. The grand mean molar particulate N:P ratio was ~ 34:1, suggesting that algal growth was P-limited. Hillebrand et al. (2013) suggested that optimal N:P molar ratios are higher for cyanobacteria with a mean from literature values of ~26:1.

*Steady-State Empirical Modelling*

The mean (2010-13) summer hydraulic and total P balance for measured inputs and outputs to Lake Dubay are shown in Table 3. The measured mean summer outflow at Lake Dubay Dam accounted for 87% mean measured inflow, suggesting ungauged sources (i.e., groundwater and local surface-subsurface watershed inputs) were probably minor. Similarly, measured mean summer P loading to Lake Dubay was only slightly greater than mean summer P discharge (Table 3), suggesting minimal P retention (Table 3).

The Wisconsin River at Chuck's Landing overwhelmingly dominated mean summer gauged P inputs to Lake Dubay (Table 3). Mean summer flow and P loading represented 78% and 65% of the gauged mean summer inputs, respectively. The mean summer flow-weighted total P concentration was 0.107 mg/L. Although the Big and Little Eau Pleine Rivers represented only 12% of the gauged mean summer inflow, the mean summer flow-weighted total P concentrations were higher at 0.135 and 0.324 mg/L, respectively. Mean summer total P loading from these inputs represented 22% of the measured summer total P load to the system. Although minor but apparent P retention of inflow P loads occurred, the weighted inflow and outflow total P concentrations were nearly identical, suggesting that advective flow-through and discharge, versus deposition of total P loads, largely regulated P concentrations in Lake Dubay. Instead, differences in inflow-outflow P loads appeared to be attributed to minor differences in flow (i.e., composited inflow was slightly greater than the outflow).

Because low summer theoretical water residence time and advection dominated the P budget, a first-order P sedimentation model (σ) was chosen to predict summer mean lake total P according to the equation,

$$P_{lake} = \frac{P_{inflow}}{(1 + \sigma\tau_{\omega})}$$

Where, $P_{lake}$ = area-weighted mean summer total P concentration (mg/m$^3$), $P_{inflow}$ = flow-weighted gauged inflow total P (mg/m$^3$), $\sigma$ = first-order sedimentation coefficient, and $\tau_\omega$ = summer theoretical water residence time (y). Of the first-order P sedimentation models, Vollenweider (1976) was chosen as the P sedimentation model (Table 4). Because the Walker (1996) chlorophyll-total P regression relationship was developed from an extensive northern lake data set, it was chosen for mean summer chlorophyll prediction. Finally, the default Secchi transparency model developed from relationships between chlorophyll and turbidity in reservoirs was chosen to estimate mean summer Secchi depth.

Observed versus predicted summer means of total P, chlorophyll, and Secchi transparency over the 2010-13 period are shown in Figure 11. Overall, empirically-predicted mean summer total P, chlorophyll, and Secchi transparency were nearly identical to the observed area-weighted means for Lake Dubay.

### *Phosphorus Loading Reduction*

Current summer P loading to Lake Dubay was reduced by 20% increments in Bathtub to examine predicted water quality responses to simulated future P loading reduction as a result of best management practices (BMP) implementation for TMDL development and goal-setting (Fig. 12). Because Lake Dubay is a run-of-the-river reservoir with low residence time and little apparent P retention (i.e., deposition), predicted summer total P concentration reductions coincided closely with tributary P load and concentration reductions (Fig. 12). For instance, a 50% reduction in P loading coincided with a 50% decline in summer total P from ~0.089 mg/L to 0.046 mg/L. Under this same P loading reduction scenario, predicted summer chlorophyll concentrations declined by 50% from ~ 25 µg/L to ~13 µg/L. Predicted Secchi transparency increased by 10% from 0.6 m to 0.7 m.

Predicted bloom frequency (i.e., percentage of the summer that chlorophyll exceeds a certain concentration) response to P loading reduction is shown in Figure 13 for various summer mean chlorophyll concentrations. Under current P loading conditions, chlorophyll blooms exceeding 20 µg/L and 60 µg/L occurred an estimated 53% and 5% of the time during the summer period, respectively. A 50% P loading reduction would result in a predicted decline in the summer bloom frequency of chlorophyll exceeding 20 µg/L and 60 µg/L to 15% and <1% of the time during the summer period, respectively. Thus, empirical models suggested that predicted reservoir trophic state indicator variables (total P, chlorophyll, and chlorophyll concentration bloom frequency) were responsive to P loading reduction.

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Table 1. Gauged inflow-outflow stations used in the Lake Dubay empirical steady-state model.

| Station ID | Gauged Inflow | Latitude | Longitude |
|---|---|---|---|
| 10029678 | Wisconsin River at Chucks Landing | 44.787080 | 89.704960 |
| 10030620 | Big Eau Pleine River at Big Eau Pleine Dam | 44.730816 | 89.759300 |
| 10031106 | Little Eau Pleine River near Rozellville | 44.713066 | 89.926285 |
| | **Gauged outflow** | **Latitude** | **Longitude** |
| 10014652 | Wisconsin River below Lake Dubay Dam | 44.665030 | 89.649981 |

Table 2. Water quality sampling station locations in Lake Dubay.

| Station ID | Name | Surface area ($km^2$) | Mean depth (m) | Segment length (km) |
|---|---|---|---|---|
| 373445 | Headwaters | 9.6 | 1.68 | 14.1 |
| 1003116 | Middle | 7.87 | 2.76 | 5.3 |
| 503163 | Dam | 5.79 | 4.02 | 2.5 |

Table 3. A comparison of mean (2010-13) summer (June - September) flow and total phosphorus (P) inputs to and discharge from Lake Dubay.

| Component | Flow | | Total P | | |
|---|---|---|---|---|---|
| | ($m^3/s$) | (% contribution) | (mg/L) | (kg/d) | (% contribution) |
| **Inputs** | | | | | |
| Wisconsin River | 98.2 | 78 | 0.090 | 764 | 65 |
| Big Eau Pleine River | 11.9 | 9 | 0.135 | 138 | 12 |
| Little Eau Pleine River | 4.2 | 3 | 0.324 | 117 | 10 |
| Ungauged inputs[1] | 11.3 | 9 | 0.156 | 152 | 13 |
| Precipitation | 1.0 | 1 | 0.022 | 2 | 0 |
| Total | 126.5 | 100 | 0.107 | 1173 | 100 |
| **Outputs** | | | | | |
| Wisconsin River at Lake Dubay Dam | 109.6 | | 0.108 | 1023 | |
| Evaporation | 1.0 | | | | |
| Total | 110.6 | | 0.108 | 1023 | |
| **Balance** | 15.9 (87%) | | | 149.9 (87%) | |

[1]Representing local subwatershed inputs estimated from the Soil and Water Assessment Tool (SWAT)

Table 4. Algorithms used for Bathtub (Walker 1996) phosphorus loading reduction modeling of Lake Dubay.

| Variable | Model |
|---|---|
| Phosphorus | Vollenweider |
| Chlorophyll | Chla:Total P linear regression |
| Secchi Transparency | versus Chlorophyll & Turbidity |

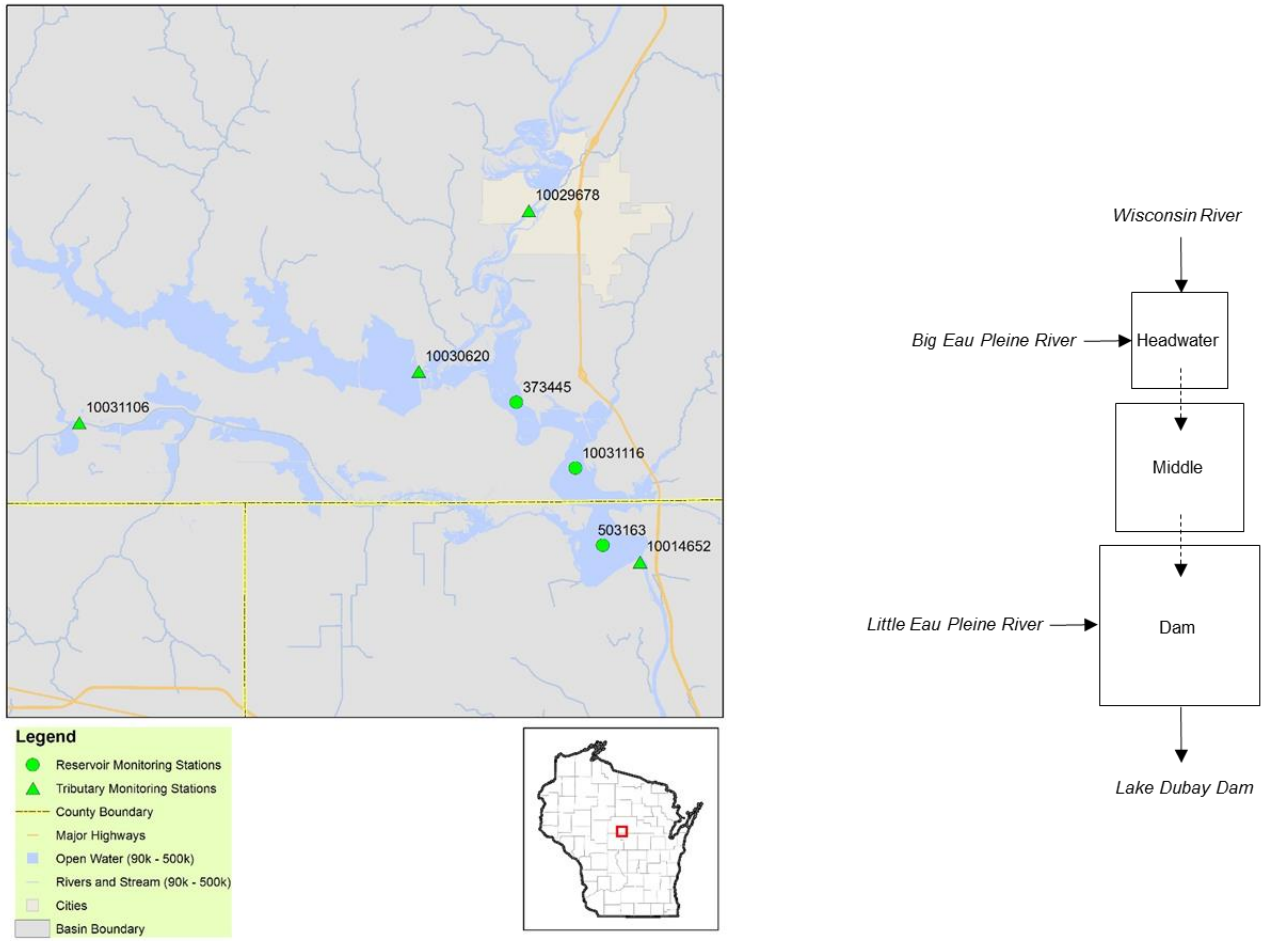



Figure 1. Water sampling station locations (left) and Bathtub conceptualization.

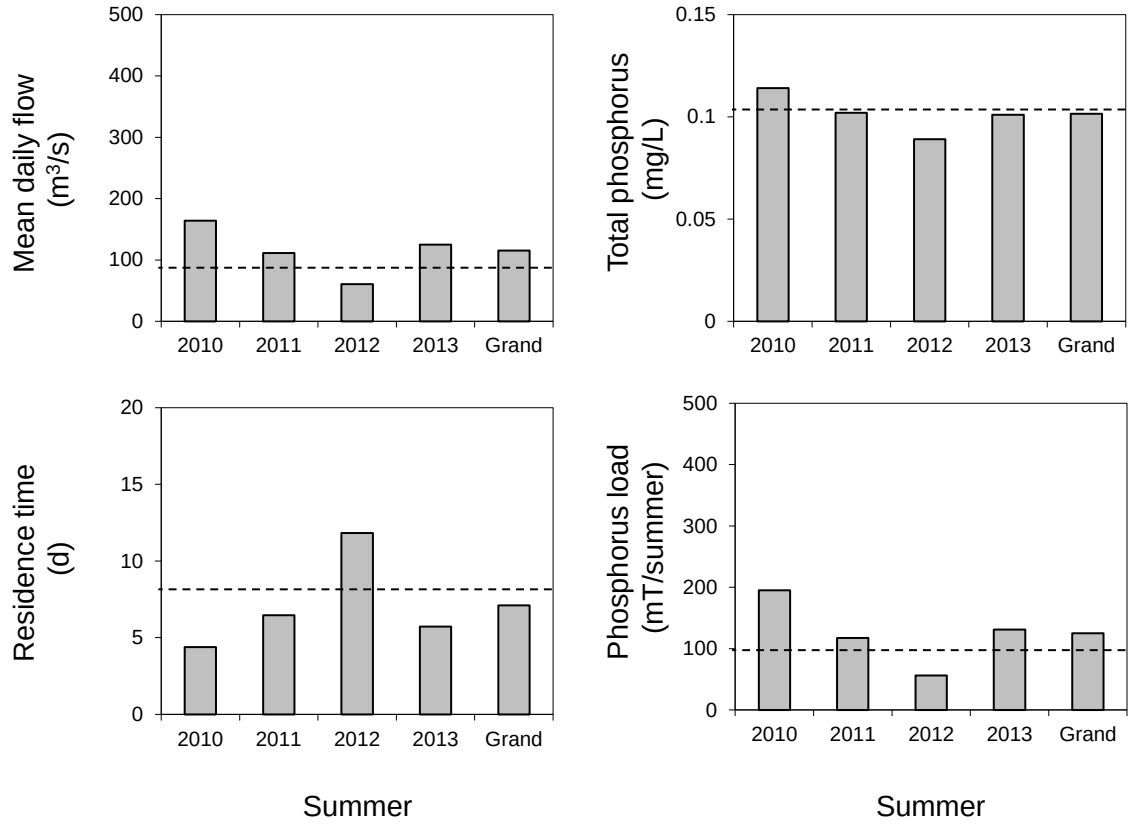



Figure 2. Summer (June – September) mean daily flow into Lake Dubay (upper left panel), theoretical water residence time (lower left panel), flow-weighted total phosphorus concentration of the inflow (upper right panel), and total phosphorus load (lower right panel) during 2010 - 2013. The horizontal dashed line denotes the 12-year average. The grand mean for each variable was estimated as the mean of the individual summer means.

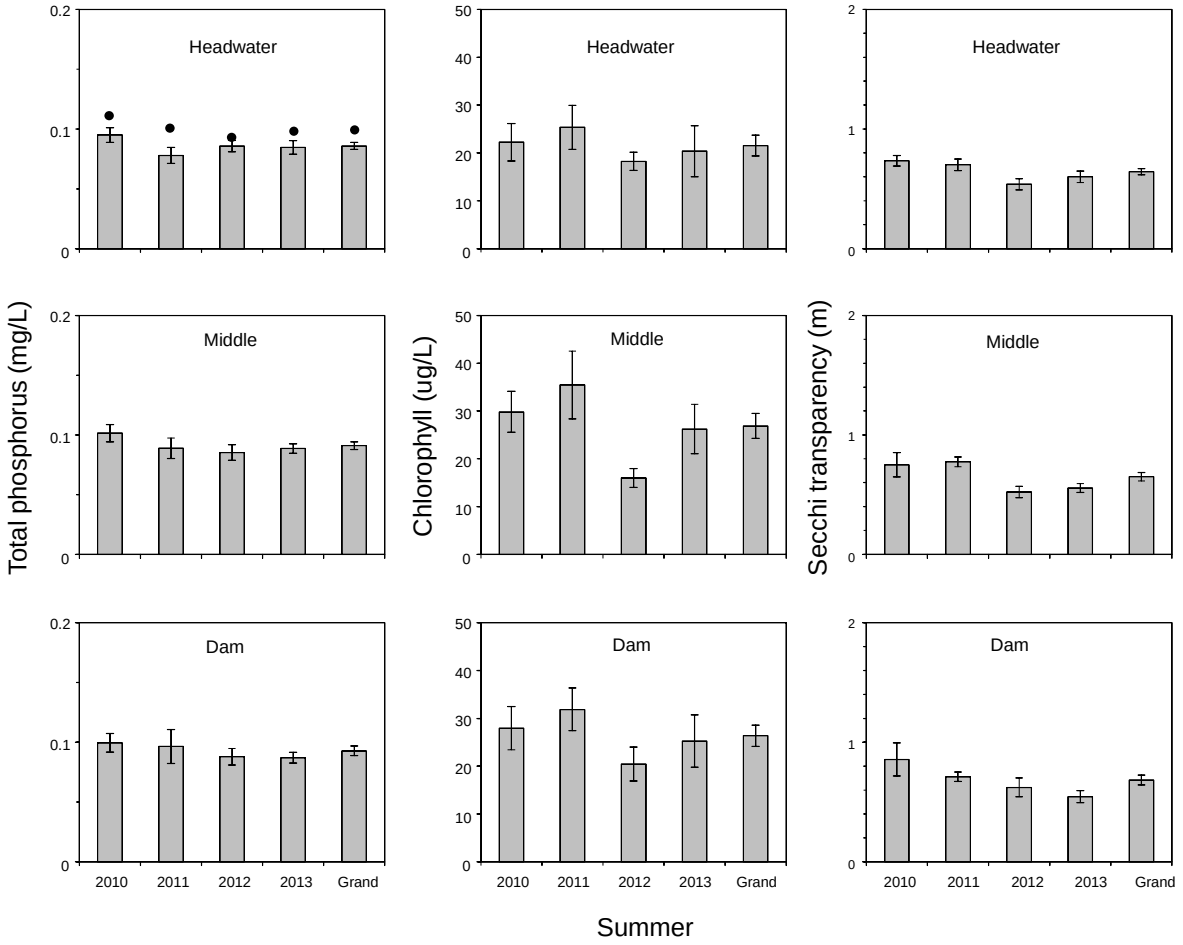



Figure 3. Summer (June – September) mean concentrations of total phosphorus (left panels), chlorophyll (middle panels), and Secchi transparency (right panels) during 2010 - 2013. The black circles denote the gauged inflow total phosphorus concentration. The grand mean for each variable was estimated as the mean of the individual summer means. Vertical lines represent ± 1 standard error.

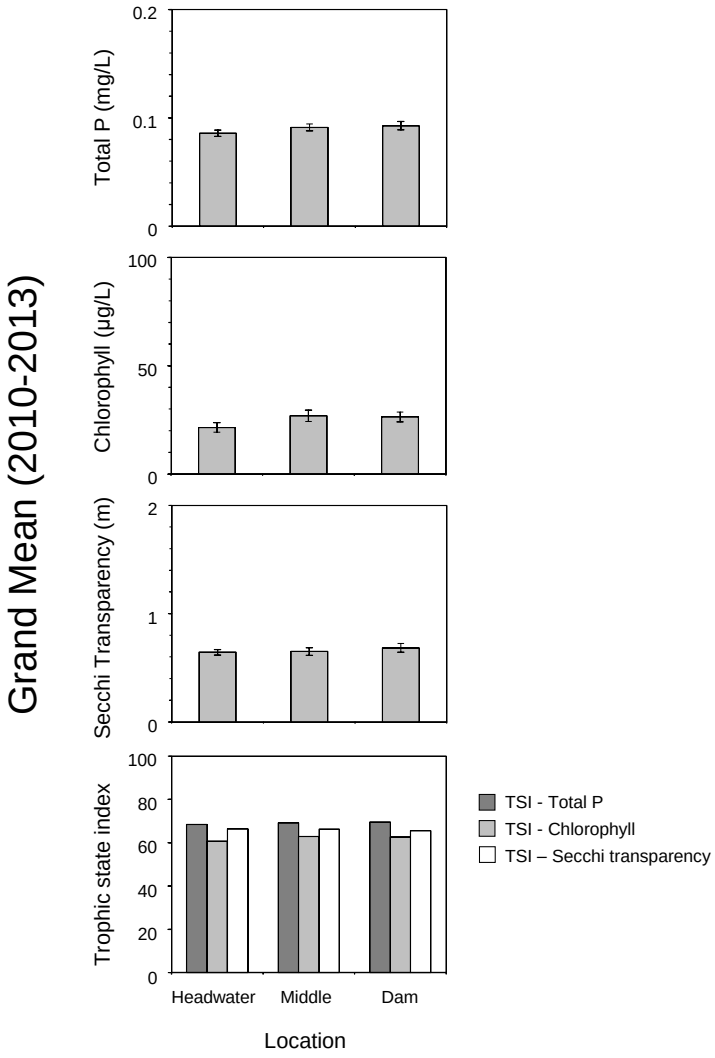



Figure 4. Variations in grand mean summer (June – September) total phosphorus (P, upper panel), chlorophyll (upper middle panel), Secchi transparency (lower middle panel), and Carlson trophic state indices (TSI) for the headwater, middle, and dam stations in Lake Dubay. Vertical lines represent ± 1 standard error of the grand mean.

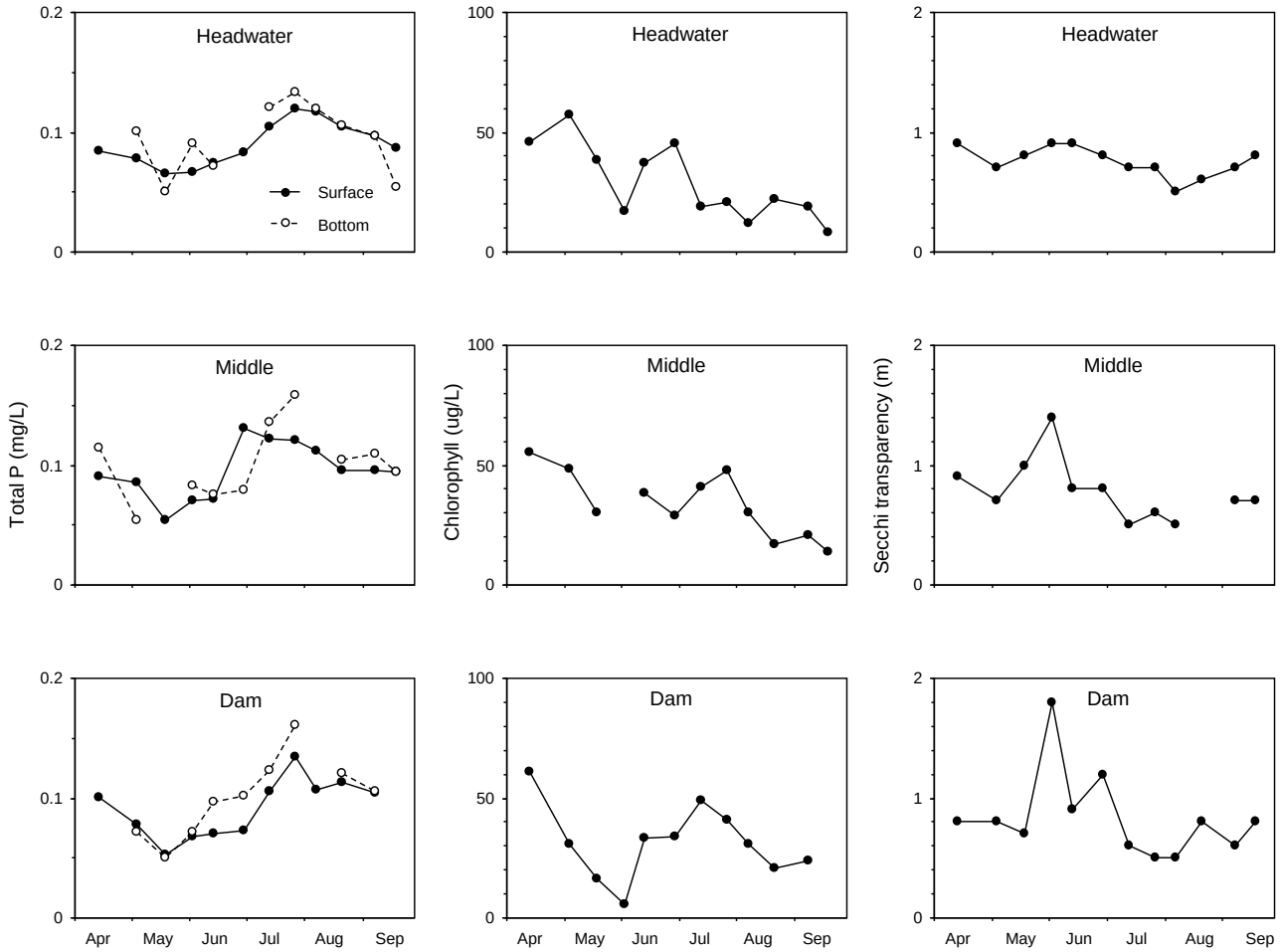



Figure 5. Seasonal variations in surface and near-bottom concentrations of total phosphorus (P, left panels), chlorophyll (middle panels), and Secchi transparency (right panels) for the headwater, middle, and dam stations during 2010.

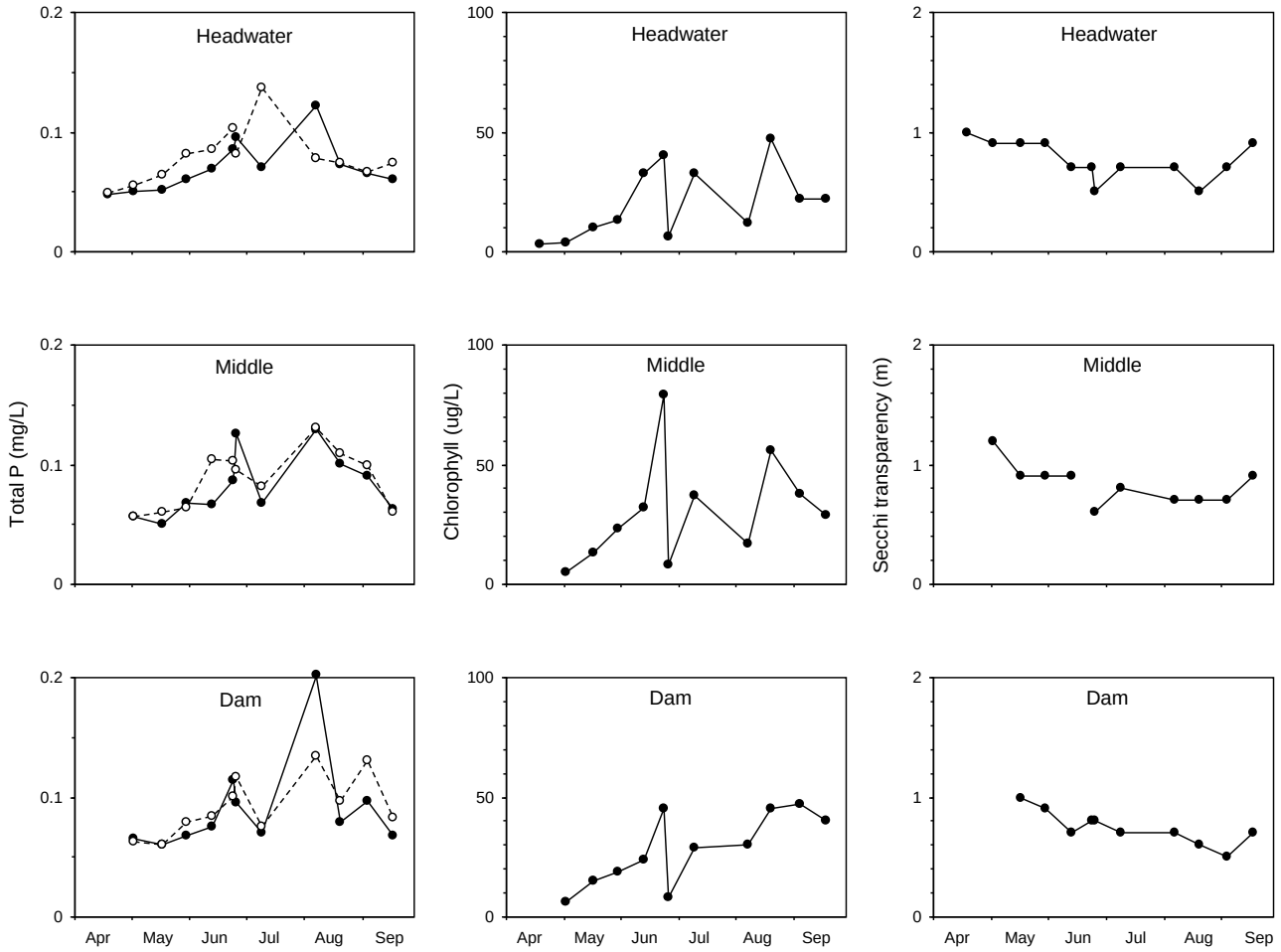



Figure 6. Seasonal variations in surface and near-bottom concentrations of total phosphorus (P, left panels), chlorophyll (middle panels), and Secchi transparency (right panels) for the headwater, middle, and dam stations during 2011.

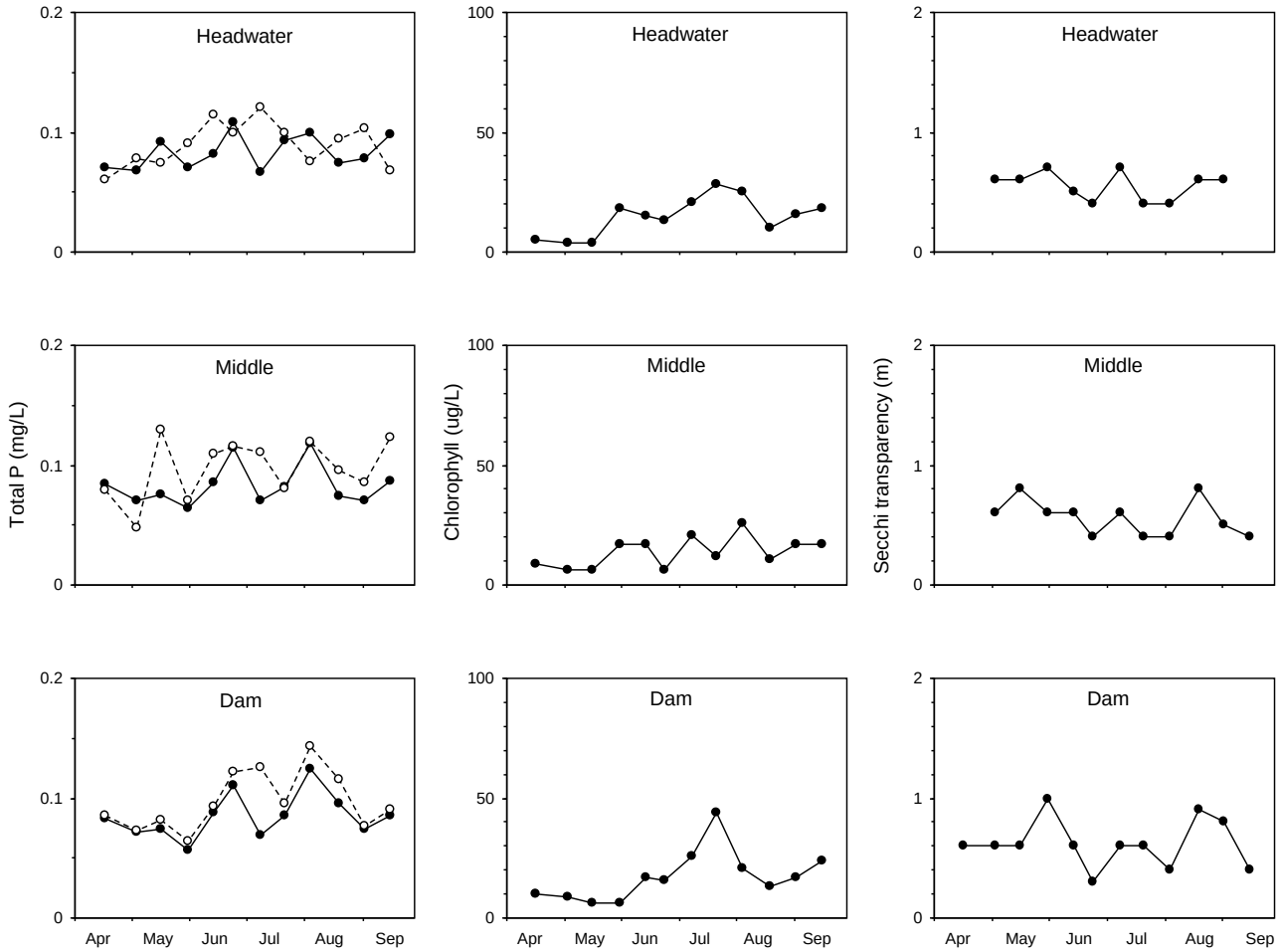



Figure 7. Seasonal variations in surface and near-bottom concentrations of total phosphorus (P, left panels), chlorophyll (middle panels), and Secchi transparency (right panels) for the headwater, middle, and dam stations during 2012.

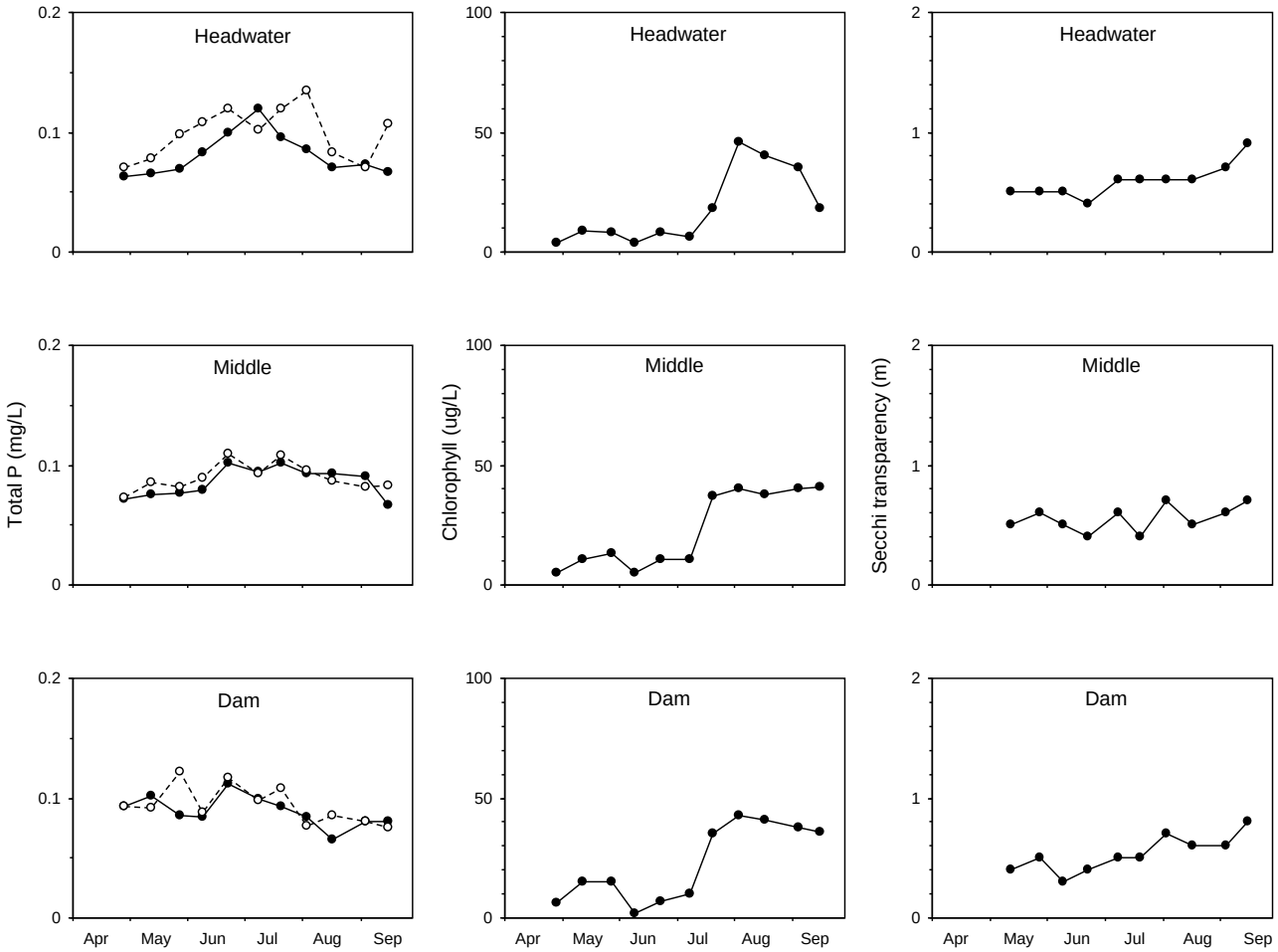



Figure 8. Seasonal variations in surface and near-bottom concentrations of total phosphorus (P, left panels), chlorophyll (middle panels), and Secchi transparency (right panels) for the headwater, middle, and dam stations during 2013.

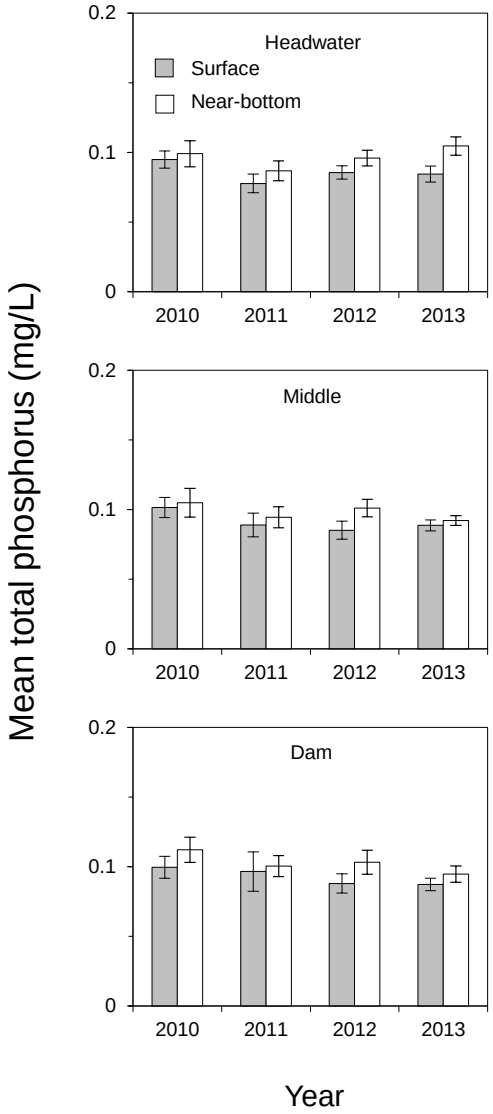



Figure 9. Variations in mean summer (June – September) surface and near -bottom total phosphorus concentrations at the headwater, middle, and dam stations in Lake Dubay. Vertical bars denote ± 1 standard error.

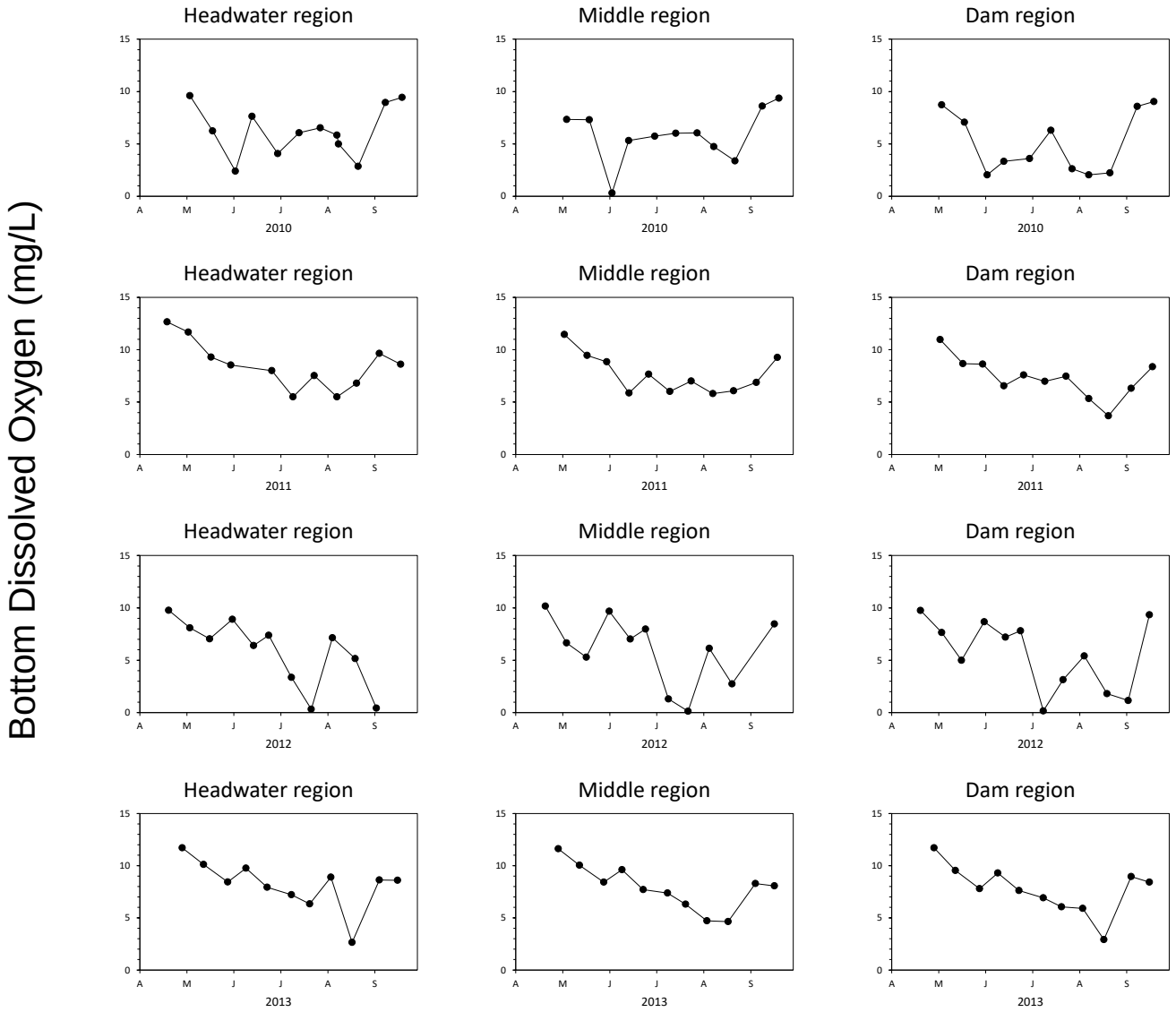
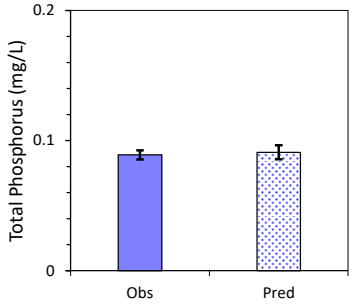
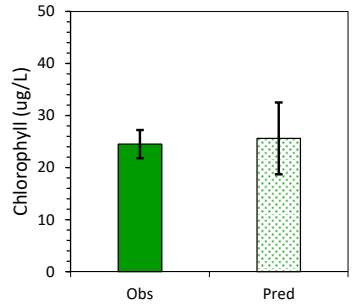



Figure 10. Seasonal variations in near-bottom concentrations of dissolved oxygen for the headwater, middle, and dam stations during 2010-2013.



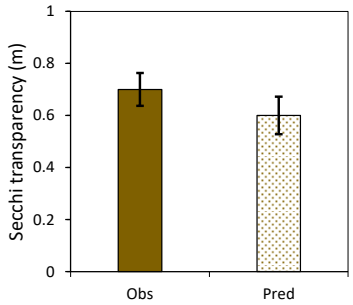




Figure 11. A comparison of mean (± 1 standard error) observed versus predicted area-weighted total phosphorus, chlorophyll, and Secchi transparency.

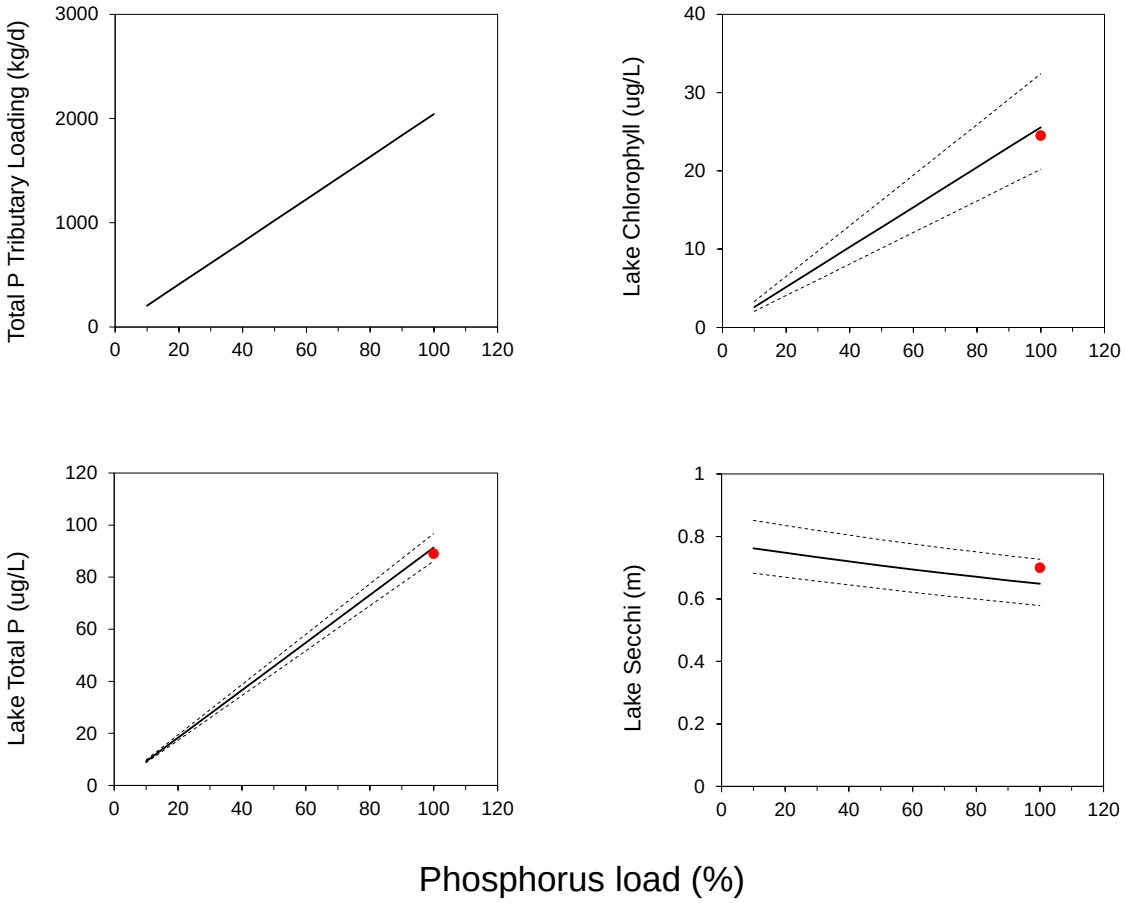



Figure 12. Bathtub (Walker 1996) model output of predicted changes in total phosphorus (P), chlorophyll, and Secchi transparency in Lake Dubay as a function of reducing current mean 2010-13 mean summer P loading by 20% increments (black lines). Dotted lines denote 95% confidence intervals. Red circles represent current measured mean summer values. 100% P load represents current loading conditions.

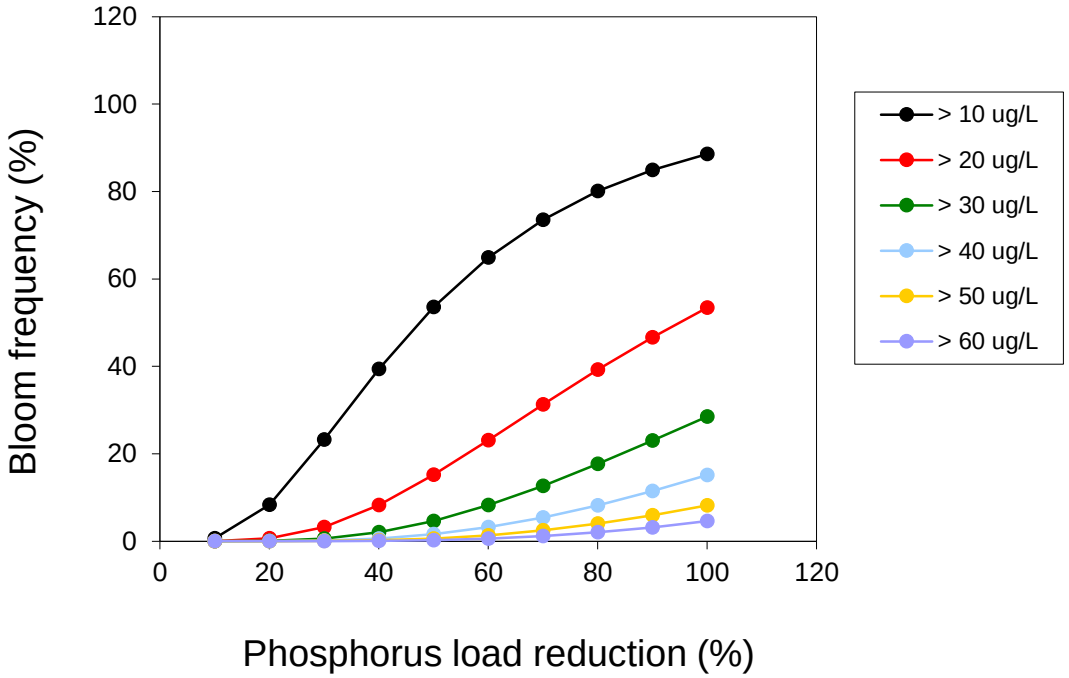



Figure 13. Bathtub (Walker 1996) model output of predicted changes in algal bloom frequency (as chlorophyll) as a function of reducing current mean 2010-13 mean summer P loading by 20% increments. 100% P load represents current loading conditions.

# APPENDICES

Appendix 1a. Lake Dubay summer (June-September to early October) means and standard errors (SE) for the headwater station.

| Statistic | Total P (Surface) | Total P (Bottom) | Chlorophyll | SRP | Secchi | TKN | NHx | N0x | Total N | Particulate N | Particulate P | N:P ratio | N:P ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (mg/L) | (mg/L) | (ug/L) | (mg/L) | (m) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mass:mass) | (Mol:Mol) |
| **2010-13** | | | | | | | | | | | | | |
| Mean[1] | 0.086 | 0.097 | 21.5 | 0.018 | 0.6 | 1.109 | 0.038 | 0.221 | 1.329 | 1.072 | 0.068 | 16.0 | 35.3 |
| SE | 0.003 | 0.004 | 2.0 | 0.003 | 0.03 | 0.028 | 0.006 | 0.028 | 0.041 | 0.027 | 0.002 | 0.4 | 0.8 |
| **2010** | | | | | | | | | | | | | |
| Mean | 0.095 | 0.099 | 22.2 | 0.028 | 0.7 | 1.250 | 0.069 | 0.293 | 1.543 | 1.181 | 0.067 | 17.8 | 39.2 |
| SE | 0.006 | 0.009 | 3.9 | 0.006 | 0.04 | 0.064 | 0.017 | 0.048 | 0.100 | 0.066 | 0.002 | 1.0 | 2.3 |
| **2011** | | | | | | | | | | | | | |
| Mean | 0.078 | 0.087 | 25.3 | 0.017 | 0.7 | 1.001 | 0.026 | 0.248 | 1.249 | 0.978 | 0.061 | 16.1 | 35.5 |
| SE | 0.007 | 0.007 | 4.6 | 0.005 | 0.05 | 0.040 | 0.006 | 0.029 | 0.047 | 0.038 | 0.003 | 0.4 | 0.8 |
| **2012** | | | | | | | | | | | | | |
| Mean | 0.086 | 0.096 | 18.2 | 0.007 | 0.5 | 1.141 | 0.017 | 0.058 | 1.199 | 1.127 | 0.079 | 14.5 | 32.0 |
| SE | 0.005 | 0.006 | 1.9 | 0.004 | 0.05 | 0.053 | 0.004 | 0.035 | 0.069 | 0.052 | 0.004 | 0.6 | 1.2 |
| **2013** | | | | | | | | | | | | | |
| Mean | 0.085 | 0.105 | 20.3 | 0.019 | 0.6 | 1.042 | 0.039 | 0.283 | 1.326 | 1.004 | 0.065 | 15.5 | 34.3 |
| SE | 0.006 | 0.007 | 5.3 | 0.005 | 0.05 | 0.030 | 0.011 | 0.066 | 0.062 | 0.029 | 0.003 | 0.5 | 1.0 |

[1]Represents the mean of all values measured between June-September to early October over 2010-13.

Appendix 1b. Lake Dubay summer (June-September to early October) means and standard errors (SE) for the middle station.

| Statistic | Total P (Surface) | Total P (Bottom) | Chlorophyll | SRP | Secchi | TKN | NHx | N0x | Total N | Particulate N | Particulate P | N:P ratio | N:P ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (mg/L) | (mg/L) | (ug/L) | (mg/L) | (m) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mass:mass) | (Mol:Mol) |
| **2010-13** | | | | | | | | | | | | | |
| Mean[1] | 0.091 | 0.098 | 26.8 | 0.016 | 0.6 | 1.153 | 0.041 | 0.175 | 1.329 | 1.112 | 0.076 | 15.0 | 33.1 |
| SE | 0.003 | 0.004 | 2.7 | 0.002 | 0.03 | 0.032 | 0.008 | 0.026 | 0.043 | 0.032 | 0.003 | 0.4 | 0.8 |
| **2010** | | | | | | | | | | | | | |
| Mean | 0.101 | 0.105 | 29.8 | 0.026 | 0.8 | 1.284 | 0.091 | 0.243 | 1.527 | 1.194 | 0.076 | 16.0 | 35.5 |
| SE | 0.007 | 0.010 | 4.3 | 0.004 | 0.10 | 0.083 | 0.024 | 0.046 | 0.104 | 0.091 | 0.006 | 0.9 | 2.1 |
| **2011** | | | | | | | | | | | | | |
| Mean | 0.089 | 0.094 | 35.4 | 0.013 | 0.8 | 1.089 | 0.021 | 0.189 | 1.278 | 1.068 | 0.076 | 14.3 | 31.7 |
| SE | 0.009 | 0.008 | 7.1 | 0.005 | 0.04 | 0.049 | 0.009 | 0.030 | 0.067 | 0.046 | 0.005 | 0.5 | 1.2 |
| **2012** | | | | | | | | | | | | | |
| Mean | 0.085 | 0.101 | 16.0 | 0.008 | 0.5 | 1.113 | 0.019 | 0.052 | 1.166 | 1.094 | 0.077 | 14.4 | 31.9 |
| SE | 0.006 | 0.006 | 1.9 | 0.002 | 0.05 | 0.053 | 0.005 | 0.039 | 0.077 | 0.054 | 0.006 | 0.6 | 1.4 |
| **2013** | | | | | | | | | | | | | |
| Mean | 0.089 | 0.092 | 26.2 | 0.015 | 0.6 | 1.127 | 0.034 | 0.218 | 1.344 | 1.092 | 0.074 | 15.0 | 33.3 |
| SE | 0.004 | 0.004 | 5.2 | 0.004 | 0.04 | 0.053 | 0.011 | 0.065 | 0.047 | 0.061 | 0.005 | 0.6 | 1.3 |

[1]Represents the mean of all values measured between June-September to early October over 2010-13.

Appendix 1c. Lake Dubay summer (June-September to early October) means and standard errors (SE) for the dam station.

| Statistic | Total P (Surface) | Total P (Bottom) | Chlorophyll | SRP | Secchi | TKN | NHx | N0x | Total N | Particulate N | Particulate P | N:P ratio | N:P ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (mg/L) | (mg/L) | (ug/L) | (mg/L) | (m) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mass:mass) | (Mol:Mol) |
| **2010-13** | | | | | | | | | | | | | |
| Mean[1] | 0.093 | 0.102 | 26.4 | 0.019 | 0.7 | 1.200 | 0.056 | 0.158 | 1.358 | 1.144 | 0.074 | 15.8 | 34.9 |
| SE | 0.004 | 0.004 | 2.3 | 0.003 | 0.046 | 0.030 | 0.008 | 0.024 | 0.040 | 0.031 | 0.003 | 0.4 | 0.8 |
| **2010** | | | | | | | | | | | | | |
| Mean | 0.100 | 0.112 | 27.9 | 0.024 | 0.9 | 1.303 | 0.077 | 0.206 | 1.509 | 1.226 | 0.076 | 16.3 | 36.1 |
| SE | 0.008 | 0.009 | 4.5 | 0.004 | 0.14 | 0.082 | 0.020 | 0.042 | 0.112 | 0.091 | 0.006 | 0.9 | 2.1 |
| **2011** | | | | | | | | | | | | | |
| Mean | 0.096 | 0.100 | 31.9 | 0.023 | 0.7 | 1.149 | 0.031 | 0.168 | 1.317 | 1.118 | 0.074 | 15.5 | 34.3 |
| SE | 0.014 | 0.007 | 4.5 | 0.011 | 0.04 | 0.045 | 0.009 | 0.033 | 0.060 | 0.043 | 0.006 | 0.7 | 1.2 |
| **2012** | | | | | | | | | | | | | |
| Mean | 0.088 | 0.103 | 20.4 | 0.012 | 0.6 | 1.198 | 0.071 | 0.062 | 1.260 | 1.127 | 0.076 | 15.1 | 33.3 |
| SE | 0.007 | 0.009 | 3.5 | 0.002 | 0.08 | 0.061 | 0.019 | 0.040 | 0.074 | 0.056 | 0.006 | 0.7 | 1.4 |
| **2013** | | | | | | | | | | | | | |
| Mean | 0.087 | 0.095 | 25.2 | 0.018 | 0.5 | 1.149 | 0.043 | 0.196 | 1.344 | 1.106 | 0.069 | 16.2 | 35.8 |
| SE | 0.004 | 0.006 | 5.5 | 0.005 | 0.05 | 0.038 | 0.013 | 0.060 | 0.041 | 0.048 | 0.003 | 0.8 | 1.3 |

[1]Represents the mean of all values measured between June-September to early October over 2010-13.

# *Steady-State Modeling Analysis of Lake Wisconsin, Wisconsin River System*

21 November, 2016

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# EXECUTIVE SUMMARY

Lake Wisconsin is a run-of-the-river hydropower reservoir on the Wisconsin River near Merrimac, WI, that currently exhibits eutrophic to hypereutrophic conditions (Carlson TSI = 65 to 71). A monitoring program was conducted between 2010 and 2013 on the reservoir to examine seasonal total phosphorus (P), chlorophyll, and Secchi transparency dynamics in relation to tributary P loading for Total Maximum Daily Load (TMDL) development. Gauged tributary flow and P inputs included the Wisconsin River at Wisconsin Dells and the Baraboo River at Reedsburg. The gauged discharge was the Wisconsin River at Prairie du Sac. Three stations were established along the longitudinal axis of the reservoir for water sampling purposes. Surface samples were collected biweekly between April and October for total P and chlorophyll analysis. Near-bottom samples were also collected for total P analysis. Secchi transparency was determined biweekly using a 20-cm alternating black and white disk.

Mean daily summer measured inflow was relatively high over the 2010-13 period at 224 $m^3/s$ (± 56 standard error, SE), resulting in a very low mean summer residence time of 7.2 d (±2.3 SE). Summer flow-weighted total P representing the gauged inflow and outflow to Lake Wisconsin were very similar at ~100 mg/L, suggesting rapid flushing of P loads through the reservoir and advective dominance of total P concentrations in the reservoir. Longitudinal variation in summer mean total P concentration between the headwater and dam stations was minimal and the area-weighted mean (i.e., over 2010-13) total P was ~ 0.098 mg/L, similar to inflow-outflow concentrations. The area-weighted grand mean chlorophyll concentration was relatively high at ~ 48 µg/L and summer mean concentrations tended to increase from the headwater to the dam station. The area-weighted grand mean Secchi transparency was low at ~ 0.7 m. The Carlson trophic state index (TSI, Carlson 1977) for P (TSI-P) was high at 70 (indicative of hypereutrophic conditions). The TSI based on chlorophyll (TSI-CHLA) was slightly lower at 68 and TSI based on Secchi transparency (TSI-SD) was 65.

Budgetary analysis of summer flow and P loads indicated an approximate balance between inflow and outflow, suggesting minor P retention during the summer. Overall, the P empirical model (settling velocity) closely predicted the observed area-weighted mean summer total P concentration in Lake Wisconsin. Tributary P inputs entirely accounted for the summer total P budget, suggesting that internal P loading was negligible. However, the chlorophyll model (Jones and Bachman 1976) over-predicted the observed area-weight mean summer chlorophyll concentration. Although concentrations were not significantly different given the variance in the observed chlorophyll versus the model, a calibration coefficient of 0.68 (i.e., versus 1.0) was used to adjust the predicted value to the observed mean. Because Lake Wisconsin is dominated by advection, low residence time, and little apparent P retention (i.e., deposition), predicted summer total P concentration reductions coincided closely with tributary P load and concentration reductions. For instance, a 50% reduction in P loading coincided with a 50% decline in summer total P from ~0.098 mg/L to 0.050 mg/L. Under this same P loading reduction scenario, predicted summer chlorophyll concentrations declined by 64% from ~ 48 µg/L to ~17 µg/L. Predicted Secchi transparency increased by 28% from 0.7 m to 0.9 m. Under current P loading conditions, chlorophyll blooms exceeding 20 µg/L and 60 µg/L occurred an estimated 85% and 33% of the time during the summer period, respectively. Using the same scenario, a 50% P loading reduction resulted in a predicted decline in the summer bloom frequency of chlorophyll exceeding 20 µg/L and 60 µg/L to 27% and 1% of the time during the summer period, respectively. Empirical steady-state models developed for Lake Wisconsin will be used in conjunction with other decision-support tools to develop a TMDL based on predicted reservoir water quality responses to P loading reduction.

# OBJECTIVES

The objectives of this investigation were to examine summer limnological conditions in Lake Wisconsin between 2010 and 2013 and project future conditions under phosphorus loading reduction scenarios using a steady-state empirical modeling approach.

# METHODS

Flow and total phosphorus (P) loadings from the Wisconsin and Baraboo Rivers (Table 1) were combined with seasonal (April – September to early October) surface water chemistry information from three stations in Lake Wisconsin (Table 2, Fig. 1) to construct a steady-state empirical model (Bathtub Version 6.14; Walker 1996) to forecast the response of limnological variables (total P, chlorophyll, and Secchi transparency) to future P loading reduction. Since the annual theoretical water residence time was relatively low (range = 4.4 d to 8.9 d), a June through September (122 d) averaging period was used for steady-state empirical modeling analysis. Gauged hydraulic inputs included the Wisconsin River at Wisconsin Dells (Station ID 573052) and the Baraboo River at Reedsburg (Station ID 573076, Table 1). The gauged hydraulic discharge from Lake Wisconsin was the Wisconsin River at Prairie du Sac Dam (Station ID 10029830, Table 1). Monthly hydraulic flow ($m^3/s$) and total P loadings (kg/month) determined by the US Geological Survey (Madison, WI) were converted to mean flow (expressed as $hm^3/y$) and total P concentration (expressed as µg/L) over the summer averaging period as input to the model. Additional hydrologic input to the model included ungauged local runoff to the reservoir from the surrounding subwatershed that was estimated using the Soil and Water Assessment Tool (SWAT) and daily precipitation records over the study period obtained from the Wisconsin State Climatology Office (Madison, WI). The coefficient of variation (CV-mean) was estimated from mean June through September flows and total P concentrations between the years 2010 and 2013 reported by the US Geological Survey (Dale M. Robertson, U.S. Geological Survey, Madison, WI,

unpublished data). The CV-mean was calculated as the standard error of the grand mean (n = 12; i.e., JUN-SEP 2010 through 2013) divided by the grand mean of each constituent. This CV-mean was used for error analysis in Bathtub as recommended in Walker (1996). A 12-year average for summer flow, total P concentration, and total P loading between 2002 and 2013 was estimated from reports and data provided by the US Geological Survey (Dale M. Robertson, U.S. Geological Survey, Madison, WI, unpublished data).

Biweekly measurements of Secchi transparency and surface concentrations of chlorophyll and total P, collected in Lake Wisconsin during the summer periods of 2010 through 2013, were averaged to estimate a mean concentration for each station segment during each year. June through September was used as the averaging period. Chemical analyses of surface water samples were conducted by the Wisconsin State Laboratory of Hygiene using standard methodological approaches. For in-lake morphometric inputs to the empirical model, the pool was divided into the 3 segments (i.e., headwater, middle, and dam segments) corresponding to the locations of sampling stations (Table 2).

The computer software program Bathtub was used to examine P loading reduction scenarios (Walker 1996). Bathtub is a windows-based software program that provides a suite of equations for predicting lake seasonal averages of total P, chlorophyll, and Secchi transparency. Grand means for total P, chlorophyll, and Secchi transparency over the summer 2010-13 period were used as input into the model. The coefficient of variation for total P, chlorophyll, and Secchi transparency of the grand mean (CV-mean) was calculated as the standard error of the grand mean divided by the grand mean of each constituent. This CV-mean was used for error analysis in Bathtub as recommended in Walker (1996).

# RESULTS AND DISCUSSION

### *Tributary Hydrology and Loading*

Mean daily summer inflow was highest in 2010 at 361 $m^3/s$ and lowest at 92 $m^3/s$ in 2012 (Fig. 2). Mean daily summer flow during the summers of 2011 and 2013 were slightly above the 12-year summer average (2004 – 2013) flows reported by the US Geological Survey. The summer theoretical water residence time exhibited the opposite pattern. It was very low during the high flow summer of 2010 at less than 4 d and greater than 13 d during the low-flow summer of 2012. The grand mean residence time over the 4-year study period was moderately low at ~ 7.2 d, similar to the 12-y average summer residence time.

Summer total P of the gauged inflow to Lake Wisconsin, representing a flow-weighted concentration for the combined Wisconsin and Baraboo Rivers, and estimated local subwatershed runoff ranged between 0.089 mg/L in 2012 and 0.115 mg/L in 2010, following a trend similar to that of mean daily summer inflow (Fig. 2). In general, the summer total P concentration was above the 12-y average in 2010 and slightly below the 12-y average in 2011 and 2013. Summer total P loading followed the same inter-annual trend. It was greatest in 2010 and 2 times higher than the 12-y average. In contrast, summer total P loading was lowest in 2012 and less than half the 1-2y average. Summer total P loading during the summers of 2011 and 2013 were near the 12-year average.

### *Reservoir Limnological Trends*

Because summer theoretical water residence time was relatively low, even during the lower inflow period of 2012, Lake Wisconsin mean summer total P concentrations were only slightly lower than the measured inflow total P (Fig. 3). In addition, mean summer total P concentrations exhibited minor variation as a function of in-lake station or

distance from the dam (Fig. 4). This pattern suggested that limnological patterns in the lake were largely dominated by riverine influences along its longitudinal axis. By contrast, longitudinal concentration gradients from headwaters to the dam can typically develop in larger reservoirs as a function of widening morphometry, decreasing flow velocity, and deposition of loads (Thornton et al. 1990). Indeed, mean concentrations either increased slightly from headwaters to the dam, as in 2011 and 2013, or increased to a peak at the middle station, as in 2012 (Fig. 3). In all cases, however, summer total P concentration differences were minimal between stations as indicated by grand mean trends over the study period (Fig. 4).

Variations between surface and near-bottom concentrations of total P were also small throughout the study period, suggesting that internal P loading from bottom sediments likely played a negligible role in P dynamics in Lake Wisconsin (Fig. 5-8). There were periods of elevated near bottom total P concentration with respect to the surface at all stations; but these concentration differences were minor and could be attributable to other mechanisms such as resuspension caused by river current shear stress or by river density underflows. Overall, differences in mean summer surface versus near-bottom total P concentrations were very minor over the study period (Fig. 9).

James (2014) found that laboratory-derived diffusive P flux from sediment collected in Lake Wisconsin was very high under anaerobic conditions (range = 26 – 27 mg/$m^2$ d) and much lower at 0.13 to 0.8 mg/$m^2$ d under aerobic conditions. Lower diffusive P flux under aerobic conditions was consistent with the classic Mortimer (1971) model of coupled Fe-P chemistry. Under this scenario, Fe is in an oxidized state as an Fe oxyhydroxide ($Fe^{3+}$~OOH) in the aerobic sediment microzone (i.e., the thin aerobic surface sediment layer often less than 1 mm in thickness) and strongly adsorbs P, resulting in its very limited diffusion into the overlying water column. Dissolved oxygen concentrations near the sediment-water interface exceeded 5 mg/L throughout the summer months at the headwater and middle stations (Fig. 10) indicating oxidized and aerobic conditions and suppressed diffusive P flux from sediment. However, there were

instances of near-bottom anoxia at the much deeper dam station in June, 2010, July and August in both 2012 and 2013. Under these conditions, reduction of $Fe^{3+}$~(OOH) to $Fe^{2+}$ and release of phosphate that was previously adsorbed or precipitated can result in enhanced diffusive P to the overlying water column. While potential anaerobic diffusive P flux occurred in the dam region during the study period, its impact on the P budget of the lake appeared to be negligible compared to watershed P loading (see below).

Mean summer chlorophyll concentrations ranged between 23 µg/L and 67 µg/L and tended to increase slightly from the headwater to the dam station (Fig. 3 and 4). Means were also greatest during the lower flow summer of 2012 and lowest during the higher flow summer of 2010, suggesting that summer theoretical residence time (and flushing) played an additional role in regulating algal growth. Overall, a strong positive relationship occurred between summer theoretical residence time and mean chlorophyll (Fig. 11). In particular, chlorophyll concentrations tended to be greatest in August through September, 2011-13, in conjunction with lower Wisconsin River flows. This pattern contrasted with the 2010 pattern of lower chlorophyll concentrations in August-September that were associated with higher flows, particularly in late July and September (Fig. 5-8).

Although there were seasonal periods when Secchi transparency slightly exceeded 1.0 m (Fig. 5-8), summer means were generally lower throughout the study period (Fig. 4), ranging between 0.6 and 1.0 m. Longitudinal variations in grand mean Secchi transparencies were also minor (headwater station = 0.8 m ± 0.03 SE; middle station = 0.7 m ± 0.04 SE; dam station = 0.8 m ± 0.06 SE; Fig. 5). Mean summer Secchi transparency varied inversely with summer theoretical residence time (Fig. 10) and mean summer chlorophyll (Fig. 12), suggesting linkages between longer residence time, greater algal biomass growth, and resulting reduced Secchi transparency.

Grand mean summer Carlson Tropic State Index (TSI) values for total P and chlorophyll were similar, ranging between 65 and 70 for the headwater, middle, and dam stations (Fig. 4). These ranges were indicative of eutrophic to hypereutrophic conditions. Grand

mean TSI was lower for chlorophyll and Secchi transparency compared to total P (Fig. 4). Lower TSI chlorophyll relative to TSI total P may have been related to relatively low residence time which could promote some algal biomass export if cellular doubling times are greater than residence time in the lake. Lower TSI Secchi transparency versus TSI chlorophyll could have been related to dominance of filamentous cyanobacteria versus colonies or high density single cells, which tend to enhance the attenuation of solar radiation.

Other variables of interest are shown in Appendix 1. The grand mean total P composition was dominated by particulate P, most likely incorporated into algal biomass. Soluble reactive P was generally low and ranged from not detectable to 0.04 mg/L. The grand mean soluble reactive P concentration was 0.011 mg/L, accounting for~ 11% of the total P composition. Particulate N accounted for 78% of the total N composition. Dissolved inorganic N was dominated by $NO_x$ at a grand mean of 0.242 mg/L. The grand mean $NH_x$ concentration was low at 0.068 mg/L and represented only 5% of the total N composition. The grand mean molar particulate N:P ratio was ~ 30:1, suggesting that algal growth was P-limited. Hillebrand et al. (2013) suggested that optimal N:P molar ratios are higher for cyanobacteria with a mean from literature values of ~26:1.

### *Steady-State Empirical Modelling*

The mean (2010-13) summer hydraulic and total P balance indicated that measured summer flow and P loading were slightly greater in the outflow than the gauged inflows to Lake Wisconsin (Table 3). Thus, additional ungauged sources of flow and P input potentially accounted for ~ 13% of the P mass imbalance. The Wisconsin River at Wisconsin Dells, WI, overwhelmingly dominated mean summer gauged P inputs to Lake Wisconsin (Table 3). Mean summer flow and P loading represented 85% and 75% of the inputs, respectively. The mean summer flow-weighted total P concentration was 0.088 mg/L. Although the Baraboo River at Reedsburg, WI, represented only 7% of the gauged inflow, the mean summer flow-weighted total P concentration was much higher at 0.247 mg/L. Mean summer total P loading from this input represented 17% of the estimated

total P load to the system. Although apparent P retention was negative due to unaccounted for local total P loads, the weighted inflow and outflow total P concentrations were nearly identical at 0.099 to 0.101 mg/L, suggesting that advective flow-through and discharge, versus deposition of total P loads, largely regulated P concentrations in Lake Wisconsin.

Because low summer theoretical water residence time and advection dominated the P budget, a first-order P sedimentation model (σ) was chosen to predict summer mean lake total P according to the equation,

$$P_{lake} = \frac{P_{inflow}}{(1 + \sigma\tau_{\omega})}$$

Where, $P_{lake}$ = area-weighted mean summer total P concentration (mg/m$^3$), $P_{inflow}$ = flow-weighted gauged inflow total P (mg/m$^3$), σ = first-order sedimentation coefficient, and $\tau_{\omega}$ = summer theoretical water residence time (y). Of the first-order P sedimentation models, Vollenweider (1976), simple first-order, and first-order settling velocity all closely predicted $P_{lake}$ and first-order settling velocity was chosen as the P sedimentation model (Table 4). Because the Jones and Bachman (1976) chlorophyll-total P regression relationship was developed from an extensive northern lake data set, it was chosen for mean summer chlorophyll prediction. Finally, the default Secchi transparency model developed from relationships between chlorophyll and turbidity in reservoirs was chosen to estimate mean summer Secchi depth.

Observed versus predicted summer means of total P, chlorophyll, and Secchi transparency over the 2010-13 period are shown in Figure 13. Overall, the P empirical model (settling velocity) closely predicted the observed area-weighted mean summer total P concentration in Lake Wisconsin. The chlorophyll model overpredicted the observed area-weighted mean summer chlorophyll concentration (Fig. 13). However, standard error bars overlapped and means were not significantly different given errors in the observed chlorophyll versus the model (Walker 1996). In addition to potential error,

overprediction of mean summer chlorophyll based on chlorophyll-total P regression relationships could have been related to 1) a portion of the total P pool that was not incorporated as algal biomass and 2) advective discharge of algal biomass due to low residence time. Adjustment to the observed summer mean chlorophyll concentration resulted in a calibration coefficient of 0.68. Since the Secchi transparency model uses summer mean chlorophyll as an input variable, predicted summer mean Secchi transparency slightly underestimated the observed mean without calibration adjustment of the chlorophyll model (Fig. 13). Chlorophyll calibration resulted in improved prediction of Secchi transparency.

### *Phosphorus Loading Reduction*

Current summer P loading to Lake Wisconsin was reduced by 20% increments in Bathtub to examine predicted water quality responses to simulated future P loading reduction as a result of best management practices (BMP) implementation for TMDL development and goal-setting (Fig. 14). Because Lake Wisconsin is a run-of-the-river reservoir with low residence time and little apparent P retention (i.e., deposition), predicted summer total P concentration reductions coincided closely with tributary P load and concentration reductions (Fig. 14). For instance, a 50% reduction in P loading coincided with a 50% decline in summer total P from ~0.098 mg/L to 0.050 mg/L. Under this same P loading reduction scenario, predicted summer chlorophyll concentrations declined by 64% from ~ 48 µg/L to ~17 µg/L. Predicted Secchi transparency increased by 27% from 0.70 m to 0.93 m.

Predicted bloom frequency (i.e., percentage of the summer that chlorophyll exceeds a certain concentration) response to P loading reduction is shown in Figure 15 for various summer mean chlorophyll concentrations. Under current P loading conditions, chlorophyll blooms exceeding 20 µg/L and 60 µg/L occurred an estimated 85% and 33% of the time during the summer period, respectively. A 50% P loading reduction would result in a predicted decline in the summer bloom frequency of chlorophyll exceeding 20 µg/L and 60 µg/L to 27% and 1% of the time during the summer period, respectively.

Thus, empirical models suggested that predicted reservoir trophic state indicator variables (total P, chlorophyll, and chlorophyll concentration bloom frequency) were responsive to P loading reduction.

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Table 1. Gauged inflow-outflow stations used in the Lake Wisconsin empirical steady-state model.

| Station ID | Gauged Inflow | Latitude | Longitude |
|---|---|---|---|
| 573052 | Wisconsin River at Wisconsin Dells | 43.605000 | 89.756667 |
| 573076 | Baraboo River at Reedsburg | 43.532444 | 90.011444 |
| | **Gauged outflow** | **Latitude** | **Longitude** |
| 10029830 | Wisconsin River below Prairie du Sac Dam | 43.305779 | 89.725590 |

Table 2. Water quality sampling station locations in Lake Wisconsin.

| Station ID | Name | Surface area ($km^2$) | Mean depth (m) | Segment length (km) |
|---|---|---|---|---|
| 10031185 | Headwaters | 7.58 | 1.68 | 12.3 |
| 10031184 | Middle | 15.31 | 3.22 | 5.4 |
| 10031186 | Dam | 9.26 | 5.07 | 11.9 |

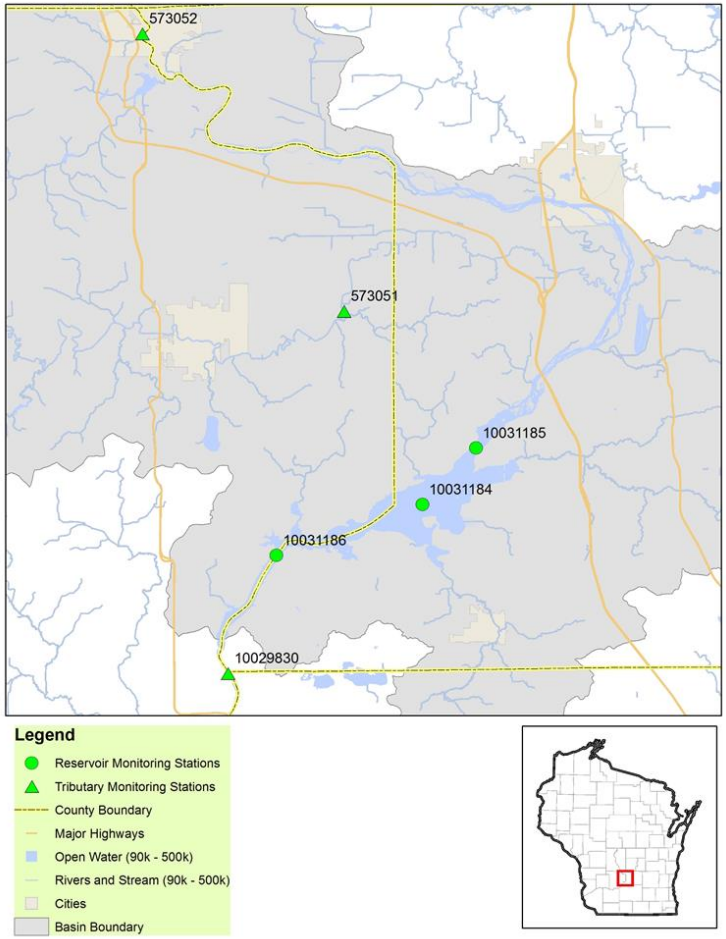
Table 3. A comparison of summer (June - September) flow and total phosphorus (P) inputs to and discharge from Lake Wisconsin.

| Component | Flow | | Total P | | |
|---|---|---|---|---|---|
| | ($m^3/s$) | (% contribution) | (mg/L) | (kg/d) | (% contribution) |
| **Inputs** | | | | | |
| Wisconsin River at Wisconsin Dells, WI | 191.2 | 84.8 | 0.088 | 1454 | 75.2 |
| Baraboo River at Reedsburg, WI | 15.6 | 7.0 | 0.247 | 332 | 17.3 |
| Ungauged[1] | 16.3 | 7.2 | 0.102 | 143 | 7.4 |
| Precipitation | 2.3 | 1.0 | 0.013 | 3 | 0.1 |
| Total | 225.3 | 100 | 0.099 | 1931.8 | 100 |
| **Outputs** | | | | | |
| Wisconsin River at Prairie du Sac Dam | 241.0 | | 0.101 | 2178 | |
| Evaporation | 2.3 | | | | |
| Total | 243.3 | | 0.101 | 2178 | |
| **Balance** | -17.9 (108%) | | | -245.9 (113%) | |

[1]Representing local subwatershed inputs estimated from the Soil and Water Assessment Tool (SWAT)

Table 4. Algorithms used for Bathtub (Walker 1996) phosphorus loading reduction modeling of Lake Wisconsin.

| Variable | Model |
|---|---|
| Phosphorus | First order settling velocity |
| Chlorophyll | Jones and Bachmann |
| Secchi Transparency | versus Chlorophyll & Turbidity |



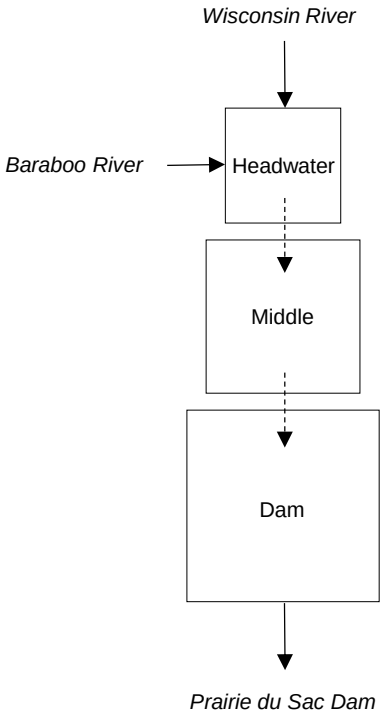




Figure 1. Water sampling station locations (left) and Bathtub conceptualization

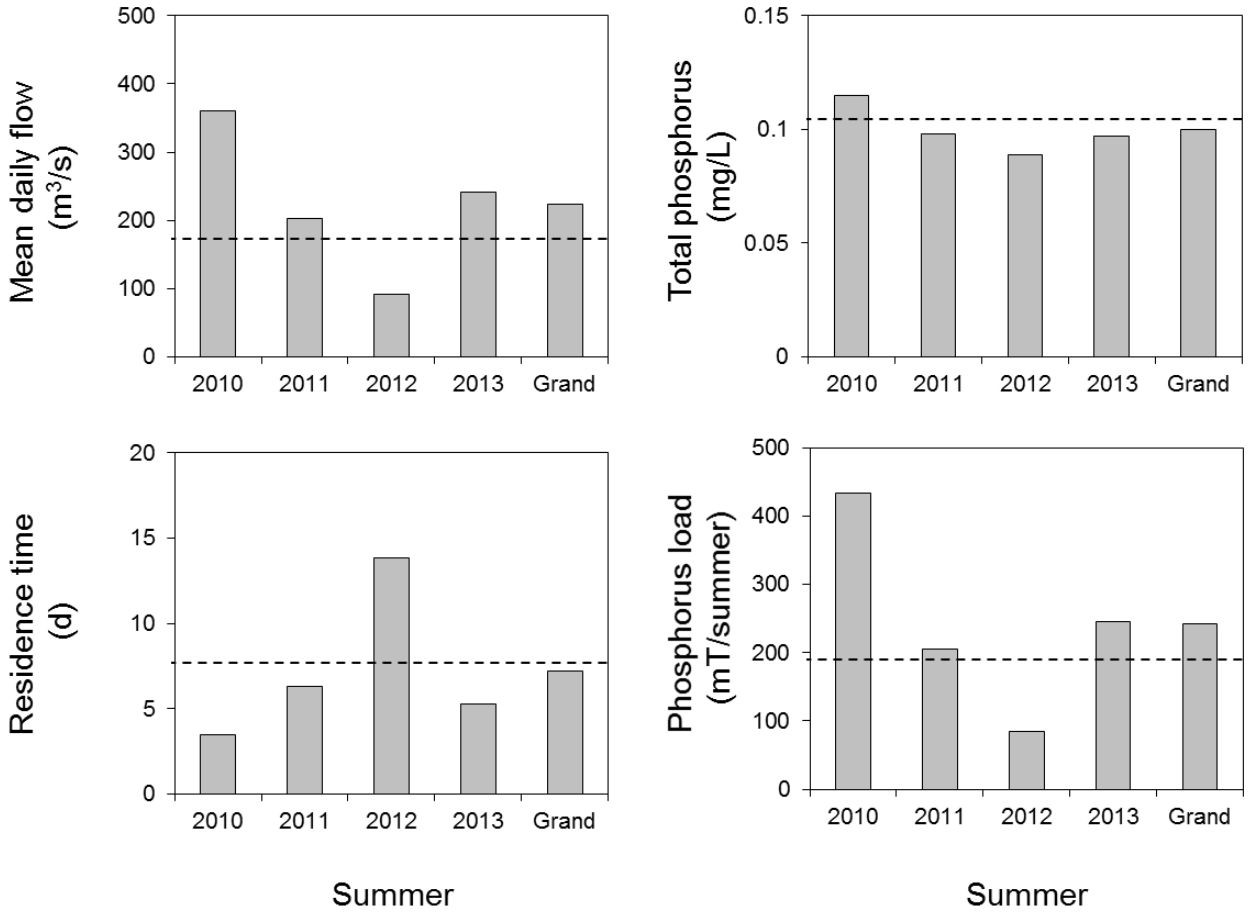



Figure 2. Summer (June – September) mean daily flow into Lake Wisconsin (upper left panel), theoretical water residence time (lower left panel), flow-weighted total phosphorus concentration of the inflow (upper right panel), and total phosphorus load (lower right panel) during 2010 - 2013. The horizontal dashed line denotes the 12-year average. The grand mean for each variable was estimated as the mean of the individual summer means.

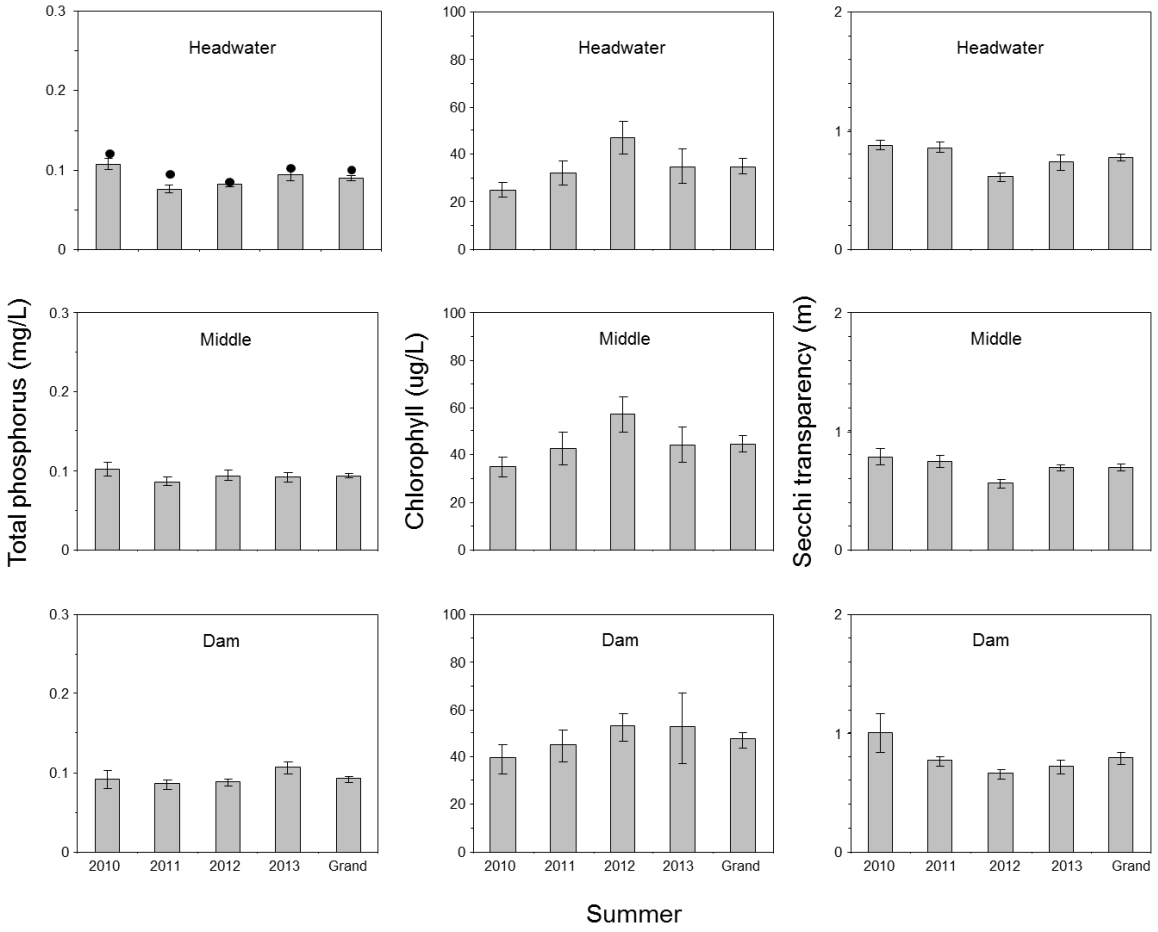



Figure 3. Summer (June – September) mean concentrations of total phosphorus (left panels), chlorophyll (middle panels), and Secchi transparency (right panels) during 2010 - 2013. The black circles denote the gauged inflow total phosphorus concentration. The grand mean for each variable was estimated as the mean of the individual summer means. Vertical lines represent ± 1 standard error.

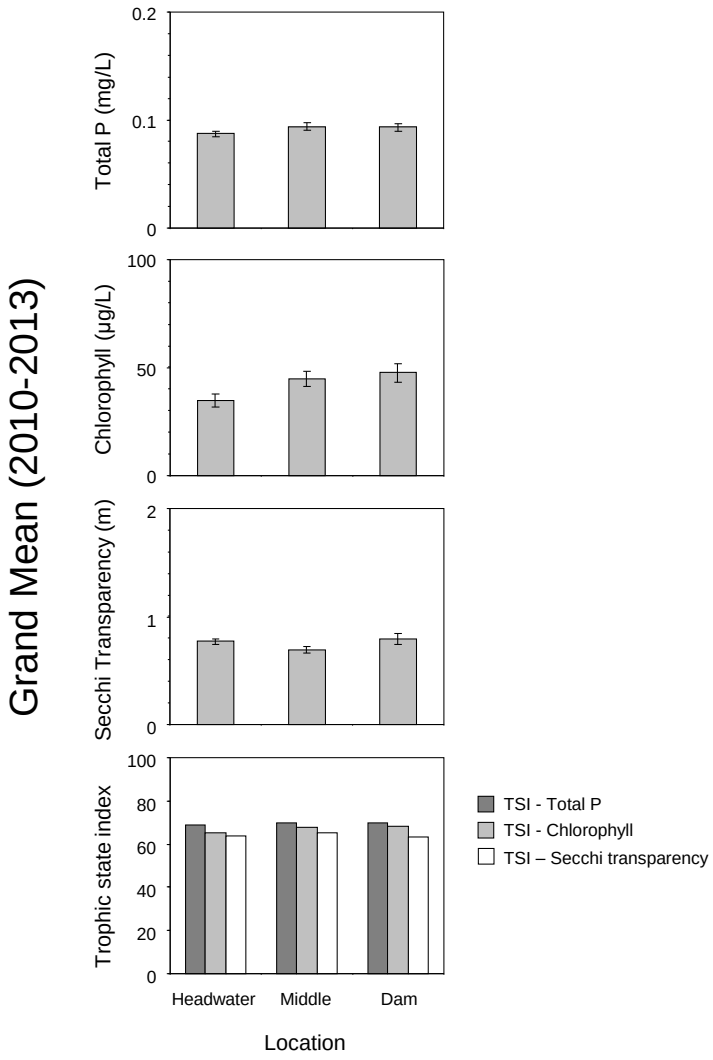



Figure 4. Variations in grand mean summer (June – September) total phosphorus (P, upper panel), chlorophyll (upper middle panel), Secchi transparency (lower middle panel), and Carlson trophic state indices (TSI) for the headwater, middle, and dam stations in Lake Wisconsin. Vertical lines represent ± 1 standard error of the grand mean.

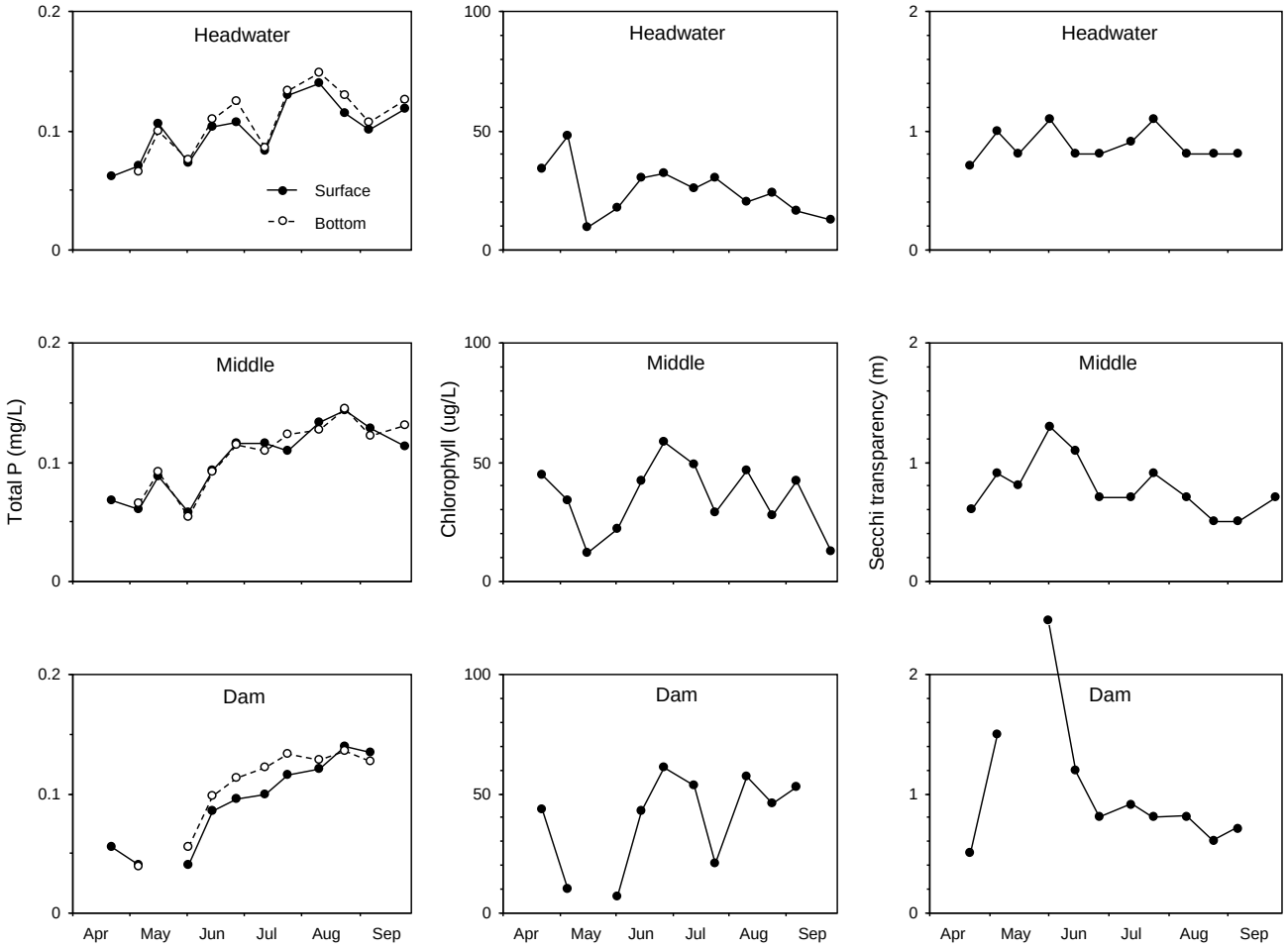



Figure 5. Seasonal variations in surface and near-bottom concentrations of total phosphorus (P, left panels), chlorophyll (middle panels), and Secchi transparency (right panels) for the headwater, middle, and dam stations during 2010.

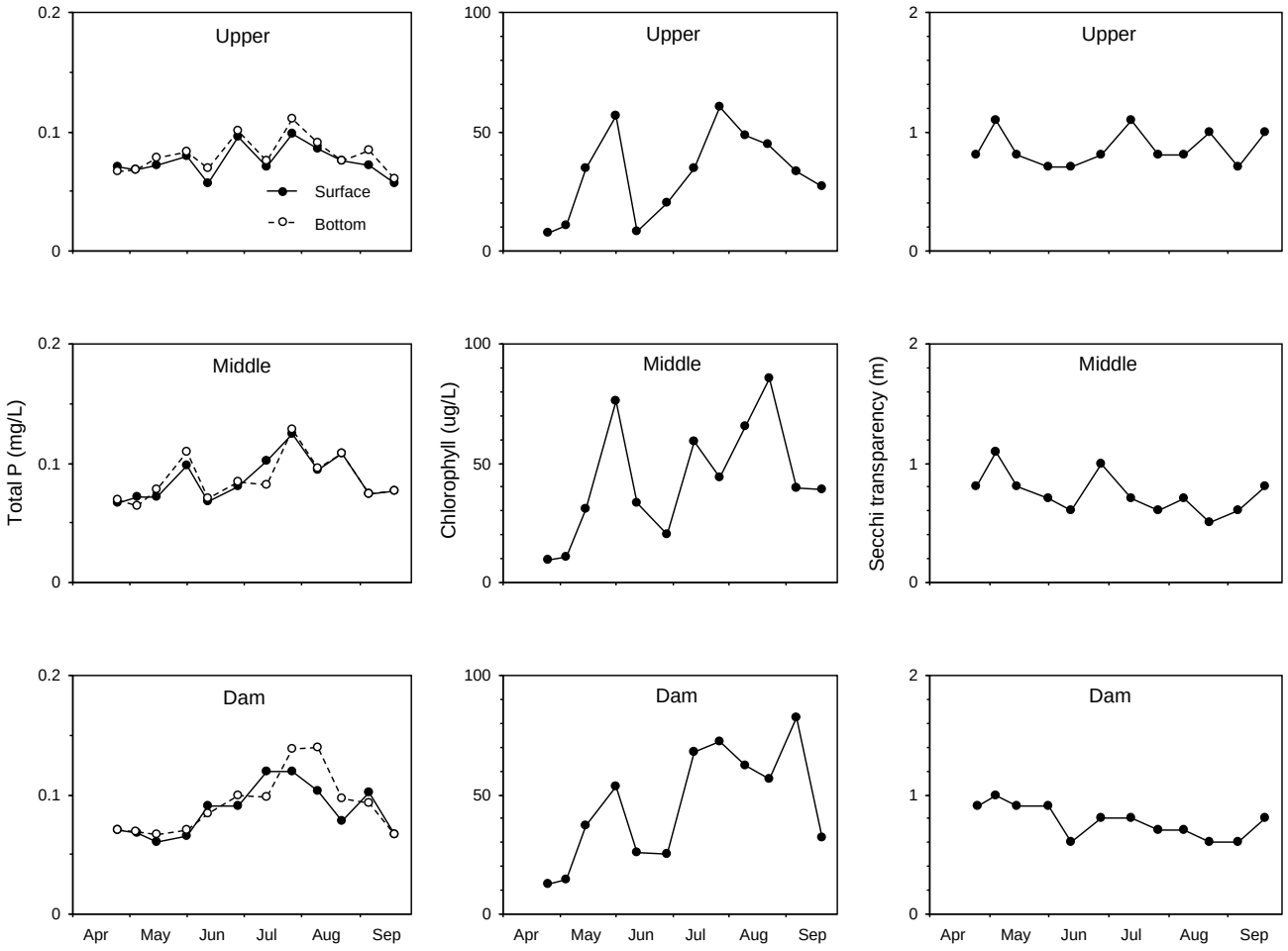



Figure 6. Seasonal variations in surface and near-bottom concentrations of total phosphorus (P, left panels), chlorophyll (middle panels), and Secchi transparency (right panels) for the headwater, middle, and dam stations during 2011.

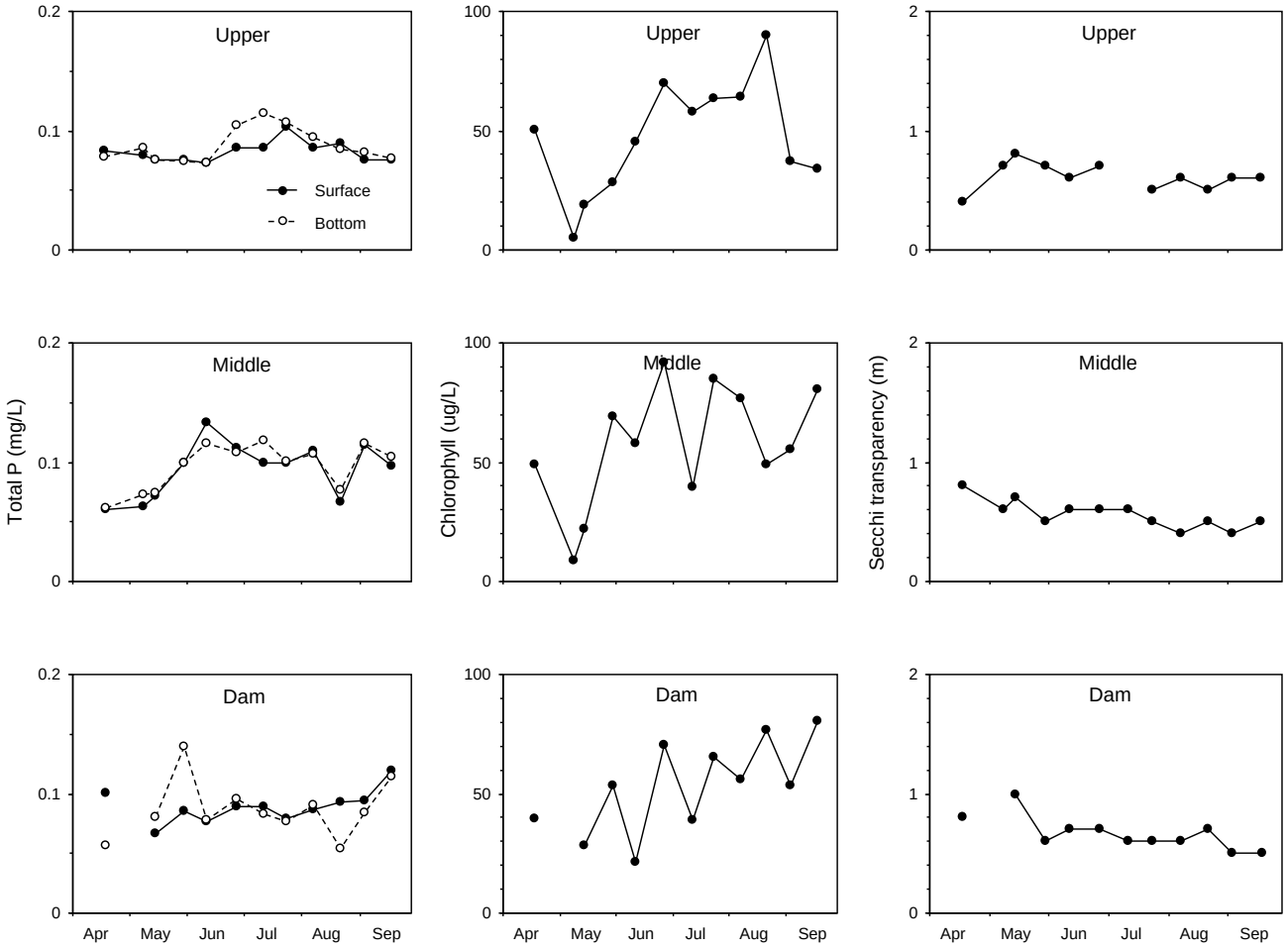



Figure 7. Seasonal variations in surface and near-bottom concentrations of total phosphorus (P, left panels), chlorophyll (middle panels), and Secchi transparency (right panels) for the headwater, middle, and dam stations during 2012.

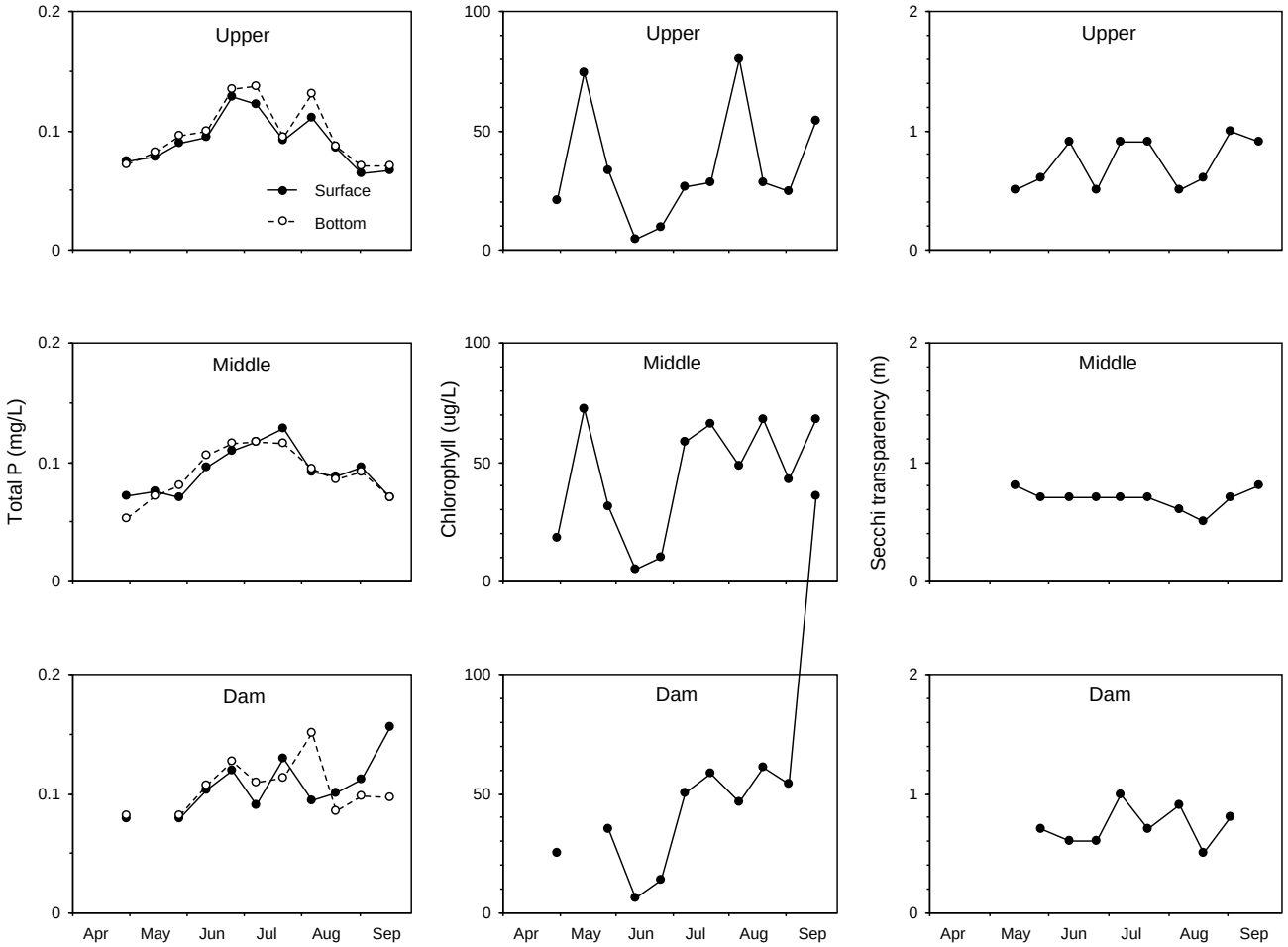



Figure 8. Seasonal variations in surface and near-bottom concentrations of total phosphorus (P, left panels), chlorophyll (middle panels), and Secchi transparency (right panels) for the headwater, middle, and dam stations during 2013.

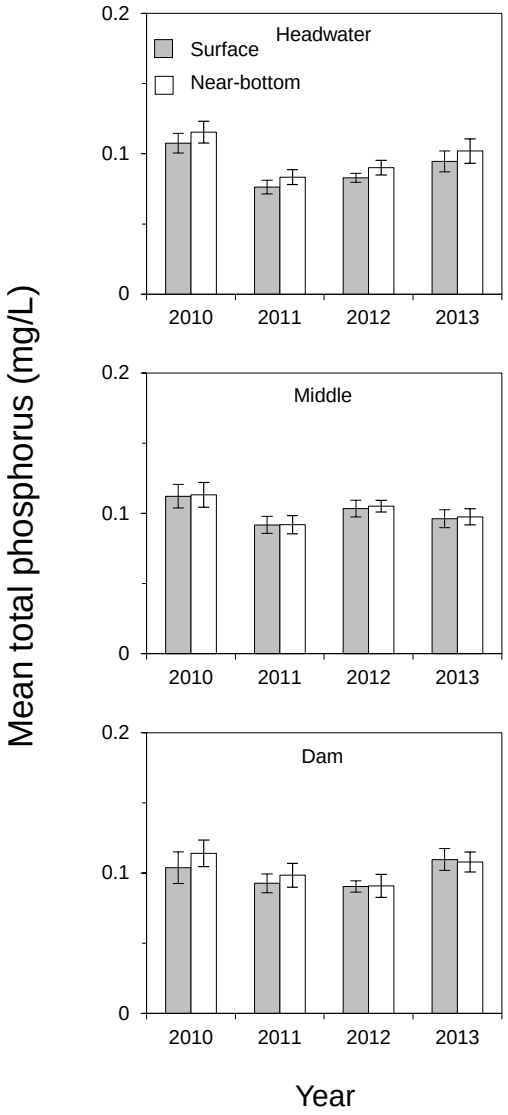



Figure 9. Variations in mean summer (June – September) surface and near -bottom total phosphorus concentrations at the headwater, middle, and dam stations in Lake Wisconsin. Vertical bars denote ± 1 standard error.

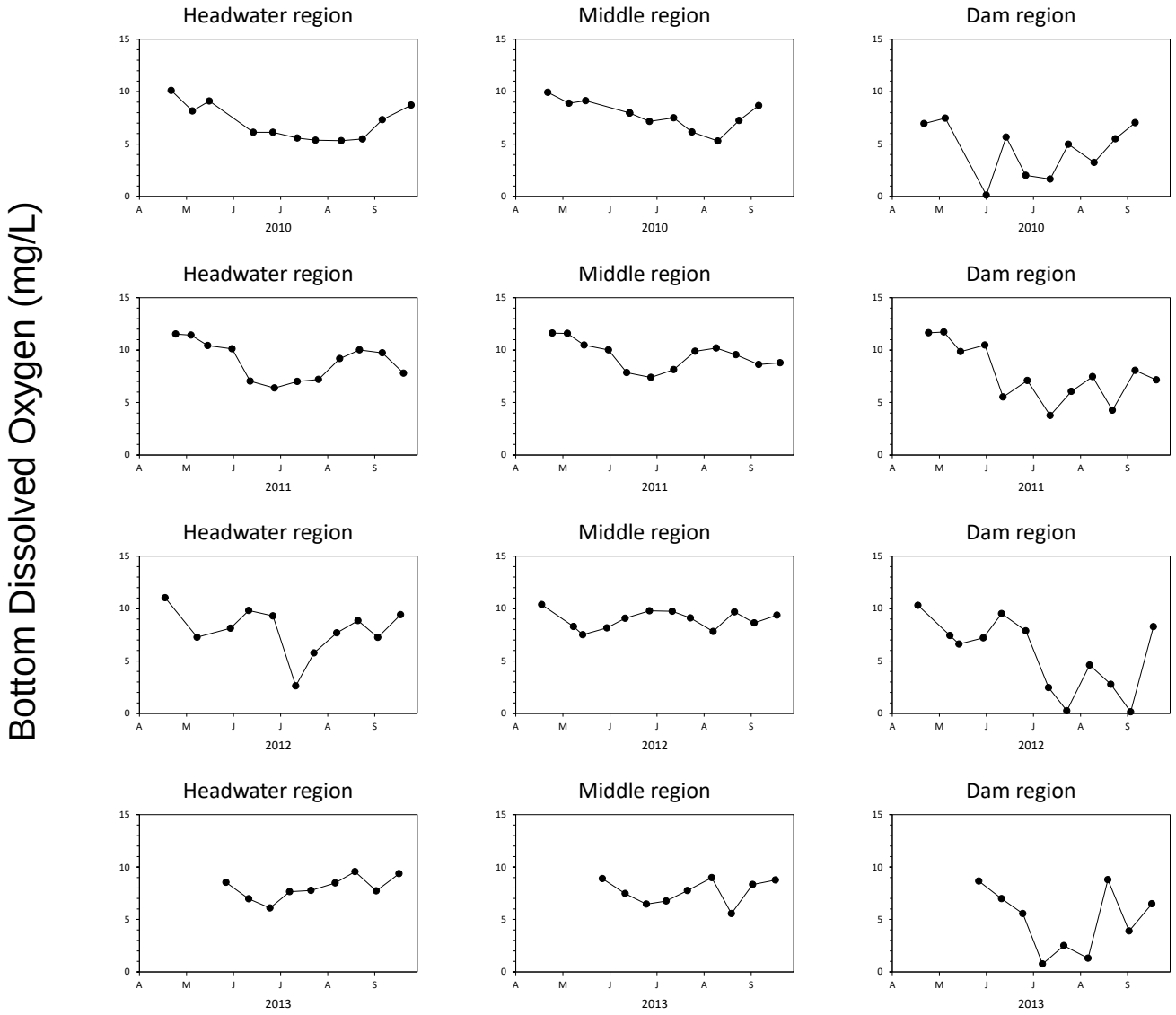



Figure 10. Seasonal variations in near-bottom concentrations of dissolved oxygen for the headwater, middle, and dam stations during 2010-2013.

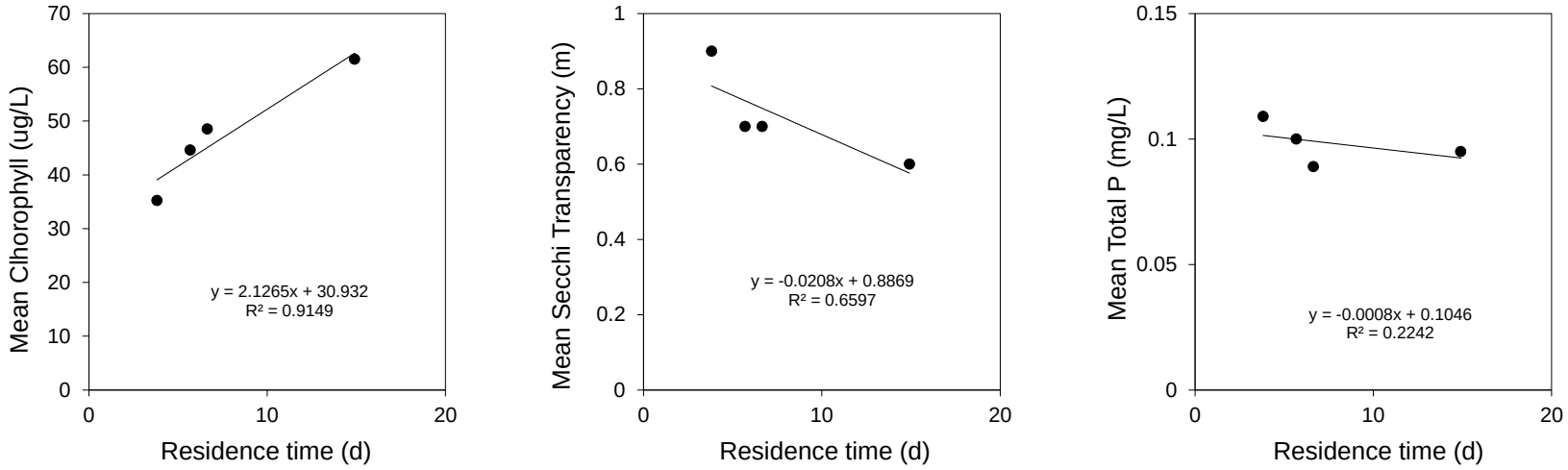



Figure 11. Regression relationships between summer (June – September) theoretical water residence time and summer area-weighted mean chlorophyll (left panel), mean Secchi transparency (middle panel), and total phosphorus (P, right panel).

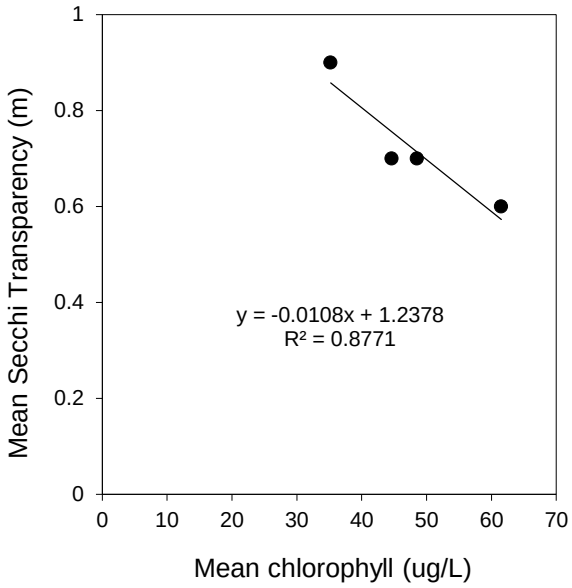



Figure 12. Regression relationships between summer (June – September) area-weighted mean chlorophyll and mean Secchi transparency.

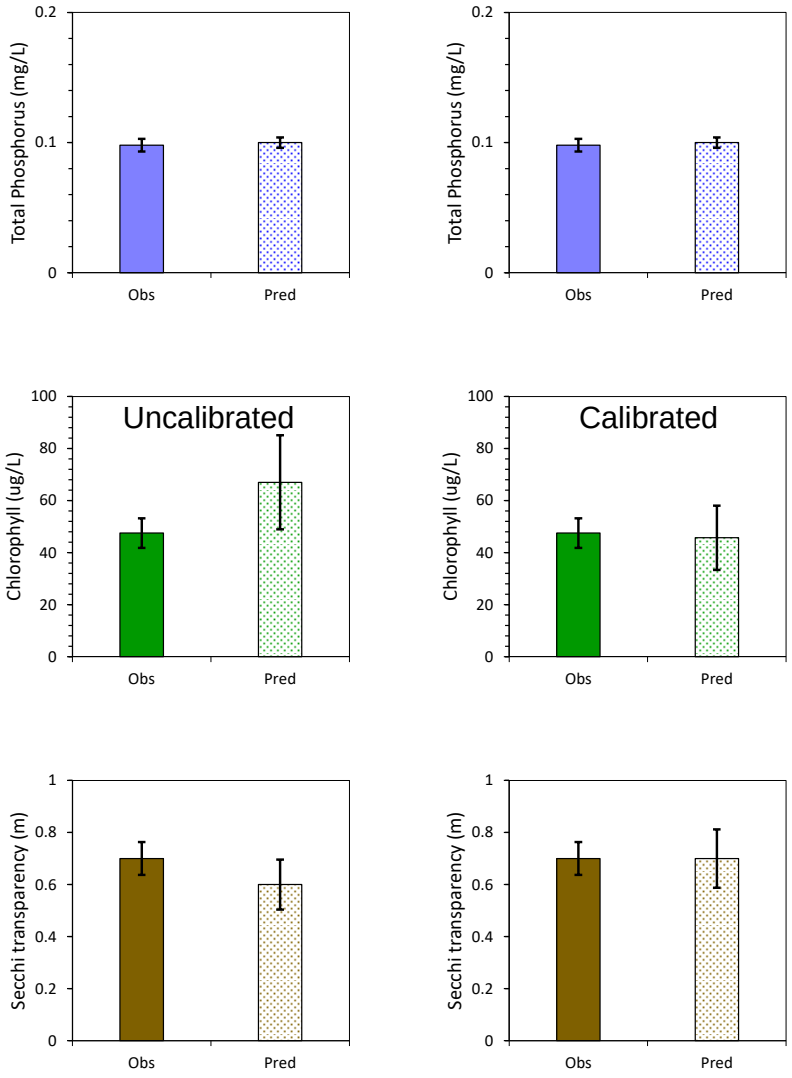



Figure 13. A comparision of mean (± 1 standard error) observed versus predicted area-weighted total phosphorus, chlorophyll, and Secchi transparency using an uncalibrated (left panel) and calibrated (right panel) chlorophyll model.

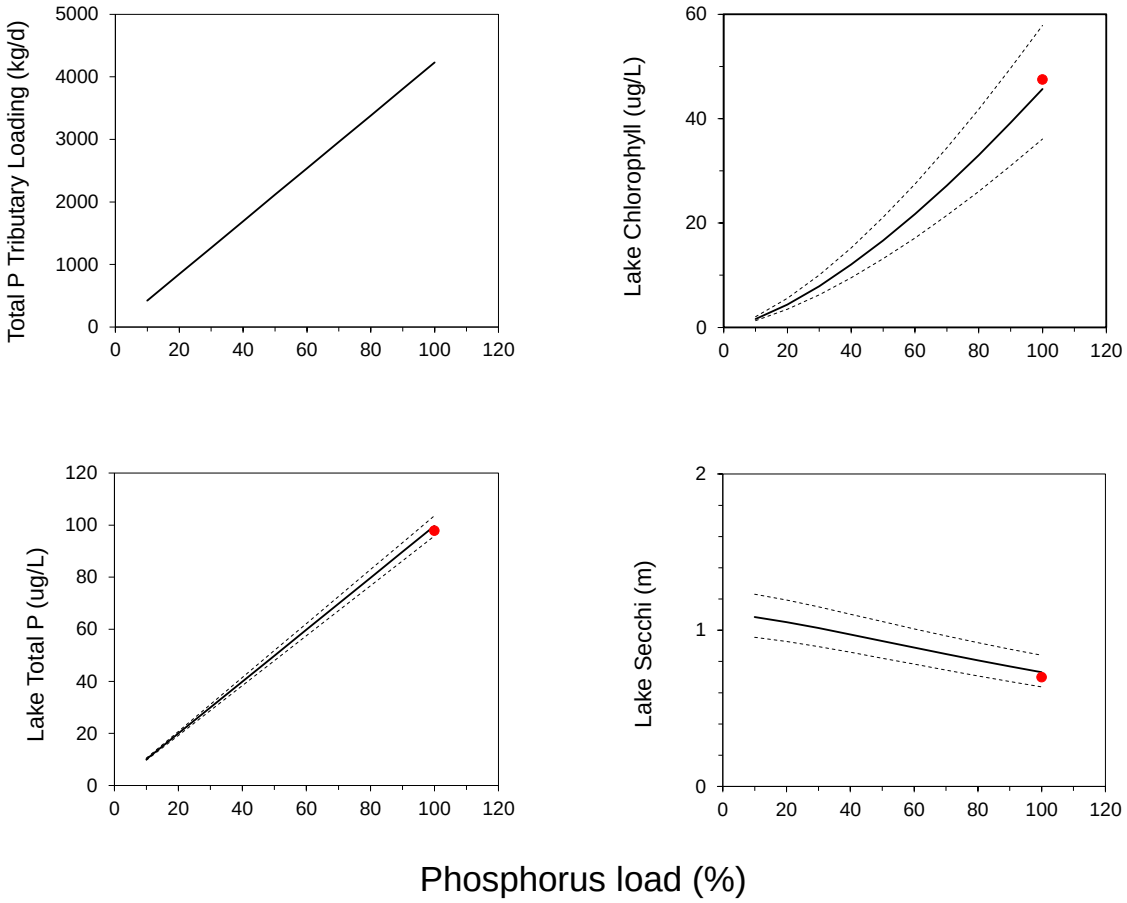



Figure 14. Bathtub (Walker 1996) model output of predicted changes in total phosphorus (P), chlorophyll, and Secchi transparency in Lake Wisconsin as a function of reducing current mean 2010-13 mean summer P loading by 20% increments (black lines). Dotted lines denote 95% confidence intervals. Red circles represent current measured mean values. 100% P load represents current loading conditions.

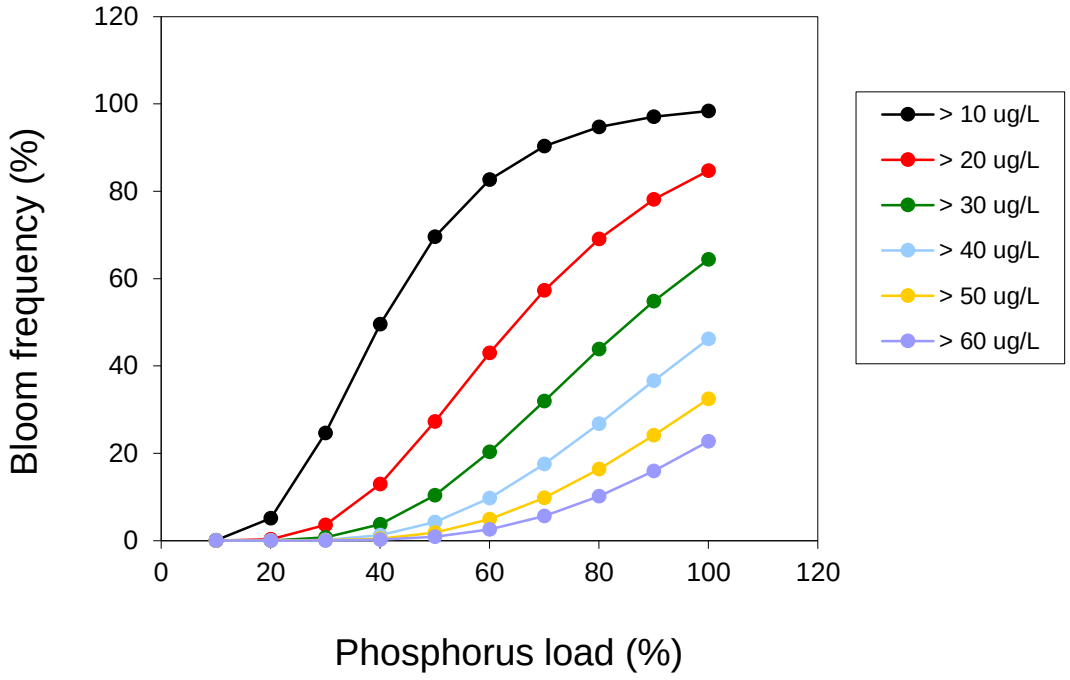



Figure 15. Bathtub (Walker 1996) model output of predicted changes in algal bloom frequency (as chlorophyll) as a function of reducing current mean 2010-13 mean summer P loading by 20% increments. 100% P load represents current loading conditions.

# APPENDICES

Appendix 1a. Lake Wisconsin summer (June-September to early October) means and standard errors (SE) for the headwater station.

| Statistic | Total P (Surface) | Total P (Bottom) | Chlorophyll | SRP | Secchi | TKN | NHx | N0x | Total N | Particulate N | Particulate P | N:P ratio | N:P ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (mg/L) | (mg/L) | (ug/L) | (mg/L) | (m) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mass:mass) | (Mol:Mol) |
| **2010-13** | | | | | | | | | | | | | |
| Mean[1] | 0.090 | 0.098 | 36.7 | 0.0142 | 0.8 | 1.072 | 0.025 | 0.299 | 1.371 | 1.047 | 0.076 | 13.8 | 30.6 |
| SE | 0.003 | 0.004 | 3.4 | 0.003 | 0.031 | 0.036 | 0.004 | 0.039 | 0.037 | 0.037 | 0.002 | 0.4 | 0.9 |
| **2010** | | | | | | | | | | | | | |
| Mean | 0.108 | 0.115 | 23.2 | 0.0298 | 0.9 | 1.043 | 0.036 | 0.397 | 1.441 | 1.007 | 0.078 | 13.1 | 28.9 |
| SE | 0.007 | 0.008 | 2.3 | 0.006 | 0.048 | 0.031 | 0.007 | 0.064 | 0.056 | 0.030 | 0.004 | 0.4 | 0.9 |
| **2011** | | | | | | | | | | | | | |
| Mean | 0.076 | 0.083 | 37.0 | 0.0077 | 0.8 | 0.949 | 0.017 | 0.335 | 1.284 | 0.932 | 0.069 | 13.7 | 30.4 |
| SE | 0.005 | 0.005 | 5.7 | 0.002 | 0.050 | 0.057 | 0.004 | 0.069 | 0.052 | 0.060 | 0.005 | 0.6 | 1.4 |
| **2012** | | | | | | | | | | | | | |
| Mean | 0.083 | 0.090 | 54.6 | 0.0022 | 0.6 | 1.157 | 0.011 | 0.132 | 1.289 | 1.146 | 0.081 | 14.2 | 31.4 |
| SE | 0.003 | 0.005 | 6.7 | 0.001 | 0.027 | 0.102 | 0.001 | 0.059 | 0.075 | 0.101 | 0.004 | 1.1 | 2.5 |
| **2013** | | | | | | | | | | | | | |
| Mean | 0.095 | 0.102 | 32.1 | 0.0171 | 0.8 | 1.138 | 0.034 | 0.331 | 1.468 | 1.103 | 0.078 | 14.4 | 31.9 |
| SE | 0.007 | 0.009 | 7.6 | 0.006 | 0.067 | 0.071 | 0.012 | 0.098 | 0.097 | 0.076 | 0.003 | 1.0 | 2.3 |

[1]Represents the mean of all values measured between June-September to early October over 2010-13.

Appendix 1b. Lake Wisconsin summer (June-September to early October) means and standard errors (SE) for the middle station.

| Statistic | Total P (Surface) | Total P (Bottom) | Chlorophyll | SRP | Secchi | TKN | NHx | N0x | Total N | Particulate N | Particulate P | N:P ratio | N:P ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (mg/L) | (mg/L) | (ug/L) | (mg/L) | (m) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mass:mass) | (Mol:Mol) |
| **2010-13** | | | | | | | | | | | | | |
| Mean[1] | 0.101 | 0.102 | 49.9 | 0.0121 | 0.7 | 1.188 | 0.037 | 0.186 | 1.374 | 1.151 | 0.089 | 13.1 | 29.1 |
| SE | 0.003 | 0.003 | 3.7 | 0.002 | 0.031 | 0.041 | 0.005 | 0.033 | 0.045 | 0.041 | 0.003 | 0.4 | 0.9 |
| **2010** | | | | | | | | | | | | | |
| Mean | 0.112 | 0.113 | 36.6 | 0.0284 | 0.8 | 1.162 | 0.060 | 0.266 | 1.429 | 1.102 | 0.087 | 13.0 | 28.7 |
| SE | 0.008 | 0.009 | 4.9 | 0.005 | 0.089 | 0.047 | 0.008 | 0.055 | 0.083 | 0.045 | 0.005 | 0.8 | 1.8 |
| **2011** | | | | | | | | | | | | | |
| Mean | 0.092 | 0.092 | 51.4 | 0.0057 | 0.7 | 1.091 | 0.023 | 0.198 | 1.289 | 1.068 | 0.086 | 12.4 | 27.5 |
| SE | 0.006 | 0.007 | 7.1 | 0.002 | 0.048 | 0.086 | 0.006 | 0.072 | 0.071 | 0.087 | 0.007 | 0.4 | 0.8 |
| **2012** | | | | | | | | | | | | | |
| Mean | 0.103 | 0.105 | 67.3 | 0.0014 | 0.5 | 1.271 | 0.019 | 0.043 | 1.314 | 1.252 | 0.102 | 12.6 | 27.9 |
| SE | 0.006 | 0.004 | 5.9 | 0.000 | 0.026 | 0.104 | 0.007 | 0.018 | 0.102 | 0.105 | 0.006 | 1.3 | 2.9 |
| **2013** | | | | | | | | | | | | | |
| Mean | 0.096 | 0.098 | 44.1 | 0.0146 | 0.7 | 1.228 | 0.044 | 0.236 | 1.463 | 1.183 | 0.082 | 14.5 | 32.1 |
| SE | 0.006 | 0.006 | 8.0 | 0.004 | 0.028 | 0.077 | 0.014 | 0.081 | 0.101 | 0.081 | 0.005 | 0.4 | 0.8 |

[1]Represents the mean of all values measured between June-September to early October over 2010-13.

Appendix 1c. Lake Wisconsin summer (June-September to early October) means and standard errors (SE) for the dam station.

| Statistic | Total P (Surface) | Total P (Bottom) | Chlorophyll | SRP | Secchi | TKN | NHx | N0x | Total N | Particulate N | Particulate P | N:P ratio | N:P ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (mg/L) | (mg/L) | (ug/L) | (mg/L) | (m) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mg/L) | (mass:mass) | (Mol:Mol) |
| **2010-13** | | | | | | | | | | | | | |
| Mean[1] | 0.099 | 0.102 | 52.5 | 0.0127 | 0.8 | 1.229 | 0.062 | 0.155 | 1.384 | 1.167 | 0.087 | 13.5 | 29.8 |
| SE | 0.004 | 0.004 | 4.9 | 0.002 | 0.053 | 0.061 | 0.010 | 0.029 | 0.055 | 0.063 | 0.003 | 0.4 | 0.9 |
| **2010** | | | | | | | | | | | | | |
| Mean | 0.104 | 0.114 | 42.6 | 0.0243 | 1.0 | 1.134 | 0.063 | 0.197 | 1.330 | 1.071 | 0.083 | 13.3 | 29.4 |
| SE | 0.011 | 0.009 | 6.7 | 0.006 | 0.194 | 0.079 | 0.018 | 0.049 | 0.060 | 0.089 | 0.007 | 0.8 | 1.8 |
| **2011** | | | | | | | | | | | | | |
| Mean | 0.093 | 0.098 | 53.1 | 0.0078 | 0.7 | 1.151 | 0.070 | 0.173 | 1.324 | 1.081 | 0.085 | 12.9 | 28.5 |
| SE | 0.007 | 0.008 | 7.0 | 0.002 | 0.036 | 0.100 | 0.024 | 0.062 | 0.101 | 0.087 | 0.006 | 0.7 | 1.6 |
| **2012** | | | | | | | | | | | | | |
| Mean | 0.090 | 0.091 | 57.4 | 0.0026 | 0.6 | 1.260 | 0.057 | 0.053 | 1.313 | 1.203 | 0.088 | 13.6 | 30.0 |
| SE | 0.004 | 0.008 | 6.3 | 0.001 | 0.026 | 0.111 | 0.026 | 0.027 | 0.097 | 0.125 | 0.004 | 1.1 | 2.4 |
| **2013** | | | | | | | | | | | | | |
| Mean | 0.110 | 0.108 | 55.7 | 0.0188 | 0.7 | 1.361 | 0.057 | 0.201 | 1.562 | 1.303 | 0.091 | 14.2 | 31.5 |
| SE | 0.008 | 0.007 | 16.2 | 0.005 | 0.059 | 0.172 | 0.016 | 0.076 | 0.151 | 0.178 | 0.009 | 0.8 | 1.8 |

[1]Represents the mean of all values measured between June-September to early October over 2010-13.

# Wisconsin River TMDL: Bathtub Lake Model Setup and Results for Minocqua Lake, Kawaguesaga Lake, and Redstone Lake

## *Introduction*

This report summarizes the setup and results of Bathtub modeling for Kawaguesaga and Minocqua Lakes in Oneida County, and Redstone Lake in Sauk County. These lakes are on Wisconsin's 303(d) list of impaired waters for phosphorus related impairments and are part of the larger Wisconsin River basin Total Maximum Daily Load for total phosphorus.

## *Model Setup and Development*

Steady-state modeling was conducted using Bathtub (Version 6.1, Walker 1996). Bathtub is a windows-based software program that provides a suite of empirical equations for predicting lake averages of phosphorus, chlorophyll, and Secchi transparency. Model outputs were only analyzed for phosphorus and no additional modeling evaluation was conducted for chlorophyll and Secchi.

Lake surface area and volume were based on values reported on WDNR lake survey maps (http://dnr.wi.gov/lakes/maps/). Mixed layer depth was based on model predictions. Redstone Lake was modeled as a single basin, while Minocqua and Kawaguesaga Lakes were modeled as two separate but connected basins. All model runs were based on annual loadings.

Table 1: Lake morphology information

| Lake | WBIC | Surface Area ($km^2$) | Length (km) | Mean depth (m) | Mixed Layer Depth (m) |
|---|---|---|---|---|---|
| **Minocqua** | 1542400 | 5.332 | 4.0 | 7.05 | 5.7 |
| **Kawaguesaga** | 1542300 | 2.792 | 2.9 | 5.18 | 4.7 |
| **Redstone** | 1280400 | 2.450 | 4.28 | 4.35 | 3.0 |

Long term annual average water and nutrient loads to each lake (Table 2) were estimated using the SWAT model developed for the Wisconsin River basin TMDL (WDNR 2016). Atmospheric loading rates were based on a precipitation rate of 0.8 m/yr and a phosphorus load of 30 $mg/m^2/yr$.

Table 2: Water and nutrient loading information

| Lake | Watershed Area ($km^2$) | Mean Annual Flow ($hm^3/yr$) | Tributary Flow Weighted Mean TP (µg/L) | Tributary P loading (kg/yr) | Atmospheric P Loading (kg/yr) | SWAT Sub-basin(s) |
|---|---|---|---|---|---|---|
| **Minocqua** | 164.51 | 54.3 | 22.8 | 1,240 | 99.0 | 134, 133, 168, 226 |
| **Kawaguesaga** | 15.63 | 4.99 | 21.4 | 107 | 51.8 | 135 |
| **Redstone** | 74.61 | 21.5 | | 3,524 | 73.5 | 13, 15, 16 |

Surficial total phosphorus results for the modeled lakes were acquired from the department's comprehensive 2014 Lake Assessment data set developed for Wisconsin's 2014 Impaired Waters List. This data set encompassed the period from 2003 through 2012.

The total phosphorus sub-model was selected based on overall model fit. Model fit was adequate in all cases and no site-specific calibration was required.

Table 3: Monitoring and Modeling Results

| Lake | Assessed Years | # Sample Results | Observed TP (µg/L) | Predicted TP (µg/L) | % diff | TP Sub-model |
|---|---|---|---|---|---|---|
| **Minocqua** | 2003-2011 | 31 | 16.7 | 17.0 | 2% | Canfield Bachman - Lakes |
| **Kawaguesaga** | 2003,2006, 2010-2012 | 14 | 17.7 | 17.3 | 2% | Canfield Bachman - Lakes |
| **Redstone** | 2006-2012 | 13 | 57.1 | 61.0 | 6% | Canfield Bachman - Reservoirs |

## *Loading Capacity*

To determine loading capacity for each lake, upstream tributary concentrations were sequentially lowered until modeled in-lake total phosphorus matched the waterbody's phosphorus criterion under NR 102.06 Wis. Admin. Code. Atmospheric phosphorus loading rates were held constant as were hydraulic loading rates.

Table 4: Loading Capacity

| Lake Name | TP Criteria (µg/L) | Tributary P loading (kg/yr) | Tributary Flow Weighted Mean TP (µg/L) | Predicted in-Lake P (µg/L) | % reduction |
|---|---|---|---|---|---|
| **Minocqua** | 15 | 1,032 | 19 | 15 | 17% |
| **Kawaguesaga** | 15 | 94.8 | 19 | 15 | 11% |
| **Redstone** | 30 | 1,175 | 60 | 30 | 67% |

# Wisconsin River TMDL: Lake Model Setup and Results for Lake Delton

## *Introduction*

This report summarizes the setup and results of modeling for Lake Delton in Sauk County. This lake is on Wisconsin's 303(d) list of impaired waters for phosphorus related impairments and are part of the larger Wisconsin River Basin Total Maximum Daily Load for total phosphorus.

## *Model Setup and Development*

Steady-state modeling was conducted using Wisconsin Lake Modeling Suite (WiLMS Version 3.318.1, WDNR 2001). WiLMS is a windows-based software program that provides a suite of empirical equations for predicting lake averages of phosphorus.

Lake surface area and volume were based on values reported on WDNR lake survey maps (http://dnr.wi.gov/lakes/maps/). All model runs were based on annual loadings not seasonal loading.

Table 1: Lake morphology information

| Lake | WBIC | Surface Area (acres) | Mean Depth (ft) |
|---|---|---|---|
| **Minocqua** | 1295400 | 249 | 12 |

Long term annual average water and nutrient loads to each lake (Table 2) were estimated using the SWAT model developed for the Wisconsin River basin TMDL (WDNR 2016). Atmospheric loading rates were based on the default loading rates from WiLMS and comprised a minor fraction of the total phosphorus budget (30 kg/yr).

Table 2: Water and nutrient loading information

| Lake | Watershed Area ($km^2$) | Mean Annual Flow ($hm^3/yr$) | Tributary P loading (kg/yr) | SWAT Sub-basin(s) |
|---|---|---|---|---|
| **Delton** | 202.3 | 63.04 | 7,385 | 30, 31, 32 |

Surficial total phosphorus results for the modeled lakes were acquired from the department's comprehensive 2016 Lake Assessment data set developed for Wisconsin's 2016 Impaired Waters List. This data set encompassed the period from 2010 through 2014.

The total phosphorus sub-model was selected based on overall model fit.

Table 3: Monitoring and Modeling Results

| Lake | Assessed Years | # Sample Results | Observed TP (µg/L) | Predicted TP (µg/L) | % diff | TP Sub-model |
|---|---|---|---|---|---|---|
| **Delton** | 2010-2014 | 10 | 73 | 74 | 1% | Canfield Bachman – Artificial Lakes |

### *Loading Capacity*

To determine loading capacity for each lake, the WiLMS load back calculation routine was used to back calculate an annual loading to match the in-lake total phosphorus criterion under NR 102.06 Wis. Admin. Code. Atmospheric phosphorus loading rates were held constant as were hydraulic loading rates.

Table 4: Loading Capacity

| Lake Name | TP Criteria (µg/L) | Tributary P loading (kg/yr) | % reduction |
|---|---|---|---|
| **Delton** | 40 | 3,371 | 54% |

# Appendix D:2

# TMDL Implementation Targeting

A Comparison of Two Subwatersheds

**Sarah Kempen**
*Bureau of Water Quality Modeling Team*
*August 22, 2013*

WISCONSIN
DEPT. OF NATURAL RESOURCES

# Outline

- *Problem*
- *TMDL background*
- *Subwatershed background*
- *Water Quality Analysis*
- *Field-scale GIS analysis*
- *Conclusions*
- *Next steps*

# Outline

- ***Problem***
- *TMDL background*
- *Subwatershed background*
- *Water Quality Analysis*
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- *Next steps*

# Problem

- Non point source runoff
- Issues with water bodies

# Problem

**Point Sources**

Industrial Waste

Municipal Waste

**Nonpoint Sources**

Non-MS4 Stormwater

Construction

Agricultural Runoff

Barnyards

Rill, Gully, & Bank Erosion

# Outline

- *Problem*
- ***TMDL background***
- *Subwatershed background*
- *Water Quality Analysis*
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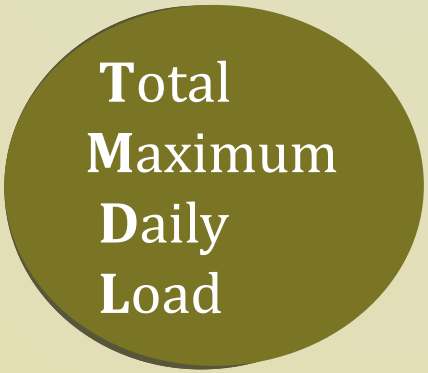
# TMDL Background



# TMDL Allocation

*For a TMDL each subwatershed is assessed for:*

**Background Load**

- Naturally occurring from wetlands, forests

**Load Allocation**

- Runoff from the landscape

**Waste Load Allocation**

- Municipal Wastewater
- Industrial Wastewater
- Stormwater (MS4s)

**TMDL**

Load Allocation + Waste Load Allocation + Margin of Safety

WISCONSIN DEPT. OF NATURAL RESOURCES

# TMDL Process

Is the water impaired?
*(not meeting water quality standards?)*

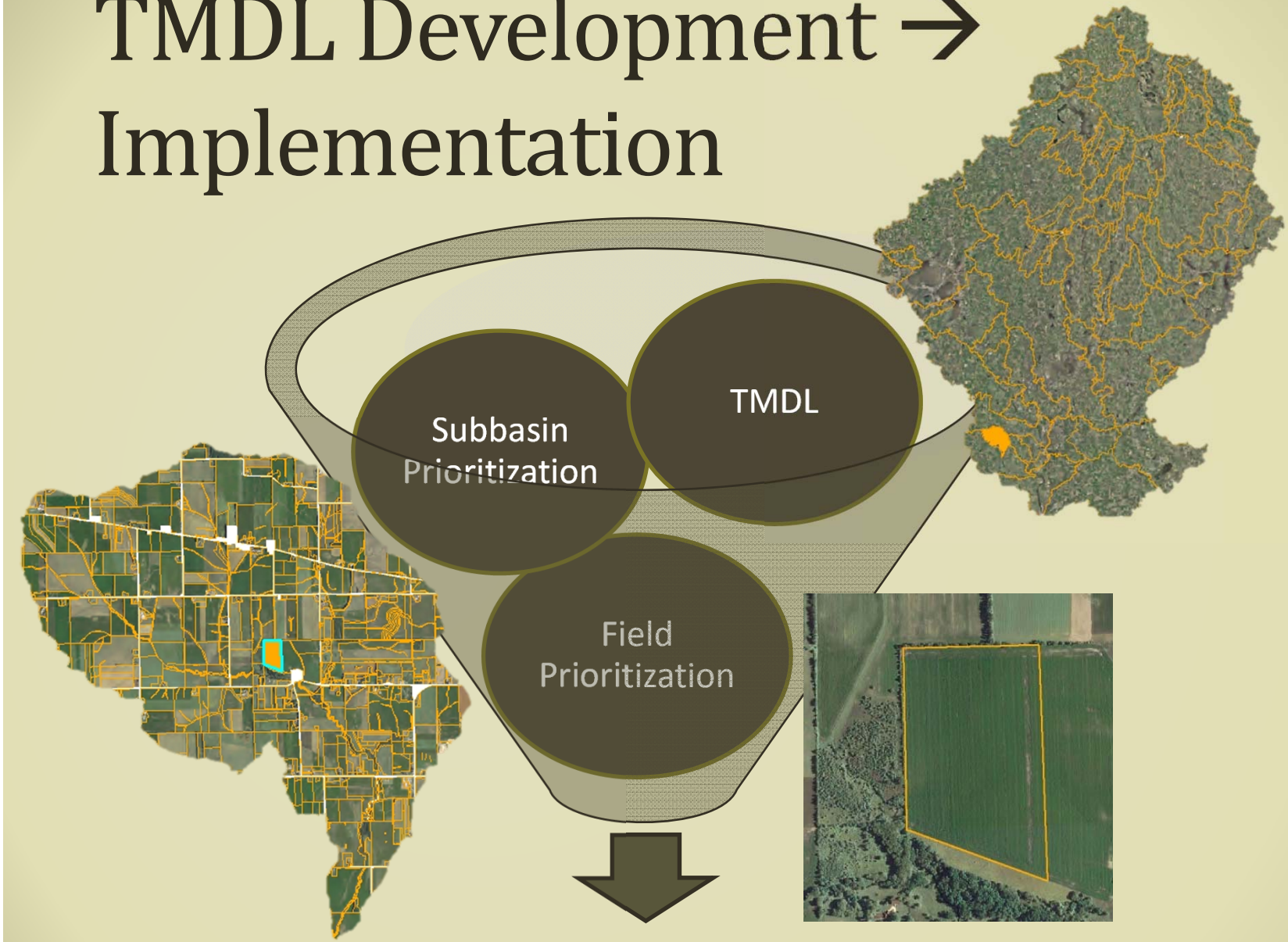
**Develop a TMDL**
- Detailed Monitoring
- Water Quality Modeling
- Allocations

**Implement TMDL**
- Wastewater Permits
- Nonpoint Reductions

**Monitor Waterbody**

**Still impaired?**
- *Yes, more implementation & monitoring*
- *No, removed from impaired waters list*

# TMDL Development → Implementation




TMDL Implementation

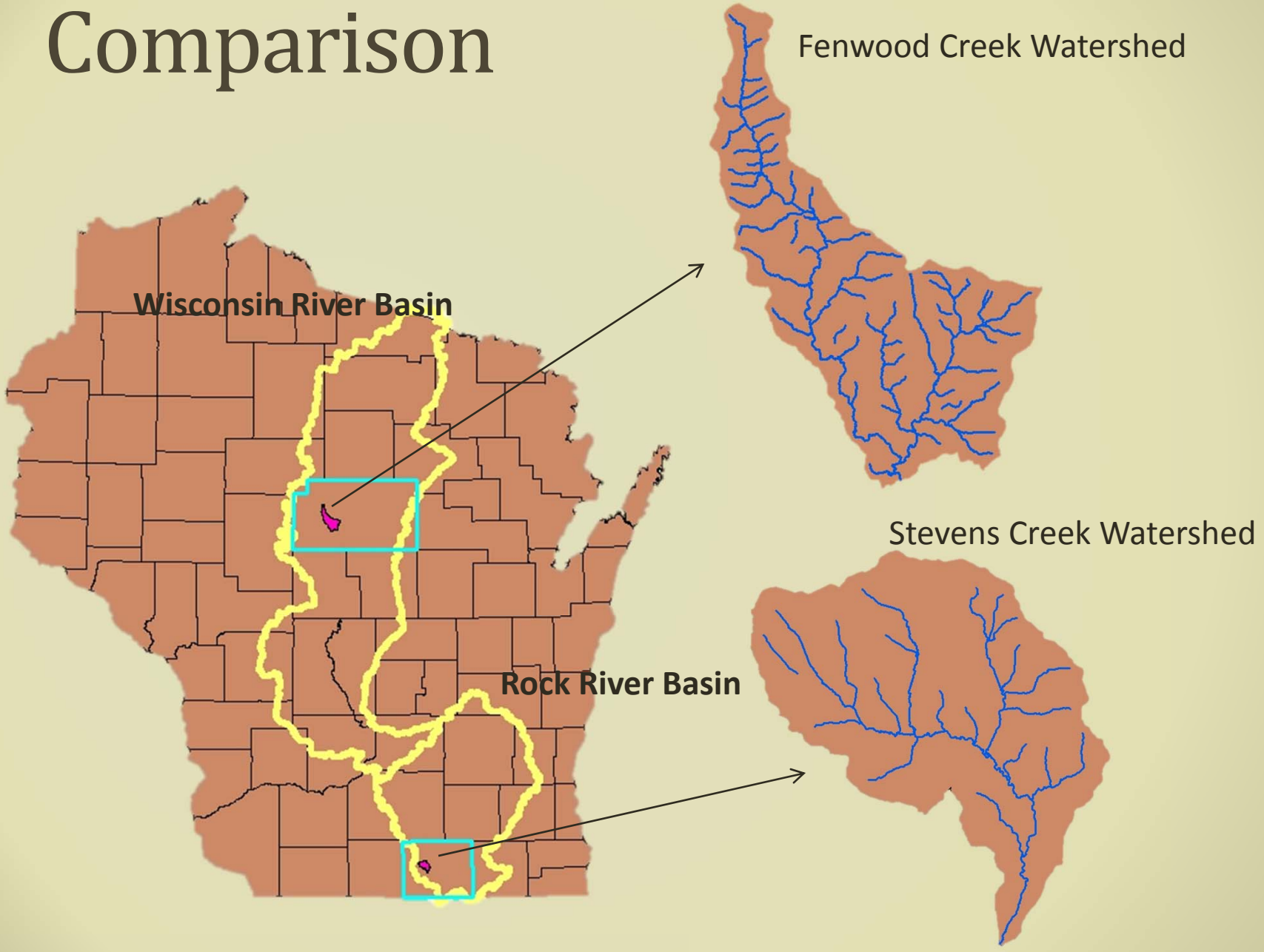
# Why Do We **Target**?

- *"Bang for Buck" Implementation*
- *Supports Adaptive Management and Water Quality Trading*
- *Provides the initial steps towards a 9-key element plan (focus on 319 funding)*

# Outline

- *Problem*
- *TMDL background*
- ***Subwatershed background***
- *Water Quality Analysis*
- *Field-scale GIS analysis*
- *Conclusions*
- *Next steps*

# Comparison


Fenwood Creek Watershed
Wisconsin River Basin
Stevens Creek Watershed
Rock River Basin

# Comparison

| Fenwood<br>*Wisconsin Basin* | | Stevens<br>*Rock Basin* |
|---|---|---|
| 37 square miles | **Area** | 14 square miles |
| High Phosphorus | **Pollutants** | High Sediment |
| 1,966 | **Agricultural Fields** | 878 |
| 0.03-3.35 | **Stream Gradient (%)** | 0.22-2.20 |
| 0.147 | **Median phosphorus concentration** (mg/L)<br>* May – October Growing Season | 0.063 |
| 0.003-0.026<br>*Jan-10 to Dec-12 | **Measured Phosphorus Yield** (lbs/acre/yr) | 0.029<br>* Oct-04 to Sep-05 |

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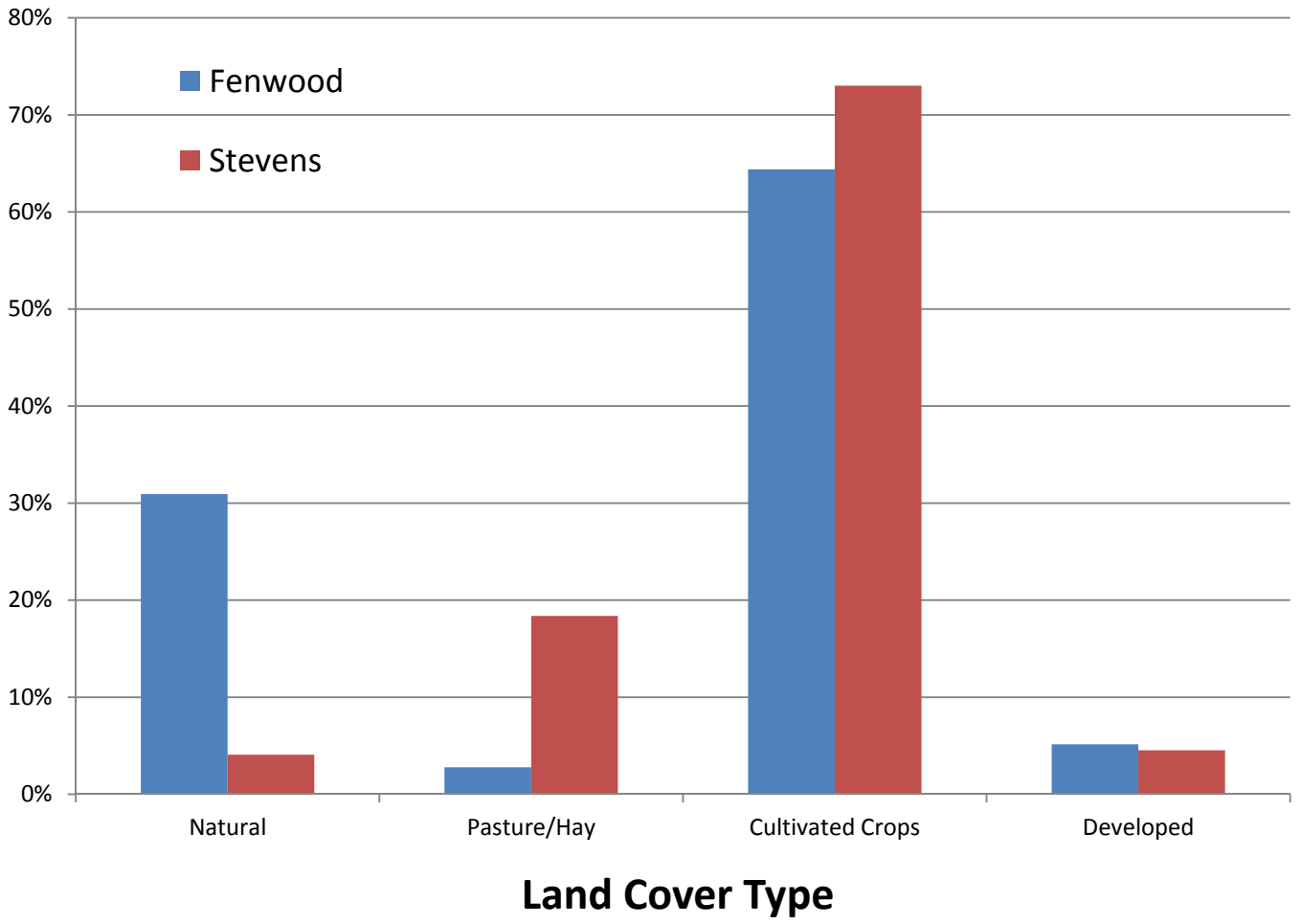
# Fenwood

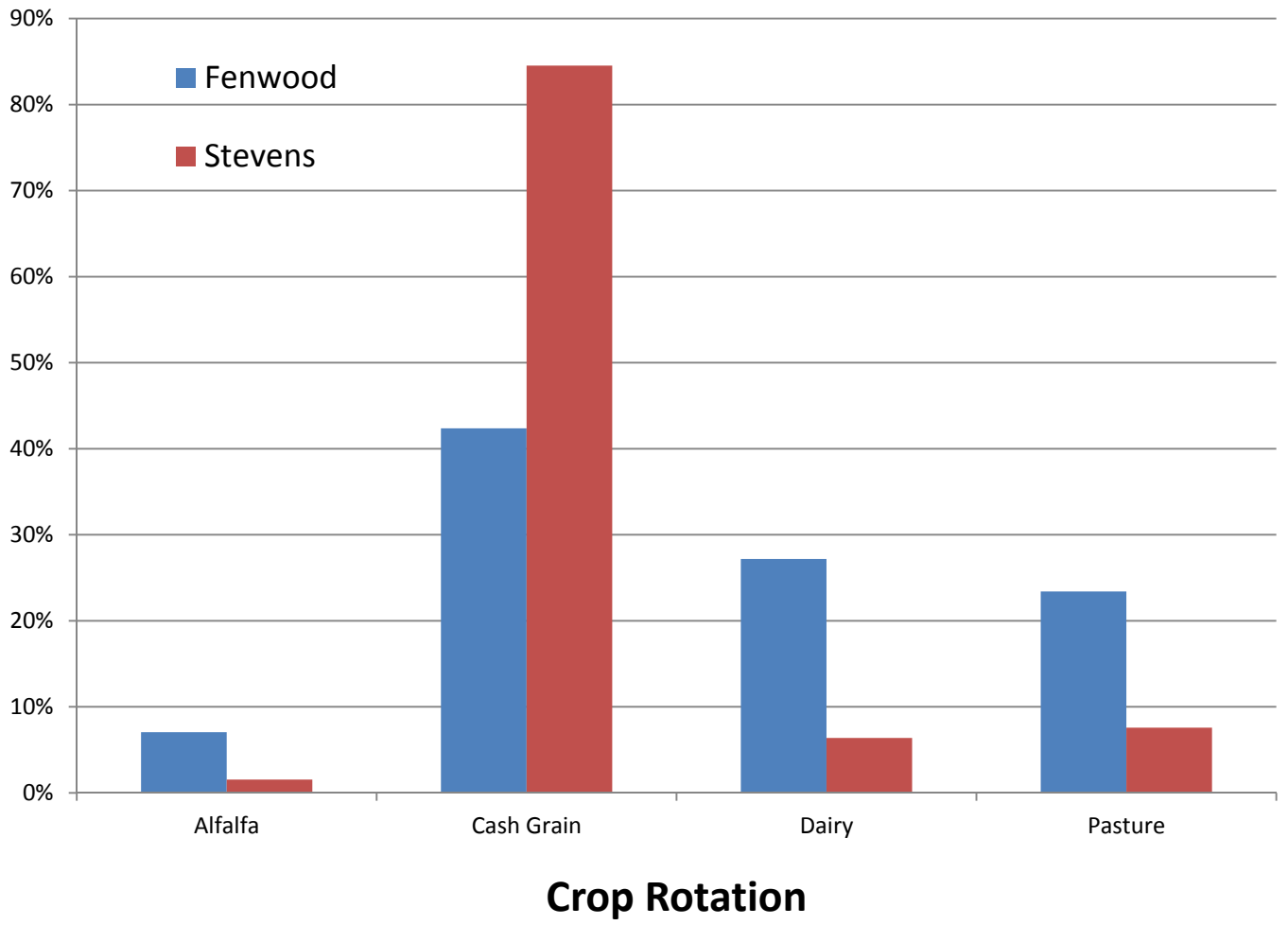
# Stevens

# Land Cover Composition




*National Land Cover Database 2006

# Crop Rotations

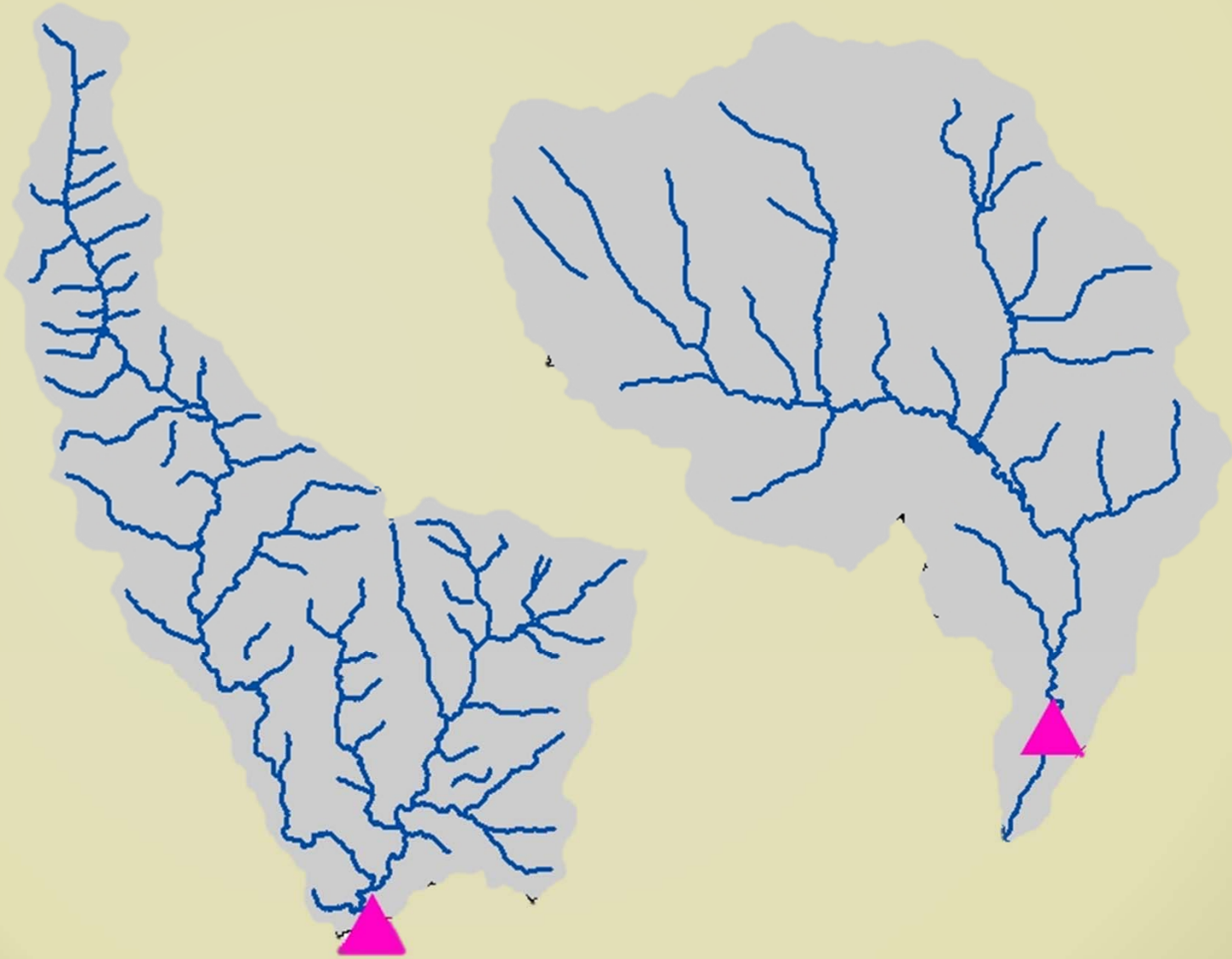



*National Agricultural Statistics Service 2008-2012

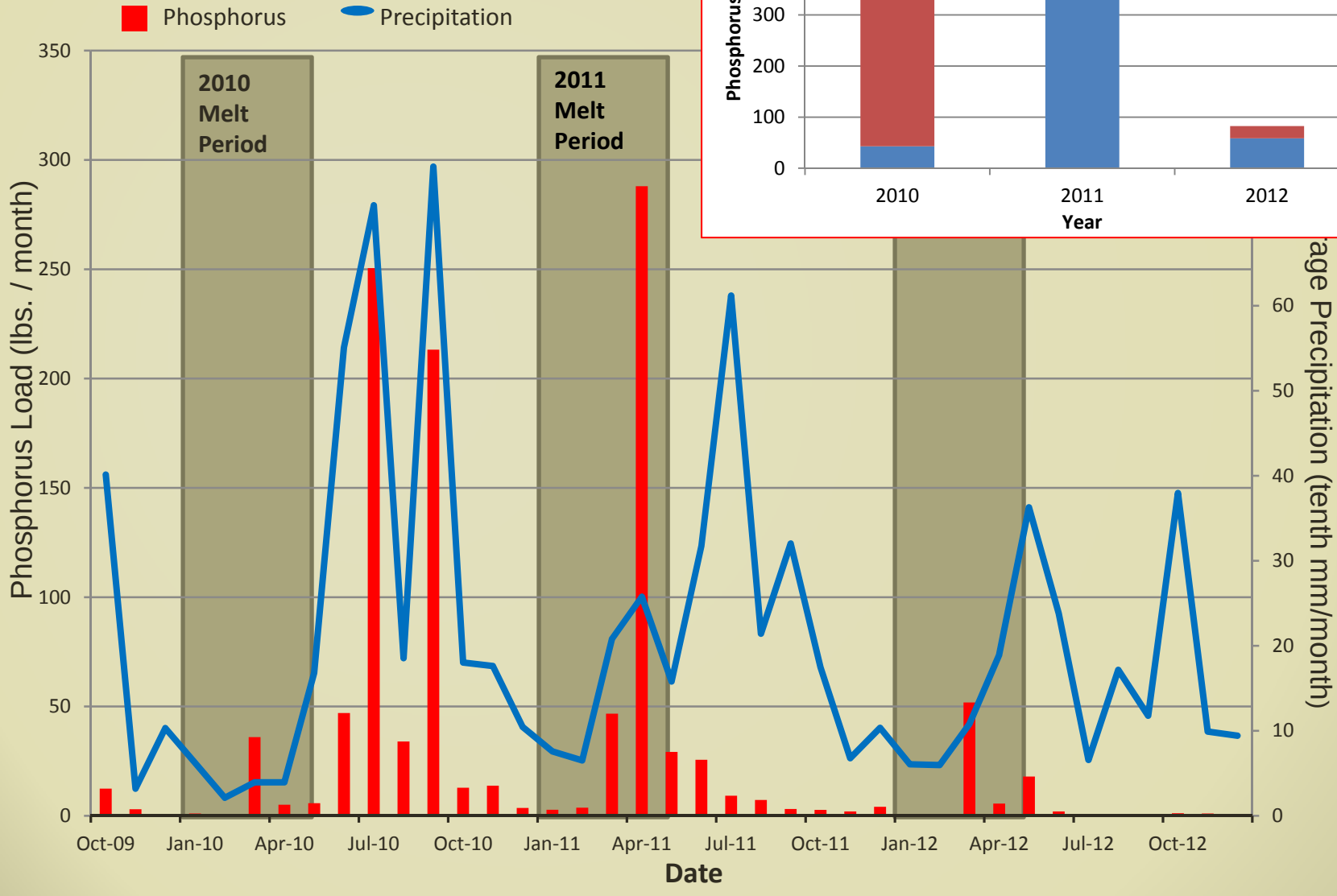
# Outline

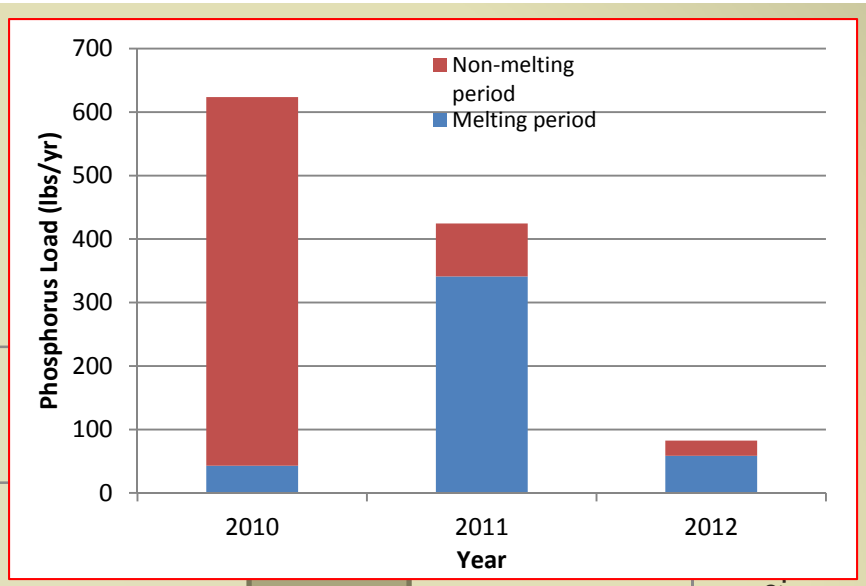
- *Problem*
- *TMDL background*
- *Subwatershed background*
- ***Water Quality Analysis***
- *Field-scale GIS analysis*
- *Conclusions*
- *Next steps*

# Monitoring Station Locations

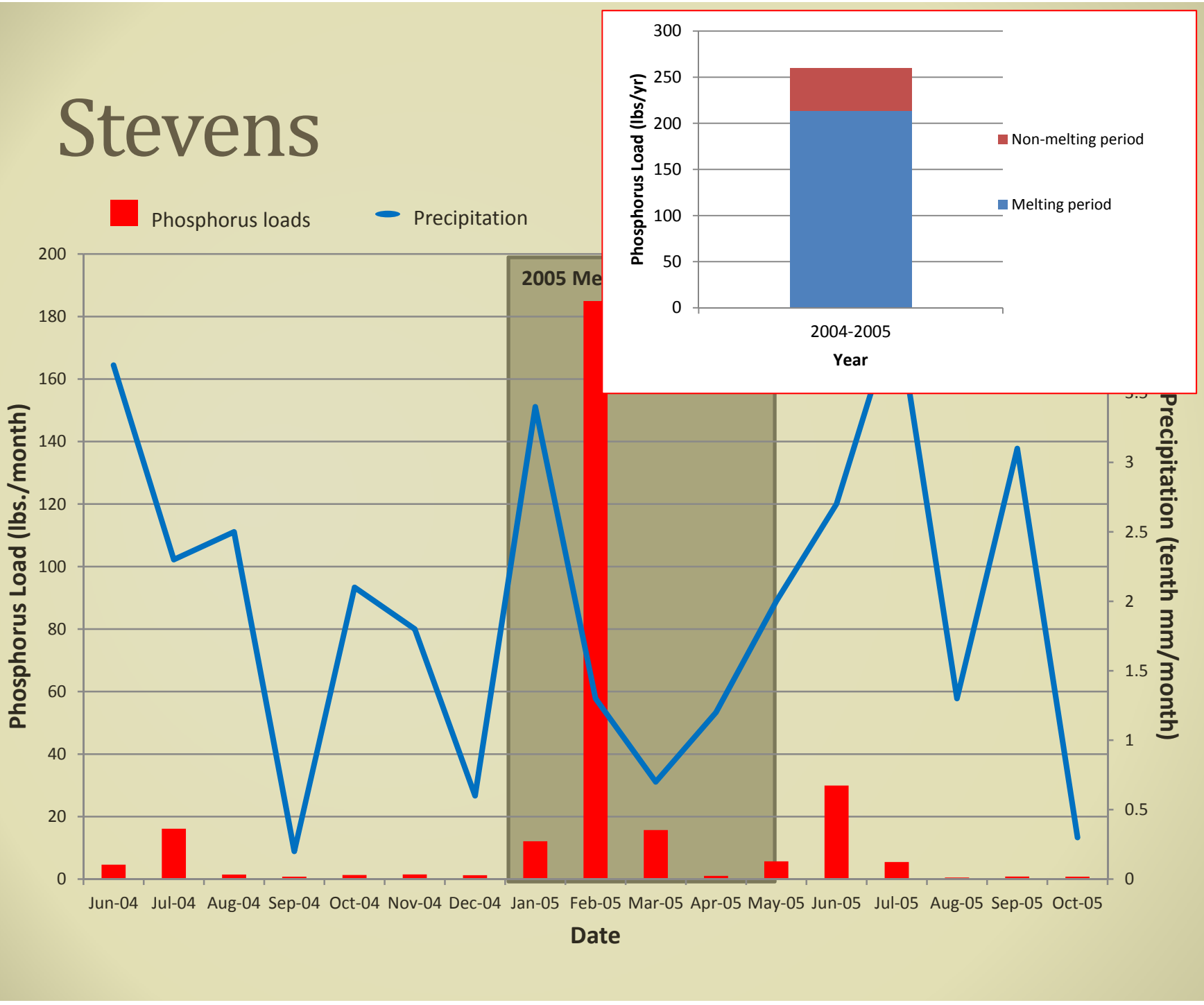


# Fenwood


Phosphorus
Precipitation
2010 Melt Period
2011 Melt Period
Phosphorus Load (lbs. / month)
Precipitation (tenth mm/month)
Date
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
Jul-12
Oct-12
0
50
100
150
200
250
300
350
10
20
30
40
50
60


Non-melting period
Melting period
Phosphorus Load (lbs/yr)
Year
2010
2011
2012
0
100
200
300
400
500
600
700

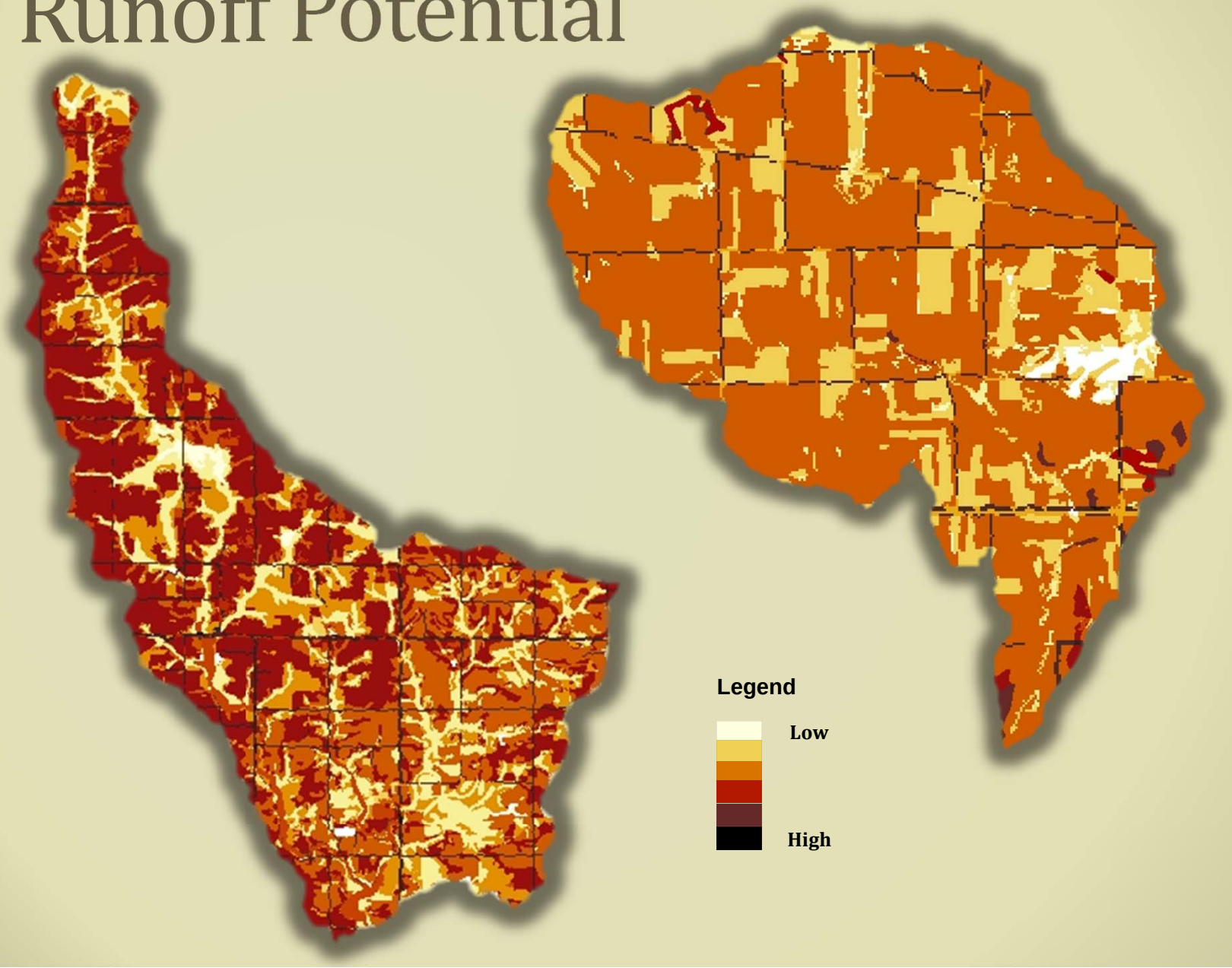
# Stevens


Phosphorus loads
Precipitation
2005 Me
Phosphorus Load (lbs./month)
Precipitation (tenth mm/month)
Date
Jun-04
Jul-04
Aug-04
Sep-04
Oct-04
Nov-04
Dec-04
Jan-05
Feb-05
Mar-05
Apr-05
May-05
Jun-05
Jul-05
Aug-05
Sep-05
Oct-05
Phosphorus Load (lbs/yr)
Non-melting period
Melting period
2004-2005
Year

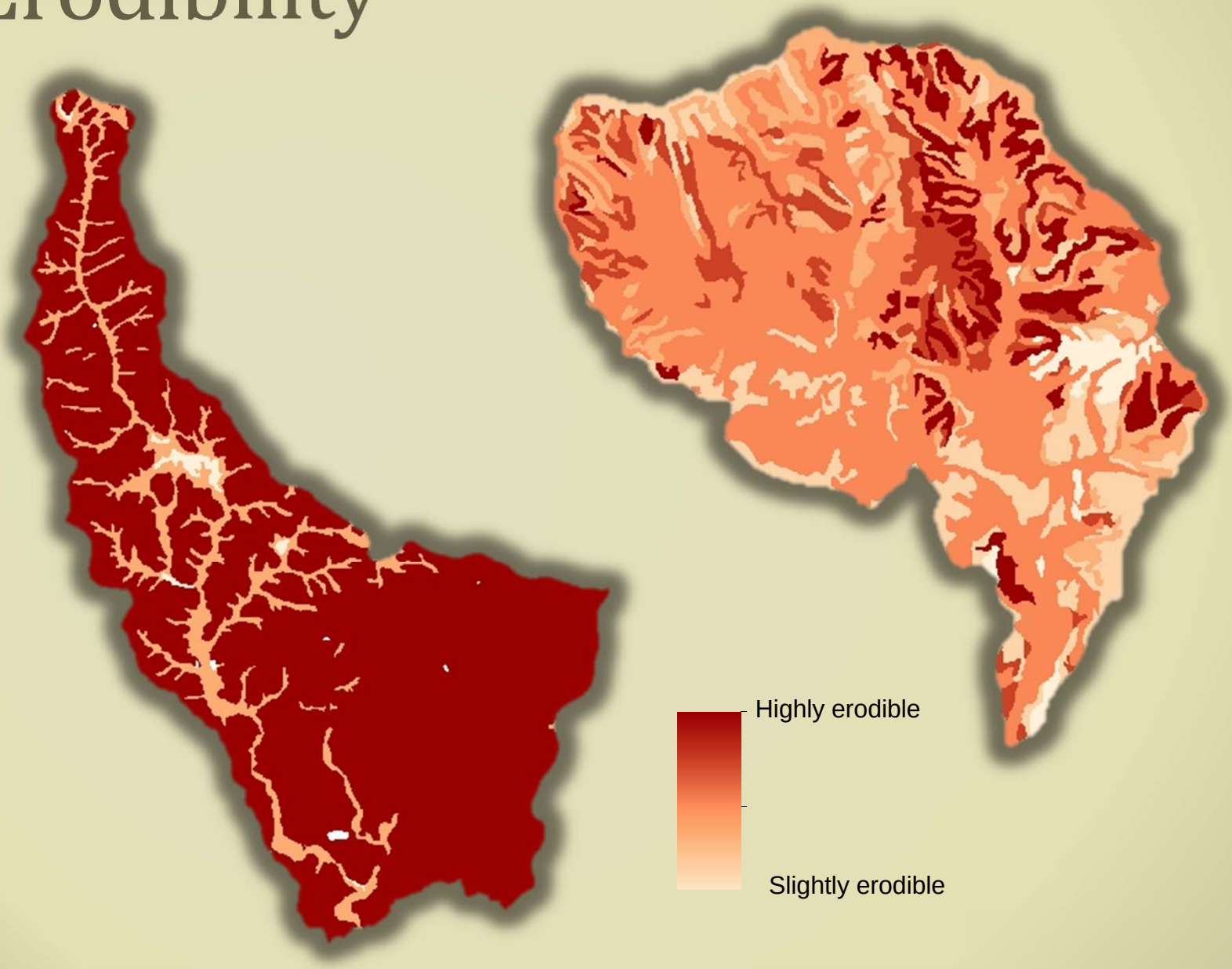
# Outline

- *Problem*
- *TMDL background*
- *Subwatershed background*
- *Water Quality Analysis*
- ***Field-scale GIS analysis***
- *Conclusions*
- *Next steps*

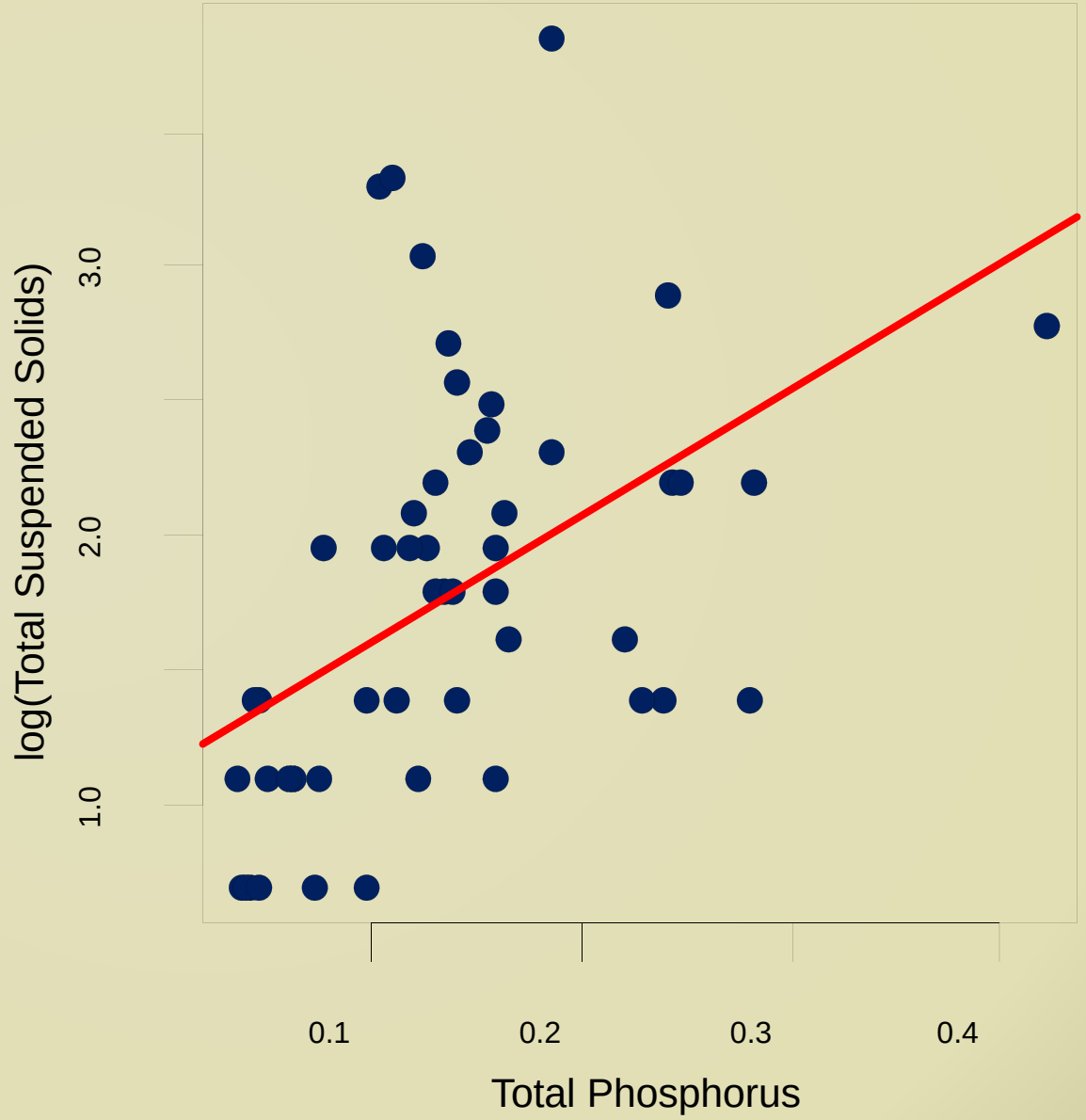
# Runoff Potential



# Erodibility



# TSS vs. TP (Fenwood Creek)




P-value < 0.001

# Priority Index Components

Distance to Animal Lot

+

Distance to Stream

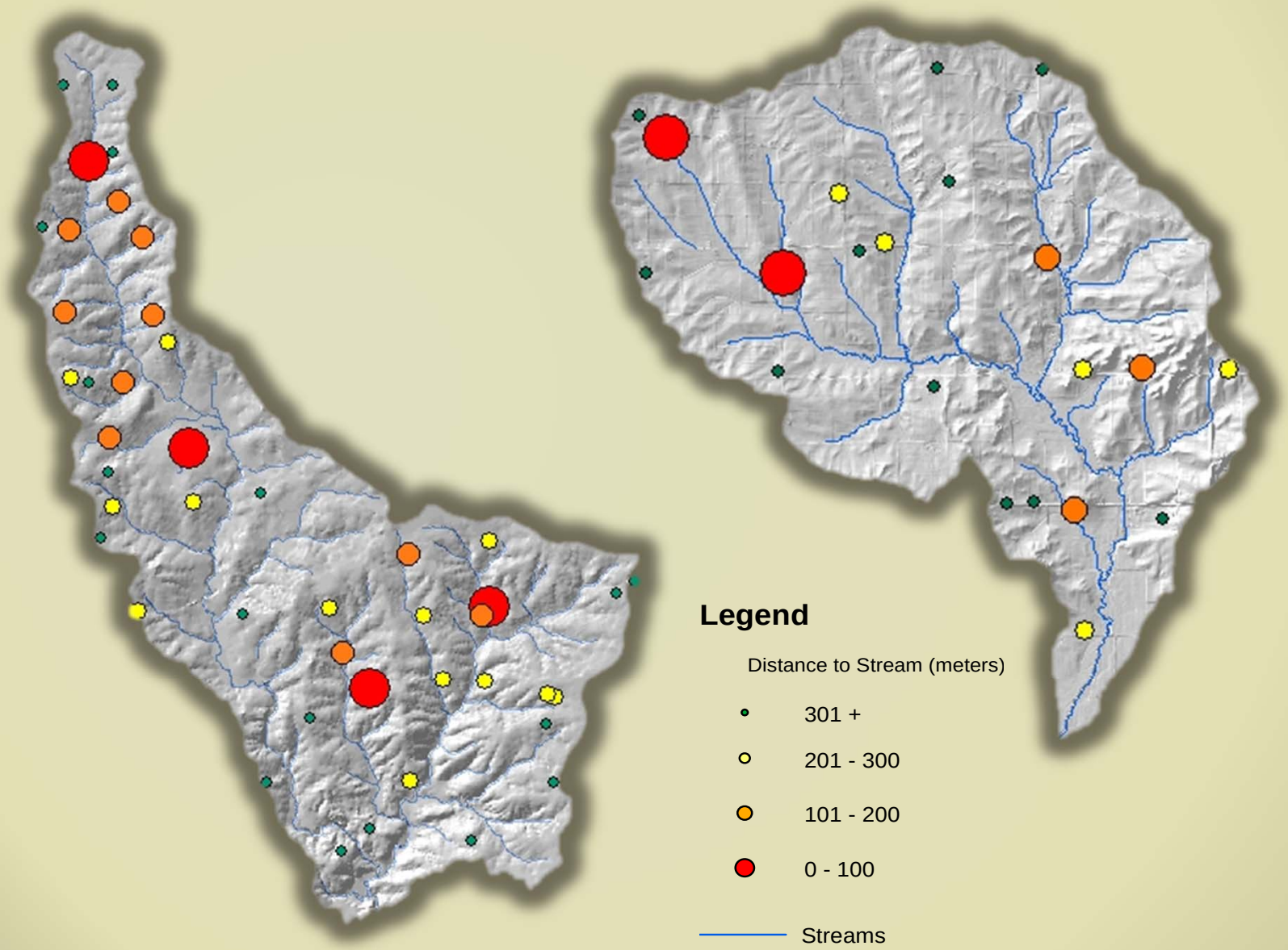
+

Erosion Score

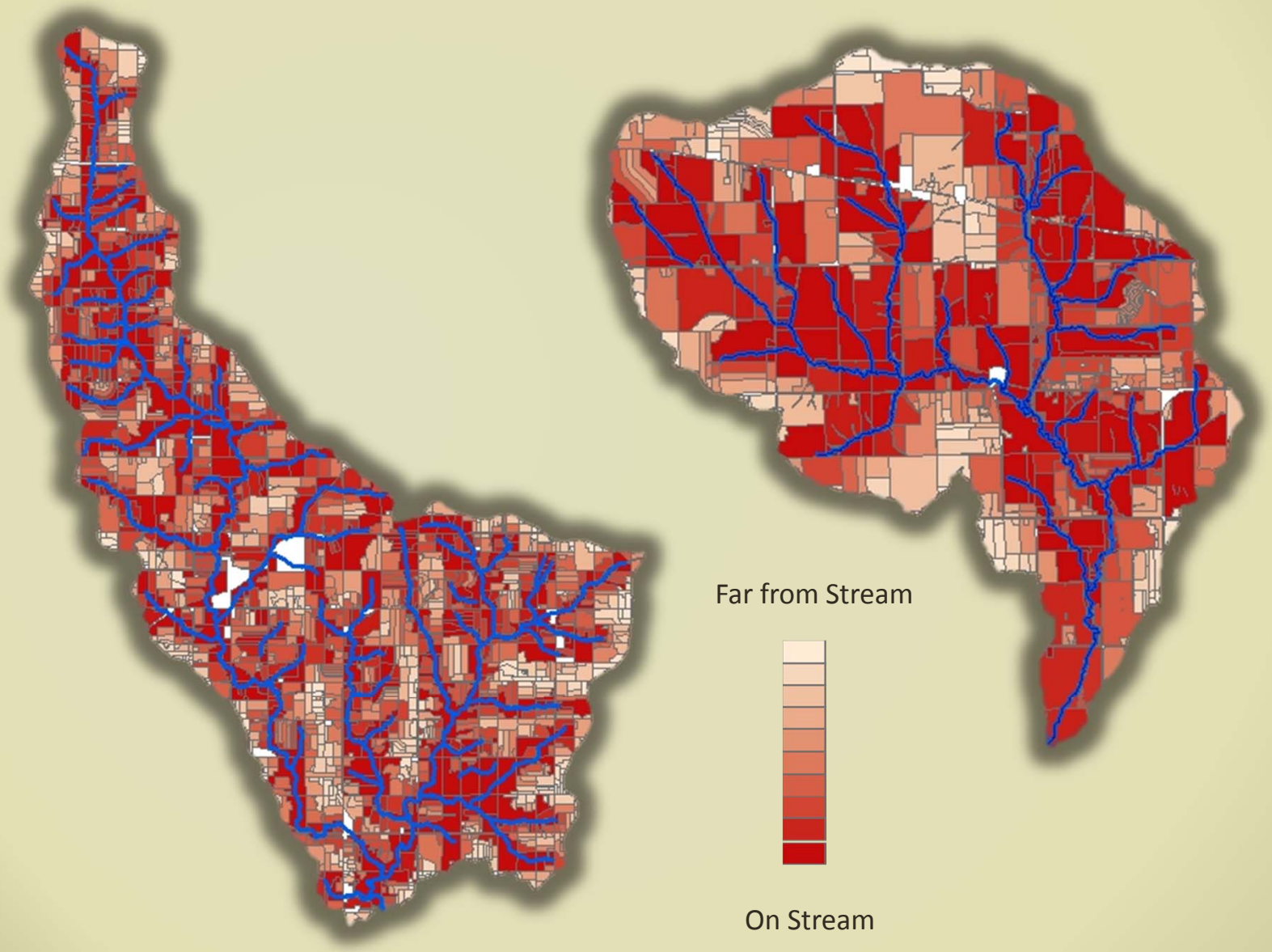
- Rainfall
- Slope
- Soils
- Topography

=

# Animal Lot Distance to Stream



# Field Distance to Stream



# LiDAR = Topography.

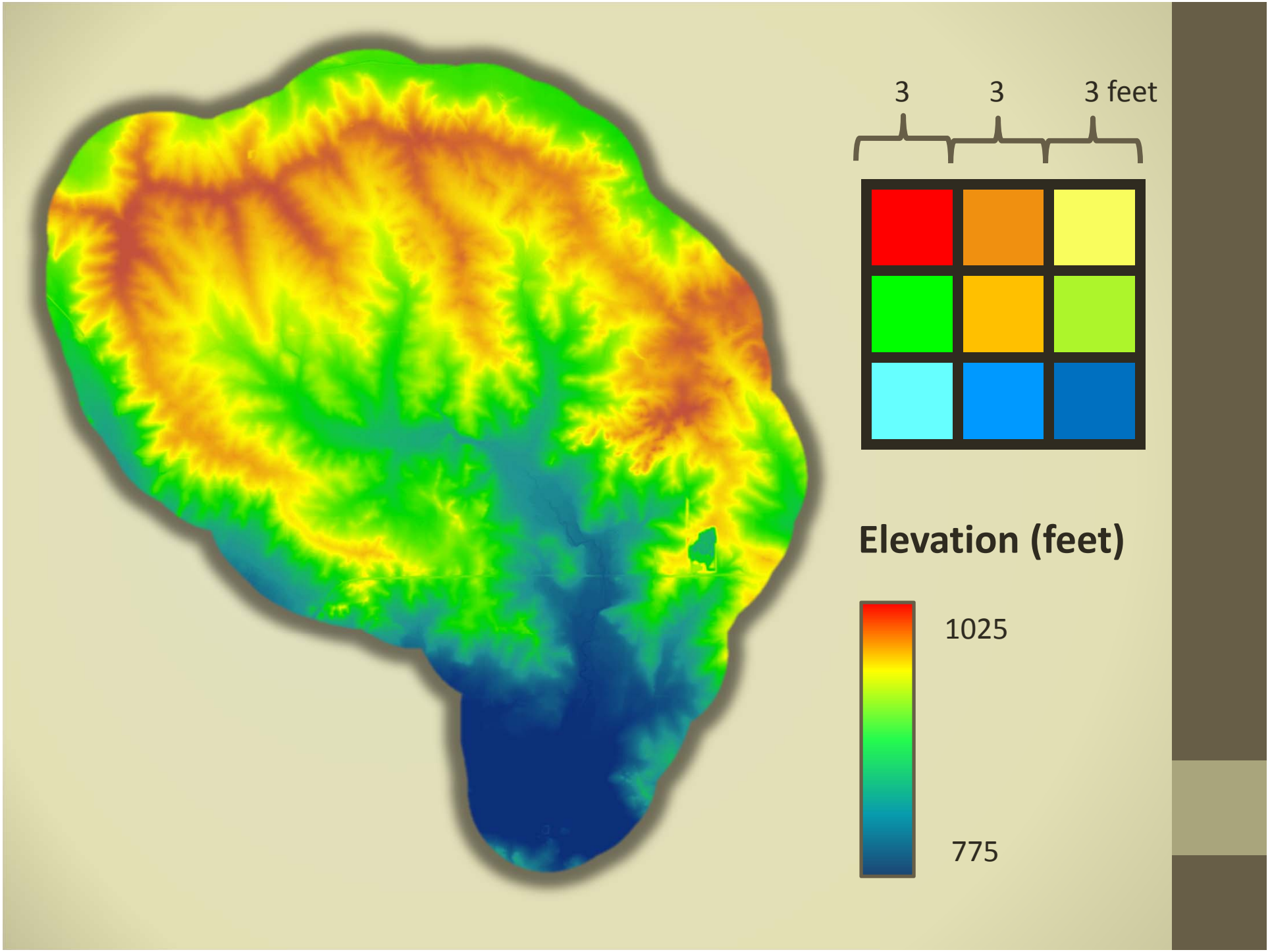
## It can help us identify erosion!

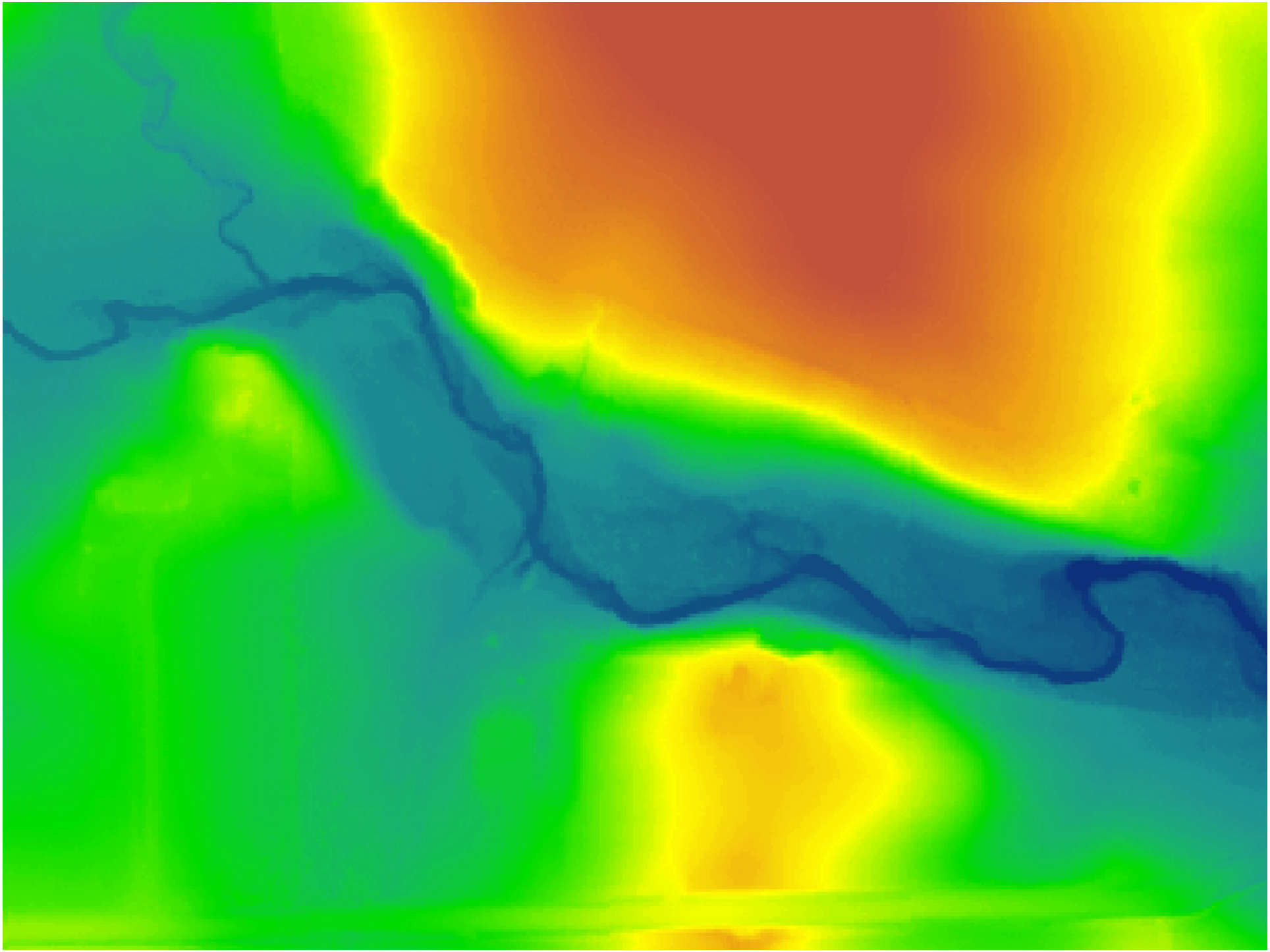
doi:10.2489/jswc.66.6.423

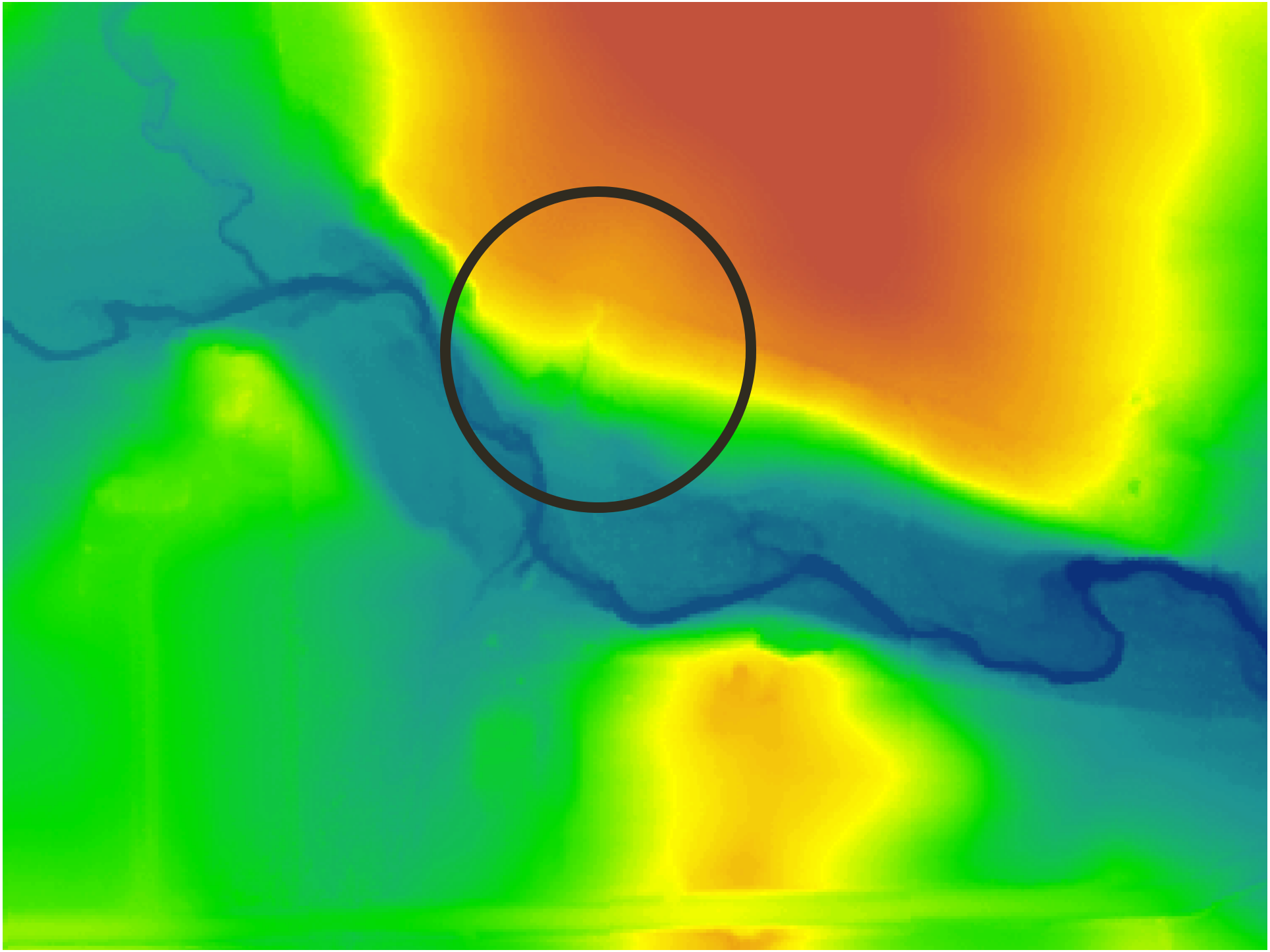
**Identifying critical agricultural areas with three-meter LiDAR elevation data for precision conservation**

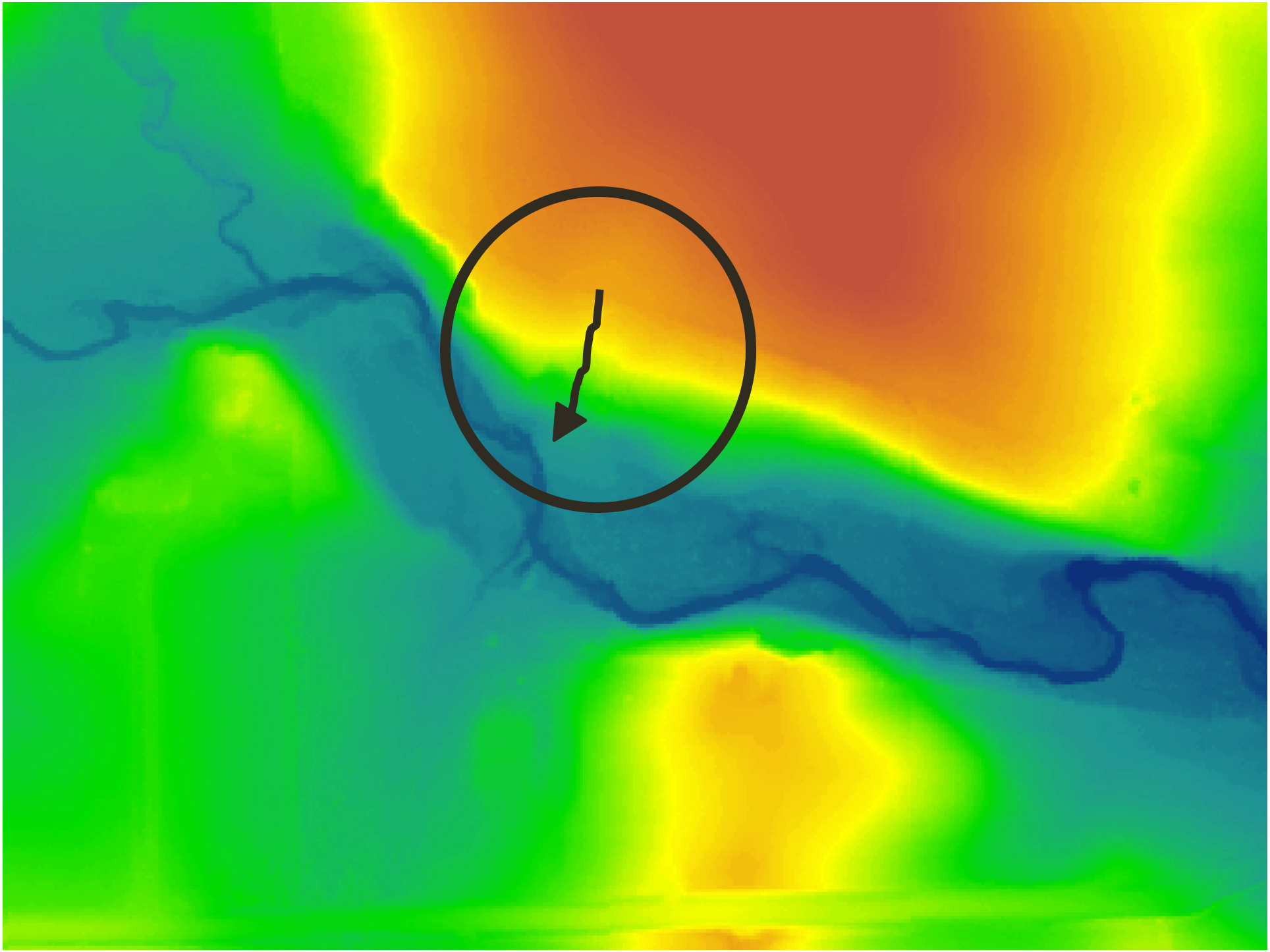
J.C. Galzki, A.S. Birr, and D.J. Mulla

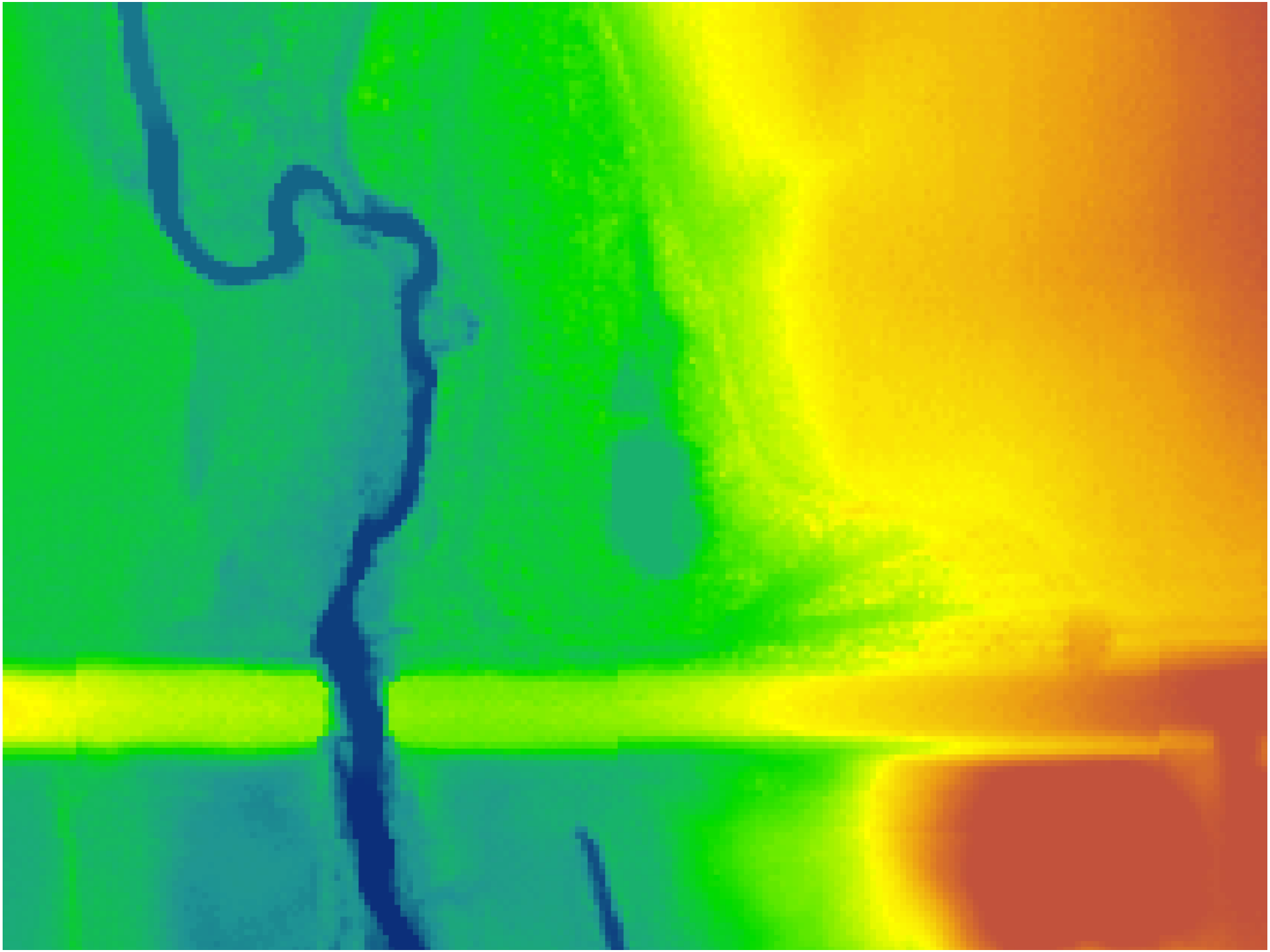
JOURNAL OF SOIL AND WATER CONSERVATION

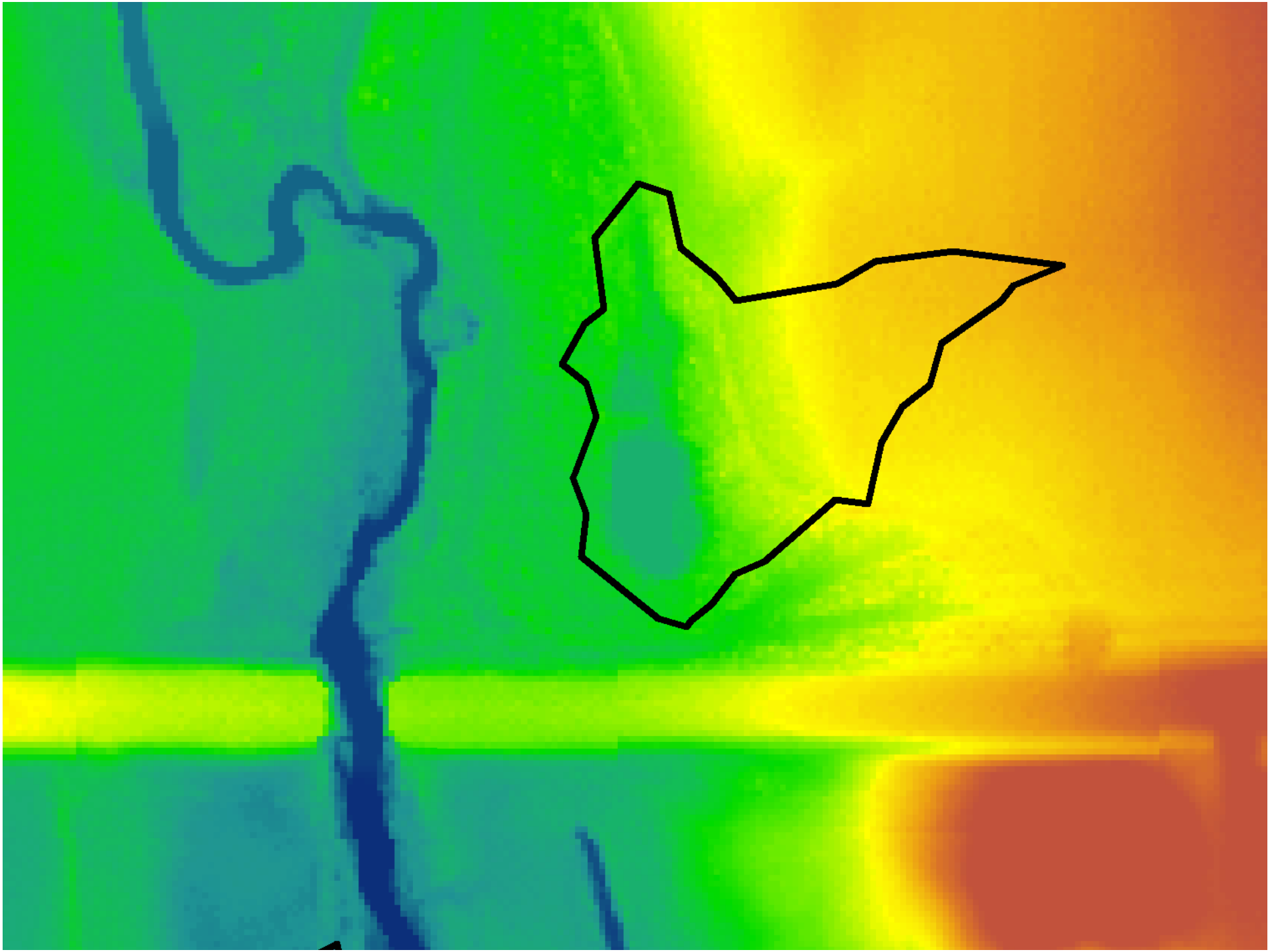

3
3
3 feet
Elevation (feet)
1025
775





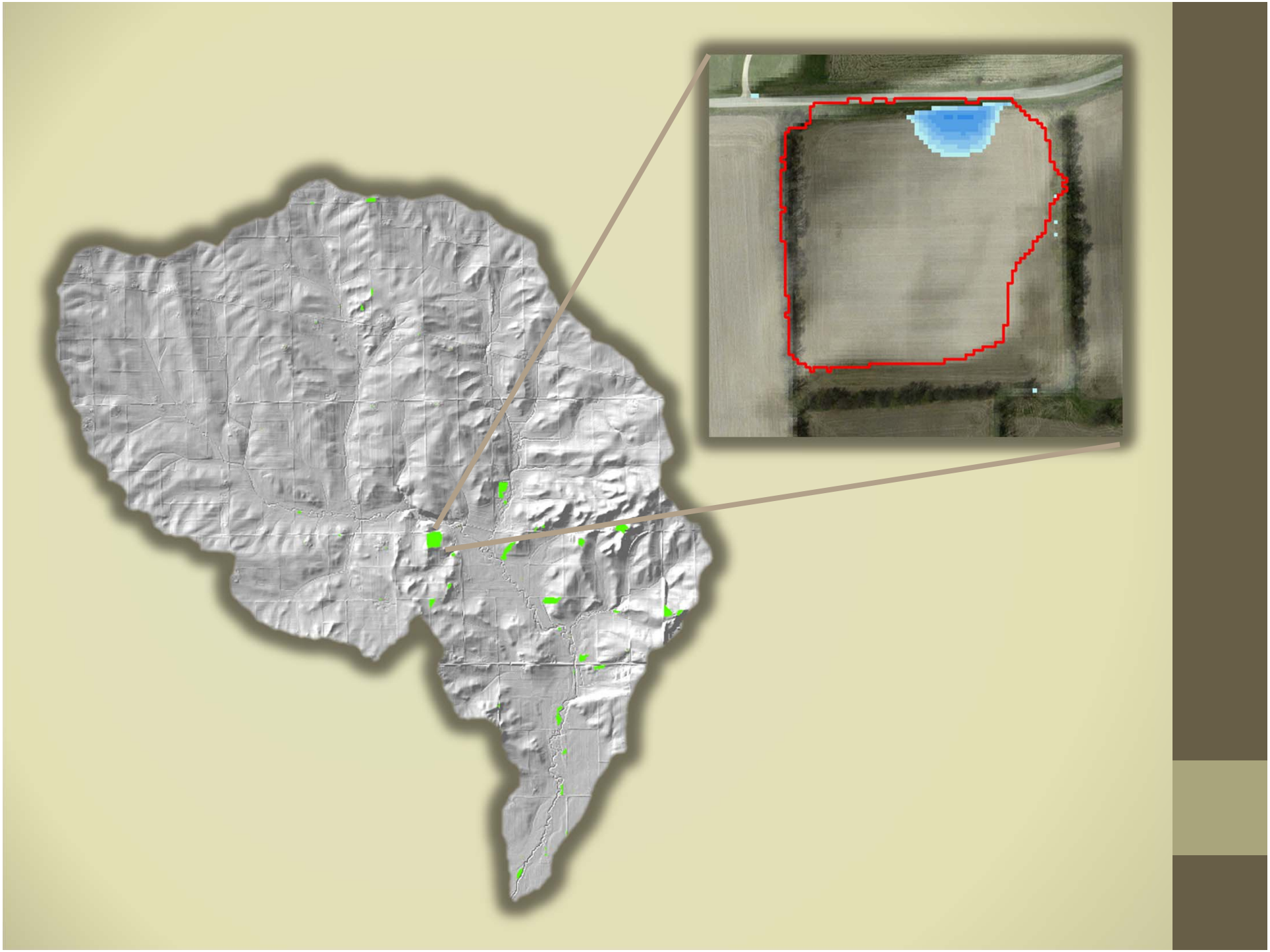


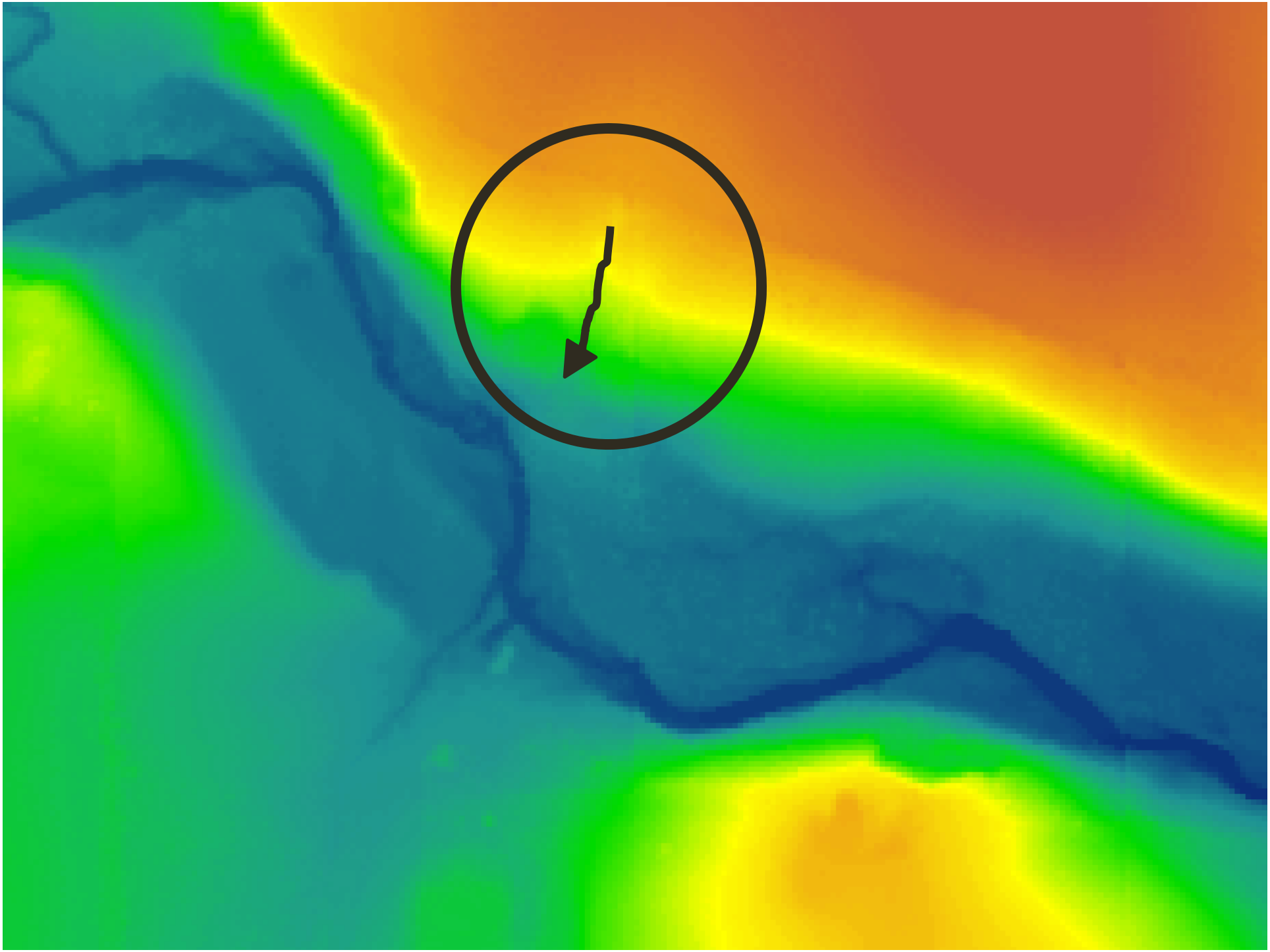


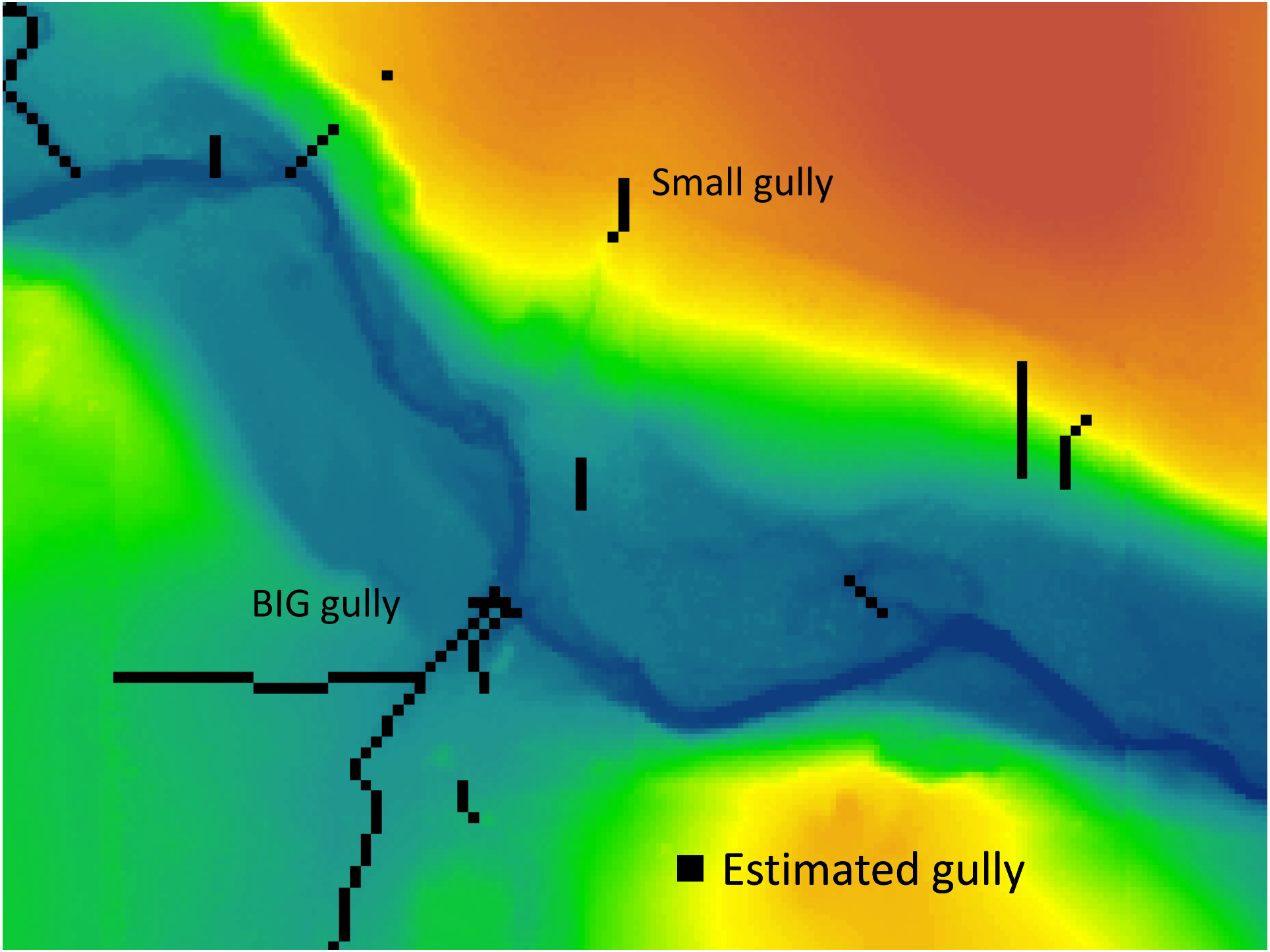


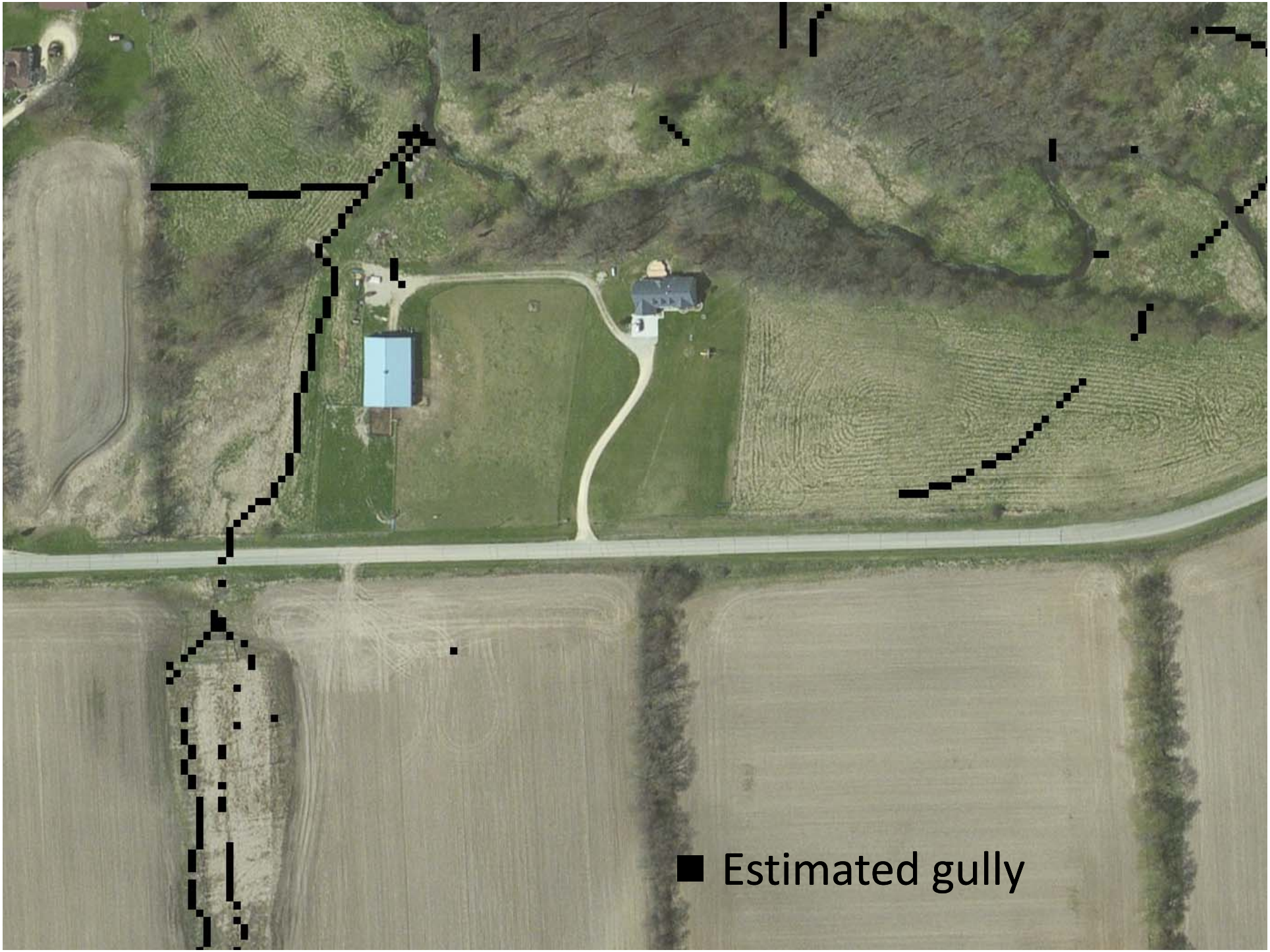
# Are there areas that typically store runoff?

Non-contributing areas

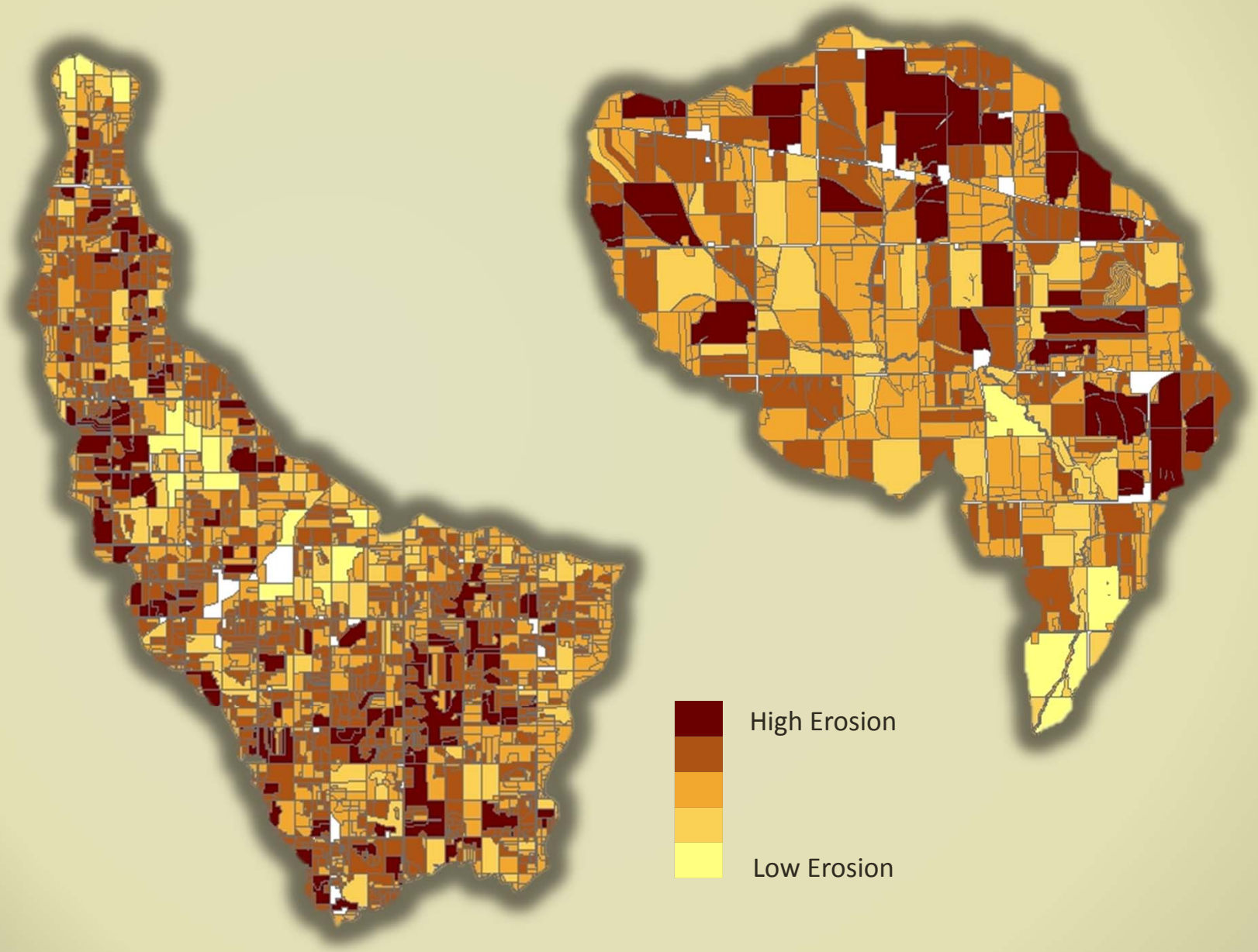




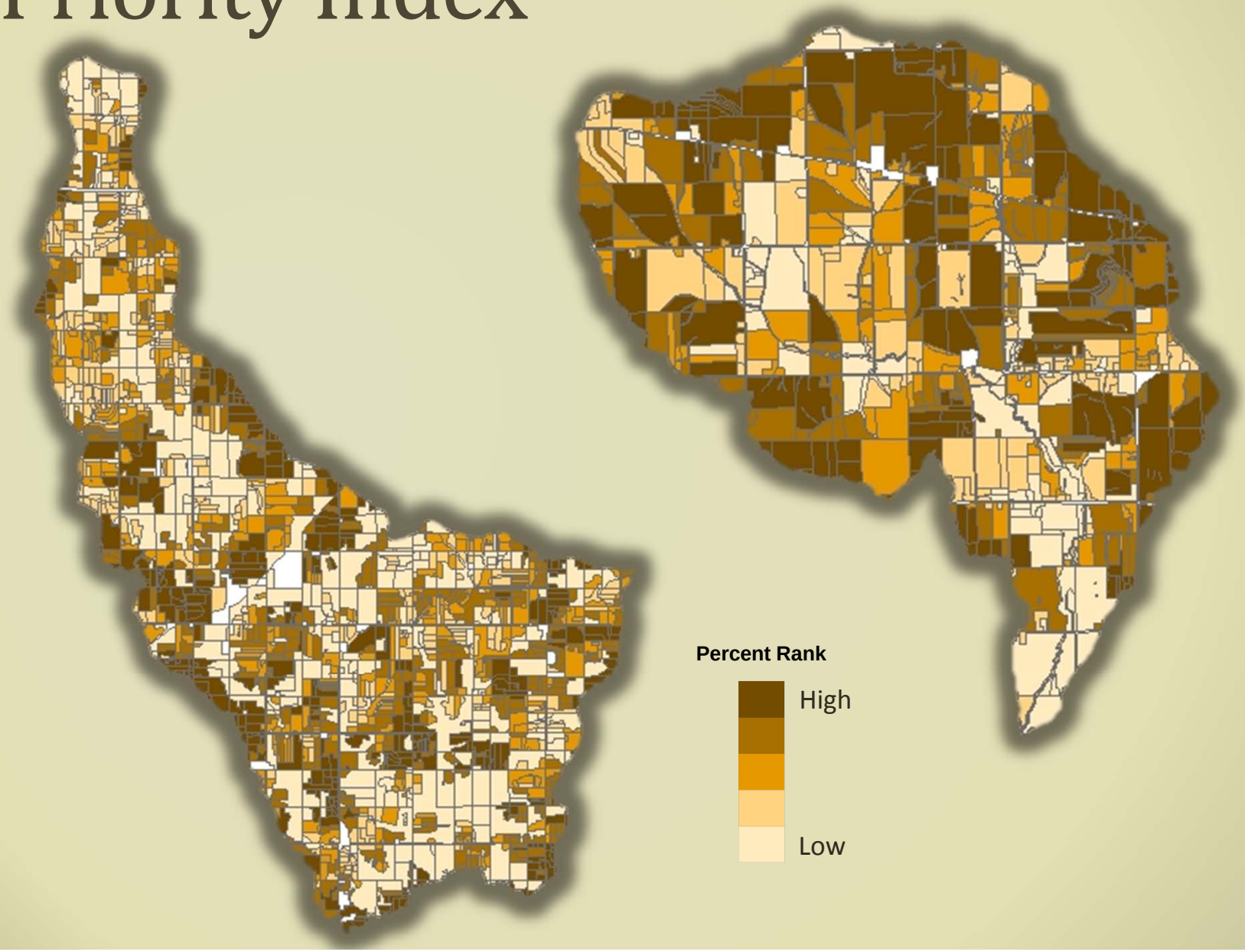

Small gully
BIG gully
Estimated gully


Estimated gully

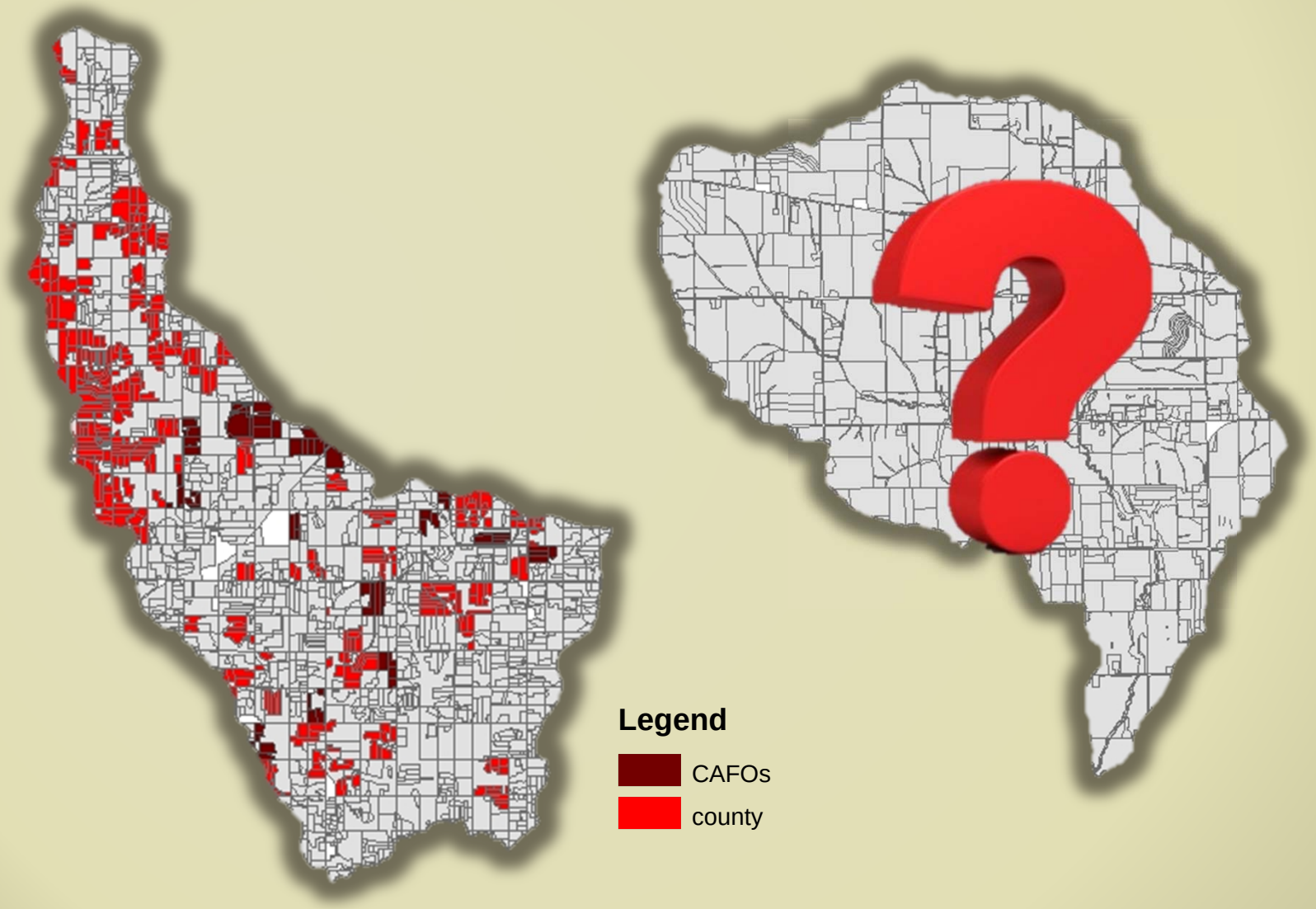
# Erosion Score



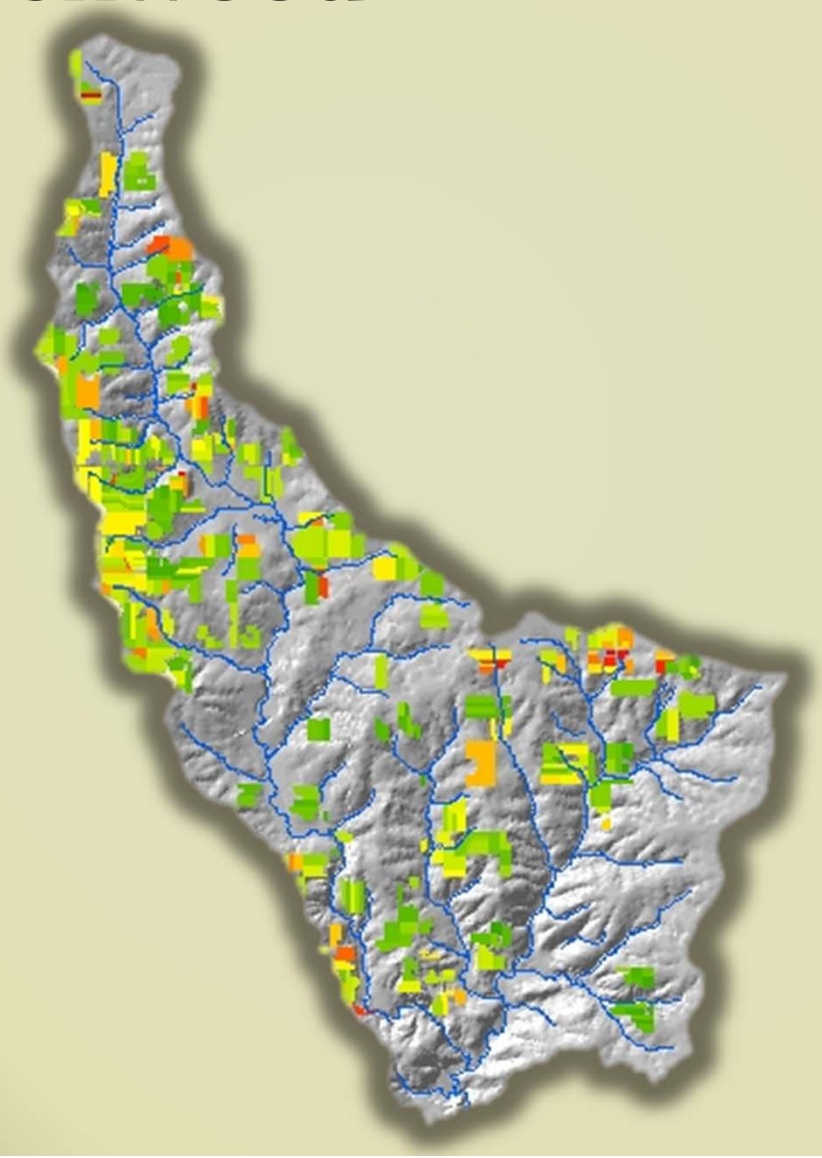
# Priority Index



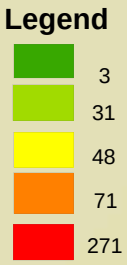
# Nutrient Management Plan Field Availability



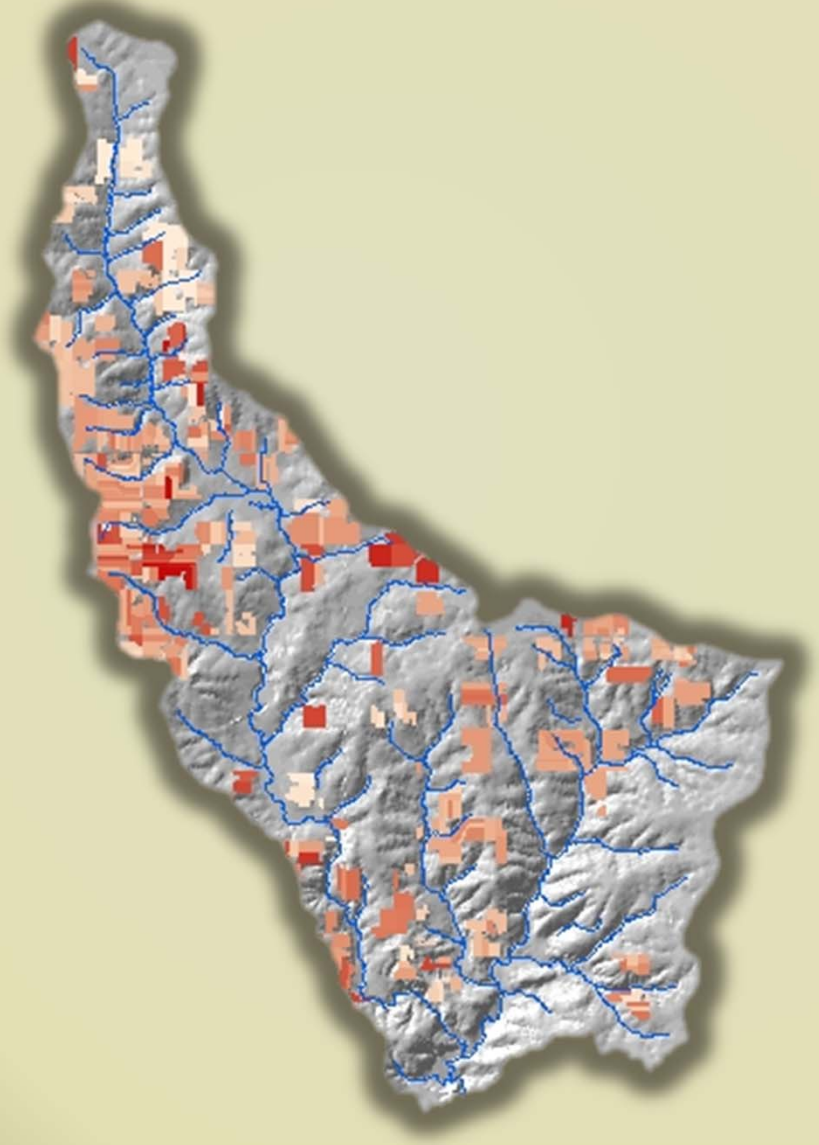
# Nutrient Management Plans for Fenwood

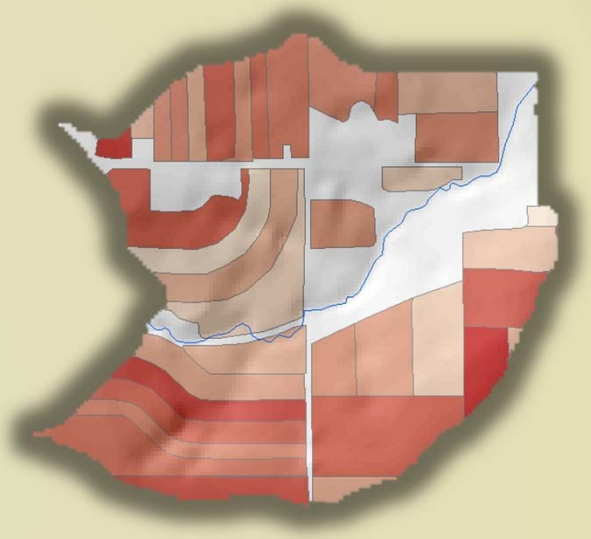


Soil Test Phosphorus (ppm)

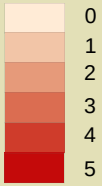


# Nutrient Management Plans for Fenwood

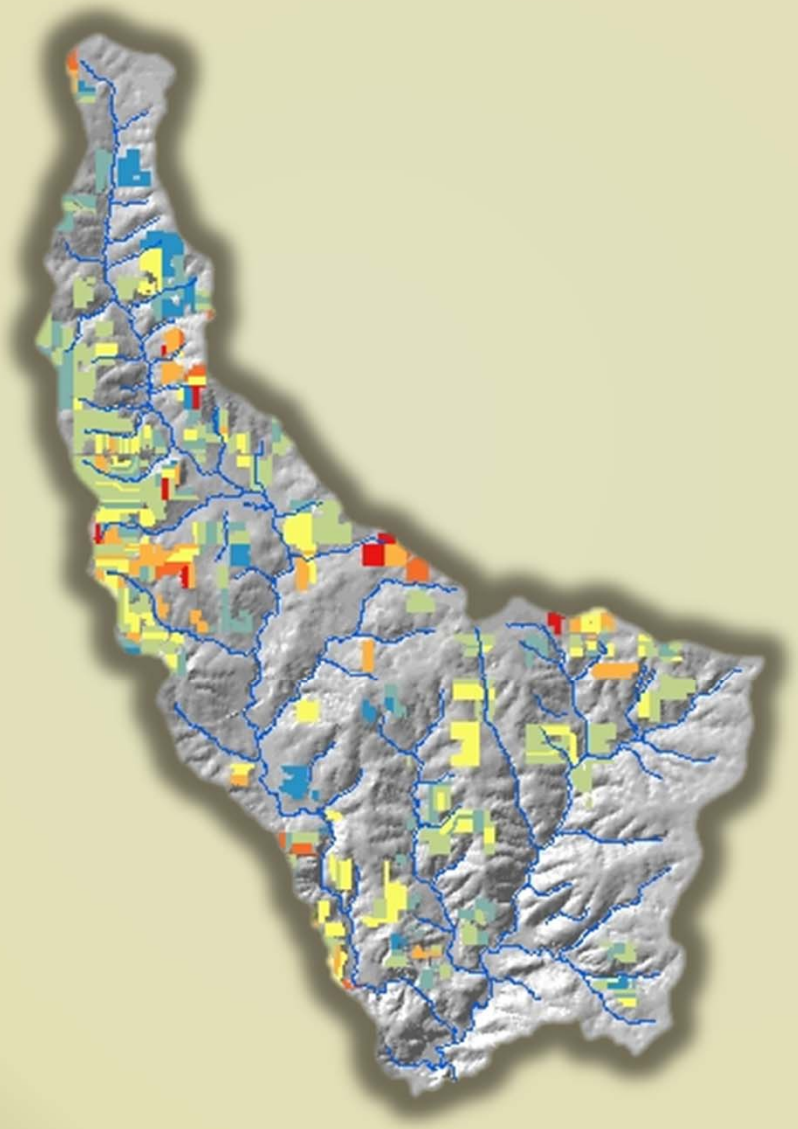


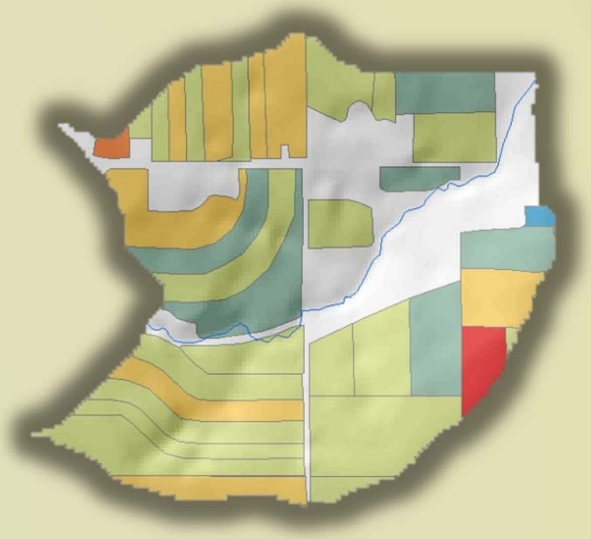


Average Soil Loss (t/acre)



# Nutrient Management Plans for Fenwood





Average Phosphorus Index
(lbs/acre/yr/rotation)

- 0
- 1
- 2
- 3
- 4
- 6

# Outline

- *Problem*
- *TMDL background*
- *Subwatershed background*
- *Water Quality Analysis*
- *Field-scale GIS analysis*
- ***Conclusions***
- *Next steps*

# Conclusions

- *Water quality → when and how*

  *GIS → where*

- *GIS offers us landscape information and provides us with targeted areas, but not management information that is required for load reduction estimation*

- *Proverbial "easy button" does not yet exist*

# Outline

- *Problem*
- *TMDL background*
- *Subwatershed background*
- *Water Quality Analysis*
- *Field-scale GIS analysis*
- *Conclusions*
- ***Next steps***

# Next steps

- *Set up field scale model to assess load reductions and water quality impacts*
- *Compare to other analyses (Pleasant Valley)*
- *Continue analysis on other high prioritized subbasins*
- *Train those interested in using tools*
- *Put analysis results online*
- *Develop data management framework*

# Acknowledgements

*I would like to thank the following:*

- **Anne Hirekatur** for the information regarding TMDLs
- My Team
  - **Adam Freihoefer** and **Theresa Nelson** for their help and support
  - **Aaron Ruesch** for all of the extra time he put aside to help develop and enhance my GIS background
- The **counties** for access to their Nutrient Management Plan Information

# Discussion

# Appendix D:3

**WCR Region Winter Runoff Study**

**Completed: 1/6/2009**
**Submitted by: Mark Hazuga – Wisconsin Department of Natural Resources**

**Background:**

Winter runoff from agricultural watersheds can deliver high concentrations of organic matter, nutrients and bacteria to surface water during snowmelt and/or winter rainfall events. The Biochemical Oxygen Demand (BOD) in runoff may not impact aquatic life in streams due to low retention time and aeration during high flows but in flowages the BOD can deplete oxygen levels under ice. Department staff in WCR believes this occurred in some flowages in the winter/spring of 2005.

Wisconsin Valley Improvement Company (WVIC) has monitored dissolved oxygen (DO) and BOD concentrations in the Big Eau Pleine Flowage weekly each winter since 1973. A BOD load is frequently documented entering the flowage from the watershed during winter runoff events which is followed by a dissolved oxygen sag (area of much lower oxygen levels) under the ice. Dairy farming is the dominant agricultural landuse type in the watershed and winter spreading of manure is a common practice. The severity of the BOD load and dissolved oxygen sag varies but in January 2005, a winter rain event delivered a large BOD load to the flowage and the oxygen sag was much worse than previous years. On April 5$^{th}$ and 6$^{th}$ 2005, DNR staff investigated a complaint of dead fish in the flowage. The investigation found ice breakup along the shoreline and dissolved oxygen concentrations were very low (<1 and 2 mg/L). Dead and dying fish represented by several species were observed in these low oxygen areas. The watershed land use in the Big Eau Pleine Watershed is dominated by agriculture.

Department Staff received a complaint in the winter of 2005 that a backwater of Lake Dubay had turbid water and dead fish were observed when fisherman drilled holes through the ice. Turbid water and low oxygen was found in the backwater but conditions improved moving out into the main flowage. The Little Eau Pleine River empties into this backwater of Lake Dubay and is located directly south of the Big Eau Pleine Watershed. Agriculture is the dominant land use type, especially in the upper two thirds of the watershed. Runoff into the Lake Dubay backwater occurred during the same time period that WVIC documented runoff into the Big Eau Pleine Flowage.

A similar situation was observed following a significant snow melt event in January to Jersey Valley Lake, an impoundment in Vernon County. This watershed is also dominated by agricultural land use and a complete fish kill of the 54 acre lake was documented by Department Staff.

**Methods**

The Big Eau Pleine Flowage and major tributaries were monitored during the winter and early spring months in 2006 and 2007 (January through March). The major tributaries

sampled include; Big Eau Pleine River at STH 153 and 97, Fenwood Creek at STH 153 and Freeman Creek at Sugar Bush Road (Figure 1). The Spirit Flowage Watershed in upper Lincoln County was selected as a reference site due to minimal agricultural land use compared to the Big Eau Pleine Watershed. The Spirit River is the major tributary to the Spirit Flowage and was sampled below Squaw Creek off STH 86 (Figure 2). The Spirit Flowage watershed consists mostly of wetland and woodland land use and agriculture comprises 11% of the watershed. In comparison, the Big Eau Pleine watershed consists of 77% agricultural land use (Purdue Extension Online Website, 2005). WVIC regulates water levels in both flowages to help maintain a uniform flow in the Wisconsin River. According to WVIC, the Spirit Flowage rarely develops winter DO sags that are frequently found in the Big Eau Pleine Flowage, even though both flowages are drawn down in a similar manner during winter (Coon, 2006).

Two different sampling periods were targetted including non event (baseflow) and active runoff events. Streamflow and river stage are continuously monitored on the Big Eau Pleine and Spirit Rivers by USGS gauging stations. These stations have an extensive historic record and were used to identify non event and events flows in the watershed. Non event sampling was completed to document parameter concentrations prior to runoff from the watersheds. Event sampling was completed when there was a substantial increase in streamflow as reported by the USGS stream flow web sites.

Water chemistry grab samples were collected during non event and event flows and shipped to the State Lab of Hygiene (SLOH) for analysis. The samples were analyzed for five day biochemical oxygen demand (BOD), ammonia, *E. coli* bacteria, and chloride. Total phosphorus was also sampled in 2007. Field measurements of dissolved oxygen, temperature, conductivity and pH were collected during each visit. BOD and ammonia are the primary constituents in animal waste that cause fish kills in surface water. High BOD concentrations can deplete oxygen levels in surface water and was the major cause of the 2005 fish kill observed in the Big Eau Pleine Flowage. Manure also contains ammonia which can be acutely toxic to aquatic life. *E. coli* bacteria are found in the intestinal tract of warm blooded animals and were sampled with BOD to provide evidence that manure was present in the water. *E. coli* bacteria can be found in undisturbed areas, but concentrations are usually much lower than those seen in areas with significant agricultural land use. Chloride is typically found in animal waste and was sampled to determine if concentrations would be helpful in detecting the presence of manure. Excessive phosphorus in surface water causes eutrophic conditions in lakes and the Big Eau Pleine Flowage experiences significant blue green algae blooms. Phosphorus sampling was added in 2007 to document the load delivered to the flowages in spring runoff.

*Non Event Sampling*

Non event water chemistry samples were collected from streams in both watersheds during stable streamflows in January or February of each year. DO and temperature profiles were conducted in each flowage starting in January or February. WVIC collects profile data weekly at each mile (total of 18 miles) of the Big Eau Pleine Flowage and

collects a BOD sample one meter below the ice. Department staff collected profile data from the Spirit Flowage periodically at five locations including Mile 1, 3, 5, 7 and 8 (Figure 2). Water samples were collected to document chemistry concentrations prior to a runoff event if anoxic conditions or unusually low oxygen levels were found in the flowages.

*Event Sampling*

The major events sampled during both years were a result of fast snowmelt conditions in March and not a result of rainfall. Event samples were collected from tributaries when substantial increases in flow were observed at the Big Eau Pleine or Spirit River USGS stations. Event sampling in the flowages consisted of identifying the location of runoff under the ice and collecting water samples one meter below the ice. Previous manure runoff sampling found that when events enter a lake the runoff generally stayed just below the ice as a result of density differences due to water temperature. The colder runoff water is similar in temperature of the water directly below the ice and is less dense than the warmer water at the bottom. The original plan was to find the runoff by profiling the lake and locate the DO sag. This was possible in 2005 because the runoff entered the Big Eau Pleine Flowage in late January so the event was under the ice long enough for the BOD to exert and consume oxygen.

During the study, the runoff events entered the flowages in mid to late March. The mid March events were found based upon turbidity of the water below the ice and in one instance the odor of manure in the Big Eau Pleine Flowage. Post event monitoring of the flowages for low DO could not be completed due to unsafe ice conditions as a result of warmer temperatures and ice breakup.

BOD and *E. coli* concentrations were graphed to show the differences between non event and event samples. Average event export rates for BOD and total phosphorus were calculated for 2007 runoff events in the Big Eau Pleine and Spirit Rivers.

In order to loads for each stream and event, watershed area flow adjustments were needed for each sampling site. Streamflow and river stage data are continuously collected on the Big Eau Pleine and Spirit Rivers by USGS stations. The Big Eau Pleine River station is located at the STH 97 crossing near Stratford. Mean daily flows from this station were used to calculate a unit area flow for each runoff event. Flows for the Big Eau Pleine River at STH 153, Fenwood Creek at STH 153 and Freeman Creek at Sugar Bush Road were determined by multiplying the drainage area above the sampling site with the unit area flow from the Big Eau Pleine River at STH 97. A flow adjustment was calculated for the Spirit River at STH 86 by calculating a unit area flow from the gage on the river at Spirit Falls (Appendix 2).

**Results**

Ammonia concentrations were substantially higher in all the event samples but the levels found were not acutely toxic to aquatic life due to near neutral pH values. Chloride

concentrations decreased in the Big Eau Pleine Watershed during event flows as a result of dilution. BOD, *E. coli* and total phosphorus concentrations are the parameters of concern and are discussed in more detail (Appendix 1).

*Nonevent Tributary Monitoring*

Nonevent water chemistry samples were collected in 2006 and 2007 from the tributaries to document parameter concentrations prior to runoff events. BOD and bacteria concentrations from tributaries were generally low or below the level of detection (Figures 3 and 4). A description of the graph labels is found in Table 1. The minimum level of detection for BOD is 2 mg/L and in most cases the reported concentration was less than 2 mg/L, however the Spirit and the Big Eau Pleine Rivers had a nonevent BOD concentrations reported as less than 3 mg/L. Low numbers of *E. coli* bacteria were detected in tributaries to the Big Eau Pleine flowage and ranged from 1 to 23 colonies per 100 ml. The Big Eau Pleine River has multiple municipal waste water treatment plants several miles upstream from the sampling site and is one likely source of *E. coli* in samples. Since *E. coli* bacteria are found in the intestinal tract of warm blooded animals, other sources of low concentrations in baseflow could be wildlife or domestic animals. Wildlife is likely the source of low bacteria concentrations in samples collected from the Spirit River since much of the watershed has protected land use. Concentrations in the Spirit River ranged from 3 to 20 colonies per 100 ml.

*Non Event Samples from Anoxic Bottom Waters*

Winter dissolved oxygen and temperature profiles were completed on each impoundment during the winter months of 2006 and 2007. WVIC completed the weekly profiles every mile on the Big Eau Pleine Flowage as part of the Big Eau Pleine annual water quality monitoring program. Anoxic conditions at six meters were sampled on January 18, 2006 at Mile 3 (BEF 3) and on February 27, 2006 at Mile 2 (BEF 2) (Figure 5). BOD concentrations were below the level of detection and bacteria counts were zero indicating the low oxygen levels were not a result of runoff or animal waste. The low oxygen levels were likely a result of sediment oxygen demand from bottom sediments in the flowage. Water samples were not collected from anoxic bottom conditions in 2007 since it was documented in 2006. No anoxia was found in the Spirit Flowage during either year of the study, therefore samples were not collected.

*Non Events Samples of Re-suspension in Big Eau Pleine Flowage*

WVIC previously documented that low oxygen concentrations in the Big Eau Pleine Flowage can occur from the re-suspension of organic material that was previously deposited from the watershed. This material is generally deposited in the upper flowage and re-suspended as water in the flowage is discharged to augment flow in the Wisconsin River. BOD concentrations can be elevated but are generally less than the concentrations brought in by significant runoff events (Coon, 2006). A water sample was collected one meter below the surface at Mile 11 (BEF 11) on March 8, 2006 when low oxygen levels (<2.5 mg/L) were measured below the ice. BOD was below the level of detection and

bacteria numbers were four colonies per 100 ml. A sample was collected at Mile 11 (BEF11) on February 20, 2007 when lower DO was found and re-suspension was the suspected source. BOD concentrations were elevated at 5.6 mg/L but bacteria numbers were zero (Appendix 1 and Figures 3 and 4). This sampling indicates that re-suspension of organic material during drawdown may be an internal source of BOD in the Big Eau Pleine Flowage but when this occurs bacteria numbers are not elevated.

*Non Event Flowage Samples Prior to Runoff*

Nonevent samples were collected from the Big Eau Pleine Flowage at Mile 7 (BEF 7) on February 27, 2006 (BEF 7) and Mile 11 (BEF 11) on March 7, 2007 to document parameter concentrations prior to anticipated runoff from the watershed. BOD concentrations were below the level of detection and *E. coli* numbers were zero. Results of non event samples collected from the Spirit Flowage at Mile 5 (SF 5) and Mile 7 (SF 7) in 2007 found BOD concentrations less than 3 mg/L and bacteria numbers were less than 7 colonies per 100 ml.

*Winter Event Monitoring*

Significant spring runoff events did not occur until March in 2006 and 2007. These events occurred as a result of rapid snow melt in the watersheds and were not related to rain events. The BOD and *E. coli* concentrations for 2006 and 2007 are found in Figures 6 and 7.

<u>2006 Events</u>

One significant event was sampled on March 13, 2006 in the Big Eau Pleine Watershed. The samples were collected from the tributaries a day after peak flow occurred on the Big Eau Pleine River. Mean flow on the sampling date was 551 cfs compared to 752 cfs the previous day. Parameter concentrations are commonly higher during the rising limb of the hydrograph. BOD and *E. coli* concentrations in all tributaries were higher than non event samples. The BOD and *E. coli* concentrations were highest in the Big Eau Pleine River and were 10 mg/L and 1200 colonies per 100 ml, respectively.

The event was documented in the Big Eau Pleine Flowage on the same day. BOD concentrations at Mile 11 (BEF 11) and Mile 5 (BEF 5) were 11.9 and 9.4 mg/l, respectively. *E. coli* numbers were 770 colonies per 100 ml at both sites. These concentrations are much higher than those documented a week earlier during non event sampling. Follow up monitoring of the flowage could not be completed due to unsafe ice conditions.

A significant runoff event occurred March 31, 2006 as a result of warm weather and rainfall. Prior arrangements were made with the lab to receive the samples on Saturday. Event samples were collected on Friday from the Big Eau Pleine and Spirit River Watersheds and shipped to SLOH but samples did not arrive at the lab until the following Monday. As a result these samples were not used for this report.

2007 Events

Two events were sampled in the Big Eau Pleine River and Spirit River Watersheds in 2007.

Event sampling in the Big Eau Pleine Watershed occurred on March 13th -14th and again on March 22nd. The Big Eau Pleine River at STH 153, Freeman Creek and Fenwood Creek were sampled on the 13th as the event started and the Big Eau Pleine was sampled on the 14th at STH 97. This sample was collected because streamflow continued rising from the previous day. BOD and *E. coli* concentrations in the tributaries were higher than non event samples. BOD concentrations from both events ranged from 11.5 to > 21 mg/L and *E. coli* numbers ranged from 300 to 2400 colonies per 100 ml in the tributaries.

The March 13th and 14th event was documented in the Big Eau Pleine Flowage at Mile 7 (BEF 7) on March 15th. The BOD and *E. coli* concentrations were 18.1 mg/L and 1200 colonies per 100 ml, respectively. The water was very turbid (turbidity tube measurement 12 cm) and had an odor of manure. A second site at Mile 2 (BEF2) was sampled on March 15th to determine if event runoff reached the lower flowage. The BOD and *E. coli* concentrations were 6 mg/L and 0 colonies per 100 ml, respectively. The elevated BOD concentration at BEF2 was not due to runoff but likely the result of re-suspension that was documented weeks earlier in the upper flowage. The water was clear and bacteria counts were zero indicating the most recent event had not reached the lower flowage. The March 22nd event could not be documented in the flowage due to unsafe ice conditions.

Event sampling in the Spirit River Watershed occurred on March 14th and March 26th. BOD concentrations in the Spirit River from both events were 10.5 and 4.6 mg/L and *E. coli* concentrations were 192 and 108 colonies per 100 ml. BOD and *E. coli* concentrations were higher than non event samples.

The March 14th event was documented in the Spirit River Flowage at Mile 5 (SF 5) on March 15th. The BOD and *E. coli* concentrations were 10.6 mg/L and 365 colonies per 100 ml, respectively.

**Discussion**

Tributary event monitoring in both watersheds found much higher concentrations of BOD and bacteria than found in non event samples. Event BOD and *E. coli* concentrations from the flowages were similar to results from their respective tributaries demonstrating delivery from the watersheds.

Pollutant concentrations in runoff events were higher in the Big Eau Pleine River compared to levels found in the Spirit River. To appreciate the difference in concentration between the Big Eau Pleine and Spirit Rivers, average BOD export rates were calculated for the 2007 events. Average event export rates for total phosphorus in each river were also calculated since phosphorus is a pollutant of concern to Wisconsin

surface waters. The estimated average BOD and total phosphorus event export rates are expressed as pounds/day/square mile. (Figures 8 and 9). Export rates for Fenwood and Freeman Creeks were not estimated due to the lack of streamflow data.

Average event BOD export rates from the Big Eau Pleine and Spirit Rivers were 648 and 152 pounds/day/square mile, respectively. The BOD export rate from the Big Eau Pleine River was over 4 times more than the Spirit River. Average event total phosphorus export rates from the Big Eau Pleine and Spirit Rivers were 31 and 4 pounds/day/square mile, respectively. The phosphorus export rate from the Big Eau Pleine River was nearly 8 times greater than the Spirit River. These estimates do not represent the total load from the spring runoff period. Overall loading from both watersheds would likely be greater if sampling captured the complete spring runoff period.

An export rate was not calculated for *E. coli* bacteria but concentrations found in the Big Eau Pleine and Spirit Rivers were graphed with USGS discharge (Figure 10). Average *E. coli* numbers in the Big Eau Pleine River were 7 times than in the Spirit River likely as a result of domestic animal waste runoff from the Big Eau Pleine Watershed. As indicated earlier, dairy farming is the dominant agricultural landuse type in the watershed and the winter spreading of manure is a common practice.

The average BOD load during three days of runoff in the Big Eau Pleine River, adjusted for natural background using data from the Spirit River (73,713), was compared to the City of Wausau's average influent (raw sewage) BOD load (5,220) for the same three day period (Appendix 3 and Figure 11). The calculated average BOD event load in the Big Eau Pleine River was 14 times greater than the influent (raw sewage) BOD load to the Wausau WWTP during same three day period.

The total BOD load for the three day event described above was estimated at 221,138 pounds. There are six municipal waste water treatment facilities in the Big Eau Pleine Watershed. The combined influent BOD loading of all the treatment plants for January through April 2007 was 231,534 pounds or just 5% higher than the three day load delivered by the Big Eau Pleine River in 2007 (Oldenburg, 2008).

According to literature, a 1,500 pound dairy cow produces 2.4 pounds of BOD each day or 144 pounds of BOD in 60 days. If 60 days of stored manure from 8,000 cows were winter spread in the watershed and only 20% was lost to runoff that would be equivalent to the estimated three day load in the Big Eau Pleine River (221,138 pounds). Based on the ratio of dairy cows to farm land acres in Marathon County, the number of dairy cows in the Big Eau Pleine Watershed could be as high as 17,000 (Appendix 4) (ASAE, 1998, USDA, 2007, Purdue Extension, 2008 and UW Extension – Marathon County, 2004).

**Conclusions**

The Big Eau Pleine Flowage is a large impoundment in a watershed where agriculture, primarily dairy farming, is the dominate land use type. A partial fish kill occurred in the spring of 2005 as a result of low dissolved oxygen concentrations in much of the flowage.

The cause of the low oxygen was high concentrations of BOD in runoff that entered the flowage during rainfall and snowmelt events the winter and spring of 2005. A significant source of BOD was likely animal waste from the watershed. The primary goal of this study was to capture runoff events to the Big Eau Pleine Flowage and document that animal waste is a significant source of BOD in the watershed. The Spirit Flowage was used as a reference to document the BOD export rate from a minimally disturbed watershed.
Results of this study clearly show the BOD and total phosphorus export rates from an agricultural watershed during snowmelt are substantially higher than from a minimally disturbed watershed. *E. coli* bacteria numbers were much higher in runoff from the agricultural watershed suggesting animal waste was a major source of organic material in the Big Eau Pleine runoff.

Dairy farming is the dominant agricultural landuse type in the Big Eau Pleine watershed and winter spreading of manure is a common practice. The winter runoff of domestic animal waste is a significant contributor of BOD, total phosphorus and bacteria to the Big Eau Pleine Flowage.

BOD and total phosphorus loads to the Big Eau Pleine Flowage from 2007 events in the Big Eau Pleine Watershed are likely higher than presented in this study. Loads from Freeman and Fenwood Creeks were not included due to the lack of streamflow data at the time of sample collection. However, loads from these streams were likely substantial given parameter concentrations and high discharge. The estimated event loads for the Big Eau Pleine River are based on one or two samples collected during an event. The estimated loads would likely be greater if samples were collected allowing quantification for the entire duration of each event.

High BOD delivered to surface water from the Big Eau Pleine Watershed did not lower dissolved oxygen levels in streams due to high stream velocities and aeration caused by the high runoff volume. Also, cold water temperatures reduce bacteria activity which slows the rate of oxygen demand. Oxygen depletion could not be documented in the flowage during this study due to timing of the events. Shortly after the mid March events entered the flowage, ice conditions became unsafe for monitoring.

The timing of winter runoff events seems to determine the level of impact on oxygen levels and fish in the flowage. If high BOD enters the flowage in later winter or early spring it has less time to exert a significant oxygen demand below the ice. Ice out in the Big Eau Pleine Flowage typically occurs by early April then re-aeration offsets the oxygen demand. However, if a significant BOD load enters the flowage in earlier winter, the BOD has weeks below the ice to exert an oxygen demand. This is what occurred in 2005. In 1981 a large aeration unit was installed in the narrows at Mile 6 to aerate low DO water as it passes downstream. The BOD load delivered to the flowage in 2005 was too significant to be dissipated completely by the aeration units and passed below the aerated area where BOD continued consuming oxygen below the ice. Thus lowing dissolved oxygen and contributing to the fish kill.

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Figure 1. Monitoring Sites in the Big Eau Pleine Watershed

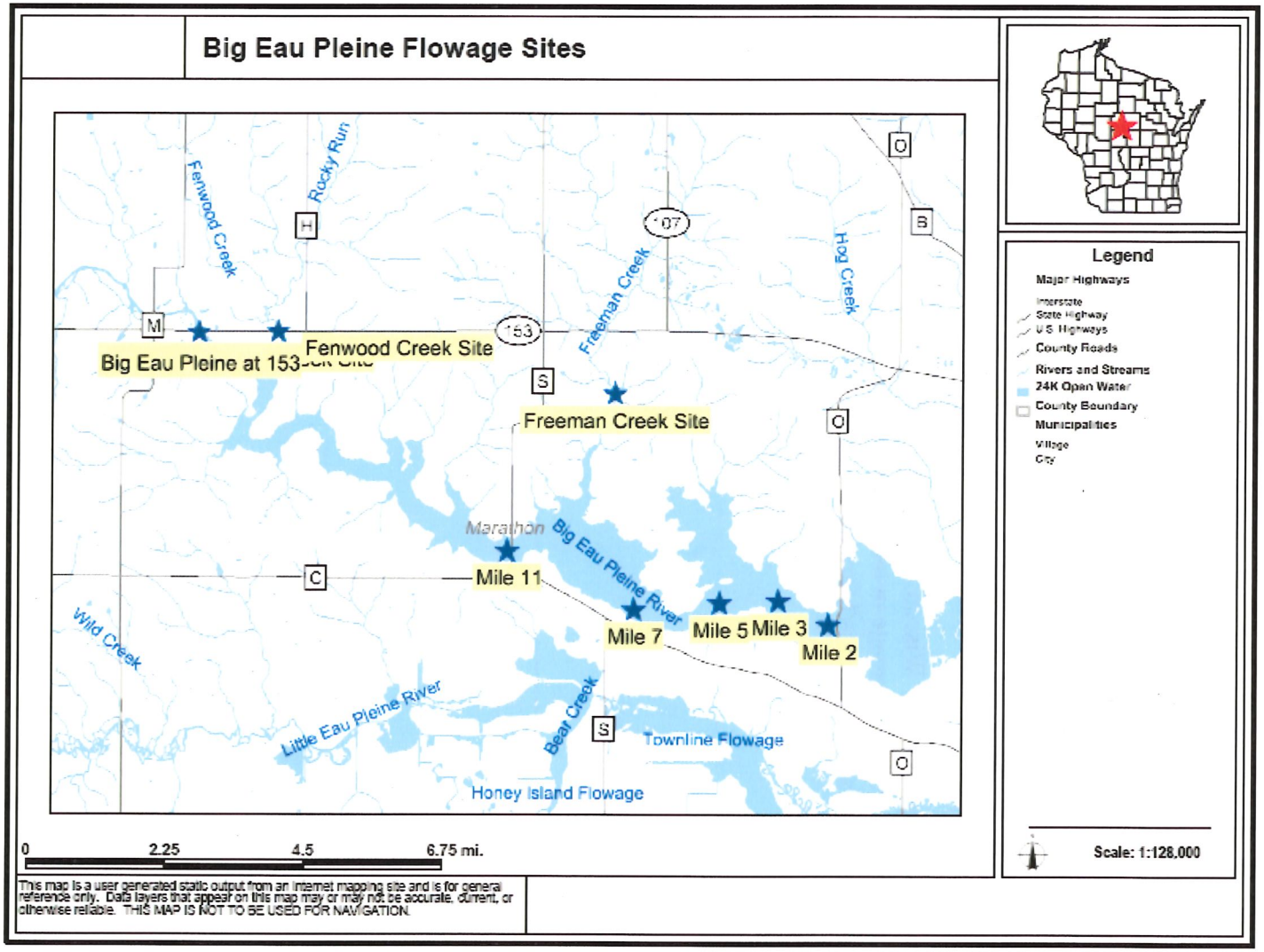


Figure 2. Monitoring Sites in the Spirit River Watershed

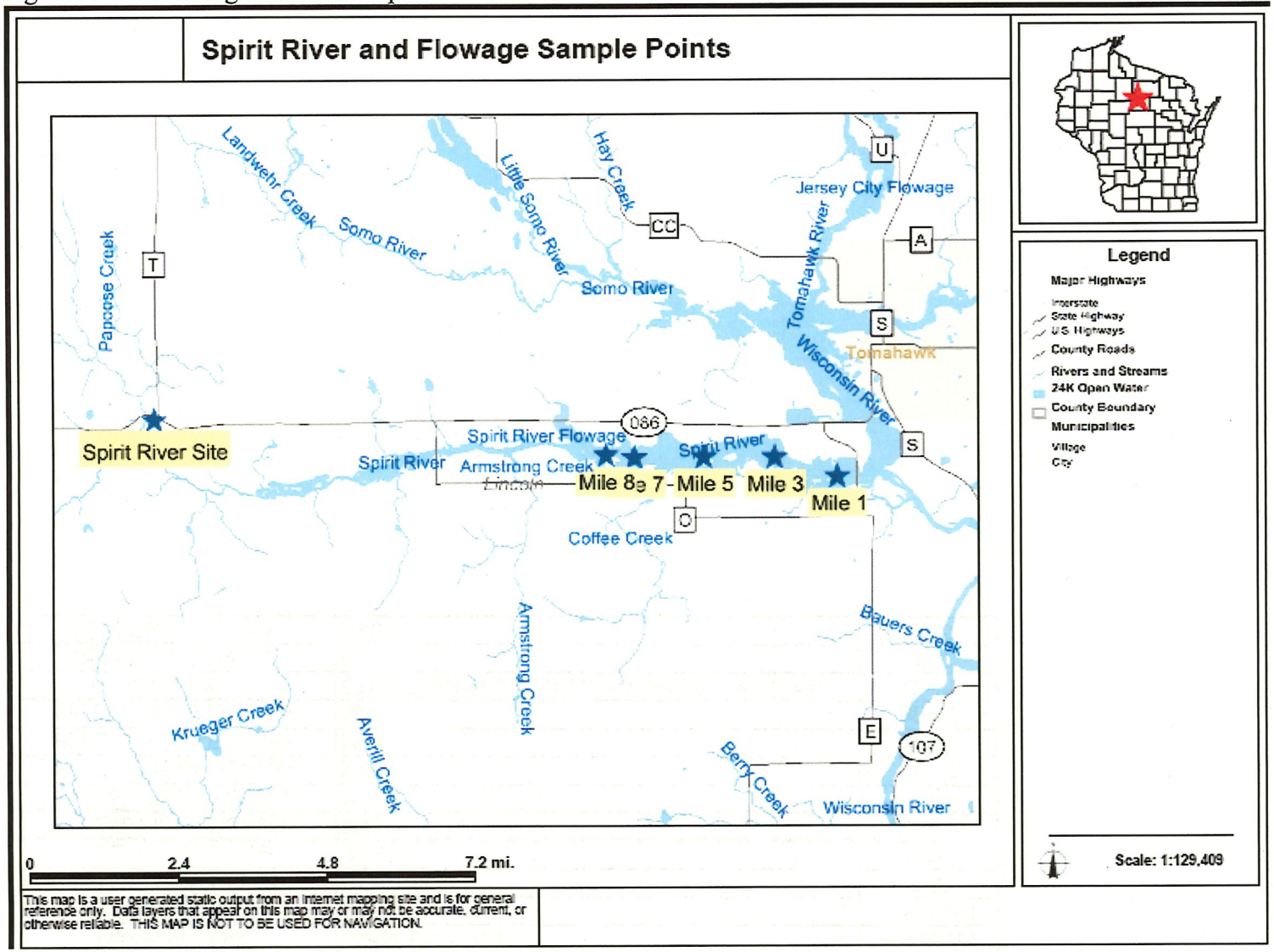


Table 1. Description of Labels used in Figures 4 through 7.

| | | |
|---|---|---|
| **Waterbody** | **Location** | **Label** |
| Freeman Creek | Sugar Bush Road | Freeman |
| Fenwood Creek | STH 153 | Fenwood |
| Big Eau Pleine River | STH 153 | BEP |
| Big Eau Pleine River | STH 97 | BEP |
| Big Eau Pleine Flowage | Mile 11 | BEF 11 |
| Big Eau Pleine Flowage | Mile 7 | BEF 7 |
| Big Eau Pleine Flowage | Mile 3 | BEF 3 |
| Big Eau Pleine Flowage | Mile 2 | BEF 2 |
| Big Eau Pleine Flowage | Mile 5 | BEF 5 |
| Spirit River | STH 86- below the confluence with Squaw Creek | Spirit |
| Spirit River Flowage | Mile 7 | SF 7 |
| Spirit River Flowage | Mile 5 | SF 5 |

**Figure 3. Non Event BOD Concentrations in Tributaries and Flowages**

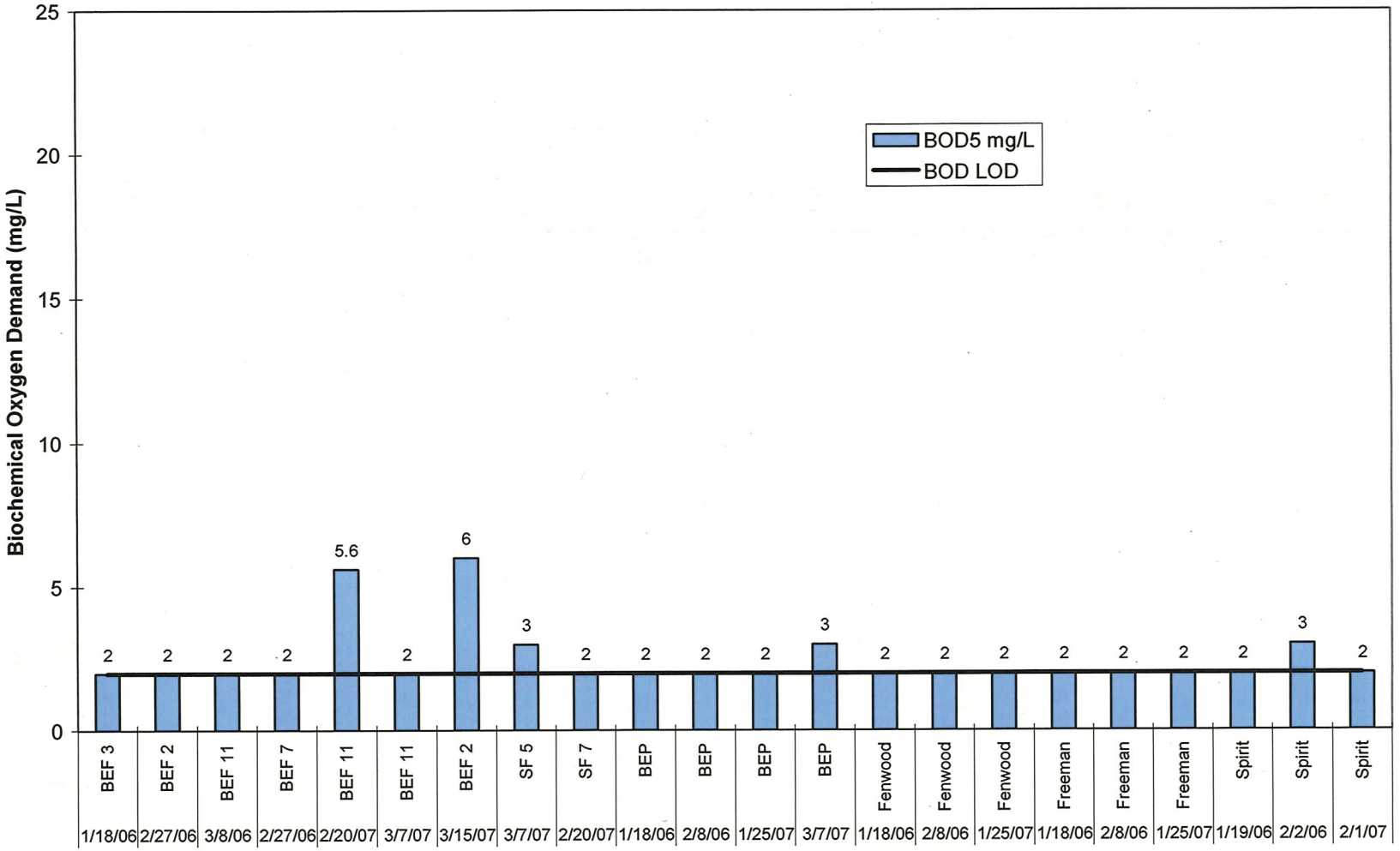


**Figure 4. Non Event E. coli Concentrations for Tributaries and Flowages**

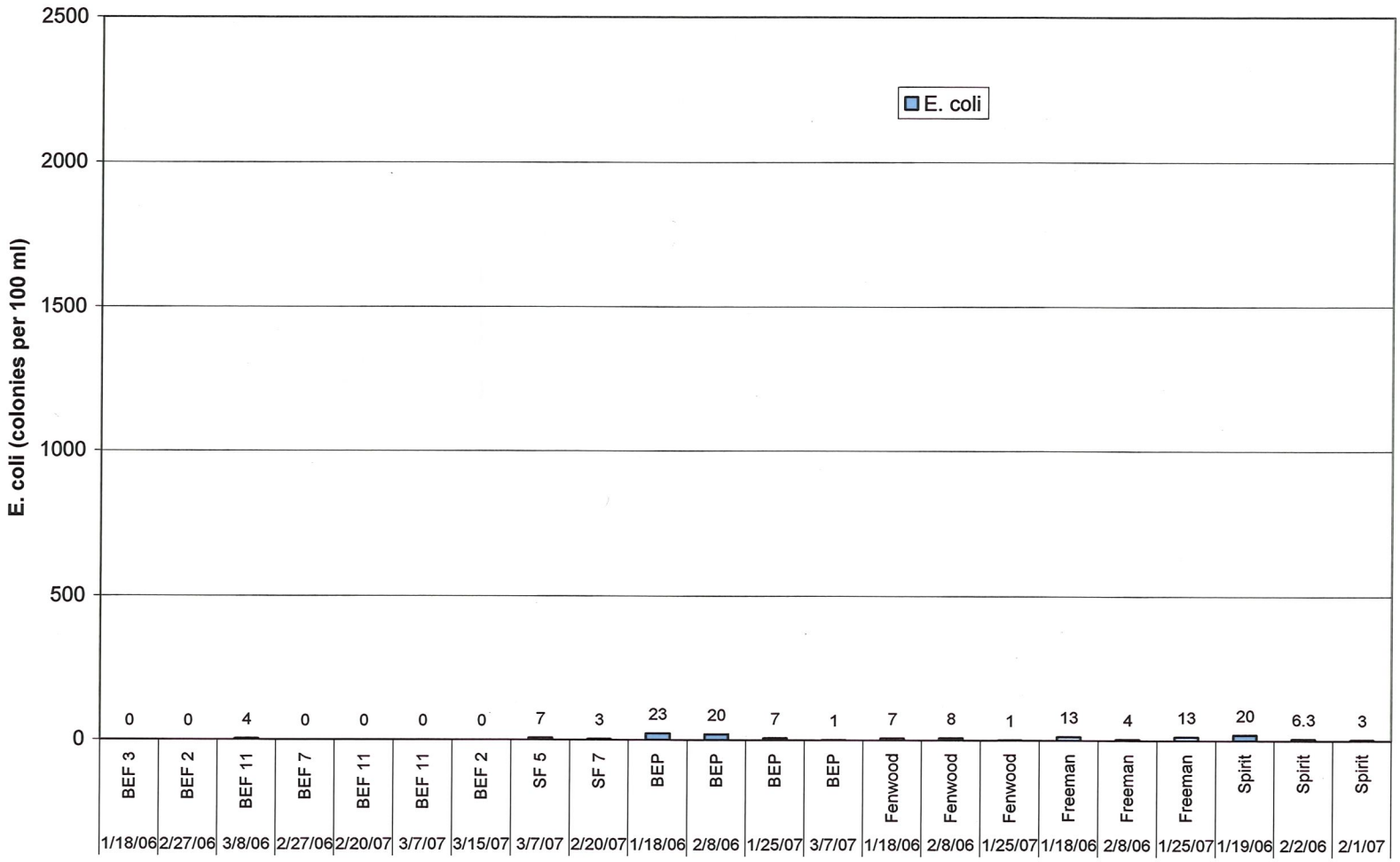


**Figure 5. Big Eau Pleine Flowage 2006 DO Profile**

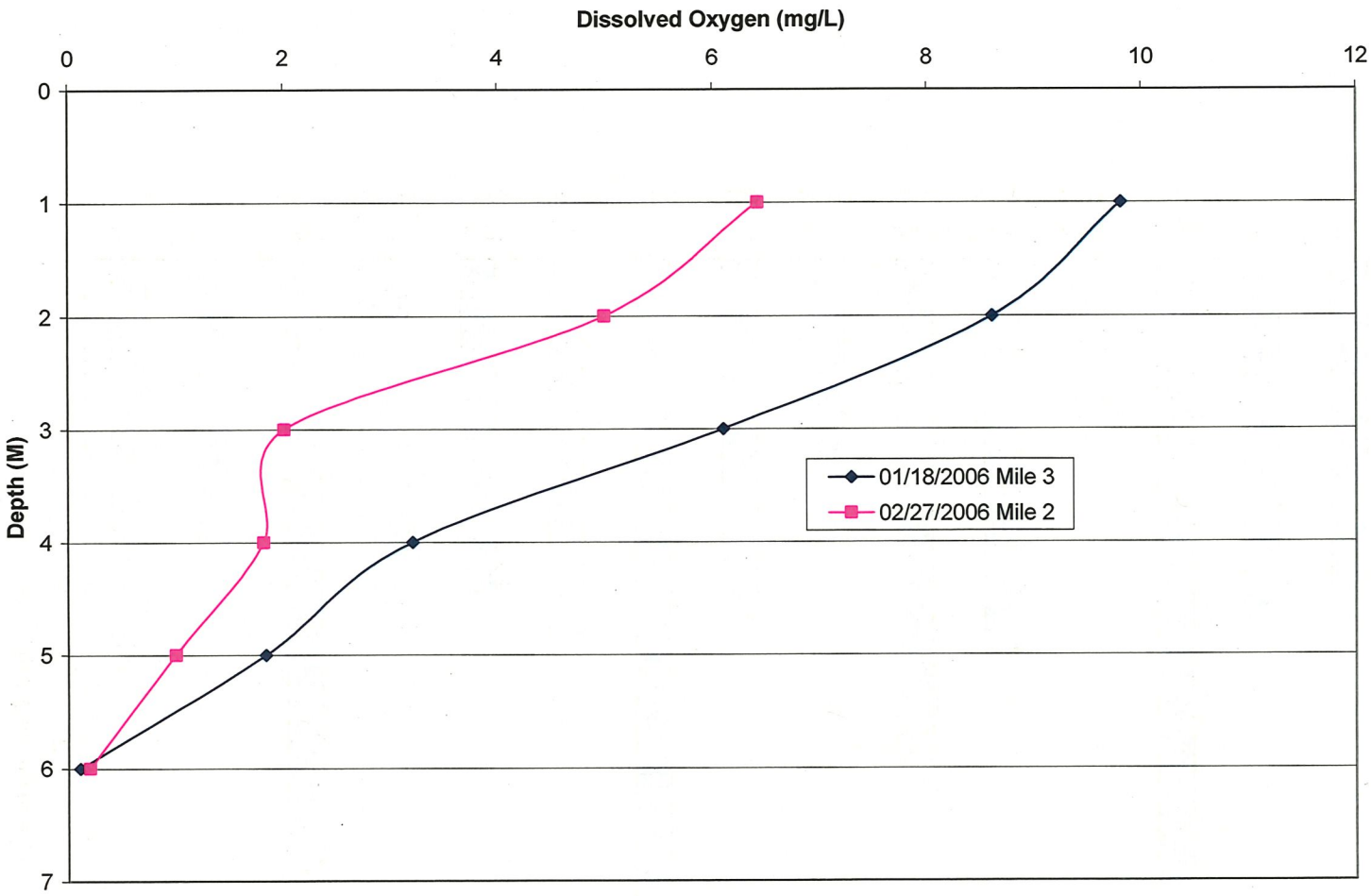


**Figure 6. Event BOD Concentrations in Tribuaries and Flowages**

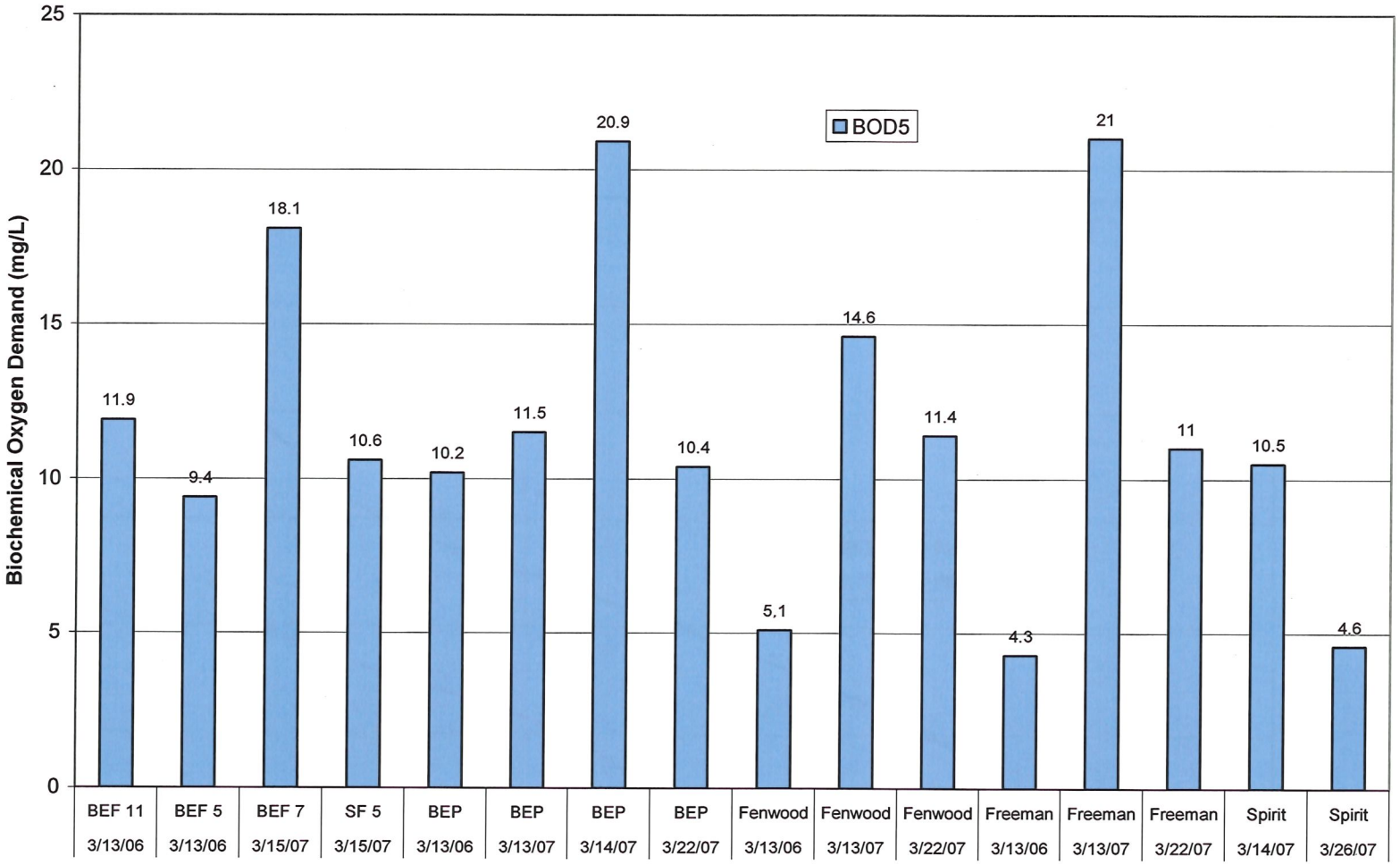


**Figure 7. Event E. Coli Concentrations for Tributaries and Flowages**

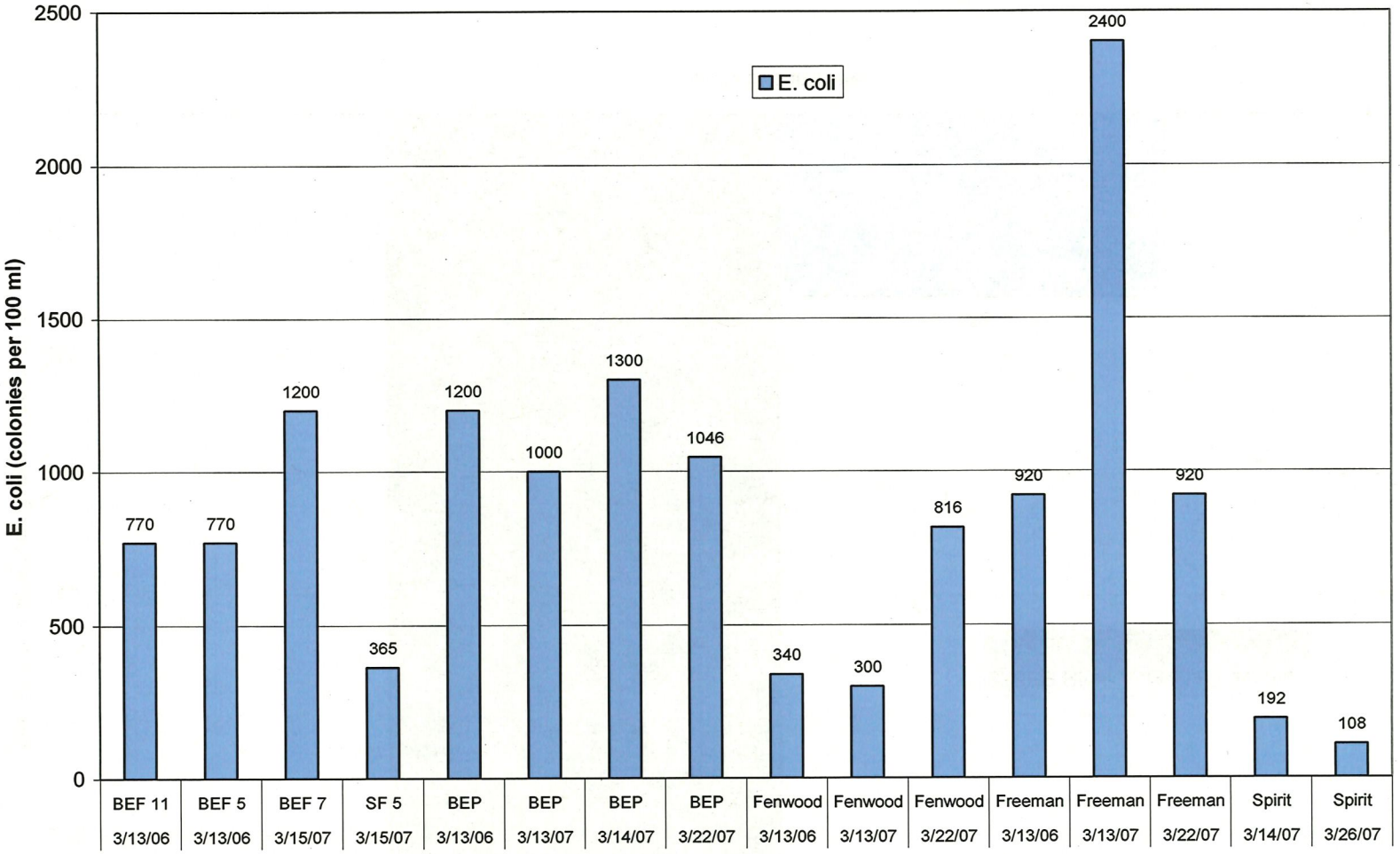


**Figure 8. Average Event BOD Export Rates for the Big Eau Pleine and Spirit Rivers March 2007**

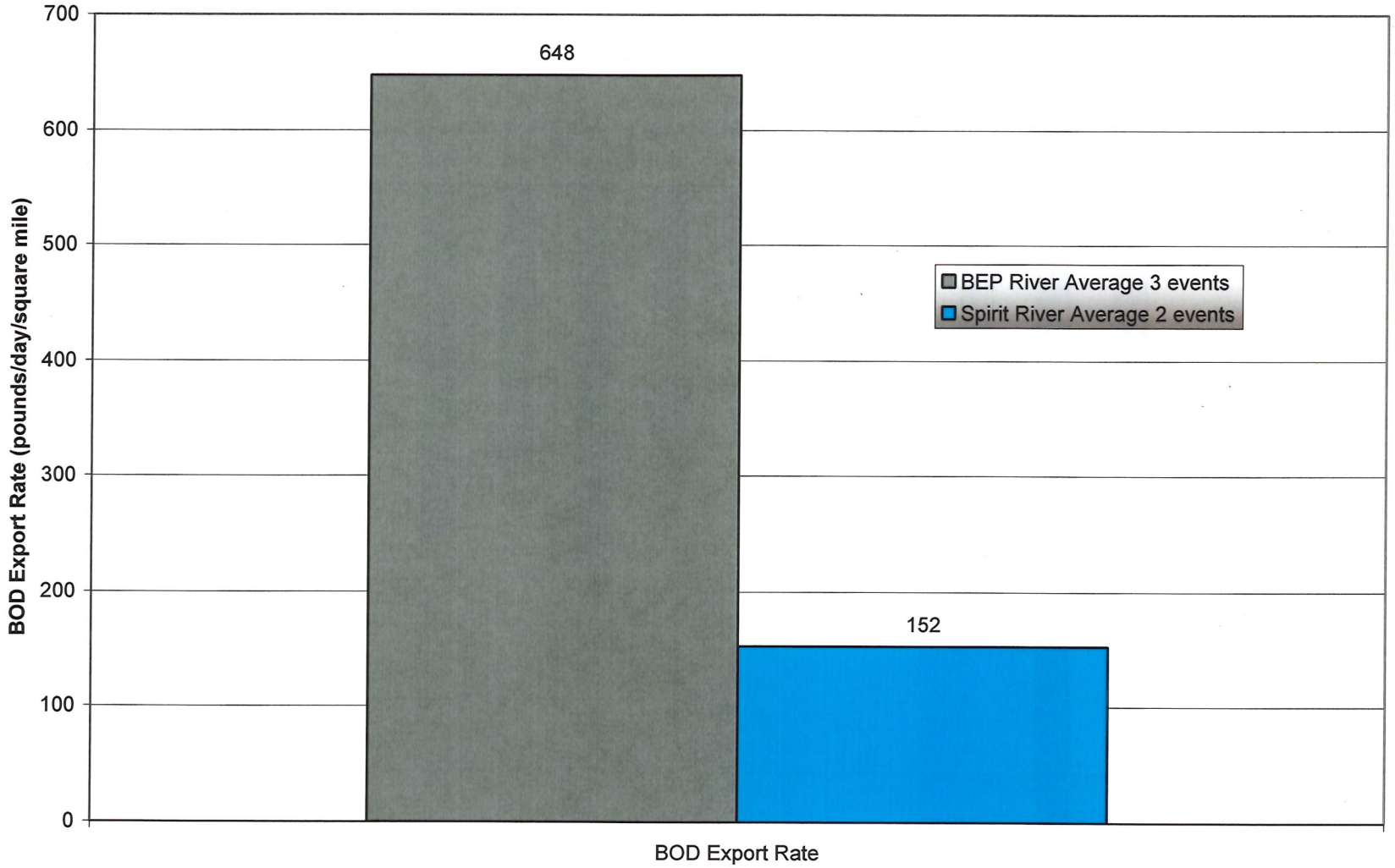


**Figure 9. Average Event Total Phosphorus Rates for the Big Eau Pleine and Spirit Rivers**
**March 2007**

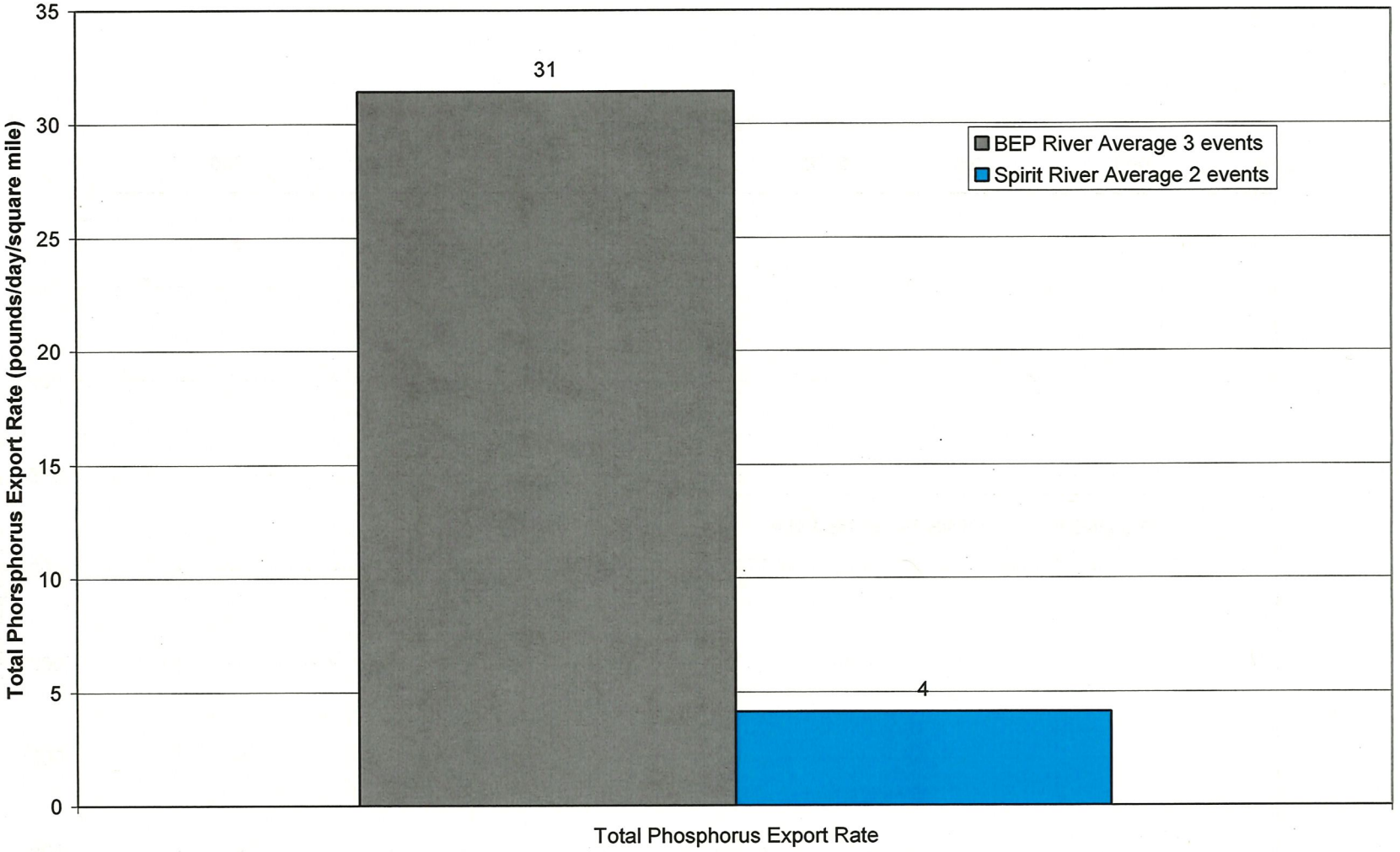


**Figure 10. Big Eau Pleine and Spirit River E. coli concentrations during Event and Non-Event Flow**

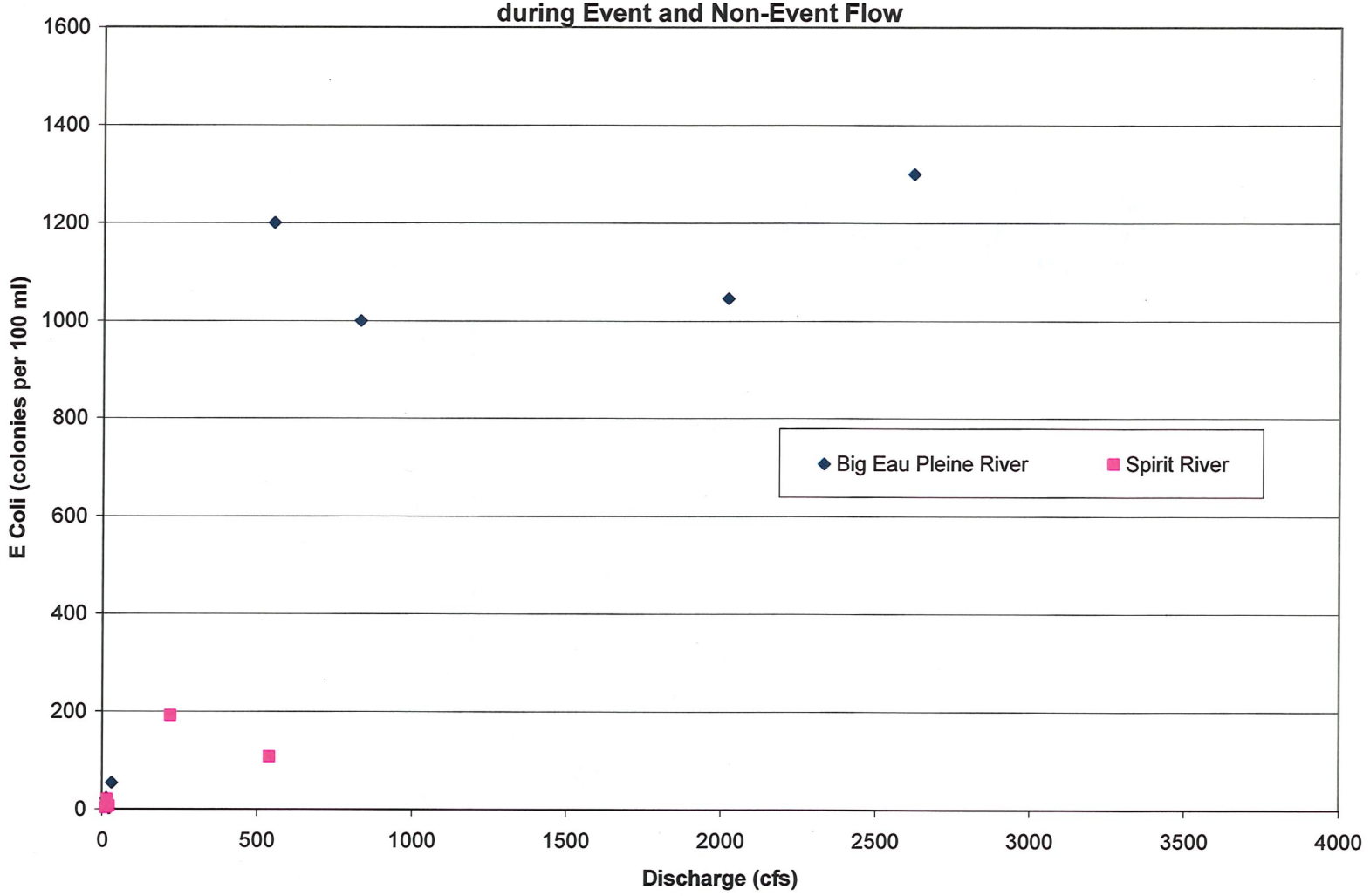
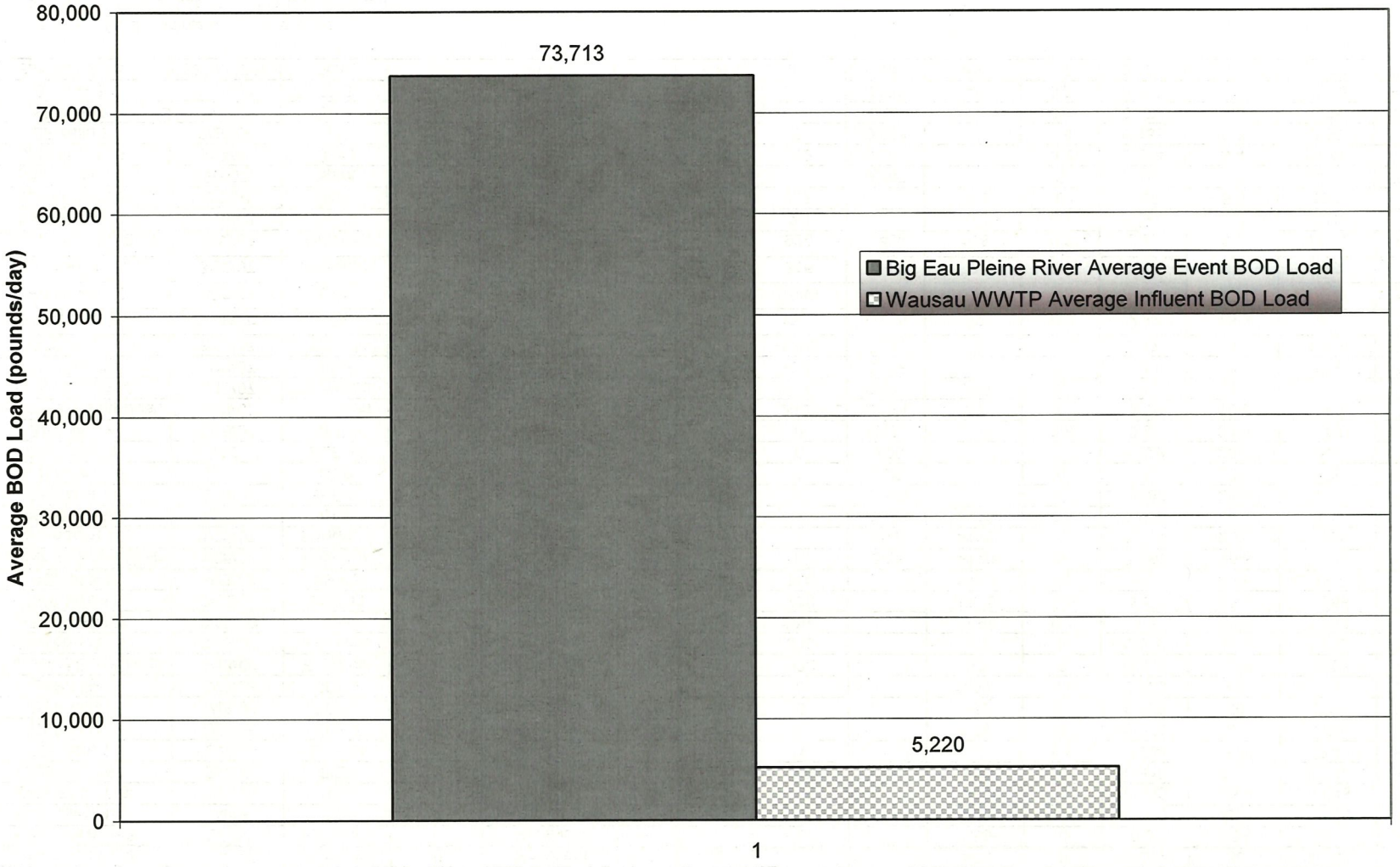


**Figure 11. Average 3 day BOD Load in Big Eau Pleine River and Wausau WWTP Influent**



Appendix 1. Summary of Non Event and Event Water Chemistry Results for Winter Runoff Study

| | | | Depth | Type of | BOD | BOD5 | E. coli | Total P | Turbidity | Temp. | Ammonia | Chloride | D.O. Field | pH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location | Date | label | Meters | Sample | level | mg/L | col./100 ml | mg/L | Tube (cm) | field C | mg/l | mg/L | mg/L | field |
| Freeman at Sugar Bush | 1/18/06 | Freeman | 0 | Nonevent | < | 2 | 13 | | >58 | 0 | 0.042 | 17.1 | 12.57 | 7.82 |
| Freeman at Sugar Bush | 2/8/06 | Freeman | 0 | Nonevent | < | 2 | 4 | | >58 | 0 | 0.026 | 20.7 | 13.16 | 7.75 |
| Fenwood at 153 | 1/18/06 | Fenwood | 0 | Nonevent | < | 2 | 7 | | >58 | 0 | 0.022 | 30 | 12.88 | 7.6 |
| Fenwood at 153 | 2/8/06 | Fenwood | 0 | Nonevent | < | 2 | 8 | | >58 | 0 | 0.31 | 33.9 | 13.3 | 7.72 |
| BEP River 153 | 1/4/06 | BEP | 0 | very small event | < | 3 | 54 | | >58 | 0.1 | 0.133 | 72.7 | 12.85 | 7.62 |
| BEP River 153 | 1/18/06 | BEP | 0 | Nonevent | < | 2 | 23 | | >58 | 0 | 0.043 | 86.9 | 11.48 | 7.53 |
| bep river 153 | 2/8/06 | BEP | 0 | Nonevent | < | 2 | 20 | | >58 | 0 | 0.115 | 87.6 | 12.42 | 7.83 |
| BEP Mile 11 | 3/8/06 | BEF 11 | 1 | Nonevent | < | 2 | 4 | | | 0.6 | 0.734 | 69 | 2.4 | 6.81 |
| BEP Mile 7 | 2/27/06 | BEF 7 | 1 | Nonevent | < | 2 | 0 | | >58 | 2 | 0.271 | 31 | 7.82 | 7.3 |
| BEP Mile 3 | 1/18/06 | BEF 3 | 6 | Nonevent | < | 2 | 0 | | >58 | 3.8 | 0.883 | 50 | 0.11 | 7.65 |
| BEP Mile 2 | 2/27/06 | BEF 2 | 6 | Nonevent | < | 2 | 0 | | >58 | 4.5 | 0.735 | 48 | 0.2 | 7.45 |
| Freeman at Sugar Bush | 3/13/06 | Freeman | 0 | Event | | 4.3 | 920 | | 53 | 0 | 0.429 | 10.9 | 13.96 | 7.17 |
| Fenwood at 153 | 3/13/06 | Fenwood | 0 | Event | | 5.1 | 340 | | 58 | 0 | 0.515 | 11.4 | 14.12 | 7.45 |
| BEP River 153 | 3/13/06 | BEP | 0 | Event | | 10.2 | 1200 | | 27.94 | 0.1 | 1.5 | 16.9 | 13.19 | 7.4 |
| BEP Mile 11 | 3/13/06 | BEF 11 | 1 | Event | | 11.9 | 770 | | 17.78 | 0.1 | 1.51 | 17.8 | 12.56 | 7.4 |
| BEP Mile 5 | 3/13/06 | BEF 5 | 1 | Event | | 9.4 | 770 | | 15.24 | 0.3 | 1.2 | 24.6 | 11.2 | 7.65 |
| Freeman at Sugar Bush | 1/25/07 | Freeman | 0 | Nonevent | < | 2 | 13 | 0.35 | >120 | 0.1 | 0.086 | 15.6 | 11.9 | 7.68 |
| Fenwood at 153 | 1/25/07 | Fenwood | 0 | Nonevent | < | 2 | 1 | 0.062 | >120 | 0 | 0.161 | 20.6 | 12.28 | 7.7 |
| BEP River 153 | 1/25/07 | BEP | 0 | Nonevent | < | 2 | 7 | 0.146 | >120 | 0.1 | 0.239 | 42.1 | 9.95 | 7.9 |
| BEP Mile 11 | 2/20/07 | BEF 11 | 1 | Nonevent | | 5.6 | 0 | 0.339 | | 1.4 | 0.482 | 25.8 | 8.27 | 7.56 |
| BEP River 153 | 3/7/07 | BEP | 0 | Nonevent | < | 3 | 1 | 0.28 | | 0 | 1.65 | 58.8 | 5.2 | 7.35 |
| BEP Mile 11 | 3/7/07 | BEF 11 | 1 | Nonevent | < | 2 | 0 | 0.26 | | 1.1 | 0.629 | 26.7 | 6.61 | 7.4 |
| BEP Mile 2 | 3/15/07 | BEF 2 | 1 | Nonevent | | 6 | 0 | 0.172 | 116 | 2.4 | 0.32 | 21.8 | 9.81 | 8.47 |
| Freeman at Sugar Bush | 3/13/07 | Freeman | 0 | Event | > | 21 | 2400 | 0.771 | 53 | 0 | 2.25 | 10.9 | 14.5 | 7.8 |
| Fenwood at 153 | 3/13/07 | Fenwood | 0 | Event | | 14.6 | 300 | 0.572 | 11.6 | 0 | 1.28 | 11.6 | 15 | 7.5 |
| BEP River 153 | 3/13/07 | BEP | 0 | Event | | 11.5 | 1000 | 0.458 | | 0 | 1.41 | 33.6 | 13.6 | 7.4 |
| BEP Mile 7 | 3/15/07 | BEF 7 | 1 | Event | | 18.1 | 1200 | 0.555 | 12 | 0 | 2.17 | 18.2 | 10.84 | 7.65 |
| BEP River 97 | 3/14/07* | BEP | 0 | Event | | 20.9 | 1300 | 0.866 | 32 | 0.2 | 2.42 | 18.1 | 14.27 | 7.95 |
| BEP River 153 | 3/22/07 | BEP | 0 | Event | | 10.4 | 1046 | 0.72 | 7 | 0.3 | 1.2 | 13.1 | 13.47 | 7.89 |
| Fenwood at 153 | 3/22/07 | Fenwood | 0 | Event | | 11.4 | 816 | 0.51 | 7 | 0.2 | 0.875 | 9.5 | 14.2 | 7.81 |
| Freeman at Sugar Bush | 3/22/07 | Freeman | 0 | Event | | 11 | 920 | 0.494 | 108 | 0.2 | 0.82 | 6.9 | 13.61 | 7.58 |
| Spirit River 86 | 1/19/06 | Spirit | 0 | Nonevent | < | 2 | 20 | | >58 | 0.1 | 0.065 | 3.3 | 12.9 | 7.8 |
| Spirit River 86 | 2/2/06 | Spirit | 0 | Nonevent | < | 3 | 6.3 | | >58 | 0 | 0.09 | 3.6 | 13.7 | 7.6 |
| Spirit River 86 | 2/1/07 | Spirit | 0 | Nonevent | < | 2 | 3 | 0.047 | | 0 | 0.149 | 3.6 | 12.94 | 7.68 |
| Spirit River 86 | 3/14/07 | Spirit | 0 | Event | | 10.5 | 192 | 0.243 | | 0.2 | 0.614 | 5.4 | 14.48 | 7.13 |
| SF Mile 7 | 2/20/07 | SF 7 | 1 | Nonevent | < | 2 | 3 | 0.078 | | 0.4 | 0.133 | 6.7 | 6.66 | 7.22 |
| SF Mile 5 | 3/7/07 | SF 5 | 1 | Nonevent | < | 3 | 7 | 0.07 | | 0.2 | 0.177 | 5.8 | 6.95 | 7.28 |
| SF Mile 5 | 3/15/07 | SF 5 | 1 | Event | | 10.6 | 365 | 0.272 | 41 | 0.2 | 0.705 | 6.9 | 12.95 | 7.53 |
| Spirit River 86 | 03/26/2007 | Spirit | 0 | Event | | 4.6 | 108 | 0.143 | 49 | 0.7 | 0.224 | 2.5 | 13.18 | 7.04 |

Following is how BOD5 lab results were graphed
2 mg/l is detection level of Lab so <2 mg/L is set to 2 mg/L
<3 BOD5 result is set at 3
When the > symbol is preceeding the concentration the result is set to that concentration even though concentrations were likely greater.

Appendix 2. Winter Runoff Study 2007 Load Calculations

| TP Load | | Watershed | Mean Daily | | Concentration | | | Unit area load |
|---|---|---|---|---|---|---|---|---|
| Stream | Date | mi2 | Flow (cfs)** | Flow MGD | (mg/L) | Lbs/gallon | Lb/day | Lbs/day/sq mile |
| Big Eau Pleine 153 | 03/13/2007 | 245 | 914 | 591 | 0.458 | 8.34 | 2256 | 9 |
| Freeman Creek Sugar Bush | 03/13/2007 | 26 | 97 | 63 | 0.771 | 8.34 | 403 | 16 |
| Fenwood Creek at 153 | 03/13/2007 | 37 | 138 | 89 | 0.572 | 8.34 | 425 | 11 |
| Big Eau Pleine 97* | 03/14/2007 | 223 | 2620 | 1693 | 0.866 | 8.34 | 12230 | 55 |
| Big Eau Pleine 153 | 03/22/2007 | 245 | 2219 | 1434 | 0.72 | 8.34 | 8612 | 35 |
| Freeman Creek Sugar Bush | 03/22/2007 | 26 | 236 | 153 | 0.494 | 8.34 | 628 | 24 |
| Fenwood Creek at 153 | 03/22/2007 | 37 | 335 | 217 | 0.51 | 8.34 | 921 | 25 |
| | | | | | | | | |
| Spirit River at 86 | 03/14/2007 | 105 | 272 | 176 | 0.243 | 8.34 | 356 | 3 |
| Spirit River at 86 | 03/26/2007 | 105 | 667 | 431 | 0.143 | 8.34 | 514 | 5 |
| | | | | | | | | |

| BOD Load | | Watershed | | | Concentration | | | Unit area load |
|---|---|---|---|---|---|---|---|---|
| Stream | Date | mi2 | Flow (cfs)** | Flow MGD | (mg/L) | Lbs/gallon | Lb/day | Lbs/day/sq mile |
| Big Eau Pleine 153 | 03/13/2006 | 245 | 605 | 391 | 10.2 | 8.34 | 33263 | 136 |
| Freeman Creek Sugar Bush | 03/13/2006 | 26 | 64 | 41 | 4.3 | 8.34 | 1483 | 57 |
| Fenwood Creek at 153 | 03/13/2006 | 37 | 91 | 59 | 5.1 | 8.34 | 2502 | 68 |
| | | | | | | | | |
| Big Eau Pleine 153 | 03/13/2007 | 245 | 914 | 591 | 11.5 | 8.34 | 56657 | 231 |
| Freeman Creek Sugar Bush | 03/13/2007 | 26 | 97 | 63 | 21 | 8.34 | 10980 | 422 |
| Fenwood Creek at 153 | 03/13/2007 | 37 | 138 | 89 | 14.6 | 8.34 | 10860 | 294 |
| Big Eau Pleine 97* | 03/14/2007 | 223 | 2620 | 1693 | 20.9 | 8.34 | 295161 | 1324 |
| Big Eau Pleine 153 | 03/22/2007 | 245 | 2219 | 1434 | 10.4 | 8.34 | 124395 | 508 |
| Freeman Creek Sugar Bush | 03/22/2007 | 26 | 236 | 153 | 11 | 8.34 | 13993 | 538 |
| Fenwood Creek at 153 | 03/22/2007 | 37 | 335 | 217 | 11.4 | 8.34 | 20585 | 556 |
| | | | | | | | | |
| Spirit River at 86 | 03/14/2007 | 105 | 272 | 176 | 10.5 | 8.34 | 15395 | 147 |
| Spirit River at 86 | 03/26/2007 | 105 | 667 | 431 | 4.6 | 8.34 | 16538 | 158 |
| | | | | | | | | |

*Big Eau Pleine sampled at STH 97 instead of STH 153

**flows based on watershed adjustment at gauges; Bold indicates actual USGS reported mean daily flow

| Location | acres above site | mi2 above site | Flow cfs | Flow cfs | Flow cfs | Flow cfs |
|---|---|---|---|---|---|---|
| Spirit River at flow gauge | 54492 | 85 | **1330** | | **540** | **220** |
| Spirit River at 86 | 67202 | 105 | 1638 | | 667 | 272 |
| Big Eau Pleine at 97 gauge | 142823 | 223 | **2620** | **2020** | **831** | **551** |
| Big Eau Pleine at 153 | 156935 | 245 | 2878 | 2219 | 914 | 605 |
| Freeman Creek at Sugar Bush | 16537 | 26 | 306 | 236 | 97 | 64 |
| Fenwood Creek at 153 | 23740 | 37 | 435 | 335 | 138 | 91 |

**Appendix 3. Comparison of BOD load between the Big Eau Pleine River and City of Wausau Waste Water Treatment Plant**

| | | | | | | |
|---|---|---|---|---|---|---|
| Date | Big Eau Pleine River event concentration | Minus Spirit River background event Concentration | BOD mg/L | Flow MGD | | Lbs/day |
| 03/13/2007 | 11.5 | 10.5 (3/14) | 1 | 591 | 8.34 | 4929 |
| 03/14/2007 | 20.9 | 10.5 (3/14) | 10.4 | 1693 | 8.34 | 146844 |
| 03/22/2007 | 10.4 | 4.6 3/26) | 5.8 | 1434 | 8.34 | 69365 |
| | | | **Big Eau Pleine River 3 day Event Load** | | | **221,138** |
| | | | **Big Eau Pleine River Average Event Load** | | | **73,713** |
| | | | Wausau Daily BOD Influent Concentration | | | |
| Date | | | BOD mg/L | Flow MGD | | |
| 03/13/2007 | | | 216 | 2.8 | 8.34 | 5044 |
| 03/14/2007 | | | 233 | 2.8 | 8.34 | 5441 |
| 03/22/2007 | | | 214 | 2.9 | 8.34 | 5176 |
| | | | **Wausau WWTP Total 3 day BOD load** | | | **15,661** |
| | | | **Wausau WWTP Average BOD Load** | | | **5,220** |

Appendix 4. Calculation Used to Determine the Number of Dairy Cows in the Big Eau Pleine Watershed and pounds of BOD in manure of Dairy Cows

1) Number of Cows in the Big Eau Pleine Watershed

| | | |
|---|---|---|
| No. of dairy cows in Marathon County in 2007[1] | 62,000 | |
| No. of farmland acres (pastures, cropland and tree farms) in Marathon County in 2004[2] | 531,263 | acres |
| The ratio of dairy cows to farmland acres (62,000/531,263) | 0.117 | |
| No. of agricultural acres (cropland, pasture, grassland) in the Big Eau Pleine Watershed[3] | 151,782 | acres |
| No. of cows in the Big Eau Pleine Watershed (151,782 x 0.117) | 17,758 | |

2) Amount of BOD Produced by dairy cows per day

| | | |
|---|---|---|
| Pounds of BOD produced in a day by dairy and beef cattle with live mass weight of 2,200 pounds[4] | 3.53 | lbs |
| Pounds of BOD produced in a day by a dairy cow with live mass weigh of 1,500 lbs (average) | 2.4 | lbs |

1 USDA website
2 UW Extension of Marathon County website
3 UW Purdue Watershed Delineation website
4 America Society of Agricultural Engineers

# Appendix D:4

# IMPACT OF MANURE APPLICATION IN DIFFERENT SEASONS ON PHOSPHORUS LOSS IN RUNOFF

Peter Vadas[1], Bill Jokela[1], and Laura Good[2]

## Introduction

Agricultural nutrient management continues to be an important area of research and policy due to concerns of phosphorus (P) loss in runoff and water quality degradation. Surface manure application to fields without incorporation can be a significant source of P loss (Daniel et al., 1998). In many northern states, winter manure application without incorporation is common (Srinivasan et al., 2006). This fact, combined with frequent snowmelt runoff, has prompted some states to restrict winter manure spreading. However, restrictions are based more on commonly held perceptions than on research. Studies of winter manure P loss are limited, and most have been observational with mixed results (Kongoli and Bland, 2002). P transport from winter-applied manure varies due to infiltration, runoff, erosion, and nutrient cycling processes, all of which are sensitive to air and soil temperatures. Manure P loss also varies with spreading practices, especially relative to manure placement beneath or on top of snow and the effect of manure on rates of snow melt (Williams et al., 2011). Overall, good understanding of P cycling and transport associated with winter manure application is still lacking.

There is an increasing demand to evaluate all agricultural systems where non-point P pollution is a priority. Relying on physical monitoring is too costly and time-consuming, so models have been developed to simulate and assess those management and process interactions that cannot be physically investigated. Vadas et al. (2007) developed the SurPhos model to predict dissolved P loss in runoff from surface-applied manures (Figure 1).

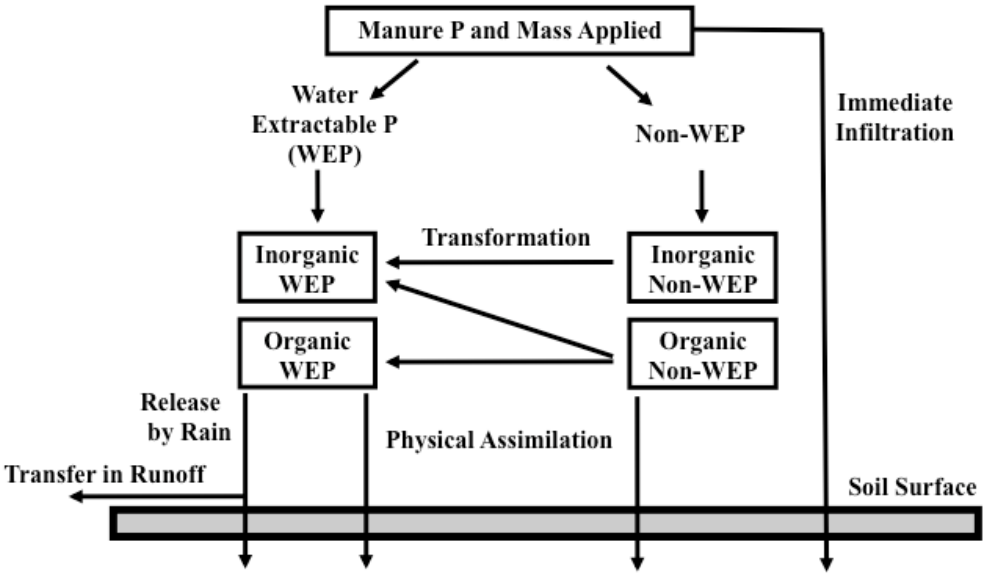



*Figure 1. Schematic of the SurPhos manure P runoff model.*

1. Scientists, USDA-Agricultural Research Service, U.S. Dairy Forage Research Center
2. Research Scientist, University of Wisconsin-Madison, Department of Soil Science.

SurPhos is a daily time-step, process-based model that simulates manure application to the soil surface, dry matter and P transformations (e.g., organic matter decomposition, organic P mineralization) as manure ages in the field, physical assimilation of manure into soil by bugs, leaching of P from manure during rain events, and loss of manure dissolved P in runoff when runoff occurs.

The USDA-ARS and the UW-Madison have a collaborative research project that is investigating the physical and chemical processes controlling P loss in runoff from winter-applied dairy manure. As part of that project, we are using the SurPhos model to help estimate how the day of manure application influences P loss in runoff. We are specifically trying to quantify how much greater the risk of manure P loss is from winter-applied manure compared to manure applied in other seasons. To do this, we collected real precipitation and field runoff data from six monitored locations in WI. In total, there were 108 site years of runoff data representing a variety of climate and soil conditions. We divided the data into three groups of high, medium, and low runoff based on how much runoff was observed during the winter period (mid-November through mid-March). We then used SurPhos to simulate a liquid dairy manure (6% solids) application of 10,000 gallons/acre, or 35 lbs total P/acre. We allowed the model to change the day of manure application so that each day of the year was represented. For example, the model was first run so manure was applied on October 1 on each year, with the model simulating about 35 years of runoff data. The results were then processed to determine an average rate of annual manure P loss in runoff. The model was then reset, and the process was repeated with manure applied on October 2, and so on until all days of the year were simulated. This entire process was conducted separately for low, medium, and high groups of runoff data

## Results and Discussion

Figure 2 shows the results of the SurPhos manure P runoff simulations. P loss is generally low for all rates of site runoff if manure is applied between March and October. For the low runoff sites, P loss in runoff increases if manure is applied in the winter, but not very dramatically. For medium and high runoff sites, applying manure during the winter can significantly increase the risk of P loss, with peak loss occurring if manure is applied around late January to early February. The results show that avoiding winter manure application could help decrease potential P loss in runoff. Because the rate of runoff (high, medium, or low) is not always the same for a given field every year (i.e., the same field could have low runoff one year and high the next), it may be difficult to reliably identify low runoff fields that may be able to receive winter-applied manure.

Table 1 presents a summary of the effect of applying manure in winter (December-March) vs non-winter on P loss in runoff. These data are averages of P loss for all winter days or non-winter days. Results show generally that applying manure in the winter can increase P loss from 2.8 to 4.2 times, with the increase greater as the amount of runoff increases. High runoff sites have the potential to lose more than seven times the amount of P from surface applied manure as low runoff sites. Medium runoff sites would lose more than three times as much manure P as low runoff sites.

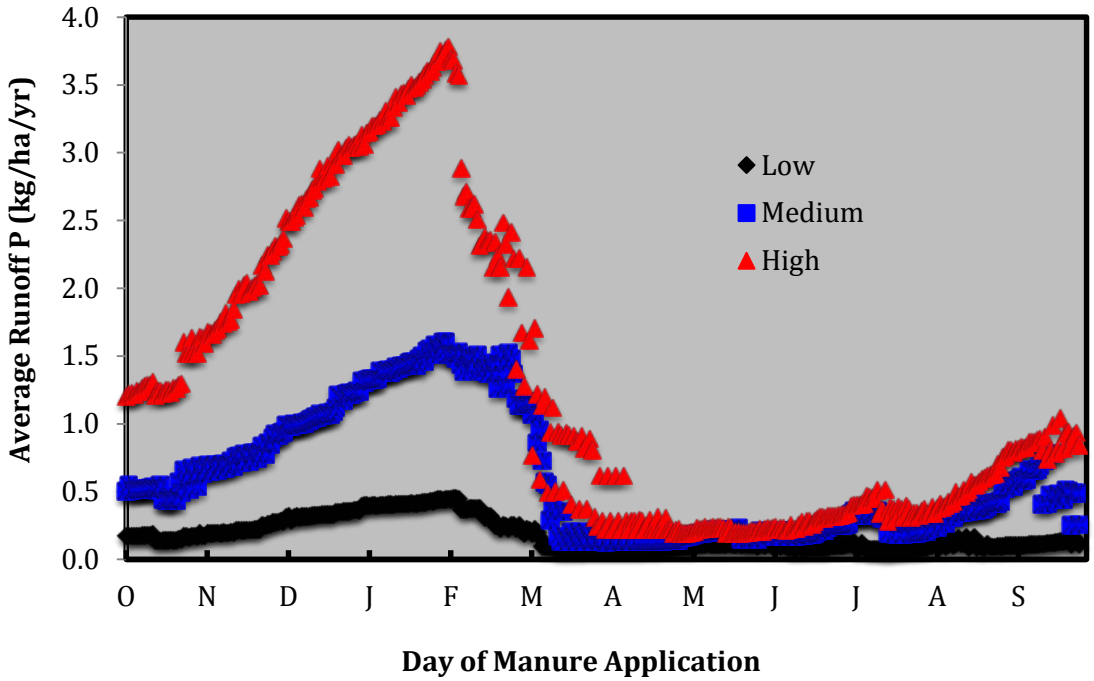



*Figure 2. Model simulations showing the effect of manure application day on P loss in runoff for low, medium, and high runoff sites.*

Table 1. Summary of the effect of applying manure in winter (December-March) vs non-winter on P loss in runoff.

| Runoff Group | Winter P Loss (kg/ha/yr) | Non-Winter P Loss (kg/ha/yr) | Season Difference | Runoff Difference over Low |
|---|---|---|---|---|
| Low | 0.33 | 0.12 | 2.8x | -- |
| Medium | 1.19 | 0.33 | 3.6x | 3.4x |
| High | 2.63 | 0.63 | 4.2x | 7.2x |

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# Appendix D:5

# Winter Manure Application: Management Practices and Environmental Impact

2016 Manure and Soil Health Working Group Data Brief


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## Background

The application of manure to frozen impermeable soils can increase the risk of manure nutrients and contaminants running off of fields during the spring thaw. Additionally, the loss of nutrients to spring thaws means a loss of soil productivity for farmers in addition to potentially impacting local water bodies (Thompson et al., 1979). As such, organizations such as the US Environmental Protection Agency (EPA) and the Natural Resource Conservation Service (NRCS) have traditionally discouraged manure application during winter (NRCS, 2013). However, winter manure application has several key benefits to farmers (Fleming and Fraser, 2000):

- Reducing the size and number of manure storage structures.
- Spreading the manure when logistics suite the farmer.
- Reducing soil compaction by avoiding equipment use on compressible soil conditions.

Winter manure application can also make a great financial impact on small farmers. A 2016 survey conducted in Michigan found that a total ban on winter application would cost small farms in the State an estimated $30 million a year collectively, with 27% of small dairy farms replying that they would need to suspend operations in the event of such a ban (Miller et al., 2017).

Despite these benefits, the preponderance of evidence suggests that applying manure to frozen or snowy impermeable soils carries an increased risk of releasing contaminants of concern via runoff in the spring (Komiskey et al., 2011; Lewis and Makarewicz, 2009; Owens et al., 2011; Williams et al., 2010). This is especially relevant given recent findings out of the National Oceanic and Atmospheric Administration (NOAA). In an effort to better predict the presence and extent of harmful algae blooms (HABs) in Lake Erie, NOAA conducted a series of regression analyses comparing factors commonly attributed to algae

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blooms with the observed bloom density. These regressions found that the most predictive single factor was spring influent of phosphorous to the lake system (Stumpf et al., 2012). In short, the very time that winter manure application is likely to run-off is the single most sensitive time for the lake system. Manure is far from the only potential source of spring phosphorus to the Great Lakes, but it still reinforces the message that we as agriculturalists need to reduce the risk of runoff events. To that end, a literature review was conducted by Smith et al. (2017) to determine the state-of-the-science regarding risk factors, policy, and best management practices. Below is a bulleted list of the report findings categorized by key issue areas.

## Effect of Application Timing

- With regard to timing, spring and fall appear to be preferable to winter for manure application. If winter application must be conducted, application in early winter is generally considered less risky. Manure application with close proximity to a thaw event is to be avoided at all costs.
  - » A 4 year study in Wisconsin (Komiskey et al., 2011) showed that nitrogen and phosphorus losses were heavily dependent on timing of manure application for both liquid dairy and solid beef manure. Late fall and early winter applications were much preferred to late winter. Applications within one week of runoff events were found to be catastrophic.
  - » Pappas et al. (2008) found that enterococcus and *E. coli* levels in drainage water were greater on winter applied manure when compared to spring and fall, though this was likely due to the lack of manure incorporation for the winter spreading event (winter manure was broadcast, spring and fall were incorporated).
  - » Phillips et al. (1981) spread liquid dairy manure onto a 0.8% slope varying the time of year applied with fall, winter, and spring being the periods of investigation. The runoff values for all nutrients investigated (nitrogen, phosphorus and potassium) were statistically significantly higher for winter spread plots than for spring or fall application plots.
- Some studies have shown potential benefits to winter manure application though it should be noted that these studies are outliers.
  - » Young and Holt (1977) and Young and Mutchler (1976) found that solid manure application on top of snow resulted in less sediment and nutrient loss than manure under snow or bare soil conditions. It is theorized that the manure provided a barrier to the soil (at a 9% slope) that helped to reduce runoff effects.
  - » Lauer et al. (1976) showed that snow covered manure displayed no ammonia volatilization, though work from Owens et al. (2011) suggests this ammonia may be lost through runoff in any event.

## Cover Crops

- Though cover crops can be a valuable tool in reducing sediment loss and should not be discounted as a general best management practice (BMP), evidence suggests they may cause increased risk of nutrient loss on winter manured soils.
  - » Runoff velocity reduction benefits can be negated by snow or ice pack that covers the crop. If impervious layers of snow and ice overtop the cover crops, all such benefits are lost.
  - » Dormancy negates the ability of cover crops to uptake nutrients (Bechmann et al., 2005).

  - » In some instances, cover crops can act as a catchment for snow thus generating a large volume of water for spring melt and subsequently increasing runoff, as was observed by Lorimor and Melvin (1996).
  - » Exposure to repeated freeze-thaw cycles has been shown to release soluble phosphrous from living cover crops such as ryegrass (Bechmann et al., 2005; Smith et al., 2016).
- Results are conflicting whether cover crops improve or hinder the soil's ability to allow infiltration at time of first thaw.
  - » Storey (1955) mentions that cover crops have the ability to reduce the incidence and depth of "concrete freezes" or completely impervious soil layer.
  - » Young and Mutchler (1976) noted that alfalfa fields stayed frozen longer than bare soil.
  - » More research is needed on this phenomena.

## Pathogens

- Results are conflicting as to whether or not exposing pathogens in manure to freeze thaw cycles will result in pathogen kills.
  - » Field research by Kibby, et al. (1978) found that freezing conditions were lethal to fecal bacteria.
  - » Bicudo (2003) found that freezing and thawing a manure/soil mixture reduced *E. Coli* levels by 90%.

## Slopes and Setbacks

- To the best of the author's knowledge, slope has not been the primary variable of interest in any winter manure application study. It is likely that researchers have viewed this as a trivial variable, as several existing models suggest that runoff risk during any season is directly proportional to slope.
- Unfortunately, this has led to a lack of empirically backed standards correlating winter manure application risk with slope.
- States have established guidelines regarding permissible slopes for winter manure application (Srinivasan et al., 2006).

## Policy

The ambiguity in standard practices for winter manure application has led to several different state policies. Table 1 shows the states that have established a total or partial ban of winter manure application as of 2017, as well as any conditions placed upon the ban.

| State | Ban Duration | Implementation Info |
|---|---|---|
| Vermont | Dec 15 – April 1 | Established in 1995 |
| Iowa | Dec 21 – April 1 | Frozen and snow covered ground Emergency spreading is allowed |
| Maryland | Dec 15 – April 1 | Slated for 2016 Enforcement (CAFO only) |
| Indiana | Dec 15 – April 1 | Emergency spreading is allowed |
| Minnesota | Dec 1 – Thaw | Solid manure not included |
| Wisconsin | Frozen or Snowy Ground, February – March | Unless incorporated, Total ban - Liquid manure |

***Table 1:*** *States with Winter Manure Application Bans*

Table 2 lists northern U.S. states that have attempted to utilize risk management strategies or best management practices to address winter manure application issues. States not listed have policies that are identical with NRCS standard 590.

| State | Notes |
|---|---|
| Ohio | NRCS Standard 633<br>• 10 tons/acre limit<br>• 90% surface residue cover required<br>• No more than 20 contiguous acres<br>• 200 ft setback<br>• Additional restriction apply to fields with >6% slope |
| Pennsylvania | • 25% residue cover<br>• 100 ft setback<br>• No more than 5000 gal/A of liquid manure.<br>• No more than 20 ton/A of dry non-poultry manure.<br>• No more than 3 tons/A poultry manure<br>• No greater than 15% slope |
| Michigan | • Michigan Generally Accepted Ag Management Practices (GAAMPS)<br>• CAFO winter manure application must be approved.<br>• CNMPs include an assessment of all fields by the Manure Application Risk Index (MARI) to determine runoff risk during winter application. |
| Illinois | • Illinois recommends avoiding applying manure on frozen or snow covered soil.<br>• Winter manure application should be limited to areas with a 5 percent slope or less and where there are acceptable erosion control practices.<br>• Manure should not be applied in the winter if the livestock wastes will runoff to the waters of the state. |

***Table 2:*** *States with Winter Manure Application Standards or Guidelines*

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# Nutrients and sediment in frozen-ground runoff from no-till fields receiving liquid-dairy and solid-beef manures

M.J. Komiskey, T.D. Stuntebeck, D.R. Frame, and F.W. Madison

**Abstract:** Nutrients and sediment in surface runoff from frozen agricultural fields were monitored within three small (16.0 ha [39.5 ac] or less), adjacent basins at a no-till farm in southwest Wisconsin during four winters from 2003 to 2004 through 2006 to 2007. Runoff depths and flow-weighted constituent concentrations were compared to determine the impacts of surface-applied liquid-dairy or solid-beef manure to frozen and/or snow-covered ground. Despite varying the manure type and the rate and timing of applications, runoff depths were not significantly different among basins within each winter period. Sediment losses were low (generally less than 22 kg $ha^{-1}$ [20 lb $ac^{-1}$] in any year) and any statistical differences in sediment concentrations among basins were not related to the presence or absence of manure or the amount of runoff. Concentrations and losses of total nitrogen and total phosphorus were significantly increased in basins that had either manure type applied less than one week preceding runoff. These increases occurred despite relatively low application rates. Lower concentrations and losses were measured in basins that had manure applied in fall and early winter and an extended period of time (months) had elapsed before the first runoff event. The highest mean, flow-weighted concentrations of total nitrogen (31.8 mg $L^{-1}$) and total phosphorus (10.9 mg $L^{-1}$) occurred in winter 2003 to 2004, when liquid-dairy manure was applied less than one week before runoff. On average, dissolved phosphorus accounted for over 80% of all phosphorus measured in runoff during frozen-ground periods. The data collected as part of this study add to the limited information on the quantity and quality of frozen-ground runoff at field edges, and the results highlight the importance of manure management decisions during frozen-ground periods to minimize nutrients lost in surface runoff.

**Key words:** edge-of-field—manure—nutrients—sediment—snowmelt

**The surface application of manure to frozen and/or snow-covered cropland soils is a common practice on livestock farms located in midlatitude, continental-climate regions.** The frozen-ground period (FGP) provides an opportunity to haul manure with minimal soil compaction, reduces the volume of manure storage required, and can increase the time available for field preparation and planting in the spring. One alternative to spreading manure during the FGP is to have adequate manure storage; however, storage compresses the time available for spreading, increases capital investment, and can pose potential environmental problems when leaks or failures occur (Kongoli and Bland 2002).

Limited studies (most predating 1980) have evaluated both the quality and quantity of surface runoff from areas receiving surface-applied manure during FGPs. A review of some of these studies showed substantial nutrient losses due to wintertime manure application (Srinivasan et al. 2006). However, some studies suggest that the application of manure to frozen and/or snow-covered soils can have no or minimal effects (Ginting et al. 1998; Young and Holt 1977) or can potentially reduce nutrient losses by reducing the volume of runoff (Kongoli and Bland 2002). It is difficult to determine exactly why varying conclusions could be made; however, there is a variety of differences in the way the studies were conducted. Some of these differences included, but were not limited to the means by which runoff was generated (snowmelt only versus rain on snowmelt) and the management style and on-farm conditions (manure amount, type of manure, application timing, tillage, field residue, soil type and texture, and slope) during the monitoring periods.

Studies have also suggested that the timing of manure applications during FGPs can influence nutrients exported in runoff. However, these studies also show conflicting results. Klausner et al. (1976) suggested that applying manure prior to snow reduces nutrients lost compared to applying manure during snowmelt, whereas Young and Mutchler (1976) showed that applying manure on top of snow keeps manure and associated nutrients out of snowmelt flow paths. Despite limited and conflicting study results, the application of manure during the FGP has been shown to have adverse effects on aquatic resources if the applied manure enters water bodies (Milne 1976; Young and Mutchler 1976; Madison et al. 1998). Most states have developed guidelines for manure management during FGPs (Srinivasan et al. 2006). These guidelines vary from state to state and have been revised and updated as more information is available.

The agricultural management practice of no-till has been promoted as a way to reduce nutrients and sediments lost in surface runoff. Most studies have shown reduced runoff volume and sediment loss from no-till fields during unfrozen conditions, compared to conventionally-tilled fields (Mickelson et al. 2001; Cox and Hendricks 2000; Andraski et al. 1985). However, limited roughness in no-till fields can potentially lead to increased runoff and nutrient losses during FGPs. Young and Mutchler (1976) showed that no-till practices posed more of a threat to nutrient losses on frozen soils than conventional tillage because the field surface is relatively smooth and nutrients accumulate at the soil surface. Hansen et al. (2000) found that this surface accumulation resulted in greater soluble phosphorus (P) losses in snowmelt runoff.

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In response to limited data and conflicting literature results available regarding winter-time runoff from no-till fields and the effects of manure applied during FGPs, research was conducted at a privately owned livestock farm. Surface runoff quantity and quality data from runoff events were collected over a four-year period to quantify runoff losses, the timing of these losses, and the conditions in which losses typically occurred. The runoff results, in addition to the manure-application data, were then used to evaluate the impacts of applying liquid-dairy or solid-beef manure to frozen and/or snow-covered ground.

## Materials and Methods

***Site Description.*** The US Geological Survey, in cooperation with the University of Wisconsin Discovery Farms program, installed three surface monitoring stations in grassed waterways within three small (6.8, 7.0, and 16.0 ha [16.9, 17.2, and 39.5 ac]), adjacent basins at a privately owned farm in southwest Wisconsin (figure 1). Each basin contained portions of two separate farm fields with 4% to 6% average slope. Field soils consisted of primarily Tama silt loam (Fine-silty, mixed, superactive, mesic Typic Argiudoll) overlying fractured limestone bedrock. The soils had not been tilled for approximately twenty years. Soil properties—pH, organic matter, and soil test P values (Bray-1 method)—were similar among basins (table 1). Average soil test P values were approximately 80 ppm (160 lb $ac^{-1}$) in each basin. Fields were planted on the contour in a rotation of two years of corn (*Zea mays* L.) followed by one year of soybeans (*Glycine max* L.). Terraces and grassed waterways were used as conservation practices to reduce soil erosion and move runoff water from the field. Corn was harvested as silage or grain, with about two-thirds of corn-grain residue removed for livestock bedding for a beef-finishing enterprise. Solid-beef manure (SBM) from the farm and liquid-dairy manure (LDM) from a neighboring confined-dairy farm were periodically surface applied to the cropped fields to meet nutrient requirements.

Monitoring stations were installed, maintained, and operated according to the methods described in Stuntebeck et al. (2008). H-flumes were used to quantify the volume of runoff, while refrigerated samplers collected discrete, time-based samples during natural rainfall- and/or snowmelt-induced runoff events. Samples were generally

**Figure 1**
**Monitoring locations, basin sizes, and field locations at a no-till farm in southwest Wisconsin.**

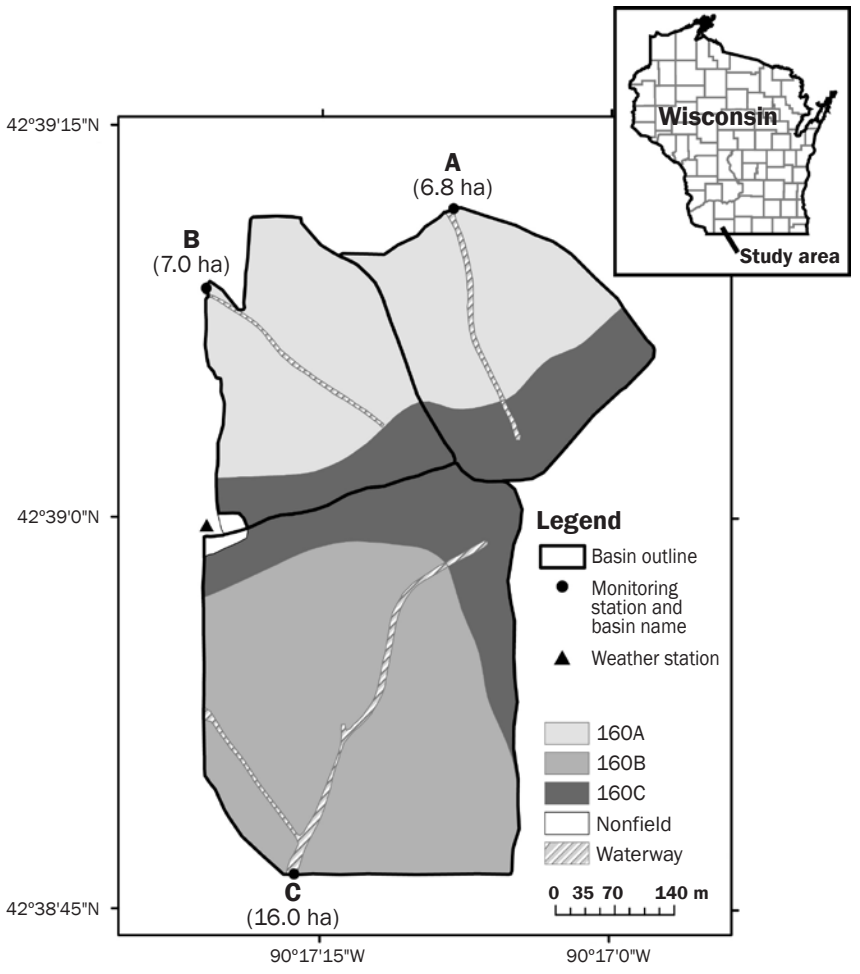


**Table 1**
**Soil properties of Tama silt loam for three monitored basins located at a no-till farm in southwest Wisconsin, sampled October 2006.**

| Basin name | Sample depth (cm) | Soil pH | Soil organic matter (%) | Soil phosphorus (ppm) |
|---|---|---|---|---|
| **A** | | | | |
| | 0 to 2.5 | 7.1 | 4.8 | 142 |
| | 2.5 to 15.2 | 7.3 | 3.4 | 83 |
| | 0 to 15.2 | 7.2 | 3.6 | 97 |
| | 15.2 to 30.5 | 7.2 | 2.7 | 25 |
| **B** | | | | |
| | 0 to 2.5 | 7.0 | 4.5 | 143 |
| | 2.5 to 15.2 | 7.0 | 3.4 | 86 |
| | 0 to 15.2 | 7.0 | 3.4 | 82 |
| | 15.2 to 30.5 | 7.1 | 2.8 | 56 |
| **C** | | | | |
| | 0 to 2.5 | 7.0 | 4.5 | 102 |
| | 2.5 to 15.2 | 7.2 | 3.4 | 48 |
| | 0 to 15.2 | 7.2 | 3.8 | 82 |
| | 15.2 to 30.5 | 7.3 | 2.8 | 20 |

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retrieved within 24 hours of the end of a runoff event and were subsequently iced and transported to the Water and Environmental Analysis Laboratory at the University of Wisconsin–Stevens Point.

A weather station on the farm collected weather and soil temperature data (figure 1). Measurements included rainfall amount and intensity, soil temperature at 2, 5, 10, 20, 40, and 80 cm (0.8, 2.0, 3.9, 7.9, 15.7, and 31.5 in), and air temperature. Frozen precipitation (snow, ice pellets, and hail) was estimated using data from the National Weather Service station in Platteville, Wisconsin, approximately 18.2 km (11.3 mi) to the northeast (National Weather Service 2007). Annual rainfall (1971 to 2000) averages 917 mm (36.1 in), and snowfall averages 1,041 mm (41.0 in) at this weather station (Midwestern Regional Climate Center 2007a; Midwestern Regional Climate Center 2007b).

Volumes were measured for all runoff events, and water samples were collected and analyzed for most runoff events for the entire period from November 2003 through September 2007; however, only runoff events that occurred when the ground was frozen, at any measured depth at the weather station, were included in this analysis. Frozen-ground periods typically extended from mid-December through mid-March. Runoff events included those derived from snowmelt only, a combination of rain and snowmelt, and rainfall only. Runoff volume was divided by the basin area and multiplied by a numerical factor to determine runoff depth (mm [in]), which normalized the runoff volume for differences in basin size.

A flow-weighted composite sample was produced for each runoff event at each station by calculating the percentage of the total event volume that each discrete sample represented, collecting appropriate aliquots from each discrete sample using a churn splitter, and combining aliquots. The composite sample was analyzed for concentrations of total dissolved solids, suspended sediment, chloride, nitrate plus nitrite–nitrogen, ammonium nitrogen, total Kjehldahl nitrogen, dissolved reactive P, and total P. The total nitrogen (TN), organic N, and particulate P fraction of each sample were calculated from the reported results. The resultant constituent concentrations for each flow-weighted sample were multiplied by the event volume and a numerical factor to determine constituent losses (kg $ha^{-1}$ [lb $ac^{-1}$]) for each event in each basin.

Each monitored basin included portions of two separately managed fields; therefore, manure application rates were adjusted to reflect rates for a basin scale, rather than a field scale (table 2). These adjusted rates, deemed "effective application rates," are field-application rates that account for the percent of each basin that received manure. For example, the effective application rate of a 20 ha (49.4 ac) field (within a 40 ha [98.8 ac] basin) that received manure on the entire field would be reported as half that of the actual field application rate.

Manure was surface applied to the fields by the producer at a time, rate, location, and method typical of his operation. Following is a brief synopsis of manure applications and some of the field conditions at the time of application during each study year. Additional details can be found in table 2.

- Some LDM was applied to basins A and B in September of 2003. Additional LDM was applied on frozen and snow-covered ground in February of 2004, less than one week before the start of snowmelt. Some LDM was applied to basin C in November of 2003, on top of frozen, but not snow-covered, ground.
- Some SBM was applied to all three basins in September and October of 2004. Some LDM was also applied to basin C in October of 2004. Basin C then received four separate, SBM applications on frozen and snow-covered ground in January and February of 2005. Some applications were made on top of melting snow.
- Some SBM was applied to basins A and B on frozen and snow-covered ground in early December of 2005 and early January of 2006. Basin C received only SBM in September and October of 2005.
- Some SBM was applied to all three basins in the fall and before the ground froze in mid-December of 2006. Basins A and B then received three spreader loads of SBM mixed with snow three days before runoff occurred in March of 2007.

Runoff depths and flow-weighted constituent concentrations (and thus constituent losses) were compared using nonparametric tests of data ranks among sets of data for each of the three basins within each year. Differences in depths and concentrations among the monitored basins were considered to be significant at $p < 0.05$. Only runoff events that were mutually common among all three basins were used in the statistical analyses. Typically, runoff events were defined from the time when runoff started to the time runoff ended, unless the event contained multiple peaks or lasted several days. In some of these cases, the event was subdivided to provide information regarding runoff volume and constituent-concentration changes throughout the event. Some small runoff events were not sampled, but sample volumes were computed; consequently, the number of values statistically compared for runoff volumes was greater than that for constituent concentrations. Unsampled events typically represented 6% or less of the total runoff volume measured in any FGP.

## Results and Discussion

***Precipitation and Surface Runoff.*** During winter 2003 to 2004, approximately 744 mm (29.3 in) of frozen precipitation fell on the basins. Using an averaged ratio of 14 in (355.6 mm) of snowfall to 1 in (25.4 mm) of liquid-water equivalent determined by Baxter et al. (2005), the liquid-water equivalent (WE) of this frozen precipitation was approximately 53 mm (2.1 in). An additional 127 mm (5.0 in) of rain fell on the basins when the ground was frozen. The approximate freeze/thaw dates extended from November 25, 2003, to March 25, 2004. This time frame represents the period in which the ground was persistently frozen at any measured depth. Five runoff events were induced by both snowmelt only and rain on snow during the FGPs between February 18 and 28, 2004 (figure 2a). Runoff depths of 32, 28, and 19 mm (1.26, 1.10, and 0.76 in) were recorded during this period for basins A, B, and C, respectively (table 3). This frozen period of runoff comprised nearly 60% of the total runoff volume monitored for the entire year (October 1, 2003, to September 30, 2004). Approximately 15% of the total precipitation that fell during the FGP was measured as runoff. Runoff depths were not significantly different among the three basins, even though basins A and B received LDM about five days before the start of runoff (tables 2 and 4).

During the winter of 2004 to 2005, approximately 925 mm (36.4 in) of frozen precipitation fell (WE = 66 mm [2.6 in]). Additional rainfall during this FGP totaled 66 mm (2.6 in). The approximate freeze/thaw dates extended from December 13, 2004,

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**Table 2**
Manure-application history for each of three monitored basins at a no-till farm in southwest Wisconsin, 2003 to 2007. All manure applications occurred between fall harvest and the end of each period of frozen-ground runoff.

| Basin name | Application date | Field name | Manure type | Analysis (g kg$^{-1}$ or g L$^{-1}$) N | P | K | Dry matter (%) | Application rate (kL ha$^{-1}$ or Mg ha$^{-1}$) | Area applied in basin (%) | Effective application rate (kL ha$^{-1}$ or Mg ha$^{-1}$)* |
|---|---|---|---|---|---|---|---|---|---|---|
| **Fall/winter 2003 to 2004** | | | | | | | | | | |
| A | 9/19/2003 | 160A | LDM | 2.3 | 0.3 | 1.5 | 5 | 40.2 | 66 | 26.7 |
| A | 2/14/2004 | 160A | LDM | 2.3 | 0.3 | 1.5 | 5 | 40.2 | 46 | 18.3 |
| B | 9/19/2003 | 160A | LDM | 2.3 | 0.3 | 1.5 | 5 | 40.2 | 77 | 31.1 |
| B | 2/14/2004 | 160A | LDM | 2.3 | 0.3 | 1.5 | 5 | 40.2 | 22 | 8.9 |
| C | Nov. 2003 | 160B | LDM | 2.3 | 0.3 | 1.5 | 5 | 65.5 | 76 | 50.1 |
| **Fall/winter 2004 to 2005** | | | | | | | | | | |
| A | 9/18/2004 | 160C | SBM | 10.6 | 3.3 | 7.3 | 25 | 5.4 | 34 | 1.8 |
| A | 10/6/2004 | 160A | SBM | 10.6 | 3.3 | 7.3 | 25 | 8.3 | 66 | 5.5 |
| B | 9/18/2004 | 160C | SBM | 10.6 | 3.3 | 7.3 | 25 | 5.4 | 22 | 1.2 |
| B | 10/6/2004 | 160A | SBM | 10.6 | 3.3 | 7.3 | 25 | 8.3 | 77 | 6.4 |
| C | 9/18/2004 | 160C | SBM | 10.6 | 3.3 | 7.3 | 25 | 5.4 | 22 | 1.2 |
| C | 10/9/2004 | 160B | LDM | 2.2 | 0.4 | 1.7 | 5 | 38.4 | 76 | 29.3 |
| C | 10/29/2004 | 160B | SBM | 10.6 | 3.3 | 7.3 | 25 | 16.0 | 51 | 8.1 |
| C | 1/1/2005 | 160B | SBM | 8.7 | 2.9 | 6.1 | 22 | 14.6 | 20 | 3.0 |
| C | 1/28/2005 | 160B | SBM | 8.7 | 2.9 | 6.1 | 22 | 14.6 | 15 | 2.2 |
| C | 2/12/2005 | 160B | SBM | 8.7 | 2.9 | 6.1 | 22 | 7.3 | 51 | 3.7 |
| C | 2/19/2005 | 160B | SBM | 8.7 | 2.9 | 6.1 | 22 | 11.2 | 39 | 4.4 |
| **Fall/winter 2005 to 2006** | | | | | | | | | | |
| A | 12/1/2005 | 160A | SBM | 8.7 | 2.9 | 6.1 | 22 | 5.6 | 33 | 1.9 |
| A | 1/1/2006 | 160A | SBM | 8.7 | 2.9 | 6.1 | 22 | 5.6 | 33 | 1.9 |
| B | 12/1/2005 | 160A | SBM | 8.7 | 2.9 | 6.1 | 22 | 5.6 | 39 | 2.2 |
| B | 1/7/2006 | 160A | SBM | 8.7 | 2.9 | 6.1 | 22 | 5.6 | 39 | 2.2 |
| C | Sep./Oct. 2005 | 160B | SBM | 8.7 | 2.9 | 6.1 | 22 | 20.2 | 76 | 15.4 |
| **Fall/winter 2006 to 2007** | | | | | | | | | | |
| A | 10/11/2006 | 160A | SBM | 8.8 | 3.4 | 5.4 | 30 | 8.3 | 33 | 2.7 |
| A | 10/28/2006 | 160A | SBM | 8.8 | 3.4 | 5.4 | 30 | 8.3 | 33 | 2.7 |
| A | 12/20/2006 | 160C | SBM | 8.8 | 3.4 | 5.4 | 30 | 8.3 | 34 | 2.8 |
| A | 3/6/2007 | 160A | SBM | — | — | — | — | 29.1 | 4 | 1.3 |
| B | 10/11/2006 | 160A | SBM | 8.8 | 3.4 | 5.4 | 30 | 8.3 | 39 | 3.2 |
| B | 10/28/2006 | 160A | SBM | 8.8 | 3.4 | 5.4 | 30 | 8.3 | 39 | 3.2 |
| B | 12/20/2006 | 160C | SBM | 8.8 | 3.4 | 5.4 | 30 | 8.3 | 22 | 1.8 |
| B | 3/6/2007 | 160A | SBM | — | — | — | — | 29.1 | 13 | 3.8 |
| C | 10/28/2006 | 160B | SBM | 8.8 | 3.4 | 5.4 | 30 | 9.6 | 76 | 7.4 |
| C | 12/27/2006 | 160C | SBM | 8.8 | 3.4 | 5.4 | 30 | 16.6 | 22 | 3.7 |

Notes: N = nitrogen. P = phosphorus. K = potassium. LDM = liquid-dairy manure. SBM = solid-beef manure with bedding corn stalks. — = manure analysis and percent dry matter not determined.

* Effective application rate is the application rate multiplied by the percentage of area applied within the basin.

to April 3, 2005. Twenty-two runoff events were recorded, totaling 111, 96, and 70 mm (4.38, 3.79, and 2.75 in) for basins A, B, and C, respectively. A majority of runoff occurred during rain on snow events on February 5 to 7 and February 13 to 15, 2005 (figure 2b). Approximately 70% of total precipitation that fell during the FGP was measured as runoff and comprised nearly 100% of the total monitored runoff for the entire year. This percentage was much greater than during the 2003 to 2004 FGP, possibly because a

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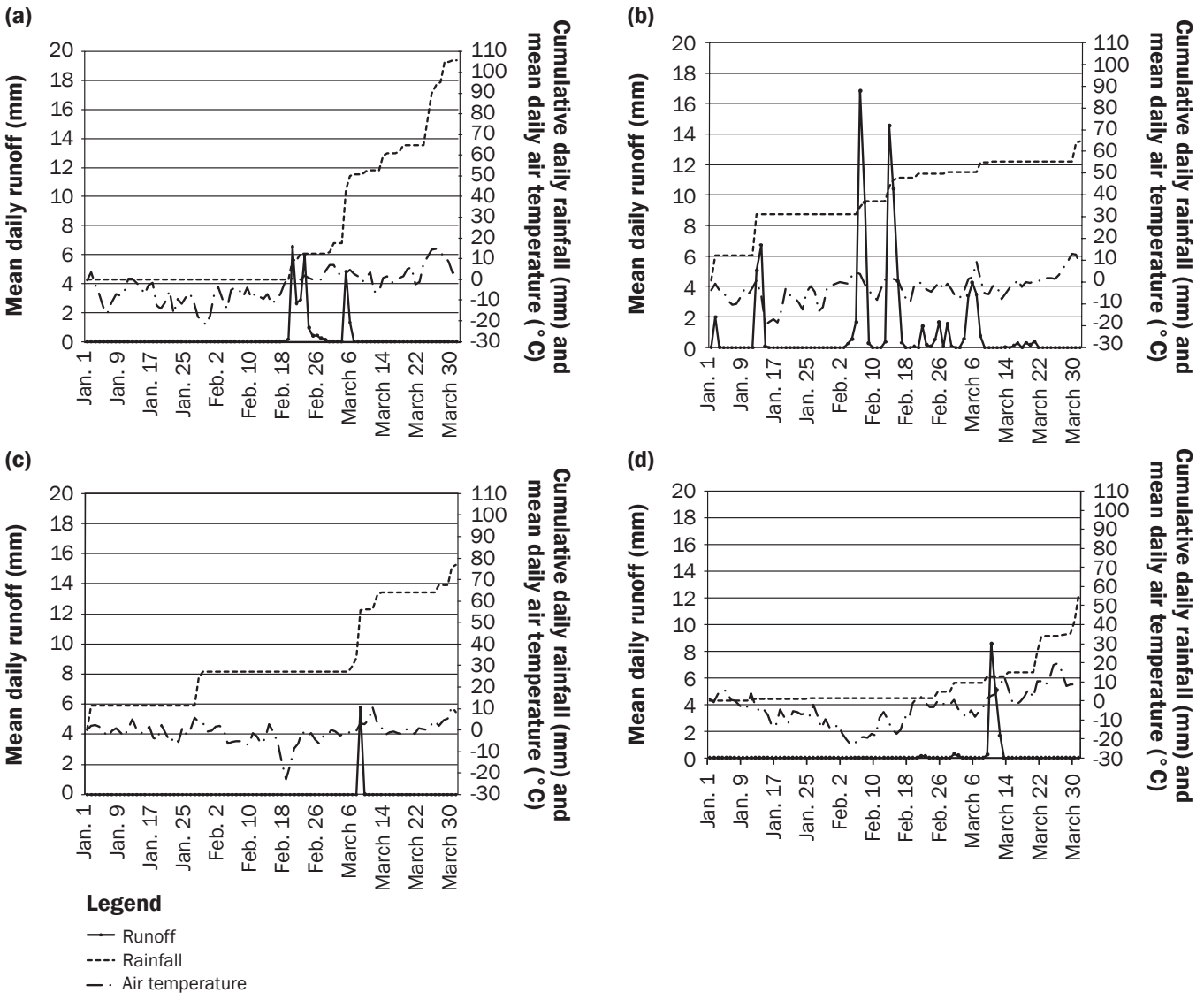
**Figure 2**

**Mean daily runoff, cumulative daily rainfall, and mean daily air temperatures from January 1 to March 31 for each of the monitored winter periods: (a) 2004, (b) 2005, (c) 2006, and (d) 2007. Date for frozen-ground periods preceding January 1 are not shown because no runoff occurred at any station. Fields were not necessarily frozen for the entire period shown for each year.**




particularly widespread ice layer had formed on the soil surface and limited infiltration. Runoff depths did not differ significantly among the three basins, even though basin C received multiple applications of SBM throughout the FGP, some on melting snow.

During the winter of 2005 to 2006, approximately 945 mm (37.2 in) of frozen precipitation fell (WE = 68 mm [2.7 in]). Rainfall during this FGP totaled 64 mm (2.5 in), and the approximate freeze/thaw dates extended from December 2, 2005, to March 26, 2006. Although precipitation amounts were similar to those in previous years, only one FGP runoff event occurred during a rain on snow event on March 8 to 9, 2006 (figure 2c). This event was the only runoff recorded for the entire year. An early snow pack formed in November and December, limiting soil frost development and possibly allowing increased infiltration. Approximately 5% of total precipitation that fell during the FGP was measured as runoff. No statistics were computed on the data for this FGP.

During the winter of 2006 to 2007, approximately 1,168 mm (46.0 in) of frozen precipitation fell (WE = 84 mm [3.3 in]). Rainfall during this FGP totaled 58 mm (2.3 in), and the approximate freeze/thaw dates extended from December 1, 2006, to March 24, 2007. Six runoff events were recorded, totaling 7, 15, and 27 mm (0.28, 0.60, and 1.06 in) for basins A, B, and C, respectively. A majority of runoff occurred on March 10 to 12, 2007, (figure 2d) which was almost exclusively from melting snow due to warm air temperatures. This runoff comprised about 80% of the total monitored runoff for the entire year. Approximately 12% of total precipitation that fell during the FGP was

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**Table 3**
Total runoff depth and mean flow-weighted concentrations of sediment, total nitrogen (TN), and total phosphorus (TP) in runoff during frozen-ground periods (FGP) for winters from 2003 to 2004 through 2006 to 2007.

| Basin name | Residue type* | Runoff (mm) | Sediment (mg $L^{-1}$) | TN (mg $L^{-1}$) | TP (mg $L^{-1}$) |
|---|---|---|---|---|---|
| **FGP winter 2003 to 2004 (*n* = 6 [runoff], *n* = 5 [constituents])** | | | | | |
| A | Corn/corn | 32.0a | 38.7a | 31.8c | 10.9c |
| B | Corn/corn | 27.9a | 80.7b | 21.2b | 8.4b |
| C | Corn/soybean-corn† | 19.3a | 17.0a | 3.8a | 2.3a |
| **FGP winter 2004 to 2005 (*n* = 22 [runoff], *n* = 9 [constituents])** | | | | | |
| A | Corn/soybean | 111.2a | 14.1a | 3.1a | 1.8a |
| B | Corn/soybean | 96.2a | 17.9a | 3.1a | 1.9a |
| C | Soybean-corn†/corn-soybean† | 69.8a | 45.1a | 11.5b | 5.8b |
| **FGP winter 2005 to 2006‡** | | | | | |
| A | Soybean/corn | 13.70 | 61.0 | 8.0 | 7.7 |
| B | Soybean/corn | <0.01 | <0.01 | <0.01 | <0.01 |
| C | Corn-soybean†/corn | 3.70 | 205.0 | 11.0 | 5.6 |
| **FGP winter 2006 to 2007 (*n* = 6 [runoff], *n* = 3 [constituents])** | | | | | |
| A | Corn/corn | 7.1a | 24.7a | 4.0a | 3.1a |
| B | Corn/corn | 17.0a | 32.4a | 7.8a | 6.7a |
| C | Corn/soybean-corn† | 27.0a | 248.1b | 5.7a | 3.6a |

Notes: Values within a column and year followed by the same letter are not significantly different at $p < 0.050$; letters correspond to nonparametric analysis based on data ranks rather than means as shown.

* Both the residue and the upcoming crop are listed. For example, corn/corn shows that the basin had corn removed in the previous fall (thus the residue) and is going back into corn the next spring.

† This basin contains two fields. The first residue type listed comprises 80% of the basin area, while the second listed comprises 20%.

‡ Statistics not computed.

measured as runoff. Surface runoff depths did not differ statistically among the three basins.

Runoff depths compared among each of the three basins were not different in any given year, despite each basin receiving different types of manure at varying rates and times. Other studies have shown decreased runoff due to manure applications (Ginting et al. 1998; Young and Holt 1977; Kongoli and Bland 2002). It is possible that the relatively low application rates used in this study were not great enough to affect runoff volumes.

Despite relatively similar precipitation amounts during each FGP, both the number and volume of runoff events varied greatly from year-to-year. From site observations, it appeared that runoff amounts were more related to the timing and type (snow/sleet/rain) of precipitation, intensity of precipitation (rainfall), air temperatures, and snow-pack properties such as depth, water equivalent, ice layers, and temperature, rather than soil temperatures or frost depth alone.

***Sediment.*** Mean flow-weighted concentrations of suspended sediment in runoff during FGPs were low, ranging between 7 and 248 mg $L^{-1}$ (table 3). Sediment losses during FGPs were also low, with each site typically having less than 22 kg $ha^{-1}$ (20 lb $ac^{-1}$) measured during any FGP (table 4). Sediment concentrations in basin B were significantly greater than in the other two basins during the 2003 to 2004 FGP, while concentrations in basin C were significantly greater than in the other two basins during the 2006 to 2007 FGP.

These differences were not associated with the presence or absence of LDM or SBM, nor were they influenced by the amount of runoff. Rather, basin-specific conditions were likely contributing factors. Greater concentrations in basin B during the 2003 to 2004 FGP were likely the result of terrace maintenance, and, to a lesser degree, to the reshaping of the waterway during the installation of the monitoring site in the fall of 2003. The greater concentrations in basin C during the 2006 to 2007 FGP were likely the result of soil erosion from end rows due to disturbance by farm equipment during harvest, which was observed at a location near the monitoring station. Regardless, the relatively low suspended sediment concentrations and losses observed are consistent with Hansen et al. (2000), who showed that wintertime runoff is not expected to cause significant soil erosion because of the slower rate of snowmelt compared to rainfall-induced runoff. Soil particles may also be less likely to become entrained in runoff when frozen together.

***Nitrogen.*** During the FGP of winter 2003 to 2004, mean flow-weighted concentrations and losses of TN in runoff from basin A were significantly greater than in basin B, and TN in both basins A and B was greater than in basin C (table 3, 4). Individual event-mean concentrations of TN ranged from 9.3 to 69.7 mg $L^{-1}$ in basins A and B and from 2.8 to 5.1 mg $L^{-1}$ in basin C. Total nitrogen losses ranged from 0.7 to 10.1 kg $ha^{-1}$ (0.6 to 9.0 lb $ac^{-1}$) among basins for the same period. These FGP losses comprised about 80%, 60%, and 40% of annual TN losses in basins A, B, C, respectively.

The greatest TN concentrations for the 2003 to 2004 FGP were observed during the onset of runoff in basins A and B and generally decreased over time. Total nitrogen concentrations were relatively constant throughout the runoff period in basin C. Although the amount of nitrogen applied in manure was relatively similar among the basins (table 4), basins A and B (which received LDM on top of snow, less than one week preceding snowmelt) exhibited significantly greater TN concentrations and losses. The greater concentrations observed in basin A compared to B are likely due to the greater effective application rate during the February 14, 2004, LDM application. These observations suggest that both the timing and amount of applied LDM were important factors for concentrations and losses of TN in runoff during FGPs.

Assuming that only nitrogen (N) from manure contributed to TN in runoff, TN losses from basins A, B, and C comprised 10%, 6%, and 1% of the TN that was applied after crop harvest (table 4). If only the TN added during the February LDM application to basins A and B was a significant TN component in runoff, 24% and 29% of this TN applied was measured in runoff, respectively. These percentages should be considered to be conservatively high since it was assumed

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**Table 4**

Suspended sediment, total nitrogen (TN), and total phosphorus (TP) losses in runoff; nutrients applied in manure and the percentage of those nutrients measured in runoff; and days between manure application and runoff during frozen-ground periods (FGP) for winters from 2003 to 2004 through 2006 to 2007. Calculated percentages assume that only nutrients applied in manure contributed to runoff.

| | Runoff losses (kg ha$^{-1}$) | | | Total nutrients applied in manure (kg ha$^{-1}$) | | | | | Nutrients in manure applied on snow only (kg ha$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Basin name | Suspended sediment | TN | TP | Manure type | N | Applied N in runoff (%) | P | Applied P in runoff (%) | Manure type | N | Applied N in runoff (%) | P | Applied P in runoff (%) | Days between last manure application and first runoff event |
| **FGP winter 2003 to 2004** | | | | | | | | | | | | | | |
| A | 12.3 | 10.1 | 3.5 | LDM* | 103 | 10 | 15 | 24 | LDM* | 42 | 24 | 6 | 62 | 4 |
| B | 22.7 | 5.9 | 2.4 | LDM* | 92 | 6 | 13 | 18 | LDM* | 20 | 29 | 3 | 70 | 6 |
| C | 3.3 | 0.7 | 0.4 | LDM* | 114 | 1 | 17 | 2 | na | na | na | na | na | 88 |
| **FGP winter 2004 to 2005** | | | | | | | | | | | | | | |
| A | 15.7 | 3.4 | 2.0 | SBM† | 77 | 4 | 24 | 9 | na | na | na | na | na | 88 |
| B | 17.2 | 3.0 | 1.8 | SBM† | 81 | 4 | 25 | 7 | na | na | na | na | na | 87 |
| C | 31.5 | 8.0 | 4.0 | Both | 279 | 3 | 80 | 5 | SBM† | 116 | 7 | 38 | 11 | 0 |
| **FGP winter 2005 to 2006** | | | | | | | | | | | | | | |
| A | 8.4 | 1.1 | 1.1 | SBM† | 33 | 3 | 11 | 9 | SBM† | 33 | 3 | 11 | 9 | 67 |
| B | <0.01 | <0.01 | <0.01 | SBM† | 38 | <1 | 12 | <1 | SBM† | 38 | <1 | 12 | <1 | 67 |
| C | 7.5 | 0.4 | 0.2 | SBM† | 135 | <1 | 45 | <1 | na | na | na | na | na | 159 |
| **FGP winter 2006 to 2007** | | | | | | | | | | | | | | |
| A | 1.8 | 0.3 | 0.2 | SBM | 73 | <1 | 28 | <1 | SBM | ‡ | ‡ | ‡ | ‡ | 3 |
| B | 5.0 | 1.3 | 1.1 | SBM | 72 | 2 | 28 | 4 | SBM | ‡ | ‡ | ‡ | ‡ | 4 |
| C | 67.0 | 1.5 | 1.0 | SBM† | 96 | 2 | 38 | 3 | na | na | na | na | na | 56 |

Notes: na = not applicable. N = nitrogen. P = phosphorus.

* Liquid-dairy manure (LDM), average analysis 2.3 g L$^{-1}$ nitrogen, 0.8 g phosphorus oxide L$^{-1}$, 1.9 g potassium oxide L$^{-1}$, and 5% dry matter.

† Solid-beef manure (SBM) with bedding corn stalks, average analysis 9.3 g N kg$^{-1}$, 7.2 g phosphorus oxide kg$^{-1}$, 7.4 g potassium oxide kg$^{-1}$, and 30% dry matter.

‡ The amount of total nutrients applied on snow is unknown but is assumed to be relatively small.

that no N sources other than manure were significant contributors.

During the FGP of winter 2004 to 2005, concentrations and losses of TN in runoff from basin C were significantly greater than those in basins A and B. Individual event-mean concentrations of TN ranged from 3.3 to 23.8 mg L$^{-1}$ in basin C and from 1.7 and 7.4 mg L$^{-1}$ in basins A and B. The greatest TN concentrations in basin C occurred during runoff periods in which SBM was recently applied on top of melting snow. This suggests that the timing of applied SBM was also an important factor for TN losses in runoff. The TN losses recorded during this FGP ranged from 3.0 to 8.0 kg ha$^{-1}$ (2.7 and 7.1 lb ac$^{-1}$) and comprised nearly 100% of the TN measured for the entire year in each basin. Assuming that only N from manure contributed to TN in runoff, TN losses from basins A, B, and C comprised 4%, 4%, and 3% of the TN that was applied in manure after crop harvest, respectively. If only the N added to basin C during the January and February SBM applications was a significant TN component in runoff, 7% of this TN applied was measured in runoff. This percentage was lower than the one for the LDM applied shortly preceding snowmelt to basins A and B during the FGP of winter 2003 to 2004, even though approximately four times more TN was applied and runoff was over twice as great. While the application of LDM or SBM to frozen and snow-covered ground shortly preceding snowmelt increased TN concentrations and losses in runoff, these observations suggest that contributions to runoff from the application LDM may be greater than those for SBM applied at similar rates, times, and field conditions.

Despite the fact that SBM was applied to basins A and B shortly preceding runoff during the 2006 to 2007 winter, TN concentrations and losses were not significantly different among basins. This is possibly due to the fact that only a small amount of TN in SBM (actual amount applied was unknown, but observations indicated that the application was a mixture of manure and snow) was applied to basins A and B, which suggests that the rate of SBM applied can also impact TN concentrations and losses. Individual event-mean concentrations in runoff ranged from 3.0 to 8.9 mg L$^{-1}$ among the basins, with measured TN losses comprising less than 2% of that applied in manure. Total nitrogen losses during this FGP comprised about 50%, 100%, and 70% of annual TN losses in basins A, B, C, respectively.

The forms of N can be used to help evaluate the potential impacts of manure applications to the environment that are not necessarily described by TN alone. Nitrogen inputs—particularly nitrate-nitrogen—to water bodies limited by N are a well-documented concern (Cerco 1995; Rabalais et al. 2001, 2002). Another concern is N toxicity to fish and other aquatic organisms. Toxic forms of N to aquatic species include unionized ammonia and the ammonium ion (USEPA 1999). Ammonia is generally considered to be more toxic, with

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the degree of toxicity primarily dependent upon pH and temperature. Ammonium nitrogen (ammonium N) reported in this article is the total concentration reported for the sum of both unionized ammonia and ammonium ion. Actual amounts of unionized ammonia were not calculated because pH and temperature were not measured.

The highest mean flow-weighted concentrations of ammonium N occurred during the FGP of winter 2003 to 2004 (table 5). Individual event-mean concentrations of ammonium N during this period ranged from 1.6 to 43.6 mg $L^{-1}$ at basin A and from 1.2 to 18.6 mg $L^{-1}$ at basin B. Each basin received LDM on frozen and snow-covered ground shortly preceding runoff. In basin A, event-mean concentrations exceeded 20 mg $L^{-1}$ for several events on consecutive days when manure was observed in the runoff water. The highest ammonium N concentrations during these events were often associated with high organic-N concentrations but relatively low nitrate plus nitrite N concentrations. Ammonium N concentrations in runoff ranged between 0.1 and 1.4 mg $L^{-1}$ at basin C, which received only LDM in November 2003 on top of frozen—but not snow-covered—ground. At the onset of runoff in this basin, the LDM had been applied to the basin for nearly three months.

During the FGP of winter 2004 to 2005, mean flow-weighted concentrations of ammonium N in basin C were not as high as those from basins A and B during the previous winter. Individual event-mean ammonium N concentrations were also lower in basin C, ranging from 0.4 to 9.5 mg $L^{-1}$. These lower concentrations occurred despite the fact that basin C received SBM on top of frozen and snow-covered ground shortly preceding runoff and that approximately four times more N was applied in the SBM application than the LDM application the previous year. The lower ammonium N concentrations could have been the result of dilution by greater runoff volumes, different runoff conditions, and/or by inherently lower ammonium N concentrations in the SBM compared to the LDM.

***Phosphorus.*** The total phosphorus (TP) concentrations and losses in runoff during FGPs and the relations between these losses and manure applications were similar to those for TN. During the FGP of winter 2003 to 2004, mean flow-weighted concentrations and losses of TP in runoff from basin A were significantly greater than in basin B, and TP in both basins A and B was greater than in basin C (tables 3 and 4). Individual event-mean TP concentrations ranged from 2.7 to 28.3 mg $L^{-1}$ in basins A and B and from 1.6 to 3.2 mg $L^{-1}$ in basin C. As was the case for TN, the timing of the LDM application was likely an important factor for greater concentrations and losses of TP in runoff during FGPs. Also, the greater effective application rate of LDM in basin A on February 14, 2004, likely increased TP concentrations and losses compared to those in basin B.

Assuming that only P from manure contributed to TP in runoff, TP losses from basins A, B, and C measured 24%, 18%, and 2% of the P that was applied in manure after crop harvest. If only the P added during the February LDM application to basins A and B was a significant TP component in runoff during the FGP of the winter of 2003 to 2004, 62% and 70% of TP applied was measured in runoff, respectively. These percentages should be considered to be conservatively high since it was assumed that no P sources other than manure were significant contributors. Total phosphorus measured in runoff during this FGP comprised about 80%, 66%, and 54% of the annual TP losses in basins A, B, and C, respectively.

During the FGP of the winter of 2004 to 2005, concentrations and losses of TP in basin C were significantly greater than in basins A and B. Individual event-mean TP concentrations ranged from 1.0 to 4.8 mg $L^{-1}$ in basins A and B and from 2.3 to 11.2 mg $L^{-1}$ in basin C. The timing of SBM application in relation to runoff was likely an important factor for these greater concentrations and losses. As with TN, the losses during this FGP comprised nearly 100% of the TP losses measured for the entire year. Assuming that only P from manure contributed to P in runoff, TP losses from basins A, B, and C measured 9%, 7%, and 5% of the TP that was applied in manure after crop harvest, respectively. If only the TP added during the January and February SBM applications to basin C was a significant TP component in runoff during this FGP, 11% was measured in runoff. This percentage was lower than for the LDM applied shortly preceding snowmelt to basins A and B during the FGP of winter 2003 to 2004, even though approximately eight times more TP was applied and runoff was over twice as great. Similar to the findings for TN, these observations suggest that the TP contributions to runoff from the application of LDM may be greater than those for SBM applied at similar rates, times, and field conditions.

Total phosphorus concentrations and losses were not significantly different among basins for the monitored runoff events dur-

**Table 5**
Mean flow-weighted concentrations of nitrogen and phosphorus species in runoff during frozen-ground periods (FGP) for winters from 2003 to 2004 through 2006 to 2007.

| | Nitrogen | | | Phosphorus | |
|---|---|---|---|---|---|
| Basin name | Nitrate plus nitrite N (mg $L^{-1}$) | Ammonium N (mg $L^{-1}$) | Organic N (mg $L^{-1}$) | Dissolved reactive P (mg $L^{-1}$) | Particulate P (mg $L^{-1}$) |
| **FGP winter 2003 to 2004** | | | | | |
| A | 2.0 | 12.2 | 17.5 | 8.2 | 2.7 |
| B | 0.8 | 9.9 | 10.5 | 6.7 | 1.8 |
| C | 1.6 | 0.4 | 1.9 | 2.0 | 0.3 |
| **FGP winter 2004 to 2005** | | | | | |
| A | 0.9 | 0.7 | 1.5 | 1.8 | 0.0 |
| B | 1.0 | 0.8 | 1.3 | 1.9 | 0.0 |
| C | 0.6 | 1.9 | 9.0 | 5.2 | 0.5 |
| **FGP winter 2005 to 2006** | | | | | |
| A | 2.1 | 1.7 | 4.2 | 6.6 | 1.1 |
| B | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| C | 1.3 | 0.8 | 8.9 | 3.2 | 2.4 |
| **FGP winter 2006 to 2007** | | | | | |
| A | 0.6 | 1.0 | 2.5 | 1.5 | 1.6 |
| B | 0.3 | 3.2 | 4.3 | 6.5 | 0.2 |
| C | 0.9 | 1.9 | 2.9 | 3.1 | 0.5 |

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ing the FGP of winter 2006 to 2007, which is most likely a result of only a relatively small amount of TP being applied in basins A and B shortly preceding runoff. This result suggests that SBM applications made prior to the FGP can result in lower TP concentrations and losses in runoff compared to applications made to frozen and snow-covered ground shortly preceding runoff. Concentrations in runoff ranged from 0.6 to 7.3 mg $L^{-1}$ among the basins, with measured TP losses in runoff being 4% or less of that applied in manure. The TP losses during this FGP comprised 76%, 100%, and 78% of the annual TP losses in basins A, B, and C, respectively.

Differentiating between P forms in runoff can help managers to determine the potential impacts on aquatic resources and the best ways to mitigate these impacts. Approximately 75% of all TP measured in runoff during the FGP of the winter of 2003 to 2004 was dissolved reactive phosphorus, and greater than 90% of dissolved reactive phosphorus was measured for the FGP of winter 2004 to 2005 (table 5). On average, dissolved reactive phosphorus accounted for over 80% of all P measured in runoff during FGPs throughout the study period. Variations in P (and dissolved reactive phosphorus) concentrations and losses measured in runoff were likely related to the timing, rate, and form of manure applications, characteristics of runoff, and field condition at the time of runoff—not just soil-test P values alone. These results are supported by other studies that have shown soil-test P to be a good indicator of the potential for dissolved P to be lost in runoff, except when manures are applied (Vadas et al. 2005a, 2005b; McDowell and Sharpley 2002). In this study, soil-test P values were relatively similar among the three basins, yet dissolved reactive phosphorus in runoff was wide-ranging.

## Summary and Conclusions

Nutrients and sediment in surface runoff from frozen agricultural fields were monitored within three small (16.0 ha [39.5 ac] or less), adjacent basins at a no-till farm in southwest Wisconsin during four winters from 2003 to 2004 through 2006 to 2007. Runoff depths and flow-weighted constituent concentrations were compared to determine the impacts of surface-applied LDM or SBM to frozen and/or snow-covered ground.

Average runoff volumes were highly variable among years, but runoff depths were not significantly different among basins within each FGP. Neither the type of manure nor the rates of application significantly affected runoff volumes. Runoff was more likely related to the form, timing, and intensity of precipitation (rainfall), air and soil temperatures, and snow-pack properties, such as depth, water equivalent, and temperature. Runoff during FGPs comprised from 60% to 100% of the total runoff measured within any given year. Most FGP runoff occurred in February and/or March.

Sediment concentrations and losses in runoff during the FGPs were low (generally less than 22 kg $ha^{-1}$ [20 lb $ac^{-1}$] in any year). Any nutrients associated with sediment particles were therefore also low. Although statistical comparisons showed that suspended sediment concentrations and losses occasionally differed among basins within a given year, these differences were not related to the presence or absence of LDM or SBM, nor were they influenced by the amount of runoff. Rather, localized in-field conditions were likely contributing factors.

Concentrations and losses of nitrogen and phosphorus were significantly greater in basins that had either LDM or SBM applied to frozen and snow-covered ground less than one week preceding runoff. These increases occurred despite relatively low manure-application rates. Lower concentrations and losses were measured in basins that had manure applied in fall and early winter and an extended period of time (months) had elapsed before runoff. Nutrient losses measured in runoff during the FGPs were substantial, accounting for 40% to 100% of the annual total nitrogen and TP losses in any given year. Greater than 80% of all P measured in runoff during FGPs was dissolved.

The application of manure to cropped fields during FGPs is part of the management strategy for many livestock producers in continental-climate regions. The results of this study indicate that both LDM and SBM applied to frozen and snow-covered fields less than one week preceding runoff can significantly contribute to nitrogen and phosphorus losses in runoff. Future research targeted at defining the relationships between the timing of manure applications and the amount of nutrients in runoff would allow for determining suitable application periods or field conditions that would potentially minimize nutrient contributions to runoff from agricultural fields. Additional research examining the differences between applications rates and methods, cropping types and/or tillage types, and more detailed analysis of the impacts of different manure types would enable manure-management guidance among different producer types and management styles.

## Acknowledgements

The authors would like to thank the farm family for access and for generous offerings of their time and equipment. Discovery Farms staff—Kevan Klingberg, Susan Frame, and Tim Popple—were instrumental in providing on-farm information. Funding was also provided by the Wisconsin Milk Marketing Board, Wisconsin Dairy Business Association, Wisconsin Farm Bureau, Professional Dairy Producers of Wisconsin, Wisconsin Pork Producers Association, and the Natural Resources Conservation Service. Further thanks are extended to Dave Owens (US Geological Survey) for technical assistance.

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Appendix D:7

January 2014

# Considerations for MID AND LATE WINTER manure applications

Winter in Wisconsin is unpredictable. We can expect some combination of snow, frozen ground, ice, warmer periods and even a bit of rain on any given year. Every year, details about how much and when runoff water moves across the land differ slightly. Factors including soil and landscape, influence the volume and timing of runoff, but weather conditions in the local area play the most significant role.

The UW-Discovery Farms Program has monitored enough locations and conditions to show that when manure is applied one week or less before a runoff event, losses of nitrogen and phosphorus are significantly increased even with relatively low application rates. This article outlines the key factors for runoff during the mid and late winter season of February, March, and even April. Farmers should be aware of these conditions and continually assess the situation in their fields before spreading manure.

## Factors for runoff

- *Warming temperatures and more intense solar radiation.* Pay attention to the amount of snowpack present and the weather forecast. A rapid and dramatic temperature increase, clear sunny skies or a layer of ice over the soil often lead to higher runoff volumes during the winter months. However, a deep snowpack doesn't always mean that a large amount of that water will end up as surface runoff. Conditions that encourage infiltration of melting snow include the absence of concrete frost in the soil, temperatures just above freezing during the day and cooler at night and foggy or overcast conditions. If you must spread manure during these months, look ahead in the forecast for days that favor infiltration (instead of runoff) of melting snow.

- *Rain on frozen/snow-covered ground.* Rain events during the winter time have a strong potential to quickly generate surface runoff. The rain causes snow to rapidly melt from the top of the snowpack first, leaving little chance for infiltration into the soil. If rain occurs on frozen ground with no snow, concrete frost in the top several inches of the soil can inhibit water from entering the soil profile. Discovery Farms data shows that almost all winter runoff events in December and January (75%) are the result of a rain event on frozen or snow-covered ground. During February and March, warmer temperatures during the day lead to more frequent rain events than earlier in the winter. Pay special attention to whether rain is forecasted within the week, as even a small amount of rain (less than ¼ of an inch) can cause runoff when the ground is frozen or snow covered.

- *Concrete frost or ice crust.* The amount and type of frost present in the soil is one of the primary factors that influence the amount of surface runoff generated by snowmelt or winter rain events in any given year. These conditions in the soil vary widely across the state, and even in your local area. Whether it is solidly frozen soil, referred to as concrete frost or a layer of ice on the soil surface, rain, melting snow, or manure from a recent application cannot infiltrate into the soil in these conditions. Some evidence exists that fields with vegetative cover through the winter freeze less solidly. In a must-spread situation, try to target fields that have had vegetative cover throughout the winter and try to get the manure onto the ground surface if possible when a snowpack is present.

- *Saturated soil.* It is impossible to know exactly when the ground will finally thaw, but usually the soil conditions during this transition switch from frozen to saturated just as the rainy spring starts. Aside from February and March, the spring months of May and June are the biggest contributors to the annual runoff total. Soil moisture is a primary factor influencing runoff. When soil is at or near saturation, additional water from precipitation or liquid manure application cannot infiltrate, and thus begins to run off from the soil surface. Logistically, this time when the soil is saturated makes it hard to bring equipment out to the field. There is increased risk of soil compaction, causing ruts in the field, or even getting stuck. Targeting fields that are relatively flat and dry out more quickly are good ways to manage your runoff risk when saturated soil conditions are present.

## Management Recommendations

It is clear that late winter is when most of the annual runoff in Wisconsin occurs. Therefore, timing of manure applications during this time period can be tricky. For farmers with storage, make sure that your storage is empty enough earlier in the winter to avoid spreading in February and March. If you don't have storage or must spread to avoid an overflowing storage, work with your advisors to identify the low risk fields for this high risk time period and watch the weather for a rain or melt event in the forecast. If possible, find areas with little snow cover or plow an area to try and get the manure as much contact with the soil as possible.

Don't start planning for winter manure application in February. Start tweaking your system and develop a strategy much earlier so that if an emergency situation arises, you have gone the extra mile to protect yourself and the water quality around your farm as much as possible. The key to reducing nutrient loss during winter manure application is to understand the local conditions and have a winter spreading plan in place.

**For more information, visit our website: www.uwdiscoveryfarms.org**

**Additional resources available on UW Discovery Farms website:**

Considerations for early winter applications of manure. November 2013

Komiskey, M.J., Stuntebeck, T.D., Frame, D.R., and Madison, F.W., 2011, Nutrients and sediment in frozen-ground runoff from no-till fields receiving liquid-dairy and solid-beef manures: Journal of Soil and Water Conservation, v.66.

Riechers Beef 7. Manure Applications on Frozen and/or Snow Covered Ground

Appendix D:8

# Manure Applications on Frozen and/or Snow Covered Ground – 7

Dennis Frame, Tim Radatz, and Amber Radatz
UW - Extension / UW - Discovery Farms

## Introduction

Managing manure applications during the frozen ground period is essential to reducing the loss of nutrients. As a state annual average, we lose about 8% of precipitation or 2.55 inches of water as surface runoff each year. Water-quality data collected through the Discovery Farms Program show that at least 50% of runoff occurs on frozen ground, even though precipitation is much greater during the non-frozen period. Monthly runoff was highest during 2 time periods: February - March, and May - June. This paper provides background on the issues, challenges and potential opportunities involved with manure application during frozen or snow covered ground periods.

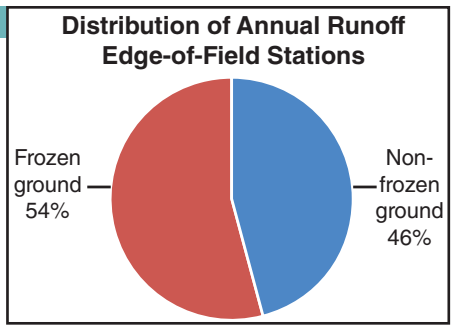


**Figure 1. Runoff distributuion 2003–08**

Riechers and other Discovery Farms sites clearly show that runoff volumes at the end of the winter months contribute an important amount of runoff. At this farm, runoff from frozen ground/snowmelt conditions contributed 80% of the total annual surface runoff (Figure 2), though only 10% of the annual precipitation occurred during this time. Frozen ground runoff was observed every year, but the contribution and timing was extremely unpredictable and varied from year to year depending on snowpack depth, rate of snowpack melt, frost depth, and rainfall amount on frozen or snow covered ground. On average, there were 11 runoff events/site/year and runoff was recorded on 7% of the days monitored (25.5 days each year).

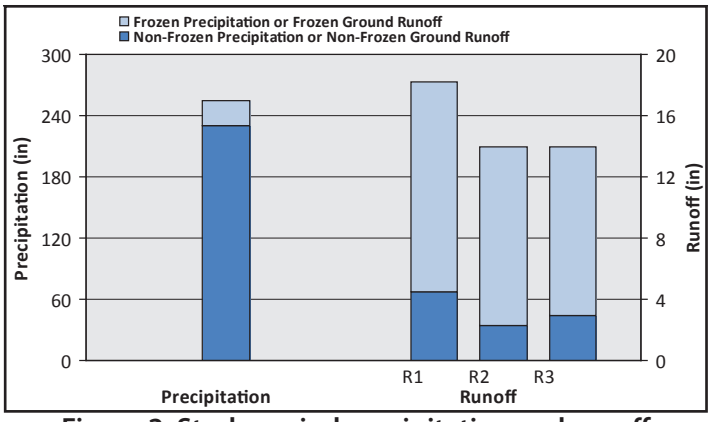


**Figure 2. Study period precipitation and runoff**

## Manure on frozen ground

Wisconsin livestock operations apply manure in the winter months for a variety of reasons. One of the main reasons is animal health and welfare. Animals can handle most cold weather as long as they are dry and clean. Keeping animals dry, clean and providing them some sort of wind protection is crucial in northern climates. Manure applications also happen when farmers have time. The period after harvest and before spring planting is often when farmers have the most time available to properly apply manure that has been stored through the growing season. Another advantage to applying manure while the ground is frozen is that it reduces the chance of soil compaction. Soil compaction can result from heavy machinery or intense animal hoof traffic compressing wet soil. It can reduce yields and increase runoff.

Manure application and handling has changed and improved over the last several decades. When it was necessary to haul manure every day, inclement weather forced operators to spread most of the winter manure on fields close to the barn, as extremely cold weather caused issues like frozen manure in the spreader. It is important to understand critical risk periods and take care to avoid applying manure during high risk periods. Spreading a load of manure every day did not provide options to spreading in high risk conditions, but the areas applied were small. Today, with larger volumes of manure applied at once, it is critical for farmers to avoid and manage for high risk time periods. Factors that increase the risk for frozen ground runoff include the amount of snowpack present, the speed at which it melts, and the amount and type of frost present in the soil. Managers should look for a rapid and dramatic temperature increase, clear sunny skies or a layer of ice over the soil as conditions that could lead to high runoff volumes during the winter months. Rain events cause snow to rapidly melt, leaving little chance for infiltration into the soil. Establishing a time period allowing or disallowing manure spreading based on the variable nature of weather, and therefore, runoff will not eliminate risk of nutrient loss.

## Runoff and winter manure applications

For information on losses at Riechers Beef, please review fact sheets 4 (sediment) & 5 (nutrients) in the report series. On this farm, 80% of the phosphorus loss occurred in February and March (Figure 3). There are two reasons for this:

- ➢ The farming system improved soil infiltration so that very little runoff occurred during non-frozen soil months,
- ➢ Losses were influenced by manure applications done either immediately preceding or during the snow melt period.

Winter manure applications occurred each year of the 7 year study period. Annual phosphorus losses ranged from 0.0 to 5.3 lb/ac (Figure 4). Phosphorus losses were higher in FY04, FY05 and FY09 and lower in FY06 and FY07. During the years with higher losses, a manure application was made during or shortly preceding runoff events in the winter.

In FY04, liquid dairy manure was surface applied in November at R3 and in September and February at R1 and R2. The manure application (February) at R1 and R2 occurred only five days before a significant runoff event. Phosphorus losses were five times greater at R1 and R2 compared to R3 for the entire year. The majority of the FY04 phosphorus loss difference between R1/R2 and R3 can be attributed to the February runoff time period. In FY05, solid beef manure was surface applied in September and October at R1 and R2 and September, October, January, and February at R3. The February manure application at R3 occurred during a snowmelt runoff event. Phosphorus losses for FY05 were two to three times greater at R3 compared to R1 and R2 and most of this disparity can be attributed to the February runoff events. In FY09, solid beef manure was applied shortly before runoff in February at R1 and R3, but not at R2. Phosphorus and nitrogen loss at R1 and R3 were two to four times greater than at R2 for FY09, again because of the February runoff events.

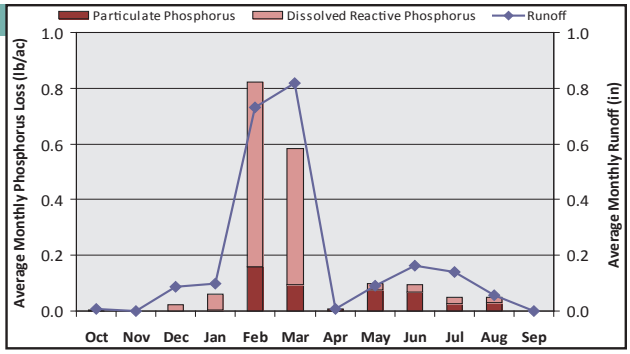


**Figure 3. Average monthly phosphorus loss**

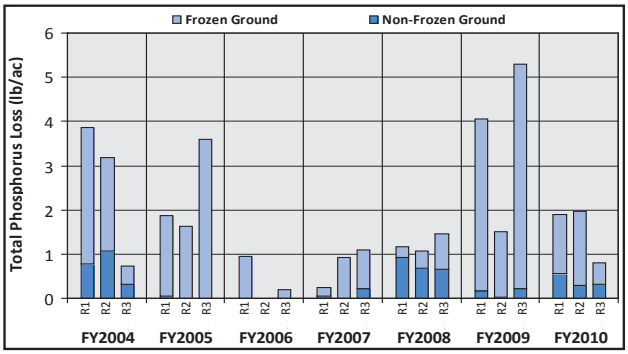


**Figure 4. Annual phosphorus losses**

## Conclusions

In Wisconsin and surrounding states, frozen soil and snow cover can be a challenge for completing field operations such as manure application. The option to spread manure while the soil is frozen but runoff is not imminent can improve farm management and animal health. Managers must understand the conditions that lead to increased nutrient loss and avoid application or find areas with the lowest risk. Manure applied on or immediately preceding snow melt can have a negative effect on the water quality. The type of manure (liquid dairy or solid beef) did not affect nutrient losses and the rate of application was well within (or below) the recommended rates. The key factor in these runoff events was the timing of the applications.

When winter manure was applied and no runoff occurred until several months/weeks after the application, the impact on nutrient losses was reduced. When applications are made during early winter or when low risk conditions exist, there is less risk of nutrient loss than from applications made during spring (saturated soil/intense storm conditions). Those considering rules and regulations on manure applications on frozen and/or snow covered ground need to evaluate the risks associated with winter spreading, and the risks associated with manure applications in the spring. Manure is a valuable source of organic matter and nutrients, and the proper use and applications can assist in improving overall farm sustainability. Manure application is a necessary practice and it has many benefits. However, over applications of manure and applications of manure at improper times can pose an unacceptable environmental risk.

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This brief is part 7 of 9 that can be found along with the rest of the information on Riechers Beef at: www.uwdiscoveryfarms.org or by calling the UW-Discovery Farms Office at 715-983-5668.

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Appendix D:9

## Considerations for early winter applications of manure

November 2014

Farms with livestock have the unique advantage of producing a valuable by-product, manure, which has many of the nutrients required for crop production. However, in order for these nutrients to be available to support crop growth, manure has to be applied with consideration for timing, method, and rate. While all these factors are important, properly timing manure application is critical to reducing nutrient loss from fields.

Data gathered by UW Discovery Farms shows that when manure is applied one week or less before a runoff event, the losses of nitrogen and phosphorus are significantly increased even with relatively low application rates. When manure applications are made several weeks or months before runoff occurs, nutrient losses can be reduced by as much as 50 to 75 percent. Understanding the conditions that increase the risk of nutrient loss can help farmers better manage manure throughout the year.

Spreading manure in the winter has unique challenges. Weather conditions that greatly increase the risk of loss include: the presence of concrete frost, development of an ice crust on the soil surface, and the amount and condition of the snow cover. In the late fall and early winter (October - December) in Wisconsin, fields are often harvested and may be frozen. However, there typically is not significant snow cover, concrete frost, or ice crusted soil that is common in late winter. Manure applied during the time period before these conditions develop has a lower chance of losing nutrients through surface runoff than applications made later in the winter (February - March).

**Management recommendations for this time period.** Farmers with manure storage capacity of three months or more should use the early winter period to make sure that the storage is empty enough to prevent a 'must spread' situation until early April. Farms with limited or no storage should use the early winter period to spread on riskier fields on the farm and save the less risky fields for the later winter, and high runoff, months of February and March. Regardless of whether your farm has storage or not, having a manure spreading plan that outlines the most and least risky fields is important for all periods of the year.

**Concrete frost.** "Concrete frost" is commonly used to describe a condition when most of the pore space in the surface of the soil is occupied by frozen water. During conditions when snow melts or rain falls in the winter, the water on the soil surface begins to infiltrate the soil and then is frozen when it reaches the frost layer below. In some situations, the upper profile of the soil becomes nearly saturated with water which freezes during the night when temperatures drop below freezing.

Concrete frost decreases the soil's ability to infiltrate water and nutrients or bind with applied manure (the soil is less porous - like concrete). It takes higher temperatures and a longer time to thaw concrete frost compared to frost formed in unsaturated soils. Weather patterns including multiple thaws with melting snow or winter rain events result in substantial development of concrete frost throughout Wisconsin.

**Ice crust.** While concrete frost can form under a snowpack or on bare soil, ice crusts are formed when rain falls on soils that are very cold. Most commonly, we see crusts develop when rain falls on soils without snow cover. Ice crusts over an inch thick have been observed, but any thickness of ice prevents proper contact of manure to the soil.

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**Amount and condition of snow cover.** There are two important factors to consider when evaluating the risk of manure applied on snow. First, take a look at how much snow is present. If there is more than 6-12 inches in the area you are planning to spread, the manure will not be able to come into contact with the soil. UW Discovery Farms data has shown that manure applied on top of a few inches of snow, especially in the early winter months, does not typically increase the risk of nutrient loss. This is because the manure achieves good soil contact and nutrients can attach to the soil as the sun radiates heat on the dark manure, slowly melting the snow. As the wintertime months progress and the snowpack becomes more dense or concrete frost develops in the soil, the potential for nutrient loss increases. In general, less snow on an area means a better chance for manure to bind with soil and stay in the field when runoff events happen later in the season.

Snow depth is not always a good indicator of the amount of water in the snowpack. During the early winter months, the snow is often light, easily blown around, and not densely packed. On the other hand, the snowpack in late winter or early spring has often undergone some thawing cycles and is typically more dense. A manure application on a few inches of light snow is less risky than the same application on a dense snow pack or slush. Manure applied on dense snow pack or slush has very little chance of binding with the soil before runoff occurs.

Concerns with winter spreading can be addressed if farmers understand the risks associated with varying soil conditions and consider weather forecasts prior to spreading on frozen ground. Spreading just before snowmelt or a winter rain event significantly increases the risk of manure and nutrient movement. Manure applications should also be avoided on deep and/or dense snowpack or if concrete frost or ice crusting of the soil is evident. This is not always possible, so applications made during these conditions should be done on internally drained fields (closed depressions) or low sloped (flat) fields to minimize the potential for loss. The key to reducing nutrient loss during winter manure application is to understand the local conditions and have a winter spreading plan in place.

Resources (available on UW Discovery Farms website):

Komiskey, M.J., Stuntebeck, T.D., Frame, D.R., and Madison, F.W., 2011, Nutrients and sediment in frozen-ground runoff from no-till fields receiving liquid-dairy and solid-beef manures: Journal of Soil and Water Conservation, v.66.

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# Appendix E

# Appendix E:1

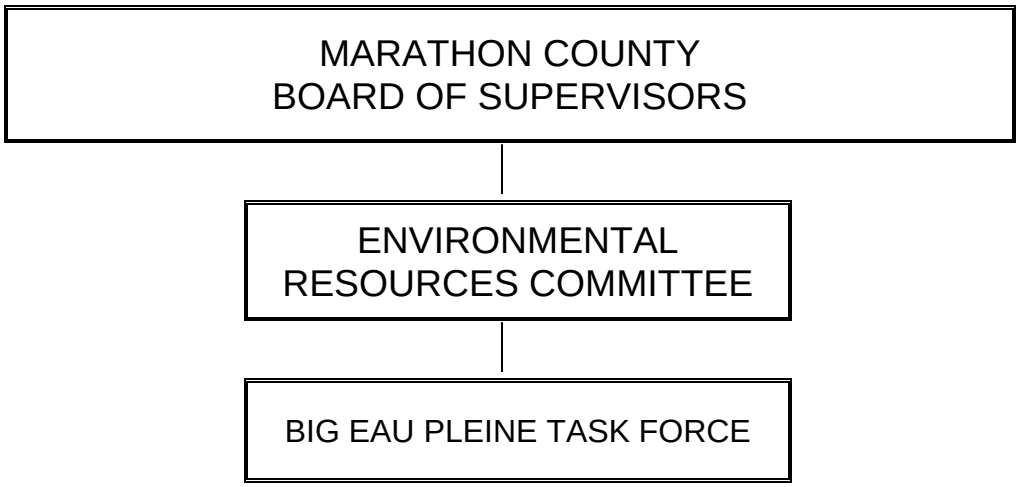
# STRATEGIC PLAN

## FOR THE

# BIG EAU PLEINE RIVER WATERSHED AND RESERVOIR

BIG EAU PLEINE TASK FORCE

December 2011

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| Andy Johnson, Environmental Resources Coordinator | Conservation, Planning & Zoning |
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STRATEGIC PLAN
FOR THE
BIG EAU PLEINE RIVER
WATERSHED AND RESERVOIR

List of Acronyms

| | |
|---|---|
| BEPCO | Big Eau Pleine Citizens Organization |
| BMP | Best Management Practices |
| DATCP | Wisconsin Department of Agriculture, Trade and Consumer Protection |
| DO | Dissolved Oxygen |
| DNR | Wisconsin Department of Natural Resources |
| FERC | Federal Energy Regulatory Commission |
| LWRM | Land and Water Resource Management |
| MOA | Memorandum of Agreement |
| NRCS | USDA-Natural Resources Conservation Service |
| POWTS | Private On-site Waste Treatment Systems |
| PPM | Part per million |
| TMDL | Total Maximum Daily Load |
| WVIC | Wisconsin Valley Improvement Company |

# INTRODUCTION

As ice melting and spring runoff events began on the Big Eau Pleine Reservoir in the spring of 2009, residents, sportsman and officials saw the first evidence of a significant fish die-off. In January, the dissolved oxygen (DO) levels throughout the reservoir had dropped below 1 part per million (ppm). Without areas of safe harbor for the fish within the reservoir or adequate aeration capacity to provide a limited refuge for fish, the fishery collapsed. Unfortunately, fish kills are not new to this river and reservoir system. Low dissolved oxygen levels during the mid to late winter have been a reality with the reservoir since its construction in 1937.

In response to the fish kill, Marathon County convened a meeting between Wisconsin Department of Natural Resources (DNR), Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP), Big Eau Pleine Citizens Organization (BEPCO) and Wisconsin Valley Improvement Company (WVIC) to develop a short term plan to assess the impact on the fishery, adequacy of the aeration system, and water quality conditions. In November 2009, the Big Eau Pleine Task Force completed the short term strategic plan which included the following:

a. Historic Case Study of the Big Eau Pleine Watershed and Reservoir. The case study summarizes nearly 70 years of water quality studies, management plans, conservation projects, and regulatory initiatives aimed at reducing the sediment and nutrient runoff.

b. Action Plan to Upgrade the 1981 Aerator System. The plan described the purpose, condition and performance of the aeration equipment as of 2009. The plan outlined improvements to the aeration equipment to improve performance, as well as a Memorandum of Agreement (MOA) to clarify the roles and contributions of the partners in the aeration equipment's on-going operations and maintenance.

c. Long Range "Plan of Work" to Address the Water Quality and Quantity of the Big Eau Pleine River System. The "plan of work" identified the partners and actions needed to assess best management practice needs.

The Big Eau Pleine Task Force submits this document to identify the role of governmental agencies, sportsman and citizen groups, educational institutions, agricultural groups, and the WVIC to improve the health of the river system while balancing the needs of community and economic interests. It will also provide a foundation of understanding for the policies that may be proposed by local leaders.

## FRAMING THE PARTNERSHIP PROCESS

The strategic plan process is designed to build upon the existing capacities and resources of agencies to efficiently leverage financial and technical assets. The task force was established by Marathon County to assure that all interested parties were represented and County policy is based upon recommendations consistent with community and economic development goals.

The task force consisted of representatives of USDA-Natural Resources Conservation Service (NRCS), DNR, WVIC, DATCP, Clark County, Marathon County, Taylor County, BEPCO, and local dairy producers. It was important for farm producers to be part of the task force to assure that members understand farming challenges and the effectiveness of conservation initiatives.

## THE ECONOMIC AND LANDSCAPE CONTEXT OF THE BIG EAU PLEINE

Policy recommendations and program activities for the Big Eau Pleine River Watershed and Reservoir need to be established with an understanding of the region's unique natural resources and economic contributions. Recommendations must realistically capture the scope of financial and technical resources required to improve the water quality and the time required for best management practices to influence change in water quality. The financial limitations of landowners, industries and public agencies require that local partnerships coordinate and leverage multiple-sourced resources to be effective.

The Big Eau Pleine is part of the Upper Wisconsin River basin which comprises nearly 20% of the State's landscape. The reservoir acts as the major source of water that is used to help regulate the flow of the Wisconsin River during low flow seasons. DNR has identified four (4) municipalities and eight (8) industries within Marathon County along the Upper Wisconsin River with Wisconsin Pollutant Discharge Elimination System permits that base respective discharge limits upon water flow in the river. The operation of the Wisconsin River System, including the Big Eau Pleine reservoir is the responsibility of WVIC with regulatory authority provided by the Federal Energy Regulatory Commission (FERC).

The Big Eau Pleine agricultural producers represent nearly 850 farms. These farms create $100 million annually of direct farm receipts from dairy and commodity crops. Fifteen percent of Marathon County's jobs are created by the agricultural industry. Profitable farmers with reasonable and achievable performance criteria and incentives are critical to the success of any

proposed policy initiatives. Success is achieved when soil and water resources are protected while assuring that landowners meet the challenge of producing food.

The Big Eau Pleine Reservoir is a regional recreation destination. The Marathon County Parks, Recreation and Forestry Department provides recreational opportunities within 3 parks in the Big Eau Pleine watershed. The most notable is the Big Eau Pleine Park which consists of 2,050 acres located on the north shore of the 7,000 acre Big Eau Pleine Flowage. Poor water quality and fish kills significantly impact the economic and recreational opportunities associated with the reservoir such as boating, swimming, fishing and businesses that support these activities. The Big Eau Pleine Park represents a major public investment of land and recreational infrastructure along the reservoir. In 2010, camping in the BEP Park generated nearly $300,000 of revenue for the local economy. According to BEPCO estimates, nearly $2 million of economic activity is generated annually from fishing opportunities in the watershed.

## MAKING THE CASE FOR ACTION IN THE BIG EAU PLEINE RIVER WATERSHED

The Big Eau Pleine watershed includes nearly 238,000 acres with 217,000 acres in Marathon County, 8,500 acres in Clark County, and 12,000 acres in Taylor County. It represents the most extensive agricultural area in Marathon County with nearly 60% of the land base under active cropping use and 17,000 cows. The fine textured soils, extensive man-made field drainage system, and loss of wetlands create a “flashy” hydrology where runoff from snowmelt and rain carry soil and manure loads to streams. The runoff contributes excessive loads of nutrients to the reservoir and Wisconsin River. The soil sediment, organic matter and nutrients compromise the water quality necessary to support a sustainable fishery and provide high quality recreational activities. Excessive nutrient loading contributes to algae blooms which occur several times annually. Decomposition of algae and organic matter sediment consumes available dissolved oxygen needed by the fishery in the winter.

Water quantity management and operational activities for the reservoir are a complicated balancing act. The WVIC must strive to meet the water flow needs of the Wisconsin River for municipal discharges, power and paper industries, as well as sustain the natural resources and recreational expectations of the local communities. The waters of the Big Eau Pleine Reservoir are necessary to help sustain the river flows during low flow periods, commonly in summer and winter.

The “60% Solution” is a water quantity management concept proposed by BEPCO to reduce the probability of fish kills. BEPCO has assessed that there is a very strong statistical correlation between fish kills and prescribed water levels over winter. The concept is supported by 40 years of operational data, but the application of the data to reservoir operations is not endorsed by all parties. The DNR recommends a winter storage goal of 60%, using operation criteria from July through November to continue protection of the Wisconsin River target flows and maximize the potential to reach the 60% winter storage goal. WVIC wants to maximize operational flexibility, but recognizes the value of winter storage goals.

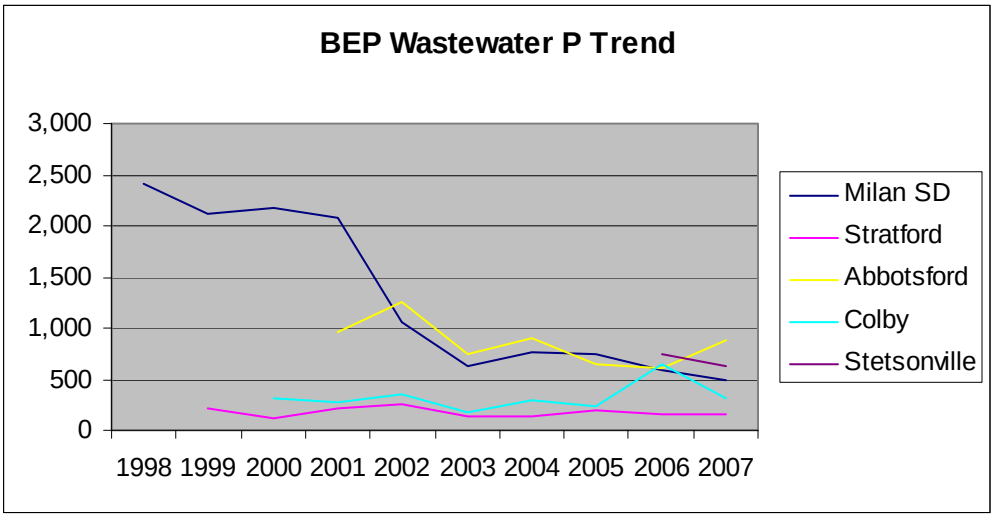
Through modeling conducted at BEPCO’s request, the WVIC determined that it is possible to change the summer and winter operating procedures and realize a significant increase in water levels over winter during drought conditions. This can be done while still protecting minimum Wisconsin River flows and without impacting flows or reservoir operations upstream of the Big Eau Pleine. However, WVIC believes that a change in reservoir operations every year is not required to help protect the fishery. Moreover, modifying the operating plan according to the modeling would result in an estimated hydropower generation loss averaging 1.7 million KWh per year whether drought conditions existed or not. Instead, the WVIC believes that its enhanced drought contingency plan is the methodology that should be used to address severe drought conditions and thereby help protect the fishery during these extreme events, not a permanent change in reservoir operations.

Agricultural producers have a long history of implementing conservation in the watershed. Although most farmers are in compliance with state agricultural performance standards and local ordinances, the sediment and nutrient loads remain too high to protect the water quality. In cases where performance standards are not being met or chronic runoff events occur that threaten the water quality and fishery, Marathon County may need to provide an increased regulatory presence. In order to require farmers to reach beyond current performance criteria, additional education, technical and financial assistance will need to be offered. Marathon County with its partners must provide producers with better strategies to minimize runoff through soil saving Best Management Practices (BMPs), nutrient management plans, and manure treatment and distribution technologies such as anaerobic digestion and manure injection equipment.

Farming is not the only contributor to pathogens, nutrients, and sediment to the Big Eau Pleine River system. Sediment from non-metallic mining, once a significant contributor of sediment to the river system, is now regulated and minimized through state codes and local ordinances. Continued support of administrative and technical efforts by local and state agencies in regulation of these mining activities is necessary. Similarly, private sanitary treatment systems contribute less than 1% of the nutrient load to the river but pose serious public health concerns when left to directly discharge into ditches and waterways. Current regulatory oversight has been effective in controlling design and operations of new Private On-site Waste Treatment Systems (POWTS), but more needs to be done to address discharges from old systems and the education of holding tank owners to reduce discharges of human wastes.

Soil erosion from non-agriculture activities has been significantly reduced since storm water permits have established erosion control standards for construction sites, road work, and industrial storage. The mass of phosphorous discharged to the Big Eau Pleine River from point sources has been reduced with the inclusion of phosphorous limits in waste water permits since 1997 (see Table 1).

Table 1. Pounds of Phosphorus Delivered/Year.




## CONCLUSION

The Big Eau Pleine River Watershed and Reservoir represent tremendous natural and cultural resource assets to our community. The watershed is home to an agricultural industry producing

and processing a variety of dairy and commodity products. The rural character of the region is defined by its land use, beauty and the local businesses. However, runoff from fields and farmsteads threatens the health of its people, soil and water resources, and community. The time to act is now.

For nearly 80 years, conservation agencies have worked with private landowners and shared in their investments to improve the management of the soil and water resources in order to sustain its inherent productivity and to help them prosper. Even though the landowners have done much to meet the expectations of state and local resource management goals, the Big Eau Pleine River and Reservoir remains a polluted water body due to runoff of nutrient, soil sediment, and organic matter. Aeration alone is not enough to protect the fishery through low oxygen periods.

Marathon County needs to lead an effort with many identified partners to efficiently leverage existing and new resources to continue improvements of water quality. Education, technical assistance and financial incentives are needed to help landowners, cities, villages, and towns better manage and protect the resources in ways that are profitable and sustainable.

The recommendations forwarded by the Big Eau Pleine River Task Force represent policies and activities that Marathon County should develop, coordinate and implement to lead a local effort to improve community and economic development opportunities, as well as minimize public health concerns associated with the watershed's water quality.

The fish kill of 2009 is symptomatic of a serious water quality problem caused by excessive soil sediments, nutrients and organic matter that flow into the Big Eau Pleine Reservoir. Conditions are made worse by low flows during drought periods. Until poor water quality is abated in the Big Eau Pleine Reservoir watershed, the potential for fish kills will remain.

## POLICY RECOMMENDATIONS

1. **Aeration System Operation and Maintenance**. The aeration system will be an ongoing and necessary management tool to the well-being of the reservoir and fishery. It opens 30-60 acres of water surface for aeration during the late winter and early spring. Operations and maintenance and capital expenditures for the system will be administered through a Memorandum of Agreement established for 5 year periods.

WVIC, the FERC licensed operator of the reservoir, and DNR, the owner of the land and aeration equipment, will serve as the primary agents to determine the start-up criteria, safety and operations of the system. These organizations will also serve as the primary water quality monitoring agents for the tributary and reservoir waters.

Participating partners should contribute funds to annual electrical costs and the repair or replacement of capital improvements such as items associated with motors, blowers, and buildings.

2. **Resource Management Initiatives**. The local, state and federal agencies serve as the primary vehicle of delivery of local conservation programming to landowners and residents. Local conservation programs include education, resource assessments and planning, technical assistance, grant funding, and administration of regulations. Marathon County will provide leadership through policy, and partnership coordination through the Marathon County Comprehensive Plan. Specifically,
    a. **Marathon County will**:
        i. Adopt and implement state agricultural performance standards in local ordinance to address chronic and significant discharges.
        ii. Minimize or eliminate winter land surface spreading activities of wastes.
        iii. Promote technologies to treat and distribute livestock waste.
        iv. Provide Best Management Practice education and training to landowners.
        v. Administer the Non-metallic Mining Ordinance.
        vi. Eliminate direct surface discharges of sanitary wastes.
        vii. Develop a reservoir recreation management plan.
        viii. Provide financial support of annual operational costs of the aerator.
        ix. Develop and implement a Fenwood Creek pilot project (see description below).
    b. **WI Department of Natural Resources (DNR) will**:
        i. Develop a reservoir management plan to protect the natural resources (land, water and fish) of the Big Eau Pleine reservoir and tributary waters. The plan will set goals for the fishery and supporting food system.
        ii. Provide lake management grants to local partners.

iii. Complete a water quality assessment of the Upper Wisconsin River Basin and develop a Total Maximum Daily Load (TMDL) plan for the Big Eau Pleine Watershed and Wisconsin River.
iv. Support Taylor, Marathon, and Clark Counties with investigation and enforcement of agricultural performance standards and prohibitions.
v. Provide Best Management Practices cost-share grants to landowners.
vi. Provide water quality monitoring of algae concentrations that threaten public health.
vii. Primary responsibility role (with WVIC) for the aeration system in an operation and maintenance plan.
viii. Coordinate aeration system operations (with WVIC).

c. **WI Department of Agriculture, Trade and Consumer Protection will**:
i. Provide BMP grants to landowners for state agricultural performance standard(s) compliance.
ii. Provide administrative support for the Farmland Preservation Program.
iii. Coordinate education with agriculture industry associations to producers on nutrient management and non-point runoff controls.

**d. Wisconsin Valley Improvement Company will:**
i. Provide water quantity and quality monitoring.
ii. Coordinate aeration system operations with DNR.
iii. Lead reservoir operation activities.
iv. Update reservoir modeling tool(s) and drought management plan at 5-year intervals (next update due 2016).

e. **USDA – Natural Resources Conservation Service will**:
i. Provide technical assistance, conservation planning, and engineering support to landowners.
ii. Provide cost-share assistance to landowners.
iii. Develop and implement manure winter spreading evaluation and planning strategies to minimize runoff risks.

f. **Big Eau Pleine Citizens Organization will**:
i. Provide a citizen's voice to community needs relative to property, resource management, and public waters.

ii. Coordinate input from community-based organizations such as recreational and lake groups to provide feedback about program outcomes and outreach needs.

iii. Pursue grant opportunities.

g. **Farm industry representatives will**:

i. Provide landowner education.

ii. Provide feedback on incentives and program initiatives.

h. **Taylor County Land Conservation Department will**:

i. Implement conservation programs focusing upon conservation compliance, nutrient management, and animal waste management through the Land and Water Resource Management (LWRM) plan.

ii. Provide education on groundwater protection and Best Management Practices.

i. **Clark County Land Conservation Department will**:

i. Implement conservation programs focusing upon conservation compliance, nutrient management, and animal waste management through the LWRM plan.

ii. Implement Heart of America's Dairyland Agricultural Enterprise Area.

3. **Fenwood Creek Watershed Project**. Because the water quality assessment activities and the Big Eau Pleine River and Reservoir Total Maximum Daily Load plan will not be completed until 2015-16, the task force recommends that the agencies initiate a small scale watershed project. The purpose of the project is to develop the strategies relative to Best Management Practices, waste treatment and distribution technology implementation, conservation planning, financial incentives, technical assistance, and education needed to achieve water quality outcomes for the watershed. The project would include the following elements:

- Water quality monitoring. Assess the management and environmental performance of BMPs, quantify the pollutant contributions of major event runoff discharges vs. chronic low-level discharges, and document changes in water quality over time.
- Education. Communicate performance expectations and regulatory requirements to landowners, towns, cities and villages.
- Nutrient management planning. Provide technical and financial assistance to landowners to assure all producers have and follow nutrient management plans.
- Manure winter spreading assessments. Develop and implement criteria to assess winter spreading runoff risks and provide planning assistance to landowners to manage risks.

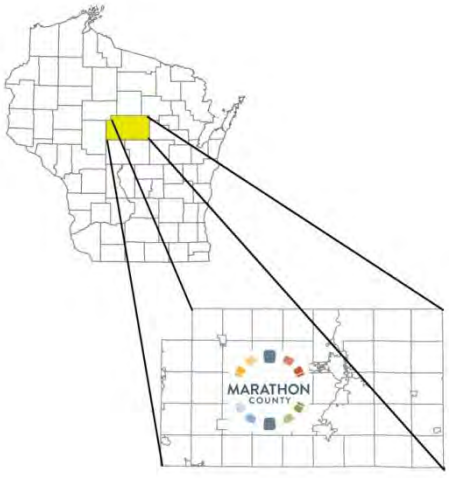
- "Edge of Field" Best Management Practices. Implement BMPs down slope of cropland to treat and reduce sediment and nutrient loading from runoff. In cases where runoff contributions are chronic and cannot be minimized to acceptable levels, permanent land use conversion strategies will be developed.
- Financial and management incentives. Develop financial and management incentives to promote BMP implementation, including long-term maintenance and performance of BMP.
- Waste treatment and distribution technology. Increase understanding and implementation of waste treatment and distribution technologies that reduce runoff risks and maximize nutrient utilization. Provide cost-benefit analysis of new technologies and develop adoption strategies.

# Appendix E:2

# FENWOOD CREEK

# WATERSHED MANAGEMENT PLAN

**Hydrologic Unit Code (HUC) 070700021602**




## In Support of the

## BIG EAU PLEINE RIVER
## WATERSHED AND RESERVOIR PROJECT

## ACKNOWLEDGEMENTS

The development of Fenwood Creek Watershed Plan involved a diverse group of individuals with a wide range of expertise. The Fenwood Creek (as well as all the western watersheds of Marathon County) was identified as a priority for programming in the Marathon County Land and Water Resource Management Plan in 2010 to address water quality concerns resulting from the impacts of agricultural runoff. At that time, the Citizen Advisory Group consisting of a diverse group of stakeholders provided key recommendations to address the runoff issues. Their input, as well as the strategic plan developed by the Big Eau Pleine Task Force in 2011 will continue to play an integral role in defining program priorities for Marathon County that respond to water quality issues. Thank you to everyone who helped with this process.

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# INTRODUCTION TO THE FENWOOD CREEK WATERSHED

The Fenwood Creek watershed drains approximately 39 square miles (24,958 acres) of land into the Big Eau Pleine (BEP) reservoir. The Fenwood Creek sub-watershed is identified by the following 12 digit hydrologic unit code: (HUC) 070700021602. The Fenwood Creek represents one of three (3) major surface water tributaries that empty into the BEP reservoir which immediately flows into Lake DuBay, both flowages of the Upper Wisconsin River Central Sub Basin. The other two tributaries include the Big Eau Pleine River and Freeman Creek. Figure 1 outlines the location of the Fenwood Creek watershed (yellow) in context to the Big Eau Pleine River watershed (blue).

The Big Eau Pleine (BEP) River Watershed is located mostly in western Marathon County with smaller areas located in Clark and Taylor counties.

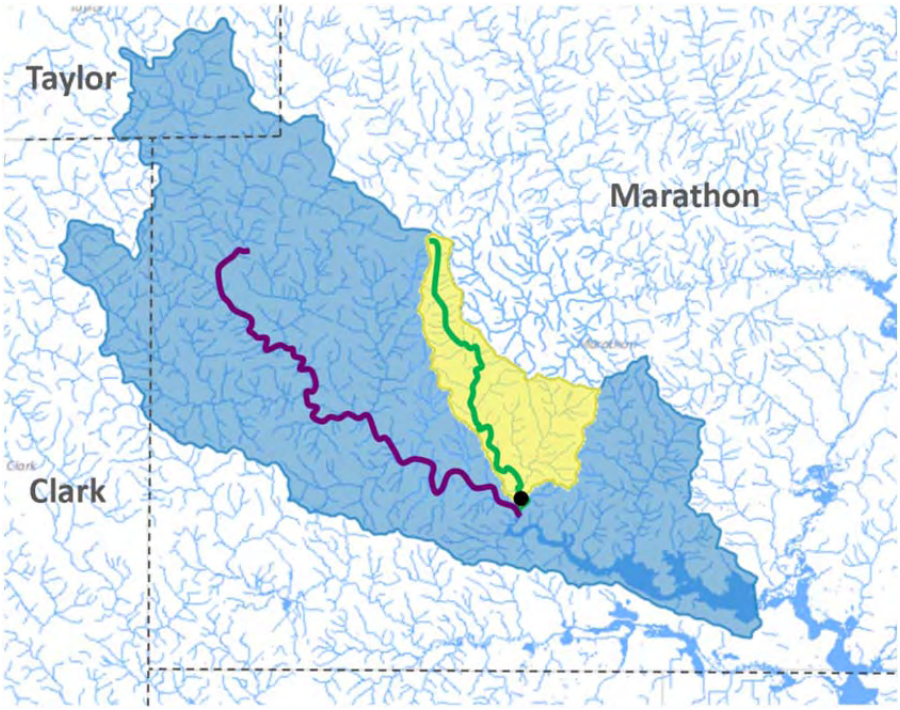



Figure 1 Big Eau Pleine River (HUC 8) and Fenwood Creek (HUC 12) Watersheds

Low dissolved oxygen levels during the spring ice melt period as well as high algae concentrations (during late summer months) have been associated with the reservoir since its construction in 1937. The reservoir acts as the major source of seasonal water that is used to regulate the flow of the Wisconsin River during low flow seasons. Poor water quality and fish kills significantly impact the economic and recreational opportunities associated with the reservoir such as boating, swimming, fishing and businesses that support these activities.

As runoff from agricultural lands increases, sediment and nutrient (phosphorus and nitrogen) loads increase. Although some of the sediment carried from cropland is deposited in the vegetated riparian areas near streams, most of the sediment and dissolved nutrients are transported to the Fenwood Creek and reservoir creating water quality degradation. The

Environmental Protection Agency (EPA) has designated the Big Eau Pleine River watershed as a 303D impaired water body due to the impacts from excessive phosphorus.

The Fenwood Creek is partially located in a farmland preservation area in Marathon County referred to as an “Agricultural Enterprise Area” (AEA). The AEA area is recognized as an important economic “cluster” based upon the competitive advantages of the dairy industry to create jobs and support related business activity. The significance of the AEA designation is that Marathon County will actively support the growth and prosperity of the dairy industry in this area. However, the challenge is to grow the industry while minimizing environmental impacts caused by excessive soil sedimentation and nutrient loading.

The following plan will provide an overview of the physical characteristics of the Fenwood Creek watershed including land use and land management. The plan will also summarize the several environmental studies and programs that increased the understanding of the causes of water quality degradation, past conservation initiatives and investments aimed at reducing agricultural runoff, and program outcomes. The intent of the background information is to provide a historical perspective of water quality and quantity issues for the watershed which will serve as a basis for developing a long range plan for the river system. Success is achieved when the long term use of soil and water resources are balanced with the safety, health and prosperity of the community.

At the time of the Fenwood Creek watershed plan submission, the Total Maximum Daily Load (TMDL) plan for the Wisconsin River basin is not complete. Marathon County acknowledges that the goals and allocation limits developed to address the current resource concerns in both streams and flowages are forthcoming. Marathon County also acknowledges that once the TMDL plan is complete, this plan may need to be modified to be consistent with the TMDL plan.

Appendix A will serve the reader as a glossary and listing of acronyms common the watershed planning in Wisconsin.

## A CALL TO ACTION: DEFINING A COMMUNITY PARTNERSHIP

As the ice gave way and spring runoff events began in the Big Eau Pleine Reservoir in the spring of 2009, residents, sportsman and local officials saw the first evidence of a significant fish die-off. In January, the dissolved oxygen (DO) levels throughout the reservoir had dropped to less than 1 part per million (ppm). Without areas of safe harbor for the fish within the reservoir or adequate aeration capacity to provide a limited refuge for fish, the fishery collapsed. Unfortunately, fish kills are not new to the reservoir. Low dissolved oxygen levels during the mid to late winter (during ice cover periods) have been a reality with the reservoir since its construction in 1937.

In response to the fish kill, Marathon County convened a meeting between Wisconsin Department of Natural Resources (DNR), Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP), dairy farmers, Clark County, Taylor County, Big Eau Pleine

Citizens Organization (BEPCO) and Wisconsin Valley Improvement Company (WVIC) to develop a strategic plan to assess the vulnerability of the fishery, adequacy of the aeration system, and current water quality conditions. The goal of the strategic plan was to improve the health of the river system and stop fish kills while balancing the needs of community and economic interests. See Appendix B: Strategic Plan for the Big Eau Pleine Watershed and Reservoir.

The key finding of the task force was that the fish kill of 2009 is symptomatic of a serious water quality problem caused by excessive soil sediments, nutrients and organic matter that flow into the Big Eau Pleine Reservoir primarily from cropping and manure management activities. Water quality conditions are made worse for the fishery by low water inflows during drought periods. Until poor water quality is abated in the Big Eau Pleine Reservoir watershed, the potential for fish kills will remain high.

## BIG EAU PLEINE TASK FORCE RECOMMENDATIONS: FENWOOD CREEK PILOT PROJECT

The strategic plan was designed to build upon the existing capacities and resources of agencies to effectively and efficiently leverage financial and technical assets. The task force was established so that all watershed stakeholders were represented and local policy is based upon recommendations consistent with community and economic development goals. Farm producers were a critical part of the task force and served to ensure that members understood farming practicalities, as well as the effectiveness of past conservation initiatives.

The recommendations forwarded by the Big Eau Pleine River Task Force represent policies and activities that Marathon County should develop, coordinate and implement to lead a local effort to improve community and economic development opportunities, as well as minimize public health concerns associated with the watershed's water quality.

The Fenwood Creek was selected as a" pilot project" by the Big Eau Pleine task force. The concept of a pilot project is to establish the education, planning, and technical assistance models with agricultural producers during the TMDL development process so that when the allocation plan is complete, the programming, education and incentive models are in place and proven for quick application to a larger Big Eau Pleine River watershed. Criteria for the pilot project identified the Fenwood Creek watershed as:

1. Representing an example of a traditional dairy agricultural watershed where the average herd size is 70 cows and cropping practices are intensifying relative to production models and resource challenges (increasing agricultural runoff).
2. Having an extensive and positive history of farmer involvement with conservation programs. During the 1990's, nearly 30% of landowners implemented BMP's through the Lower Big Eau Pleine River priority watershed project.
3. Having a long history of water quality monitoring to allow Marathon County to evaluate the trends of past farming activities against water quality changes (phosphorus and sediment loading).

4. Having farmers and town leaders who are actively interested in the TMDL and can help share the message with peers.

Marathon County with this plan is seeking funding and program support for the Fenwood Creek Pilot Project, but drawing upon all previous watershed data, studies, assessments and monitoring to describe the resource concerns, the cause of water quality degradation and best management practice application strategies.

## CHAPTER 1: CHARACTERIZING THE FENWOOD CREEK WATERSHED

The Fenwood Creek watershed drains 24,958 acres of which 65% (16,222 acres) is utilized as agriculture cropland and 25% as woodland. Of the 16,222 acres of cropland, Marathon County estimates approximately 14,600 acres are tillable. The balance (1,622 acres) is considered marginal, transitional land lying at the downslope edge of cropland and drainage corridors.

There are 64 livestock operations within the Fenwood Creek watershed representing beef, dairy heifer, and dairy cow enterprises. These livestock operations range in scale from 6 to 120 head per site with an estimated total of nearly 5,000 head of cattle. The watershed contains one Wisconsin Pollutant Discharge Elimination System (WPDES) permitted municipality (Village of Fenwood).

The Fenwood Creek watershed is one of several HUC 12 watersheds (070700021602) that comprise the Big Eau Pleine (BEP) River Watershed which drains approximately 238,000 acres of land. The land use in the BEP River watershed is as follows: cropland (60%) – 142,800 acres, pasture (15%) 35,700 acres, woodland (17%) – 40,460 acres; and miscellaneous (8%) – 19,040 acres. See figure 2.

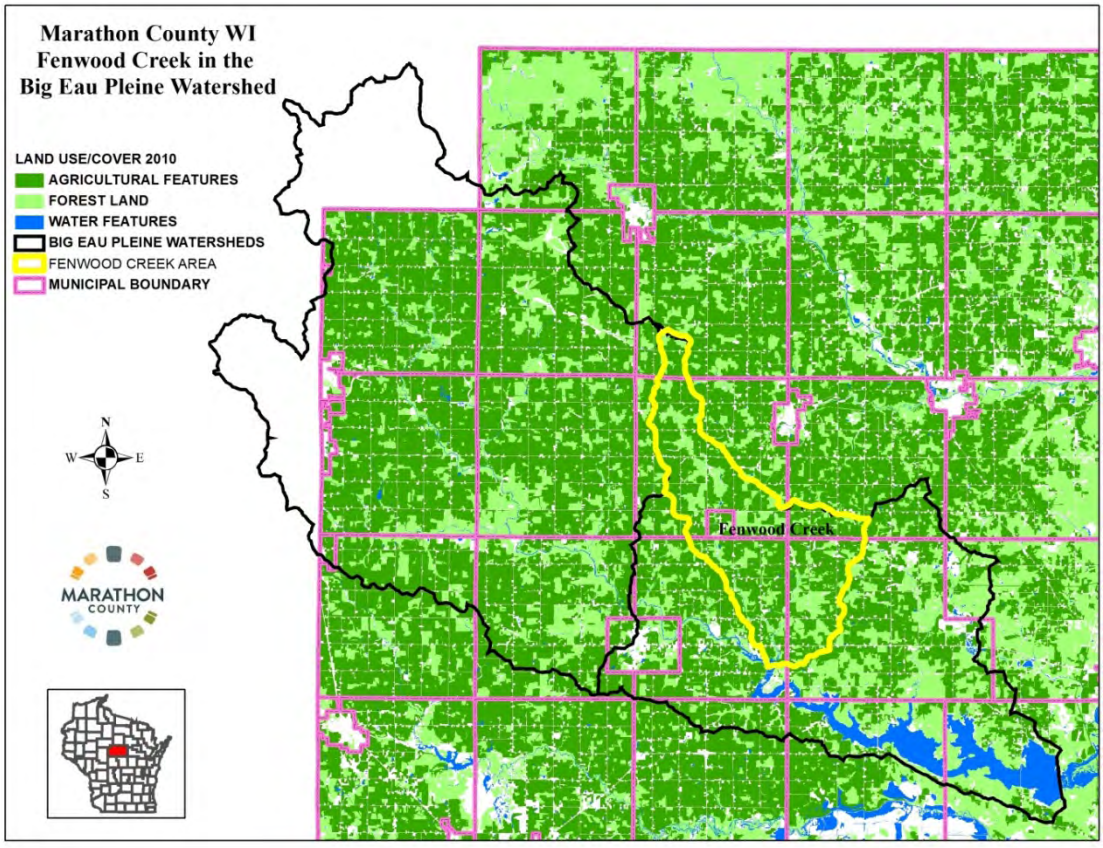



Figure 2 Land Use Map of Fenwood Creek Watershed

The Fenwood Creek watershed lies west of a terminal moraine. The gently rolling landscape is characterized by a well-developed surface drainage system that was developed through nearly four decades of governmental assistance (See Figure 3). Since there are very few undrained depressions, essentially every acre of cropland drains to a surface channel and eventually to the reservoir. The "flashiness" of the watershed's hydrology is the result of a prolonged effort to drain the croplands to accommodate row crop production. For example, in September 2015, a 3 inch rain in the Big Eau Pleine watershed caused the flow rate of the Big Pleine River to increase from approximately 30 cubic feet second (cfs) to nearly 10,000 cfs within 6 hours. Water quality assessments indicate that flashiness of hydrology (the rapid rate of runoff) is a major contributor to degradation of water quality, aquatic habitat, and the fishery of the river system.

The watershed is covered with relatively deep (5-10 feet) fine textured, loamy glacial till over granitic bedrock. The fine textured, highly plastic till has a low permeability, but conducts free water (storm events and groundwater) both vertically and horizontally throughout the soil profile in fractures comparable to fractures in crystalline bedrock. Shallow dug wells are common in this landscape and are responsive to rain and snowmelt events because of the highly developed structural fracturing within the glacial till. Along river and intermittent surface water flows, the glacial till has been eroded to expose Precambrian rock.

**Figure 3 Typical surface drainage feature in BEP Watershed**

The soils of the watershed provide the basis for a productive agricultural industry; however, the soils of the Fenwood Creek watershed are characterized by low infiltration and permeability rates (Hydrologic Group B and C). The non-erosive removal of surface water through a system of terraces, grassed diversions, waterways, and drainage ditches to create an aerated root zone is the basis of most historical conservation and agricultural initiatives. Without functional surface drainage systems, crop failure was expected 1 out of every 10 years. Soil textures create three agricultural management practices that pose direct negative water quality implications in this watershed:

1. *Seasonal Soil Saturation and Waste Applications.* Manure applications that occur in the fall and spring coincide with saturated surface soil conditions and groundwater recharge.
2. *Waste Application onto Frozen Soils*. Many manure spreading operations (emptying of waste storage facilities) occur after soils freeze (fall) or before they thaw (spring) in order to support the weight of loaded manure equipment.

3. *Fall Tillage*. Fall plowing is beneficial in allowing the producer to distribute the labor needs for nutrient management, tillage and seedbed preparation over two seasons. Nearly 80% of cropland is fall tilled with most utilizing the mowboard plow.

The wetland characteristics of the Fenwood Creek watershed have been drastically altered by the development of agriculture land and associated surface drainage activities. It is estimated that nearly 50% of the BEP watershed was wetland prior to agricultural development.

The Fenwood Creek region has experienced a decline of dairy farms over the past 43 years with the consolidation of the smaller herds into concentrated feedlot animal operations (CAFO's). Since the 1970's, the number of dairy farms has declined to nearly half the previous numbers, yet the number of cattle has remained nearly constant. Although the Fenwood Creek watershed does not house a CAFO site, the watershed has 64 small scale livestock operations as of 2014.

## EARLY CONSERVATION INITIATIVES

The following section outlines the many conservation activities that have been initiated and completed in response to the agricultural runoff concerns in the Fenwood Creek and the larger BEP River watershed (See Appendix C). Our understanding of the resource concerns associated with the agricultural industry rest upon the work of previous local and federal conservation staff and researchers. There is a great respect for the resource professionals and farmers who collaborated to install best management practices to improve water quality.

During the 1940-1950's the focus of conservation efforts was to develop and improve the productive potential of agricultural lands within Marathon County. Government assistance provided public financial and technical assistance to farmers through liming, fertility, erosion control, and design of water disposal systems (drainage). The following list identifies key dates, policies, and civic activities that defined early conservation efforts:

- 1941 – Marathon County Soil and Water Conservation District established.
- 1958 – Big Eau Pleine Citizens Organization (BEPCO) established.
- 1965 – Inventory of BEP River Watershed project completed. Sedimentation and pollution from agriculture identified and assessed for the first time.
- 1972 – Clean Water Act establishes federal water quality policy.
- 1982 – Wisconsin Chapter 92 becomes law and farmer led conservation districts are eliminated as the conservation program model in Wisconsin. Local conservation now administered by county and state government.

## RESOURCE STUDIES AND ASSESSMENTS

1. 1958 – The Wisconsin Valley Improvement Company (WVIC) begins measuring and tracking dissolved oxygen levels in the Big Eau Pleine Reservoir.
2. 1965 – First Big Eau Pleine River watershed inventory of resource concerns.

3. 1972 – National Eutrophication Study. Annual Phosphorus (P) load to reservoir estimated at approximately 92,500 lbs.
4. 1974 – UW-Stevens Point Study of Reservoir. Predicts that 50% reduction in P loads would be needed to reduce algae concentrations in reservoir by 57%. Studies by EPA and UW-Stevens Point indicate a Phosphorus (P) load of 100,000 lbs. annually. Study identifies that 95% of pollutant load comes from agriculture.
5. 1984-1994 – DNR Upper Big Eau Pleine Priority Watershed Project. Appraisal determined that phosphorus was the primary pollutant of concern and flashy hydrology is a huge concern to the condition and use of the water system.
6. 1993-2003 – DNR Lower Big Eau Pleine Watershed Project. Total phosphorus load delivery to the reservoir is 163,636 lbs. annually with 78,860 lbs. point-sourced (42,161 lbs. controllable) and 84,776 lbs. non-point sourced (29,196 lbs. controllable).
7. *2009 – Big Eau Pleine Flowage Winter Runoff Study*. The dominant land use of dairy farming in the BEP River watershed contributes significantly to increased delivery of bacteria, BOD and P to tributaries.
8. Marathon County Soil Erosion Transect Survey (1999-2016). From 1999-2006, the erosion rates within the Fenwood Creek watershed had averaged approximately 2.4 tons per acre per year. Ninety five (95) percent of the sediment delivery to the streams and reservoir is sourced from this upland soil erosion. Since 2010, the soil erosion rates have steadily increased to a rate of 3.2 tons/acre/year. Note that the transect data does not include ephemeral or snowmelt erosion contributions which are significant in the watershed. See Table 1.

Table 1. Annual Soil Erosion Rates

| Year | County Average Soil Erosion Rate (tons/acre/year) | Fenwood Creek Average Soil Erosion Rate (tons/acre/year) |
|---|---|---|
| 2000 | 2.0 | 1.9 |
| 2002 | 2.3 | 3.2 |
| 2004 | 2.3 | 2.8 |
| 2006 | 2.1 | 2.4 |
| 2008 | 1.7 | 2.1 |
| 2010 | 1.8 | 2.3 |
| 2012 | 2.3 | 2.6 |
| 2014 | 2.2 | 3.0 |
| 2016 | 2.2 | 3.2 |

Source: Marathon County Soil Erosion Transect Survey

9. Wisconsin River Basin Clean Waterways Projects. Monitoring for the Upper Wisconsin TMDL provided four years (2010-2013) of regular water data in Fenwood Creek to measure the current nutrient and sediment concentration and loading levels. The average median phosphorus concentration (May-October 2010-13) in the Fenwood Creek during the monitoring period was determined to be 129 µg/L (see Figure 4).

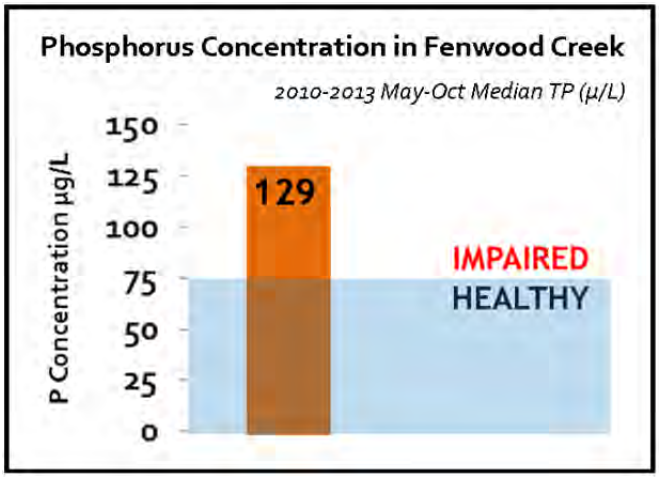



**Figure 4 Phosphorus concentrations in Fenwood Creek**

Figure 5 and Table 2 show the average amount of phosphorus (pounds) and suspended solids entering Fenwood Creek each year. The amount of phosphorus and sediment varies greatly from year-to-year depending on annual and seasonal variations in rainfall, snowmelt and other climate variables. The average annual phosphorus for this monitoring period was 11,228 pounds.

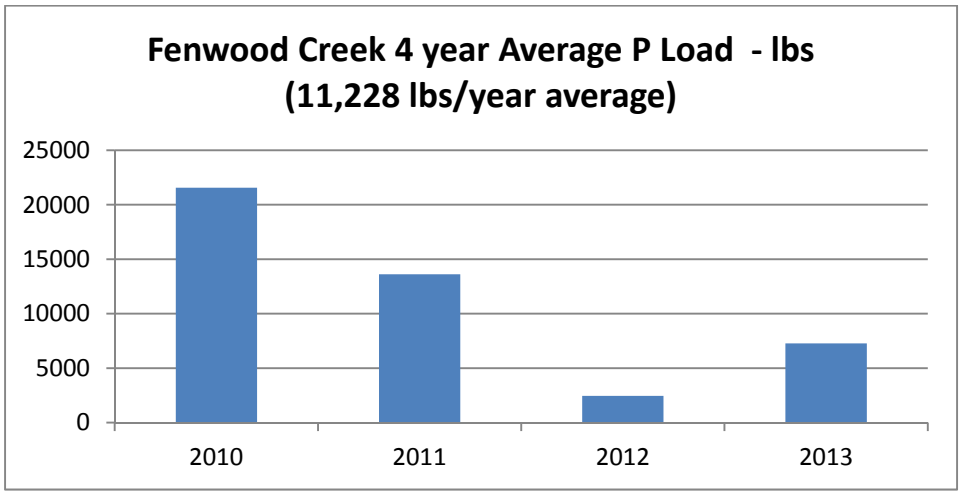



**Figure 5 Fenwood Creek Total Annual Phosphorus Load (lbs.)**

**Table 2. Total Suspended Solids (TSS) Load (tons) at TMDL Monitoring Sites***

| Year | BEP River | Freeman | Fenwood | | BEP Outlet |
|---|---|---|---|---|---|
| 2011 | 8161 | 294 | 436 | | 2637 |
| 2012 | 1982 | 85 | 69 | | 1670 |
| 2013 | 7810 | 287 | 168 | | 3671 |

**Draft, USGS Load Calculations*

## CONSERVATION PROGRAMMING

Conservation efforts aimed at addressing the sediment and nutrient impacts to water quality in the Fenwood Creek and BEP River watersheds began in the 1930's. In the first four decades, the work focused on developing drainage systems to increase productivity of heavy-textured soils via the installation of terraces and waterways to shorten slope lengths to reduce the energy (erosiveness) of runoff. The following is a short summary of past and current conservation programming in the Fenwood Creek area.

1. *Model Implementation Program* – MIP (United States Department of Agriculture, USDA and Environmental Protection Agency, EPA, 1977). WVIC began measuring dissolved oxygen levels in 1958 and observed oxygen depletion to one part per million or less almost every year with fish kills occurring during most of those years (1958 to 1977). The MIP Pilot Project was designed to show how voluntary landowner cooperation and targeting financial and technical resources can improve the resource problems of the watershed.
2. *Hamann Creek Watershed Project-1978.* (16,000 acre drainage area). The project's funds ($100,000) provided cost-share assistance to landowners for best management practices such as vegetated channels, terracing, soil treatment (liming), permanent vegetated areas, and pond dugouts. The intent of the project was to focus conservation efforts on a relatively small watershed with monitoring to determine if technical assistance and funds could provide measurable water quality benefits.
3. *Upper Big Eau Pleine Priority Watershed Project (UBEP) 1984-1994* with *Final Report by DNR (June 1997)*. The estimated total P load is 161,636 lbs. annually. The project plan projected that if conservation objectives met, overall P delivery would be reduced 16.2%. This would also reduce amount of algae by 16%.
4. *Lower Big Eau Pleine Priority Watershed Project (LBEP) 1993-2003.* LBEP is a continuation of the UBEP effort aimed at reducing polluted runoff from barnyards and feedlots; sediment from cropland; and runoff from winter spread manure.
5. *Marathon County Nutrient Management (NM) Program (March 1993).* Marathon County initiates a Nutrient Management Program in April 1991, as part of the Priority Watershed Project. Project provided technical and planning assistance to farmers on a voluntary basis and initially works with farmers receiving municipal and industrial wastes for cropland applications. The project provides free soil and manure sampling for participants. The NM program finds that landowners are over applying fertilizer by 65% based on soil tests and UW technical recommendations. Since NM is considered a new concept and management skill for landowners, most farmers are hesitant to participate.

   In 2014, Marathon County had nearly 154,000 acres of cropland under certified nutrient management (NM) plans which guide application decisions for livestock manure and commercial fertilizer. This represents nearly 54% of total cropland acres. In the Fenwood Creek approximately 5,614 acres of cropland are under certified NM plans out of the 16,222 acres of total cropland (only 34% participation).

## REGULATORY PROGRAMS AND COMPLIANCE

*Local Land Management Ordinances:*

1. 1984 – Marathon County Board approves Animal Waste Storage Ordinance to regulate the construction and significant alteration of waste storage impoundments (earthen lagoons only). Regulatory compliance is guided by State and federal technical standards, but administered through local ordinances.

   The ordinance is modified in 1990's to extend regulatory reach to the construction or modification of waste storage structures (concrete and steel containment facilities).

2. 2006 – Livestock Facility Siting Ordinance. This ordinance authorizes the County to regulate Concentrated Animal Feedlot Operations (CAFO's) with specific livestock types with 500 or greater animal units. For existing livestock operations at 500 animal units or greater in October 2006, the ordinance will apply at a point they expand livestock numbers over 20% of 2006 cattle population. Regulatory guidelines are provided by State Statute 93 and Administrative Rule ATCP 51.

3. 2009 – Waste Storage Facility and Nutrient Management Ordinance. This revision for the first time provides clear authority to the County to regulate nutrient management planning when associated with waste storage facilities.

4. 2015 – Modifications to animal waste regulatory policies initiated by Marathon County. Initiatives include citation authority to enforce code violations, increased attention to "operation and maintenance" plans, spills reporting, and nutrient management planning. Specific focus on addressing agricultural runoff problems. Citation authority is authorized to increase the efficiency of regulatory compliance efforts.

## CHAPTER 2: SPECIFIC RESOURCE CONCERNS

The Fenwood Creek watershed is representative of the larger BEP River watershed relative to the resource concerns. As stated in Chapter 1, the Fenwood Creek is impacted primarily by nonpoint agricultural runoff. All studies, research, and monitoring efforts point to two primary causes of water quality degradation: soil sedimentation and nutrient enrichment.

1. Soil sedimentation. Soil is primarily sourced from upland cropland erosion with most of the delivery to riparian buffers and surface water occurring between March and July. It is important to note that the Revised Universal Soil Loss Equation (RUSLE) does not estimate the erosion associated with snowmelt or ephemeral erosion dynamics (See Figures 6 and 7). More specific causes of the erosion include:
   a. Nearly 80% of cropland is fall tilled with aggressive chisel or mowboard equipment.
   b. Flashiness of hydrology is due to highly developed, surface drainage systems.
   c. Intensification of cropping (corn silage and soybean acres and less grass/legume in rotations) and increased tonnage yields.
   d. Hydrologic group C soils dominate the landscape (low infiltration).

**Figure 6 Ephemeral erosion in Fenwood Creek Watershed**

**Figure 7. Ephemeral erosion in Fenwood Creek Watershed**

2. Nutrient enrichment. The source of nutrient runoff is primarily livestock manure and commercial fertilizers with most (80%) contaminants being delivered to the edge of fields between February and June (See Figure 8). More specific causes of the discharge include:
    a. Manure applications coinciding with saturated soil conditions,
    b. Manure applications to frozen and snow-covered cropland in late fall and early spring (See Figure 10),
    c. Over-application of liquid manure to cropland,
    d. Un-treated barnyard and feedlot runoff,
    e. Un-treated feed storage leachate runoff (See Figure 9).

Specific values for delivery of phosphorus and soil sediment can be found in TMDL monitoring results (see Figure 5 and Table 2), priority watershed reports (1983-2002), soil transect surveys (1999-2016), and UW-Stevens Point research and assessments (1970's). See Chapter 1. Based upon the median phosphorus concentration of the Fenwood Creek, the predicted average annual phosphorus load delivered to the reservoir is 11,288 pounds.

The Village of Fenwood is the only WPDES permitted point source in watershed. The village currently has an estimated annual phosphorus load about 44 lbs. over a 5 year average (DNR, 2015). The average phosphorus concentrations for effluent (2010-2015) were 0.95 mg/l with over 28 million gallons of effluent released. In 2017, a new WPDES permit will be issued based upon the 0.075 mg/l water quality based effluent limits. The village has a storage lagoon and therefore, a seasonal discharger. The village is not allowed to discharge January-March and June-September.

**Figure 8 Manure applications on saturated soils.**

**Figure 9 Feed storage leachate runoff.**

**Figure 10 Manure applications on frozen and snow covered soils.**

# CHAPTER 3: GOALS AND IMPLEMENTATION STRATEGIES

Marathon County is initiating a pilot project in the Fenwood Creek watershed which is a representative HUC 12 dairy-based watershed within the Big Eau Pleine River watershed. The proposed project has secured funds from the Wisconsin Targeted Resource Management (TRM) grant program. Implementation will commence in 2016 and end in 2018. Although the TRM project is only three (3) years in length, Marathon County will document a 10 year project implementation schedule for the purpose of the 9 Key Element Plan. Initial and Intermediate outcomes for the Fenwood Creek project will focus upon TRM funded activities. Long-term outcomes will be administered through the proposed Wisconsin River Total Maximum Daily Load (TMDL) plan. The intent of the pilot project is to support:

1. Education and Outreach: Develop a communication, education, and community capacity model that includes primary stakeholders in local water quality activities in the community.

2. Technical assistance to landowners/farmers:

    a. Provide landowners and farmers with information about their farms relative to resource concerns, as well as the status of their current conservation activities relative to state agricultural performance standards (WI Administrative Code 151) and local ordinances.

    b. Provide conservation plan, nutrient management plan, and best management practice (BMP) design support to landowners to maintain and improve conservation performance (reduced sediment and nutrient loading) on their respective farms.

The Fenwood Creek pilot project will serve to develop a new conservation delivery model based upon increased community capacity that collaboratively minimizes resource concerns and improves watershed soil health, while targeting staff and financial assets to areas of disproportionate contaminant delivery. The new conservation delivery model with specific education and technical strategies will be proven and transferable to the larger western Marathon County watersheds when the TMDL is completed in 2017.

### IN STREAM PHOSPHORUS CONCENTRATION BASELINE AND REDUCTION GOALS

In 2015, WI Department of Natural Resources staff determined that the current estimated phosphorus concentration (expressed as the flow-weighted mean) for Fenwood Creek is 187 micrograms per liter. Furthermore, the DNR staff estimated that a 45% reduction in the flow-weighted mean concentration is needed to reach median concentration of 75 micrograms per liter, the water quality goal for the Fenwood Creek. A 45% annual reduction of in-stream phosphorus represents nearly 5,080 pounds (based on the 11,200 pound 4 year average) determined by DNR 2010-2013 stream monitoring.

Strategically, Marathon County will pursue the interim in-stream concentration reduction goal of 45% by focusing on education; ordinance and program administration activities; best

management practices implementation; and cost-share assistance to agricultural producers. Specifically, county efforts will focus on reducing phosphorus and sediment delivery from farmsteads and cropland by 45%. As noted previously, the 45% reduction goal may be modified when the allocation limits developed for the pending TMDL plan are released in 2017.

The SNAP+ model predicts phosphorus delivered from cropland to stream; however, it cannot be directly compared with the measured in-stream P concentration and loading at mouth of the watershed. Marathon County will utilize the SNAP+ mode (cropland) and BARNY model (animal feedlot delivery) to establish the following:

- "Baseline" values for cropland and farmstead phosphorus contributions that reflect current agricultural practices within the watershed.
- Reductions of phosphorus and soil sediment loading after the implementation of structural best management practices funded with the Targeted Resource Management grant ($805,000). This is phase 1 of the Fenwood Creek project and will be the focus of county field activities in 2016-2019.
- Reductions of phosphorus and soil sediment loading after the implementation of non-structural best management practices funded by segregated funding sources. This is phase 2 of the Fenwood Creek project and will be the focus of county field activities in 2019-2025.

## BASELINE CROPLAND PHOSPHORUS CONTRIBUTIONS: BASELINE DELIVERY AND REDUCTION GOALS

The SNAP+ model was used to model Fenwood Creek watershed average cropland phosphorus loss (pounds/acre) and soil erosion rates (tons/acre/year) by incorporating the following variables provided in the WIDNR Wisconsin River Basin SWAT model and Revised Universal Soil Loss Equation (RUSLE):

1. Cropping rotations: the modeling used the following spatial distribution of rotational options based upon Conservation, Planning and Zoning Department staff performing conservation compliance evaluations of agricultural performance standards for various programs:
   a. Dairy forage rotation (60% of cropland acres): corn silage (2 years), soybeans, alfalfa directly seeded, and alfalfa (2 years). Estimates equally reflected both solid and liquid manure application scenarios.
   b. Cash commodity rotation (40% of cropland acres): corn grain and soybeans.
2. Predominant soil types for cropland (See Appendix E)
3. Average soil slope steepness and slope lengths for cropland
4. Current conservation management practices
5. Current tillage management practices

See Table 3 for estimated "baseline" delivery values for phosphorus (expressed as Phosphorus Index – PI value) and soil erosion rates (expressed as tons per acre per year). Baseline calculations found in Appendix F.

Table 3: Baseline Phosphorus Index and Soil Erosion Rates Values for Fenwood Creek

| Rotation | Phosphorus Index | Soil Erosion Rate |
|---|---|---|
| Dairy (with liquid manure) | 6.0 | 3.7 |
| Dairy (with solid manure) | 5.3 | 2.3 |
| Average Dairy (60%) | 5.6 | 3.0 |
| Commodity Crop (40%) | 3.5 | 3.2 |
| **Weighted Watershed Average** | **4.8** | **3.1*** |

*Footnote: The 2016 Marathon County Soil Erosion Transect Survey estimates that the soil erosion rate for the Fenwood Creek watershed is 3.2 tons per acre per year.

**For the Fenwood Creek Watershed 9 Key Element Plan, Marathon County will use a phosphorus index of 4.8 and a soil erosion rate of 3.1 to calculated weighted watershed contributions of phosphorus and soil sediment from cropland fields**.

A 45% reduction of the baseline weighted watershed phosphorus is the long term goal of the Fenwood Creek project. Therefore, the plan proposes to lower the watershed's average PI from 4.8 (lbs. /acre) to 2.6 over time. Similarly, the average soil erosion rate will be reduced from the current average of 3.1 (tons/acre/year) to 1.7. Table 4 provides a summary of the proposed phosphorus and soil erosion reduction goals.

Table 4. Baseline Phosphorus and Soil Sediment Delivery Estimates for Cropland in Fenwood Creek

| Pollutant | Cropland Acres | Current Weighted Watershed Average | Proposed Weighted Watershed Average | Current Total Estimated Loading | Proposed 45% Load reduction |
|---|---|---|---|---|---|
| Phosphorus | 14,600 | 4.8 Phosphorus Index | 2.6 Phosphorus Index | 70,080 pounds/acre/year | 31,536 pounds/acre/year |
| Soil Sediment | 14,600 | 3.1 tons/acre/year | 1.7 tons/acre/year | 45,260 tons/acre/year | 20,367 tons/acre/year |

Calculation of potential phosphorus delivery and reductions and soil erosion rates for individual cropland fields will be based upon SNAP+ model. For delivery estimates of phosphorus associated with animal feedlots, the BARNY model will be utilized. SNAP+ modeling will include evaluation of sites before and after BMP implementation to determine the environmental benefits of BMP implementation and investments. The monitoring of phosphorus delivery at the

individual cropland field level is impractical, and therefore, must be completed by DNR at the watershed level.

For cropland without existing SNAP+ or conservation planning information available to establish a beginning baseline soil erosion rate and phosphorus delivery value, Marathon County will utilize an average dairy rotation with standardized slope values and conservation practices. These standardized values are consistent with the values utilized by DNR staff for Total Maximum Daily Loading (TMDL) modeling.

When calculating estimated load reductions, the plan will take into account the reality that not all implemented practices will be maintained or function with the same pollutant reduction efficiency over time. Some practices provide diminishing returns/pollutant reductions over time. Therefore, this plan will follow EPA technical memorandum on BMP depreciation to evaluate modeled pollutant reductions and plan implementation. See Appendix D.

Farm assessment information will be gathered by CPZ staff conducting on-farm and cropland field assessments that evaluate the condition and performance of the best management practices. Assessments included verification of rotations, manure applications, waste storage facility condition, feedlot runoff controls, residue management, grassed waterways, roof runoff control systems, gullies, tillage, and conservation practices. It will not include ephemeral or event driven runoff events. Assessment data will be integrated into SNAP+ modeling to demonstrate current sediment and nutrient delivery loading to provide an accurate estimate of reductions.

### Phase 1: Structural Practices - Targeted Resource Management Funding

In 2016, Marathon County received an $805,000 grant from the WI Department of Natural Resources through the Targeted Resource Management (TRM) program. The funds will primarily provide cost-share to landowners and agricultural producers for structural practices. The TRM grant phase of the Fenwood Creek project will extend from 2016 -2018 and focus on structural best management practices located in the farmstead, cropland, and edge of field.

For waste storage facilities, the phosphorus reduction estimates were determined with the SNAP+ model comparing the manure applications as a daily haul versus a spring and fall distribution.

For barnyard phosphorus estimates, the BARNY model was utilized to compare before and after practice implementation scenarios along with analysis of previously installed practices during the LBEP priority watershed project. The Fenwood Creek watershed has 42 active barnyard sites of which 26 are considered commercial in nature. The average weighted discharge from the barnyards is 42 pounds of phosphorus annually (or 1,516 total pounds/total). Table 5 provides a listing of primary best management practice categories and estimated load reductions to be implemented in phase 1 (TRM funded) of the project. Note that within the primary categories of practices listed in table 5, there are subsets of specific, site specific practices that landowners may choose to implement (See Table 6).

Table 5: Phase 1: Fenwood Creek Sub-watershed Load Reductions

| Practice | No. of BMP's | Estimated P-load reduction Potential/unit | Estimated P-reduction Total (lbs.) | Cost/Unit | Total Cost |
|---|---|---|---|---|---|
| Nutrient Management[1] | 3,244 acre | 0.5 lb./ac. | 1,622 | $28/acre | $91,000 |
| Cropland Management –factors[2] | 850 acre | 0.25 lb./ac. | 125 | $29.11/acre | $24,750 |
| Hydrologic P-factors[3] | 1000 acre | 0.25 lb./ac. | 250 | $50/acre | $50,000 |
| Waste Storage Facilities | 3 | 200 lb. | 600 | $100,000 | $300,000 |
| Feed Leachate Treatment[4] | 3 | 200 lb. | 600 | $50,000 | $150,000 |
| Farmstead barnyards[5] | 6 | 40 lb. | 240 | $40,000 | $200,000 |
| | | | **+/-3,437** | | **$816,000** |

[1] Nutrient Management represents the positive impact that planning and improved management decisions have on load reductions. The estimated phosphorus load reduction represents the SNAP+ calculated benefits of improved practices. Source of load reduction estimates is from landowner nutrient management plans.

[2] "Cropland management factors" is a primary BMP category. Within this category are specific BMP's such as high residue management systems (tillage and cover crops), contour cropping, and rotational grazing. The estimated phosphorus load reduction is the average load reduction after BMP implementation per SNAP+ model.

[3] "Hydrologic P-factors" is primary BMP category. Within this category are specific BMP's such as clean water diversions, grassed waterways, and sediment basins. The estimated phosphorus load reduction is the average load reduction after BMP implementation per SNAP+ model.

[4] Feed leachate treatments represent structural practices implemented to collect and treat leachate runoff. Specific best management practices include leachate collection and storage in waste storage facilities, as well as vegetated treatment areas. The estimated phosphorus load reductions are estimates of reductions derived from Discovery Farms research.

[5] "Farmstead barnyards" is a primary BMP category. It represents collection treatment systems such as sediment basins, vegetated treatment areas, clean water runoff controls, and heavy use protection. The estimated phosphorus load reductions are estimates after structural best management practices implementation. Values derived from BARNY model applied to average sized feedlots within the watershed.

Table 6 provides a detailed summary of proposed "hard" practices to be implemented in phase 1 (TRM funded) of the project.

Table 6. Phase 1: Structural Practices: BMP implementation and cost estimate

| BMP | No. of BMP's | Cost/BMP | Total Cost |
|---|---|---|---|
| Stream crossing | 2 | $1500 | $3000 |
| Trails and lanes | 1000 ft. | $10/ft. | $10,000 |
| Waste storage facility<br>Engineering (12%) | 3 | $180,000<br>$21,600 | $540,000<br>$64,800 |
| Waste transfer | 3 | $12,000 | $36,000 |
| Waste storage closure | 4 | $10,000 | $40,000 |
| Milk house/feed storage VTA's | 6 | $5,000 | $30,000 |
| Barnyard | 6 | $30,000 | $180,000 |
| Roof runoff system | 6 | $1,500 | $9,000 |
| Diversion | 2000 ft. | $2.25/FT | $4,500 |
| Waterway | 1000 ft. | $3.00/FT | $3,000 |
| Sediment basin | 2 | $5,000 | $10,000 |
| WASCOB (edge of field) | 3 | $10,000 | $30,000 |
| Outlets | 6 | $500 | $3,000 |
| Subsurface drains | 6 | $500 | $3,000 |
| Heavy use protection | 6 | $10,000 | $60,000 |
| Waste water treatment | 3 | $3,000 | $9,000 |
| Wetland | 1 | $12,000 | $12,000 |
| Grazing | 250 ac | $25/Ac | $6,250 |
| Fencing | 1000 ft. | $0.50/ft. | $500 |
| Riparian buffer | 3 | $1,000 | $3,000 |
| | | | **$1,057,050** |

## Phase 2: Cropland Management Practices

After structural practices are initiated utilizing the TRM funds, Marathon County will begin education and technical assistance to address the cropland erosion and nutrient runoff contributions of phosphorus across the watershed.

The remainder of this chapter will outline and describe the estimates of the load reductions expected from proposed "soft" conservation measures (which are non-structural, management practices). In August 2016, Marathon County was notified of approval of a $50,000 grant from Greenheck Foundation that will provide financial support of both types of practices, as well as

staff. The project will focus on the reduction of soil sediment and manure runoff contributions by reducing erosion rates through the implementation of conservation cropping practices.

Table 7 describes the plan's Phase 2 - 10 year implementation strategy, beginning in YR 2016 and ending in YR 2025. Estimated interim P and soil erosion reductions resulting from a combination of cropland practices implemented on 64% (9,344 acres) of the total cropland acres (14,600 acres) within the Fenwood Creek watershed are shown.

Table 7. Phase 2 Phosphorus and Soil Erosion Rate Delivery Comparisons

| Practice | Acres | % of Land Application | Phosphorus Index (PI) Difference | Soil Erosion Rate Difference | Total Phosphorus Reduction (lbs.) | Total Soil Sedimentation Reduced (Tons) |
|---|---|---|---|---|---|---|
| CREP | 146 | 1% | 4.8 | 3.1 | 701 | 453 |
| Rotational Grazing[1] | 1314 | 15% | 4.6 | 3 | 6044 | 3942 |
| Cover Crops | 730 | 5% | 1.1 | 1.0 | 803 | 730 |
| Contour | 1460 | 10% | 1.6 | 1 | 2336 | 1460 |
| No Till | 730 | 5% | 3 | 2.5 | 2190 | 1825 |
| Chisel/Reduced Till | 1460 | 10% | 0.4 | 0.6 | 584 | 876 |
| Rotation (Increase hay 1 yr.) | 1314 | 15% | 0.7 | 0.4 | 920 | 526 |
| Reduced Tillage: Spring Chisel | 2190 | 15% | 0.7 | 0.9 | 1533 | 1971 |
| Totals | 9,344[2] | | | | **15,111** **(48%)** | **11,783** **(58%)** |
| Average reduction per acre | | | | | 1.6 lb. | 1.26 ton |
| Phase 1 reduction (table 5) | | | | | 3,437 lb. | |
| Phase 1 + Phase 2 reductions<br>Total % phosphorus reduction of plan reduction goal - 31,536 lbs. | | | | | **18,548 lb.**<br>**(60%)** | |

[1]Total acres for these are 8760 because only 60% of total acres are dairy
[2]Total acres of cropland implementing a best management practice(s). Note that some acres may benefit from more than one best management practice.

The plan's ten year "interim" reduction goals/practices will not achieve in-stream water quality standards of 75 micrograms/liter, but will be used as plan implementation milestones to

determine, in combination with WQ monitoring by DNR or other entities, if substantial progress is being made towards meeting Wisconsin's numeric phosphorus criteria. Implementation of similar or additional cropland practices listed in Table 7 will likely be needed on remaining cropland (5,256 acres) in watershed to meet the plan's overall phosphorus and soil sediment reduction goals and to meet achieve in-stream water quality standards of 75 micrograms/liter phosphorus concentration. Marathon County, along with its partners, will monitor and evaluate the project relative to successfully achieving the proposed **interim** reduction goals in Table 7 both during and after this plan's ten year schedule. After plan evaluation is completed, Marathon County will work with DNR and its other partners to adaptively manage and revise this plan to reflect additional programming and practices within the watershed necessary to achieve the remaining reductions necessary to achieve the plan's **long-term** phosphorus and sediment reduction goals.

The strategies to improve conservation performance in the Fenwood Creek watershed include: 1. regulatory, 2. conservation planning, and 3. technical and financial assistance.

## LOCAL REGULATORY POLICY STRATEGIES

In response to significant, documented agricultural runoff events, the Marathon County Board of Supervisors has initiated several regulatory–based policy initiatives to address excessive soil erosion and nutrient runoff activities with specific attention focused upon spill or event discharges. The intent of these regulatory initiatives is to provide local education and enforcement support to landowners. The focus of these efforts will minimize the occurrence of spills and discharge events due to the mismanagement of wastes and to ensure that there is an adequate response by responsible parties in case of discharge events. It is important to note that event discharges of phosphorus sources and soil sediment (such as ephemeral erosion) are not quantified through the SNAP+ model. Therefore, it is important to quantify, qualify and respond to these events in a regulatory manner. The regulatory and policy development strategy and time line is as follows:

### Animal Waste Storage Facilities and Nutrient Management Ordinance (AWO) and Livestock Facility Siting License Ordinance (LSO)

Goals

1. Reduce the number of spills or discharge events that contribute direct and significant sediment and nutrient discharges to the state's waters.
2. Structural performance and management expectations of BMP's will be clearly articulated in an "operation and maintenance" plan for waste storage facilities and barnyard systems.
3. The impact of unexpected agricultural runoff events involving soil sediment and nutrients sources will be minimized relative to water quality.

Objectives

1. April 2015: Marathon County Conservation, Planning and Zoning Department (CPZ) given citation authority. Regulated activities include the following:
   A. Construction of new Waste Storage Facilities (WSF's)
   B. Significant modification of existing WSF's
   C. Closure/deconstruction of abandoned WSF's
   D. Development of nutrient management plans by all permitted WSF's
   E. Development of nutrient management plans by unpermitted WSF's (pre-*1985)*

2. Spring 2017: Proposed regulatory administration emphasis of local ordinances (current permittees only) will extend to include:
   A. Direct runoff from manure applications to cropland and pastures
   B. Development and implementation of *Emergency Response Plans*
   C. Development and implementation of *Operation and Maintenance Plans*
3. Spring 2018: Proposed local ordinances will expand service and administrative authority of CPZ to include:
   A. Nutrient Management Plans for all landowners/producers applying commercial and/or organic fertilizers and amendments to cropland and pastures.
   B. Spills Management: Enforcement will include:
      1) Direct runoff of manure and contaminated runoff from farmstead areas
      2) Overflowing WSF's
      3) Unconfined manure storage in Surface Water Management Areas.

Outcomes

1. Initial Outcome (YR 2017)
   A. Landowners will understand state agricultural performance standards and compliance status of their respective farms.
   B. Landowners will understand spill reporting requirements, event minimization, and prevention.
   C. Landowners, agronomists, and farmers will understand value of emergency response plans.
   D. Landowners and consulting engineers will understand value of "operation and maintenance plans.

2. Intermediate Outcome (2017-2019)

    A. All landowners will develop, train staff and contracted workers, and follow an emergency response plan

    B. All landowners will develop, train staff and contracted workers, and follow an "operation and maintenance" plan for structural and management conservation practices.

3. Long term outcome (2019-2025)

    A. All landowners and cropland acres (14,600) will meet 100% compliance with state agricultural performance standards (WI Administrative Code NR 151)

    B. Beyond compliance with state agricultural performance standards, apply cropland BMP's to achieve a 58% reduction of soil sediment delivery to edge of field.

    C. Beyond compliance with state agricultural performance standards, apply cropland and farmstead practices to achieve a 60% reduction of phosphorus delivery to field edge.

    D. Inform community leaders and producers of progress of plan implementation and assess the adequacy of agricultural performance standards and level of practice implementation to achieve or not achieve the P water quality standard.

    E. Educate local officials and agricultural producers that in order to comply with the water quality standards, a 45% reduction in phosphorus delivery to Fenwood Creek from cropland acres is necessary. The plan contains ten year interim and will then need to be amended to reflect the long term phosphorus reduction goals.

    F. Number of event discharges or spills of soil sedimentation or manure less than 5 annually.

**Private Sewage Systems Ordinance**

Although the contribution of nutrients from private on-site wastewater treatment systems (POWTS) to the waters of the Fenwood Creek is low (less than 1%), Marathon County will continue to administer standards for the construction, modification and maintenance of POWTS. Figure 11 shows the location of existing permitted POWTS. The proposed Fenwood Creek Pilot Project will provide education, inventory and enforcement activities for unpermitted systems, as well as the maintenance of permitted systems.

<u>Goals</u>

- Complete an inventory of all private on-site waste treatment systems (POWTS) in the Fenwood Creek watershed (permitted and non-permitted)
- Develop a plan to address high risk discharges from POWTS

Outcomes

1. Initial Outcome (2016-2017)
    A. Landowners will understand status of POWTS construction and maintenance compliance.
2. Intermediate Outcome (2017-2018)
    A. All landowners with non-compliant POWTS will be notified of status and solution process.
3. Long term outcome (2019-2021)
    A. All (100%) POWTS will be in compliance with standards.

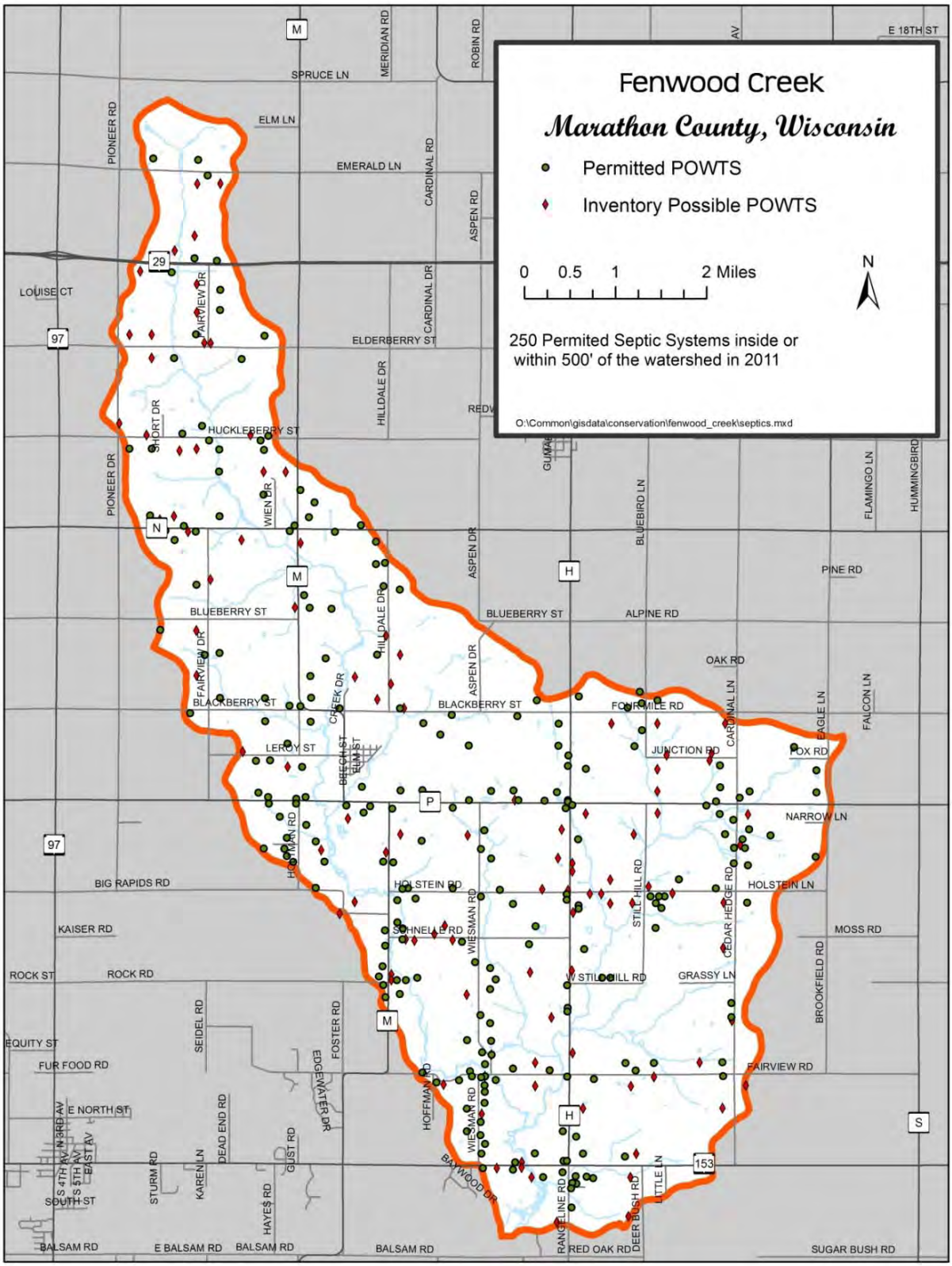



Figure 11 Location of POWTS in Fenwood Creek Watershed

## CONSERVATION PLANNING STRATEGIES: DEFINING DISPROPORTIONALITY

Conservation planning will be an important part of the education and outreach to landowners in the Fenwood Creek watershed. There are two primary points of emphasis that Marathon County will communicate to agricultural landowners:

1. Disproportionality: identifying and targeting the most serious farm field and farmstead contributors of soil sedimentation, organic matter and phosphorus.

2. Current performance of conservation practices installed in prior years through ordinances, federal and state programs, and local conservation efforts.

Disproportionality is a watershed planning concept that simply states that a few cropland acres or facilities produce the largest percentage of the water quality degradation. Historically, this was expressed as the "80-20 rule" where 80% of the problem is caused by 20% of the people/acres. Finding these specific attributes of the Fenwood Creek disproportionality will be important to best target limited staff and financial resources to the landowners where phosphorus and sediment reduction needs are greatest. Farmer input from the BEP task force indicated that farmers would be quite receptive to targeting efforts rather than the traditional whole farm planning approach.

Research that evaluated the application of the universal soil loss equation (USLE) in the Big Eau Pleine River watershed showed the USLE ***significantly underestimates soil loss*** by not accounting for ephemeral and snowmelt erosion. Additionally, research has identified that as slope steepness increases (doubles) the erosion rate increases 250%. Because of long slopes and fine textured soil, Marathon County will initially define disproportionality on cropland as follows:

- Cropland field slopes greater than 3%
- Slope lengths over 200 ft.
- Fenwood, Withee and Marathon soil types

Figure 12 and Figure 13 are useful maps that indicate and target programming priorities based upon soil slope lengths and soil erosion vulnerability within the Fenwood Creek watershed.

Marathon County will utilize BARNY, and SNAP+ models to identify high risk fields and farmsteads.

Conservation planning for most farms in the Fenwood Creek watershed will begin with an evaluation of previously installed best management practices either from the priority watershed era of 1993-2002, or through programming with the waste storage facility and nutrient management ordinance and farmland preservation. Marathon County estimates that approximately 30% of cropland fields and barnyards have best management practices currently

in place through previous local conservation programming. The purpose of the planning assessment is to determine if existing BMP's are functioning as designed. The assessment of existing best management practices for the entire watershed will be the basis of either revising or re-committing to the BMP to achieve the planned benefit. Because many BMP's have been installed, the new conservation activities should build upon previous efforts.

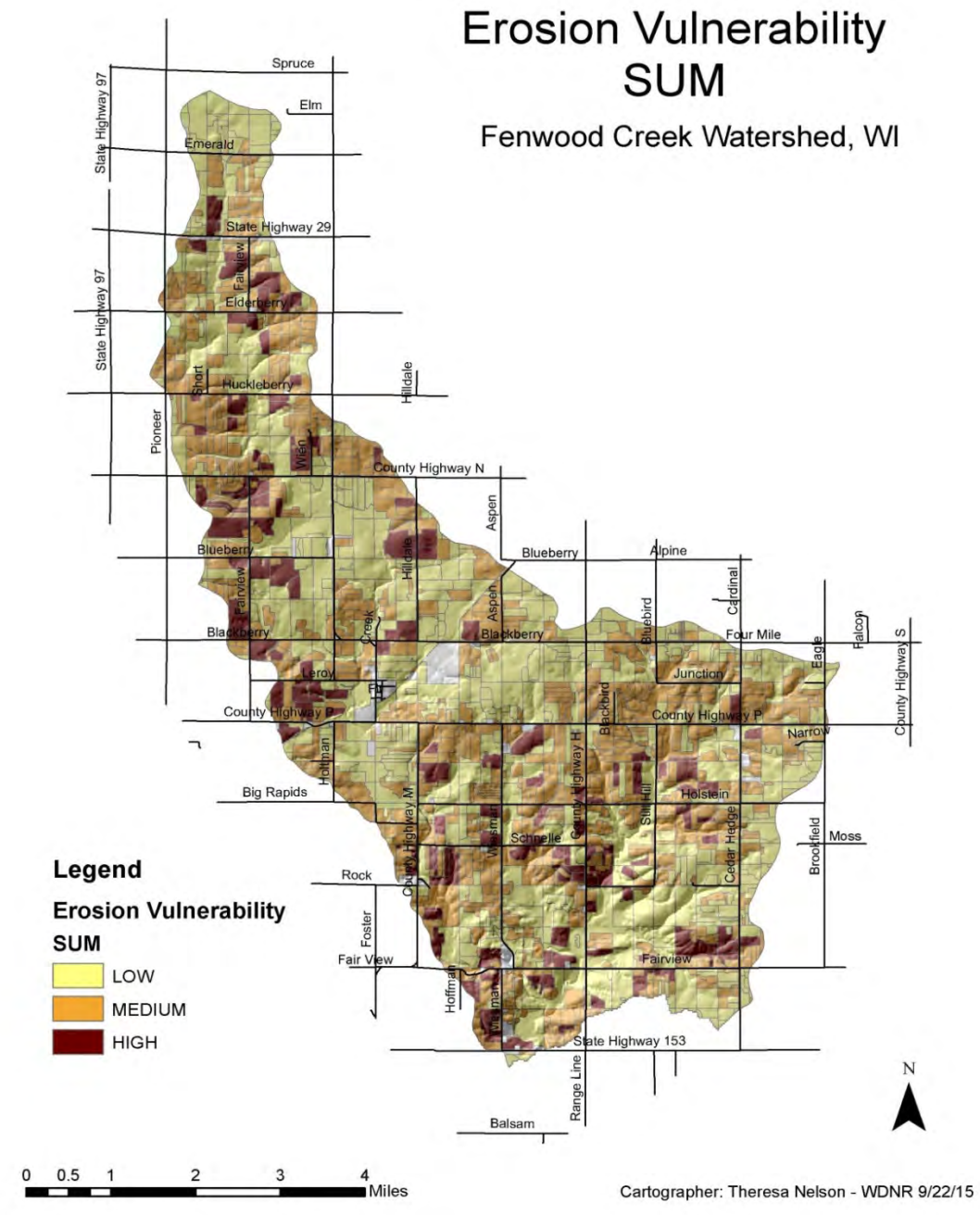



**Figure 12 Erosion Vulnerability SUM**

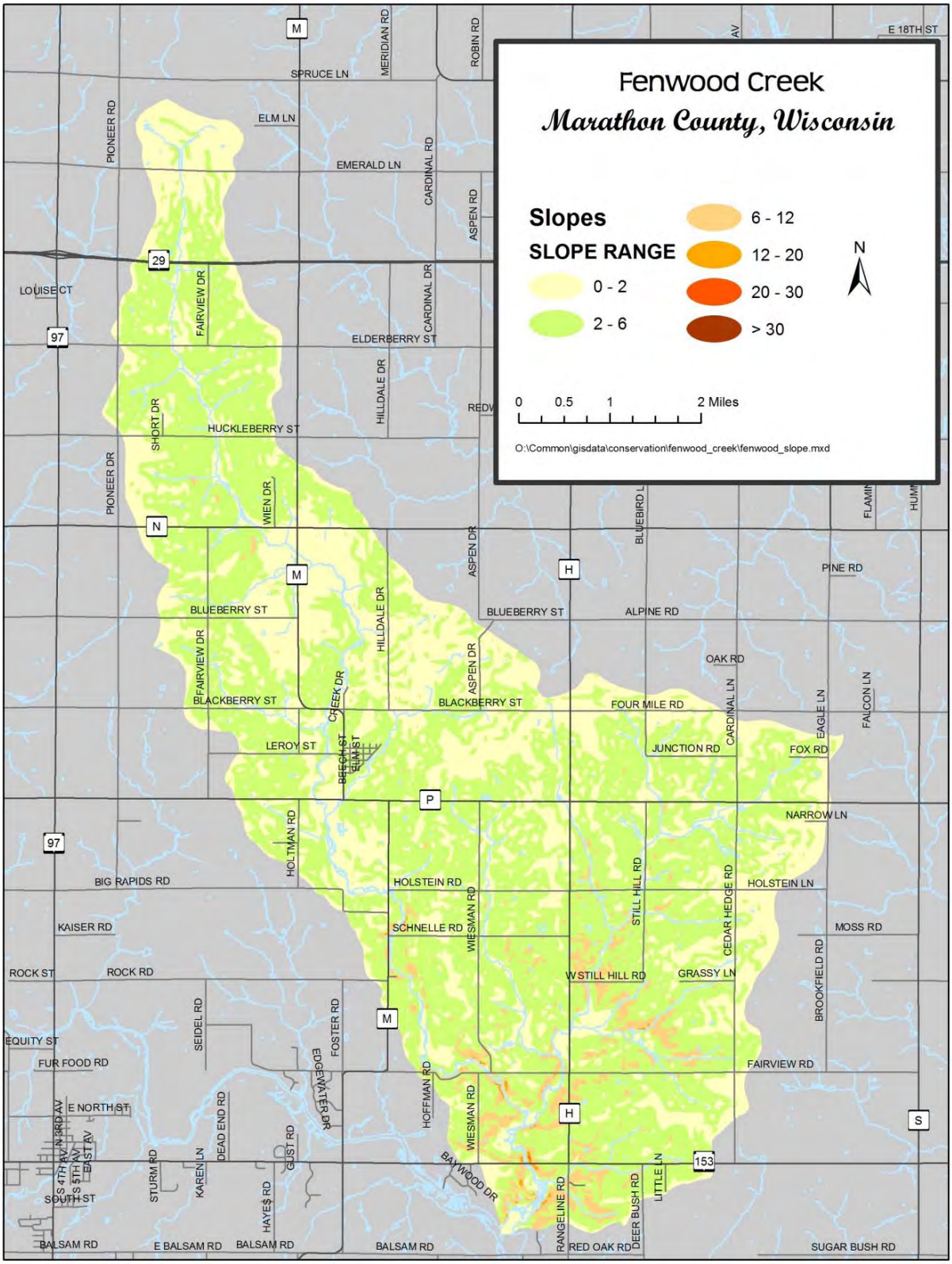



**Figure 13 Fenwood Creek cropland slope grades**

See Figures 14 for existing inventory of waste storage facilities and animal barnyards and Figure 15 for nutrient management plans in the Fenwood Creek watershed. The maps differentiate between facilities that were cost-shared or not through local conservation programming.

Goals

1. Reduce average soil loss rate in the Fenwood Creek watershed to 1.7 (current soil erosion rate 3.1).
2. Reduce average soil phosphorus index in the Fenwood Creek watershed to 2.6 on cropland (current average phosphorus index 4.8).

Outcomes

1. Initial Outcome (YR 2017)
    A. Landowners will understand compliance requirements of state agricultural performance standards (WI Administrative Code NR 151).
    B. Landowners will understand how the contributions of sediment and nutrients from farms impact water quality in the Fenwood Creek watershed.
    C. Farmer Council will be initiated to provide opportunity for landowners and producers to develop education and program activities and strategies for water quality improvements within the watershed.
2. Intermediate Outcome (2017-2019)
    A. Complete an inventory and assessment of existing waste storage facilities and barnyards to determine compliance with previous contracts and performance standards (WI Administrative Code NR 151).
    B. All landowners with non-compliance systems will be notified of status and solution process.
    C. Lower modeled potential cropland phosphorus delivery in watershed by 3,437 pounds.
    D. Lower modeled soil erosion within cropland fields by 3,000 tons/acre/year.
3. Long term outcome (YR 2019 – 2025)
    A. Lower average or modeled cropland phosphorus delivery in watershed by 18,548 pounds using figures 12 and 13 and practices listed in Table 7.
    B. Lower modeled soil erosion within cropland fields by 11,783 tons/acre/year using figures 12 and 13 and practices listed in Table 7.
    C. All landowners will be 100% in compliance with ordinances and state agricultural performance standards (per WI Administrative Code NR 151).

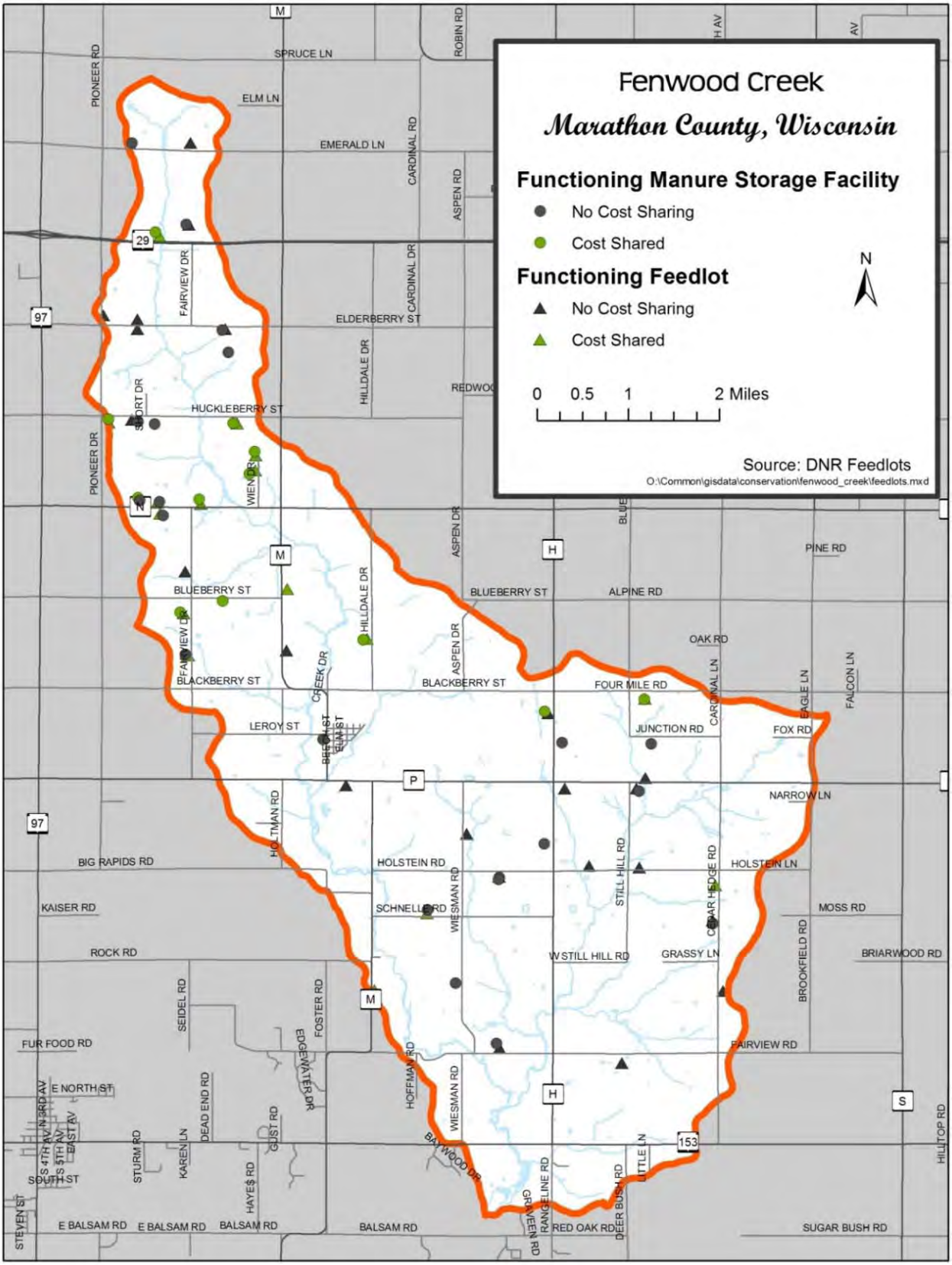



**Figure 14 Current waste storage facilities and barnyards in Fenwood Creek**

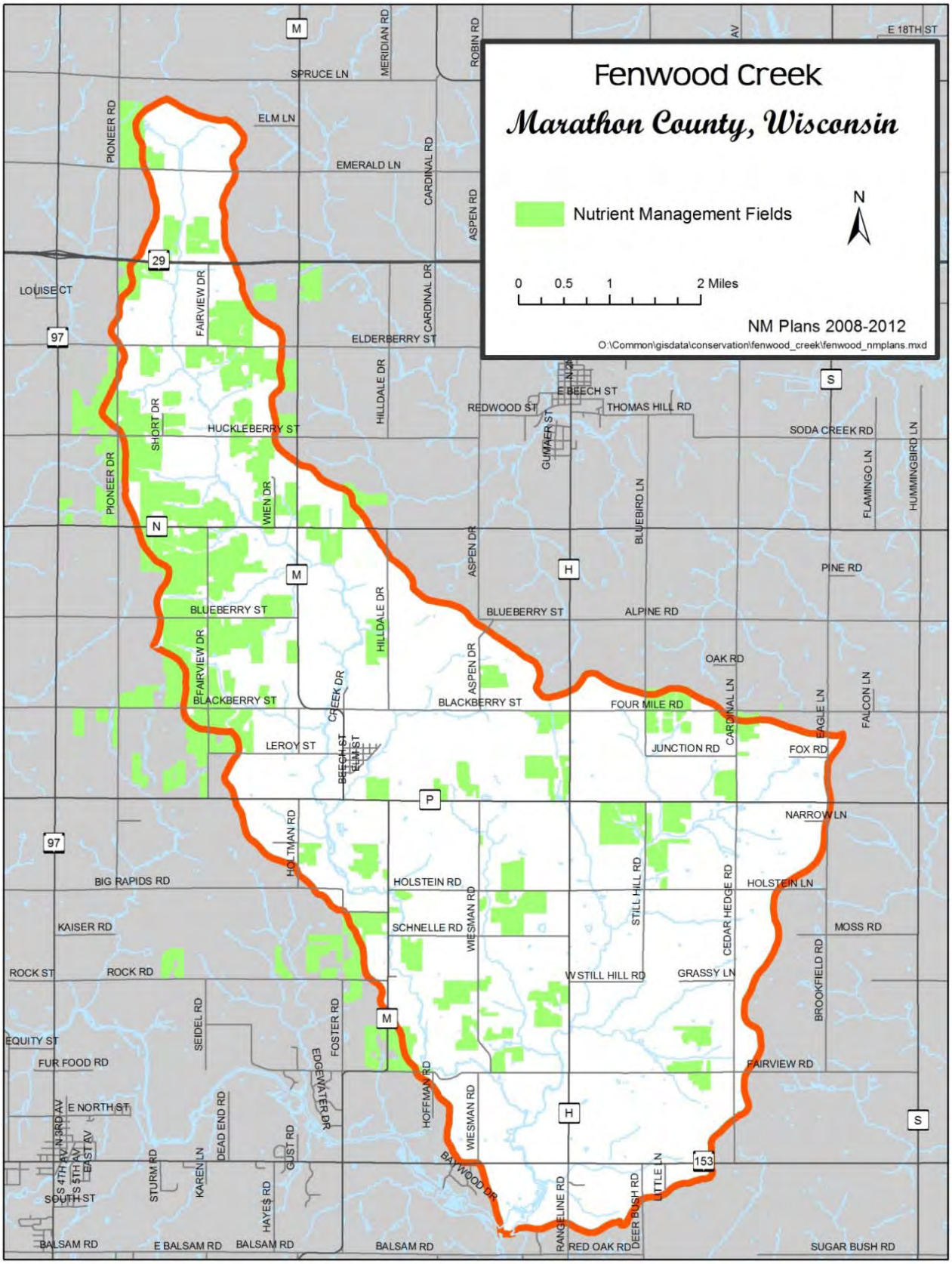



**Figure 15 Acres under nutrient management plans in Fenwood Creek**

## TECHNICAL AND FINANCIAL ASSISTANCE AND ACTIVITIES

The following section identifies the best management practices that Marathon County will plan and implement to resolve resource concerns. Because the Fenwood Creek watershed plan is written prior to the final TMDL plan completion, this plan will be modified, if needed, to reflect the needs of the final TMDL plan.

1. In Field Soil Erosion - sedimentation

   A. Slope length and gradient factor (LS): Research indicates that a doubling of slope steepness on the soil types prevalent in the Fenwood Creek watershed results in 250% increase in erosion. Because we cannot change steepness grades in cropland, conservation practices must be installed to shorten slope lengths.

      BMP choice: Terraces and diversions to shorten slopes along with grass waterways to safely convey water to edge of field.

   B. Conservation management factor (C): The greatest benefit to the water quality and soil health of the watershed would be to add vegetated cover or residue cover to the cropland during spring and fall. The trend in the watershed is to increase the presence of row crops with low residue additions and less grass/hay mixtures.

      BMP choice:

      1. Rotational grazing or increasing the length of hay in crop rotation.
      2. Winter cover crops. Cover crops protect the soil between commodity crops and can improve soil health over time.
      3. No-till: Tillage breaks up soil pores and reduces the amount of residue on the soil surface.
      4. Reduce prevalence of fall tillage (currently 80% of cropland tilled in fall).
      5. Modify crop rotations. Increase grass and hay in dairy rotation. See Figure 16 for current crop rotation in the Fenwood Creek watershed.

   C. Conservation practice factors (P): This factor reflects the effect of practices that will reduce the amount and rate of the water runoff and thus reduce the amount of cropland erosion.

      BMP Choice:

      1. Contour cropping
      2. Field strip cropping

In comparing the practice of straight-row farming up and down the slopes, cropping practices such as cross-slope cultivation, contour farming and strip cropping can reduce the soil erosion by 25% to 75%.

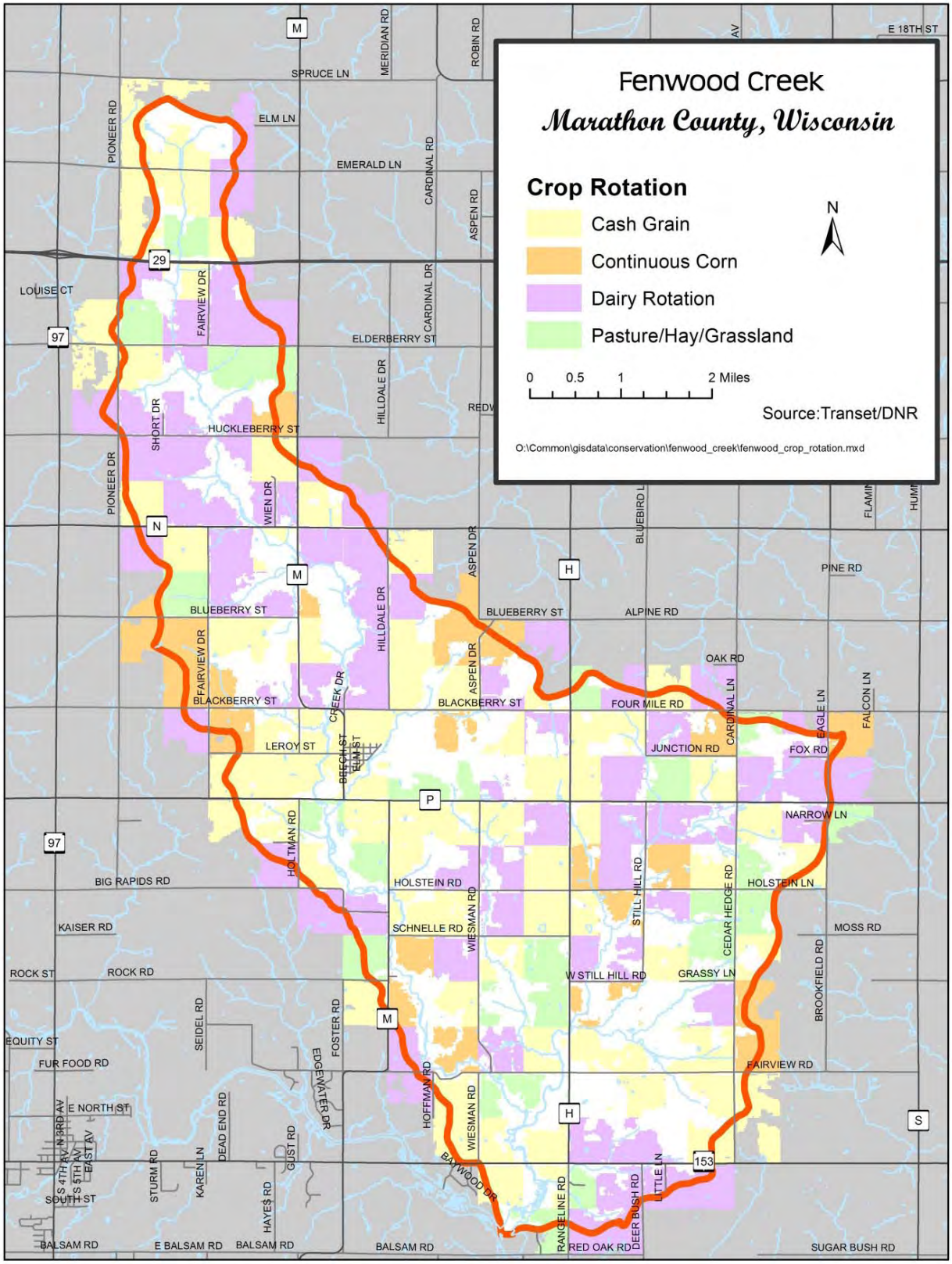



**Figure 16 Crop rotations in Fenwood Creek Watershed**

2. Animal Waste and Nutrient Management

   A. Nutrient management planning assistance to landowners and agronomists

   B. Improved barnyard runoff controls with sediment basins, heavy use protection and vegetated treatment strips

   C. Technology adoption: Manure injection systems allow producers to inject liquid manure below the soil surface with minimum disturbance. This process improves nitrogen use efficiency, preserves soil structure, retains crop residue and reduces nutrient losses associated with surface application of manure.

   D. Waste storage facilities will be implemented on farms where winter spreading is at a high risk. This will reduce phosphorus, nitrogen, and organic loading during spring runoff periods. Storage facilities constructed will also capture milking center waste that currently discharges to waters of the state. Landowners with long-term storage facilities will not be allowed to spread liquid wastes during frozen, saturated or snow-covered conditions.

   E. Barnyard and feedlot runoff controls will be implemented to reduce phosphorus, nitrogen, and organic loading. Marathon County estimates that the barnyards that are active throughout the year contribute as much as 1,516 lbs. of phosphorus per year.

   F. Milk house discharge controls. Marathon County estimates that there are approximately 8 landowners that directly discharge their milking center waste to waters of the Fenwood Creek. This accounts for an estimated 4,000 lbs. of biological oxygen demand annually. This waste stream also accounts for 520 lbs. of total phosphorus, 280 lbs. of soluble phosphorus, and 900 lbs. of suspended solids per year.

3. Edge of Field Practices: Re-establish riparian corridor wetland.

   Wetland restorations provide many benefits and are appropriate projects for areas where cropland fields are usually too wet to plant or harvest. Wetlands act as natural filtration systems for agricultural chemicals, and nutrients and serve as catchment areas for sediment. Wetlands can help recharge groundwater supplies, and provide habitat for migratory birds and important pollinator species that many crops rely on, such as bees.

   In the Fenwood Creek watershed, Marathon County will implement three Water and Sediment Control Basin practices to minimize sediment collection at the edge of cropland to prevent discharge into streams. Marathon County will rely on the use of LiDAR two foot contour maps to aid in developing edge of field buffers especially where delivery of sediment is adjacent to waters of the state. Marathon County and the BEP task force identified this land use practice as a BMP with great potential in the Fenwood Creek and larger BEP River watershed to reduce sedimentation into the river and reservoir system.

Goals

1. Reduce soil erosion on cropland.
2. Reduce sedimentation delivery from cropland to streams and rivers.
3. Reduce phosphorus delivery from farms.

Outcomes

1. Initial Outcome (YR 2016)
    a. Landowners will understand soil erosion processes and delivery dynamics of sediment from their farm.
    b. Landowners will understand principles of nutrient management and delivery of phosphorus from their farms.
    c. Landowners will understand the purpose and value of riparian wetlands to protect the stream from sediment discharges.
2. Phase 1(TRM ) Outcome (2017-2019)
    a. Complete a conservation plan for 3,244 cropland acres in watershed.
    b. Complete a nutrient management plan and other C and P soil erosion practices for 3,244 cropland acres in watershed. Includes winter spreading plans for high risk fields.
3. Long term outcome (2019-2026)
    a. Complete a conservation plan for all tillable cropland acres (14,600 acres) in watershed.
    b. Complete a nutrient management plan and other C and P soil erosion practices for 64% (9,344) tillable cropland acres in watershed. Includes winter spreading plans for high risk fields.
    c. Evaluate if amount and types of practices implemented on 64% cropland acres (9,344 acres) do or do not result in average watershed soil loss (tons/acre/year) of 1.7 and average phosphorus index of 2.6 (lbs./acre/year).

# CHAPTER 4: STAFFING AND FINANCIAL RESOURCE NEEDS WITH TIMELINE OF ACTIVITIES

Marathon County believes the Fenwood Creek pilot project will prove to be cost effective. Through previous landowner work with the Environmental Quality Improvement Program, Lower Big Eau Pleine River priority watershed program, farmland preservation program, Livestock Facility Siting Ordinance, Animal Waste and Nutrient Management ordinance, and Concentrated Animal Feedlot Operation permitting (WPDES), there are many conservation practices and compliance elements in place that control runoff that can be used to evaluate effectiveness, and ensure and promote the benefits of installed practices.

The Marathon County Conservation, Planning and Zoning (CPZ) department will address any current situations where performance standards are not being met such as barnyards, overflowing waste storage facilities, manure stacking in late winter and spring, and winter spreading of manure. A full description of the Marathon County implementation strategy for the agricultural performance standards found in WI Administrative Code NR 151 can be found in Marathon County Land and Water Resource Management Plan Chapter 4, section C. The most extensive work **will be to improve agronomic practices with contour farming, cropping practices, residue management, time of tillage, edge of field buffers (ephemeral erosion), and crop rotations**.

CPZ will identify and advance strategies to improve liquid manure application and distribution methods to promote immediate soil incorporation, increase soil organic matter, and reduce soil compaction. Marathon County will also develop strategies (regulatory and voluntarily) to minimize or prevent liquid manure application on snow-covered or frozen soils.

## STAFFING RESOURCES

The Conservation Division of the Conservation, Planning and Zoning Department consists of approximately 6.25 Full Time Equivalent (FTE) staff members that are focused on Land and Water Resource Management Plan efforts. To the extent possible, Marathon County will target existing staff to focus their priorities in alignment with the Fenwood Creek project. In addition, staffing grants will be sought to augment the program delivery of the project. The breakdown for staff time and responsibilities is as follows:

1. 0.5 FTE – Education and Outreach. Staff will assist with development of Farmer Councils and education to stakeholders and community partnerships to develop community capacity.
2. 0.25 FTE – Farmland Preservation/Regulatory and program compliance. Staff will be responsible for the administration of ordinances including permit and license application review and approval, and annual monitoring.
3. 0.5 FTE – Technical Assistance. Staff will provide educational and technical assistance to livestock producers, schools and lenders, as well as administering federal and state cost-share funds to landowners to implement best management practices.

4. 0.25FTE – Agronomic and Nutrient Management Support. Staff will provide training to landowners and agronomists on issues concerning, technical standards, spills reporting, plan compliance, and emergency response planning.

Additional staff time within the CPZ Department is available to provide grant administration, Geographical Information System, Comprehensive Planning, and regulatory assistance. See Table 8 for a breakdown of estimated staffing hours and costs.

Along with the county staff, the CPZ Department relies on the following agencies to provide the specialized assistance to local conservation program delivery.

1. Department of Natural Resources – Coordination of WPDES permit monitoring and compliance, site evaluations and administration of Targeted Resource Management projects, enforcement inspections and compliance checks of performance standards.
2. USDA–Natural Resource Conservation Service – Conservation planning, engineering standards review; EQIP grant administration and project selection; CREP administration and education; and Grazing Initiative projects.
3. UW-Extension – Information sharing and development of handouts to keep producers and professional groups aware of program and performance standards requirements.
4. Department of Agriculture, Trade and Consumer Protection – Engineering design, grant allocations for staffing and LWRM Plan implementation activities, soil erosion transect support, and CPZ staff training and education.

Marathon County CPZ proposes that implementing the BMP's will provide for a significant advancement in reduction of sediment and phosphorus from agricultural lands.

**Fenwood Creek Pilot Project**
**Targeted Runoff Management Grant – 2015**

Table 8. Staffing estimate

| **Activity** | **Hours/year** | **Total project Hours** |
|---|---|---|
| Landowner Contacts | 500 | 1500 |
| Education | 250 | 750 |
| Inventory | 250 | 750 |
| Targeting | 333 | 1000 |
| CSA | 250 | 750 |
| Design/Implementation | 500 | 1500 |
| Project Management | 333 | 1000 |
| Evaluations | 250 | 750 |
| Final Report | - | 100 |
| Enforcement | 250 | 750 |
| Total | | **8850** |

Cost Summary: (8850 hours) x $45/hour= $398,250
Staffing: 1.5 FTE/year

## FISCAL RESOURCES

Marathon County CPZ will use the cost control methods as prescribed in the state administrative rules for grants. The two common methods utilized to contain costs are bidding and average costing. Cost estimates for proposed management and structural practices are based upon average costs of implementation tracked by Marathon County annually. Each year, CPZ staff tracks installation of "bid" projects to maintain an average costs per unit of construction. The cost projections always reflect the staff's familiarity with BMP installation in this region where shallow bedrock will influence siting of projects and construction materials.

Cost containment for project implementation will be based on two (2) considerations:

1. Each project will consist of an inventory of past practice implementation to ensure that those BMP's are realizing their full potential. Project funds will not be utilized to maintain or rebuild previously funded practice work.
2. Project bidding. CPZ will utilize competitive bidding to obtain estimated costs of all BMP's. In cases where a landowner prefers to select the contractor without open, competitive bidding, the CPZ will determine costs by utilizing average cost methods.

Please note that if additional federal dollars or local funds are found, cropping practices and barnyard waste storage facility work will be enhanced to focus on spring time to prevent spring runoff of nutrients and sediment when heaviest loads are encountered.

# CHAPTER 5: BUILDING COMMUNITY CAPACITY – INFORMATION AND EDUCATION

An information and education component will be used to enhance public understanding of the project and encourage the public's early and continued participation in selecting, designing, and implementing the appropriate non-point source management strategies and conservation practices.

Marathon County will actively lead efforts to build community capacity of both public and private partners to improve the water quality of the Fenwood Creek watershed. To help effectively engage the public and the specific stakeholders, the Big Eau Pleine Citizens Organizations (with a grant from the WI Department of Natural Resources) partnered with Marathon County, University of Wisconsin- Stevens Point, River Alliance of Wisconsin and the DNR to conduct a survey of riparian landowners and farmers. The results of the survey will be incorporated into this plan to guide Marathon County's outreach. Specifically, the survey will provide the following insight and understanding into the Fenwood Creek community:

1. Economic value of clean water to residents and users
2. Economic barriers to BMP implementation
3. Perception and value of regulatory strategies to improve water quality
4. The governance capacity of the towns and village to support water quality activities
5. Community assets available to change behavior and invest in practices
6. Communication preferences of the diverse watershed stakeholders

When the survey results and analysis become available in 2017, Marathon County will utilize this social science information to design a community engagement plan with its partners.

The UW Agriculture Research Station (ARS), located in Town of McMillan, will support the project by providing research based documentation of sedimentation and pollutant runoff from cropland and pastures. The ARS has landscape, drainage systems and farming practices very comparable to the Fenwood Creek. Currently, the ARS has edge of field agricultural runoff monitoring available to help determine the effect of crop residue management on soil and phosphorus delivery to concentrated, surface drainage systems common to western Marathon County. Although research into the role and effectiveness of best management practices such a riparian buffers and edge of field sediment basins to control sediment and phosphorus will be initiated at the ARS, the research will not be available for this initial project.

Specific educational activities for the Fenwood Creek watershed will include:

1. In the first year of the project,(January 2017), Marathon County and the University of Wisconsin Extension will establish a farmer council to provide conservation staff with conservation planning and payment incentive strategies best suited to area farmers. Farm councils provide an opportunity for farmers to interact with peers, agency support staff and

community partners. Education, innovation and community sharing in solutions are the hope of developing these councils. The establishment of the farmer councils will be shaped and designed by a farmer survey conducted by Aaron Thompson. Although the design of the farmer council will emulate similar efforts in western Wisconsin within the St. Croix and Red Cedar watersheds, the specific information about the Fenwood Creek area farmers will be used to customize this project's effort. Develop education material and plan formats with these leaders to improve understanding of management goals and performance of BMP's. Create a website to distribute information to stakeholders, citizens and community members.

2. BEPCO/River Alliance/NRCS/Marathon County will host a social and educational meeting in fall 2016 in the Fenwood Creek watershed and on the reservoir to discuss runoff changes and unique challenges and commitments of the groups
3. Farm assessments in 2016-2017 to determine current farm practice compliance with state agricultural performance standards utilizing SNAP+ and BARNY models. Provide planning to achieve increased performance with enhanced BMP implementation.
4. Provide landowners (10 per year) with conservation planning, financial grant administration, and technical assistance (NRCS/Marathon County).
5. One-on-one landowner education and consulting to provide farm specific assessments and planning.
6. Provide town and village officials with information support for local comprehensive planning, zoning, and resource protection strategies that improve soil and water resource protection.
7. Identification of and contact with key stakeholders in the watershed to solicit their participation in improvements to water quality.
8. Support BEPCO organizational to build the capacity to lead landowners.

**BEP TASK FORCE**

In 2010, in response to the fish kill, Marathon County convened a meeting between Wisconsin Department of Natural Resources (DNR), Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP), farm producers, Clark and Taylor County staffs, Big Eau Pleine Citizens Organization (BEPCO) and Wisconsin Valley Improvement Company (WVIC) to

develop a short term plan to assess the impact on the fishery, adequacy of the aeration system, and water quality conditions.

The Big Eau Pleine Task Force prepared a document to identify the role of governmental agencies, sportsman and citizen groups, educational institutions, agricultural groups, and the WVIC to improve the health of the river system while balancing the needs of community and economic interests. It will also provide a foundation of understanding for the policies that may be proposed by local leaders.

The task force was established by Marathon County to ensure that all interested parties were represented and County policy is based upon recommendations consistent with community and economic development goals.

The recommendations forwarded by the Big Eau Pleine River Task Force represent policies and activities that Marathon County should develop, coordinate and implement to lead a local effort to improve community and economic development opportunities, as well as minimize public health concerns associated with the watershed's water quality.

## POLICY RECOMMENDATIONS

An effective education and outreach effort will help develop and create local policies that support reasonable strategies and implementation tactics that include a mix of volunteering and enforcement measures. Below are the policy recommendations as well as the commitments made by partners of the Fenwood Creek Pilot Project:

- **Aeration System Operation and Maintenance**. The aeration system will be an ongoing and necessary management tool to the well-being of the reservoir and fishery. Operations and maintenance and capital expenditures for the system will be administered through a Memorandum of Agreement established for 5 year periods.

  WVIC, the FERC licensed operator of the reservoir, and DNR, the owner of the land and aeration equipment, will serve as the primary agents to determine the start-up criteria, safety

and operations of the system. These organizations will also serve as the primary water quality monitoring agents for the tributary and reservoir waters.

Participating partners should contribute funds to pay for annual electrical costs and the repair or replacement of capital improvements such as items associated with motors, blowers, and buildings.

- **Resource Management Initiatives**. The local, state and federal agencies serve as the primary vehicle of delivery of local conservation programming to landowners and residents. Local conservation programs include education, resource assessments and planning, technical assistance, grant funding, and administration of regulations. Marathon County will provide leadership through policy, and partnership coordination through the Marathon County Comprehensive Plan. Specifically,

  **a. Marathon County will**:
  i. Adopt and implement state agricultural performance standards in local ordinance to address chronic and significant discharges.
  ii. Minimize or eliminate winter land surface spreading activities of wastes.
  iii. Promote technologies to treat and distribute livestock waste.
  iv. Provide Best Management Practice education and training to landowners.
  v. Administer the Non-metallic Mining Ordinance.
  vi. Eliminate direct surface discharges of sanitary wastes.
  vii. Develop a reservoir recreation management plan.
  viii. Provide financial support of annual operational costs of the aerator.
  ix. Develop and implement a Fenwood Creek pilot project (see description below).

  **b. WI Department of Natural Resources (DNR) will**:
  i. Develop a reservoir management plan to protect the natural resources (land, water and fish) of the Big Eau Pleine reservoir and tributary waters. The plan will set goals for the fishery and supporting food system.
  ii. Provide lake management grants to local partners.
  iii. Complete a water quality assessment of the Upper Wisconsin River Basin and develop a Total Maximum Daily Load (TMDL) plan for the Big Eau Pleine Watershed and Wisconsin River.
  iv. Support Taylor, Marathon, and Clark Counties with investigation and enforcement of agricultural performance standards and prohibitions.
  v. Provide Best Management Practices cost-share grants to landowners.
  vi. Provide water quality monitoring of algae concentrations that threaten public health.
  vii. Primary responsible agency role (with WVIC) for the aeration system in an operation and maintenance plan.
  viii. Coordinate aeration system operations (with WVIC).

  **c. WI Department of Agriculture, Trade and Consumer Protection will**:
  i. Provide BMP grants to landowners for state agricultural performance standard(s) compliance.
  ii. Provide administrative support for the Farmland Preservation Program.

iii. Coordinate education with agriculture industry associations and producers on nutrient management and non-point runoff controls.

**d. Wisconsin Valley Improvement Company will:**

i. Provide water quantity and quality monitoring.
ii. Coordinate aeration system operations with DNR.
iii. Lead reservoir operation activities.
iv. Update reservoir modeling tool(s) and drought management plan at 5-year intervals (next update due 2016).

**e. USDA – Natural Resources Conservation Service will**:

i. Provide technical assistance, conservation planning, and engineering support to landowners.
ii. Provide cost-share assistance to landowners.
iii. Develop and implement manure winter spreading evaluation and planning strategies to minimize runoff risks.

**f. Big Eau Pleine Citizens Organization will**:

i. Provide a citizen's voice to community needs relative to property, resource management, and public waters.
ii. Coordinate input from community-based organizations such as recreational and lake groups to provide feedback about program outcomes and outreach needs.
iii. Pursue grant opportunities. Specifically, grants to support development of lake management plans and studies to better understand the dynamics of sediment, water level management, and nutrient enrichment in the watershed.

**g. Farm industry representatives will**:

i. Provide landowner education through Farmer Councils.
ii. Provide feedback on incentives and program initiatives.

**h. Taylor County Land Conservation Department will**:

i. Implement conservation programs focusing upon conservation compliance, nutrient management, and animal waste management through the Land and Water Resource Management (LWRM) plan.
ii. Provide education on groundwater protection and Best Management Practices.

**i. Clark County Land Conservation Department will**:

i. Implement conservation programs focusing upon conservation compliance, nutrient management, and animal waste management through the LWRM plan.
ii. Implement Heart of America's Dairyland Agricultural Enterprise Area.

- **Fenwood Creek Watershed Project**. Because the water quality assessment activities and the Big Eau Pleine River and Reservoir Total Maximum Daily Load plan will not be completed until 2016-17, the task force recommends that the agencies initiate a small scale watershed project. The purpose of the project is to develop the strategies relative to Best Management Practices, waste treatment and distribution technology implementation, conservation planning, financial incentives, technical assistance, and education needed to

achieve water quality outcomes for the watershed. The project would include the following elements:

- Water quality monitoring. Assess the management and environmental performance of BMPs, quantify the pollutant contributions of major event runoff discharges vs. chronic low-level discharges, and document changes in water quality over time.
- Education. Communicate performance expectations and regulatory requirements to landowners, towns, cities and villages.
- Nutrient management planning. Provide technical and financial assistance to landowners to assure all producers have and follow nutrient management plans.
- Manure winter spreading assessments. Develop and implement criteria to assess winter spreading runoff risks and provide planning assistance to landowners to manage risks.
- "Edge of Field" Best Management Practices. Implement BMPs down slope of cropland to treat and reduce sediment and nutrient loading from runoff. In cases where runoff contributions are chronic and cannot be minimized to acceptable levels, permanent land use conversion strategies will be developed.
- Financial and management incentives. Develop financial and management incentives to promote BMP implementation, including long-term maintenance and performance of BMP.
- Waste treatment and distribution technology. Increase understanding and implementation of waste treatment and distribution technologies that reduce runoff risks and maximize nutrient utilization. Provide cost-benefit analysis of new technologies and develop adoption strategies.

# CHAPTER 6: MONITORING AND REPORTING

Measuring progress is essential to determine if the goals of the plan are being accomplished. Several methods will be used to measure planning, assessment and BMP implementation progress. Marathon County has developed a parcel based tracking and monitoring system for conservation activities and monitoring. Furthermore, the conservation plan will function as the primary document to record decisions made by landowners and conservation staff for BMP activities and planned compliance. The tracking system will document the following information on a specific land parcel:

1. Landowner/Address
2. Compliance Status relative to NR 151, pertinent local ordinances and codes, and compliance status
3. Program Participation Status: Federal programs as well as Farmland Preservation, Grazing, Priority Watershed, CREP, etc.
4. Existing and Planned Conservation Best Management Practices
5. Maps and Field Delineations
6. Follow-up inspections/Verification of practice implementation

Throughout the Fenwood Creek plan there are number of intermediate goals and outcomes identified such as:

- The number agricultural best management practices implemented and adopted
- Modeled Reduction in phosphorus (pounds) and soil sediment (tons) annually delivered from cropland to the Fenwood Creek
- Modeled Reduction of average annual soil erosion rate on cropland
- Modeled Reduction of average annual potential to deliver phosphorus (watershed phosphorus Index).

These intermediate outcomes will serve to establish short-term and long-term milestones that will allow CPZ staff to track the implementation success of proposed strategies.

Specific tracking of activities include the following:

## A. SOIL EROSION

The County will continue its soil erosion transect survey every other year in the spring. The survey shows land use and cropping trends and evaluates the rate of application of conservation practices.

Program status reviews and ordinance monitoring activities are conducted by CPZ and NRCS staff to ensure landowners and operators are in compliance with their conservation plans, permits and licenses.

Reductions in sediment delivery will be calculated for projects in the Fenwood Creek watershed areas utilizing SNAP+ model. Staff will continue to develop a report to assess the trends in organic matter content of topsoil utilizing soil testing data in nutrient management plans.

Acreages of farm plans prepared and revised will continue to be recorded. All conservation plans will be developed to assure that the NR 151 cropland performance standards are met. Once landowners are determined to meet agricultural standards (Wi Administrative Code NR 151), including erosion standards, a certification letter is sent to them.

Once soil erosion risk maps are developed to identify cropland to show areas of disproportionality, Marathon County will track conservation planning, nutrient management planning, and BMP implementation on those fields to ensure that 100% of these fields are below tolerable soil loss rates.

## B. WATER QUALITY

The calculated amounts of phosphorus runoff reduction will be totaled for barnyard practices and reductions in winter spread manure due to construction of waste storage structures. All practices installed under the Marathon County Waste Storage Facility and Nutrient Management code will be properly permitted by CPZ and certification letters sent to landowners upon BMP completion verifying satisfaction with performance standards and ordinances.

## C. SPOT CHECKS, AUDITS AND ANNUAL REPORTS (includes basic performance standards as well as additional efforts)

The DATCP and NRCS will conduct annual engineering and conservation planning spot checks on work performed by Conservation staff. These checks ensure financial and quality control of landowner cost-share grants, staffing grants, administration responsibilities and technical design work.

DNR performs similar program and financial audits on projects funded by Targeted Runoff Management or Notice of Discharge grants. The county also conducts financial audits each year. Those audits ensure quality control from an administrative perspective.

Items in the Goals section will be reported by the units or numbers as they appear. CPZ will complete and submit an Annual Report of progress to DNR that relates information concerning Best Management Practice installations, status of informational activities initiated, acres of Conservation Plans developed, compliance status of agricultural performance standards (Wi Administrative Code NR 151) within the watershed, and staff hours spent on the various program efforts.

## D. OUTCOME MEASUREMENT

Marathon County has developed a scorecard method of evaluating program outcomes. Specifically, the county is utilizing a "Logic Model" approach that identifies resource inputs, such as grants, staff, equipment and partnerships, activities, and both short term and long term outcomes of the county's efforts relative to conservation programming. The scorecard tracks outcomes and trends toward successful implementation of programs. The scorecard will be developed annually to present to the Marathon County Environmental Resources Committee, BEPCO, DNR and local officials. For purposes of meeting element 8 of EPA's 9 Key Elements, if less than 20% of the milestones listed within Tables 5 and 7 are achieved by 2021, then this plan's goals, objectives and milestones will be revised to reflect the lack of plan implementation. See Table 9 – Fenwood creek Project Logic Model.

## E. RESOURCE EVALUATION AND MONITORING

In consultation with the Central Wisconsin River Basin and DNR staff, Marathon County will advance efforts to monitor best management practices and water quality improvements and status of the County's water resources in the Fenwood Creek Watershed and the Big Eau Pleine River Watershed. By utilizing both professional and volunteer monitoring programs, Marathon County hopes to advance the information sharing required to communicate the resource problems that impact communities.

Specific activities for evaluation and monitoring include:

1. Marathon County will survey all landowners pre and post project to assess their understanding and value of the farm runoff dynamics and performance standards.
2. Marathon County will provide a summary report of farmer council feedback relative to BMP adoption barriers, appropriate strategies for incentives, and alternative Best Management Practices strategies and technologies needed to improve water quality.
3. Documentation of educational and implementation activities and progress. CPZ will maintain records of education and conversation with individual landowners as well as decisions related to BMP compliance status and future BMP implementation schedules.
4. CPZ will develop and submit a regular status report of the pilot project to its partners and DNR. Quarterly, the project status will be presented to the authorized local county committees, local Town officials, and BEPCO.
5. CPZ will provide biannual and annual status reports to DNR, BEPCO and Farmer Council to track farmer interaction, financial administration and distribution of funds, implementation of BMP's, water quality monitoring results, and environmental performance of implemented BMP's.

   Because of the pilot nature of the project, landowners and partnerships will be assessing the effectiveness of education and implementation strategies. The status of the project will be reviewed regularly with DNR, farmer councils, and partnership to determine if strategies need to be modified and re-directed.

Lessons learned and changes will be included in monthly and annual reports to document challenges and effectiveness of changes.

6. In-stream water monitoring: Currently, the only sites DNR has committed to routine water chemistry monitoring are its long-term trend monitoring sites. Those are the large river sites at Merrill, Biron, and Wisconsin Dells on the Wisconsin, plus one site on the Baraboo River. DNR has indicated that they will rely on implementation tracking of this plan and other efforts as the trigger to reinstate more intense DNR-led monitoring activities to determine in stream P concentrations and loads.

   CPZ will consult with DNR to conduct water quality sampling at the mouth of the Fenwood Creek watershed and after implementing cropland BMP's to determine if sediment and phosphorus reductions are occurring. Marathon County will request monitoring after Targeted Resource Management (TRM) activities have concluded (2019) and also after modeled reductions from implementation of practices on > 50% of cropland acres in watershed are shown (2025).

   That being said, there certainly are opportunities for volunteer trend monitoring to take place between these two time periods.

   Annual Total Phosphorus (TP) loading is variable. For example, in 2012 (drought year), the TP load was approximately 12,500 lbs. per year and in 2010 (wet year), the TP was 2,500 pounds per year. Marathon County, in consultation with DNR, estimates that the average annual TP load is approximately 11,200 pounds. DNR WQ biologists recommend TP load monitoring be done for a minimum of 2 to 3 years to in a watershed to understand annual TP variability. Marathon County will evaluate progress first by using land use models and if modeled reductions are found, then the in-stream load monitoring will be requested.

## Table 9. FENWOOD CREEK PROJECT – LOGIC MODEL

**Contact Name**: Andy Johnson, Environmental Resources Coordinator
**Standing Committee**: Environmental. Resources Committee
**Working Committees:** Land Conservation & Zoning Committee
**Program customer**: Fenwood Creek: Towns, Village of Fenwood, and landowners

| COMMITMENTS | ACTIVITIES | | OUTCOMES | | |
|---|---|---|---|---|---|
| Category | Outputs/Milestones | Current | Initial (YR 2016) | Intermediate (YR 2017-2018) | Long Term (YR 2019-2026) |
| 1. **TRM Project (Phase 1)**<br><br>Education<br><br>Improve nutrient management<br><br>Improve Cropland Management Practices<br><br>Improve cropland erosion control and runoff practices<br><br>Improve livestock waste management in farmstead and cropland<br><br>Improve feed leachate runoff control practices<br><br>Improve open feedlot runoff practices | Nutrient management planning and education<br><br>Conservation planning<br><br>Farmstead runoff evaluations, planning, and design support | Animal Waste and Nutrient Management Ordinance | Landowner and agronomist education about Standard 590 and impacts of phosphorus in water<br><br>3,244 acres additional nutrient management planned<br><br>1,850 acres of cropping and cropland runoff control practices<br><br>3 waste storage facilities<br><br>3 feed leachate runoff control systems<br><br>6 feedlot runoff control systems | 1,622 lbs. phosphorus reduction due to improved nutrient application practices<br><br>375 pounds phosphorus reduction due to improved cropping and runoff control practices<br><br>600 lbs. of phosphorus reduction due to reduced winter spreading of manure<br><br>600 lbs. of phosphorus reduction due to collection and storage of feed leachate<br><br>240 lbs. of phosphorus reduction due to collection and treatment of feedlot runoff. | NA |

| COMMITMENTS | ACTIVITIES | | OUTCOMES | | |
|---|---|---|---|---|---|
| Category | Outputs/Milestones | Current | Initial (YR 2016) | Intermediate (YR 2017-2018) | Long Term (YR 2019-2026) |
| 2. **Local Regulatory Policy**:<br><br>Reduce the number of spills or event discharge events that contribute direct and significant sediment and nutrient discharges to the state's waters.<br><br>Structural performance and management expectations of BMP's will be clearly articulated in an "operation and maintenance" plan for waste storage facilities and barnyard systems.<br><br>The impact of unexpected agricultural runoff events involving soil sediment and nutrients sources will be minimized relative to water quality. | Ordinance Revisions:<br><br>Administrative Guidelines<br><br>Policy Guidelines<br><br>Education and Outreach Plan | Livestock Facility Siting Ordinance<br><br>Animal Waste and Nutrient Management Ordinance | Landowners will understand state agricultural performance standards and compliance status of their respective farms.<br><br>Landowners will understand spill reporting requirements, event minimization, and prevention.<br><br>Landowners and agronomists and farmers will understand value of emergency response plans.<br><br>Landowners and consulting engineers will understand value of "operation and maintenance plans.<br><br>CPZ and UW-Extension will organize a Farmer Council | All landowners will develop, train staff and contracted workers, and follow an "emergency response plan" for existing structural BMP's<br><br>All landowners will develop, train staff and contracted workers, and follow an "operation and maintenance" plan for existing structural and management conservation practices.<br><br>3,437 (pounds) reduction in phosphorus delivery to Fenwood Creek (Snap+ based) | All landowners and tillable cropland acres (14,600) will meet 100% compliance with state agricultural performance standard (NR 151)<br><br>18,548 (pounds) reduction in phosphorus delivery to Fenwood Creek (Snap+ based)<br><br>58% reduction of soil sediment delivery to edge of field<br><br>Number of event discharges or spills of soil sedimentation or manure less than 5 annually |

| COMMITMENTS | ACTIVITIES | | OUTCOMES | | |
|---|---|---|---|---|---|
| Category | Outputs/Milestones | Current | Initial (YR 2016) | Intermediate (YR 2017-2018) | Long Term (YR 2019-2026) |
| 3. **Determine Watershed Disproportionality and BMP Inventory/Assessment**:<br><br>Determine specific cropland attributes of the Fenwood Creek that lead disproportionality to high pollutant delivery loading to best target staff and financial resources to the landowners where needs are greatest.<br><br>Complete an inventory of previously implemented agricultural BMP's<br><br>Assess existing agricultural BMP's to determine compliance with contracted "Operation & Maintenance" requirements and environmental performance<br><br>Improve Community Capacity to address water quality concerns. | Disproportionality Report (Criteria and spatial location)<br><br>Fenwood Creek Best Management Practice Inventory and Assessment Report (establish baseline) | No data exist for targeting cropland or farmstead best management practices<br><br>No data exists for current condition or performance of previously implemented best management | Landowners will understand state agricultural performance standards and compliance status of their respective farms.<br><br>Landowners receive an on-farm assessment of existing BMP.<br><br>CPZ will develop methodologies and evaluations to define disproportionality in the Fenwood Creek Watershed.<br><br>Form a Farmer Council of individuals and organizations in the watershed to collectively resolve water quality concerns. | Landowners will receive a farm specific report describing their current cropland and farmstead conservation practices and environmental performance.<br><br>Producers out of compliance with WI Adm. Code NR 151 will be notified of compliance status and solution alternatives.<br><br>CPZ will establish a baseline of current BMP's and performance relative to phosphorus and soil sediment delivery.<br><br>CPZ will establish the criteria to identify high priority cropland and farmstead sites for conservation/nutrient planning in order to target staff and fiscal resources.<br><br>Reduce average soil phosphorus delivery by 3,437 pounds annually.<br><br>Lower soil erosion rate from cropland by 3,000 tons annually | All landowners and acres (14,600)( will meet 100% compliance with state agricultural performance standard (NR 151)<br><br>18,548 (pounds) reduction in phosphorus delivery to Fenwood Creek from cropland via various practices on 64% of cropland acres (see Table 7)<br><br>58% reduction of soil loss from cropland via various cropland practices (see table 7) |

| COMMITMENTS | ACTIVITIES | | OUTCOMES | | |
|---|---|---|---|---|---|
| Category | Outputs/Milestones | Current | Initial (YR 2016) | Intermediate (YR 2017-2018) | Long Term (YR 2019-2026) |
| 4. **Technical Assistance and BMP Implementation**:<br><br>Provide conservation and nutrient planning support to agricultural producers.<br><br>Provide administrative support and guidance to producers for best management practice design and installation<br><br>Provide administrative and reporting support to BMP installation and environmental response reports. | Conservation planning<br><br>Nutrient Planning<br><br>Waste Storage Facilities – Construction<br><br>Waste Storage Facility Closure<br><br>Livestock Barnyards<br><br>Feed Leachate Control Systems<br><br>Cropland “C” and “P” BMP’s | 5,614 acres<br><br>5,614 acres<br><br>31<br><br>8<br><br>33<br><br>0<br><br>5,614 acres | 5,614 acres<br><br>5,614 acres<br><br>32<br><br>9<br><br>33<br><br>0<br><br>5,614 acres | 7,114 acres<br><br>7,114 acres<br><br>34<br><br>11<br><br>34<br><br>1<br><br>7,114 acres | 9,344 acres<br><br>9,344 acres<br><br>37<br><br>14<br><br>37<br><br>2<br><br>9,344 acres |

# APPENDIX A

**Land and Water Resource Management Plan**
**Glossary and List of Acronyms**

1. **AFO – Animal Feeding Operation:** feedlot or facility, other than pasture, where animals have been, are or will be fed, confined, maintained or stabled for a total of 45 days or more in any 12 month period. Administrative Code NR 243.

2. **A.U. – Animal Units:** a unit of measure used to determine the total number of single animal types or combination of animal types which are fed, confined, maintained or stabled in an animal feedlot operation. Administrative Code NR 243, local ordinances (Zoning, Livestock Facility License, and Waste Storage Facility/Nutrient Management).

3. **AWO – Waste Storage Facility and Nutrient Management Ordinance:** Chapter 11.02 of General Code of Ordinances.

4. **BMP – Best Management Practices:** means structural and non-structural measures, practices and techniques or devices employed to avoid or minimize soil, sediment, or pollutants carried in runoff to waters of the state.

5. **CAFO – Confined Animal Feeding Operation (>1000 A.U):** means an animal feeding operation which feeds, confines, maintains or stables 1,000 animal units or more.

6. **CNMP – Comprehensive Nutrient Management Program:** conservation plans unique to livestock operations. These plans document practices and strategies adopted by livestock operations to address natural resource concerns related to soil erosion, livestock manure and disposal of organic by-products.

7. **CPZ – Department of Conservation, Planning and Zoning (Marathon County):** the Department mission is to create, advocate and implement strategies to conserve natural and community resources.

8. **CREP – Conservation Reserve Enhancement Program:** a partnership between the USDA Farm Service Agency, Wisconsin Department of Agriculture, Trade and Consumer Protection, USDA, Natural Resources Conservation Service, the Wisconsin Department of Natural Resources, and participating county land conservation departments throughout the state. It is an opportunity for Wisconsin landowners to enroll agricultural lands into various practices such riparian buffers, wetland restoration and establishment of native grassland areas, among others.

9. **CRP – Conservation Reserve Program:** a program that reduces soil erosion protects the Nation's ability to produce food and fiber, reduces sedimentation in streams and lakes, improves water quality, establishes wildlife habitat, and enhances forest and wetland resources. It encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as tame or native grasses, wildlife plantings, trees, filter strips, or riparian buffers. Farmers receive an annual rental payment for the term of the multi-year contract. Cost sharing is provided to establish the vegetative cover practices. The program is administered through the Farm Service Agency (FSA). Natural Resources Conservation Service works with landowners to develop their application, and to plan, design and install the conservation practices on the land. County Land Conservation Departments and the Wisconsin Department of Natural Resources also provide technical support for the Conservation Reserve Program.

10. **CSP – Conservation Security Program:** a voluntary program that provides financial and technical assistance for the conservation, protection, and improvement of soil, water, air, energy, plant and animal life, and other conservation purposes on Tribal and private lands. The program provides payments for producers who practice good stewardship on their agricultural lands and incentives for those who want to do more. The program is designed to reward the best conservation stewards of the most environmentally sensitive areas in targeted watersheds.

11. **DATCP – Department of Agriculture, Trade and Consumer Protection:** State agency responsible for food safety, animal and plant health, protecting water and soil and monitoring fair and safe business practices. The Soil and Water Resource Management Grant Program supports locally led conservation efforts. Each year DATCP awards grants primarily to counties to pay for conservation staff and provide landowner cost sharing to implement Land and Water Resource Management plans.

12. **DFP - Discovery Farms Program:** takes a real-world approach to finding the most economical solutions to overcoming the challenges environmental regulations place on farmers. The Discovery Farms Program will develop on-farm and related research to determine the economic and environmental effects of Best Management Practices on a diverse group of Wisconsin farms; and educate and improve communications among the agricultural community, consumers, researchers, and policy-makers to better

identify and implement effective environmental management practices that are compatible with profitable agriculture.

13. **DOC - Dissolved Organic Carbon:** a measure of a wide range of plant and animal-derived organic compounds that have sufficiently broken down to become dissolved in lake water. Some DOC compounds affect lake water pH, while others stain the water a tea-like color. DOC is strongly influenced by the surrounding landscape of the water body.

14. **EQIP – Environmental Quality Incentive Program:** a voluntary conservation program. It supports production agriculture and environmental quality as compatible goals. Through EQIP, farmers may receive financial and technical help with structural and management conservation practices on agricultural land. EQIP offers financial assistance to help off-set the costs of eligible conservation practices. Incentive payments may also be made to encourage a farmer to adopt land management practices, such as nutrient management, manure management, integrated pest management, or wildlife habitat management.

15. **EWR – Exceptional Water Resources:** a lake, stream, or flowage exhibiting the same high quality resource values as outstanding waters, but may be affected by point source pollution or have the potential for future discharge from a small sewer community.

16. **FCL – Forest Crop Law:** was a landowner incentive program that encouraged long-term, sustainable management of private woodlands by reducing and deferring property taxes. The FCL program was enacted in 1927 and enrollment was closed on January 1, 1986.

17. **FEMA – Federal Emergency Management Agency:** On March 1, 2003, FEMA became part of the U.S. Department of Homeland Security (DHS). The primary mission of the Federal Emergency Management Agency is to reduce the loss of life and property and protect the Nation from all hazards, including natural disasters, acts of terrorism, and other man-made disasters, by leading and supporting the Nation in a risk-based, comprehensive emergency management system of preparedness, protection, response, recovery, and mitigation.

18. **FIRM – Flood Insurance Rate Map:** the official map of a community on which FEMA has delineated both the special hazard areas and the risk premium zones applicable to the community.

19. **FOTG – Field Office Technical Guide:** the primary technical reference tool used in accomplishing the Natural Resources Conservation Service (NRCS) mission. WI-FOTG contains technical reference material to be used when planning, designing, applying, and maintaining conservation practices.

20. **FPP – Farmland Preservation Program:** The Wisconsin Farmland Preservation Program was created in 1977 to preserve agricultural resources by supporting local government efforts to manage growth. Eligible farmland owners receive a state income tax credit. To participate in the program, the county must have an agricultural preservation plan that meets the standards of Chapter 91, Wisconsin Statutes, and has been certified by the state Land and Water Conservation Board (LWCB). The program assists in preserving Wisconsin's valuable farmland by supporting counties in creating county agricultural preservation plans. These lay the groundwork for towns, municipalities and the county to develop exclusive agriculture zoning districts. Farmers also can participate by signing an individual, long-term agreement. The farmland preservation program provides state income tax credits to farmers who meet the program's requirements; to meet soil and water conservation standards; and to use the land for agriculture only.

21. **GIS – Geographical Information System:** captures, stores, analyzes, manages, and presents data that is linked to location. It includes mapping software and its application with remote sensing, land surveying, aerial photography, mathematics, photogrammetry, geography, and tools that can be implemented with GIS software.

22. **GLCI – Grazing Lands Conservation Initiative:** a partnership between USDA Natural Resources Conservation Service, the Wisconsin Department of Agriculture, Trade, and Consumer Protection, and private sector agricultural and conservation groups, working together to promote best management practices on Wisconsin private grazing lands. GLCI focuses on providing technical assistance to help new graziers begin using rotational grazing methods. Trained grazing specialists work one-on-one with farmers, developing grazing plans, including seeding recommendations, fencing and watering plans.

23. **GPR – General Purpose Revenue**

24. **HUC – Hydrologic Unit Code:** Hydrologic unit codes are a way of identifying all of the drainage basins in the United States in a nested arrangement from largest (regions) to smallest (cataloging units).

25. **LWCB – Land and Water Conservation Board:** connects local and state governments on conservation and farmland preservation issues. The board certifies agricultural preservation plans for the farmland preservation program and exclusive agricultural zoning ordinances for counties and towns; reviews and makes recommendations on county land and water plans; and recommends how funds are to be allocated to Wisconsin counties to put conservation plans into action. The LWCB is composed of three members of county land conservation committees, three state agency leaders, one Governor-appointed member that serves a two-year term, and four Governor-appointed members representing urban, rural, river management, and natural resource preservation areas.

26. **LWRM – Land and Water Resource Management Planning Program:** Through 1997 Act 27 and 1999 Act 9, the Wisconsin legislature established the land and water resource management (LWRM) planning program, (Wis. stats. Ch. 92). This program is the primary statewide vehicle for implementing conservation practices as identified in Department of Agriculture, Trade and Consumer Protection Administrative Rules (ATCP 50). Under this program, counties are required to develop land and water resource management plans for the purpose of conserving soil and water resources. Every 5 years, counties must revise these plans and are scheduled to present these revisions to the Wisconsin Land and Water Conservation Board (LWCB). The LWCB is responsible for recommending the plans for approval by the Department of Agriculture, Trade and Consumer Protection (DATCP). Only counties with DATCP-approved land and water resource management plans are eligible to receive annual funding through the soil and water resource management grant program.

27. **MIG – Management Intensive Grazing:** a best management practice for livestock production where permanent pasture is divided into smaller areas or paddocks, often using portable fencing. One paddock is grazed for a short time, while the remaining paddocks rest and recover.

28. **MFL – Managed Forest Law:** a landowner incentive program that encourages sustainable forestry on private woodlands by reducing and deferring property taxes. It was enacted in 1985 and replaced the Woodland Tax Law and the Forest Crop Law. It

is the only forest tax law that is open to enrollment. Land enrolled in the MFL program must be managed according to a plan agreed to by the landowner.

29. **NOD – Notice of Discharge:** is issued by the Department of Natural Resources under Chapter NR 243 (Animal Feeding Operations) to small and medium animal feeding operations that pose environmental threats to state water resources.

30. **OWR – Outstanding Water Resources:** means a lake, stream or flowage having excellent water quality, high recreational and aesthetic value and high quality fishing. ORW waters are free from point source or nonpoint source pollution.

31. **"P" – WI Phosphorus Index:** is a runoff phosphorus loss risk assessment tool for cropland management planning. It uses information that is readily available to farmers and agricultural consultants to evaluate the potential for phosphorus in runoff from a specific field entering a nearby stream. The P Index currently has two types of uses: 1. nutrient management planning and 2. water quality improvement planning to identify where the major sources of phosphorus (P) are on the landscape. It also shows why these areas are problems. Field P Index values are calculated using the SNAP+ nutrient management and soil loss assessment software program.

32. **POWTS – Private On-Site Waste Treatment Systems:** a sewage treatment and disposal system serving a single structure with a septic tank and soil absorption field located on the same parcel as the structure. This term also means an alternative sewage system approved by the department including a substitute for the septic tank or soil absorption field, a holding tank, a system serving more than one structure or a system located on a different parcel than the structure. A private sewage system may be owned by the property owner or by a special purpose district.

33. **PS&P – Agricultural Performance Standards and Prohibitions:** All cropland and livestock operations in Wisconsin, regardless of size, must abide by the agricultural performance standards and manure management prohibitions.

    a. Agricultural performance standards include:

        - Control cropland erosion to meet tolerable rates.
        - Build, modify or abandon manure storage facilities to accepted standards.
        - Divert clean runoff away from livestock and manure storage areas located near streams, rivers, lakes or areas susceptible groundwater contamination.

- Apply manure and other fertilizers according to an approved nutrient management plan.

b. Manure management prohibitions include:

- No overflow of manure storage facilities.
- No unconfined manure piles near water bodies.
- No direct runoff from feedlots or stored manure into state waters.
- No trampled stream banks or shorelines from livestock.

34. **RC&D – Resource Conservation and Development:** Wisconsin has seven RC&D areas, covering all Wisconsin counties. RC&D works to stir up new opportunities, link people together, and help promote economic develop while protecting the natural resources. RC&D is a USDA program administered by the Natural Resources Conservation Service.

35. **SEG – Segregated Funding**

36. **SNAP+ - Soil Nutrient Application Program:** is a Microsoft Windows® based Nutrient Management Planning software program designed for the preparation of nutrient management plans in accordance with Wisconsin's Nutrient Management Standard Code 590.

37. **SSA – Sewer Service Area:** The State's Area wide Water Quality Management Planning code (Wisconsin Administrative Code, NR 121) establishes Sewer Service Area (SSA) Planning. The WDNR is responsible for working with regional planning commissions, county governments, municipalities, townships and the public to develop SSA plans that guide publicly sewered growth and which protect water quality.

38. **SWRM – Soil and Water Resource Management:** The Soil and Water Resource Management Grant Program supports locally-led conservation efforts. Each year DATCP awards grants primarily to counties to pay for conservation staff and provide landowner cost-sharing to implement Land and Water Resource Management plans.

39. **"T" – Tolerable annual soil erosion rate:** represents the tolerable soil loss for any specific soil. The term signifies the point at which new soil is naturally produced in greater or equal amounts to that which is lost to erosion. T values range from one to five tons per acre per year, depending on the soil type.

40. **TMDL – Total Maximum Daily Load:** the amount of pollutant that a water body can tolerate before it exceeds water quality standards. A TMDL is required for each state impaired water body to address each pollutant or impairment.

41. **TSS – Total Suspended Solids:** the amount of organic and inorganic particles suspended in the water column. TSS measures the weight of the particles and high values can have implications on light penetration, recreational value, and habitat value.

42. **TRM – Targeted Runoff Management:** A DNR administered program that provide grants to local communities to control polluted runoff from both urban and rural sites. The grants are targeted at high-priority resource problems. Projects funded by TRM grants are site-specific and serve areas generally smaller in size than a sub watershed. The grant period is 2 years, with a possible 1-year extension. The maximum cost-share rate available to TRM grant recipients is 70 percent of eligible costs, with the total of state funding not to exceed $150,000.

43. **USDA-FSA – Farm Services Agency:** administers and manages farm commodity, credit, conservation, disaster, and loan programs as laid out by Congress through a network of federal, state and county offices. These programs are designed to improve the economic stability of the agricultural industry and to help farmers adjust production to meet demand.

44. **USDA-NRCS – Natural Resources and Conservation Services:** The Natural Resources Conservation Service is the federal agency that works with landowners on private lands to conserve natural resources. NRCS is part of the U.S. Department of Agriculture. Three-fourths of the technical assistance provided by the agency goes to helping farmers and ranchers develop conservation systems uniquely suited to their land and individual ways of doing business.

45. **UWEX – University of Wisconsin Extension Service:** offers Wisconsin people access to university resources to engage in lifelong learning, wherever they live and work.

46. **WBI – Wisconsin Buffer Initiative:** was a collaborative effort between a diverse group of Wisconsin citizens and UW-Madison scientists to develop recommendations for the Wisconsin DNR on how riparian buffers can be part of a larger conservation system to address agricultural nonpoint source pollution. Instead of a fixed standard that would be uniformly applied across the diversity of Wisconsin's agricultural landscapes, the

collaboration developed an innovative approach that identified site-specific areas where buffers, as part of a larger conservation system, would have the greatest likelihood of reducing pollution in waters that would benefit the most from this reduction.

47. **WisDNR – Wisconsin Department of Natural Resources:** The State agency dedicated to the preservation, protection, effective management, and maintenance of Wisconsin's natural resources. It is responsible for implementing the laws of the state and, where applicable, the laws of the federal government that protect and enhance the natural resources of our state.

48. **WLI – Working Lands Initiative:** included as part of the 2009 – 2011 state budget signed into law by Governor Doyle on June 29, 2009. Three main components in the budget include updates to the state's current Farmland Preservation Program.

49. **WLWCA – Wisconsin Land and Water Conservation Association:** a 501(c)(3) nonprofit organization representing Wisconsin's County Board Land Conservation Committees and Departments.

50. **WPDES – Wisconsin Pollution Discharge Elimination System:** Through the Wisconsin Pollutant Discharge Elimination System (WPDES) permit program, the DNR regulates municipal, industrial, and animal waste operations discharging water to surface or ground waters. Because of the potential water quality impacts from CAFOs, animal feeding operations with 1,000 animal units or more are required to have a Wisconsin Pollutant Discharge Elimination System (WPDES) Concentrated Animal Feeding Operation permit. These permits are designed to ensure that operations choosing to expand to 1,000 animal units or more use proper planning, construction, and manure management to protect water quality from adverse impacts.

51. **WTA – Wisconsin Towns Association:** a statewide, voluntary, non-profit and non-partisan association of member town and village governments in the State of Wisconsin controlled by its Board of Directors. WTA's twin purposes are to (1) support local control of government and to (2) protect the interest of towns.

52. **WVIC – Wisconsin Valley Improvement Company:** a private corporation that operates 21 water storage reservoirs to regulate a uniform flow in the Wisconsin River. WVIC coordinates the operation of the 25 hydroelectric plants on the Wisconsin River that are owned and operated by ten utilities or paper companies.

53. **303 (d) "impaired" water resources:** identifies surface waters that do not meet water quality standards expressed in Chapters NR 102-105 of the Wisconsin Administrative Code. The Impaired Waters List is submitted every two years to the United States Environmental Protection Agency (USEPA) as required under Section 303(d) of the federal Clean Water Act.

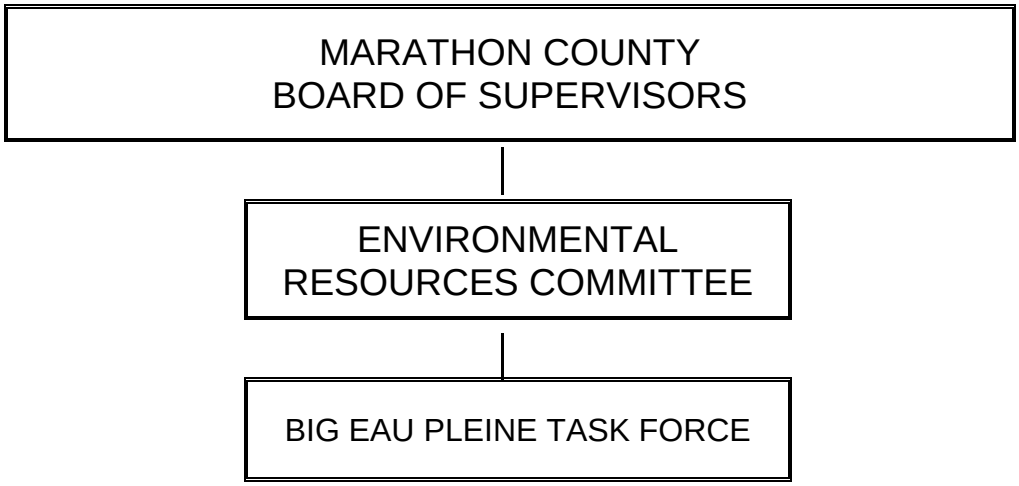
# APPENDIX B

# STRATEGIC PLAN

## FOR THE

# BIG EAU PLEINE RIVER WATERSHED AND RESERVOIR

December 2011




## BIG EAU PLEINE TASK FORCE

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| Jim Burgener, Director | Conservation, Planning & Zoning |
| Andy Johnson, Environmental Resources Coordinator | Conservation, Planning & Zoning |
| William Duncanson, Director | Parks, Recreation and Forestry |
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| Scott Watson, Basin Supervisor | Wisconsin Dept. Natural Resources |
| David Coon, Director Environmental Affairs | Wisconsin Valley Improvement Company |
| Matt Zoschke, County Conservationist | Clark County |
| Amy Niegum, District Conservationist | Natural Resources Conservation Service |
| Steve Oberle, County Conservationist | Taylor County |
| Dave Ruesch | Farm Producer |
| Ken Hein, Maple Ridge Dairy | Farm Producer |
| Michael R. Paul, President<br>Ken Dorshorst, Member | Big Eau Pleine Citizen Organization |

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STRATEGIC PLAN
FOR THE
BIG EAU PLEINE RIVER
WATERSHED AND RESERVOIR

List of Acronyms

| | |
|---|---|
| BEPCO | Big Eau Pleine Citizens Organization |
| BMP | Best Management Practices |
| DATCP | Wisconsin Department of Agriculture, Trade and Consumer Protection |
| DO | Dissolved Oxygen |
| DNR | Wisconsin Department of Natural Resources |
| FERC | Federal Energy Regulatory Commission |
| LWRM | Land and Water Resource Management |
| MOA | Memorandum of Agreement |
| NRCS | USDA-Natural Resources Conservation Service |
| POWTS | Private On-site Waste Treatment Systems |
| PPM | Part per million |
| TMDL | Total Maximum Daily Load |
| WVIC | Wisconsin Valley Improvement Company |

# INTRODUCTION

As ice melting and spring runoff events began on the Big Eau Pleine Reservoir in the spring of 2009, residents, sportsman and officials saw the first evidence of a significant fish die-off. In January, the dissolved oxygen (DO) levels throughout the reservoir had dropped below 1 part per million (ppm). Without areas of safe harbor for the fish within the reservoir or adequate aeration capacity to provide a limited refuge for fish, the fishery collapsed. Unfortunately, fish kills are not new to this river and reservoir system. Low dissolved oxygen levels during the mid to late winter have been a reality with the reservoir since its construction in 1937.

In response to the fish kill, Marathon County convened a meeting between Wisconsin Department of Natural Resources (DNR), Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP), Big Eau Pleine Citizens Organization (BEPCO) and Wisconsin Valley Improvement Company (WVIC) to develop a short term plan to assess the impact on the fishery, adequacy of the aeration system, and water quality conditions. In November 2009, the Big Eau Pleine Task Force completed the short term strategic plan which included the following:

a. Historic Case Study of the Big Eau Pleine Watershed and Reservoir. The case study summarizes nearly 70 years of water quality studies, management plans, conservation projects, and regulatory initiatives aimed at reducing the sediment and nutrient runoff.

b. Action Plan to Upgrade the 1981 Aerator System. The plan described the purpose, condition and performance of the aeration equipment as of 2009. The plan outlined improvements to the aeration equipment to improve performance, as well as a Memorandum of Agreement (MOA) to clarify the roles and contributions of the partners in the aeration equipment's on-going operations and maintenance.

c. Long Range "Plan of Work" to Address the Water Quality and Quantity of the Big Eau Pleine River System. The "plan of work" identified the partners and actions needed to assess best management practice needs.

The Big Eau Pleine Task Force submits this document to identify the role of governmental agencies, sportsman and citizen groups, educational institutions, agricultural groups, and the WVIC to improve the health of the river system while balancing the needs of community and economic interests. It will also provide a foundation of understanding for the policies that may be proposed by local leaders.

## FRAMING THE PARTNERSHIP PROCESS

The strategic plan process is designed to build upon the existing capacities and resources of agencies to efficiently leverage financial and technical assets. The task force was established by Marathon County to assure that all interested parties were represented and County policy is based upon recommendations consistent with community and economic development goals.

The task force consisted of representatives of USDA-Natural Resources Conservation Service (NRCS), DNR, WVIC, DATCP, Clark County, Marathon County, Taylor County, BEPCO, and local dairy producers. It was important for farm producers to be part of the task force to assure that members understand farming challenges and the effectiveness of conservation initiatives.

## THE ECONOMIC AND LANDSCAPE CONTEXT OF THE BIG EAU PLEINE

Policy recommendations and program activities for the Big Eau Pleine River Watershed and Reservoir need to be established with an understanding of the region's unique natural resources and economic contributions. Recommendations must realistically capture the scope of financial and technical resources required to improve the water quality and the time required for best management practices to influence change in water quality. The financial limitations of landowners, industries and public agencies require that local partnerships coordinate and leverage multiple-sourced resources to be effective.

The Big Eau Pleine is part of the Upper Wisconsin River basin which comprises nearly 20% of the State's landscape. The reservoir acts as the major source of water that is used to help regulate the flow of the Wisconsin River during low flow seasons. DNR has identified four (4) municipalities and eight (8) industries within Marathon County along the Upper Wisconsin River with Wisconsin Pollutant Discharge Elimination System permits that base respective discharge limits upon water flow in the river. The operation of the Wisconsin River System, including the Big Eau Pleine reservoir is the responsibility of WVIC with regulatory authority provided by the Federal Energy Regulatory Commission (FERC).

The Big Eau Pleine agricultural producers represent nearly 850 farms. These farms create $100 million annually of direct farm receipts from dairy and commodity crops. Fifteen percent of Marathon County's jobs are created by the agricultural industry. Profitable farmers with reasonable and achievable performance criteria and incentives are critical to the success of any proposed policy initiatives. Success is achieved when soil and water resources are protected while assuring that landowners meet the challenge of producing food.

The Big Eau Pleine Reservoir is a regional recreation destination. The Marathon County Parks, Recreation and Forestry Department provides recreational opportunities within 3 parks in the Big Eau Pleine watershed. The most notable is the Big Eau Pleine Park which consists of 2,050 acres located on the north shore of the 7,000 acre Big Eau Pleine Flowage. Poor water quality and fish kills significantly impact the economic and recreational opportunities associated with the reservoir such as boating, swimming, fishing and businesses that support these activities. The Big Eau Pleine Park represents a major public investment of land and recreational infrastructure along the reservoir. In 2010, camping in the BEP Park generated nearly $300,000 of revenue for the local economy. According to BEPCO estimates, nearly $2 million of economic activity is generated annually from fishing opportunities in the watershed.

## MAKING THE CASE FOR ACTION IN THE BIG EAU PLEINE RIVER WATERSHED

The Big Eau Pleine watershed includes nearly 238,000 acres with 217,000 acres in Marathon County, 8,500 acres in Clark County, and 12,000 acres in Taylor County. It represents the most extensive agricultural area in Marathon County with nearly 60% of the land base under active cropping use and 17,000 cows. The fine textured soils, extensive man-made field drainage system, and loss of wetlands create a “flashy” hydrology where runoff from snowmelt and rain carry soil and manure loads to streams. The runoff contributes excessive loads of nutrients to the reservoir and Wisconsin River. The soil sediment, organic matter and nutrients compromise the water quality necessary to support a sustainable fishery and provide high quality recreational activities. Excessive nutrient loading contributes to algae blooms which occur several times annually. Decomposition of algae and organic matter sediment consumes available dissolved oxygen needed by the fishery in the winter.

Water quantity management and operational activities for the reservoir are a complicated balancing act. The WVIC must strive to meet the water flow needs of the Wisconsin River for municipal discharges, power and paper industries, as well as sustain the natural resources and recreational expectations of the local communities. The waters of the Big Eau Pleine Reservoir are necessary to help sustain the river flows during low flow periods, commonly in summer and winter.

The “60% Solution” is a water quantity management concept proposed by BEPCO to reduce the probability of fish kills. BEPCO has assessed that there is a very strong statistical correlation between fish kills and prescribed water levels over winter. The concept is supported by 40 years of operational data, but the application of the data to reservoir operations is not endorsed

by all parties. The DNR recommends a winter storage goal of 60%, using operation criteria from July through November to continue protection of the Wisconsin River target flows and maximize the potential to reach the 60% winter storage goal. WVIC wants to maximize operational flexibility, but recognizes the value of winter storage goals.

Through modeling conducted at BEPCO's request, the WVIC determined that it is possible to change the summer and winter operating procedures and realize a significant increase in water levels over winter during drought conditions. This can be done while still protecting minimum Wisconsin River flows and without impacting flows or reservoir operations upstream of the Big Eau Pleine. However, WVIC believes that a change in reservoir operations every year is not required to help protect the fishery. Moreover, modifying the operating plan according to the modeling would result in an estimated hydropower generation loss averaging 1.7 million KWh per year whether drought conditions existed or not. Instead, the WVIC believes that its enhanced drought contingency plan is the methodology that should be used to address severe drought conditions and thereby help protect the fishery during these extreme events, not a permanent change in reservoir operations.

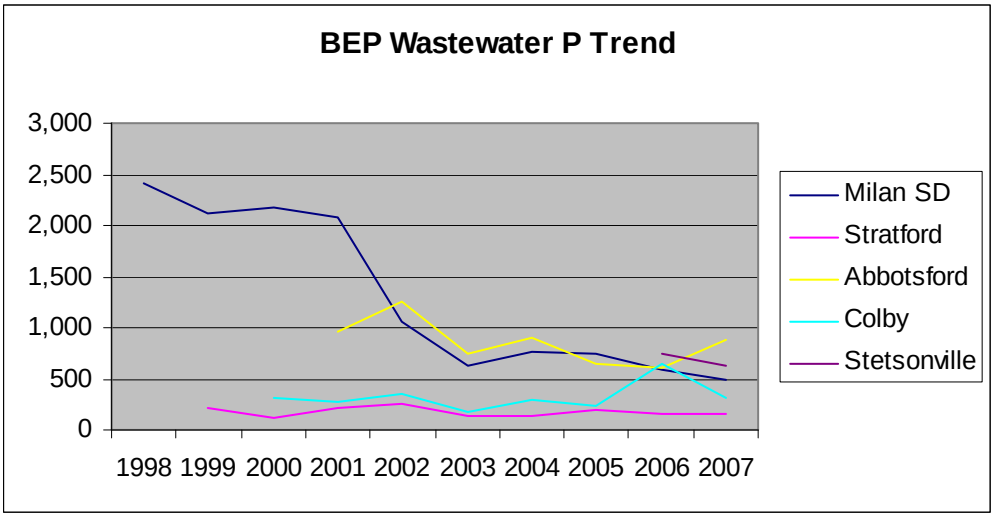
Agricultural producers have a long history of implementing conservation in the watershed. Although most farmers are in compliance with state agricultural performance standards and local ordinances, the sediment and nutrient loads remain too high to protect the water quality. In cases where performance standards are not being met or chronic runoff events occur that threaten the water quality and fishery, Marathon County may need to provide an increased regulatory presence. In order to require farmers to reach beyond current performance criteria, additional education, technical and financial assistance will need to be offered. Marathon County with its partners must provide producers with better strategies to minimize runoff through soil saving Best Management Practices (BMPs), nutrient management plans, and manure treatment and distribution technologies such as anaerobic digestion and manure injection equipment.

Farming is not the only contributor to pathogens, nutrients, and sediment to the Big Eau Pleine River system. Sediment from non-metallic mining, once a significant contributor of sediment to the river system, is now regulated and minimized through state codes and local ordinances. Continued support of administrative and technical efforts by local and state agencies in regulation of these mining activities is necessary. Similarly, private sanitary treatment systems contribute less than 1% of the nutrient load to the river but pose serious public health concerns

when left to directly discharge into ditches and waterways. Current regulatory oversight has been effective in controlling design and operations of new Private On-site Waste Treatment Systems (POWTS), but more needs to be done to address discharges from old systems and the education of holding tank owners to reduce discharges of human wastes.

Soil erosion from non-agriculture activities has been significantly reduced since storm water permits have established erosion control standards for construction sites, road work, and industrial storage. The mass of phosphorous discharged to the Big Eau Pleine River from point sources has been reduced with the inclusion of phosphorous limits in waste water permits since 1997 (see Table 1).

Table 1. Pounds of Phosphorus Delivered/Year.




## CONCLUSION

The Big Eau Pleine River Watershed and Reservoir represent tremendous natural and cultural resource assets to our community. The watershed is home to an agricultural industry producing and processing a variety of dairy and commodity products. The rural character of the region is defined by its land use, beauty and the local businesses. However, runoff from fields and farmsteads threatens the health of its people, soil and water resources, and community. The time to act is now.

For nearly 80 years, conservation agencies have worked with private landowners and shared in their investments to improve the management of the soil and water resources in order to sustain its inherent productivity and to help them prosper. Even though the landowners have done

much to meet the expectations of state and local resource management goals, the Big Eau Pleine River and Reservoir remains a polluted water body due to runoff of nutrient, soil sediment, and organic matter. Aeration alone is not enough to protect the fishery through low oxygen periods.

Marathon County needs to lead an effort with many identified partners to efficiently leverage existing and new resources to continue improvements of water quality. Education, technical assistance and financial incentives are needed to help landowners, cities, villages, and towns better manage and protect the resources in ways that are profitable and sustainable.

The recommendations forwarded by the Big Eau Pleine River Task Force represent policies and activities that Marathon County should develop, coordinate and implement to lead a local effort to improve community and economic development opportunities, as well as minimize public health concerns associated with the watershed's water quality.

The fish kill of 2009 is symptomatic of a serious water quality problem caused by excessive soil sediments, nutrients and organic matter that flow into the Big Eau Pleine Reservoir. Conditions are made worse by low flows during drought periods. Until poor water quality is abated in the Big Eau Pleine Reservoir watershed, the potential for fish kills will remain.

## POLICY RECOMMENDATIONS

- **Aeration System Operation and Maintenance**. The aeration system will be an ongoing and necessary management tool to the well-being of the reservoir and fishery. It opens 30-60 acres of water surface for aeration during the late winter and early spring. Operations and maintenance and capital expenditures for the system will be administered through a Memorandum of Agreement established for 5 year periods.

  WVIC, the FERC licensed operator of the reservoir, and DNR, the owner of the land and aeration equipment, will serve as the primary agents to determine the start-up criteria, safety and operations of the system. These organizations will also serve as the primary water quality monitoring agents for the tributary and reservoir waters.

  Participating partners should contribute funds to annual electrical costs and the repair or replacement of capital improvements such as items associated with motors, blowers, and buildings.

- **Resource Management Initiatives**. The local, state and federal agencies serve as the primary vehicle of delivery of local conservation programming to landowners and residents. Local conservation programs include education, resource assessments and planning, technical assistance, grant funding, and administration of regulations. Marathon County will provide leadership through policy, and partnership coordination through the Marathon County Comprehensive Plan. Specifically,

  **j. Marathon County will**:

  i. Adopt and implement state agricultural performance standards in local ordinance to address chronic and significant discharges.
  ii. Minimize or eliminate winter land surface spreading activities of wastes.
  iii. Promote technologies to treat and distribute livestock waste.
  iv. Provide Best Management Practice education and training to landowners.
  v. Administer the Non-metallic Mining Ordinance.
  vi. Eliminate direct surface discharges of sanitary wastes.
  vii. Develop a reservoir recreation management plan.
  viii. Provide financial support of annual operational costs of the aerator.
  ix. Develop and implement a Fenwood Creek pilot project (see description below).

  **k. WI Department of Natural Resources (DNR) will**:

  i. Develop a reservoir management plan to protect the natural resources (land, water and fish) of the Big Eau Pleine reservoir and tributary waters. The plan will set goals for the fishery and supporting food system.
  ii. Provide lake management grants to local partners.
  iii. Complete a water quality assessment of the Upper Wisconsin River Basin and develop a Total Maximum Daily Load (TMDL) plan for the Big Eau Pleine Watershed and Wisconsin River.
  iv. Support Taylor, Marathon, and Clark Counties with investigation and enforcement of agricultural performance standards and prohibitions.
  v. Provide Best Management Practices cost-share grants to landowners.
  vi. Provide water quality monitoring of algae concentrations that threaten public health.
  vii. Primary responsibility role (with WVIC) for the aeration system in an operation and maintenance plan.
  viii. Coordinate aeration system operations (with WVIC).

  **l. WI Department of Agriculture, Trade and Consumer Protection will**:

i. Provide BMP grants to landowners for state agricultural performance standard(s) compliance.
ii. Provide administrative support for the Farmland Preservation Program.
iii. Coordinate education with agriculture industry associations to producers on nutrient management and non-point runoff controls.

**m. Wisconsin Valley Improvement Company will:**

i. Provide water quantity and quality monitoring.
ii. Coordinate aeration system operations with DNR.
iii. Lead reservoir operation activities.
iv. Update reservoir modeling tool(s) and drought management plan at 5-year intervals (next update due 2016).

**n. USDA – Natural Resources Conservation Service will**:

i. Provide technical assistance, conservation planning, and engineering support to landowners.
ii. Provide cost-share assistance to landowners.
iii. Develop and implement manure winter spreading evaluation and planning strategies to minimize runoff risks.

**o. Big Eau Pleine Citizens Organization will**:

i. Provide a citizen's voice to community needs relative to property, resource management, and public waters.
ii. Coordinate input from community-based organizations such as recreational and lake groups to provide feedback about program outcomes and outreach needs.
iii. Pursue grant opportunities.

**p. Farm industry representatives will**:

i. Provide landowner education.
ii. Provide feedback on incentives and program initiatives.

**q. Taylor County Land Conservation Department will**:

i. Implement conservation programs focusing upon conservation compliance, nutrient management, and animal waste management through the Land and Water Resource Management (LWRM) plan.
ii. Provide education on groundwater protection and Best Management Practices.

**r. Clark County Land Conservation Department will**:

i. Implement conservation programs focusing upon conservation compliance, nutrient management, and animal waste management through the LWRM plan.

ii. Implement Heart of America's Dairyland Agricultural Enterprise Area.

- **Fenwood Creek Watershed Project**. Because the water quality assessment activities and the Big Eau Pleine River and Reservoir Total Maximum Daily Load plan will not be completed until 2015-16, the task force recommends that the agencies initiate a small scale watershed project. The purpose of the project is to develop the strategies relative to Best Management Practices, waste treatment and distribution technology implementation, conservation planning, financial incentives, technical assistance, and education needed to achieve water quality outcomes for the watershed. The project would include the following elements:

    - Water quality monitoring. Assess the management and environmental performance of BMPs, quantify the pollutant contributions of major event runoff discharges vs. chronic low-level discharges, and document changes in water quality over time.
    - Education. Communicate performance expectations and regulatory requirements to landowners, towns, cities and villages.
    - Nutrient management planning. Provide technical and financial assistance to landowners to assure all producers have and follow nutrient management plans.
    - Manure winter spreading assessments. Develop and implement criteria to assess winter spreading runoff risks and provide planning assistance to landowners to manage risks.
    - "Edge of Field" Best Management Practices. Implement BMPs down slope of cropland to treat and reduce sediment and nutrient loading from runoff. In cases where runoff contributions are chronic and cannot be minimized to acceptable levels, permanent land use conversion strategies will be developed.
    - Financial and management incentives. Develop financial and management incentives to promote BMP implementation, including long-term maintenance and performance of BMP.

Waste treatment and distribution technology. Increase understanding and implementation of waste treatment and distribution technologies that reduce runoff risks and maximize nutrient utilization. Provide cost-benefit analysis of new technologies and develop adoption strategies.

# APPENDIX C

# CASE STUDY

# FOR

# BIG EAU PLEINE WATERSHED

December 2009

## BIG EAU PLEINE TASK FORCE

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| Bill Duncanson, Director | Parks, Recreation and Forestry |
| Scott Watson, Basin Supervisor | Wisconsin Dept. Natural Resources |
| David Coon, Director Environmental Affairs | Wisconsin Valley Improvement Company |
| Michael R. Paul, Vice President | Big Eau Pleine Citizen Organization |

## INTRODUCTION

In the spring of 2009, during the seasonal runoff and ice melting period, the Big Eau Pleine Reservoir experienced a significant fish kill. Low dissolved oxygen levels during the spring, as well as high algae concentrations have been associated with the reservoir since its construction in 1937. This case study will provide an overview of the physical characteristics of the watershed, land use, land management, environmental studies, and a history of the conservation initiatives that define the story of the watershed. The intent of the case study is to provide a historical perspective of water quality and quantity issues for the watershed to serve as a basis for developing a long range plan for the river system.

## PHYSICAL OVERVIEW

*Geography*. The watershed includes 363 square miles. The Big Eau Pleine River flows into the reservoir (which swells to 6,677 acres when full) and then to Lake DuBay, both flowages of the Upper Wisconsin River Central Sub Basin. The BEP River Watershed drains approximately 238,000 of the following land use distribution: cropland (60%) – 142,800 acres, pasture (15%) 35,700 acres; 3. Woodland (17%) – 40,460 acres; and 4. Miscellaneous (8%) – 19,040.

The BEP watershed includes the following Villages and Cities: Stratford, Colby, Abbotsford, Dorchester, Stetsonville, Fenwood, and Milan.

*Soil Resources*. The soils of the watershed provide the basis for a productive agricultural industry. The soils of the Upper BEP Watershed are poorly drained with low infiltration and permeable rates. The non-erosive removal of surface water through a system of terraces, grassed diversions, waterways, and drainage ditches to create an aerated root zone is the basis of most historical conservation and agricultural initiatives. Soil textures create three agricultural management practices that pose direct water quality implications in this watershed:

1. *Seasonal Soil Saturation and Waste Applications.* Manure applications occur in the fall and spring and coincide with saturated surface soil conditions and groundwater recharge.
2. *Waste Application onto Frozen Soils*. Many manure spreading operations (emptying of waste storage facilities) occur after soils freeze (fall) or before they thaw (spring) in order to accommodate and support the weight of loaded equipment.
3. *Fall Tillage*. Fall plowing is beneficial in allowing the producer to distribute the labor for nutrient management, tillage and seedbed preparation over two seasons. Hauling waste in the late fall and early winter also minimizes road loading stress and conflicts during the spring when weights limits are necessary to protect roads as the frost and water are leaving the roadbed.

*Water Resources*. The BEP River Watershed consists of nearly 210 miles (116 in UBEP and 94 LBEP) of rivers and streams. Much of the early agricultural development was supported by relatively shallow dug wells. Because of the extensive surface drainage system, the recharge of the aquifer has been compromised. Water quality assessments indicate that flashiness of hydrology (the rapid rate of runoff) is a major contributor to degradation of water quality, aquatic habitat, and the fishery of the river system. In recent years, due to increase water consumption of industry, agriculture, residential, and municipal interests, the quantity of groundwater is becoming a concern. See Map 4 for surface water delineations, including Outstanding and Exceptional Waters.

*Farms.* In 1972, the BEP watershed consisted of 1,050 dairy farms with an average size of 180-200 acres. These farms managed on average a dairy herd of 70 cows with calves. 900 dairy farms during the 1980's.

## CONSERVATION INITIATIVES

During the 1940-1950's the focus on conservation was to develop the productive agricultural potential of Marathon County. Government assistance provided public financial and technical assistance to farmers through liming, fertility, erosion control, and design of water disposal systems. The following list key dates and activities of early conservation efforts:

- 1941 - Marathon County Soil and Water Conservation District established
- 1958 – BEPCO and Rib River Watershed Association.
- 1965- Inventory of BEP Watershed project completed. Sedimentation and pollution from agriculture identified and assessed for first time.
- 1972 – Clean Water Act establishes federal policy.

## STUDIES AND ASSESSMENTS

10. 1958 – The Wisconsin Valley Improvement Company (WVIC) began measuring dissolved oxygen levels in the BEP Reservoir.
11. 1965 – First BEP watershed inventory.
12. 1972 National Eutrophication Study. A predicted annual P load of 92,500 lbs.
13. 1974 UW- Stevens Point Study of Reservoir. Predicts that 50% reduction in P loads would reduce algae concentrations in reservoir by 57%. Independent studies by EPA and UW-Stevens Point indicate that Phosphorus (P) is the limiting or controlling nutrient levels in the BEP. A similar loading of 100,000 lbs. was calculated, a 58% P reduction would need to be realized to achieve a perceivable improvement of water quality. The UWSP study indicated that 75% of P load was delivered during November and April. About 95% of load came from agriculture (3% from municipal and industrial sources). Septic tanks are contributing approximately 1%. Manure is major source of the organic pollutant and Phosphorus load. The UWSP study indicated that 87% of farm operations spread manure in winter.
14. 1982 – 1992 Non-point Priority Watershed (Upper and Lower Sections). The appraisal determined that phosphorus was the primary pollutant of concern. The report indicated that the flashy hydrology is a huge concern to the condition and use of the water system. Headwaters streams are often fed by wetland drainage. It is estimated that 54% of nutrient enrichment occurs during the spring season with runoff and snowmelt.
15. 1992 - DNR LBEP River Resource Appraisal Final Report (Jim Krietlow). This reports states that the total P load delivery to the reservoir is 163,636 lbs. annually from the BEP watershed of which 78,860 lbs. is point-sourced (42,161 lbs. controllable) and 84,776 lbs. non-point sourced (29,196 lbs. controllable).

16. *2009 - Big Eau Pleine Flowage Winter Runoff Study* (Mark Hazaga). The dominant land use of dairy farming in the BEP contributes significantly to increased delivery of bacteria, BOD and P to tributaries. The average BOD load of the BEP during three days of runoff was compared to Wausau's average 3 day influent of BOD. The BOD load in BEP was 14 times greater than the influent (raw sewage) BOD load to Wausau Wastewater Treatment Plant.
17. Soil Erosion Transect Survey (1999-2008). Over the period of tracking, the erosion rates within the BEP watershed have averaged approximately 2.3 tons per acre per year. Ninety five percent of the sediment delivery to the streams and reservoir is sourced from this upland soil erosion.

## CONSERVATION PROGRAMMING

6. *Model Implementation Program* – MIP (United States Department of Agriculture, USDA and Environmental Protection Agency, EPA, 1977). Robert Gall indicates that WVIC began measuring dissolved oxygen levels in 1958 and has observed oxygen depletion to one part per million or less almost every year with fish kills occurring during most of those years (1958 to 1977). The MIP Pilot Project was designed to show how agency cooperation and the positive benefits/efficiencies of targeting financial and technical resources can improve the resource problems of the watershed. Landowners have access to ASCS funds, but are expected to shoulder some costs and to maintain best management practices. The program's structural policy is based upon voluntary participation in programs with financial and technical support provided by public agencies.

   A rapid improvement of water quality was expected because of the program efforts. The improvement (outcome) would be seen as a reduction in the intensity of algae bloom.

7. *Hamann Creek Watershed Project-1978.* (16,000 acre drainage area).

This voluntary project was established in March 1978 in response to the failure of Model Implementation Program bid. The project's funds ($100,000) were administered through the Marathon County Agricultural Stabilization and Conservation Service (ASCS). Conservation best management practices focused on vegetated channels, terracing, soil treatment (liming), permanent vegetated areas, and pond dugouts. The intent of the project was to focus conservation efforts on a relatively small watershed (third order) with monitoring to determine if technical assistance and funds could provide measurable water quality benefits.

3. *Upper Big Eau Pleine (UBEP).* Implementation began July 1987 and was completed in August 1995.

Of the approximately 900 farms inventoried for the UBEP project, Table 2 identifies the breakdown of landowners/resource concerns that were determined to be eligible for program funds and technical assistance.

Table 2. Rankings of Evaluated UBEP farms:

| | Manure Spreading | Cropland Erosion | Animal Lot Runoff |
|---|---|---|---|
| No. Eligible Operations | 212 | 244 | 121 |
| Pollutant Reduction if all eligible operations participate | 70% | 90% | 70% |

According to this report, the estimated total P load is 161,636 lbs. annually (1987). With 1989 point source sampling results, the estimated P load was reduced to 128,613 lbs. annually. The nonpoint contribution is 106,500 lbs. Point sources represent overall 17% of P load. resource objectives.

*Final Report by DNR (June 1997)*. The project plan estimated that if objectives met, overall P delivery would be reduced 16.2%. This would also reduce amount of algae by 16%.

During the 10-year period of the Upper and Lower Big Eau Pleine non-point source pollutant reduction programs, total phosphorus concentrations within the reservoir showed no improvement (no decline) from 1985 through 1994 based on WVIC water chemistry data. WVIC Trophic State Index (TSI) water quality studies conducted from 2000 through 2002 showed a slight increase in total phosphorus and chlorophyll 'a' throughout the reservoir. Secchi depth (water transparency) declined during this same period. The reasons cited by landowners for non-participation in the watershed program were: 1. avoidance of government, 2. too costly for BMP's, 3. cost-share offer not high enough, 4. poorly understood the eligibility criteria, 5. close to retirement age, and 6. left farming or uncertain of future.

In 1989, 17% of total P load to reservoir was from discharges of wastewater treatment plants. In 1995, it was determined that the point source loadings were close to 1985 levels. Regulatory rules are in place to improve this point source contribution by 2000 (See Table 3).

Land Management Evaluations:

1. Barnyard Runoff – thirty three (33) practices installed. UBEP project funded 31 projects and 2 were completed without cost-share money. Approximately 1000 lbs. Total P/ yr. in a 10 year storm event have been reduced or 42% of project goal. (42% of 70% = 29% reduction).
2. Manure Storage – realized 74% of project goal in eliminating winter spread manure. Sixty-seven (67) waste storage facilities were funded by project and 13 installed without cost-share funds. Note that Marathon County developed and adopted the first county-wide Animal Waste Storage Ordinance via leverage of the Priority Watershed Project.

3. Cropland Erosion – goal to reduce 25% of sediment delivery from cropland. Cropland is 95% of sediment source to reservoir. Only 10% of goal achieved (3% reduction in total erosion). Targeted rate of 2 Tons/acre/year. This was a difficult sell because most program compliance requirements are 4 tons/acre/year.
8. Milking center wastes – project did not address this waste source of P. This waste stream was addressed at 67 farms where the dilute waste was incorporated into designs for waste storage facility systems.

Financial evaluation:

1. State expended $1,786,429 for UBEP project.
   - $685,687 for local assistance (includes Taylor and Clark Counties) and
   - $1,100,742 for practice implementation, could have been much greater if all agreements were implemented (nearly 36% of agreements expired without action).

*Summary* – The BEP Reservoir will likely always be eutrophic, hampered by nutrients originating from agricultural lands. Sedimentation continues to be the major concern with phosphorus contributions.

Tracking progress hindered by lack of updated farm information (before vs. after).

Note that "critical sites" became a planning concept in 1993 but not incorporated into the UBEP project.

See Appendix B for list of participating landowners, cost-share agreements, and BMP implementation.

*4. Lower Big Eau Pleine Watershed – LBEP (1991-2003).* (139 sq. mi)

Inventory begins in 1991. Implementation begins in 1993 and ended in 2003. LBEP is a continuation of the UBEP effort aimed at reducing: polluted runoff from barnyards and feedlots, sediment from cropland, and runoff from winter spread manure.

*Ground Water Assessment:* A groundwater assessment involved well sampling; also a feature of this watershed: 23 % of wells collected had nitrates exceeding 10 mg/l (enforcement standard -ES) and 65% of wells had nitrates between 2-10 mg/l (preventative advisory level-PAL). The area wells were considered to have a significant nitrate concern. Triazine is found in 1% wells at ES levels while 19% of wells above PAL.

*Surface Water Resource Assessments*:

- 95% of the inventoried sediment source from cropland and 3% from streambanks
- Barnyards – 208 yards assessed contributing 9,873 lbs. P annually to waters.
- Streambanks – 99 miles assessed contributing 830 tons of sediment annually (3% of total).
- 12 miles of reservoir shoreline found to have eroding concerns contributing 513 tons annually. Affects 55 landowners.
- Upland sediment – 91,526 acres inventoried. Streams receive 23,755 tons annually (95% of total). 80% cropland, 8 grazed woods, and 3% pasture.

*Pollution reduction Goals:*

- sediment reduction by 35% (33% reduction of agricultural uplands, 45% reduction of streambank sediment, and 60% reduction of shoreland reduction)
- P reduction by 50%. To accomplish this goal 70% reduction from barnyard sources; 50% of winter spread organic pollutant sources on "unsuitable" acres; and sediment sourced P must be achieved. Unsuitable acres for winter spreading include acres located within 200 feet of surface water that have a significant surface drainage development, slopes greater than 4%, and flood prone.
- Algae controls reduction of 57%. A combined 50% reduction in P load from both UBEP and LBEP will reduce algae in reservoir by 57%.

*Landowner participation: Voluntary:*

- Agricultural lands: Category I eligible if eroding > 4.0 tons/ac/y. (16,379 ac or 31% of total sediment load), Category II eligible if erosion 2.0-4.0 tons/ac/y (9% of sediment load)
- Animal Lots (115 of 208 sites need control of runoff): Category I if > 40 lbs. P/year; Category II is 20-24 lb. P/year. The target delivery rate is 20 lbs. P/yr. (today's performance standard is 15 lbs. P/yr. or 5 lbs. P/yr. in a Surface Water Management Area).
- Manure Spreading: Category I if winter spread of 16 or more acres of unsuitable acres. Category II if spreading on 11-15 critical acres. Critical acres are those with slopes of 4% or if flood prone.

*Funding projections:*

- $5,902,043 ($4,738,750 for BMP installation w/ $2,391,865 cost-share portion, $50,000 for easements w/ 437,500 c/s, $1,099,733 staffing w/ $824,800 state local assistance, $13,560 for educational activities w/ $10,170 state allocation).

See Appendix C for list of participating landowners, cost-share agreements, and BMP implementation.

*LBEP Close-out Report (compiled by CPZ staff):*

Barnyard Runoff. There were 53 barnyard runoff projects installed through the priority watershed project. These projects reduced phosphorus loadings an estimated 6,142 pounds/annually (during a 10 year storm event) which is 62% reduction. The reduction goal was 70% reduction of P from this source. The cost for barnyards was $816,900.

Waste Storage Facilities. There were 28 waste storage facilities installed to reduce winter spreading applications of manure. These projects addressed 930 "critical acres." The project goal was to reduce manure applications to critical acres by 50% or 374 acres. The subset inventory may have underestimated the total critical acres in the watershed. The total cost for waste storage facilities was $681,213.

Cropland Erosion. The goal for cropland erosion was a 33% reduction. The project achieved 23% of its goal or a total reduction of 7.5% overall.

Streambank Erosion. The watershed goal was to reduce streambank erosion by 50%. The project installed 13,500 lineal feet of streambank fencing to limit cattle access and trampling of the stream banks. As a result, the project achieved 75% of its goal for an overall sedimentation reduction of 37.5%.

Other Practices. The watershed project also funded 4,482 acres of nutrient management plans, 977 acres of managed intensive grazing, 34 acres of wetland restoration, 12 acres of waterways, 30 milking center waste control systems, and 4 well abandonments. In all, 88 cost-share agreements were developed and implemented with $1,701,872.82 allocated to landowners.

9. *Marathon County Nutrient Management (NM) Program (March 1993).*

Marathon County initiates a Nutrient Management Program in April 1991, as part of the Priority Watershed Project. Project provided technical and planning assistance to farmers on a voluntary basis and initially works with farmers receiving municipal and industrial wastes for cropland applications. The project provides free soil and manure sampling for participants. The NM program finds that landowners are over applying fertilizer by 65% based upon soil tests and UW technical recommendations. Since NM is considered a new concept and management skill for landowners, most farmers are hesitant to participate. Most participation is limited to a small percentage of cropland in order to assure that reduced nutrient application does not lower yield production. The lack of whole farm participation makes it difficult to determine the environmental and economic implication of current fertilizer programs.

## REGULATORY PROGRAMS AND COMPLIANCE

*Local Land Management Ordinances:*

- 1984 – Marathon County Board approves Animal Waste Storage Ordinance to regulate the construction and significant alteration of waste storage impoundments (earthen lagoons only). Incidental non-regulatory mention of STD 633-nutrient management. See Appendix D – history of AWO or Waste Storage Facility and Nutrient Management Ordinance.
- 2002 – State Agricultural Performance Standards and Prohibitions (NR 150's). This effort fully develops a statewide regulatory direction to conservation compliance and long term maintenance of public conservation investments. Regulatory compliance is guided by State agencies, but implemented through local ordinances and administration. See Appendix E – State Agricultural Performance Standards and Prohibitions (PS&P's). Note that administrative rules that implement the PS&P's are found in NR 151, 152, and 153, as well as ATCP 50. Chapter 92 of State Statutes provides County Land Conservation Committees authority to regulate these activities, conduct resource studies, and administer cost-share funding to implement rules.
- 2008 – Livestock Facility Siting Ordinance. This ordinance authorizes the County to regulate Concentrated Animal Feedlot Operations (CAFO's) with specific livestock types when over 500 animal units and they expand by over 20% of 2006 cattle population. Regulatory guidelines are provided by State Statute 93 and Administrative Rule ATCP 51. Marathon County CPZ Department works closely with regional DNR staff to coordinate the regulatory administration of this ordinance with NR 243 regulatory activities administered by DNR for CAFO's over 1000 animal units.
- 2009 – Waste Storage Facility and Nutrient Management Ordinance. This revision for the first time provides clear authority to the County to regulate nutrient management planning when associated with waste storage facilities. As of 2008, there are approximately 60,103 acres (40%) of cropland under Nutrient Management (NM) planning compliance in the BEP watershed. This represents 230 individual landowner/operator NM plans of which 104 are associated with Waste Storage Facilities (WSF's) constructed prior to 1985; 115 NM plans are associated with WSF's constructed after 1985 construction; and 11 NM plans are associated with program compliance requirement (not ordinance). There remain 19 total WSF systems currently without a NM plan (no cost-share to impose compliance). See Map 6 for farms with a NM plan. According to the 2007 CPZ Inventory of Waste Storage Facilities, there are a total of 313 waste storage facilities in the BEP watershed of which 252 are currently utilized (See Map 7 for location of waste storage facilities). Since 1997, when the closure of abandoned waste storage facilities became regulated by Marathon County through ordinance, the CPZ has closed 51 facilities in the BEP watershed.

*Land Use Ordinances and Initiatives:*

1. Zoning ordinances
2. Non-metallic Mining Ordinance.
3. Sanitary ordinances. See Map 8.
4. Farmland Preservation Program (41,344 acres enrolled). See Map 6.

i. Contract Agreement – Compliance per Soil and Water Standards.
ii. Zoning Certificates- PS&P's compliance

*5.* Managed Intensive Grazing Project

*6. Regulatory Compliance:*

Table 3. BEP Wastewater Permits: WPDES P loadings for municipalities (Lbs./year).

| Municipality | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|
| Milan SD | 2404 | 2109 | 2183 | 2073 | 1058 | 620 | 769 | 738 | 597 | 492 |
| Stratford | | 222 | 125 | 219 | 256 | 141 | 144 | 192 | 150 | 165 |
| Colby | | | 311 | 277 | 352 | 173 | 290 | 229 | 642 | 314 |
| Abbotsford | | | | 958 | 1259 | 736 | 908 | 641 | 604 | 884 |
| Stetsonville | | | | | | | | | 747 | 629 |

Source NC – DNR (Jim Schmidt, 2007).

Table 4. BEP WPDES – DNR Concentrated Animal Feedlot Operation (CAFO) permits

| Permit No | Facility | Animal Units | Dairy | Heifers | Calves |
|---|---|---|---|---|---|
| WI-0061841-02-0 | Heeg Bros | 1385 | 950 | 55 | |
| WI-0061832-02-0 | Maple Ridge | 1465 | 975 | 70 | 150 |
| WI-0062413-01-0 | Lynn Bros | 3623 | | | |
| | Miltrim Farms (land) | 2520 | 1800 | 0 | 0 |
| | Bach Dairy (land) | >1000 | | | |
| | Dic-Wisco Farms (land) | >1000 | | | |

Table 5. Marathon County Regulatory Programming Compliance

| Program | Animal Units | Acres | No. | |
|---|---|---|---|---|
| Waste Storage Facility Ordinance | | | 252 | |
| NM Planning | | 60,103 | 230 | |
| Farmland Preservation | | 41,344 | | |
| WSF abandonments | | | 51 | |
| SWRM compliance | | | | |
| TRM compliance | | | 24 | |
| Livestock Siting Ordinance<br>• DeJong Dairy<br>• Hein Homestead Farms | <br>710<br>700 | | | |
| Managed Intensive Grazing Project | | | | |

USDA programming to be determined.

List of Information or Inventory Needs

1. How much winter manure is spread? See Shaw's study for primary cause. Utilize SNAP+ modeling and landowner report capabilities to track fields and actual applications. Compare applications to weather and field conditions (saturation and frozen soil conditions).
2. Project monitoring should include stream sampling and soil conditions during fall, winter, and spring distribution periods.
3. How many cheese factories (1974 fish kill thought to be whey) still processing and disposing waste in watershed? Contribution to pollutant load? What are their respective treatment systems?
4. No distinction made relative to dynamics of delivery between liquid or solid manures. Is the increase in the presence of liquid waste (a function of feeding and waste water generation) creating a different pollutant loading and water chemistry dynamic?
5. How about the waste water contributions for farmers? Is the increasingly wet nature of the waste stream recognized? How about feed leachate contributions?
6. Determine the number of BMP's still in-place? No current inventory exists to determine how many BMP's still performing as designed.
7. How many farm facilities abandoned?
8. Determine condition of BMP's?
9. Find and evaluate the sub watershed monitoring of water parameters and habitat (if they exist).
10. Find annual and close-out summary of pollutant reductions as a result of BMP installation for all conservation initiatives.
11. Note the history of BEP Watershed Organization: 1956 (landowners and farmers).
12. Is proposed North Breeze Dairy located in BEP watershed?
13. Operational Plan – Does plan provide guidance to WVIC for drought conditions? In 2/26/1995 news article by *Wausau Daily Herald,* the following condition combinations assessed and identified over previous 16 years that would minimize fish kills:
    a. Reservoir volume at start of winter drawdown > 60%
    b. Base flow on BEP River = or > 6 fps
    c. Drawdown to a level below 10 ft. below capacity (which triggers scouring and promotes oxygen sag) did not occur until Feb 1.

14. The aeration system in BEP reservoir was first in state for a reservoir. Do we have experiences today of other similar attempts to aerate a reservoir where water levels fluctuate?
15. How does FERC license provide balance between hydropower and other public benefits such as fisheries, recreation, flood control and wastewater permitting?
16. Before Natzke project, how many practices (Waste Storage Facilities, barnyards, filter strips installed)?
17. Can we reduce flashiness through wetland developments and vegetated corridor work? Do we need to know the resuspension impact to water quality upstream? Is this load comparable to the reservoir loading due to re-suspension?
18. Using Appendix B & C can we do an assessment of BMP condition, utilization, and effectiveness of investments?
19. Do not know which landowners/sites were distinguished as eligible or eligible nonessential. Did the critical sites get the funding assistance?
20. Summary of livestock concentration trends, waste volume trends, and waste characteristics (liquid and solid).

# APPENDIX D

United States Environmental Protection Agency

## Technical Memorandum #1

This Technical Memorandum is one of a series of publications designed to assist watershed projects, particularly those addressing nonpoint sources of pollution. Many of the lessons learned from the Clean Water Act Section 319 National Nonpoint Source Monitoring Program are incorporated in these publications.

October 2015

Fields near Seneca Lake, New York.

# Adjusting for Depreciation of Land Treatment When Planning Watershed Projects

Donald W. Meals and Steven A. Dressing. 2015. Technical Memorandum #1: Adjusting for Depreciation of Land Treatment When Planning Watershed Projects, October 2015. Developed for U.S. Environmental Protection Agency by Tetra Tech, Inc., Fairfax, VA, 16 p.

Available online at www.epa.gov/xxx/tech_memos.htm

## Introduction

Watershed-based planning helps address water quality problems in a holistic manner by fully assessing the potential contributing causes and sources of pollution, then prioritizing restoration and protection strategies to address the problems (USEPA 2013). The U.S. Environmental Protection Agency (EPA) requires that watershed projects funded directly under section 319 of the Clean Water Act implement a watershed-based plan (WBP) addressing the nine key elements identified in EPA's *Handbook for Developing Watershed Plans to Restore and Protect our Waters (USEPA 2008)* EPA further recommends that all other watershed plans intended to address water quality impairments also include the nine elements. The first element calls for the identification of causes and sources of impairment that must be controlled to achieve needed

load reductions. Related elements include a description of the nonpoint source (NPS) management measures—or best management practices (BMPs)—needed to achieve required pollutant load reductions, a description of the critical areas in which the BMPs should be implemented, and an estimate of the load reductions expected from the BMPs.

Once the causes and sources of water resource impairment are assessed, identifying the appropriate BMPs to address the identified problems, the best locations for additional BMPs, and the pollutant load reductions likely to be achieved with the BMPs depends on accurate information on the performance levels of both BMPs already in place and BMPs to be implemented as part of the watershed project. All too often, watershed managers and Agency staff have assumed that, once certified as installed or adopted according to specifications, a BMP continues to perform its pollutant reduction function at the same efficiency (percent pollutant reduction) throughout its design or contract life, sometimes longer. An important corollary to this assumption is that BMPs in place during project planning are performing as originally intended. Experience in NPS watershed projects across the nation, however, shows that, without diligent operation and maintenance, BMPs and their effects probably will depreciate over time, resulting in less efficient pollution reduction. Recognition of this fact is important at the project planning phase, for both existing and planned BMPs.

Knowledge of land treatment depreciation is important to ensure project success through the adaptive management process (USEPA 2008). BMPs credited during the planning phase of a watershed project will be expected to achieve specific load reductions or other water quality benefits as part of the overall plan to protect or restore a water body. Verification that BMPs are still performing their functions at anticipated levels is essential to keeping a project on track to achieve its overall goals. Through adaptive management, verification results can be used to inform decisions about needs for additional BMPs or maintenance or repair of existing BMPs. In a watershed project that includes short-term (3–5 years) monitoring, subtle changes in BMP performance level might not be detectable or critical, but planners must account for catastrophic failures, BMP removal or discontinuation, and major maintenance shortcomings. Over the longer term, however, gradual changes in BMP performance level can be significant in terms of BMP-specific pollutant control or the role of single BMPs within a BMP system or train. The weakest link in a BMP train can be the driving force in overall BMP performance.

Application of and methods for BMP tracking in NPS watershed projects are described in detail in *Tech Notes 11* (Meals et al. 2014).

This technical memorandum addresses the major causes of land treatment depreciation, ways to assess the extent of depreciation, and options for adjusting for depreciation. While depreciation occurs throughout the life of a watershed project, the emphasis is on the planning phase and the short term (i.e., 3–5 years).

# Causes of Depreciation

Depreciation of land treatment function occurs as a result of many factors and processes. Three of the primary causes are natural variability, lack of proper maintenance, and unforeseen consequences.

## Natural Variability

Climate and soil variations across the nation influence how BMPs perform. Tiessen et al. (2010), for example, reported that management practices designed to improve water quality by reducing sediment and sediment-bound nutrient export from agricultural fields can be less effective in cold, dry regions where nutrient export is primarily snowmelt driven and in the dissolved form, compared to similar practices in warm, humid regions. Performance levels of vegetation-based BMPs in both agricultural and urban settings can vary significantly through the year due to seasonal dormancy.

In a single locale, year-to-year variation in precipitation affects both agricultural management and BMP performance levels. Drought, for example, can suppress crop yields, reduce nutrient uptake, and result in nutrient surpluses left in the soil after harvest where they are vulnerable to runoff or leaching loss despite careful nutrient management. Increasing incidence of extreme weather and intense storms can overwhelm otherwise well-designed stormwater management facilities in urban areas.

## Lack of Proper Maintenance

Most BMPs—both structural and management—must be operated and maintained properly to continue to function as designed. Otherwise, treatment effectiveness can depreciate over time. For

example, in a properly functioning detention pond, sediment typically accumulates in the forebay. Without proper maintenance to remove accumulated sediment, the capacity of the BMP to contain



and treat stormwater is diminished. Similarly, a nutrient management plan is only as effective as its implementation. Failure to adhere to phosphorus (P) application limits, for example, can result in soil P buildup and increased surface and subsurface losses of P rather than the loss reductions anticipated.

Jackson-Smith et al. (2010) reported that over 20 percent of implemented BMPs in a Utah watershed project appeared to be no longer maintained or in use when evaluated just 5 years after project completion. BMPs related to crop production enterprises and irrigation systems had the lowest rate of continued use and maintenance (~75 percent of implemented BMPs were still in use), followed by pasture and grazing planting and management BMPs (81 percent of implemented BMPs were still in use). Management practices (e.g., nutrient management) were found to be particularly susceptible to failure.

Practices are sometimes simply abandoned as a result of changes in landowner circumstances or attitudes. In a Kansas watershed project, farmers abandoned a nutrient management program because of perceived restrictive reporting requirements (Osmond et al. 2012).

Abandoned waste storage structure.

In the urban arena, a study of more than 250 stormwater facilities in Maryland found that nearly one-third of stormwater BMPs were not functioning as designed and that most needed maintenance (Lindsey et al. 1992). Sedimentation was a major problem and had occurred at nearly half of the facilities; those problems could have been prevented with timely maintenance.

Hunt and Lord (2006) describe basic maintenance requirements for bio retention practices and the consequences of failing to perform those tasks. For example, they indicate that mulch should be removed every 1–2 years to both maintain available water storage volume and increase the surface infiltration rate of fill soil. In addition, biological films might need to be removed every 2–3 years because they can cause the bio retention cell to clog.

In plot studies, Dillaha et al. (1986) observed that vegetative filter strip-effectiveness for sediment removal appeared to decrease with time as sediment accumulated within the filter strips. One set of the filters was almost totally inundated with sediment during the cropland experiments and filter effectiveness dropped 30–60 percent between the first and second experiments. Dosskey et al. (2002) reported that up to 99 percent of sediment was removed from cropland runoff when uniformly distributed over a buffer area, but as concentrated flow paths developed over time (due to lack of maintenance), sediment removal dropped to 15–45 percent. In the end, most structural BMPs have a design life (i.e., the length of time the item is expected to work within its specified parameters). This period is measured from when the BMP is placed into service until the end of its full pollutant reduction function.

## Unforeseen Consequences

The effects of a BMP can change directly or indirectly due to unexpected interactions with site conditions or other activities. Incorporating manure into cropland soils to reduce nutrient runoff, for example, can increase erosion and soil loss due to soil disturbance, especially in comparison

to reduced tillage. On the other hand, conservation tillage can result in accumulation of fertilizer nutrients at the soil surface, increasing their availability for loss in runoff (Rhoton et al. 1993). Long-term reduction in tillage also can promote the formation of soil macropores, enhancing leaching of soluble nutrients and agrichemicals into ground water (Shipitalo et al. 2000). Stutter et al. (2009) reported that establishment of vegetated buffers between cropland and a watercourse led to enhanced rates of soil P cycling within the buffer, increasing soil P solubility and the potential for leaching to watercourses.

Despite widespread adoption of conservation tillage and observed reductions in particulate P loads, a marked increase in loads of dissolved bioavailable P in agricultural tributaries to Lake Erie has been documented since the mid-1990s. This shift has been attributed to changes in application rates, methods, and timing of P fertilizers on cropland in conservation tillage not subject to annual tillage (Baker 2010; Joosse and Baker 2011). Further complicating matters, recent research on fields in the St. Joseph River watershed in northeast Indiana has demonstrated that about half of both soluble P and total P losses from research fields occurred via tile discharge, indicating a need to address both surface and subsurface loads to reach the goal of 41 percent reduction in P loading for the Lake Erie Basin (Smith et al. 2015).

Several important project planning lessons were learned from the White Clay Lake, Wisconsin, demonstration projects in the 1970s, including the need to accurately assess pollutant inputs and the performance levels of BMPs (NRC 1999). Regarding unforeseen consequences, the project learned through monitoring that a manure storage pit built according to prevailing specifications actually caused ground water contamination that threatened a farmer's well water. This illustrates the importance of monitoring implemented practices over time to ensure that they function properly and provide the intended benefits.

Control of urban stormwater runoff (e.g., through detention) has been widely implemented to reduce peak flows from large storms in order to prevent stream channel erosion. Research has shown, however, that although large peak flows might be controlled effectively by detention storage, stormflow conditions are extended over a longer period of time. Duration of erosive and bankfull flows are increased, constituting channel-forming events. Urbonas and Wulliman (2007) reported that, when captured runoff from a number of individual detention basins in a stream system is released over time, the flows accumulate as they travel downstream, actually increasing peak flows along the receiving waters. This situation can diminish the collective effectiveness of detention basins as a watershed management strategy.

# Assessment of Depreciation

The first—and possibly most important—step in adjusting for depreciation of implemented BMPs is to determine its extent and magnitude through BMP verification.

## BMP Verification

At its core, BMP verification confirms that a BMP is in place and functioning properly as expected based on contract, permit, or other implementation evidence. A BMP verification process that documents the presence and function of BMPs over time should be included in all NPS watershed projects.

At the project planning phase, verification is important both to ensure accurate assessment of existing BMP performance levels and to determine additional BMP and maintenance needs. Verification over time is necessary to determine if BMPs are maintained and operated during the period of interest.

Documenting the presence of a BMP is generally simpler than determining how well it functions, but both elements of verification must be considered to determine if land treatment goals are being met and whether BMP performance is depreciating. Although land treatment goals might not be highly specific in many watershed projects, it is important to document what treatment is implemented. Verification is described in detail in *Tech Notes 11* (Meals et al. 2014). This technical memorandum focuses on specific approaches to assessing depreciation within the context of an overall verification process.

## Methods for Assessing BMP Presence and Performance Level

Whether a complete enumeration or a statistical sampling approach is used, methods for tracking BMPs generally include direct measurements (e.g., soil tests, onsite inspections, remote sensing) and indirect methods (e.g., landowner self-reporting or third-party surveys). Several of these methods are discussed in *Tech Notes 11* (Meals et al. 2014). Two general factors must be considered when verifying a BMP: the presence of the BMP and its pollutant removal efficiency. Different types of BMPs require different verification methods, and no single approach is likely to provide all the information needed in planning a watershed project.

### Certification

The first step in the process is to determine whether BMPs have been designed and installed/ adopted according to appropriate standards and specifications. Certification can either be the final step in a contract between a landowner and a funding agency or be a component of a permit requirement.

Certification provides assurance that a BMP is fully functional for its setting at a particular time. For example, a stormwater detention pond or water and sediment control basin must be properly sized for its contributing area and designed for a specific retention-and-release performance level. A nutrient management plan must account for all sources of nutrients, consider current soil nutrient levels, and support a reasonable yield goal. A cover crop must be planted in a particular time window to provide erosion control and/or nutrient uptake during a critical time of year. Some jurisdictions might apply different nutrient reduction efficiency credits for cover crops based on planting date. Some structural BMPs like parallel tile outlet terraces require up to 2 years to fully settle and achieve full efficiency; in those cases, certification is delayed until full stability is reached. Knowledge that a BMP has been applied according to a specific standard supports an assumption that the BMP will perform at a certain level of pollutant reduction efficiency, providing a baseline against which future depreciation can be compared. Practices voluntarily implemented by landowners without any technical or financial assistance could require special efforts to determine compliance with applicable specifications (or functional equivalence). Pollution reduction by practices not meeting specifications might need to be discounted or not counted at all even when first installed.

## Depreciation assessment indicators

Ideally, assessment of BMP depreciation would be based on actual measurement of each BMP's performance level (e.g., monitoring of input and output pollutant loads for each practice). Except in very rare circumstances, this type of monitoring is impractical. Rather, a watershed project generally must depend on the use of indicators to assess BMP performance level.

The most useful indicators for assessing depreciation are determined primarily by the type of BMP and pollutants controlled, but indicators might be limited by the general verification approach used. For example, inflow and outflow measurements of pollutant load can be used to determine the effectiveness of constructed wetlands, but a verification effort that uses only visual observations will not provide that data or other information about wetland functionality. A central challenge, therefore, is to identify meaningful indicators of BMP performance level that can be tracked under different verification schemes. This technical memorandum provides examples of how to accomplish that end.

### *Nonvegetative structural practices*

Performance levels of nonvegetative structural practices—such as animal waste lagoons, digesters, terraces, irrigation tailwater management, stormwater detention ponds, and pervious pavement—can be assessed using the following types of indicators:

- Measured on-site performance data (e.g., infiltration capacity of pervious pavement),
- Structural integrity (e.g., condition of berms or other containment structures), and
    - Water volume capacity (e.g., existing pond volume vs. design) and mass or volume of captured material removed (e.g., sediment removed from stormwater pond forebay at cleanout).

In some cases, useful indicators can be identified directly from practice standards. For example, the Natural Resources Conservation Service lists operation and maintenance elements for a water and sediment control basin (WASCoB) (*USDA-NRCS 2008*) that include:

- Maintenance of basin ridge height and outlet elevations,
- Removal of sediment that has accumulated in the basin to maintain capacity and grade,
    - Removal of sediment around inlets to ensure that the inlet remains the lowest spot in the basin, and
    - Regular mowing and control of trees and brush.

These elements suggest that ridge and outlet elevations, sediment accumulation, inlet integrity, and vegetation control would be important indicators of WASCoB performance level.

Required maintenance checklists contained in stormwater permits also can suggest useful indicators. For example, the *Virginia Stormwater Management Handbook* (VA DCR 1999) provides an extensive checklist for annual operation and maintenance inspection of wet ponds. The list includes many elements that could serve as BMP performance level indicators:

- Excessive sediment, debris, or trash accumulated at inlet,
- Clogging of outlet structures,

- Cracking, erosion, or animal burrows in berms, and
- More than 1 foot of sediment accumulated in permanent pool.

Assessment of these and other indicators would require on-site inspection and/or measurement by landowners, permit-holders, or oversight agencies.

### *Vegetative structural practices*

Performance levels of vegetative structural practices—such as constructed wetlands, swales, rain gardens, riparian buffers, and filter strips—can be assessed using the following types of indicators:

- Extent and health of vegetation (e.g., measurements of soil cover or plant density),
- Quality of overland flow filtering (e.g., evidence of short-circuiting by concentrated flow or gullies through buffers or filter strips),
- On-site capacity testing of rain gardens using infiltrometers or similar devices, and
- Visual observations (e.g., presence of water in swales and rain gardens).

Parking lot rain garden.

As for non-vegetative structural practices, assessment of these indicators would require on-site inspection and/or measurement by landowners, permit-holders, or oversight agencies.

### *Nonstructural vegetative practices*

Performance levels of nonstructural vegetative practices—such as cover crops, reforestation of logged tracts, and construction site seeding—can be assessed using the following types of indicators:

- Density of cover crop planting (e.g., plant count),
- Percent of area covered by cover crop, and
- Extent and vitality of tree seedlings.

These indicators could be assessed by on-site inspection or, in some cases, by remote sensing, either from satellite imagery or aerial photography.

### *Management practices*

Performance levels of management practices—such as nutrient management, conservation tillage, pesticide management, and street sweeping—can be assessed using the following types of indicators:

- Records of street sweeping frequency and mass of material collected,
- Area or percent of cropland under conservation tillage,

- Extent of crop residue coverage on conservation tillage cropland, and
- Fertilizer and/or manure application rates and schedules, crop yields, soil test data, plant tissue test results, and fall residual nitrate tests.

Illustration of line-transect method for residue.

Assessment of these indicators would generally require reporting by private landowners or municipalities, reporting that is required under some regulatory programs. Visual observation of indicators such as residue cover, however, can also be made by on-site inspection or windshield survey.

## Data analysis

Data on indicators can be expressed and analyzed in several ways, depending on the nature of the indicators used. Indicators reporting continuous numerical data—such as acres of cover crop or conservation tillage, manure application rates, miles of street sweeping, mass of material removed from catch basins or detention ponds, or acres of logging roads/landings revegetated—can be expressed either in the raw form (e.g., acres with 30 percent or more residue cover) or as a percentage of the design or target quantity (e.g., percent of contracted acres achieving 30 percent or more of residue cover). These metrics can be tracked year to year as a measure of BMP depreciation (or achievement). During the planning phase of a watershed project, it might be appropriate to collect indicator data for multiple years prior to project startup to enable calculation of averages or ranges to better estimate BMP performance levels over crop rotation cycles or variable weather conditions.

Indicators reporting categorical data—such as maintenance of detention basin ridge height and outlet elevations, condition of berms or terraces, or observations of water accumulation and flow— are more difficult to express quantitatively. It might be necessary to establish an ordinal scale (e.g., condition rated on a scale of 1–10) or a binary yes/no condition, then use best professional judgment to assess influence on BMP performance.

In some cases, it might be possible to use modeling or other quantitative analysis to estimate individual or watershed-level BMP performance levels based on verification data. In an analysis of stormwater BMP performance levels, Tetra Tech (2010) presented a series of BMP performance curves based on monitoring and modeling data that relate pollutant removal efficiency to depth of runoff treated (Figure 1). Where depreciation indicators track changes in depth of runoff treated as the capacity of a BMP decreases (e.g., from sedimentation), resulting changes in pollutant removal could be determined from a performance curve. This type of information can be particularly useful during the planning phase of a watershed project to estimate realistic performance levels for existing BMPs that have been in place for a substantial portion of their expected lifespans.

The performance levels of structural agricultural BMPs in varying condition can be estimated by altering input parameters in the *Soil and Water Assessment Tool* (SWAT) model (Texas A&M University 2015a); other models such as the *Agricultural Policy/Environmental eXtender* (APEX) model (Texas A&M

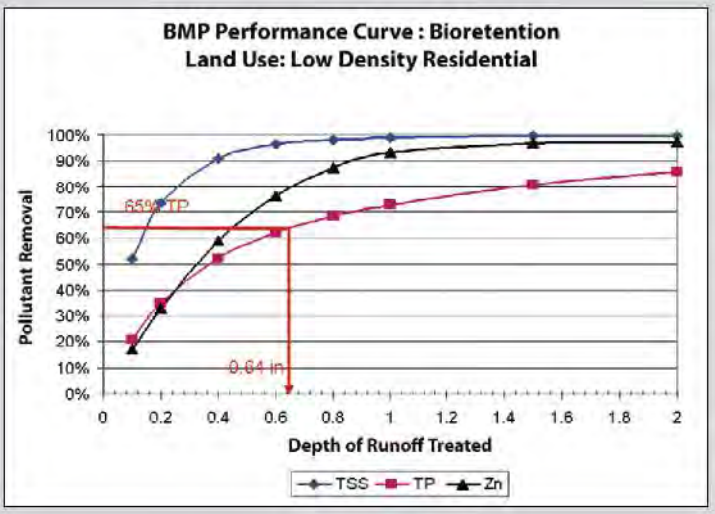


Figure 1. BMP Performance Curve for Bioretention BMP (Tetra Tech 2010).

University 2015b) also can be used in this way (including application to some urban BMPs). For urban stormwater, engineering models like *HydroCAD* (HydroCAD Software Solutions 2011) can be used to simulate hydrologic response to stormwater BMPs with different physical characteristics (e.g., to compare performance levels under actual vs. design conditions). Even simple spreadsheet models such as the Spreadsheet Tool for Estimating Pollutant Load *STEPL* (USEPA 2015) can be used to quantify the effects of BMP depreciation by varying the effectiveness coefficients in the model.

Data from verification efforts and analysis of the effects of depreciation on BMP performance levels must be qualified based on data confidence. "Confidence" refers mainly to a quantitative assessment of the accuracy of a verification result. For example, the number of acres of cover crops or the continuity of streamside buffers on logging sites determined from aerial photography could be determined by ground-truthing to be within +10 percent of the true value at the 95 percent confidence level. Confidence also can refer to the level of trust that BMPs previously implemented continue to function (e.g., the proportion of BMPs still in place and meeting performance standards). For example, reporting that 75 percent of planned BMPs have been verified is a measure of confidence that the desired level of treatment has been applied.

While specific methods to evaluate data confidence are beyond the scope of this memo, it is essential to be able to express some degree of confidence in verification results—both during the planning phase and over time as the project is implemented. For example, an assessment of relative uncertainty of BMP performance during the planning phase can be used as direct follow-up to verification efforts to those practices for which greater quantification of performance level is needed.
In addition, plans to implement new BMPs also can be developed with full consideration of the reliability of BMPs already in place.

# Adjusting for Depreciation

Information on BMP depreciation can be used to improve both project management and project evaluation.

## Project Planning and Management

### Establishing baseline conditions

Baseline conditions of pollutant loading include not only pollutant source activity but also the influence of BMPs already in place at the start of the project. Adjustments based on knowledge of

BMP depreciation can provide a more realistic estimate of baseline pollutant loads than assuming that existing land treatment has reduced NPS pollutant loads by some standard efficiency value.

Establishing an accurate starting point will make load reduction targets—and, therefore, land treatment design—more accurate. Selecting appropriate BMPs, identifying critical source areas, and prioritizing land treatment sites will all benefit from an accurate assessment of baseline conditions. Knowledge of depreciation of existing BMPs can be factored into models used for project planning (e.g., by adjusting pollutant removal efficiencies), resulting in improved understanding of overall baseline NPS loads and their sources.

While not a depreciation issue per se, when a BMP is first installed—especially a vegetative BMP like a buffer or filter strip—it usually takes a certain amount of time before its pollutant reduction capacity is fully realized. For example, Dosskey et al. (2007) reported that the nutrient reduction performance of newly established vegetated filter strips increased over the first 3 years as dense stands of vegetation grew in and soil infiltration improved; thereafter, performance level was stable over a decade. When planning a watershed project, vegetative practices should be examined to determine the proper level of effectiveness to assume based on growth stage. Also, because of weather or management conditions, some practices (e.g., trees) might take longer to reach their full effectiveness or might never reach it. The Stroud Preserve, Pennsylvania, section 319 National Nonpoint Source Monitoring Program (NNPSMP) project (1992–2007) found that slow tree growth in a newly established riparian forest buffer delayed significant $NO_3$–N (nitrate) removal from ground water until about 10 years after the trees were planted (Newbold et al. 2008).

The performance of practices can change in multiple ways over time. For example, excessive deposition in a detention pond that is not properly maintained could reduce overall percent removal of sediment because of reduced capacity as illustrated in Figure 1. The relative and absolute removal efficiencies for various particle size fractions (and associated pollutants) also can change due to reduced hydraulic retention time. Fine particles generally require longer settling times than larger particles, so removal efficiency of fine particles (e.g., silt, clay) can be disproportionally reduced as a detention pond or similar BMP fills with sediment and retention time deteriorates. Expert assessment of the condition and likely current performance level of existing BMPs, particularly those for which a significant amount of pollutant removal is assumed, is essential to establishing an accurate baseline for project planning.

## Adaptive watershed management

Watershed planning and management is an iterative process; project goals might not all be fully met during the first project cycle and management efforts usually need to be adjusted in light of ongoing changes. In many cases, several cycles—including mid-course corrections—might be needed for a project to achieve its goals. Consequently, EPA recommends that watershed projects pursue a dynamic and adaptive approach so that implementation of a watershed plan can proceed and be modified as new information becomes available (USEPA 2008). Measures of BMP implementation commonly used as part of progress assessment should be augmented with indicators of BMP depreciation. Combining this information with other relevant project data can provide reliable progress assessments that will indicate gaps and weaknesses that need to be addressed to achieve project goals.

### BMP design and delivery system

Patterns in BMP depreciation might yield information on systematic failures in BMP design or management that can be addressed through changes to standards and specifications, contract terms, or permit requirements. This information could be particularly helpful during the project planning phase when both the BMPs and their implementation mechanisms are being considered. For example, a cost-sharing schedule that has traditionally provided all or most funding upon initial installation of a BMP could be adjusted to distribute a portion of the funds over time if operation and maintenance are determined to be a significant issue based on pre-project information. Some BMP components, on the other hand, might need to be dropped or changed to make them more appealing to or easier to manage by landowners. Within the context of a permit program, for example, corrective actions reports might indicate specific changes that should be made to BMPs to ensure their proper performance.

## Project Evaluation

### Monitoring

Although short-term (3–5 year) NPS watershed projects will not usually have a sufficiently long data record to evaluate incremental project effects, data on BMP depreciation might still improve interpretation of collected water quality data. Even in the short term, water quality monitoring data might reflect cases in which BMPs have suffered catastrophic failures (e.g., an animal waste lagoon breach), been abandoned, or been maintained poorly. Meals (2001), for example, was able to interpret unexpected spikes in stream P and suspended sediment concentrations by walking the watershed and discovering that a landowner had over-applied manure and plowed soil directly into the stream.

Longer-term efforts (e.g., total maximum daily loads[1]) might engage in sustained monitoring beyond individual watershed project lifetime(s). The extended monitoring period will generally allow detection of more subtle water quality impacts for which interpretation could be enhanced with information on BMP depreciation. While not designed as BMP depreciation studies, the following two examples illustrate how changes in BMP performance can be related to water quality.

In a New York dairy watershed treated with multiple BMPs, Lewis and Makarewicz (2009) reported that the suspension of a ban on winter manure application 3 years into the monitoring study led to dramatic increases in stream nitrogen and phosphorus concentrations. First and foremost, knowledge of that suspension provided a reasonable explanation for the observed increase in nutrient levels. Secondly, the study was able to use data from the documented depreciation of land treatment to determine that the winter spreading ban had yielded 60–75 percent reductions in average stream nutrient concentrations.

The Walnut Creek, Iowa, Section 319 NNPSMP project promoted conversion of row crop land to native prairie to reduce stream $NO_3$-N levels and used simple linear regression to show association of two monitored variables: tracked conversion of row crop land to restored prairie vegetation and stream $NO_3$-N concentrations (Schilling and Spooner 2006). Because some of the restored prairie was plowed back into cropland during the project period—and because that change was

[1] "Total maximum daily loads" as defined in §303(d) of the Clean Water Act.

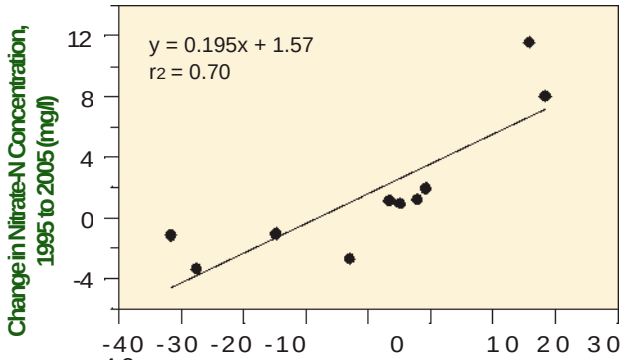


Figure 2. Relating Changes in Stream Nitrate Concentrations to Changes in Row Crop Land Cover in Walnut Creek, Iowa (Schilling and Spooner 2006)).

The magnitude of implementation (e.g., acres of treatment) and the spatial distribution of both annual and structural BMPs should be part of model input and should not be static parameters. Where BMPs are represented by pollutant reduction efficiencies, those percentages can be adjusted based on verification of land treatment performance levels in the watershed. Incorporating BMP depreciation factors into models might require setting up a tiered approach for BMP efficiencies (e.g., different efficiency values for BMPs determined to be in fair, good, or excellent condition) rather than the currently common practice of setting a single efficiency value for a practice assumed to exist. This approach could be particularly important for management practices such as agricultural nutrient management or street sweeping, in which degree of treatment is highly variable. For structural practices, a depreciation schedule could be incorporated into the project, similar to depreciating business assets. In the planning phase of a watershed project, multiple scenarios could be modeled to reflect the potential range of performance levels for BMPs already in place.

## Recommendations

The importance of having accurate information on BMP depreciation varies across projects and during the timeline of a single project. During the project planning phase, when plans for the achievement of pollutant reduction targets rely heavily on existing BMPs, it is essential to obtain good information on the level of performance of the BMPs to ensure that plan development is properly informed. If existing BMPs are a trivial part of the overall watershed plan, knowledge of BMP depreciation might not be critical during planning. As projects move forward, however, the types of BMPs implemented, their relative costs and contributions to achievement of project pollutant reduction goals, and the likelihood that BMP depreciation will occur during the period of interest will largely determine the type and extent of BMP verification required over time. The following recommendations should be considered within this context:

- For improved characterization of overall baseline NPS loads, better identification of critical source areas, and more effective prioritization of new land treatment during project planning, collect accurate and complete information about:
  - Land use,

  - Land management, and
  - The implementation and operation of existing BMPs. This information should include:
    - Original BMP installation dates,
    - Design specifications of individual BMPs,
    - Data on BMP performance levels if available, and
    - The spatial distribution of BMPs across the watershed.
- Track the factors that influence BMP depreciation in the watershed, including:
  - Variations in weather that influence BMP performance levels,
  - Changes in land use, land ownership, and land management,
  - Inspection and enforcement activities on permitted practices, and
  - Operation, maintenance, and management of implemented practices.
- Develop and use observable indicators of BMP status/performance that:
  - Are tailored to the set of BMPs implemented in the watershed and practical within the scope of the watershed project's resources,
  - Can be quantified or scaled to document the extent and magnitude of treatment depreciation, and
  - Are able to be paired with water quality monitoring data.
- After the implementation phase of the NPS project, conduct verification activities to document the continued existence and function of implemented practices to assess the magnitude of depreciation and provide a basis for corrective action. The verification program should:
  - Identify and locate all BMPs of interest, including cost-shared, non-cost-shared, required, and voluntary practices;
  - Capture information on structural, annual, and management BMPs;
  - Obtain data on BMP operation and maintenance activities; and
  - Include assessment of data accuracy and confidence.
- To adjust for depreciation of land treatment, apply verification data to watershed project management and evaluation by:
  - Applying results directly to permit compliance programs,
  - Relating documented changes in land treatment performance levels to observed water quality,
  - Incorporating measures of depreciated BMP effectiveness into modeling efforts, and
  - Using knowledge of treatment depreciation to correct problems and target additional practices as necessary to meet project goals in an adaptive watershed management approach.

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# APPENDIX E

## APPENDIX E
## Predominate Soil Types for Cropland in Fenwood Creek

| Ranking | MUSYM | Soil Name | Slope % Range | Average slope | Acres |
|---|---|---|---|---|---|
| 1 | LoB | Loyal silt loam | 1 to 6 | 3.5 | 5561 |
| 2 | WtA | Withee silt loam | 0 to 3 | 1.5 | 5510 |
| 3 | FgB | Fewwood-Rozellville silt loam | 2 to 6 | 4 | 4834 |
| 4 | MfA | Marshfield silt loam | 0 to 3 | 1.5 | 2500 |
| 5 | RcB | Rietbrock silt loam | 1 to 8 | 4.5 | 1872 |
| 6 | ShA | Sherry silt loam | 0 to 3 | 1.5 | 1756 |
| 7 | ReB | Rietbrock silt loam, stony | 1 to 8 | 4.5 | 1042 |
| 8 | Fh | Fordum silt loam | 0 to 1 | 0.5 | 555 |
| 9 | MdB | Marathon silt loam | 2 to 6 | 4 | 449 |
| 10 | FeC | Fenwood silt loam | 6 to 12 | 9 | 236 |
| 11 | Ch | Cathro muck | 0 to 1 | 0.5 | 175 |
| 12 | FfC | Fewood silt loam, stony | 2 to 15 | 8.5 | 156 |
| 13 | MzB | Mylrea silt loam, stony | 1 to 6 | 3.5 | 145 |
| 14 | MdC | Marathon silt loam | 6 to 12 | 9 | 74 |
| 15 | Oe | Oesterle loam | 0 to 2 | 1 | 71 |
| 16 | MeC | Marathon silt loam, stony | 2 to 15 | 8.5 | 41 |
| 17 | MyB | Mylrea silt loam | 1 to 6 | 3.5 | 35 |
| 18 | LoC | Loyal silt loam | 6 to 12 | 9 | 34 |
| 19 | AmC | Amery silt loam | 5 to 15 | 10 | 20 |
| 20 | Mn | Minocqua sandy loam | 0 to 2 | 1 | 12 |
| 21 | McA | Mahtomedi loamy sand | 0 to 3 | 1.5 | 7 |
| 22 | FnC | Freeon silt loam | 6 to 12 | 9 | 6 |
| 23 | FnB | Freeon silt loam | 2 to 6 | 4 | 6 |
| 24 | SdA | Scott Lake silt loam | 0 to 3 | 1.5 | 6 |
| | | | | **Total** | **25107** |

| Type | # of farmers | Acres | Soil Test P |
|---|---|---|---|
| Crop Farmer | 2 | 656 | 20 |
| Dairy Farmer | 4 | 798 | 34 |

# APPENDIX F

## APPENDIX F
## BASELINE CALCULATIONS

**PI and T from SNAP+**

| | | | Baseline | | Cover Crops | | Difference vs Baseline | | Increase Hay by 1 yr. | | Difference vs Baseline | | No-Till | | Difference vs Baseline | | Chisel/reduced tillage | | Difference vs Baseline | | Spring chisel/ recduced tillage | | Difference vs Baseline | | Tillage on Contour | | Difference vs Baseline | | Grazing | | Difference vs Baseline | | Cover Crops 2 | | Difference vs Baseline | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MUSYM | Soil Name | Type | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T |
| LoB | Loyal silt loam | Dairy-307 (liquid manure) | 10 | 6.3 | 8 | 4.7 | 2 | 1.6 | 9 | 5.4 | 1 | 0.9 | 3 | 1.5 | 7 | 4.8 | 8 | 5 | 2 | 1.3 | 7 | 4 | 3 | 2.3 | 7 | 4.4 | 3 | 1.9 | 1 | 0 | | | | | 6 | 3.6 | 4 | 2.7 |
| WtA | Withee silt loam | Dairy-307 (liquid manure) | 4 | 2.4 | 4 | 1.9 | 0 | 0.5 | 4 | 2.1 | 0 | 0.3 | 2 | 0.7 | 2 | 1.7 | 4 | 2 | 0 | 0.4 | 3 | 1.6 | 1 | 0.8 | 3 | 1.9 | 1 | 0.5 | 1 | 0 | | | | | 3 | 1.5 | 1 | 0.9 |
| FgB | Fenwood-Rozellville silt loam | Dairy-307 (liquid manure) | 7 | 4.5 | 5 | 3.4 | 2 | 1.1 | 6 | 3.9 | 1 | 0.6 | 2 | 1.2 | 5 | 3.3 | 6 | 3.7 | 1 | 0.8 | 5 | 3 | 2 | 1.5 | 5 | 3.1 | 2 | 1.4 | 1 | 0 | | | | | 4 | 2.8 | 3 | 1.7 |
| MfA | Marshfield silt loam | Dairy-307 (liquid manure) | 3 | 1.3 | 2 | 1 | 1 | 0.3 | 2 | 1.1 | 1 | 0.2 | 1 | 0.4 | 2 | 0.9 | 2 | 1 | 1 | 0.3 | 2 | 0.9 | 1 | 0.4 | 2 | 1.1 | 1 | 0.2 | 1 | 0 | | | | | 5 | 0.8 | -2 | 0.5 |
| RcB | Rietbrock silt loam | Dairy-307 (liquid manure) | 9 | 5.7 | 7 | 4.3 | 2 | 1.4 | 7 | 5 | 2 | 0.7 | 3 | 1.5 | 6 | 4.2 | 7 | 4.6 | 2 | 1.1 | 6 | 3.8 | 3 | 1.9 | 6 | 3.9 | 3 | 1.8 | 1 | 0 | | | | | 5 | 3.4 | 4 | 2.3 |
| ShA | Sherry silt loam | Dairy-307 (liquid manure) | 4 | 2 | 3 | 1.5 | 1 | 0.5 | 3 | 1.7 | 1 | 0.3 | 2 | 0.6 | 2 | 1.4 | 3 | 1.6 | 1 | 0.4 | 3 | 1.3 | 1 | 0.7 | 3 | 1.5 | 1 | 0.5 | 1 | 0 | | | | | 3 | 1.3 | 1 | 0.7 |
| ReB | Rietbrock silt loam, stony | Dairy-307 (liquid manure) | 7 | 4.9 | 6 | 3.7 | 1 | 1.2 | 6 | 4.3 | 1 | 0.6 | 2 | 1.3 | 5 | 3.6 | 6 | 4 | 1 | 0.9 | 5 | 3.2 | 2 | 1.7 | 5 | 3.4 | 2 | 1.5 | 1 | 0 | | | | | 5 | 3 | 2 | 1.9 |
| LoB | Loyal silt loam | Dairy-308 (solid manure) | 8 | 3.9 | 10 | 3.7 | -2 | 0.2 | 7 | 3.4 | 1 | 0.5 | 4 | 0.8 | 4 | 3.1 | 9 | 3.6 | -1 | 0.3 | 8 | 2.9 | 0 | 1 | 6 | 2.8 | 2 | 1.1 | | | | | | | 8 | 2.8 | 0 | 1.1 |
| WtA | Withee silt loam | Dairy-308 (solid manure) | 4 | 1.5 | 6 | 1.4 | -2 | 0.1 | 4 | 1.4 | 0 | 0.1 | 4 | 0.4 | 0 | 1.1 | 5 | 1.3 | -1 | 0.2 | 5 | 1.1 | -1 | 0.4 | 3 | 1.1 | 1 | 0.4 | | | | | | | 5 | 1.1 | -1 | 0.4 |
| FgB | Fenwood-Rozellville silt loam | Dairy-308 (solid manure) | 6 | 2.9 | 7 | 2.8 | -1 | 0.1 | 5 | 2.5 | 1 | 0.4 | 4 | 0.7 | 2 | 2.2 | 7 | 2.7 | -1 | 0.2 | 7 | 2.2 | -1 | 0.7 | 4 | 2 | 2 | 0.9 | | | | | | | 7 | 2.2 | -1 | 0.7 |
| MfA | Marshfield silt loam | Dairy-308 (solid manure) | 3 | 0.8 | 5 | 0.8 | -2 | 0 | 3 | 0.7 | 0 | 0.1 | 3 | 0.2 | 0 | 0.6 | 4 | 0.8 | -1 | 0 | 4 | 0.7 | -1 | 0.1 | 2 | 0.7 | 1 | 0.1 | | | | | | | 5 | 0.7 | -2 | 0.1 |
| RcB | Rietbrock silt loam | Dairy-308 (solid manure) | 8 | 3.6 | 9 | 3.5 | 1.5 | 0.9 | 7 | 3.2 | 1 | 0.4 | 4 | 0.9 | 4 | 2.7 | 8 | 3.4 | 0 | 0.2 | 8 | 2.8 | 0 | 0.8 | 5 | 2.6 | 3 | 1 | | | | | | | 8 | 2.8 | 0 | 0.8 |
| ShA | Sherry silt loam | Dairy-308 (solid manure) | 4 | 1.3 | 5 | 1.3 | -1 | 0 | 3 | 1.1 | 1 | 0.2 | 4 | 0.4 | 0 | 0.9 | 5 | 1.2 | -1 | 0.1 | 5 | 1 | -1 | 0.3 | 3 | 1 | 1 | 0.3 | | | | | | | 5 | 1 | -1 | 0.3 |
| ReB | Rietbrock silt loam, stony | Dairy-308 (solid manure) | 7 | 3.1 | 8 | 3 | -1 | 0.1 | 6 | 2.7 | 1 | 0.4 | 4 | 0.7 | 3 | 2.4 | 7 | 2.9 | 0 | 0.2 | 7 | 2.4 | 0 | 0.7 | 5 | 2.2 | 2 | 0.9 | | | | | | | 7 | 2.4 | 0 | 0.7 |
| LoB | Loyal silt loam | Crop-400 | 6 | 5.3 | 6 | 5 | 0 | 0.3 | n/a | n/a | - | - | 1 | 0.4 | 5 | 4.9 | 4 | 3.7 | 2 | 1.6 | 4 | 3.6 | 2 | 1.7 | 3 | 3 | 3 | 2.3 | | | | | | | 4 | 3.4 | 2 | 1.9 |
| WtA | Withee silt loam | Crop-400 | 3 | 2.1 | 2 | 2 | 1 | 0.1 | n/a | n/a | - | - | 0 | 0.2 | 3 | 1.9 | 2 | 1.5 | 1 | 0.6 | 2 | 1.5 | 1 | 0.6 | 2 | 1.4 | 1 | 0.7 | | | | | | | 2 | 1.2 | 1 | 0.9 |
| FgB | Fenwood-Rozellville silt loam | Crop-400 | 4 | 3.9 | 4 | 3.7 | 0 | 0.2 | n/a | n/a | - | - | 0 | 0.3 | 4 | 3.6 | 3 | 2.8 | 1 | 1.1 | 3 | 2.7 | 1 | 1.2 | 2 | 2.2 | 2 | 1.7 | | | | | | | 3 | 2.6 | 1 | 1.3 |
| MfA | Marshfield silt loam | Crop-400 | 1 | 1.1 | 1 | 1 | 0 | 0.1 | n/a | n/a | - | - | 0 | 0.1 | 1 | 1 | 1 | 0.8 | 0 | 0.3 | 1 | 0.8 | 0 | 0.3 | 1 | 0.9 | 0 | 0.2 | | | | | | | 1 | 0.7 | 0 | 0.4 |
| RcB | Rietbrock silt loam | Crop-400 | 5 | 4.9 | 5 | 4.7 | 0 | 0.2 | n/a | n/a | - | - | 1 | 0.4 | 4 | 4.5 | 4 | 3.5 | 1 | 1.4 | 4 | 3.4 | 1 | 1.5 | 3 | 2.8 | 2 | 2.1 | | | | | | | 4 | 3.2 | 1 | 1.7 |
| ShA | Sherry silt loam | Crop-400 | 2 | 1.7 | 2 | 1.6 | 0 | 0.1 | n/a | n/a | - | - | 0 | 0.2 | 2 | 1.5 | 2 | 1.3 | 0 | 0.4 | 2 | 1.2 | 0 | 0.5 | 1 | 1.1 | 1 | 0.6 | | | | | | | 1 | 1.2 | 1 | 0.5 |
| ReB | Rietbrock silt loam, stony | Crop-400 | 4 | 4.2 | 4 | 4 | 0 | 0.2 | n/a | n/a | - | - | 1 | 0.3 | 3 | 3.9 | 3 | 3 | 1 | 1.2 | 3 | 3 | 1 | 1.2 | 3 | 2.4 | 1 | 1.8 | | | | | | | 3 | 2.8 | 1 | 1.4 |

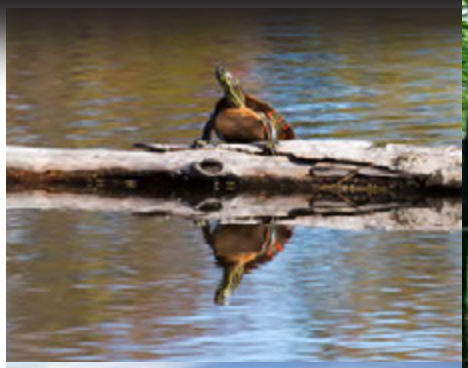
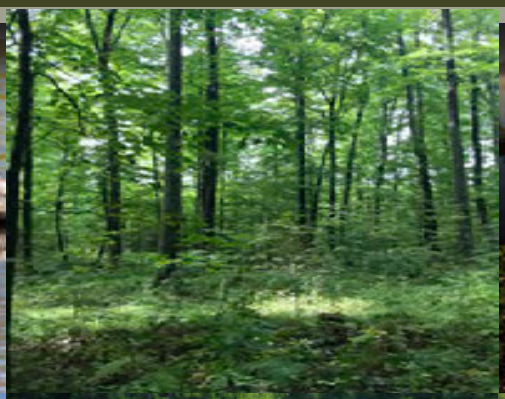
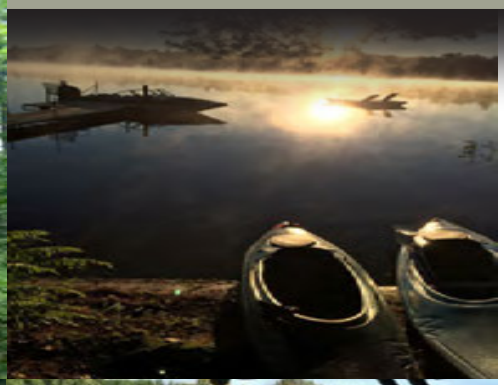
**Weighed average based on area of soil in Fenwood Creek Watershed**

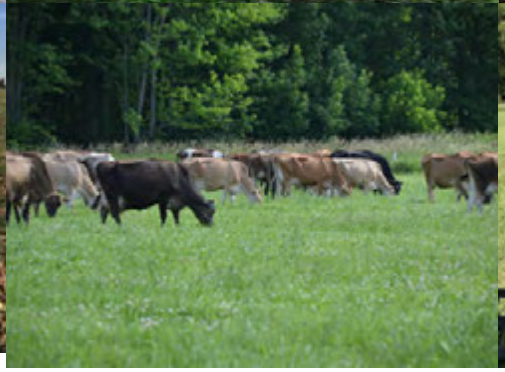
| | | | | Baseline | | Cover Crops | | Difference vs Baseline | | Increase Hay by 1 yr. | | Difference vs Baseline | | No-Till | | Difference vs Baseline | | Chisel/reduced tillage | | Difference vs Baseline | | Spring chisel/ recduced tillage | | Difference vs Baseline | | Tillage on Contour | | Difference vs Baseline | | Cover Crops 2 | | Difference vs Baseline | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MUSYM | Soil Name | Type | % of Land | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T | PI | T |
| LoB | Loyal silt loam | Dairy-307 (liquid manure) | 0.222 | 2.22 | 1.4 | 1.776 | 1.0434 | 0.444 | 0.3552 | 2.00 | 1.20 | 0.22 | 0.20 | 0.666 | 0.333 | 1.554 | 1.0656 | 1.776 | 1.11 | 0.444 | 0.2886 | 1.554 | 0.888 | 0.666 | 0.5106 | 1.554 | 0.9768 | 0.666 | 0.4218 | 1.332 | 0.7992 | 0.888 | 0.5994 | | |
| WtA | Withee silt loam | Dairy-307 (liquid manure) | 0.219 | 0.876 | 0.5 | 0.876 | 0.4161 | 0 | 0.1095 | 0.88 | 0.46 | 0.00 | 0.07 | 0.438 | 0.1533 | 0.438 | 0.3723 | 0.876 | 0.438 | 0 | 0.0876 | 0.657 | 0.3504 | 0.219 | 0.1752 | 0.657 | 0.4161 | 0.219 | 0.1095 | 0.657 | 0.3285 | 0.219 | 0.1971 | | |
| FgB | Fenwood-Rozellville silt loam | Dairy-307 (liquid manure) | 0.193 | 1.351 | 0.9 | 0.965 | 0.6562 | 0.386 | 0.2123 | 1.16 | 0.75 | 0.19 | 0.12 | 0.386 | 0.2316 | 0.965 | 0.6369 | 1.158 | 0.7141 | 0.193 | 0.1544 | 0.965 | 0.579 | 0.386 | 0.2895 | 0.965 | 0.5983 | 0.386 | 0.2702 | 0.772 | 0.5404 | 0.579 | 0.3281 | | |
| MfA | Marshfield silt loam | Dairy-307 (liquid manure) | 0.1 | 0.3 | 0.1 | 0.2 | 0.1 | 0.1 | 0.03 | 0.20 | 0.11 | 0.10 | 0.02 | 0.1 | 0.04 | 0.2 | 0.09 | 0.2 | 0.1 | 0.1 | 0.03 | 0.2 | 0.09 | 0.1 | 0.04 | 0.2 | 0.11 | 0.1 | 0.02 | 0.5 | 0.08 | -0.2 | 0.05 | | |
| RcB | Rietbrock silt loam | Dairy-307 (liquid manure) | 0.075 | 0.675 | 0.4 | 0.525 | 0.3225 | 0.15 | 0.105 | 0.53 | 0.38 | 0.15 | 0.05 | 0.225 | 0.1125 | 0.45 | 0.315 | 0.525 | 0.345 | 0.15 | 0.0825 | 0.45 | 0.285 | 0.225 | 0.1425 | 0.45 | 0.2925 | 0.225 | 0.135 | 0.375 | 0.255 | 0.3 | 0.1725 | | |
| ShA | Sherry silt loam | Dairy-307 (liquid manure) | 0.07 | 0.28 | 0.1 | 0.21 | 0.105 | 0.07 | 0.035 | 0.21 | 0.12 | 0.07 | 0.02 | 0.14 | 0.042 | 0.14 | 0.098 | 0.21 | 0.112 | 0.07 | 0.028 | 0.21 | 0.091 | 0.07 | 0.049 | 0.21 | 0.105 | 0.07 | 0.035 | 0.21 | 0.091 | 0.07 | 0.049 | | |
| ReB | Rietbrock silt loam, stony | Dairy-307 (liquid manure) | 0.042 | 0.294 | 0.2 | 0.252 | 0.1554 | 0.042 | 0.0504 | 0.25 | 0.18 | 0.04 | 0.03 | 0.084 | 0.0546 | 0.21 | 0.1512 | 0.252 | 0.168 | 0.042 | 0.0378 | 0.21 | 0.1344 | 0.084 | 0.0714 | 0.21 | 0.1428 | 0.084 | 0.063 | 0.21 | 0.126 | 0.084 | 0.0798 | | |
| | | **Weighted Average** | | **6.0** | **3.7** | **4.8** | **2.8** | **1.2** | **0.9** | **5.2** | **3.2** | **0.8** | **0.5** | **2.0** | **1.0** | **4.0** | **2.7** | **5.0** | **3.0** | **1.0** | **0.7** | **4.2** | **2.4** | **1.8** | **1.3** | **4.2** | **2.6** | **1.8** | **1.1** | **4.1** | **2.2** | **1.9** | **1.5** | | |
| LoB | Loyal silt loam | Dairy-308 (solid manure) | 0.222 | 1.776 | 0.9 | 2.22 | 0.8214 | -0.444 | 0.0444 | 1.554 | 0.755 | 0.222 | 0.111 | 0.888 | 0.1776 | 0.888 | 0.6882 | 1.998 | 0.7992 | -0.222 | 0.0666 | 1.776 | 0.6438 | 0 | 0.222 | 1.332 | 0.6216 | 0.444 | 0.2442 | 1.776 | 0.6216 | 0 | 0.2442 | | |
| WtA | Withee silt loam | Dairy-308 (solid manure) | 0.219 | 0.876 | 0.3 | 1.314 | 0.3066 | -0.438 | 0.0219 | 0.876 | 0.307 | 0.000 | 0.022 | 0.876 | 0.0876 | 0 | 0.2409 | 1.095 | 0.2847 | -0.219 | 0.0438 | 1.095 | 0.2409 | -0.219 | 0.0876 | 0.657 | 0.2409 | 0.219 | 0.0876 | 1.095 | 0.2409 | -0.219 | 0.0876 | | |
| FgB | Fenwood-Rozellville silt loam | Dairy-308 (solid manure) | 0.193 | 1.158 | 0.6 | 1.351 | 0.5404 | -0.193 | 0.0193 | 0.965 | 0.483 | 0.193 | 0.077 | 0.772 | 0.1351 | 0.386 | 0.4246 | 1.351 | 0.5211 | -0.193 | 0.0386 | 1.351 | 0.4246 | -0.193 | 0.1351 | 0.772 | 0.386 | 0.386 | 0.1737 | 1.351 | 0.4246 | -0.193 | 0.1351 | | |
| MfA | Marshfield silt loam | Dairy-308 (solid manure) | 0.1 | 0.3 | 0.1 | 0.5 | 0.08 | -0.2 | 0 | 0.300 | 0.070 | 0.000 | 0.010 | 0.3 | 0.02 | 0 | 0.06 | 0.4 | 0.08 | -0.1 | 0 | 0.4 | 0.07 | -0.1 | 0.01 | 0.2 | 0.07 | 0.1 | 0.01 | 0.5 | 0.07 | -0.2 | 0.01 | | |
| RcB | Rietbrock silt loam | Dairy-308 (solid manure) | 0.075 | 0.6 | 0.3 | 0.675 | 0.2625 | -0.075 | 0.9 | 0.525 | 0.240 | 0.075 | 0.030 | 0.3 | 0.0675 | 0.3 | 0.2025 | 0.6 | 0.255 | 0 | 0.015 | 0.6 | 0.21 | 0 | 0.06 | 0.375 | 0.195 | 0.225 | 0.075 | 0.6 | 0.21 | 0 | 0.06 | | |
| ShA | Sherry silt loam | Dairy-308 (solid manure) | 0.07 | 0.28 | 0.1 | 0.35 | 0.091 | -0.07 | 0 | 0.210 | 0.077 | 0.070 | 0.014 | 0.28 | 0.028 | 0 | 0.063 | 0.35 | 0.084 | -0.07 | 0.007 | 0.35 | 0.07 | -0.07 | 0.021 | 0.21 | 0.07 | 0.07 | 0.021 | 0.35 | 0.07 | -0.07 | 0.021 | | |
| ReB | Rietbrock silt loam, stony | Dairy-308 (solid manure) | 0.042 | 0.294 | 0.1 | 0.336 | 0.126 | -0.042 | 0.0042 | 0.252 | 0.113 | 0.042 | 0.017 | 0.168 | 0.0294 | 0.126 | 0.1008 | 0.294 | 0.1218 | 0 | 0.0084 | 0.294 | 0.1008 | 0 | 0.0294 | 0.21 | 0.0924 | 0.084 | 0.0378 | 0.294 | 0.1008 | 0 | 0.0294 | | |
| | | **Weighted Average** | | **5.3** | **2.3** | **6.7** | **2.2** | **-1.5** | **0.1** | **4.7** | **2.0** | **0.6** | **0.3** | **3.6** | **0.5** | **1.7** | **1.8** | **6.1** | **2.1** | **-0.8** | **0.2** | **5.9** | **1.8** | **-0.6** | **0.6** | **3.8** | **1.7** | **1.5** | **0.6** | **6.0** | **1.7** | **-0.7** | **0.6** | | |
| LoB | Loyal silt loam | Crop-400 | 0.222 | 1.332 | 1.2 | 1.332 | 1.11 | 0 | 0.0666 | - | - | - | - | 0.222 | 0.0888 | 1.11 | 1.0878 | 0.888 | 0.8214 | 0.444 | 0.3552 | 0.888 | 0.7992 | 0.444 | 0.3774 | 0.666 | 0.666 | 0.666 | 0.5106 | 0.888 | 0.7548 | 0.444 | 0.4218 | | |
| WtA | Withee silt loam | Crop-400 | 0.219 | 0.657 | 0.5 | 0.438 | 0.438 | 0.219 | 0.0219 | - | - | - | - | 0 | 0.0438 | 0.657 | 0.4161 | 0.438 | 0.3285 | 0.219 | 0.1314 | 0.438 | 0.3285 | 0.219 | 0.1314 | 0.438 | 0.3066 | 0.219 | 0.1533 | 0.438 | 0.2628 | 0.219 | 0.1971 | | |
| FgB | Fenwood-Rozellville silt loam | Crop-400 | 0.193 | 0.772 | 0.8 | 0.772 | 0.7141 | 0 | 0.0386 | - | - | - | - | 0 | 0.0579 | 0.772 | 0.6948 | 0.579 | 0.5404 | 0.193 | 0.2123 | 0.579 | 0.5211 | 0.193 | 0.2316 | 0.386 | 0.4246 | 0.386 | 0.3281 | 0.579 | 0.5018 | 0.193 | 0.2509 | | |
| MfA | Marshfield silt loam | Crop-400 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0 | 0.01 | - | - | - | - | 0 | 0.01 | 0.1 | 0.1 | 0.1 | 0.08 | 0 | 0.03 | 0.1 | 0.08 | 0 | 0.03 | 0.1 | 0.09 | 0 | 0.02 | 0.1 | 0.07 | 0 | 0.04 | | |
| RcB | Rietbrock silt loam | Crop-400 | 0.075 | 0.375 | 0.4 | 0.375 | 0.3525 | 0 | 0.015 | - | - | - | - | 0.075 | 0.03 | 0.3 | 0.3375 | 0.3 | 0.2625 | 0.075 | 0.105 | 0.3 | 0.255 | 0.075 | 0.1125 | 0.225 | 0.21 | 0.15 | 0.1575 | 0.3 | 0.24 | 0.075 | 0.1275 | | |
| ShA | Sherry silt loam | Crop-400 | 0.07 | 0.14 | 0.1 | 0.14 | 0.112 | 0 | 0.007 | - | - | - | - | 0 | 0.014 | 0.14 | 0.105 | 0.14 | 0.091 | 0 | 0.028 | 0.14 | 0.084 | 0 | 0.035 | 0.07 | 0.077 | 0.07 | 0.042 | 0.07 | 0.084 | 0.07 | 0.035 | | |
| ReB | Rietbrock silt loam, stony | Crop-400 | 0.042 | 0.168 | 0.2 | 0.168 | 0.168 | 0 | 0.0084 | - | - | - | - | 0.042 | 0.0126 | 0.126 | 0.1638 | 0.126 | 0.126 | 0.042 | 0.0504 | 0.126 | 0.126 | 0.042 | 0.0504 | 0.126 | 0.1008 | 0.042 | 0.0756 | 0.126 | 0.1176 | 0.042 | 0.0588 | | |
| | | **Weighted Average** | | **3.5** | **3.2** | **3.3** | **3.0** | **0.2** | **0.2** | | | | | **0.3** | **0.3** | **3.2** | **2.9** | **2.6** | **2.2** | **1.0** | **0.9** | **2.6** | **2.2** | **1.0** | **1.0** | **2.0** | **1.9** | **1.5** | **1.3** | **2.5** | **2.0** | **1.0** | **1.1** | | |

# Appendix E:3

# MARATHON COUNTY
# LAND & WATER
## Resource Management Plan

MARATHON COUNTY



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Marathon County Conservation, Planning, and Zoning staff

Marathon County Parks, Recreation and Forestry staff

## *Foreword*

*The foundation of the Land and Water Resource Management Plan is to put in place an underlying assessment of the land and water resources with accompanying goals, objectives and strategies to achieve the county's overall goal to protect and improve our land and water resources. This must be done within the framework of protecting our community's land and environment because the economic strength and vitality of our community is dependent on the quality of our resources.*

*Through leadership, accountability, engagement of community stakeholders and collaborative partnerships this plan will promote thoughtful and deliberate use of the natural resources and innovative solutions to ensure Marathon County has healthy people, a healthy economy and a healthy environment today and tomorrow.*

Paul Daigle

Land and Water Program Director

# ACKNOWLEDGEMENTS


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# EXECUTIVE SUMMARY

The Marathon County Land and Water Resource Management Plan (LWRM Plan) represents a coordinated public and private investment effort to establish the framework to identify goals, objectives, and strategies for the implementation of soil and water conservation. This coordinated effort is intended to align county, state, federal and local desired outcomes aimed to protect and conserve natural resources by improving human interaction and use of these resources in a manner that is protective of the natural environment.

## Conservation, Planning and Zoning Mission Statement

**Protect our community's land and environment because the economic strength and vitality of our community is dependent on the quality of our resources. Through leadership, accountability, community engagement, and collaborative partnerships we promote thoughtful and deliberate use of resources and innovative solutions to ensure Marathon County has healthy people, a healthy economy, and a healthy environment today and tomorrow.**

The vision and goals of the LWRM Plan embody a vision of the county's future to support resilient rural economic growth and development while improving the county's land and water quality. The initiatives found within, will guide the Conservation, Planning & Zoning Department's Land and Water Program over the next 10 years from 2021 through the year 2030. The focus and main body of the LWRM Plan is organized into five areas; introduction; resource assessment; plan goals, objectives, strategies, and measurable outcomes; plan implementation; and monitoring and evaluation.

### *Introduction*

Chapter 1. Introduction - The 2021 LWRM Plan update is the county's third decennial major revision and represents a major revision to the county's LWRM Plan strategies since 2010. The introduction explains the plan development methodology, related plans and ordinances, and endeavors of the Marathon County Conservation, Planning & Zoning Department, with focus on the Land and Water Program area responsible with implementation, management, and interrelationships of the LWRM Plan for the continued planning and proper management of natural resources.

### *Resource Assessment*

Chapter 2. Resource Assessment - provides information, figures, and data specific to Marathon County respective to soils, topography, groundwater, watersheds, surface water, shorelands, wetlands, land uses, water quality, agriculture, and population.

### *Plan Goals, Objectives, Strategies, and Measurable Outcomes*

Chapter 3. Plan Goals, Objectives, Strategies, and Measurable Outcomes - Plan goals were identified by the Local Advisory Committee (LAC) through a facilitated meeting process to assure alignment with the County's Strategic Plan and the main thrust of the LWRM Plan. Objectives, strategies, measurable outcomes, and contributing partners support and clarify the most important operational components in pursuit of the major effort to target resources, and establish clear benchmarks to evaluate the specific outcomes of the Land and Water Program.

### *Plan Implementation*

Chapter 4. Plan Implementation – Serves as a companion piece in conjunction with elements found in Chapter 3. This chapter provides particular attention to enhance the collaboration of both public and private partners for the advancement of identified goals, objectives, and strategies; various potential funding sources; and clarifies the Land and Water work plan to achieve and support plan implementation.

### *Monitoring and Evaluation*

Chapter 5. Monitoring and Evaluation – Procedures and methods are discussed to confirm and verify existing water quality and habitat conditions and weighed against established measurable outcomes to determine whether the county and its partners are successful in terms of improving or conserving natural resources. Conversely, identifying threats to natural resources are always dynamic in nature, and proper monitoring could minimize adverse impacts.

## Public Participation

The LWRM Plan is the product of the collaborative efforts of many individuals representing the county, conservation agencies, local watershed groups, health department, farmers, Wisconsin Department of Natural Resources, representatives from the USDA – Natural Resources Conservation Services, Department of Agriculture, Trade and Consumer Protection, and the University of Wisconsin-Madison Division of Extension who assisted staff in formulating this plan.

The LAC, established June 6, 2019 by the Marathon County Administrator and approved by the Marathon County Environmental Resources Committee (ERC), met seven times, in the fourth quarter of 2019 and the first quarter of 2020, to determine overarching goals, objectives, strategies, outcomes, and the implementation strategy for the plan. The Technical Advisory Committee (TAC) comprised of members from the Wisconsin DNR, Wisconsin Valley Improvement Company, USDA – Natural Resources Conservation Service, and the UW-Madison Marshfield Agricultural Research Station, Pheasants Forever, a private agronomist, Big Eau Pleine Citizens Organization (BEPCO), a biologist, and Conservation, Planning & Zoning Department staff, met four times via virtual meetings due to the COVID-19 pandemic to provide input and clarification of goals, strategies, objectives, and measurable outcomes on the following dates: March 25, 31, April 20 and 29, 2020. The LAC also met to review and provides comments of the draft plan in order to establish a final draft plan for public review and consideration. The ERC approved the draft LWRM Plan for public review at their Novermber 3, 2020 meeting.

### *Public Hearing*

The Public Hearing was held on December 1, 2020 and January 5, 2021, and a quorum of the ERC was present to receive the comments. See Appendix X for the public hearing notice. On January 5, 2021, the ERC approved the LWRM Plan for submission to the Wisconsin Land and Water Board (LWCB), and forwarded to Marathon County Board for its favorable consideration by resolution.

The Marathon County Board of Supervisors adopted the LWRM Plan on TBD.

The LWRM Plan was presented to the LWCB on Date, 2021, and DATCP submitted a letter formally adopting the LWRM Plan on DATE, 2021.

## Assessment of Water Quality, Soil Erosion, and Other Nonpoint Sources of Water Pollution

### *Surface Water Resources*

Marathon County is the largest county in the State of Wisconsin with an approximate total square mile area of 1,584 or 1,013,760 acres. The county's Land Information Office calculated the total square mile area of Marathon County. Marathon County is primarily located within the Central Wisconsin River Basin with the exception of a small southeastern portion, approximately 65,000 acres, being divided by the Subcontinental Divide, which flows into the Fox-Wolf River Watershed of the Great Lakes Basin. The County has 202 lakes with a total surface area of 28,322 acres. The Big Eau Pleine Reservoir is the largest body of water with a potential area of 6,830 acres when full. Other lakes in the county include Lake Wausau, Half Moon Lake, and Lake DuBay and are the result of dams along river systems. Most natural lakes tend to be small and vary in depths ranging from one foot to thirty-four feet.

The county has 356 rivers and streams with a surface area of 3,748 acres. The Wisconsin River flows south through the

county. Several dams on the mainstream and tributaries, which are controlled by the Wisconsin Valley Improvement Corporation (WVIC), regulate the river. Major tributaries flowing from the east to west include the Trappe, Eau Claire, Little Eau Claire and Plover Rivers. The major tributaries flowing from west to east are the Little Rib, Big Rib, Big Eau Pleine, and the Little Eau Pleine Rivers. The county contains all or part of 21 Hydrologic Unit Code (HUC) -10 watersheds.

The two most significant wetland areas of the county include the Mead (33,000 acres) and the McMillan (5,700 acres) Wildlife Areas. These wetlands are important for nesting waterfowl, spawning fishes, flood protection, filtration, and natural resource areas for flora and fauna. Many lakes, reservoirs, rivers, and wetlands in the county support recreational uses, aquatic life, and flood protection. Local officials should look to protect these water bodies whenever there is evidence that existing controls may not be adequate to protect the continued use of the resource for recreational use purposes.

The complex interaction of surface water and nonpoint source pollution is a result of activities that take place on the land surface and the water dynamics that occur as a result e.g., how water runs off the land surface or is absorbed into the ground. Consequently, all land use activities have the potential to contribute to nonpoint source pollution problems. In rural Marathon County, the 2019 Wisconsin River Total Maximum Daily Load report has identified agricultural runoff as the major source of runoff pollution and cause of surface water impairment. There is an emerging realization that unchecked storm water runoff, carrying debris, nutrients, E-coli, Chemical Biological Oxygen Demand (CBOD), substances, oils and toxic materials from impervious surfaces, are in some cases a major contributor or polluted runoff to critical water resources.

### *Development Impacts*

In 2019, population estimate for Marathon County is 136,517. Over the last decennial period, population changes or shifts occurred in Marathon County. Per the Wisconsin Department of Administration (WDOA) Demographic Services Center, Final 2018 Population Estimates, 48,140 or 35.41 percent of the people live in incorporated areas of the county. Since 1990, the population of Marathon County increased by 17.8 percent, from 115,400 to 135,922 in 2018. According to the Wisconsin Blue Book - 2017-2018, in 2016, Marathon County ranked 10th in terms of population with a population density of 87.7 people per square mile.

The WDOA projects the county population to increase from 134,063 to 152,790 between 2010 and 2040. The City of Wausau and its surrounding communities is the center of growth in terms of population and economic growth. These communities are located along 2 major transportation corridors along I-39/US-52 and STH-29 and contribute to the development pattern of the greater metropolitan area.

The communities along US-51 have grown toward each other and have become a contiguous metropolitan area. The City of Wausau has generally expanded to the west and east into the Towns of Stettin and Wausau, respectively. Rural and suburban areas on the fringe of the City of Wausau have experienced the effects of growth and development during the last decade with commercial, industrial, and residential growth. (2016 Marathon County Comprehensive Plan)

The combined population increase, and growth of residential, commercial, and industrial development including land use activities contribute to decreased water quality and increased stormwater runoff. The Cities of Marshfield, Mosinee, Schofield, and Wausau; Villages of Kronenwetter, Rothschild, Weston; Town of Rib Mountain; and Marathon County are all permitted Municipal Separate Storm Sewer System (MS4) communities and must comply with regulations to reduce stormwater pollution. Conversely, agricultural activities and changing trends negatively contribute to diminished water quality through the removal of buffering vegetation, increase in annual row crops, channelized ditches, increasing soil erosion, phosphorus and nutrient loading, and poor manure management.

### *Groundwater Resources*

Groundwater is the major source of drinking water for 17 municipal-owned and operated water treatment facilities for public water supply for domestic, and industrial use in Marathon County. Groundwater is also the primary source for private, domestic, industrial, and agricultural water supplies not served by municipal water. According to the Wisconsin Department of Natural

Resources (WDNR), drinking water data, wells constructed since 1987 for private homeowners, approximately 11,470 private water wells were constructed in Marathon County. The availability of groundwater varies across the county depending on the local geology. Areas along the Wisconsin and Rib Rivers provide ample water supply from alluvial aquifers; however, adequate groundwater is limited in parts of the county where dense bedrock is close to the surface.

The need for clean groundwater is both a health and economic issue. Groundwater quality and quantity, in both rural and urban areas varies from location to location. Where groundwater becomes polluted, property values drop and a natural resource is diminished from its full potential. For this reason, local land use activities can significantly influence groundwater quality and quantity in terms of whether a valuable resource is protected and how all key-stakeholders have an important role in its protection.

### Agricultural Trends

Agriculture in Marathon County, like the rest of Wisconsin, has experienced significant changes over the past 30 years. There are numerous reasons for these shifts in agricultural activities and practices including changes in economics, population growth, societal changes, operational practices, support services, and state and national policies. From 1987-2017 there has been a 19% decrease in acres of land in farms and a 27% decrease in the number of farm operations. Similar to most other farming areas in Wisconsin, farm operations have tended to become larger, with more acres per farm—an 11% increase. There has also been a decline in the number of dairy farms—a 68% decrease—and a subsequent decrease in traditional perennial dairy forage crops such as alfalfa and grass hay, with a shift to more annual cash grain crops like corn and soybeans with annual tillage.

Along with this shift in farm and crop rotations, there has been an increase in soil erosion and its negative impacts on soil health and water quality. The 2020 Soil Erosion Transect Survey conducted by Marathon County Conservation, Planning and Zoning (CPZ) indicates an increase in average county-wide cropland soil erosion from 1.6 tons/acre/year in 1999—the first year the survey was conducted—to 2.6 tons/acre/year in 2020, and a decrease in cropland fields meeting the Tolerable Soil Loss ("T" level) erosion rate from 86% in 1999 to 75% in 2020.

*Polluted spring runoff carrying soil and manure into local streams*

*Mud Lake Marathon County*

To address resource concerns such as soil health and water quality, this Land and Water Resource Management Plan will continue to rely upon proven farm conservation programs and practices such as the NR151 performance standards and prohibitions, nutrient management, soil health prinicples and managed grazing. This Plan will place greater emphasis on new and innovative engagement and adoption strategies to greatly increase the use of additional best management practices on not only on cropland but also adjacent to shorelands, stormwater, and any major land disturbance activity that can contribute to sediment and nutrient loadings into the water in order to align efforts to meet applicable Total Maximum Daily Load (TMDL) report and help meet water quality standards.

## SUMMARY OF WORK PLAN

The following LWRM Plan goals, objectives, strategies, and measurable outcomes reflect a 10-year time period. They were developed by the LAC, with input, review and clarification by the TAC, both through a facilitated planning process include the following:

### Plan Goals

The goals and supplemental details are also presented in an infographic and text format for a more user-friendly presentation for both readers and implementers of this document.

- **Goal 1:** Land resources are improved and protected county-wide.
- **Goal 2:** Surface water quality is improved and protected.
- **Goal 3:** Groundwater quality and quantity is improved and protected.
- **Goal 4:** Actively educate and engage all community stakeholders to develop an understanding of land, surface water, and groundwater quality concerns.

### Water Quality Objectives in Consultation with the Department of Natural Resources

Coordination with the Wisconsin DNR is paramount to implement water quality objectives as outlined in the LWRM Plan and the Wisconsin River and Fox-Wolf River Total Maximum Daily Load (TMDL) reports for total phosphorus. TMDL is one important tool required by the Clean Water Act (CWA) and employed by Wisconsin DNR to quantitatively assess a stream's water quality and allocate allowable pollutant loads among sources along the stream. TMDLs must be developed for water bodies impaired by point sources and/or nonpoint sources.

Section 303(d) of the Clean Water Act and Title 40 of the Code of Federal Regulations, Part 130 require states to develop TMDLs for waters not meeting quality standards for its designated uses under technology-based controls for pollution. A TMDL helps determine how much pollution a water-body can assimilate and still meet water quality standards. The TMDL process quantitatively assesses a water bodies condition causes of impairment and reductions from both point and nonpoint sources, needed to restore and protect the quality of impaired water resources. The U.S. Environmental Protection Agency Region 5 approved the Wisconsin River Basin TMDL on April 26, 2019, and the Upper Fox and Wolf Basin TMDL on February 27, 2020. This LWRM Plan will support the Wisconsin River Basin and Fox-Wolf River Basin TMDL reports.

### Agricultural Performance Standards and Prohibitions

Since the passing of legislation in 2002, Marathon County conservation programming is committed to develop programs and plans, provide financial and technical assistance to landowners, and regulatory ordinances to successfully implement Wisconsin's NR151 agricultural performance standards and prohibitions (APSP) , where required. APSP's will continue to be achieved through a mix of voluntary and regulatory approaches identified in the LWRM Plan to increase the land in Marathon County achieving compliance with these requirements.

Under the leadership of the Environmental Resources Committee, the implementation of the APSP is a primary focus of the conservation staff in terms of compliance monitoring and enforcement of the Waste Management Ordinance, Livestock Siting Facility Ordinance, and the Farmland Preservation Program. Achieving compliance with the APSP will aslo be a primary startegy used by conservation staff for implementing TMDL pollutant reduction goals.

### Marathon County LWRM Plan Accomplishments – 2010-2020

Timeline of significant accomplishments that supported implementation of the 2010 LWRM Plan goals:

- **2010** – Led Wisconsin Conservation Observance Day in Marathon County, with over 200 in attendance, for Wisconsin Land and Water Conservation Association "Conservation Farmers of the Year".
- **2011(a)** – Initiated Eastern Marathon County Lakes Project with engaged Lake Associations, shoreland property owners, and sporting groups.
- **2011(b)** – Completed Big Eau Pleine Watershed and Reservoir Strategic Plan and began implementation efforts, including completion of new aeration system for the Reservoir.
- **2012** – Awarded $400,000 US EPA Brownfields Assessment Grant for River District remediation in Wausau.
- **2013(a)** – Joined Heart of America's Dairyland and Antigo Flats Agricultural Enterprise Areas-140,343 acres included and eligible for Farmland Preservation Program participation.
- **2013(b)** – Engaged community to update 1982 Farmland Preservation Plan-adopted by County Board.
- **2014(a)** – Adopted new Farmland Preservation Zoning District protecting 111,434 acres from conversion to other uses.
- **2014(b)** – Completed 28,000 acres of grazing plans on 389 farms since 1998 as part of Managed Grazing Program.
- **2015(a)** – Completed and adopted all eleven Eastern Marathon County Lakes lake management plans utilizing technical assistance and grants acquired by CPZ staff.
- **2015(b)** – Completed closure of 150th idle or failing waste storage facility as part of Safe Water Project.
- **2016(a)** – Initiated Fenwood Creek "Pilot" Watershed Project securing nearly $1,000,000 in grant funds.
- **2016(b)** – Completed certification of 265 farms meeting Agricultural Performance Standards and Prohibitions, insuring conservation performance in place and eligibility for Farmland Preservation Tax Credits for landowners.
- **2016(c)** – Ranked number one (and continuing through 2020) in total DATCP funding to county conservation departments for land and water conservation programming-up from number 16 in 2004.
- **2017(a)** – Provided the catalyst, vision and secured initial funding for the Eau Pleine Partnership for Integrated Conservation (EPPIC), Wisconsin largest community-led watershed partnership.
- **2017(b)** – Completed "Strategies for Reducing Fish Kills in the Big Eau Pleine Reservoir" strategic plan in partnership with Big Eau Pleine Citizens Organization.
- **2018(a)** – Completed Lake Wausau management plan.
- **2018(b)** – Developed metallic mining regulations to protect environment, especially the water resources, of the county.
- **2019(a)** – Completed Mission Lake and Lake Dubay lake restoration and demonstration projects.
- **2019(b)** – Educated and qualified/requalified over 105 different Marathon County farmers to develop their own Nutrient Management Plan through Wisconsin's largest multi-county Nutrient Management Farmer Education training program, over the last decade.
- **2020 -** Completed and closed out the last of 21 Environmetal Impact Fund projects.

### Water Quality and Habitat Monitoring

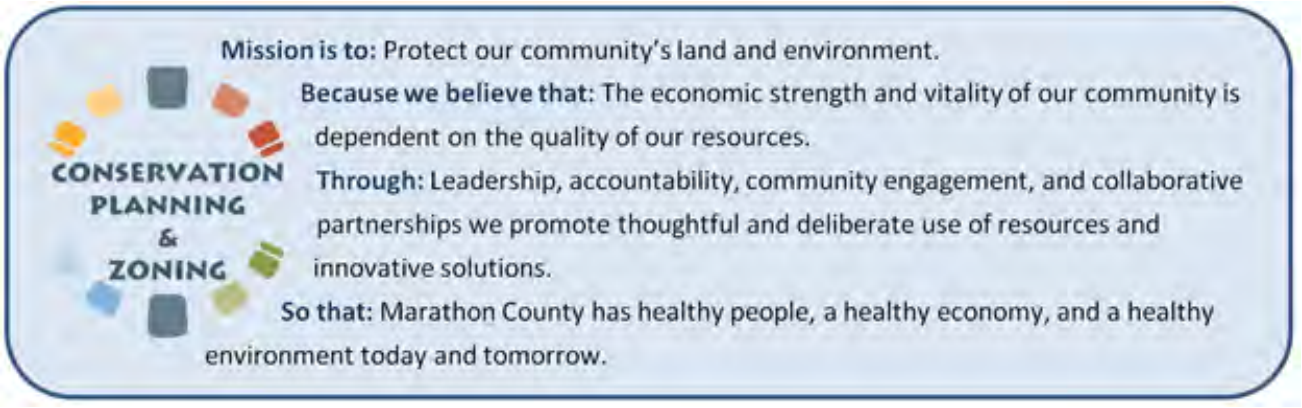
Water quality and habitat monitoring within selected watersheds are critical to assess, and recommend measures to improve agricultural practices, minimize nonpoint pollution, habitat destruction and soil loss. Continued analysis of impaired water resources can help prioritize and align conservation efforts to reduce phosphorus levels to target levels identified in the Wisconsin River and Upper-Fox Wolf River Basin TMDLs.

Various state, local government, private companies, and non-profit entities are key stakeholders in terms of collecting water quality and habitat data over the next decennial period. The Wisconsin Valley Improvement Company will continue to monitor water quality parameters in the Wisconsin River Basin, Eau Pleine Reservoir and Fenwood Creek Watershed to assess the water quality in relation to private, public water use along with outdoor and recreational uses that are being impaired by exceedances of phosphorus. Other lake groups and organizations will continue to promote sound land use and nonpoint source best management practices to protect their respective lakes. DNR Water Quality Biologists have been, and will continue to be, relied upon for technical assistance for completing water quality monitoring and measuring progress towards meeting TMDL reductions goals in specific watersheds in Marathon County.

### Plan Evaluation

*Progress Tracking*

The 2020-2030 LWRM Plan moves beyond identifying goals, objectives, strategies, and measurable outcomes as identified by the local advisory committee. The operational component will be measured each year to assess progress toward each overarching goal of protecting the land and water resources. Annual work plan activities of the Land and Water Program will be reflective of progress in terms of meeting identified goals, objectives, strategies, and measurable outcomes of the LWRM Plan, but also align with the 2016 Marathon County Comprehensive Plan, and the approved Wisconsin River and Fox-Wolf River Basin TMDL Reports.



Wisconsin Chapter 92.10 and ATCP 50.12 provide guidance for counties to develop a land and water resource management plan. This plan revises and supersedes all previously approved plans and reflects an overall effort to strengthen conservation programs, available grant funding, and other resources to effectively address the land and water resource management issues facing Marathon County, with intended outcome of improving and protecting the land and water resources which the county's citizens, farmers, landowners, businesses and industries are dependent upon for their livelihood.

Marathon County's LWRM Plan is intended to complement and coordinate with existing plans, specifically the County's Comprehensive and Strategic Plans to ensure the county is proactive in enhancing health, safety, and prosperity by protecting the environment, and providing recreational and economic opportunities which make Marathon County a preferred place to live, work, visit, and do business.

The goals, objectives, strategies and measurable outcomes outlined in this plan will serve to guide and align CPZ's Land and Water Program initiatives through the year 2030. The outcomes of these measures help to further define success with respect to allocating various local, state and federal resources to further initiatives identified in annual work plans required of this plan.

### Plan Development Process

With oversight provided by the Marathon County Environmental Resource Committee (ERC), the LWRM Plan is a product of the collaborative efforts of Conservation and Planning staff, and the LAC comprised of key individuals representing the stakeholders in soil health, lake and reservoir management, wildlife and diverse farming operations.

Marathon County Conservation staff provided pertinent input and assisted with the development of specific target areas, overall review, and authored elements of this plan. Seven meetings were held by the LAC to review and consider staff recommendations to determine and advance identified final overarching goals, objectives, strategies, outcomes, and the implementation strategy for the plan. The LAC also met to review, and provides comments of the draft plan in order establish a final draft plan for public review and consideration.

Local Advisory Committee meeting dates:

- August 21, 2019
- October 30,2019
- January 7, 2020
- January 28, 2020
- February 11, 2020
- February 25, 2020
- March 31, 2020

A Technical Advisory Committee (TAC) comprised of members from the Wisconsin Department of Natural Resources (DNR), Wisconsin Valley Improvement Company, United States Department of Agriculture (USDA) – Natural Resources Conservation Service, the University of Wisconsin – Marshfield Agricultural Research Station (MARS), wildlife groups, lake groups, and an agronomist met five times via virtual meetings due to the COVID-19 pandemic to review goals, strategies, objectives, and measurable outcomes on the following dates: March 25, 31, and April 20, 29, and finally on May 6, 2020. In addition, Conservation and Planning Staff had bi-weekly LWRM plan meetings beginning January 22, 2019. The staff provided detailed input and recommendations to both committees to have a plan that is clear to the committees and Marathon County. The 2020 LWRM Plan incorporates the most recent available data and maps from CPZ, DNR, Department of Agriculture, Trade and Consumer Protection (DATCP), Department of Administration (DOA), Environmental Protection Agency (EPA),

Natural Resources Conservation Service (NRCS), U.S. Census Bureau, and Geographic Information System data sources and updates resource information used in the 2010 where possible.

## PLAN REQUIREMENTS

The Marathon County LWRM Plan was developed to meet the requirements of the county Land and Water Management Planning Program. ATCP 50.12 codifies specific standards for the approval of the LWRM Plan and was verified against the ARM-LWR-167 LWRM Plan Review Checklist, Wis. Stats. § 92.10 & Adm. Code § ATCP 50.12 (August, 2017).

The LAC's recommendations were presented to the Marathon County Environmental Resource Committee on June 2 and June 30, 2020 for the Committee's favorable consideration. The Environmental Resource Committee will hold a public hearing January 5, 2021. The ERC noticed and conducted a public hearing to solicit broad public input and recommendations. The notice of public hearing, and minutes can be found in Appendix X. The LWRM Plan was approved by County Board on XX, 2021.

## PERFORMANCE STANDARDS & PROHIBITIONS

In NR151, the DNR established agricultural and non-agricultural performance standards and prohibitions to reduce runoff and protect water quality. In ATCP 50, the DATCP identified conservation practices that farmers must follow to meet the DNR standards. These standards require counties to consult with DNR and identify how they will assist landowners to achieve compliance with performance standards and prohibitions.

As a condition of the Marathon County's land and water program and state law, the CPZ staff must notify landowners and land users if APSP determinations are made. Landowners may receive individual determinations involving conditions on their property through a) conservation plans, b) compliance status reports, and c) compliance status letters authorized under the NR151 implementation strategy, and notices issued under NR151.09 or NR151.095. DNR staff may be consulted with before or after CPZ staff make NR151 compliance determinations.

Marathon County is devoted to develop programs and plans to successfully implement Wisconsin's agricultural performance standards and prohibitions(APSP). The blend of program coordination and plans add accountability and organization to the nonpoint program efforts. The agricultural nonpoint program relies upon the leadership of the ERC and the Conservation, Planning and Zoning Department staff to implement the standards consistent with State Statute 92.10(6)(a)5 and ATCP 50.12(2)(i) Wis. Adm. Code.

Since the adoption of NR 151, local conservation programming has been tied directly to providing technical and financial assistance to landowners required or wanting to comply with state APSP. APSP are measurable goals to be achieved by farm operators for specific production practices. Technical standards ensure that practices installed

*emerging seeding from no-till cropland planting*

*managed grazing*

on the land meet uniform design requirements to accomplish stated objectives and are outlined by ATCP 50.

The implementation of the APSP are a primary focus of the administration, compliance monitoring and enforcement of the Animal Waste Management Ordinance, Livestock Siting Facility Ordinance, and Farmland Preservation Program. These programs provide direct compliance and local enforcement of specific performance standards. Additionally, the Managed Grazing program and educational activities provide extensive outreach and application opportunities for landowners to apply best management practices to meet performance standards.

## RELATED PLANS

### Marathon County Groundwater Protection Guide – 2001

The Groundwater Protection Guide was first developed in 1988. In April 2001, the plan was updated to reflect the changing programs and policies within the county as well as to acknowledge the increased level of regulation by state agencies to protect the groundwater resources of Marathon County. The guide identifies sources of groundwater in the county as well as consumption trends for the various community users. Environmental protection programs and responsibilities for implementation are identified for all the various State and local departments and agencies. Along with conservation programming, the enforcement of performance standards, zoning, wellhead protection activities, and groundwater monitoring will be necessary to help protect the groundwater.

The residents and businesses of the county evaluate special considerations that recognize that groundwater is a primary source of all water consumption. As residential sprawl continues into the rural areas of the county and the scale of agricultural activities increasingly threatens the groundwater, the conservation efforts to protect the resource will need to increase. The Groundwater Plan and Central Wisconsin Basin Plan together identify risk concerns relative to type of pollutant sources present in specific watersheds as well as the relative risk of groundwater sources to potential problems.

Strategy A, Outcome Measure 1, of the 2018-2022 Marathon County Strategic Plan, requires the Marathon County Board adopt a new groundwater protection plan by December 31, 2022.

### Marathon County Farmland Preservation Plan – 2014

The Marathon County Farmland Preservation Plan is required under Chapter 91 of the Wisconsin Statutes. The purpose of this plan is to guide and manage growth and development in a manner that will preserve the rural character; protect the agricultural base and natural resources; and contribute to the County's overall goal of promoting public safety, health and prosperity within the County. This plan is the primary policy document in directing preservation of agricultural production capacity, farmland preservation, soil and water protection, and future land development while respecting private property rights and individual units of government. The Marathon County Board adopted the Marathon County Farmland Preservation Plan on January 21, 2014.

**Vision Statement and Goals**

Marathon County agriculture will be diverse, sustainable, and profitable now and in the future. Through shared responsibility and stewardship of resources and community engagement/cooperation, we will enjoy a sufficient and sustainable supply of ground water, high quality water resources, and productive soil. Agriculture will be supported by adequate economic and structural infrastructure; access to technological advances in equipment, communication, and waste management; access to local, domestic, and international markets, ample land supply, and a balanced mix of land uses.

**Agriculture Goals**

General Goals

- Users of the land will be good stewards of the land
- Programs must fairly and equitably support a diverse and profitable agriculture
- Protect a sufficient and sustainable ground water quantity
- Protect and improve ground and surface water quality
- Support small farms and/or family farms
- Respect a balanced mixed land use
- Preserve the rural character and aesthetic quality of Marathon County
- Participation of all county communities to achieve the goals of the county's strategic plan
- Provide educational outreach on topics such as farmland preservation zoning and AEAs

Agricultural Preservation

- Minimize nonagricultural development on prime agricultural soils
- Maintain the integrity of agricultural economic clusters

Housing and Development

- Design and locate rural housing to minimize adverse impacts on agriculture
- Encourage higher-density residential development in non-farmland preservation areas
- Encourage nonagricultural industries to locate in areas where public utilities will be available

*Residential development on prime farmland soils*

Regional Food Distribution and Networks

- Support food distribution systems to access the local food initiatives of the community
- Provide education and technical support to small scale producers and direct marketers

*Policies Related to Farmland Preservation Plan Requirements*

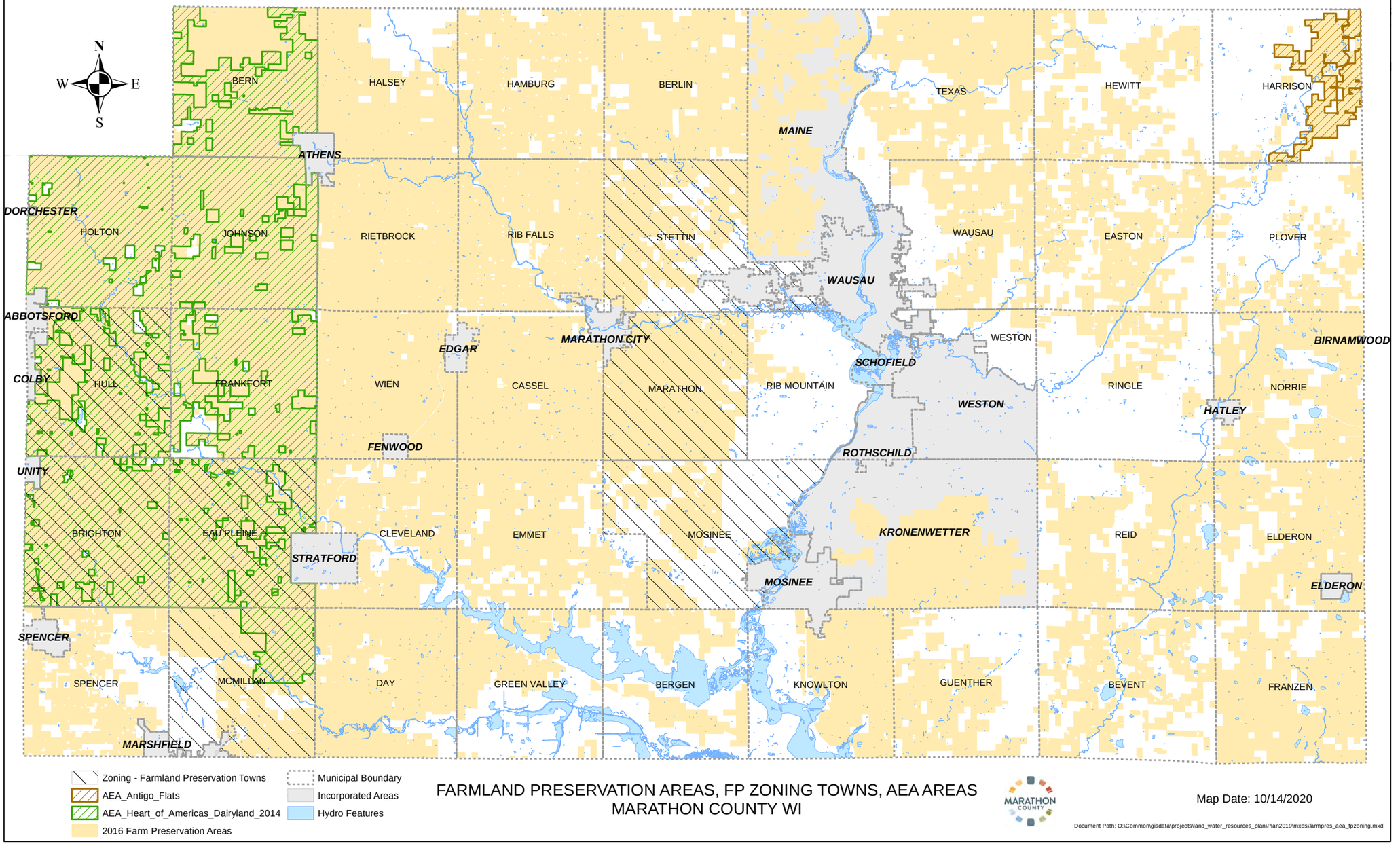
The farmland preservation plan is a significant policy for the Marathon County Board of Supervisors. It defines the importance of agriculture in the region relative to land use, culture, resource management, and economic contributions. As policy, the plan includes four components that Marathon County will initiate to preserve farmland and its contributions to the community. The four components include:

- Provision of services;
- Customization of services;
- Cost of services; and
- Prioritization of services.

In implementing the plan, the farmland preservation area will include eligible land for farmland preservation zoning and/or Agricultural Enterprise Areas (AEA). The county will continue to work with town officials, and landowner petitions to establish and delineate farmland preservation districts and AEAs.

Figure 1-1, illustrates the current towns participating in farmland preservation zoning: Brighton, Eau Pleine, Hull, Marathon, McMillan, Mosinee, and Stettin. There are also two AEAs in Marathon County: Antigo Flats in the Town of Harrison, and Heart of America's Dairyland in the Towns of Bern, Brighton, Eau Pleine, Frankfort, Holton, Hull, Johnson, and McMillan. As of August 2020, there are 111,464 acres in a farmland preservation zoning district, and 140,343 acres in the AEAs. The identified 2016 FP areas allow for the expansion of both FP zoning and AEA's.

FIGURE 1-1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MARATHON CITY
WESTON
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RIB MOUNTAIN
WESTON
RINGLE
NORRIE
HATLEY
FENWOOD
ROTHSCHILD
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EAU PLEINE
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Zoning - Farmland Preservation Towns
AEA_Antigo_Flats
AEA_Heart_of_Americas_Dairyland_2014
2016 Farm Preservation Areas
Municipal Boundary
Incorporated Areas
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### Fenwood Creek Watershed Management Plan – 2016-2026

The Fenwood Creek watershed is representative of the larger Big Eau Pleine (BEP) River watershed relative to resource concerns and is impacted primarily by nonpoint agricultural runoff. The Fenwood Creek watershed drains approximately 39 square miles (24,958 acres) of land into the BEP reservoir. All studies, research, and monitoring efforts point to two primary causes of water quality degradation: soil erosion and nutrient runoff, mainly phosphorus, from agriculture.

In 2014, -Marathon County initiated a pilot project for the Fenwood Creek watershed, which is a representative Hydrologic Unit Code (HUC) 12, dairy-based watershed within the BEP River watershed. The project involved working with DNR to develop a watershed-based plan consistent with the USEPA 9 key elements. This plan was completed and approved by DNR and USEPA in 2015 and has since secured DNR funds for implementation. Implementation of the pilot project started in 2016 and will end in 2026. Marathon County will document plan implementation over the 10-year project implementation schedule for the purpose of the 9 Key Element Plan. Initial and Intermediate outcomes for the Fenwood Creek project will focus upon grant funded and required APSP activities. Long-term outcomes will ultimately be determined through the Wisconsin River Total Maximum Daily Load (TMDL) plan. Ultimately, the Fenwood Creek watershed-based will help determine whether CPZ's nonpoint strategies to address impaired waters are effective and, if so, transferable to other impaired watersheds within the county. If not, CPZ needs to re-assess and evaluate non-point strategies until they are successful in the Fenwood Creek Watershed before expending additional resources in new watersheds.

### Marathon County Comprehensive Plan – 2016

The Marathon County Board of Supervisors adopted the Comprehensive Plan in February 16, 2016. The Marathon County Comprehensive Plan will help guide County decision makers on a wide array of issues over the next twenty years in creating a preferred place to live, work, visit, and do business. The Marathon County Comprehensive Plan is a policy plan. The overall goal of the Comprehensive Plan is to add a county-level perspective and planning direction that complements and strengthens local planning efforts. The planning effort established six sub regions which contain similar land use, natural resources, terrain, population, and housing. Figure 1-2, is from Marathon County's 2016 Comprehensive Plan and provides a brief description of each sub region and include the following areas: Antigo Flats, Heart of America, Wisconsin River Influence, Wisconsin Central, Lumberjack, and Eastern Lakes regions. It will also provide guidance to the 41 towns, 15 villages and 6 cities within the County, along with community partners. All these communities, working together, make Marathon County a special place.

This plan moves in a new direction, while still addressing the requirements outlined in Wisconsin Statutes 66.1001, to the extent applicable. That law requires that at minimum these elements or issues be discussed: Issues & Opportunities, Natural, Agricultural & Cultural Resources, Housing, Transportation, Utilities & Community Facilities, Economic Development, Land Use, Intergovernmental Cooperation, and Implementation. New topics and chapters added to this plan cover Health and Human Services, Water Resources, and Community Character.

### Marathon County Strategic Plan – 2018-2022

The Marathon County 2018–2022 Strategic Plan identifies 12 specific objectives from the Marathon County 2016 Comprehensive Plan, clarifying which broad objectives are most important over the next 5 years and linking our Comprehensive Plan to our annual budget and work plans. The Strategic Plan embodies the vital partnership that exists between elected County Board Supervisors, who are entrusted with setting policy, and county staff, who are charged with carrying out operations in support of that policy.

The policy set by the 2018–2022 Strategic Plan is in the form of the selection of the 12 priority objectives drawn from the Comprehensive Plan. As part of its prioritization process, the County Board of Supervisors sought input from community leaders throughout Marathon County, conducted a survey of County Board of Supervisors, and held a retreat to discuss the issues confronting us today and those we anticipate in the coming 5 years. The result of the County Board's deliberative process is the list of 12 priority objectives set forth in this Strategic Plan.

The operational components of the plan exist in the form of the strategies identified as necessary action steps in pursuit of each

## Six Regions Terrain

**Antigo Flats**
The Antigo Flats region includes the towns of Harrison and Plover. The area is characterized by large tracts of publicly owned land and outdoor recreation areas (Bitzke Bird Walk, Dells of the Eau Claire, Ice Age Trail, and Plover River state fishery). Private lands are mixed agriculture and forest lands with scattered large lot residential development.

The agriculture industry in the Antigo Flats region is primarily seed potato and vegetable crops.

**Heart of America**
The Heart of America region is named after the Heart of America's Dairyland Agricultural Enterprise Area in eastern Clark and western Marathon counties. The region includes the towns of Bern, Halsey, Hamburg, Berlin, Holton, Johnson, Rietbrock, Rib Falls, Hull, Frankfort, Wien, Cassel, Marathon, Brighton, Eau Pleine, Emmet, Spencer, McMillan, and Day; the villages of Dorchester, Unity, Spencer, Stratford, Fenwood, Edgar, Marathon City, and Athens; and the cities of Marshfield, Abbotsford, and Colby. Pre-settlement, the area was dominated by wetlands, which were drained to make way for agriculture. The region is characterized by a flat to gently rolling landscape, with large tracts of contiguous farmland, and forest in the wetter areas and along streams.

**Wisconsin River Influence**
The Wisconsin River influence region includes the Big Eau Pleine Reservoir, Lake DuBay, Wisconsin River, Mead Wildlife Area, and the surrounding area in the towns of Cleveland, Green Valley, Bergen, and Knowlton. The region is characterized by a surface water features, forest, and farmland.

**Wisconsin Central**
Wisconsin Central region includes the cities of Wausau, Schofield, and Mosinee; the villages of Rothschild and Kronenwetter; and the towns of Stettin, Rib Mountain, Mosinee, and Guenther. The area is the urban center of the county and serves as the employment, higher education, goods and services provider, and social recreation center of the county. Agricultural lands in the Wisconsin Central region are historically under the most non-agricultural development pressure in the county due to the availability of urban amenities. With the downturn in the economy and resulting decreased housing construction, this development pressure has lessened in recent years. However, it is anticipated to return to pre-recession levels in the future.

The agriculture industry in the Wisconsin Central region includes greenhouses, grain, ginseng, dairy, and agribusinesses that provide agricultural services and products. Wisconsin Central serves as a regional marketplace for producers to sell goods at farmers markets and local businesses.

**Lumberjack**
The Lumberjack region includes the towns of Maine, Texas, Hewitt, Easton, Wausau, Weston, Ringle, and the village of Weston. The area is characterized by large tracts of forested lands with scattered smaller agricultural tracts, mixed with large lot residential development.

The agriculture industry in the Lumberjack region is smaller scale grain, beef, and "lifestyle farms". Lifestyle farming is characterized by family operations of small agri-tourism and activity farming such as corn mazes, pumpkin patches, and hayrides, etc.

**Eastern Lakes**
The Eastern Lakes region includes the towns of Norrie, Elderon, Franzen, Reid, and Bevent; and the village of Hatley. The area was glaciated, resulting in a forested landscape with many kettle lakes. The area is characterized by smaller tracts of forested and agricultural lands. Many residences are seasonal lake homes and hunting cabins. Residential development averages 1.8 acres, but lot size is highly variable due to the mix of larger residential area in agricultural areas, smaller residential area in the forested areas, and smallest residential area along lakeshores.

The Six Regions of Marathon County include many types of places.

*FIGURE 1-2*

priority objective and in the form of the outcome measures against which we will assess our progress. Our strategies are drawn from our elected officials and the many subject matter experts within each of our various county departments. The 2018–2022 Strategic Plan represents an evolutionary step forward in our planning efforts, moving beyond simply identifying goals and objectives, by incorporating specific outcome measures. These measures help to further define success with respect to our objectives and serve as targets toward which we can align our resources and benchmarks against which we can evaluate the effectiveness of our services.

### Total Maximum Daily Load for Total Phosphorus in the Wisconsin (2019) and Fox-Wolf River Basins (2020)

Section 303(d) of the Clean Water Act established the TMDL program. The TMDL program identifies and restores polluted rivers, lakes, streams, and other surface water bodies by detailing in a quantitative assessment the water quality problems and contributing sources of pollution. The TMDL determines how much a pollutant needs to be reduced to meet water quality standards, and provides the foundation for taking actions locally to restore a water body to fishable and swimmable standards.

TMDLs must be developed for water bodies impaired by point sources and/or nonpoint sources. The TMDL is one important tool required by the Clean Water Act and employed by Wisconsin DNR to quantitatively assess a stream's water quality and allocate allowable pollutant loads among sources along the stream and/or river. U.S. EPA approved the Fox-Wolf River TMDL on February 27, 2020 and the Wisconsin River TMDL on April 26, 2019. The plans provide specific pollutant allocation limits for all dischargers in the watershed to achieve statewide water quality goals.

### Marathon County Forest Comprehensive Land Use Plan 2006 – 2020

This plan includes recommendations to guide management of forest land in Marathon County in accordance with the Parks, Recreation and Forestry Department's mission to manage and protect the county forest on a sustainable basis for ecological, economic, educational, recreational, and research needs of present and future generations. It provides substantial information on existing forest resources, as well as information regarding the roles of the various agencies and regulatory framework related to forest management.

In the development of the Marathon County Forest Comprehensive Plan, there was strong resident support for purchasing more land wherever available for protection, recreation, and timber. One of the major issues identified was woodland fragmentation. The County recognizes that subdividing and parceling off large tracts of land for home construction contributes to the problem of fragmentation. The Plan also suggests that the County should strategically purchase forestland and wetland parcels in order to maintain a countywide network of linked open space/forestland/wildlife corridors. In some areas, particularly the eastern half of the County adjacent to County owned forestland, it is still possible to purchase more land to create larger corridors.

In accordance with the Marathon County Strategic Plan 2018 – 2022, the Parks, Recreation, and Forestry Department will support Objective 5.2: Promote sound land use decisions that conserve and preserve natural resources in decisions with economic development and growth. Strategy F – indicates an approach to acquire land for Public Park and forest use to retain natural landscapes and resources. Outcome Measure 3 – indicates that the County acquires an average of 320 acres of land per year through 2022.

### Wausau Urban Area Sewer Service Plan 2040

The Marathon County Metropolitan Planning Commission adopted the Wausau Urban Area Sewer Service Plan in May 2018. This report is intended to update and replace the previous, 2025 Wausau Urban Area Sewer Service Plan for the City of Wausau and surrounding urban area. These types of plans are also known as area-wide water quality management plans.

The general purpose of this area-wide water quality management plan, herein referred to as Sewer Service Area Plan, is to maintain a twenty-year sanitary sewer service boundary for the Wausau Urban Area and an institutional structure for implementing the Plan and managing the extension of sanitary sewage services within this urban area.

The urban sanitary sewer service area boundary identifies the geographic land area within which sanitary sewer service could be made available by the year 2040 in a cost-effective, environmentally acceptable manner.

In addition to delineating an urban sewer service boundary, the Sewer Service Area Plan provides a framework for future planning at each individual municipal level. The data, trends, projections and findings developed in this Plan are consistent with detailed community plans for the Cities of Mosinee, Schofield & Wausau, the Villages of Brokaw, Kronenwetter, Maine, Rothschild & Weston, and the Town of Rib Mountain. The goals and policies developed throughout this planning process will also be applicable and useful in the development of local policy direction with respect to land use decisions within these communities.

Thus, the Sewer Service Area Plan will serve the following overall purposes:

- It establishes the geographic boundaries for possible sanitary sewer service to the year 2040;
- It provides a technical basis to anticipate future needs for wastewater collection and centralized treatment facilities for the planning area;
- It establishes an institutional structure for reviewing boundary and plan amendments and for approving sewer extensions and expansions of sewage treatment plants;
- It serves as a guide for community officials as they make land development decisions within their respective communities;
- It identifies areas to be protected from development by designating them as environmentally sensitive areas. Such areas will control and direct the growth of communities in order to protect environmental, social, and economic concerns; and
- The Plan will become a component of the Central Wisconsin River Basin Integrated Management Plan.

### Central Wisconsin River Basin Plan - 2010

The Central Wisconsin River Basin Plan was updated in 2010. Findings from the Basin Plan were used to assure that the LWRM Plan addresses those impacted waters and targeted activities of the county with the greatest need. The Basin Plan identifies:

- Impacted Watersheds,
- Exceptional waters and outstanding waters,
- 303(d) waters, and
- Significant sources of pollutants or activities impacting the waters.

The Conservation, Planning and Zoning Department will continue to coordinate initiatives with appropriate agencies to address the following basin priorities:

- Develop monitoring programs with citizens and professionals to evaluate and track the quality of surface and groundwater resources within the county. Special consideration for monitoring shall target the Lower Big Rib River and the Big Eau

Pleine River Watersheds, as well as the Eastern Lakes Project.

- Encourage conservation measures for land use activities, water consumption and discharge activities to minimize resource impacts and to promote sustainable use.
- Evaluate impacts to water quality from non-metallic mining through permit compliance.
- Continue to monitor the sources and quantity of sediment delivery into the surface waters. Primary attention will be agricultural sediment sources of soil and manure.
- Promote the abandonment of unused wells on agricultural lands and agricultural transition areas.

*Big Eau Pleine Reservoir*

### Big Eau Pleine Reservoir Lake Management Plan - 2017

**Big Eau Pleine Citizens Organization's mission is:** The purpose of the Big Eau Pleine Citizens Organization is to preserve, protect, and improve the quality of the Big Eau Pleine Reservoir. Land and water management programs address the water quality of the Big Eau Pleine Reservoir and its watershed area.

This plan is the result of a stakeholder-driven effort, which involved many partners combining insight, knowledge, and expertise throughout the process. More than 112 participants gathered at a series of community conversations, which provided opportunities to learn from one another and make suggestions about the fishery, water quality, habitat, and land management in the Big Eau Pleine watershed. The Big Eau Pleine Citizens Organization (BEPCO) hosted the meetings at venues throughout the watershed between February and July 2015. The Plan includes the following goals:

- Goal 1 - Sustain and Improve the Fishery of the BEP Reservoir,
- Goal 2 - Improve Water Quality in the BEP Reservoir and Watershed, and
- Goal 3 - Develop, Engage & Sustain Partnerships Necessary to Implement the Plan for Reducing Fish Kills in the BEP.

### Marathon County Aquatic Invasive Species Plan (AIS) – A guide for Proactive AIS Management – 2018

In 2010, Marathon County CPZ collaborated with Golden Sands Resource Conservation & Development Council, Inc. (RC&D) to acquire grant funding from the DNR to support a Regional AIS program. Through the AIS Program, information was gathered about the status of AIS infestations in Marathon County, volunteer activity levels, training and education needs, and other information regarding AIS in Marathon County. The purpose of the AIS plan is to identify short-term and long-term goals toward establishing a coordinated, county-wide approach to protecting Marathon County's lakes.

The AIS Plan was revised in 2018, and contains the following recommended actions:

- County-wide promotion of native vegetation,

- Implement and enforce shoreland regulations,
- Provide technical assistance to shoreland owners for native shoreland buffers and invasive species removal,
- Apply for grants to fund lake protection projects,
- Review annually the funding for cost-sharing incentive programs,
- Continue to distribute informational packets to new lakeshore property owners, and
- Continue to promote native vegetation through: news articles, social media, educational handouts/resources, citizen organization newsletters, Lake District and Lake Association meetings, and press releases.

### Marathon County Eastern Lakes Project – 2013 through 2015

The Eastern Lakes Project is a partnership of citizens, eastern Marathon County communities, Marathon County government, and the University of Wisconsin Stevens Point. This project effort created lake studies, lake management plans, and final summary lake reports for Bass Lake, Big Bass Lake, Lilly Lake, Lost Lake, Mayflower Lake, Mission Lake, Mud Lake, Norrie Lake, Pike Lake, Rice Lake, and Wadley Lake.

The three common land and water goals for the Eastern Lakes Management Plans include the following:

**In-Lake Habitat and a Healthy Lake**

- Fish Community – fish species, abundance, size, important habitat and other needs
- Aquatic Plant Community – habitat, food, health, native species, and invasive species
- Critical Habitat – areas of special importance to the wildlife, fish, water quality, and aesthetics of the lake

**Landscapes and the Lake**

- Water Quality and Quantity – water chemistry, clarity, contaminants, lake levels
- Shorelands – habitat, erosion, contaminant filtering, water quality, vegetation, access
- Watershed Land Use – land use, management practices, conservation programs

**People and the Lake**

- Recreation – access, sharing the lake, informing lake users, rules
- Communication and Organization – maintaining connections for partnerships, implementation, community involvement
- Governance – protection of the lake, constitution, state, county, local municipalities

*Big Rib River, Marathon County*

## MARATHON COUNTY ORDINANCES

### Animal Waste Management Ordinance – Chapter 11.02

Marathon County adopted its first Manure Storage Ordinance in 1985. Several revisions have occurred included the action taken by The Marathon County Board of Supervisors adopted an Amended ordinance what is now referred to as the "Animal Waste Management Ordinance" in June of 2020. The purpose of this ordinance is to regulate the location, design, construction, installation, alteration, operation, maintenance, closure, use, and application of animal waste from all waste storage facilities covered by this ordinance so as to protect the health and safety of residents and transients; prevent the degradation of surface and groundwater thereby preventing the spread of disease and promoting the prosperity and general welfare of the citizens of Marathon County; and protect the groundwater and surface water resources of Marathon County. It is also intended to provide for the administration and enforcement of the ordinance and provide penalties for its violations.

Dairy cattle in Marathon County produce an estimated 2.6 million gallons of manure per day or nearly one billion gallons annually (the equivalent of 1500 Olympic size swimming pools). To assure that this organic matter and nutrient source is contained and managed with sound practices, a permit is required to construct, install, modify or close a facility. On-going operation storage facilities are also required to insure facilities are in sound condition and that the animal waste stored in them are applied at the correct time, amount, and location through required Nutrient Management Plans which are required for all landowners with waste storage facilities.

On average, the county issues 12 permits per year. Since the adoption of the 1985 ordinance, the department has issued over 400 permits to constructed waste storage facilities.

The closure of idle or abandoned waste storage facilities is regulated by this ordinance and in the period from 1999 to 2018, the number of county dairy herds decreased by approximately 580. For example, in 1999 Marathon County had 63,000 cows with 1100 active dairy farms while in 2018, the total cows dropped to 61,000 with 520 active dairy farms.

*concrete lined waste storage facility*

In 2006, Marathon County initiated a targeted inventory and project to focus technical and financial resources toward the closure of abandoned waste storage facilities. Currently, Marathon County has enforced and assisted in the closure of approximately 160 idled facilities with financial assistance received from Soil and Water Resource Management and Targeted Runoff Management grants from DATCP and DNR, respectively.

The most recent ordinance revision (June, 2020) incorporated most of the APSP of the State. This gives CPZ more tools to address the most critical sources of runoff pollution to surface and ground waters, thereby safeguarding land and water resources.

### Livestock Facilities Licensing Ordinance – Chapter 13

Marathon County adopted its first Livestock Facilities Licensing Ordinance, Chapter 13 of the General Code of Ordinances in October of 2006. The County Board of Supervisors adopted an amendment to Chapter 13 in September of 2019. The purpose of this ordinance is to comply with requirements of Section 93.90 of Wis. Statutes and Ch. ATCP 51, Wis. Adm. Code (ATCP51), and to establish standards and authority to protect the public health, environmental resources, and safety of the people of Marathon County. This ordinance sets forth the procedures for obtaining a license for the siting of new and expanded livestock facilities in Marathon County. It is also intended to provide for the administration and enforcement of the ordinance and provide penalties for its violations.

A license issued by the Department is required for new or expanded livestock facilities that has or will have 500 or more animal units. A livestock facility shall remain licensed under this ordinance until such time as the facility is designated as a Concentrated Animal Feeding Operation (CAFO) by the Wisconsin Department of Natural Resources (DNR), issued a Wisconsin Pollutant Discharge Elimination System (WPDES) permit by the DNR, and provides documentation to the county of its WPDES permit.

Since October of 2006, the County has reviewed, approved and issued 17 Livestock Facility Licensing Permits. Three new applications have been initiated. Currently, 12 farms in the county have a DNR issed WPDES Concentrated Animal Feeding Operation (CAFO) permit in 2019 with another one pending approval. Marathon County may have as many as 15 farms under (CAFO) permit in the next five years.

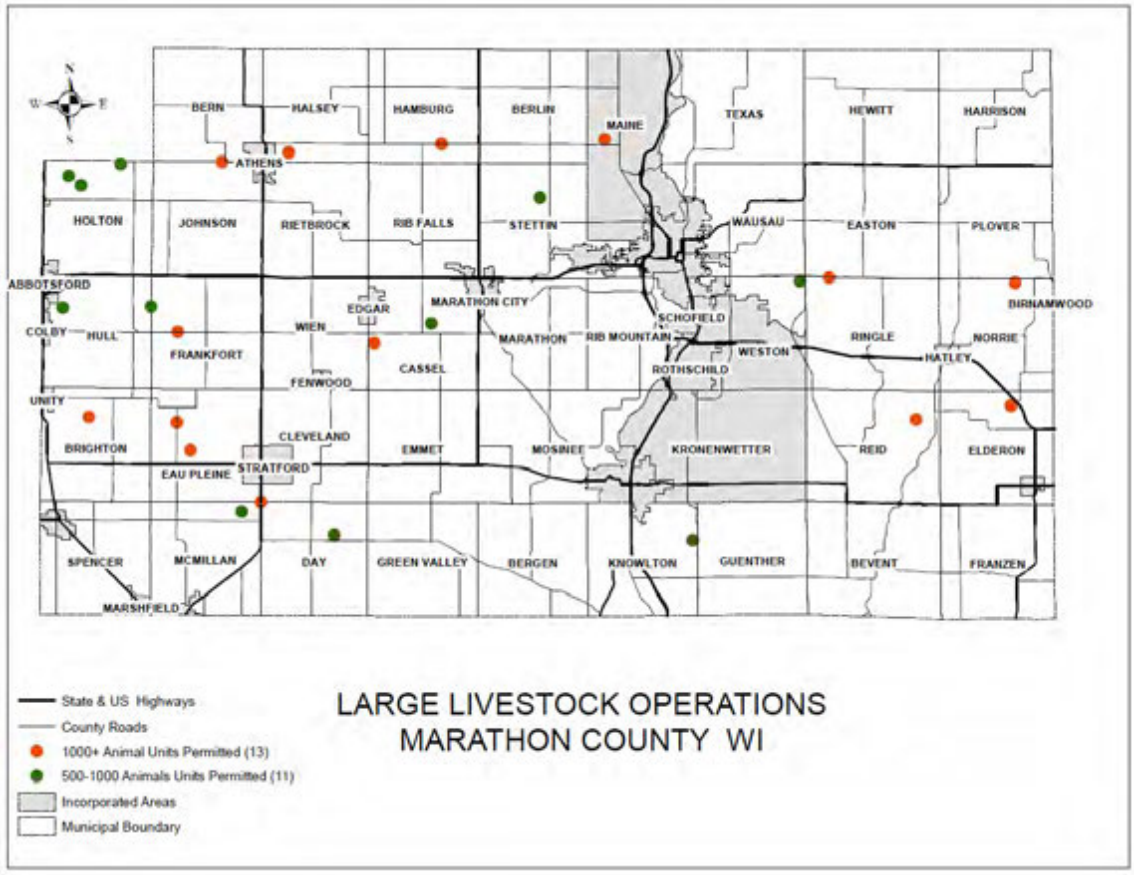



*Figure 1-3 Source: CPZ GIS data records*

The County may be involved in the review of facility and operational permits for an additional 30 farms that are between 500-1000 animal units.

An assessment on the effectiveness of this ordinance will be completed to determine if it is the most effective way to regulate medium sized livestock farms. DNR staff may be consulted with as part of completing this assessment.

### Private Sewage System Ordinance - Chapter 15

In February 2019, the Marathon County Board of Supervisors approved a general text amendment to the county's Private Sewage Systems – Chapter 15. This ordinance is adopted to promote and protect public health and safety by assuring the proper siting, design, installation, inspection and management of private on-site wastewater treatment systems and non-plumbing sanitation systems, and to assure the timely repair or replacement of failing private sewage systems.

The code requires CPZ to ensure the replacement of failing POWTS. In 2018, it resulted in the replacement of 29 systems. Over the next six years, it is anticipated that approximately 7000 systems will be inspected to ensure there is not a surface discharge or a failing tank across the county. Of those systems approximately 1000 systems will need to be replaced. These systems, constructed prior to 1980, will be added to the maintenance program which requires regular inspection and if necessary pumping of the septic tank to keep them performing as designed.

Marathon County established a low interest loan program in 2019 for low-income residents and some small businesses to help cover part of the cost to replace their system. MCDEVCO is partnering with the county to administer the loan with assistance from CPZ. Available starting in 2020, the loan can be payable at the time of sale of the property. Nearly one million dollars is now available for this loan program with funding coming from the Environmental Impact Fund. The loan program is replacing the Wisconsin Grant fund program, which served a similar purpose since 1980.

In addition, the amendment aligns with the Marathon County Strategic Plan Objective 6.3 - To protect and enhance the quantity and quality of potable groundwater and potable surface water supplies, and Outcome measure 2: By December 31, 2022, the number of Private Onsite Wastewater Treatment Systems (POWTS) discharging to the ground surface will be reduced by 750 systems or more.

### Zoning Code - Chapter 17

In February 2016, the Marathon County Board of Supervisors approved a comprehensive revision of the General Code of Ordinances for Marathon County Chapter 17 – Zoning Code. Chapter 17 is updated on an annual basis as required to address and improve regulation of zoning issues on a county-wide basis. In April, 2018, the Marathon County Board of Supervisors approved the Metallic Mining Amendment to be incorporated into Chapter 17 in response to 2017 WI ACT 134, which removed barriers to the initiation of nonferrous metallic mining in the State of Wisconsin.

In March 2019, the Board of Supervisors approved the latest revision of the Zoning Code. The purpose of the zoning code is to: promote the public health, safety, comfort, and general welfare of the residents of Marathon County; to establish and maintain zoning districts in order to protect the property rights of all individuals by assuring the compatibility and efficient relationships of uses and practices within districts; to preserve and protect natural resource areas, flood plains, stream corridors; and preserve the character and quality of agricultural areas from adverse impacts of land development.

### Land Division and Surveying Regulations - Chapter 18

In December 2019, the Marathon County Board of Supervisors adopted Chapter 18 – Land Division and Surveying Regulations. Chapter 18 regulations are adopted under the authority granted by Wis. Stats. 59.02, 82.27(6), 281.31, Chapter 236 and Chapter 703 of the Wisconsin Statutes. The provisions of this Chapter apply to all unincorporated lands within Marathon County. Where a duly adopted town subdivision ordinance is more restrictive than this chapter, the town's greater restrictions shall apply.

The purpose of Chapter 18 is to regulate the division of land, and to promote the public health, safety, and general welfare of the community. These regulations are intended to secure and provide for Marathon County the following objectives:

- The proper arrangement of streets or highways in relation to existing or proposed streets and highways for safe and convenient vehicular and pedestrian movement.
- Adequate and convenient open spaces for traffic, utilities, access for firefighting apparatus, recreation, light and air, and air, and the avoidance of congestion of the population.
- The orderly, efficient, and appropriate development of land.
- The orderly and efficient provision of community facilities at minimum cost and maximum convenience.
- The promotion of public health, safety, comfort, convenience, prosperity, general welfare, and the protection of the environment.
- The accurate surveying of land, preparing and recording of plats.
- The equitable handling of all subdivision and condominium plats by providing uniform procedures and standards for observance by both the approving authority and subdivider as defined herein.

*Big Eau Pleine Resevoir*

### Nonmetallic Mining Reclamation Code - Chapter 21

Marathon County first adopted a Nonmetallic Mining Ordinance in 1989, and recently received approval by the County Board of Supervisors to amend the Nonmetallic Mining Reclamation Code – Chapter 21 in December 2018. Nonmetallic mining is recognized as an important industry, which contributes to the county's economic and social well-being. However, the long-term damage to the physical environment and tax base that can be caused by nonmetallic mining must be reduced. It is the purpose of Chapter 21 to establish regulations for nonmetallic mining site reclamation that will restore the site to a purposeful and acceptable landscape appearance and use.

According to CPZ's records, historically, over 278 nonmetallic excavation sites operated within the County of Marathon. As of 2019, 166 nonmetallic mining operations have been reclaimed within the county assuring environmental impacts are minimized and the site is returned to a reasonable land use.

Currently in 2019, 123 active mining sites are in operation under NR 135, 17 additional mining sites are under the jurisdiction of NR 340, and six active mining sites are split between NR 135 and NR 340. The Village of Marathon City has two active mining sites are under their jurisdiction or authority. These mining sites are administered through the partnership of DNR and county regulations to protect surface and groundwater resources.

### Shoreland, Shoreland-Wetlands & Floodplain Code - Chapter 22

The Marathon County Board of Supervisors adopted an amendment of the Shoreland, Shoreland-Wetland, and Floodplain Code in September 2018. These regulations are applicable in all unincorporated areas of the County. Wisconsin law mandates counties to adopt and administer a zoning ordinance that regulates land use in Shoreland, Shoreland-Wetland and Floodplain areas for the entire area of the county outside of villages and cities. The legislature of Wisconsin has delegated responsibility to the counties to further the maintenance of safe and healthful conditions; prevent and control water pollution; protect spawning grounds, fish and aquatic life; control building sites, placement of structures and land uses; and to preserve shore cover and natural beauty.

Areas regulated by this ordinance include lands within 1,000 feet of the ordinary high water mark of navigable lakes, ponds or flowages and areas within 300 feet of the ordinary high water mark of navigable rivers or stream or to the landward side of the floodplain, whichever distance is greater. When development is permitted in a wetland, the development should occur in a manner that minimizes adverse impacts upon the wetland.

Most of the development regulations are aimed at establishing buffers and minimizing runoff to protect water quality. While the County adopted and enforces shoreland regulations within Marathon County, the WDNR maintains oversight responsibilities to ensure compliance with State Statutes.

## RELATED STATE AND FEDERAL REGULATIONS

### Department of Agriculture, Trade and Consumer Protection (ATCP) 50: Wisconsin's Soil and Water Resource Management Rule

Per the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) website, "ATCP 50 is the administrative rule used by the DATCP to implement state and federal laws. It covers soil and water resource management grants to counties, county resource management planning, and conservation compliance for farmland preservation tax credits, local ordinances, nutrient management and other conservation practices. DATCP cooperates with the Wisconsin DNR, county land conservation committees and other agencies to administer conservation programs.

Effective February 1, 2018, ATCP 50 has been revised to incorporate the 2015 Natural Resources Conservation Service (NRCS) 590 Standard for nutrient management. Documents here and on our nutrient management pages reflect those changes."

### ATCP 51: Wisconsin's Livestock Facility Siting

DATCP is responsible for maintaining and revising the standards in ATCP 51 used by local governments in issuing permits. As part of this responsibility, DATCP must review siting standards in ATCP 51 every four years based on criteria set forth in 93.90 (2)(b). Wisconsin State Statute 93.90 – Livestock facility siting and expansion provides uniform regulation of livestock facilities statewide.

According to the livestock facility siting law, a county, town, city or village ("political subdivision") may not prohibit or disapprove a new or expanded livestock facility of any size unless one of the following applies:

- The site is located in a zoning district that is not an agricultural zoning district.
- The site is located in an agricultural zoning district where the livestock facility is prohibited. A prohibition, if any, must be clearly justified on the basis of public health or safety. The livestock facility siting law limits exclusionary zoning based solely on livestock facility size.
- The proposed livestock facility violates a valid local ordinance adopted under certain state laws related to shoreland zoning, floodplain zoning, and construction site erosion control or stormwater management.
- The proposed livestock facility violates a local building, electrical or plumbing code that is consistent with the state building, electrical or plumbing code for that type of facility.
- The proposed livestock facility will have 500 or more "animal units."

### Department of Natural Resources (DNR) NR 151: Runoff Management

Agricultural Runoff Management is described in subchapter II – APSP. These standards are intended to create good farming practices to reduce nonpoint source pollution runoff to protect water quality and include the following standards Under NR 151, either the CPZ or DNR may be required to make a "bona fide" offer of cost sharing when requiring farmers to meet these APSP:

- Sheet, rill and wind erosion.
- Tillage setback.
- Phosphorus index performance.
- Manure storage facilities.
- Process wastewater handling.
- Clean water diversion.
- Nutrient management.
- Cropland and livestock performance standards and prohibitions.

*clean spring runoff diverted around farmstead*

### NR 216: Construction Site Erosion

Construction site erosion and uncontrolled storm water runoff from land disturbing activities can have significant adverse impacts upon local water resources. Under subchapter III of NR 216, Wis. Adm. Code, a notice of intent shall be filed with the DNR by any landowner who disturbs one or more acres of land. This disturbance can create a point source discharge of storm water from the construction site to waters of the State and is therefore regulated by the DNR. Agriculture is exempt from this requirement for activities such as planting, growing, cultivating, and harvesting crops for human or livestock consumption and pasturing or yarding of livestock, as well as sod farms and tree nurseries.

Agriculture is not exempt from the requirement to submit a notice of intent for one or more acres of land disturbance for the construction of barns, manure storage facilities or barnyard runoff control systems. Furthermore, construction of an agricultural building or facility must follow an erosion and sediment control plan consistent with NR 216.46, Wis. Adm. Code and including meeting the performance standards of s. NR 151.11, Wis. Adm. Code.

An agricultural building or facility is not required to meet the post-construction performance standards of NR 151.12, Wis. Adm. Code.

### NR 243: Concentrated Animal Feeding Operations (CAFO)

The U.S. Environmental Protection Agency (EPA) delegate's implementation of the Clean Water Act (CWA) and Federal NPDES CAFO permit program to states. In Wisconsin, animal feeding operations with 1,000 animal units or more also called a Concentrated Animal Feeding Operation (CAFO) is required to have a Wisconsin Pollutant Discharge Elimination System (WPDES) permit in place when they to operate. WPDES permits requirements under NR 243 include the following:

- Zero discharge standard for runoff to navigable waters from production areas.
- Manure and process wastewater storage and handling systems.
- Manure and non-manure spill response plan.
- A plan for manure and process wastewater application on cropped fields.
- Manure application restrictions.

- Manure storage.
- Inspection, monitoring and reporting requirements.

### DNR: Wisconsin's Managed Forest Law

Enrollment into the Managed Forest Law (MFL) program is open to all private owners of forested land. To be eligible for the MFL program, a landowner must have a minimum of 20 acres of contiguous land and at least 80 percent of that land must be productive forestland. To participate in the MFL program, landowners designate property as "Open" or "Closed" to public access for recreation, and commit to a 25 or 50-year sustainable forest management plan. According to the Wisconsin DNR Forest Crop Law & Managed Forest Law – 2019 Master Listing, 14,727.4 acres are listed as "open" and 97,636.4 acres are listed as "closed."

The MFL program provides incentives to protect privately owned woodlands from destructive timber cutting practices and over harvesting and prevents land from becoming developed and/or converted to agricultural land use. Lands are enrolled in the MFL program; these properties are no longer susceptible to further subdivision and continued residential housing sprawl, without penalty and withdrawal.

### The United States Environmental Protection Agency (USEPS):

#### Storm Water Phase II: Municipal separate storm sewer systems

The USEPA Storm Water Phase II Final Rule was promulgated on December 8, 1999 (64FR68722), effective March 10, 2003, is designed to significantly control off lot discharges. Municipal separate storm sewer systems (MS4s) generally serving populations of covers urbanized areas that together have a residential population of at least 50,000 and an overall population density of at least 1,000 people per square mile and areas outside of an urbanized area of at least 10,000 and a population of at least 1,000 people per square mile.

A Wisconsin Pollution Discharge Elimination System (WPDES) storm water program address impairments caused by polluted runoff, the Clean Water Act (CWA) of 1990 established a program to address storm water quality coming from developed urbanized areas to reduce contamination of storm water runoff and prohibit illicit discharges. MS4 program communities include the following six minimum control measures:

- Public Education and Outreach
- Public Participation/Involvement
- Illicit Discharge Detection and Elimination
- Construction Site Runoff Control
- Post-Construction Runoff Control
- Pollution Prevention/Good Housekeeping

### The USEPA: Clean Water Act (CWA) Section 303(d): Total Maximum Daily Load (TMDL)

Section 303(d) of the CWA established the TMDL program. The TMDL program identifies and restores polluted rivers, lakes, stream, and other surface waterbodies by detailing in a quantitative assessment the water quality problems and contributing sources of pollution. It is required of all waterbodies that do not meet Wisconsin's water quality standards. The document determines how much a pollutant needs to be reduced to meet water quality standards, and provides the foundation for taking actions locally to restore a waterbody to fishable and swimmable standards.

Wisconsin is required by the Clean Water Act to submit a prioritized list of impaired waterbodies to the U.S. EPA every two years. A TMDL is the amount of pollutant that can be assimilated by a water body without a violation of water quality standards,

and includes wasteload allocations for point sources, load allocations for nonpoint sources, and a margin of safety.

### Federal Soil and Water Conservation Programs:

CPZ's Conservation Program works closely with other Federal Soil and Water voluntaryprograms including the following:

- *Conservation Reserve Enhancement Program (CREP)*. CREP provides annual payments up to 15 years for taking cropland near surface water out of production. A strip of land adjacent to streams must be planted and maintained in vegetative cover consisting of certain mixtures of tree, shrub, forbs, and/or grass species. Incentives and technical assistance are provided for planting and maintenance of the vegetative strips.
- *Conservation Reserve Program (CRP)*. CRP is a program available to agricultural producers to help them safeguard environmentally sensitive land. Producers enrolled in CRP plant long-term, resource conserving covers to improve the quality of water, control soil erosion, and enhance wildlife habitat. In return, the Farm Service Agency (FSA) provides participants with rental payments and cost-share assistance.
- *Environmental Quality Incentive Program (EQIP)*. EQIP is a federal cost-share program administered through the Natural Resources Conservation Service (NRCS) that provides farmers with technical and financial assistance. Farmers receive flat rate payments for installing and implementing runoff management practices.

## MARATHON COUNTY CONSERVATION, PLANNING & ZONING DEPARTMENT

The Conservation, Planning and Zoning Department is comprised of 3 main public service areas providing a myriad of regulatory, professional, educational and technical services to the general public and local governments of Marathon County. These program and service areas include the following:

### *Land and Water Services*

The Land and Water staff provides the implementation and administration of County policy established to protect land and water resources, balance sustainable land use with economic opportunities, promote community health and safety, protect public infrastructure, and minimize land use conflicts.

*local stream with proper vegetated riparian buffer*

*deer grazing*

Land and Water Program Includes:
Animal waste storage and nutrient management, brownfields assessment and remediation, comprehensive zoning, farmland preservation, lakes and rivers classification and management, land division, livestock facility siting, managed grazing, non-metallic mining, metallic mining, private on-site treatment sewage system management, shoreland, wetland, and floodplain protection, and non-metallic mining reclamation.

*Planning Services*

The Planning staff provides the leadership and expertise to Marathon County, local officials, local municipalities and communities, and advocate groups to develop policies and plans to address community and resource concerns and promote community and economic development.

Planning Program Includes:
Community development and planning (comprehensive), strategic planning, farmland preservation, hazard mitigation, lake and river management, land and water resource management, land division, re-districting, storm water management, transportation planning & the Wausau Metropolitan Planning Organization (MPO), and Wausau area sewer service.

*Land Information Services*

The Land Information staff provides the data, data analysis, maps and tools to support the implementation of policies related to improved public safety response, economic development, land use, resource protection, and the protection of private property.

Land Information Services Includes:
Property mapping, community mapping, county-wide (departmental) mapping and database support, data distribution/sale of land information (government agencies and private businesses), emergency services mapping (address, response districts, dispatch location), floodplain mapping, Geographic Information System (GIS), Land Information Office (LIO), and County Surveyor Office, public access (intranet, internet, and public access terminal), resource protection mapping: protected areas and land conversion, survey corner section re-monumentation, and watershed protection analysis.

### Land & Water Conservation Program Responsibilities

Land & Water Conservation Services, is driven by Marathon County's LWRM Plan. The LWRM Plan outlines a comprehensive strategy for the implementation of soil and water conservation in Marathon County from 2020 through 2030. The county's conservation responsibilities include the following:

- First and foremost, implement the Land and Water Resource Management Plan.
- Conserve, protect, and enhance the quality of natural resources such as water, ground water, land, and the environment to ensure public health and safety.
- Prevent adverse land use activities, minimize conflicts, maximize investments, and protect rural character. Ensure compliance with federal, state, and local regulatory programs.
- Provide sound financial and technical assistance, and effective forward-thinking education activities promoting innovative agricultural practices.

### Financial and Technical Assistance

To implement conservation practices of the LWRM Plan the county will access available grants from county, state and federal sources to support staffing expenditures and to fund grants for landowners to implement best management practices (BMPs). Along with the county conservation staff, the CPZ Department rely upon the DNR, USDA-NRCS and Farm Services Agency (FSA), UW-Extension, DATCP, USEPA to provide specialized and technical assistance to local conservation program delivery. Progress toward various program objectives are tracked by conservation staff to ensure compliance.

### Technical Review for State and Local Regulatory Programs

Conservation program staff provides oversight and coordination of conservation programs, monitoring of program and regulatory compliance requirements, enforcement activities, preparation of resource management plans, special project studies and educational activities. Staff provides review of designs for standards and construction, project implementation oversight, proper certification, inspection and construction oversight, livestock licensing, verification for cost share funding, assist financial management and reimbursement, farmland preservation certification, and verify compliance with the NR 151 agriculture performance standards and prohibitions.

### Educational Activities

#### *The Eau Pleine Partnership for Integrated Conservation (EPPIC)*

EPPIC is a watershed group dedicated to finding solutions to water resource concerns in Western Marathon County. CPZ, along with several other partners, initiated the formation of this group in 2017, which now includes representatives from the Big Eau Pleine Citizens Organization (BEPCO), CPZ, Dairy Grazing Apprenticeship Program, Farm Bureau, Farmers Union, UW-Marshfield Agricultural Research Station, Natural Resources Conservation Service, Pheasants Forever, River Alliance of Wisconsin, University of Wisconsin–Extension, Wisconsin Department of Natural Resources, Wisconsin Valley Improvement Company, as well as local farmers and agronomists.

EPPIC's Mission Statement, "Integrating resilience into the natural resources, community, and economy of the Eau Pleine Watershed," recognizes the need for community-wide landowner involvement (beyond producer led or special interest groups) in practices that protect land and water resources from agricultural, homeowner, industrial and other pollution sources. EPPIC leads educational efforts in the Eau Pleine Watershed by engaging citizens, landowners and farmers through events, peer group learning, demonstration fields, social media, public service announcements and economic analysis of conservation practices. These efforts are funded through several public and private grant programs.

#### *Lakes Program*

Marathon County Conservation, Planning and Zoning (CPZ) Department's Lake Program builds surface water resource health by educating landowners and fostering local partnerships.

Education and outreach efforts focus on engaging shoreland owners to adopt practices that benefit water quality and wildlife habitat, such as shoreland buffers and native vegetation, removal of aquatic invasive species, and stormwater management. Landowners are educated and engaged through various platforms, such as: educational events, shoreland buffer and rain garden demonstration sites, shoreland owner guides, newsletters, social media, and staff technical assistance. CPZ also partners with lake groups and organizations to address goals and objectives listed within Lake Management Plans.

A shoreland buffer restoration cost-share program was offered to shoreland owners from 2016-2018 (funded by the Wisconsin Department of Natural Resources Surface Water Lake Protection Grant), in which over 1,000 feet of shoreland was restored on the Eastern Lakes (Mission, Big Bass, Mayflower, and Pike), and Lake DuBay. CPZ received a second Lake Protection Grant for 2019-2021 to continue Lake Program efforts and projects.

Lake Management Plans for the Eastern Lakes, Lake Wausau, and the Big Eau Pleine Reservoir provide the framework for cultivating partnerships with groups like the Lake Wausau Association, Big Bass Lake Protection and Rehabilitation District, Mayflower Lake District, Sportsman Clubs, the Big Eau Pleine Citizens Organization, Golden Sands Resource Conservation and Development Council, and other local groups and organizations. By building partnerships with citizens and organizational leaders, CPZ strives to create communities that value and protect surface water resources.

*Source: EPPIC*

## ADDITIONAL CONSERVATION, PLANNING & ZONING DEPARTMENT AND RELATED COUNTY PROGRAMS

### Farmland Preservation Program

Marathon County adopted its first Farmland Preservation Plan in 1982. The goals of the program are twofold, to preserve Wisconsin farmland for production of commodities by means of local land use planning and soil conservation practices and to provide tax relief to landowners. For the landowner to receive tax credits they must be in compliance with current applicable NR 151 Agricultural Performance Standards and Prohibitions.

In 2008, the State created the Working Lands Initiative to update and enhance the Farmland Preservation Program. In 2013, Marathon County completed an update of its Farmland Preservation Plan to incorporate the new program opportunities of the Working Land Initiative into local programming.

The protection of agricultural cropland and woodland land uses are important to maintaining the rural and cultural integrity and diversity of Marathon County, but more importantly assure that the economic benefits of these sectors is maintained and enhanced. Sound land use requires policies that conserve resources and allow for the profitable use of the land. Conversion and fragmentation of agricultural cropland and woodlands from productive use are continuing concerns in Wisconsin and Marathon County.

The Farmland Preservation Program in Marathon County has a 42-year history of incentivizing adoption and implementation Enterprise Areas—Heart of America's Dairyland, and Antigo Flats--are eligible through 15-year Farmland Preservation Agreements. Additionally, there are areas where Farmland Preservation Zoning and the Agricultural Enterprise Areas overlap, where landowners are eligible through both Farmland Preservation Zoning and the Agricultural Enterprise area.

The state income tax credit incentives that Farmland Preservation Program participants are eligible for range from $5.00 to $10.00 per acre per year, depending on where in the county the land is located and what level of participation a landowner chooses. Participants with land in an Agricultural Enterprise Area who enroll in a Farmland Preservation Agreement are eligible for $5.00 per acre per year. Participants with land in a Farmland Preservation Zoning district are eligible for $7.50 per acre per year. And participants with land in both are eligible for $10.00 per acre per year. Figure 1-3 illustrates these eligibility areas and state income tax credit incentive levels.

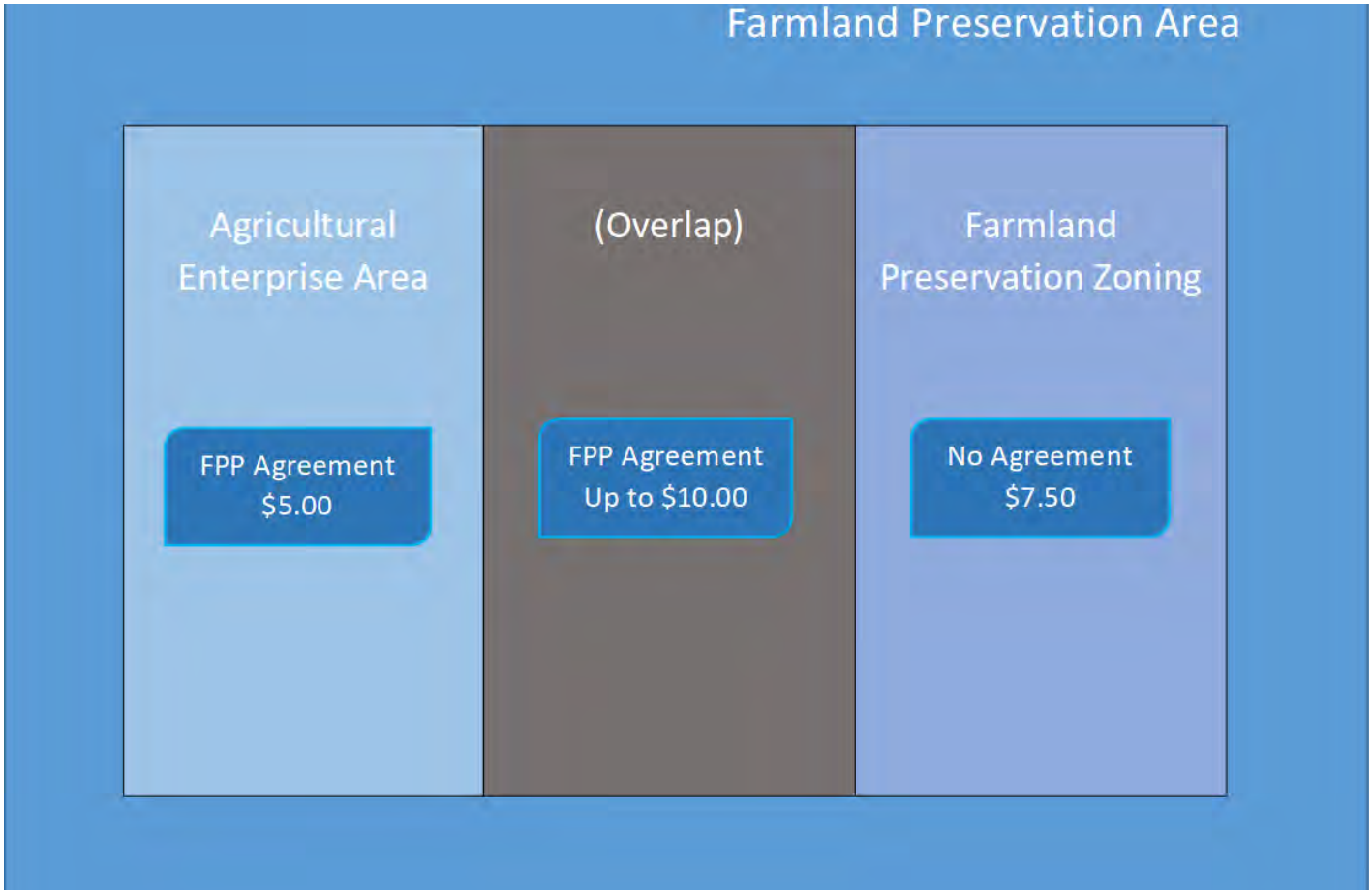
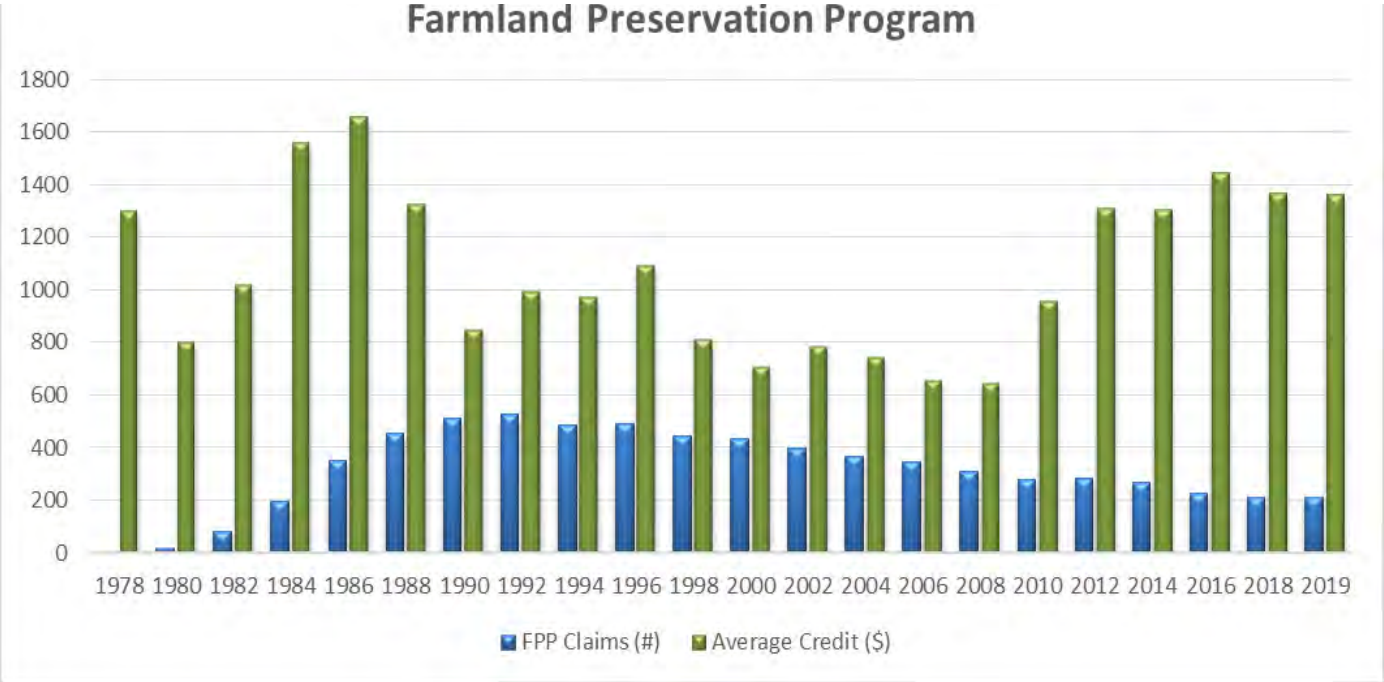



*FIGURE 1-4*

As of August 2020, Marathon County landowners had 9,957 acres enrolled in Farmland Preservation Agreements and 40,093 acres participating through Farmland Preservation Zoning. There were also 4,148 additional acres enrolled and participating through both a Farmland Preservation Agreement and Farmland Preservation Zoning, totaling 54,198 acres in the Farmland Preservation Program in the county. In 2019, 209 participating landowners claimed state income tax incentive credits totaling $285,381. Figure 1-4 shows Farmland Preservation claims and the average annual credit per claim, from the beginning of the program in 1978.

The Marathon County CPZ staff is responsible for administering each participant's soil conservation plan and monitoring compliance with soil and water conservation standards. CPZ conducts compliance "spot checks" on 25% of the program participants annually. The tax credits are intended as an incentive to keep land in active farming and meeting soil and water conservation standards.

The county will continue to implement the farmland preservation program in accordance with Chapter 91, Wisconsin statutes. Figures 1–5 and 1-6 illustrates the Farmland Preservation Program participation distribution within Marathon County as of August 2020.




*Source: WI DATCP and DOR Farmland Preservation Tax Credit Statistics*

*FIGURE 1-5*

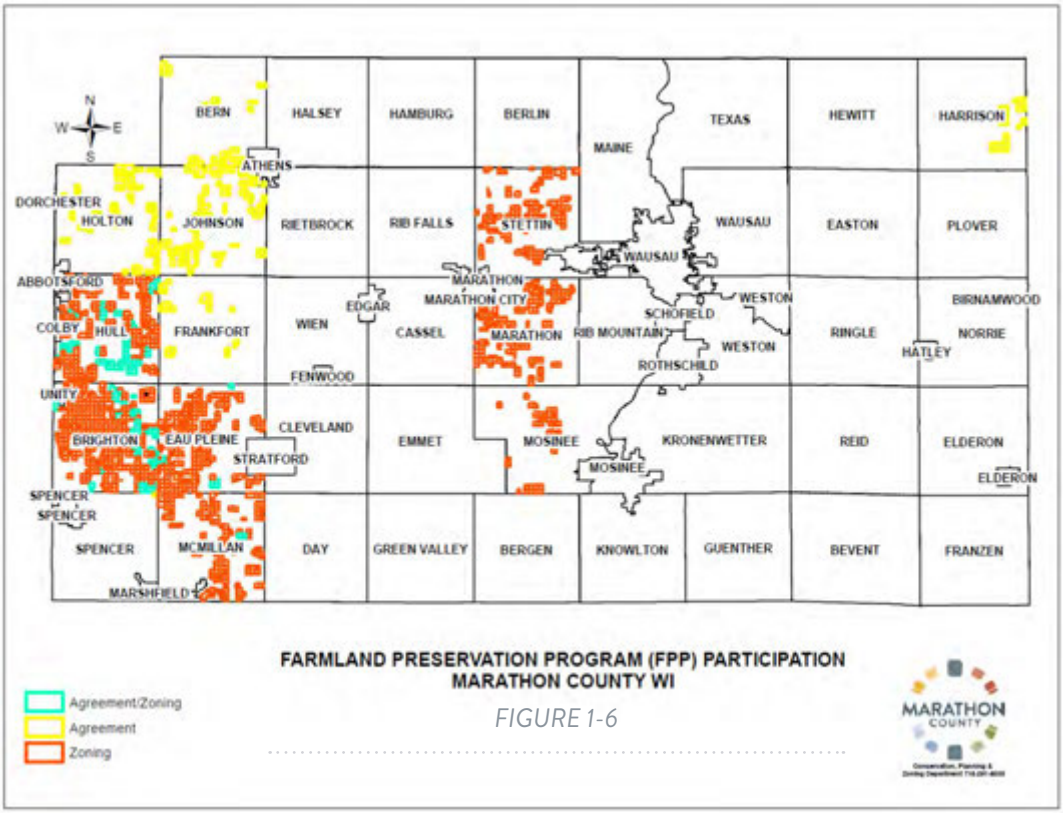



*FIGURE 1-6*

### Nutrient Management Program

Nutrient management is defined as managing the amount, form, placement, and timing of applications of animal waste and commercial fertilizer to provide essential plant nutrients. The purpose is to ensure a proper supply of plant nutrients for crop production while minimizing the entry of nutrients to surface water and groundwater. Under the NRCS Nutrient Managment Technical 590 standard for Wisconsin, nutrient management plans must also minimize soil erosion and phosphorus loss from cropland to surface waters.

Marathon County requires nutrient management plans for landowners constructing and operating waste storage facilities, as well as for other programs such as the Farmland Preservation Program. As of 2008, all landowners that apply manure and/or fertilizer to cropland are required to have a nutrient management plan for those activities as outlined in NR 151.07. In 2019, 404 Marathon County landowners have nutrient management plans on 169,363 acres (57%) of cropland; please refer to nutrient management plan Figure 1 - 7. Since 2007, Marathon County has worked with the UW-Extension, North Central Technical College, and Wisconsin Nutrient and Pest Management Program to train and prepare 198 different Marathon County landowners to develop their own nutrient management plans. This effort has been very successful and will be continued.

CPZ staff will work with DNR staff to implement and enforce the nutrient management plan requirements by conducting complaint investigations with DNR staff, providing compliance reports, providing administration of grants and tracking implementation. Efforts will also be taken to monitor the land spreading activities of off-farm generated waste sources such as industrial, municipal and septic producers. These land-spreading activities must comply with specific State and local regulations and be consistent with agricultural best management practices.

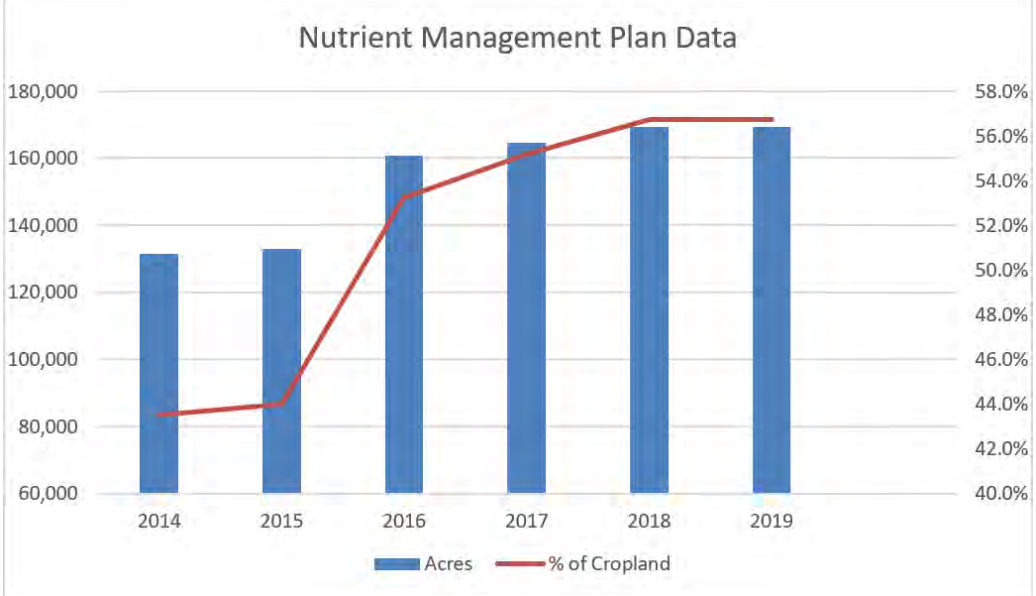



*FIGURE 1-7 Source: CPZ, Nutrient Management Plan records and National Agricultural Statistics Service*

### Managed Grazing Program

Marathon County Conservation, Planning and Zoning Department, Lincoln Land Conservation Department, UW-Extension, and the Natural Resources Conservation Service have been partners along with farmers and farm business in supporting the Central Wisconsin River Graziers Network. Marathon and Lincoln County embarked upon a joint grazing project in 1998 to meet the increased technical and educational needs of the landowners in both counties. The objectives of the project are still relevant today and include:

*managed grazing local dairy herd*

- Provide one-on-one farm planning assistance to farmers wanting to implement Managed Grazing. This would include fencing design and layout, travel lanes, and watering systems.
- Educate farmers and agricultural professionals about the benefits of Managed Grazing through pasture walks, winter conferences, and media.
- Educate local agricultural lenders, educators, and leaders about the benefits of Managed Grazing.

Between 1998 and 2019, 467 managed grazing plans for 32,914 acres of pasture have been developed. These plans provide design assistance to landowners for practices such as cattle travel lanes, watering systems, fencing and pasture management. A key part of this project is to provide educational and technical support on the farm to individual farmers during their transition to grazing. Farmers new to rotational grazing receive bi-weekly on-farm technical assistance for the first 2 years to implement the new practices and develop grazing skills. Each year project staff visit 60 - 100 farmers to assure that their transitions are successful and proper management is being carried out.

### Local Tree Planting Program

In cooperation from the Department of Natural Resources, CPZ has promoted the planting of trees for forestry, windbreak and wildlife benefits to the private landowners of Marathon County. Specifically, the DNR has provided forest plan assistance, access to State tree nurseries and ordering assistance to landowners to plant trees. Marathon County rents two tree planters to local landowners with large plantings.

### Land Use Code Administration & Enforcement

The administration and enforcement of the land use code is to promote the public health, safety, comfort, and welfare of the residents of the County of Marathon and to establish and maintain zoning districts in order to protect the property rights of all individuals by assuring the compatibility and efficient relationships of uses and practices within districts. The authority is granted by Wisconsin State Statutes.

### Comprehensive Planning

Marathon County has a strong tradition of planning to become the healthiest, safest and most prosperous county in the state. Obviously, planning efforts are much more than just developing a county-wide Comprehensive Plan that meets the requirements outlined in Wisconsin Statute 66.1001, and other relevant statutes. For the reason, the 2016, Comprehensive Plan incorporated new topics to address Health and Human Services, Water Resources, and Community Character of the county.

### Land Information

In partnership with the Wisconsin Land Information Program (WLIP), administered by the Division of Intergovernmental Relations within the Department of Administration (DOA), CPZ serves as the Land Information Office for Marathon County under the authority Wisconsin Statutes.

#### *Marathon County Land Information Officer*

Performs all duties to ensure modernization of local land records as governed by state statutes 16.967 and 59.72, as well as Administrative Rule Chapter Adm. 47.

#### *Marathon County Surveyor*

Performs all duties required by Wisconsin Statutes Chaper 59.45, which includes working with town and municipal officials to prevent disturbing and destruction of survey monuments because of road construction or re-building. Review certified surveys, preliminary and final county palts, and repliminary and final state plats to assure compliance with Wisconsin Statutes Chapter 236 and the Marathon County Land Division Ordinance.

### POWTS

#### *Maintenance Program*

Marathon County adopted a POWTS maintenance program in 1980 and currently administers a program, which includes all POWTS installed since 1980. The Wisconsin Administrative Code mandates that all counties now include every POWTS, regardless of age, in their maintenance program as governed under Chapter SPS 383, Wisconsin Administrative Code.

### Health Department

#### *Environmental Services*

This county program responds to reports or concerns from the public or other agencies about potentially hazardous situations. The range of possible hazards includes garbage, unsafe structural housing, hoarding, environmental contamination, pet/rodent/insect issues, asbestos, mold, lead, blastomycosis, blue-green algae, pests, groundwater contamination, methamphetamine drugs, and animal manure affecting property or groundwater.

*Marathon County Water Testing Laboratory*

The Marathon County provides convenient, reliable, and reasonably priced water-testing services to the citizens of Marathon County and surrounding counties, with the goal of safer water supplies. The lab is involved in monitoring public drinking water supplies which include municipal community water systems and those involved in our Department of Natural Resources (DNR) transient non-community water (TNC) systems program.

Clean, safe drinking water is one of the most important elements of good health. Testing well water on an annual basis is one of the easiest things a private well owner can do to protect their health. It's estimated that 20-25% of Wisconsin wells have bacterial contamination, so Marathon County Health Department advises all private well owners to have their well water tested for coliform bacteria. If there are infants under six months of age or women of childbearing age drinking the water, it should also be tested for nitrates.

### Solid Waste Department – Recycling

The Solid Waste Department (SWD) provides a wide range of solid waste and recycling services for local residents, businesses and municipalities of central and north-central Wisconsin. From programs to help reduce waste volume and recycle more materials, to state-of-the art landfill disposal including leachate treatment and landfill gas-to-energy production, the SWD provides cost-effective means to dispose of or effectively manage waste – including hazardous materials and industrial byproducts – while protecting public health and the environment. The SWD is a member of state and national waste organizations, looking always to expand services that will extend the life and effectiveness of our waste management investments in Marathon County.

### Parks, Recreation, and Forestry Department

Marathon County has nine forest units totaling 30,195 acres. The Marathon County park system is based on large parks that typically focus upon a high quality natural feature and provide limited areas of development that support low intensity recreation uses, such as picnicking, hiking, fishing, swimming, and camping. These parks serve large areas of the county. The county park system also provides specialized facilities that serve the entire county or major populations within the county, such as the fairgrounds, shooting range, softball complex, and indoor ice-skating.

The park and forest recreation system is intended to meet the needs of current and future gernerations, preserve and protect the county's open space, water, historical, cultural, and natural resources; and provide recreation opportunities that are designed to enhance the county's quality of life.

*algae bloom from excess phosphorus*
*Source: Marathon County Health Department*

*Photo by Roger Zimmermann.*

Marathon County, the largest county in the state, is located in the north central area of Wisconsin (Figure 2 - 1). Moving in a clock-wise direction, the county is surrounded by Lincoln County to the north, Langlade County to the northeast, and Shawano County to the east, and Waupaca County to the southeast, and Portage County to the southeast, and Wood County to the southwest, and Clark County to the southwest, and Taylor County to the northwest.

In an attempt to illustrate the latest available land cover data for Marathon County, Figure 2 – 2: Land Cover, provides land cover data obtained from DNR. Based on land cover data generated for the State of Wisconsin, the acreage for each land cover type such as urban, agricultural, grassland, forest, open water, wetland, barren, and scrubland are included in the legend of Figure 2-2.

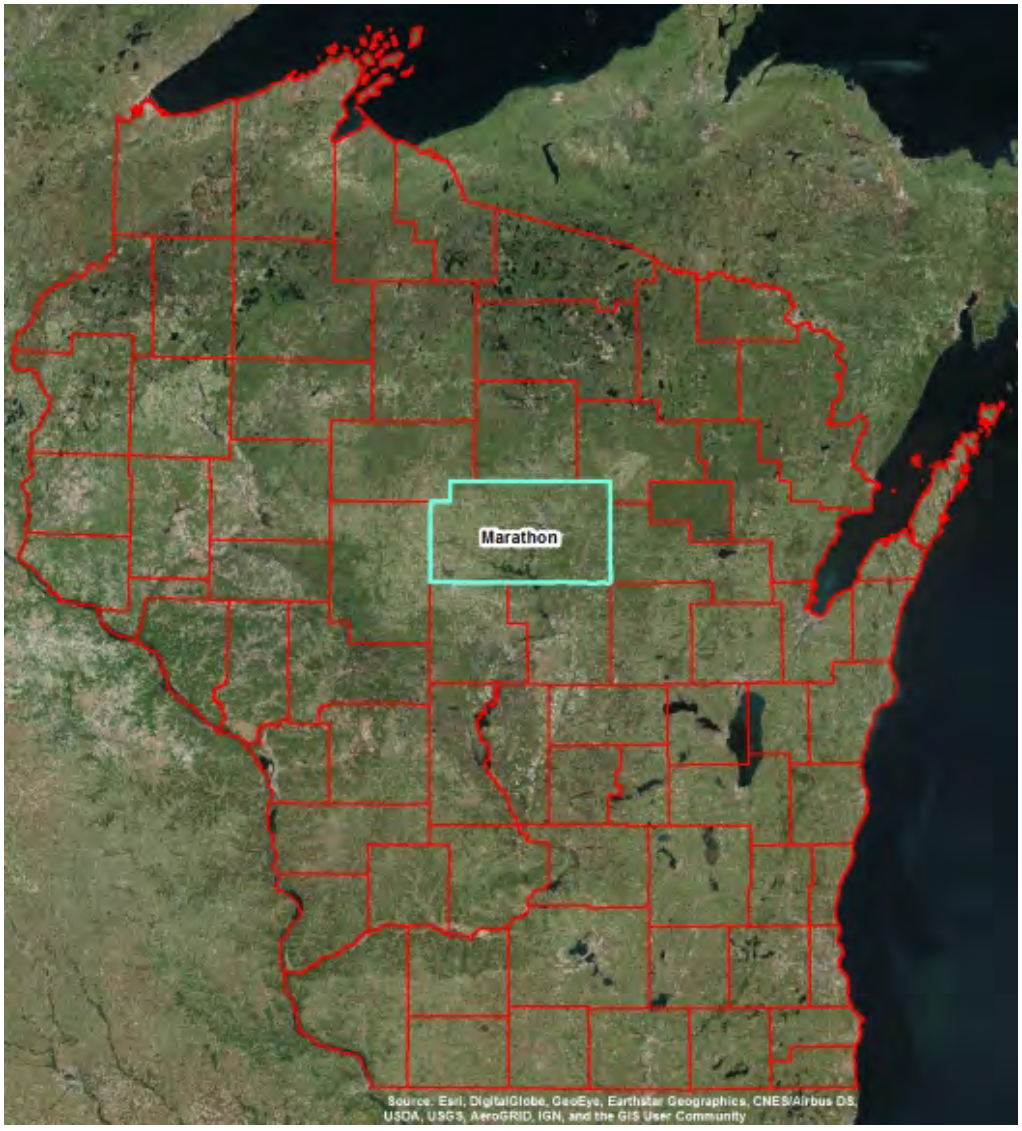
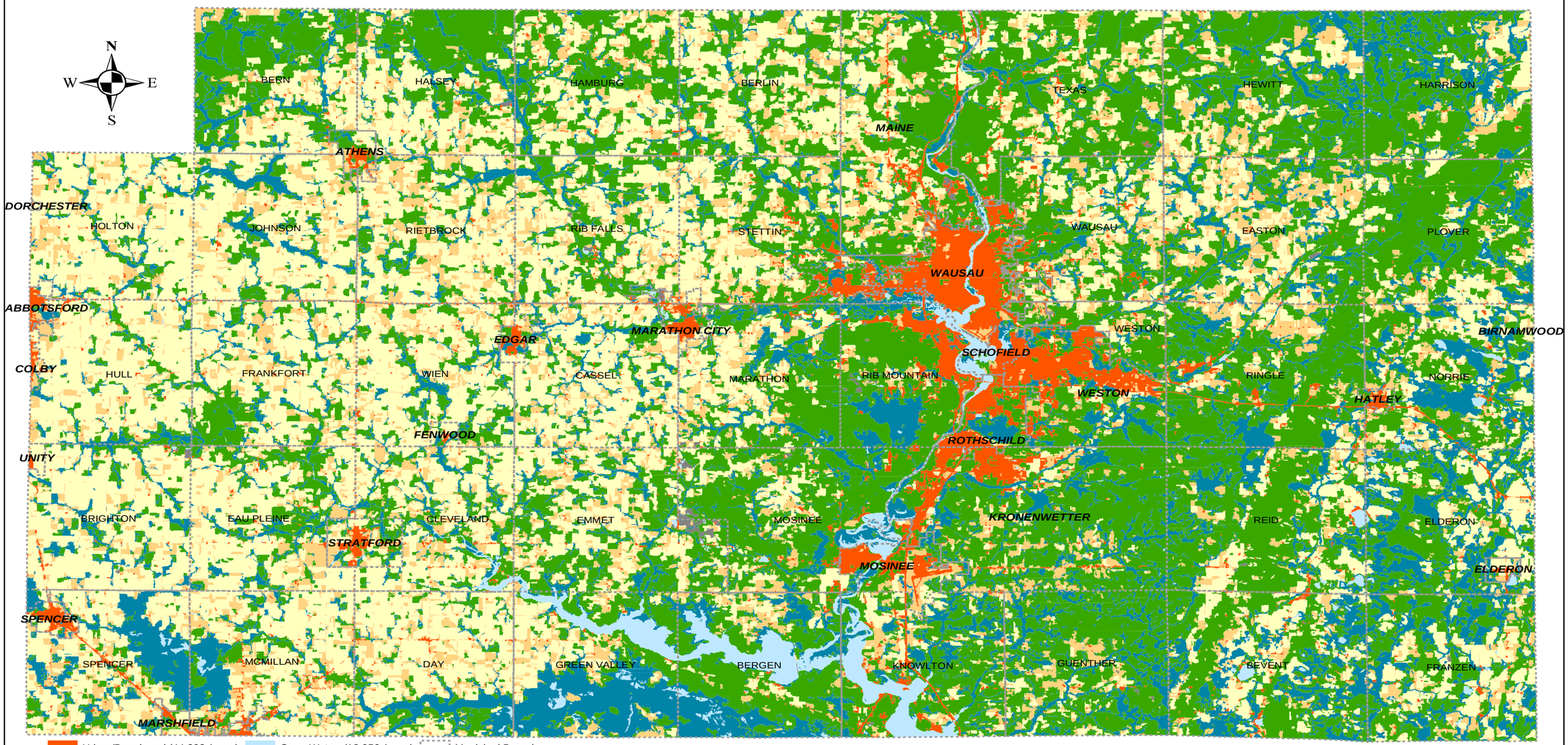



*Figure 2-1 Location of Marathon County, WI*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RIB FALLS
STETTIN
WAUSAU
EASTON
PLOVER
WAUSAU
ABBOTSFORD
EDGAR
MARATHON CITY
WESTON
BIRNAMWOOD
SCHOFIELD
COLBY
HULL
FRANKFORT
WIEN
CASSEL
MARATHON
RIB MOUNTAIN
RINGLE
NORRIE
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HATLEY
FENWOOD
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FRANZEN
MARSHFIELD
Urban/Developed (44,293 Acres)
Agriculture (295,105 Acres)
Grassland (131,967 Acres)
Forest (375,143 Acres)
Open Water (18,050 Acres)
Wetland (142,679 Acres)
Barren (1,730 Acres)
Shrubland (42 Acres)
Municipal Boundary
Beginning in 2014, the University of Wisconsin-Madison and DNR partnered on a project to map the current land cover of Wisconsin. The resulting dataset, known as Wiscland 2.0, was completed and delivered to the DNR in August 2016. The Wiscland 2.0 digital database is a complete update to the previous statewide Wisconsin land cover map.
WISCLAND 2.0 LANDCOVER AREAS
MARATHON COUNTY WI
Figure 2-2
MARATHON COUNTY
Map Date: 8/11/2020
Document Path: O:\Common\gisdata\projects\land_water_resources_plan\Plan2019\mxds\wisconsin_landcover_data.mxd

## Topography and Soils

### *Topography*

Marathon County's terrain is primarily the result of glaciation. The far northern and western areas of the county are broad, nearly level to sloping ground moraines. The central area, except for the Wisconsin River Valley, is a mixed terrain of ground moraines and uplands underlain by bedrock at a depth of 2 to 20 feet. The Wisconsin River Valley is composed of nearly level to very steep outwash terraces and nearly level and gently sloping flood plains. The southeastern area of the county consists mainly of nearly level to steep outwash plains and stream terraces and undulating to very hilly moraines and drumlins. Figure 2 – 3: Terrain – Elevation map illustrates the variation in elevation found within the County.

### *Soil Associations*

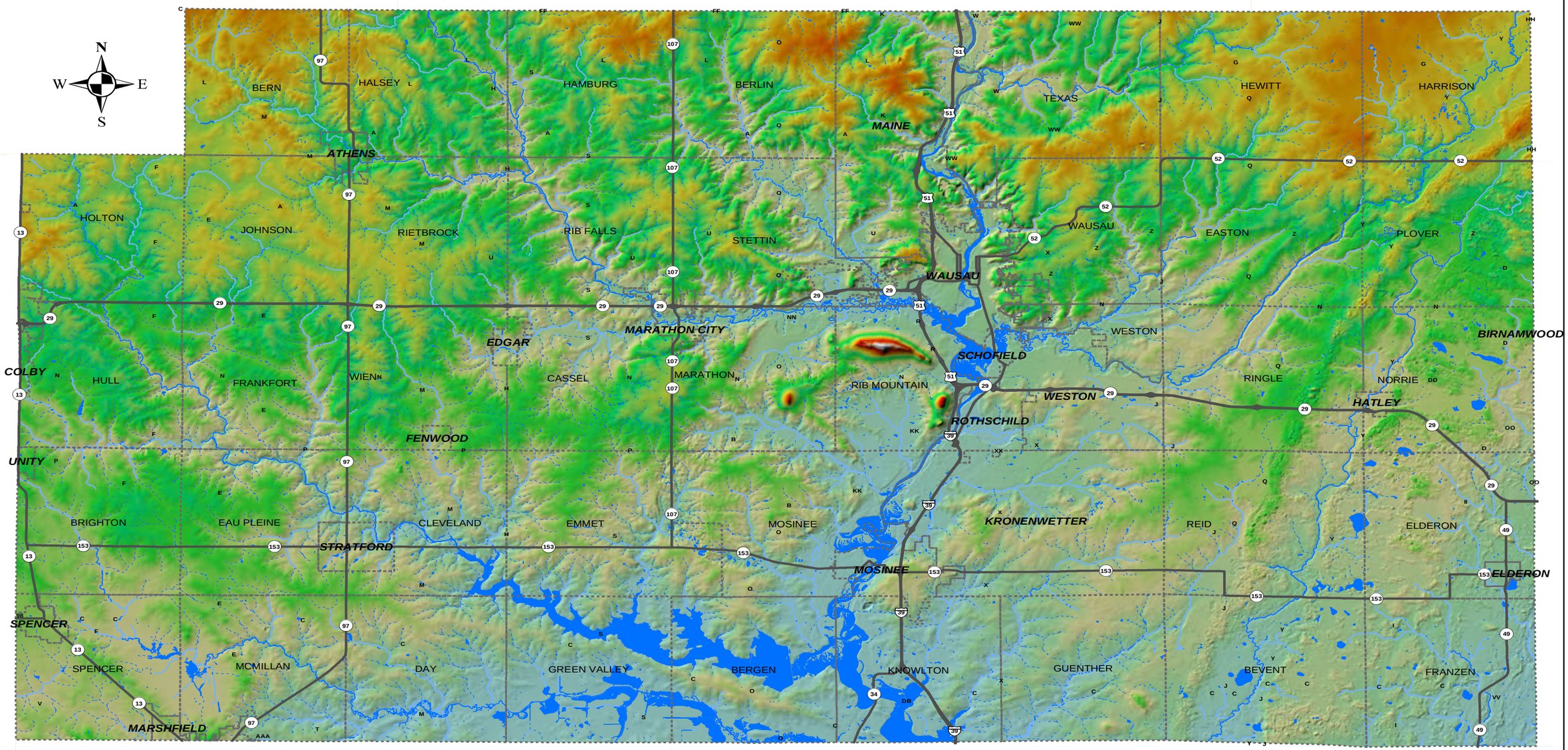
Most of the soils found in the county are best used for cropland and woodlands. The soils of Marathon County are primarily derived from the weathering of glacial drift, outwash, and bedrock. A few soils have formed in glaciolacustrine deposits, alluvial deposits, or organic material. The U.S. Department of Agriculture's Natural Resources Conservation Service conducted a Soil Survey, which described the kinds of soils that exist in an area. Soils are described in terms of their location on the landscape, profile characteristics, relationship to one another, suitability for various uses, and needs for particular types of management. The Survey identified 10 primary soil associations (Figure 2 – 4: Generalized Soils Map) in Marathon County. These soil association include the following: Cathro-Seelyville, Chetek-Rosholt-Oesterle, Fenwood-Rietbrock-Rozellville, Kennan-Hatley, Loyal-Withee-Marshfield, Magnor-Cable, Mahtomedi-Fordum-Sturgeon, Mahtomedi-Graycalm-Meehan, Marathon-Mylrea-Moberg, and Mosinee-Meadland-Dancy.

Another method of describing soils is through hydrologic soil groups. Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms. Surface runoff refers to the loss of water from an area by flow over the land surface. Surface runoff classes are based on slope, climate, and vegetative cover.

Soils play a significant role in determining the suitability for a site for development. Most soils in Marathon County are suitable for agriculture, except those with excessive slopes or areas that are poorly drained. The United States Department of Agriculture (USDA) has identified areas most suitable for agriculture production, with minimal limitations and requiring minimal inputs for successful production as "prime farm lands". Not all lands classified as prime farm soils are used for farming; some have been developed with residential or other uses. The western half of the County is home to most of the prime farmland. However, several areas of prime farmland are found east of the Wisconsin River, particularly northeast of the City of Wausau and along the Eau Claire and Plover Rivers. The Marathon County Farmland Preservation Plan includes more detailed information on prime farm soils.

*Eau Claire Dells, Marathon County, WI*

*trout stream in Marathon County*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Hydro Features
Elevation Information from 2012 LiDAR Data
Elevation Ranges from approximately 1058' to 1941'
TERRAIN - ELEVATION
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FIGURE 2-3
MARATHON COUNTY
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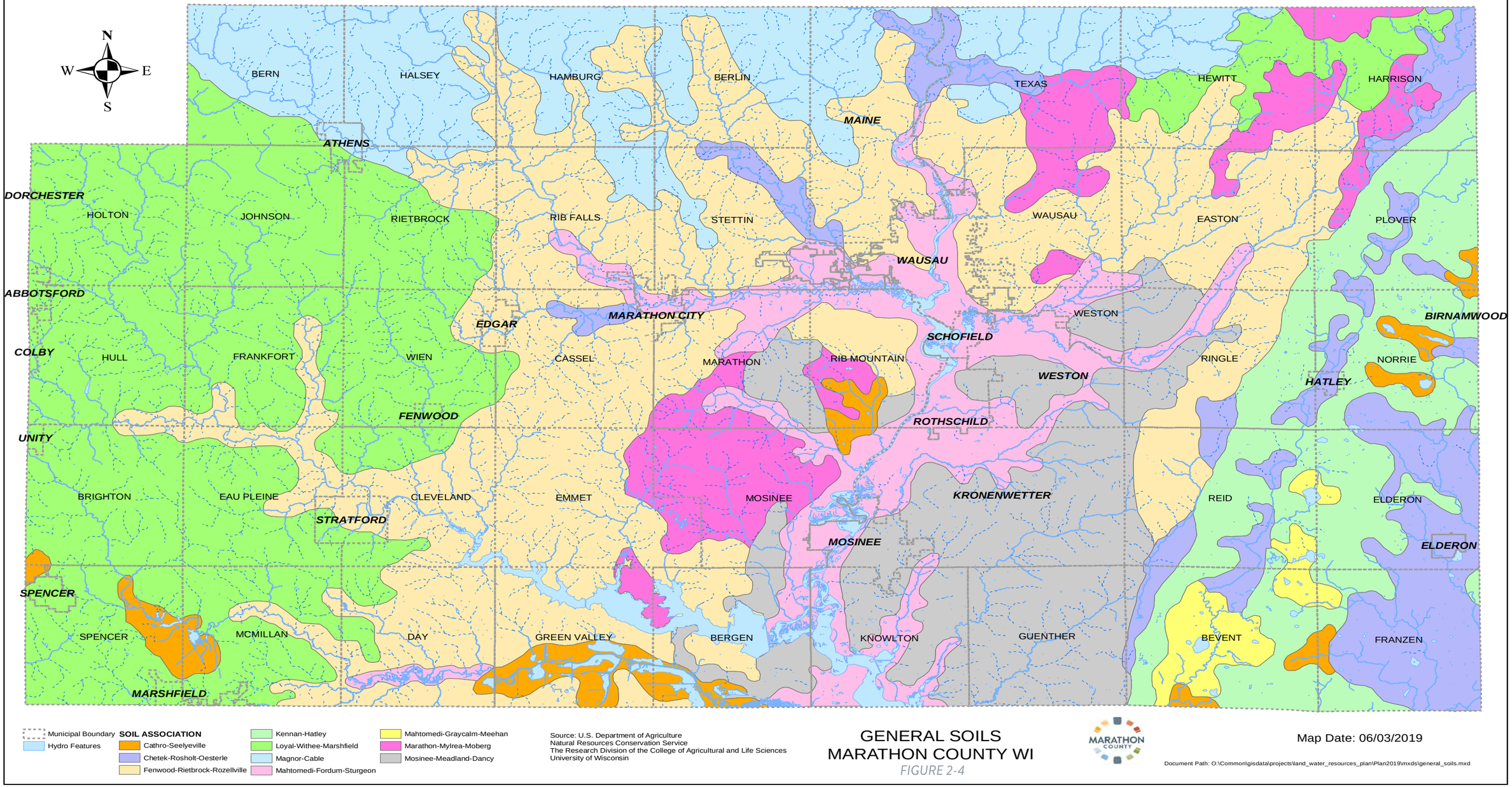


Source: U.S. Department of Agriculture
Natural Resources Conservation Service
The Research Division of the College of Agricultural and Life Sciences
University of Wisconsin

GENERAL SOILS
MARATHON COUNTY WI
*FIGURE 2-4*

Map Date: 06/03/2019

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### *Topography and Soil Associations*

In an effort to illustrate the complex relationship among various soils associations, terrain and elevation, and the hydrologic transport system of watersheds within Marathon County. The connectivity with potential intense land use activities, the importance of soil retention, soil types, drainage patterns and hydrology, and how nonpoint source stormwater, phosphorus and nutrients can travel quickly through the hydrologic system within watersheds which influence the overall water quality, aquatic health, and biodiversity of a watershed.

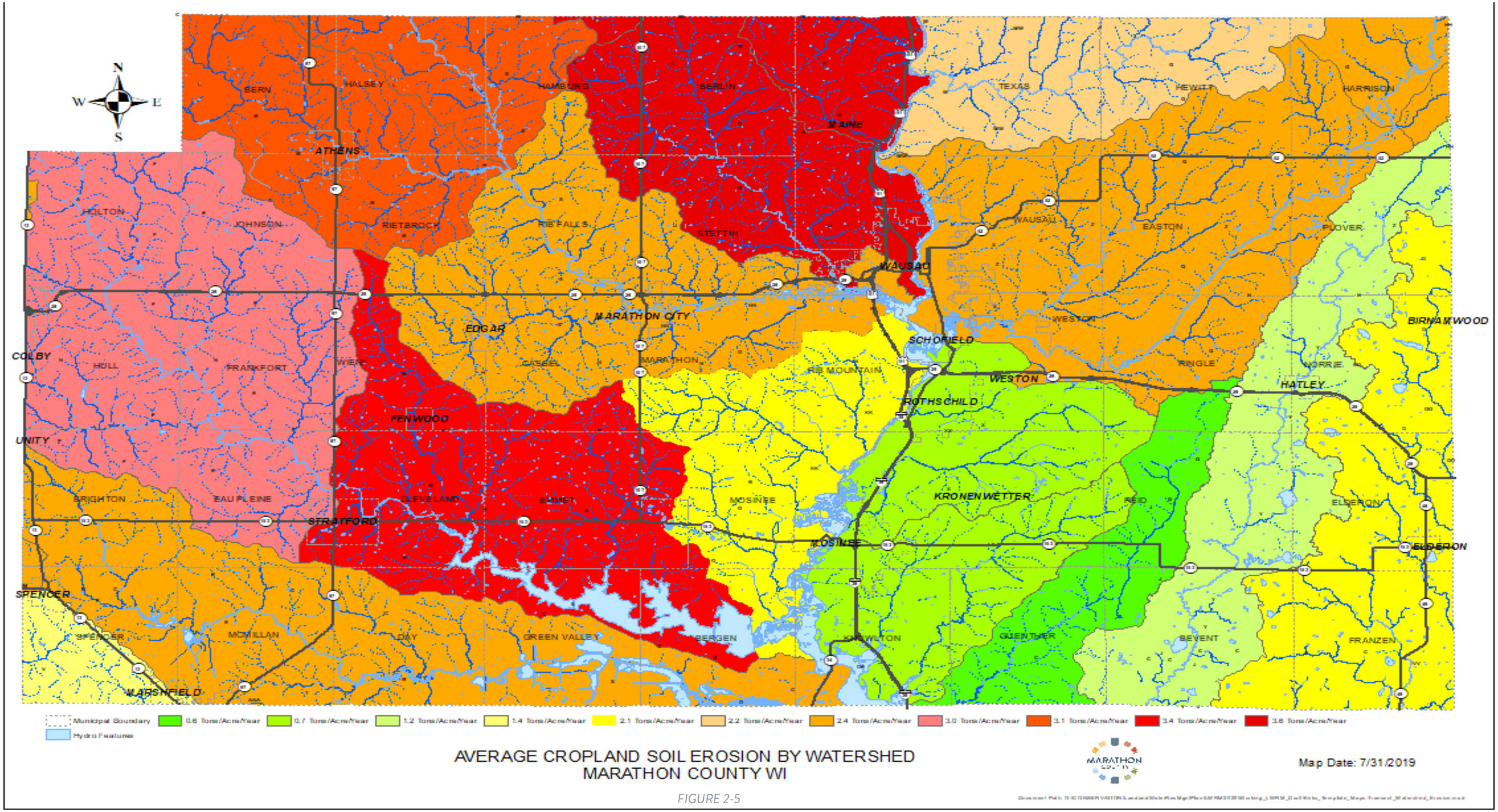
### *Soil Erosion*

The primary concerns with soil erosion are the potential loss of productive farm soils and the impact of sediment and nutrient runoff on water quality in relation to the eroded soil. To maintain long-term soil productivity, an average soil erosion rate of three to five tons per acre per year for cropland, depending on soil type, is considered allowable or tolerable ("T" level) in Marathon County. The 2020 average soil loss rate for Marathon County cropland is 2.6 tons per acre per year. To preserve water quality, the County's goal is to keep soil erosion rates below "T" levels, particularly in water-quality management areas. Most soil erosion in Marathon County is associated with agricultural activities. Soil erosion can also be a problem related to mining, development of buildings and roads, and forest clearing.

A variety of efforts are currently used or encouraged to control and minimize soil erosion include conservation tillage, stormwater permitting requirements, management intensive grazing, crop rotations, development restrictions on steep slopes, and construction best management practices.

Soil erosion has many potential sources within the county but based upon the resource assessments agricultural land is the primary contributor. With 298,524 acres of cropland within the county, agricultural soil erosion has been a longtime concern for the CPZ Department. However, other land disturbances such as mining, residential and commercial construction, roads and forestry have the potential to deliver significant amounts of sediment to waterways. Soil erosion delivers soil sediment, organic material and nutrients to surface waters and is considered the primary nonpoint source of pollutant to our waterways. Figure 2-5 illustrates the average cropland erosion by watershed in 2018.

*Source: Matt Oehmichen, 2019 gully soil erosion*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3.6 Tons/Acre/Year
AVERAGE CROPLAND SOIL EROSION BY WATERSHED
MARATHON COUNTY WI
MARATHON COUNTY
Map Date: 7/31/2019

*FIGURE 2-5*

### *Soil Erosion Transect Survey*

In June 1999, Marathon County conducted its first transect survey. The survey was repeated every year from 1999 to 2004 and has been repeated every other year from 2006 to 2020. The cropland average annual "tolerable" soil loss rate ("T" level) for Marathon County is 3.7 tons per acre per year, which is the highest recorded erosion rate since soil erosion transect survey began in 1999. The current estimated average county-wide cropland soil erosion rate is 2.6 tons/acre/year, with an upward trend. It is important to understand that soil loss calculations and acceptable "T" are performance values based on maintaining soil productivity, not protecting water quality, which creates an inherent conflict among local, state, and federal agencies in terms of achieving water quality standards as specified in the Wisconsin River and Upper-Fox Wolf River TMDLs. The following trends can be identified from the Transect Survey, and are illustrated in Figures 2-6 thru 2-8 below:

1. Cropland soil erosion rates are increasing over the last ten years.
2. Cropping practices are trending toward more annualand erodible crop types being grown.
3. Tillage practices are trending toward less erodible methods being used, but a higher percentage of cropland is being tilled annually.

Based on these trends identified by the Transect Survey, the following conclusion can be drawn: the increase in erodibility of the crop types being grown, and the increase in cropland being tilled annually, more than offset the decreased erodibility of the tillage methods being used.

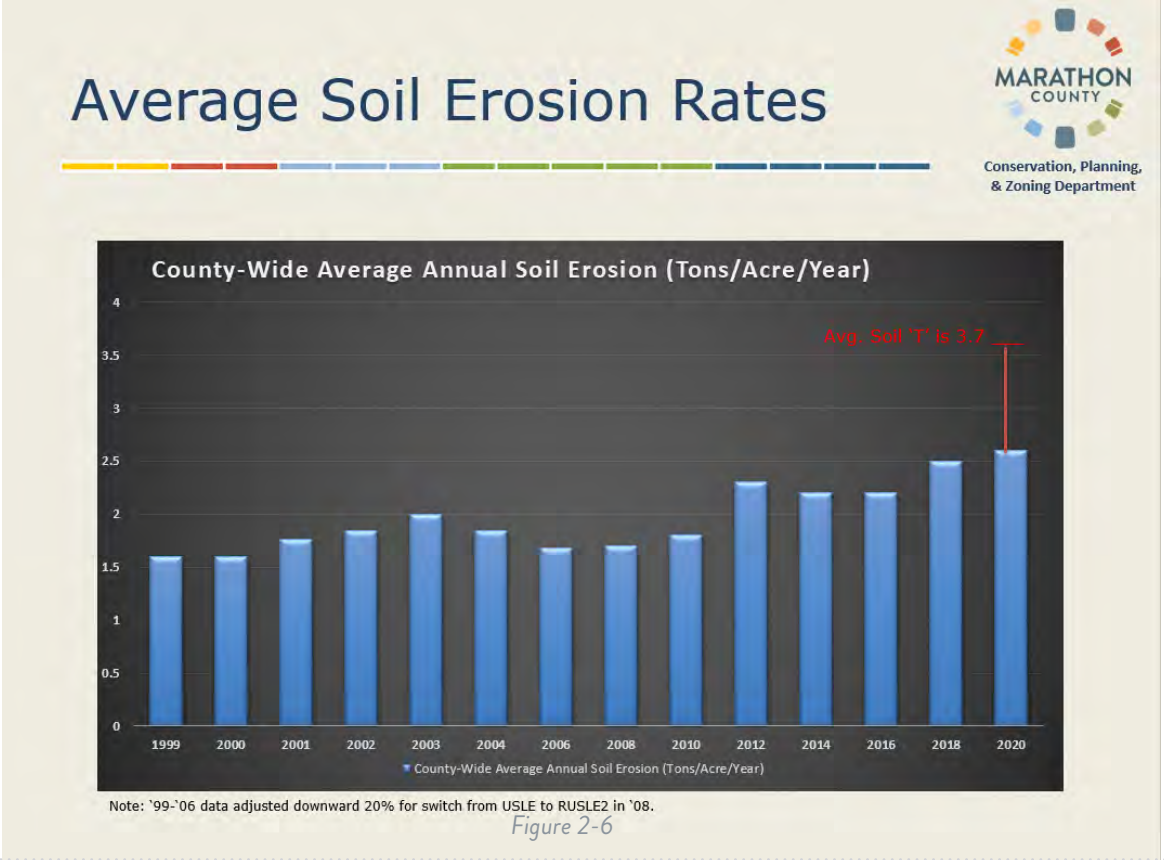



*Figure 2-6*

## Crop Types – 1999 vs. 2020

MARATHON COUNTY
Conservation, Planning, & Zoning Department

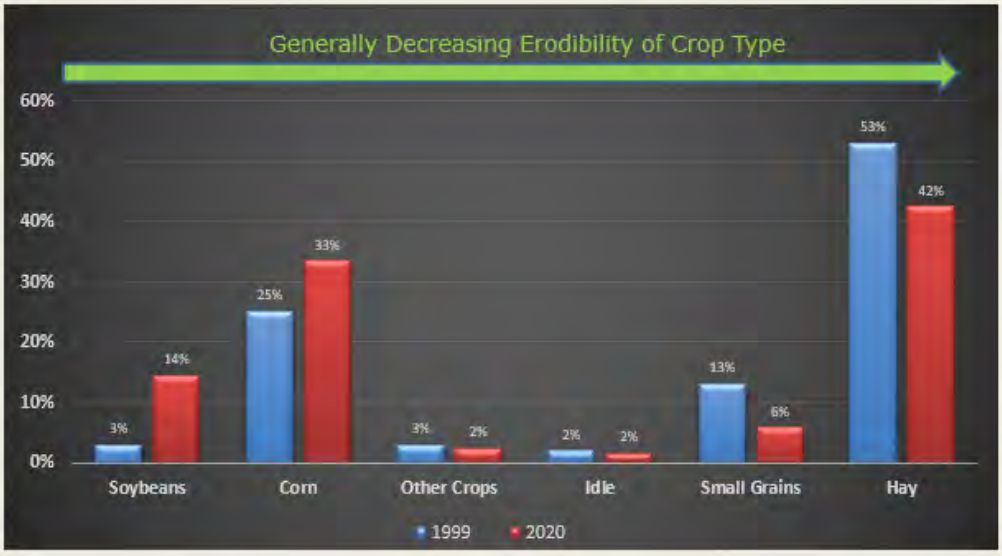



*Figure 2-7*

## Tillage Methods – 1999 vs. 2020

MARATHON COUNTY
Conservation, Planning, & Zoning Department

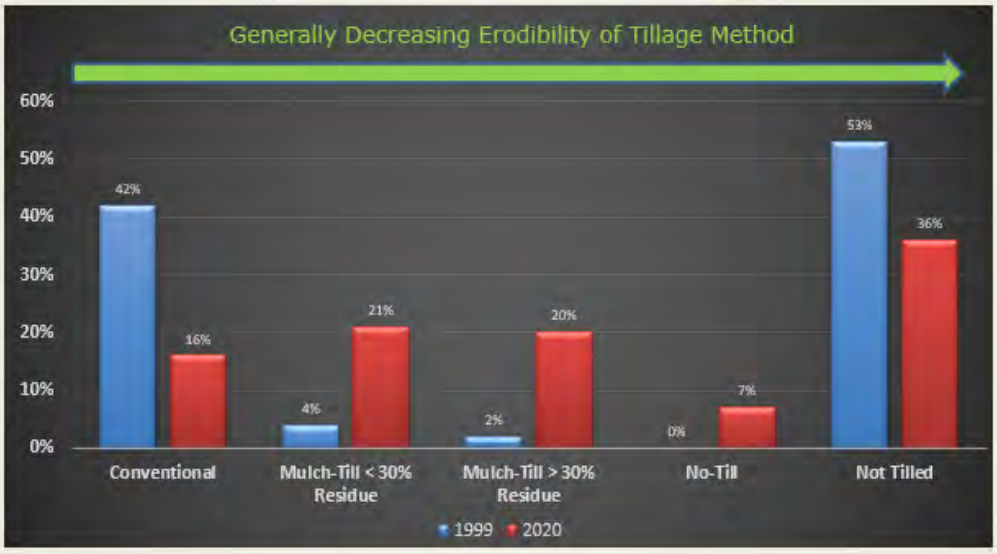



*Figure 2-8*

### *Soil and Wastewater from POWTS*

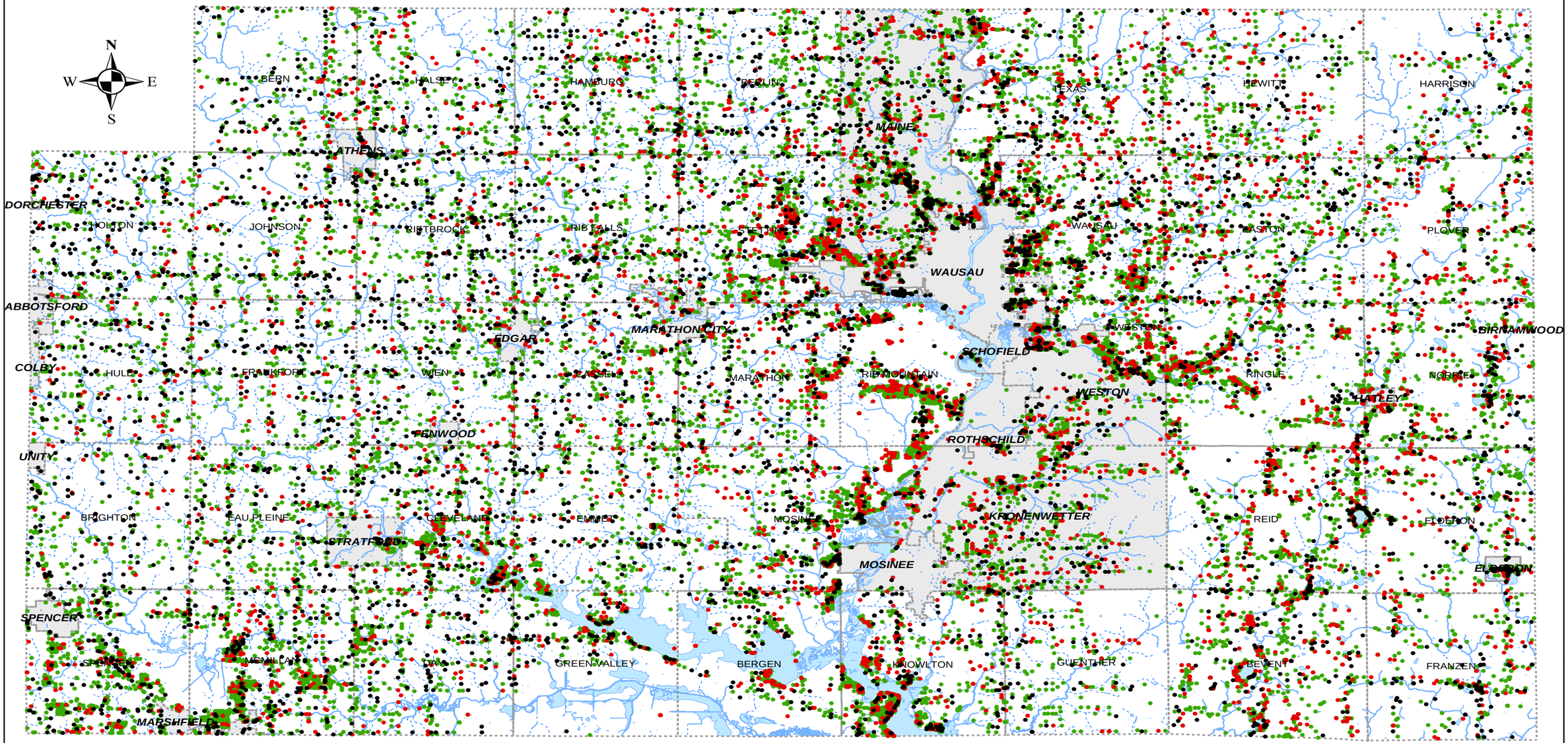
Current regulations rely heavily on the ability of the soil to treat and disperse wastewater (effluents) discharged from a POWTS. Chapter SPS 385 establishes requirements for evaluating and reporting soil and site characteristics that may affect the treatment or dispersal of wastewater. Chapter SPS 383 establishes uniform standards and criteria for design and installation of POWTS appropriate for the soil & site characteristics of each individual site. The attached map (Figure 2-9) shows the locations of existing POWTS in Marathon County. Of the POWTS installed in the last five years, only 21.1% had soil conditions suitable for a conventional (in-ground) system; 47.9% required mound systems, due to shallow depths to groundwater or bedrock; and 29.5% installed holding tanks, because the site did not meet minimum standards for another type of POWTS.

POWTS installed prior to county adoption of the Private Sewage System Ordinance (Figure 2-9) or installed before adoption of current versions of Chapters 381-391 (primarily those identified as "Pre July 1st, 1980" on Figure 2-9) were installed without the benefit of a Soil & Site Evaluation or system design, installation and inspection specified by current regulations. These POWTS may not conform to current standards and may be "failing" POWTS, as defined in s145.245, Wisconsin Statutes. When a POWTS is identified as failing system, installation of a replacement POWTS, which complies with current versions of the regulations referenced above, will be required.

POWTS, commonly referred to as "septic systems", in Marathon County, are regulated by the Private Sewage Systems Ordinance (Chapter 15 of the General Code of Ordinances for Marathon County). The purpose of this ordinance is, "to promote and protect public health and safety by assuring the proper siting, design, installation, inspection and management of private sewage systems and non-plumbing sanitation systems, and to assure the timely repair or replacement of failing private sewage systems". This ordinance is administered by the Conservation, Planning & Zoning Department in accordance with Chapter 145, Wisconsin Statutes, and Chapters SPS 381-391, Wisconsin Administrative Code.

*finished mound septic system*

*finished conventional septic system*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POWTS NO RECORD (6024)
POWTS 1969-1980 (7337)
POWTS 1980 OR NEWER (17866)
Municipal Boundary
Incorporated Areas
Hydro Features
POWTS DATA FROM 12/2016
PRIVATE ONSITE WASTE SYSTEMS (POWTS)
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Map Date: 06/03/2019
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*FIGURE 2-9*

### *Municipal Separate Storm Sewer System (MS4)*

Wis. Administration Code NR 151, "Non-agricultural Performance Standards" requires that Best Management Practices - BMPs be followed on all construction sites exceeding one acre in size. Furthermore, changes in NR 216 – Storm Water and Erosion Control will minimize the issues of storm water control and treatment. Nonpoint problems are both water quality and quantity based. Nonpoint pollution is a result of activities that take place on the land surface, and how water runs off the land surface or seeps into the ground. Most land use activities have the potential to contribute to nonpoint pollution problems. There is an emerging realization that unchecked storm water runoff from more intensively used land surfaces are also a major threat to water resources. This occurs due to the alteration of the surface runoff regime and alteration of the hydrologic processes involved in groundwater recharge.

The solution to nonpoint source and storm water runoff problems is watershed specific. Therefore, successful solutions must be carried out using a watershed approach, which often involves multiple governmental jurisdictions. Also, the nonpoint management programs that need to be utilized in any given watershed will vary depending upon the type of water resources present, the threats to those resources that exist locally, the existing land use, the future land use trends, the governmental structure having jurisdiction over land use decisions, and the level of citizen involvement.

To address impairments caused by polluted runoff, the Clean Water Act (CWA) of 1990 established a program to address storm water quality coming from developed urbanized areas. Each community that is included must develop and implement a storm water management program (SWMP) to reduce contamination of storm water runoff and prohibit illicit discharges. Phase II of the WPDES Storm Water Program requires permits for small MS4s that are located in an "urbanized area" as determined by the Bureau of the Census.

For urban runoff, the highest priority in Marathon County is the implementation and compliance with Municipal Separate Storm Sewer System (MS4). A Municipal Separate Storm Sewer System is a federally mandated program. Marathon County is a WPDES permittee regulated under Wis. Adm. Code NR 216. As part of the WPDES permit strategy, the County has developed a Memorandum of Agreement with Wausau Metropolitan communities to form a Storm Water Coalition to coordinate the educational and technical requirements of the permit. Through this coalition the urban communities will advance consistent model ordinances, educational strategies, and monitoring of storm water and construction site activities.

The Phase II Rule defines six minimum control measures that, when administered in concert, are expected to result in reduction of the discharge of pollutants into receiving streams or lakes. The management of storm water runoff is a complex and inexact, undertaking implementation of best management practices and the achievement of measurable goals to satisfy each of the following six minimum control measures:

- Public Education and Outreach
- Public Participation/Involvement
- Illicit Discharge Detection and Elimination
- Construction Site Runoff Control
- Post-Construction Runoff Control
- Pollution Prevention/Good Housekeeping

### *Nonmetallic Mining*

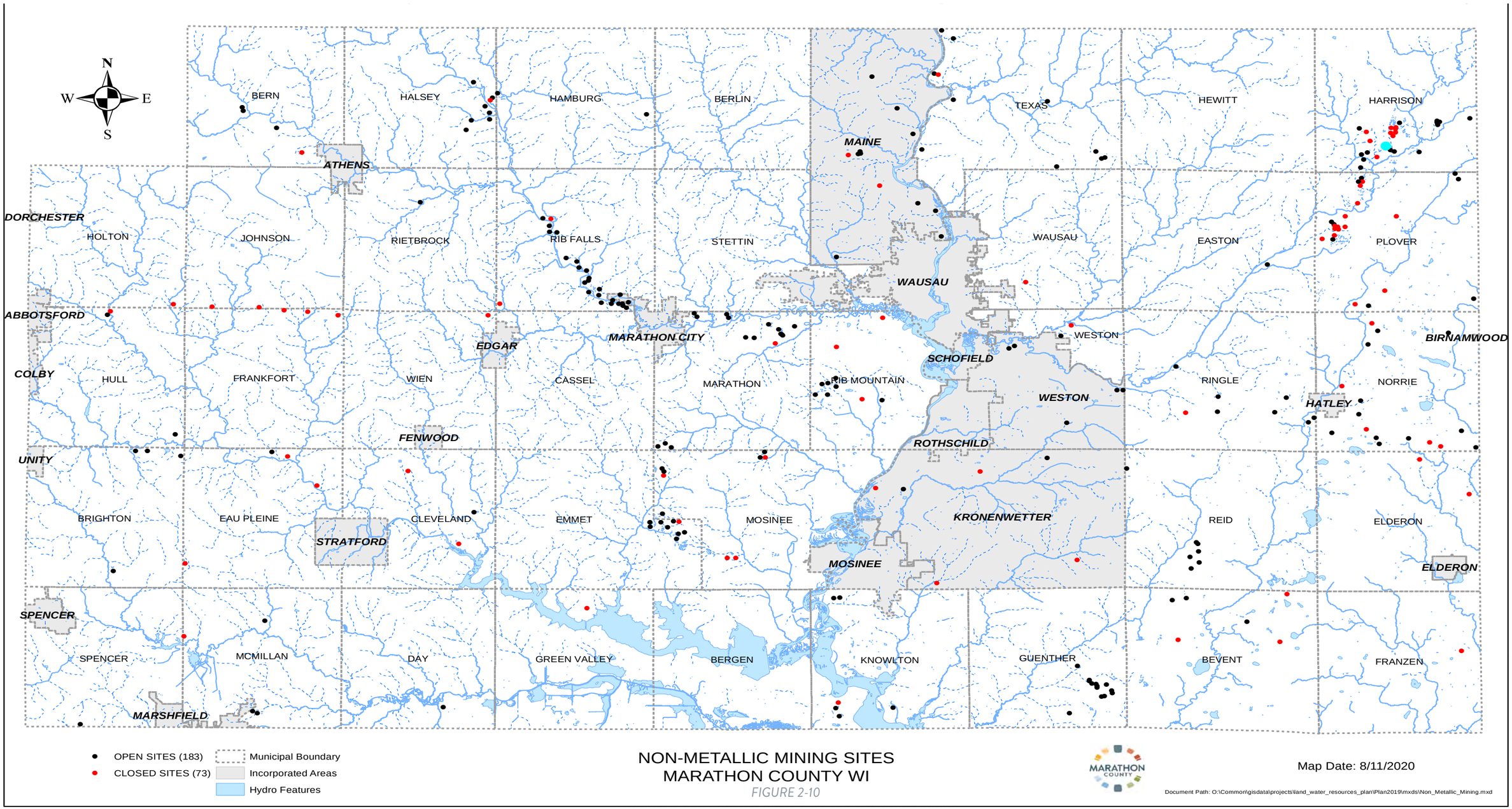
As shown in Figure 2-10, non-metallic mining is an important industry in Marathon County. Sand and gravel is removed from the sandy outwash areas along the rivers. Additionally, rotten granite for road material and landscaping is mined in several areas of the county. Hard rock quarrying is done for road material, granite monuments, buildings, landscaping and roofing granules. Each of these activities has the potential to contribute sediment to surface waters.

Marathon County first adopted a Nonmetallic Mining Ordinance in 1989, and recently received approval by the County Board of Supervisors to amend the Nonmetallic Mining Reclamation Code – Chapter 21 in December 2018. Nonmetallic mining is recognized as an important industry, which contributes to the county's economic and social well-being. However, the long-term damage to the physical environment and tax base that can be caused by nonmetallic mining must be reduced. It is the purpose of Chapter 21 to establish regulations for nonmetallic mining site reclamation that will restore the site to a purposeful and acceptable landscape appearance and use.

According to CPZ's records, historically, over 278 nonmetallic excavation sites operated within the County of Marathon. As of 2019, 166 nonmetallic mining operations have been reclaimed within the county assuring environmental impacts are minimized and the site is returned to a reasonable land use.

Currently in 2020, 125 active mining sites are in operation under NR 135, 17 additional mining sites are under the jurisdiction of NR 340, and six active mining sites are split between NR 135 and NR 340. The Village of Marathon City has two active mining sites are under their jurisdiction. These mining sites are administered through the partnership of DNR and county regulations to protect surface and groundwater resources.

*Sand and Gravel Nonmetallic Mine*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OPEN SITES (183)
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Municipal Boundary
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NON-METALLIC MINING SITES
MARATHON COUNTY WI
FIGURE 2-10
MARATHON COUNTY
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### *Metallic Mining*

Gold was discovered in Marathon County in the 1920s in what is called the Reef deposit, located in the Town of Easton. A Canadian company owns the mining rights and has done exploratory drilling as recently as 2012. According to the Wisconsin Geological and Natural History Survey, the Reef deposit contains between 120,000 and 140,000 ounces of gold. High gold prices could lead to mining in the future, although the company doesn't have current plans to mine the site.

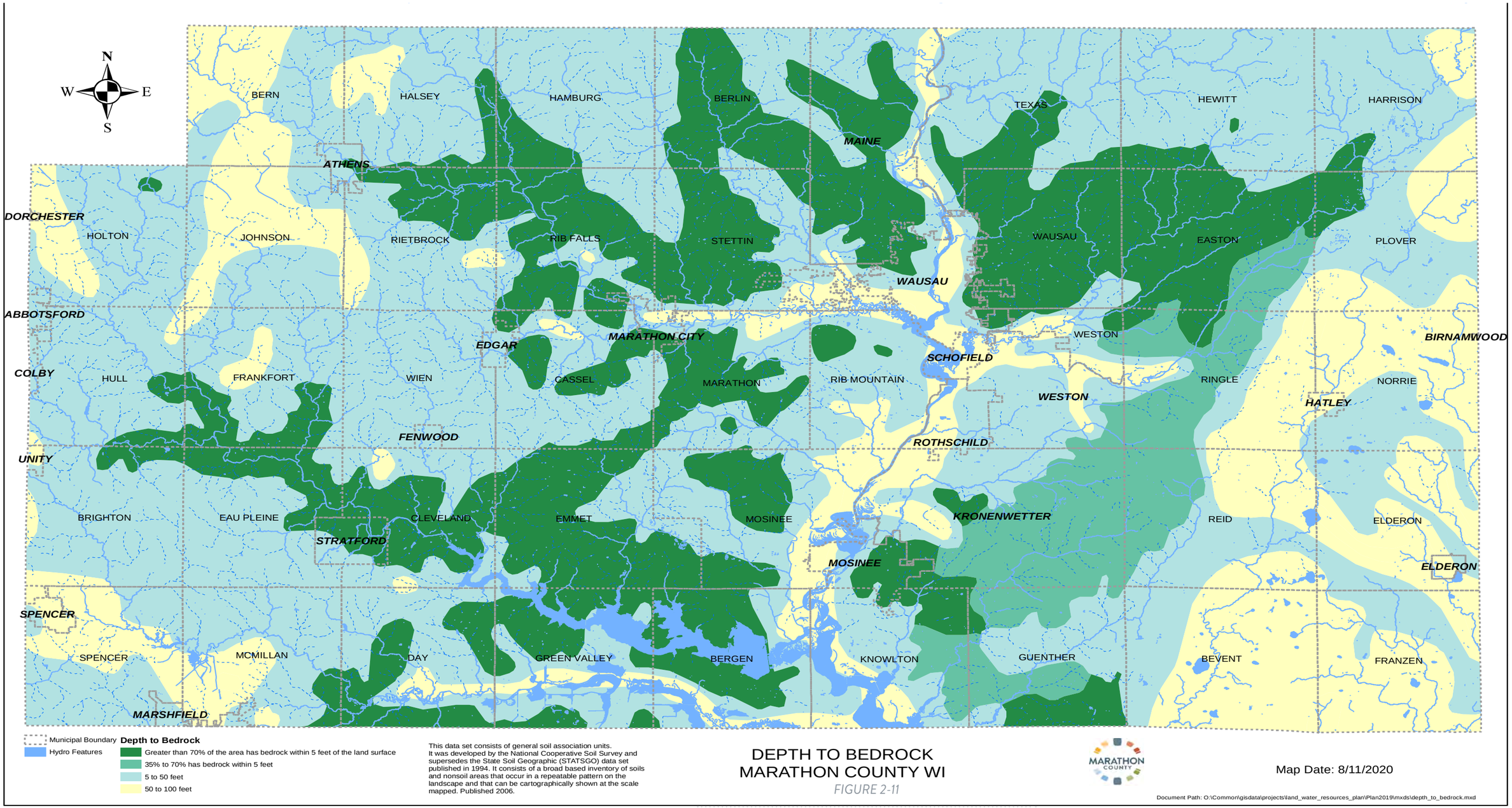
In response to 2017 WI ACT 134, which removed barriers to the initiation of nonferrous metallic mining in the State of Wisconsin, Marathon County Board of Supervisors, in April, 2018, approved the Metallic Mining Amendment to be incorporated into Chapter 17, the zoning code ordinance. If not properly regulated, metallic mineral mining could have an adverse impact on the environmental character and quality of the affected communities in Marathon County. The purpose of regulating metallic mining is to promote the public health, safety, and general welfare and accomplish the purposes under WI Stats. 59.69(1), including but not limited to the protection of water, groundwater, forest and other natural resources, and the protection of property values and the property tax base.

*Source: Tom Quigley- Aquila Resources Inc., An example of gold bearing quartz from the Reef Deposit*

## Groundwater

The need for clean groundwater is both a health and economic issue. Groundwater quality and quantity, in both rural and urban areas can vary in any location at any time. Where groundwater becomes polluted, property values drop and a natural resource is diminished from its full potential. For this reason, local land use activities can significantly influence groundwater quality and quantity in terms of whether a valuable resource is protected and how all key stakeholders have an important role in its protection.

The availability of groundwater varies across the county depending on the local geology. Areas along the Wisconsin and Rib Rivers provide ample water supply from alluvial aquifers; however, adequate groundwater is limited in parts of the county where dense bedrock is close to the surface as shown in figures (Figure 2 – 11: Depth of Bedrock, Figure 2 – 12: Generalized Groundwater Availability, and Figure 2-13: Depth to Groundwater, respectively). Areas along the Wisconsin River, Rib River, and Eau Claire River, the Mahtomedi-Fordum-Sturgeon Association is dominant. This association, with its coarse texture soil type, has a high infiltration rate and high permeability rate because of its large pore space.




This data set consists of general soil association units. It was developed by the National Cooperative Soil Survey and supersedes the State Soil Geographic (STATSGO) data set published in 1994. It consists of a broad based inventory of soils and nonsoil areas that occur in a repeatable pattern on the landscape and that can be cartographically shown at the scale mapped. Published 2006.

DEPTH TO BEDROCK
MARATHON COUNTY WI

*FIGURE 2-11*

Map Date: 8/11/2020

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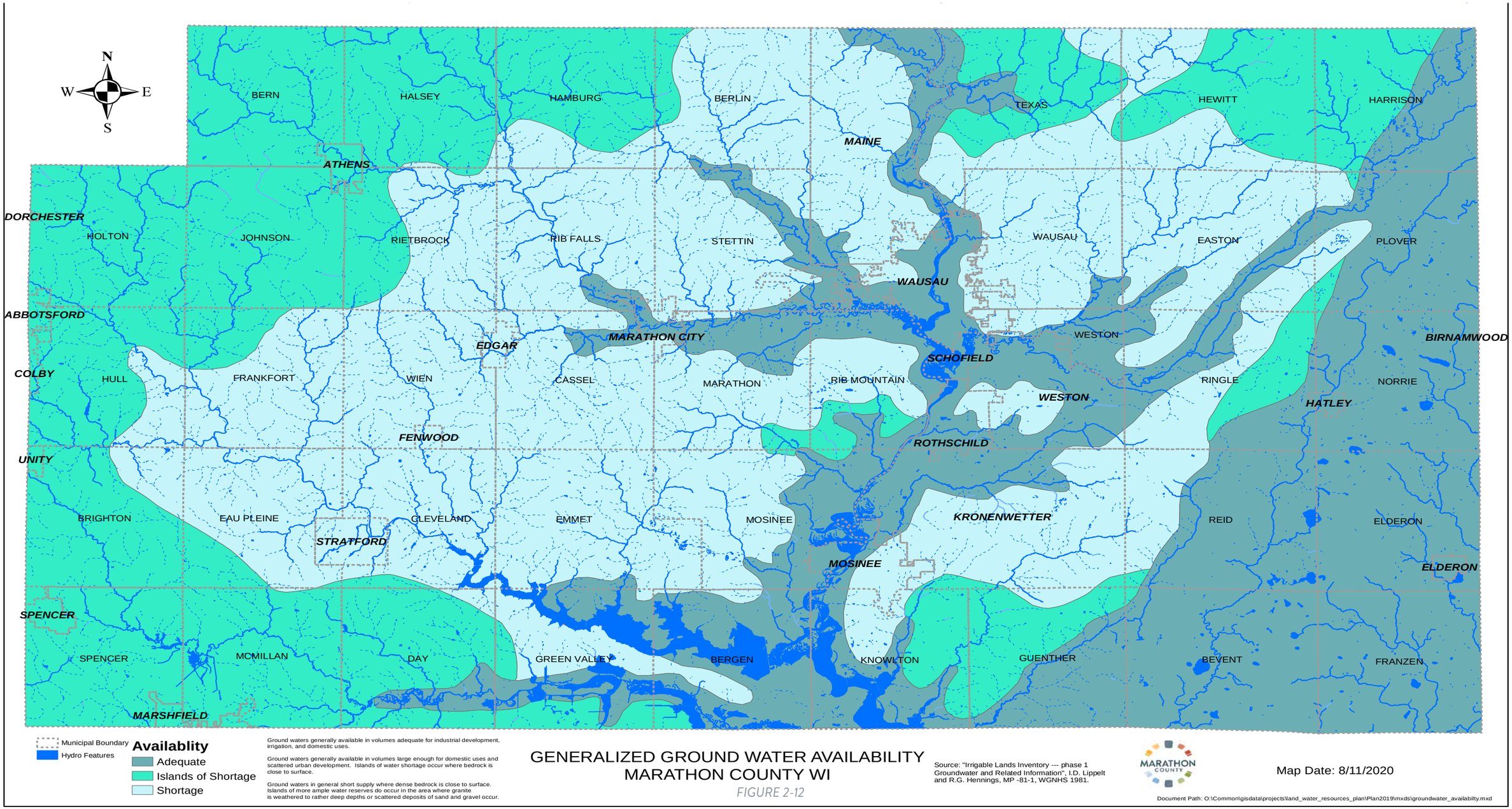


GENERALIZED GROUND WATER AVAILABILITY
MARATHON COUNTY WI

*FIGURE 2-12*

Source: "Irrigable Lands Inventory --- phase 1 Groundwater and Related Information", I.D. Lippelt and R.G. Hennings, MP -81-1, WGNHS 1981.

Map Date: 8/11/2020

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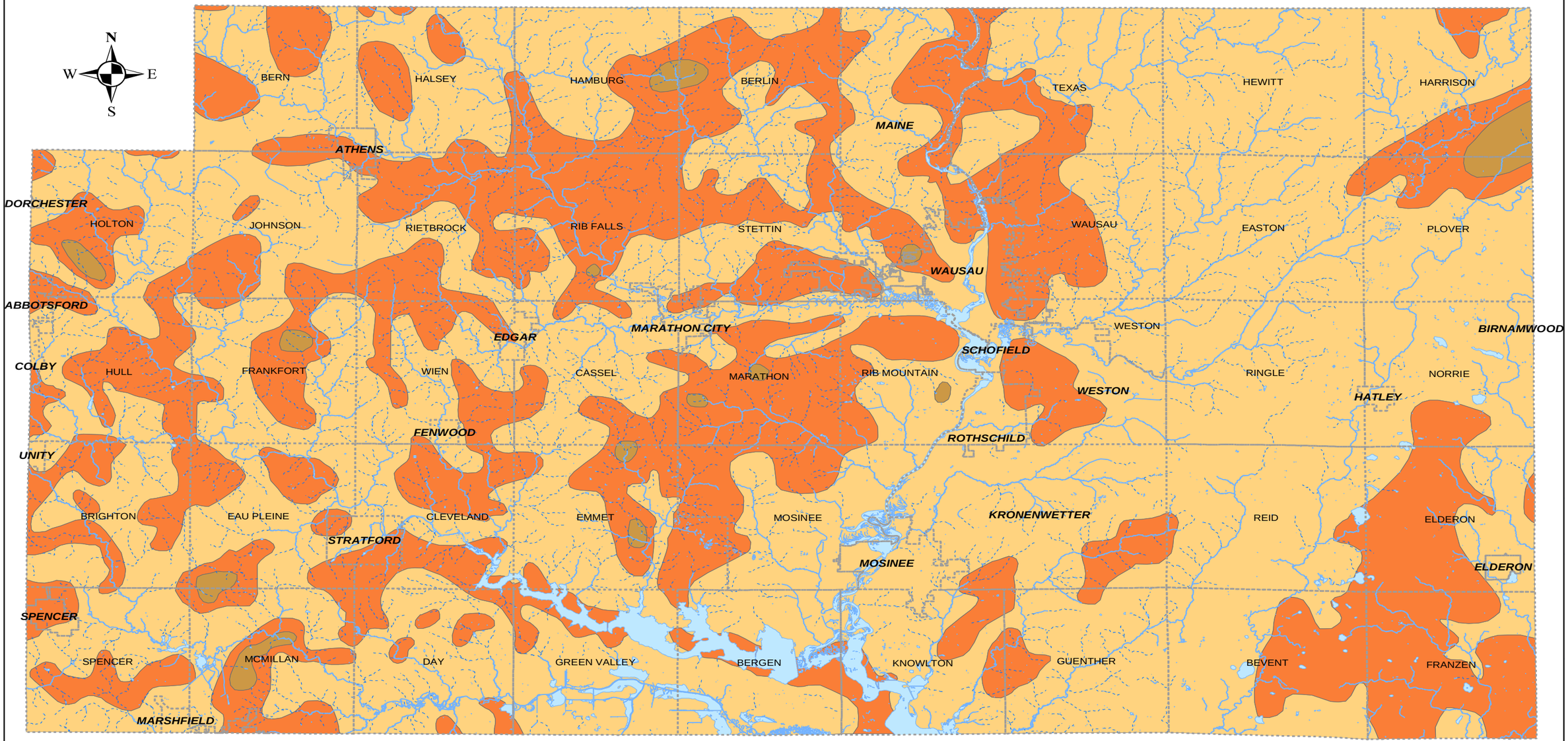
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KNOWLTON
GUENTHER
BEVENT
FRANZEN
MARSHFIELD
Municipal Boundary
Hydro Features
0-20 feet
20-50 feet
>50 feet
Source: "Irrigable Lands Inventory --- phase 1 Groundwater and Related Information", I.D. Lippelt and R.G. Hennings, MP -81-1, WGNHS 1981.
DEPTH TO GROUND WATER
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*FIGURE 2-13*

### *Groundwater Use*

The Wisconsin Water Use 2017 Withdrawal Summary, developed by DNR, indicates Marathon County as ranking 8th in the state for groundwater withdrawal. Marathon County is one of four counties withdrawing greater than 10 billion gallons as shown in Figure 2-14.

The number indicates ranking of total withdrawal by county (#1 = highest, #71 = lowest)

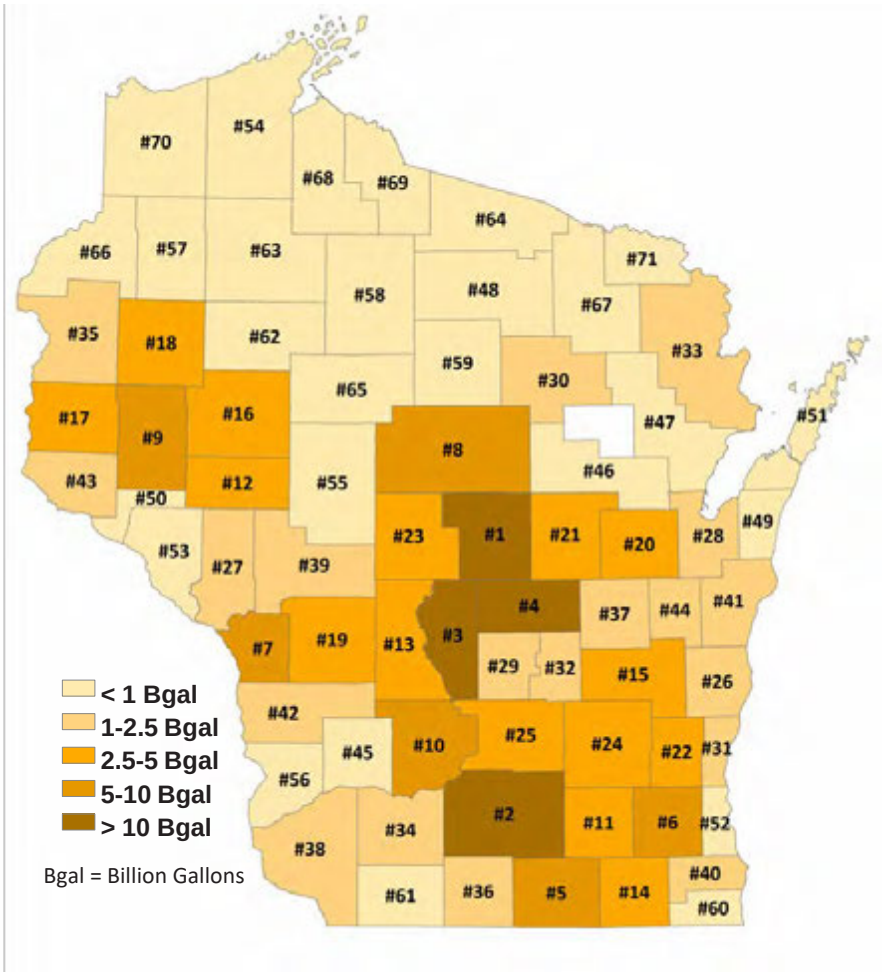



*Figure 2-14 Average Groundwater Withdrawals by County 2011-2017*

Source: https://dnr.wi.gov/topic/WaterUse/documents/WithdrawalReportDetail2017.pdf

### *Groundwater Use*

Groundwater is the major source of 17 municipal-owned and operated water treatment facilities for public water supply for domestic, and industrial use in Marathon County. Groundwater is also the primary source for private, domestic, industrial, and agricultural water supplies not served by municipal water. According to the Wisconsin Department of Natural Resources (WDNR), drinking water data, there were 11,501 wells constructed since 1987 for private homeowners in the county.

Most water used in Marathon County is drawn up from groundwater via high capacity wells. A high capacity well system is a water supply system that has the potential to draw over 100,000 gallons per day or 70 gallons/minute. The DNR High Capacity Well data displays high capacity wells by number of wells per square mile according DNR's (424 (306 https://dnr.wi.gov/wateruse/pub_v3_ext/Source) high capacity wells in Marathon County: Source DNR, July, 2015). The largest numbers of wells are found in the Wausau metro area and in the agricultural area in the southeastern portion of the County. The four largest wells reported quantities of water higher than most wells by several million gallons. These highest use wells are the Weston Power Plant, the Domtar Mill, the Mosinee Paper Mill, and the City of Wausau.

### *Groundwater and Agriculture*

Farms are major users of water; crop farming in the eastern half of Marathon County requires irrigation and accounts for most of the high capacity wells found in that area. However, on dairy farms, water is used for animal consumption, milk cooling, cleaning and sanitizing equipment, cow cooling, irrigating crops, producing value added products, moving manure, and cleaning barns through flush systems. The average dairy cow drinks 43.6 gallons of water per day and requires 6.3 gallons per day for cleaning, a total of almost 50 gallons per cow.

Marathon County is home to twelve permitted CAFOs as of 2019 according to the WDNR. CAFOs congregate animals, feed, manure and urine, and production operations on a small land area. These operations require large quantities of water for animal consumption, cleaning, and other uses. Runoff from CAFOs can have negative impacts to water quality due to the amount of animal waste on site.

### *Groundwater Contamination Susceptibility*

The porosity of soil profiles, textures of soil materials, and depth of the soil influence groundwater characteristics of the various soil associations. These unique soil characteristics play a functional role in both quality and quantity of groundwater resources. However, because of high infiltration and permeability rates of coarse soil types, the groundwater is vulnerable to contamination because of a low attenuation potential. Attenuation potential of a soil indicates the natural capability of a soil to reduce the impact of a contaminant by nature of its filtering characteristics.

Susceptibility of groundwater to pollutants is the ease with which a contaminant can be transported from the land surface to groundwater. Many materials that overlie the groundwater offer good protection from contaminants that might be transported by infiltrating waters. The amount of protection offered by the overlying material varies depending on the materials. In some areas, the overlying soil and bedrock materials allow contaminants to reach the groundwater more easily than in other areas.

Five physical resource characteristics are used to determine how easily a contaminant can be carried through overlying materials to the groundwater. These characteristics are depth to bedrock, type of bedrock, soil characteristics, depth to water table, and characteristics of surficial deposits. Figure 2-15: Groundwater Contamination Susceptibility, shows a composite map compiling all five of these characteristics into one map which shows the combined  suscenptibility score for each area.

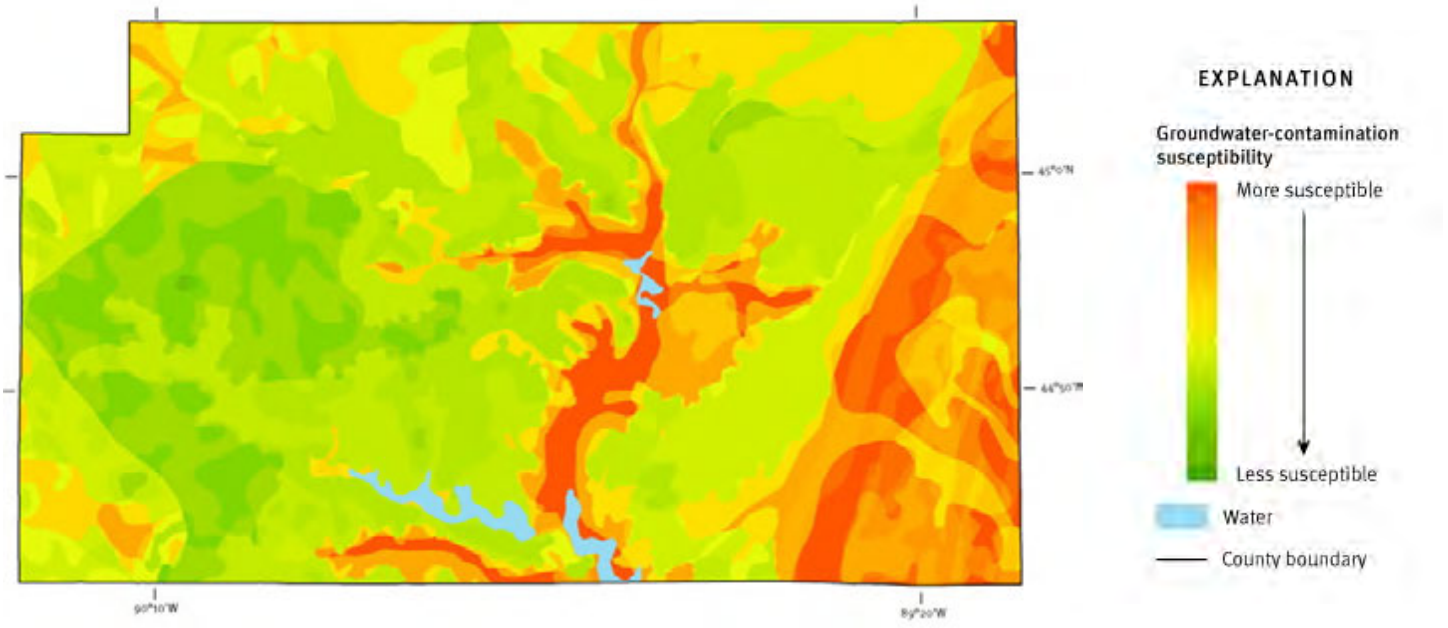



*Figure 2-15: Groundwater Contamination Susceptibility*

This groundwater-contamination susceptibility map is a compostie of five resource characteristic maps, each of which was derived from generalized statewide information at small scales, and cannot be used for any site-specific purposes.

Map source: Schmidt, R.R., 1987, Groundwater contamination susceptibility map and evaluation: Wisconsin Deparmtment of Natural Resources, Wisconsins's Groundwater Management plan Report 5, PUBL_WR-177-87, 27p.

Figure created for the "Protecting Wisconsin's Groundwater Through Comprehensive Planning" website, 2007, http://wi.water.usgs.gov/gwcomp/

## Source Water Protection

On December 20, 2018, the U.S. President signed the Agriculture Improvement Act of 2018, commonly known as the Farm Bill. The Bill earmarked source water protection a priority within U.S. Department of Agriculture conservation programs and to designate significant funding towards those efforts. NRCS is an agency within the U.S. Department of Agriculture (USDA) that works with private landowners including farmers and ranchers.

Under the new Farm Bill, ten percent of spending on Conservation Title programs is to be directed to source water protection, providing at least $4 billion over the next 10 years. These programs are intended to assist farmers, ranchers, and forest landowners protect and enhance environmental outcomes that have benefits both on and off-farm. Moreover, there is a now a directive for USDA to work closely with utilities to identify and prioritize areas that need source water protection.

Protecting sources of drinking water is an effective way to reduce risks to public health, control water treatment costs, and address water quality concerns at the source. Private landowners support safe drinking water through conservation practices to protect source water. The USDA's Natural Resources Conservation Service (NRCS), which helps farmers, ranchers and agricultural landowners address source water protection and other resource concerns, is launching a new effort in Wisconsin.

Figure 2-16 Illustrates Wisconsin's effort to target eight watersheds that will be eligible for special source protection efforts.

*Figure 2-16*

In Marathon County, the Plover River Watershed is a proposed source water protection watershed. The Plover River Watershed is located in the southeast portion of Marathon County and is an important water resource in the County.

## Drinking Water

### *Drinking Water Quality*

The Marathon County Strategic Plan 2018-2022 contains Objective 6.3: Protect and enhance the quantity and quality of potable groundwater and potable surface water supplies. Under Objective 6.3, five strategies include the following:

***Strategy A*** Update the 2001 Groundwater Protection Plan.

***Strategy B*** Continue to develop and implement watershed management plans and targeted management plans to minimize the impacts on water quality.

***Strategy C*** Evaluate the county's role in conducting tests and analysis of contaminants in private wells and in evaluating whether such tests should be mandatory instead of voluntary.

***Strategy D*** Explore alternative methods for snow and ice removal from hard surfaces to reduce the impact of salt on surface water and groundwater.

***Strategy E*** Create partnerships with agencies and organizations to further efforts to protect surface water and groundwater.

Groundwater is the major source of public water supply for private, domestic, agricultural, and industrial use in Marathon County. Areas along the Wisconsin and Rib Rivers provide ample water supply from alluvial aquifers; however, adequate groundwater is limited in parts of the county where dense bedrock is close to the surface.

The need for clean groundwater is both a health and economic issue. Groundwater quality and quantity, in both rural and urban areas can vary in any location at any time. Where groundwater becomes polluted, property values drop and a natural resource is diminished from its full potential. For this reason, local land use activities can significantly influence groundwater quality and quantity in terms of whether a valuable resource is protected and how all key stakeholders have an important role in its protection.

According to WI Department of Agriculture, Trade and Consumer Protection website, 4,395 acres of land in west central Marathon County is located in an Atrazine Prohibited Area. The University of Wisconsin-Stevens Point, Center for Watershed Science and Education, WI Well Water Quality Viewer indicates of 93 samples tested for atrazine, 21 samples or 23 percent detected atrazine while 4 samples or 4% exceeds the 3.0 ppb total atrazine standard. In addition, 1,256 samples were tested for Nitrate, 116 or 9% exceeds the health standard of >10mg/L N. A total of 540 samples were tested for bacteria, 121 or 22% tested positive for bacteria while 81 samples were tested for E. coli, 7 or 9% of the 81 samples tested positive.

The University of Wisconsin-Stevens Point, Center for Watershed Science and Education, provides a portal through the university's website to view water quality data for all counties in the State of Wisconsin. The Wisconsin Well Water Quality Viewer

for Private Well Data offers information regarding general well water data for Marathon County; however, drinking water quality data for Marathon County is still limited and would require more sampling or testing data to establish a better understanding of possible water quality concerns that may or may not exist within the county. Therefore, it must be carefully considered whether a well testing program is required to make better-informed decisions regarding public health.

### Surface Water Resources

Marathon County is the largest county in the State of Wisconsin with an approximate total square mile area of 1,584 or 1,013,760 acres. The county's Land Information Office calculated the total square mile area of Marathon County. Marathon County is primarily located within the Central Wisconsin River Basin with the exception of a small southeastern portion, approximately 65,000 acres, being divided by the Subcontinental Divide, which flows into the Fox-Wolf River Watershed of the Great Lakes Basin. The County has 202 lakes with a total surface area of 28,322 acres. The Big Eau Pleine Reservoir is the largest body of water with a potential area of 6,830 acres when full. Other lakes in the county include Lake Wausau, Half Moon Lake, and Lake DuBay and are the result of dams along river systems. Most natural lakes tend to be small and vary in depths ranging from one foot to thirty-four feet.

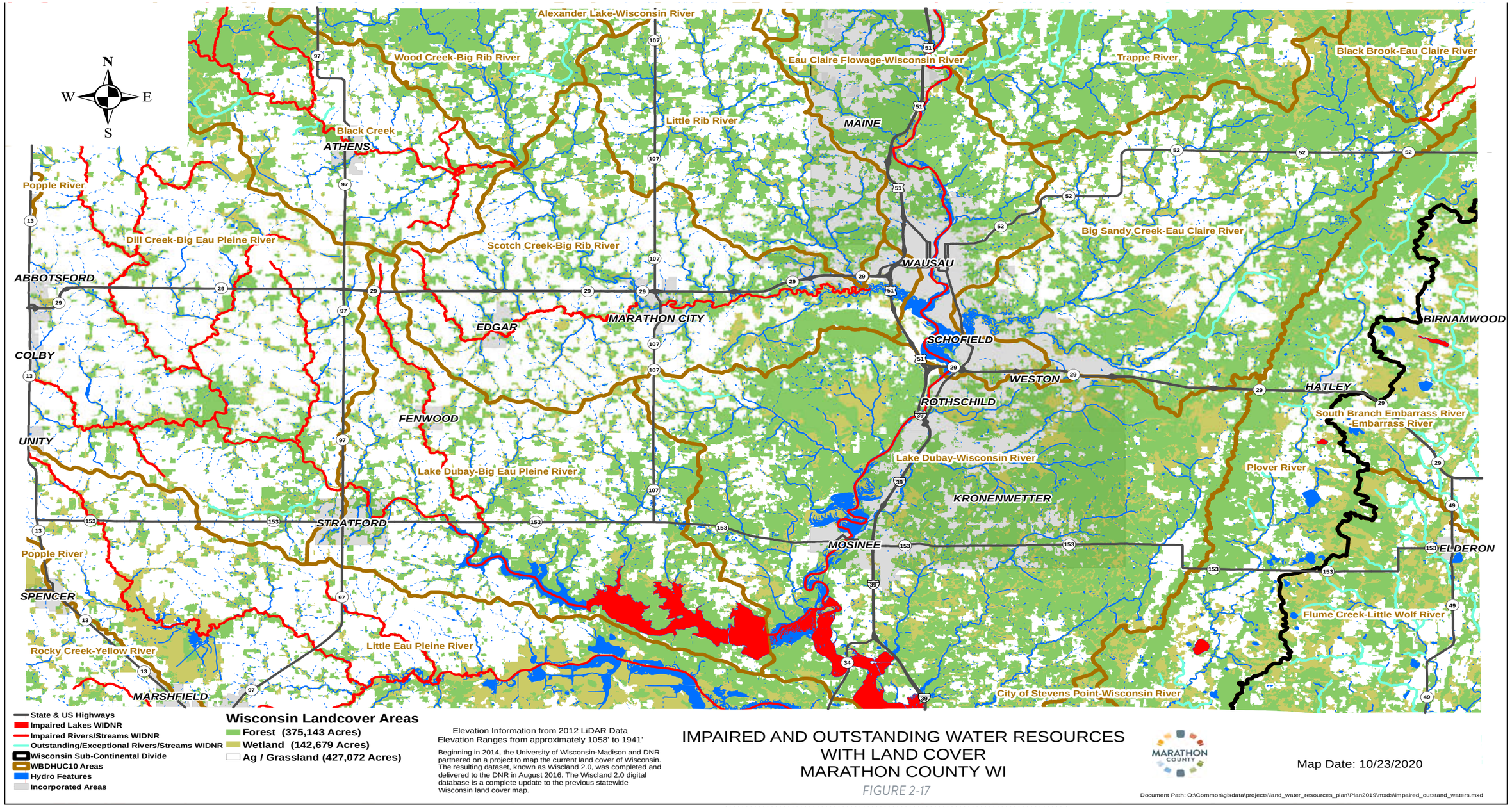
The county has 356 rivers and streams with a surface area of 3,748 acres. The Wisconsin River flows south through the county. Several dams on the mainstream and tributaries, which are controlled by the Wisconsin Valley Improvement Corporation (WVIC), regulate the river. Major tributaries flowing from the east to west include the Trappe, Eau Claire, Little Eau Claire and Plover Rivers. The major tributaries flowing from west to east are the Little Rib, Big Rib, Big Eau Pleine, and the Little Eau Pleine Rivers. The county contains all or part of 21 Hydrologic Unit Code (HUC) -10 watersheds as shown on Figure 2-17.

The two most significant wetland areas of the county include the Mead (33,000 acres) and the McMillan (5,700 acres) Wildlife Areas. These wetlands are important for nesting waterfowl and spawning fishes. Many lakes, reservoirs, rivers and wetlands in the county support recreational uses. Local officials should look to protect these water bodies whenever there is evidence that existing controls may not be adequate to protect the continued use of the resource for recreational use purposes.

The complex interaction of surface water and nonpoint source pollution is a result of activities that take place on the land surface and the water dynamics that occur as a result e.g., how water runs off the land surface or is absorbed into the ground. Consequently, all land use activities have the potential to contribute to nonpoint source pollution problems. In particular, there is an emerging realization that unchecked storm water runoff, carrying debris, nutrients, E-coli, CBOD, substances, oils and toxic materials from impervious surfaces, is in some cases a major stressor of critical water resources.

In Marathon County, many lakes, reservoirs, rivers, intermittent streams, headwater areas, and wetlands support recreational and other uses. Each of these resource areas are subject to its geographic location in terms of the type of stressors it may encounter. For example, whether a resource is located in an agricultural or urban area is important in terms of how different land use and human activities may have a positive or negative impact on the resource.

The need for careful judgment to facilitate the management and protection of regionally important water resource systems, which are sensitive to local environmental impacts and provide important benefits to Marathon County residents and the region, is essential. A number of protective measures were identified as possible means of enhancing water quality protection in the county under the auspices of the LWRM Plan. State and federal governments have identified water resources that warrant special protection through special water quality designations. The special protection available to these waters includes programs such as the TMDL study for the Wisconsin River, and classification designations established by DNR.




State & US Highways
Impaired Lakes WIDNR
Impaired Rivers/Streams WIDNR
Outstanding/Exceptional Rivers/Streams WIDNR
Wisconsin Sub-Continental Divide
WBDHUC10 Areas
Hydro Features
Incorporated Areas

**Wisconsin Landcover Areas**
Forest (375,143 Acres)
Wetland (142,679 Acres)
Ag / Grassland (427,072 Acres)

Elevation Information from 2012 LiDAR Data
Elevation Ranges from approximately 1058' to 1941'

Beginning in 2014, the University of Wisconsin-Madison and DNR partnered on a project to map the current land cover of Wisconsin. The resulting dataset, known as Wiscland 2.0, was completed and delivered to the DNR in August 2016. The Wiscland 2.0 digital database is a complete update to the previous statewide Wisconsin land cover map.

IMPAIRED AND OUTSTANDING WATER RESOURCES
WITH LAND COVER
MARATHON COUNTY WI

*FIGURE 2-17*

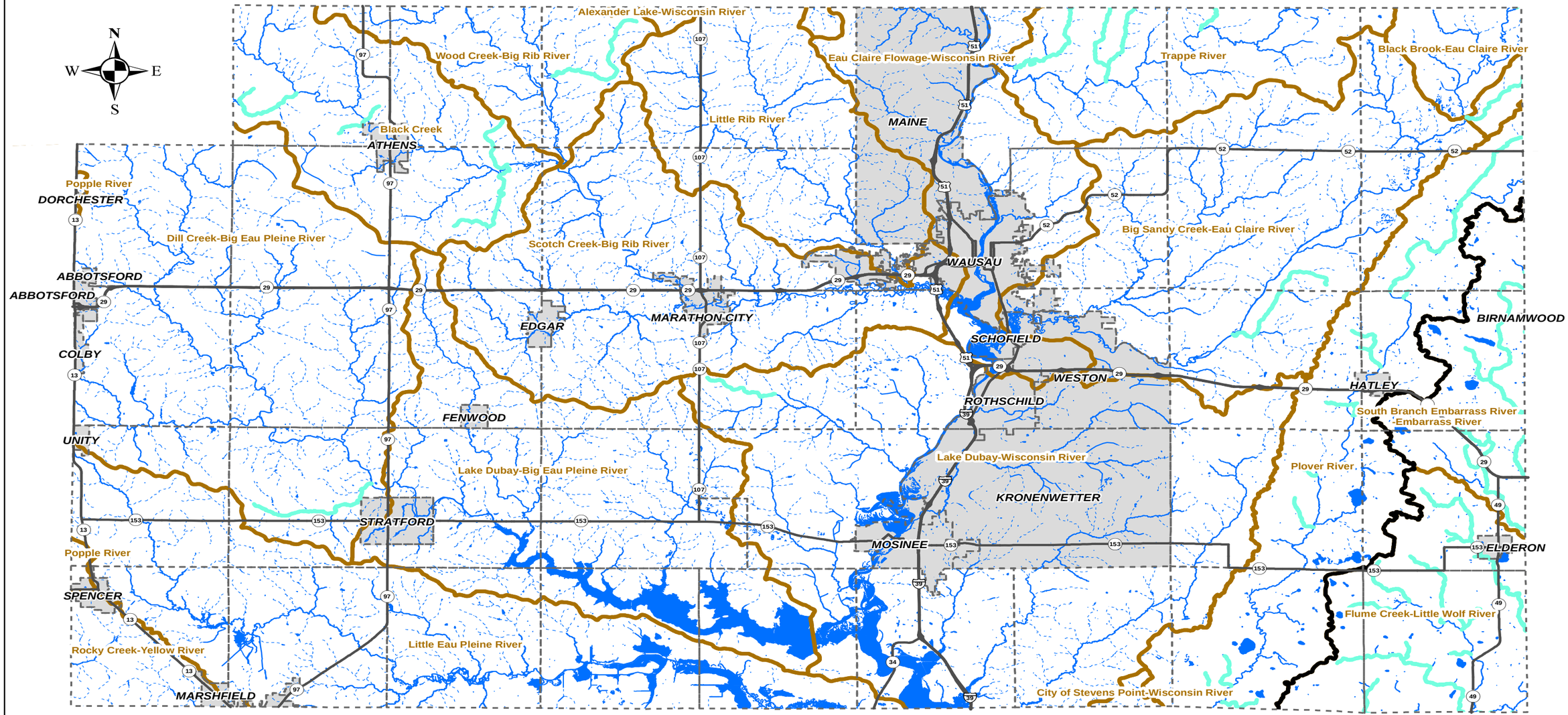
Map Date: 10/23/2020

Document Path: O:\Common\gisdata\projects\land_water_resources_plan\Plan2019\mxds\impaired_outstand_waters.mxd

## Watershed Water Quality Conditions

### *Outstanding and Exceptional Resource Waters*

An Outstanding Resource Water (ORW) is a lake, stream or flowage having excellent water quality, high recreational and aesthetic value and high quality fishing. ORW waters are free from point source or nonpoint source pollution. An Exceptional Resource Water (ERW) is a lake, stream, or flowage exhibiting the same high quality resource values as outstanding waters, but may be affected by point source pollution. Several streams in the County are classified as ORW or ERW as shown in (Figure 2-18). Outstanding and exceptional resource waters, found in Appendix D, is data collected from DNR and provides greater detail of each outstanding or exceptional water resource in Marathon County.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Alexander Lake-Wisconsin River
Wood Creek-Big Rib River
Eau Claire Flowage-Wisconsin River
Trappe River
Black Brook-Eau Claire River
Little Rib River
Black Creek
ATHENS
MAINE
Popple River
DORCHESTER
Dill Creek-Big Eau Pleine River
Scotch Creek-Big Rib River
Big Sandy Creek-Eau Claire River
WAUSAU
ABBOTSFORD
ABBOTSFORD
EDGAR
MARATHON CITY
BIRNAMWOOD
SCHOFIELD
COLBY
WESTON
HATLEY
ROTHSCHILD
FENWOOD
South Branch Embarrass River
Embarrass River
UNITY
Lake Dubay-Wisconsin River
Lake Dubay-Big Eau Pleine River
Plover River
KRONENWETTER
STRATFORD
MOSINEE
ELDERON
Popple River
SPENCER
Flume Creek-Little Wolf River
Rocky Creek-Yellow River
Little Eau Pleine River
City of Stevens Point-Wisconsin River
MARSHFIELD
Outstanding/Exceptional Rivers/Streams WIDNR
Wisconsin Sub-Continental Divide
WBDHUC10 Areas
Hydro Features
Municipal Boundary
Incorporated Areas
State & US Highways
OUTSTANDING & EXCEPTIONAL WATER RESOURCES
MARATHON COUNTY WI
MARATHON COUNTY
Map Date: 10/20/2020
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*FIGURE 2-18*

*Eastern Lakes Project*

The Eastern Lakes Project is a partnership of citizens, eastern Marathon County communities, Marathon County government, and the University of Wisconsin Stevens Point. The project will assess the lakes of Eastern Marathon County and plan for lake management and protection.

The Eastern Lakes Project includes lake studies, lake management plans and final summary lake reports for the following lakes: Bass, Big Bass, Lilly, Lost, Mayflower, Mission, Mud, Norrie, Pike, Rice, and Wadley Lakes. For review each plan, visit the Marathon County website at: http://www.co.marathon.wi.us/Departments/ConservationPlanningZoning/ConservationServices/WatershedInformation.aspx.

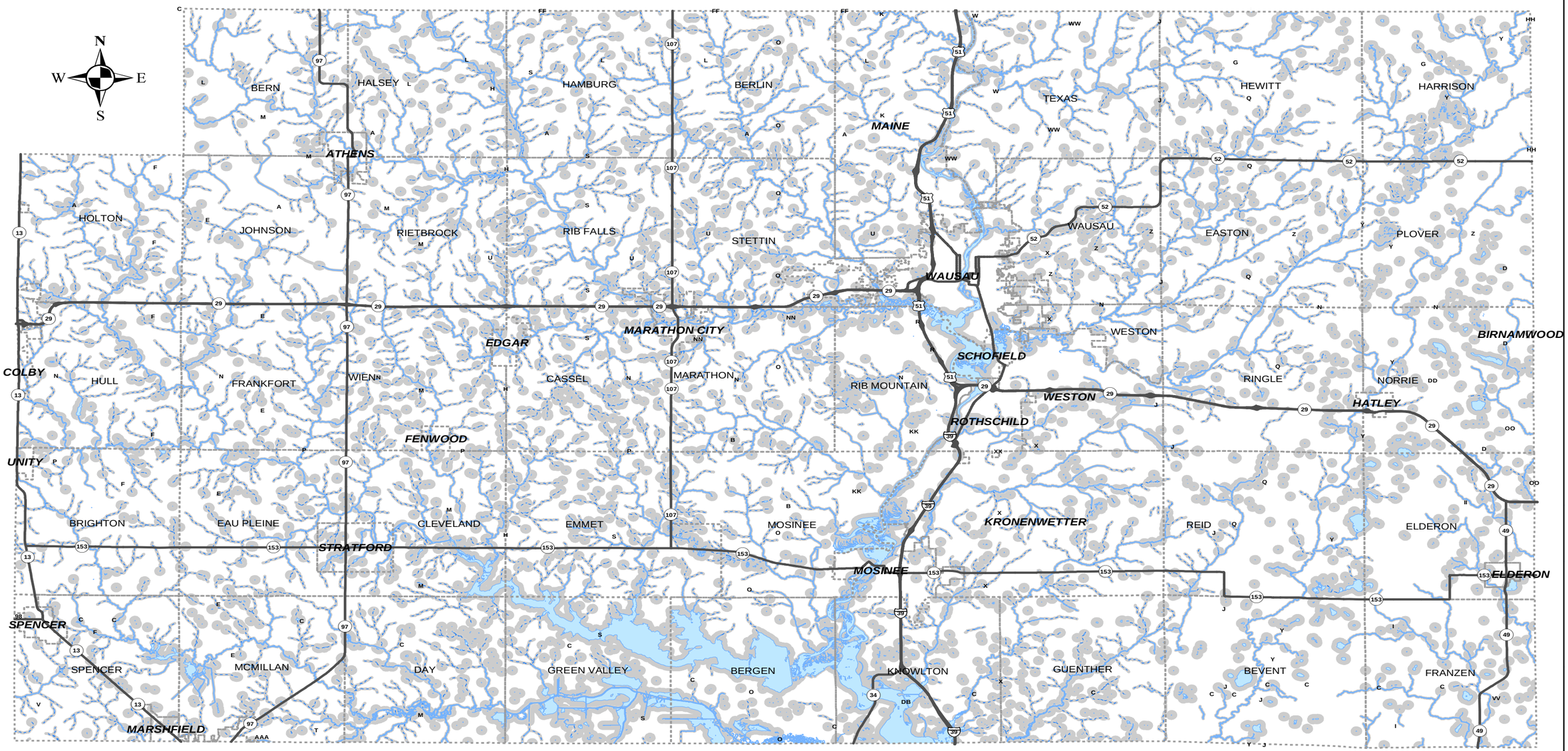
## Shoreland Areas

*Water Quality Management Areas (WQMA's)*

A WQMA or shoreland area is defined as an area located within 1000 feet from the ordinary high-water mark of navigable ponds, lakes, or flowages and areas within 300 feet from the ordinary high-water mark of navigable rivers and streams or landward edge of a floodplain. Marathon County has delineated the WQMA's areas greater than five acres in size as shown in Figure 2-19.

Wisconsin Administrative Code NR115 dictates the shoreland management program, which requires counties to protect the natural buffer, and to manage the disturbance of critical habitat and reduce erosion and runoff into these resource areas.

*spring runoff in impaired watershed*




Municipal Boundary
300 Feet Streams; 1000 Feet Lakes
Hydro Features

## WATER QUALITY MANAGEMENT AREAS
## MARATHON COUNTY WI

*FIGURE 2-19*

Map Date: 8/11/2020

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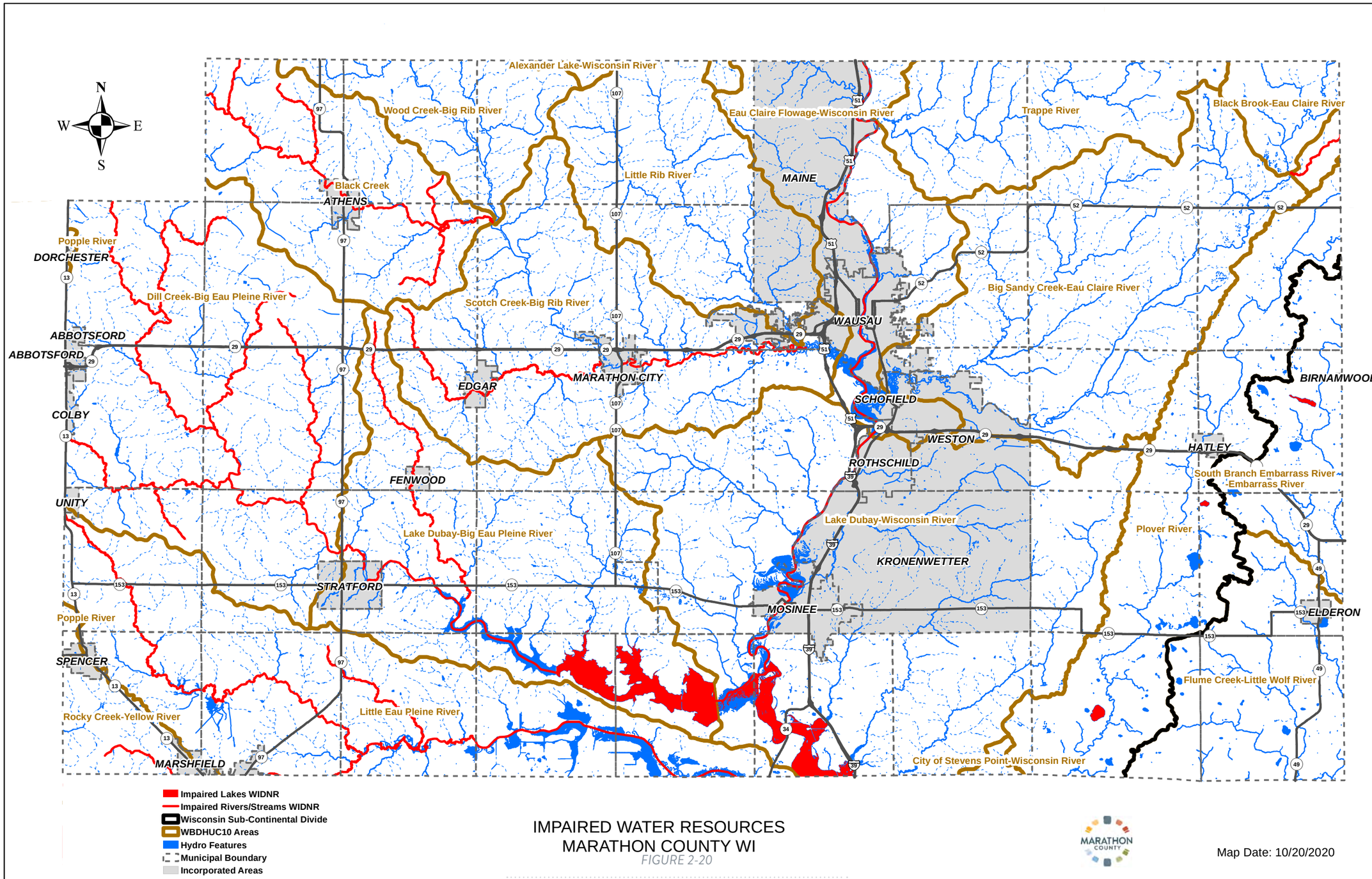
### Impaired Water Quality Conditions

Marathon County encompasses portions of 22 watersheds (Figure 2-20) that comprise a network of rivers, streams and creeks. Several surface waters within these watersheds have been identified as "impaired waters" on the "303 (d) list" of the U.S. Clean Water Act. The list identifies waters that do not meet current water quality standards and merit water quality improvement and protection.

Appendix E, is a complete list of Section 303(d) listed impaired water resources as determined by the WI DNR. Impaired waters within Marathon County are typically located west of the Wisconsin River including the Wisconsin River itself and the impairment is primarily caused from low dissolved oxygen and phosphorus associated with agricultural nonpoint runoff.

The list, required by the Environmental Protection Agency (EPA) under the Clean Water Act, identifies water bodies that do not meet water quality standards. The Department of Natural Resources uses the 303(d) list as the basis for establishing strategies to improve water bodies using total maximum daily loads.

*runoff in Big Eau Pleine River*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Alexander Lake-Wisconsin River
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Eau Claire Flowage-Wisconsin River
Trappe River
Black Brook-Eau Claire River
Little Rib River
Black Creek
ATHENS
MAINE
Popple River
DORCHESTER
Dill Creek-Big Eau Pleine River
Scotch Creek-Big Rib River
Big Sandy Creek-Eau Claire River
WAUSAU
ABBOTSFORD
ABBOTSFORD
EDGAR
MARATHON CITY
BIRNAMWOOD
SCHOFIELD
COLBY
WESTON
HATLEY
ROTHSCHILD
FENWOOD
South Branch Embarrass River
Embarrass River
UNITY
Lake Dubay-Big Eau Pleine River
Lake Dubay-Wisconsin River
Plover River
KRONENWETTER
STRATFORD
MOSINEE
ELDERON
Popple River
SPENCER
Flume Creek-Little Wolf River
Rocky Creek-Yellow River
Little Eau Pleine River
MARSHFIELD
City of Stevens Point-Wisconsin River
Impaired Lakes WIDNR
Impaired Rivers/Streams WIDNR
Wisconsin Sub-Continental Divide
WBDHUC10 Areas
Hydro Features
Municipal Boundary
Incorporated Areas
IMPAIRED WATER RESOURCES
MARATHON COUNTY WI
FIGURE 2-20
MARATHON COUNTY
Map Date: 10/20/2020

### Wisconsin River TMDL

Section 303(d) of the Clean Water Act established the TMDL program. The TMDL program identifies and restores polluted rivers, lakes, streams, and other surface waterbodies by quanitatively assessing the water quality problems and contributing sources of pollution. The TMDL determines how much a pollutant needs to be reduced to meet water quality standards, and provides the foundation for taking actions locally to restore a waterbody to fishable and swimmable standards.

TMDLs must be developed for waterbodies impaired by point sources and/or nonpoint sources. The TMDL is one important tool required by the Clean Water Act and employed by Wisconsin DNR to quantitatively assess the quality of a waterbody and allocate allowable pollutant loads among sources along the stream and/or river. The U.S. EPA approved the Wisconsin River TMDL in 2019. This plan specifies pollutant load allocations for all dischargers in the watershed to achieve statewide water quality goals.

According to Wisconsin DNR, the Wisconsin River TMDL study includes an area from Vilas County to Lake Wisconsin in Columbia County, covering 9,156 square miles – approximately 15 percent of the state. The project area also encompasses:

- More than 110 wastewater dischargers
- 2nd & 5th largest inland lakes in Wisconsin
- 4 reaches impaired for suspended solids
- 16 reaches impaired for phosphorus
- 85 Cities and Villages
- 25 major tributaries
- 21 Counties

The Wisconsin River Basin TMDL report indicates that Marathon County should focus efforts to reduce exceedances of phosphorus limits. As expected phosphorus reductions vary across the county based on parameters set for rivers, streams, reservoirs, and lakes. In Marathon County, the Upper Wisconsin River main stem has a phosphorus criterion of 100 µg/L, while the Big Eau Pleine and Little Eau Pleine River TP standard is 75 µg/L. For Lost Lake, Big Eau Pleine Reservoir, and Lake Du Bay, the TP standard is 20, 30 and 100 µg/L, respectively.

Figure 2-21 indicates a trend of increasing stream miles as being phosphorus impaired.

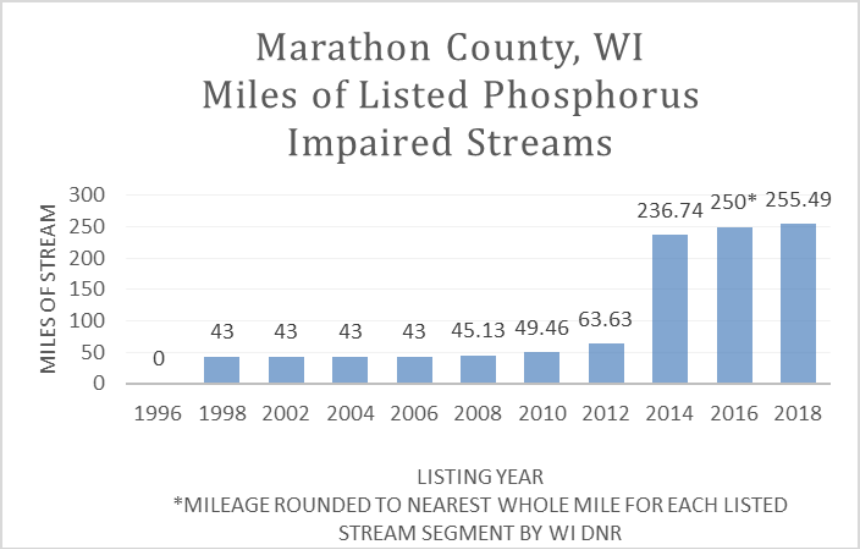



*Figure 2-21 Source: Wisconsin Department of Natural Resources*

Figure 2-20, illustrates the subbasins or stream reaches as designated by the Wisconsin River Watershed TMDL report which influence Marathon County. The subbasins impaired by exceedances of phosphorus as per DNR data and the approved TMDL are outlined in red and are generally located in the western portion of the county. In addition, WISLAND2.0 land cover data clearly demonstrates a correlation or strong association in terms of land cover type (agriculture) and phosphorus impaired subbasins within Marathon County. According to CPZ's GIS analysis, Marathon County's overall land cover in descending order indicates the following breakdown; Forest – 37%, Agriculture – 29%, Wetland – 14%, Grassland -13%, Urban – 5%, and Open Water – 2%, respectively.

Further analysis of the TMDL and land cover data indicates an increasing trend of total subbasin acreage being located in a watershed reach impaired by phosphorus. For example, in 2008, 82,071.38 acres were located in an identified 303(d) impaired subbasin and in 2018 509, 967.79 acres were located in a 303(d) impaired sub-basin. This six-fold increase over a ten year period, reveal a discouraging trend in Marathon County. Various factors influence the increase of total acreage within phosphorus impaired sub-basins, and greater attention and analysis should be directed on a reach-by-reach investigation toward limiting or reversing this negative trend. This trend also indicates that the current NR 151 APSP are not sufficient to improve water quality conditions on a watershed level basis.

Appendix J-Allocations Current Criteria, Table J-5 of the TMDL report identifies the annual total phosphorus reductions from baseline conditions in order to meet local and downstream criteria for each TMDL reach. The Big Eau Pleine River Watershed is 358.1 square miles and is located in Clark, Marathon and Taylor Counties with an average annual phosphorus load of 69.8 tons. The impaired waters within this watershed include; Big Eau Pleine River, Dill Creek, East Branch Big Eau Pleine River, Fenwood Creek, Hamann Creek, Raeder Creek, Randall Creek, West Branch Big Eau Pleine River, and the Big Eau Pleine Flowage. To achieve the total phosphorus reductions goal, the Big Eau Pleine Reservoir calls for an 84% downstream reduction of phosphorus to meet the reservoir water quality TP standard of 30 µg/L and indicates a total phosphorus reduction of 113,031 pounds per year.

The Little Eau Pleine River Watershed is 250 square miles and is located in Clark, Marathon, Portage, and Wood Counties with an average annual phosphorus load of 38.3 tons. The impaired waters in this watershed include Little Bear Creek, Little Eau Pleine River, Squaw Creek, and Wild Creek. To achieve the total phosphorus reductions goal, the Petenwell Reservoir, with a TP standard of 40 µg/L, calls for a 79% downstream reduction of phosphorus is required and indicates a total phosphorus reduction

of 57,746 pounds per year.

The Rib River Watershed is 488.2 square miles and is located in Taylor, Marathon, and Lincoln Counties with an average annual phosphorus load of 52.2 tons. The impaired waters include Black Creek and Scotch Creek. To achieve the total phosphorus reductions goal, the Petenwell Reservoir calls for a 79% downstream reduction of phosphorus is required and indicates a total phosphorus reduction of 67,366 pounds per year.

The Upper Wisconsin River Corridor is 539 square miles and is located in Lincoln, Marathon, and Portage Counties with an average annual phosphorus load of 65.3 tons. Impaired waters within this watershed include the Wisconsin River, Eau Pleine Reservoir, and Lake Du Bay. The total phosphorus reductions goal calls for a 79% downstream reduction of total phosphorus reduction of 3,798 pounds per year.

Appendix N of the TMDL focuses on the agricultural phosphorus load allocations that reflect the phosphorus yields at the edge of field for each reach in Marathon County. The purpose of appendix N is to help provide agricultural practitioners, and producer's meaningful data to attain TMDL phosphorus-loading targets on cropland. Target levels vary per reach or subbasin and will require site-specific practices to be incorporated in order to achieve identified phosphorus reductions. It should be noted that compliance with total TMDL phosphorus reduction targets is voluntary unless the targets are adopted by county ordinance and DNR revision of the current NR 151 performance standards to reflect TMDL cropland reduction goals. Currently, NR 151 has an agricultural performance standard for phosphorus loss from cropland and pastures (i.e. fields must bemanaged to maintain a (P-Index score) 6. If a lower P-Index performance standard is not established by the State, Marathon County will never meet its phosphorus reduction goals to improve water quality standards in TMDL and 303(d) listed watersheds.

Appendix F of the TMDLs report contain tables showing HUC12 watersheds within Marathon County and the recommended phosphorus reduction necessary to meet water quality standards. The site-specific criteria (SSC) within the tables, allow aquatic parameters to be adjusted to local conditions and are often less costly to meet federal or state water quality standards.

### *Fenwood Watershed Pilot Project*

Fenwood Creek Subwatershed is representative of the larger Big Eau Pleine (BEP) River Watershed relative to phosphorus loading, natuarl resource concerns and from primarily by nonpoint agricultural runoff. The Fenwood Creek Watershed drains approximately 39 square miles (24,958 acres) of land into the BEP reservoir. All studies, research, and monitoring efforts point to two primary causes of water quality degradation: soil sedimentation and nutrient enrichment, primarily from agriculture.

Marathon County initiated a pilot project in the Fenwood Creek watershed, which is a representative HUC 12 dairy industry-based watershed within the BEP River watershed. CPZ has and will continue to secure staff and cost share funding to implement and document improvements in the watershed. The Fenwood Creek wastershed has an EPA and DNR approved 9 Key Element Watershed-Based Plan. Initial and Intermediate outcomes for the Fenwood Creek plan will focus upon grant funded activities. Long-term outcomes will be administered through the proposed Wisconsin River Total Maximum Daily Load (TMDL) plan.

Water Quality monitoring by the DNR for the Upper Wisconsin TMDL provided four years (2010-2013) of water data in the Fenwood Creek to measure current nutrient loading levels. Based upon the median phosphorus concentration of the Fenwood Creek, the predicted average annual phosphorus load delivered to the Big Eau Pleine Reservoir is 11,288 pounds. In 2015, WI Department of Natural Resources staff determined that the current estimated phosphorus concentration (expressed as the flow-weighted mean) for Fenwood Creek is 187 µg/L. Furthermore, the DNR staff estimated that a 45% reduction in the flow-weighted mean concentration is needed to reach median concentration of 75 µg/L, the water quality goal for the Fenwood Creek. A 45% reduction of in-stream phosphorus represents nearly 5,080 pounds (based on the 11,200 pound 4 year average) determined by DNR 2010-2013 stream monitoring.

During the development of this report, CPZ staff conducted a simple qualitative habitat evaluation of land cover using WISCLAND2.0 data in a 60 meter buffer of all streams in the Fenwood Creek Watershed in a typical Marathon County

phosphorus impaired watershed, see Figures 2-22 and 2-23. The Fenwood Creek Watershed area includes the following Wisconsin River TMDL stream reaches 88, 89, 90, 325, and 326. The intent of this exercise was to evaluate land cover within the 60-meter buffer in comparison of all the overall land cover in the watershed. The findings within the buffer indicate the following land cover breakdown by percentage: 34% wetland, 30% forest, 23% agriculture, 13% grassland, with zero percentage for urban, open water, barren, and shrubland. Conversely, the land cover for the entire Fenwood Creek watershed had the following results: 51% agriculture, 24% forest, 14% grassland, 10% wetland, 1% urban with a zero percentage of open water, barren, and shrubland.

The initial observation of approved USEPA TMDL phosphorus data for the Fenwood Creek Watershed in comparison with land cover data appear to indicate that the dynamics and balance of land use and land cover is overloading the watershed's hydrologic and wetland complex system, thereby, preventing the ability of the natural system to function properly. This overloading and/or loss of function to assimilate nutrient loading within the Fendwood Creek watershed is also common in other 303(d) phosphorus impaired watersheds in Marathon County.

*completed wetland restoration project*

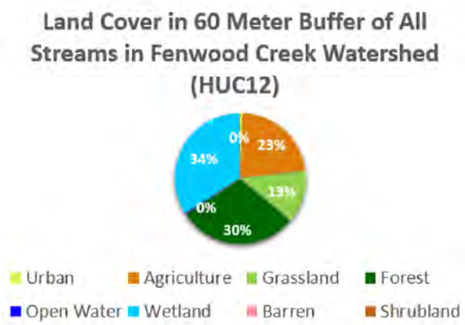
### Wetland Conditions

According to WISLAND 2.0 digital data, Marathon County has 142,679 acres of wetland. The Mead (33,000 acres) and the McMillan (5,700 acres) Wildlife Areas are the most extensive wetland and grassland regions located in the county. Wetlands are important for nesting waterfowl and spawning fishes. The flowages in these areas were developed to create waterfowl nesting sites and feeding areas for migratory waterfowl.

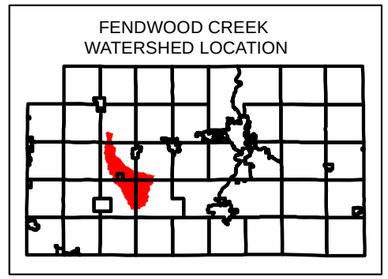
The Wisconsin Wetland Inventory (WWI) completed for the state in 1985 using aerial photography from 1978-79, shows approximately 5.3 million acres of wetlands remaining in the state representing a loss of about 47% of original estimated 10 million wetland acreage; however, this figure excludes small wetlands typically under 2 acres. A similar trend occurred in Marathon County, as wetlands were drained from the late 1940's through the 1970's, on the west side of the county for cropland through constructed "w"-shaped surface ditches. These long, narrow drainage channels improved crop production, but also increased runoff rates and the flashy nature of the streams. The majority of "w"-shaped surface drainage ditches still function in agriculture areas. As a result, many functions of wetlands have been disrupted in terms of providing critical habitat, water storage to help prevent flooding, groundwater recharge areas, and capacity to filter pollutants.

FENWOOD CREEK WATERSHED
LAND COVER IN 60 METER
BUFFER OF ALL STREAMS

MARATHON COUNTY, WI




WISCLAND2.0 LAND COVER
Beginning in 2014, the University of Wisconsin-Madison and DNR partnered on a project to map the current land cover of Wisconsin. The resulting dataset, known as Wiscland 2.0, was completed and delivered to the DNR in August 2016. The Wiscland 2.0 digital database is a complete update to the previous statewide Wisconsin land cover map.




**Legend**

TMDL Subbasins
Fenwood Creek Watershed

**Land Cover - 60 M Buffer (Fenwood)**

Wetland
Urban/Developed
Shrubland
Open Water
Grassland
Forest
Barren
Agriculture

MARATHON COUNTY

Map Date: 01/30/2020

*FIGURE 2-22*

Document Path: O:\CONSERVATION\Watersheds\Marathon_Stream_Data\DNR_Impaired_Waters_Projects\MXDs\MXDs_For_Map_Making\HUC_12_Fenwood_All_Stream_Buffers.mxd

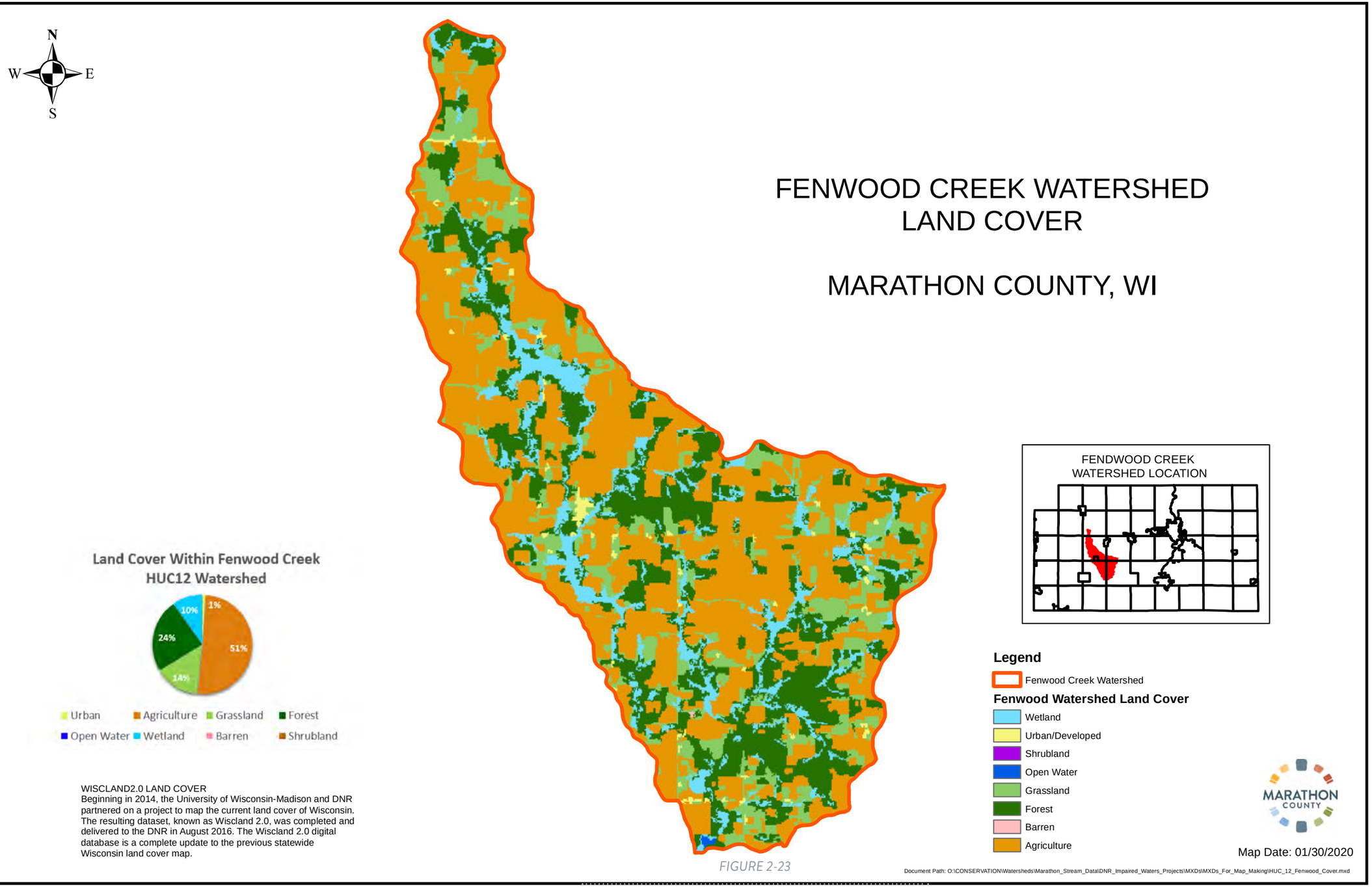

N
W
E
S
FENWOOD CREEK WATERSHED
LAND COVER
MARATHON COUNTY, WI
Land Cover Within Fenwood Creek
HUC12 Watershed
1%
51%
14%
24%
10%
Urban
Agriculture
Grassland
Forest
Open Water
Wetland
Barren
Shrubland
WISCLAND2.0 LAND COVER
Beginning in 2014, the University of Wisconsin-Madison and DNR partnered on a project to map the current land cover of Wisconsin. The resulting dataset, known as Wiscland 2.0, was completed and delivered to the DNR in August 2016. The Wiscland 2.0 digital database is a complete update to the previous statewide Wisconsin land cover map.
FENDWOOD CREEK
WATERSHED LOCATION
Legend
Fenwood Creek Watershed
Fenwood Watershed Land Cover
Wetland
Urban/Developed
Shrubland
Open Water
Grassland
Forest
Barren
Agriculture
MARATHON COUNTY
Map Date: 01/30/2020
Document Path: O:\CONSERVATION\Watersheds\Marathon_Stream_Data\DNR_Impaired_Waters_Projects\MXDs\MXDs_For_Map_Making\HUC_12_Fenwood_Cover.mxd

*FIGURE 2-23*

Marathon County Chapter 22, Shoreland, Shoreland-Wetland, and Floodplain regulate wetlands; however, consideration should be given to establish greater protections in order to safeguard the remaining wetlands. The federal government and the DNR restrict development in wetlands through Section 404 of the Clean Water. Wetlands meeting the state definition are subject to DNR regulations and federal regulations may apply in addition to or instead of state regulations.

### Woodland Conditions

According to DNR's Wisland 2.0 data, Marathon County has approximately 375,143 acres of forest. Much of the forest areas are managed and owned by private landowners. The county's Parks, Recreation, and Forestry Department manage nine forest units totaling 30,195 acres. The mission of the Marathon County Forest program is to manage and protect these natural resources on a sustainable basis for ecological, economic, educational, recreational, and research needs of present and future generations.

In the Marathon County Strategic Plan 2018 – 2022, the Parks, Recreation, and Forestry Department will support:

**Objective 5.2:** Promote sound land use decisions that conserve and preserve natural resources in decisions with economic development and growth.

**Strategy F:** Acquire land for Public Park and forest use to retain natural landscapes and resources.

**Outcome Measure 3:** The County acquires an average of 320 acres of land per year through 2022.

The long-term goal is to administer the Marathon County Forest Program, considering the recommendations of interested citizens, in a manner consistent with the mission statement and the purpose of the County Forest Law:

". . . to provide the basis for a permanent program of county forests and to enable and encourage the planned development and management of the county forests for optimum production of forest products, together with recreational opportunities, wildlife, watershed protection and stabilization of stream flow, giving full recognition to the concept of multiple use to assure maximum public benefits; to protect the public rights, interests and investments in such lands; and to compensate the counties for the public uses, benefits and privileges these lands provide; all in a manner which will provide a reasonable revenue to the Towns is which such lands lie." (Sec.28.11, Wis. Statutes)

The DNR MFL program provides incentives to protect privately owned woodlands from unmanaged timber practices, improper harvesting and prevents land from becoming developed and/or converted to agricultural land use. Lands are enrolled in the MFL program; these properties are no longer susceptible to further subdivision and continued residential housing sprawl, without penalty and withdrawal. According to the Wisconsin DNR Forest Crop Law & Managed Forest Law – 2019 Master Listing, Marathon County has 14,727.4 acres listed as "open" and 97,636.4 acres are listed as "closed."

### Rare, Endangered, and Threatened Species and Communities

The Wisconsin Natural Heritage Inventory, last updated in August 2018, is a working list containing known species to be rare, endangered or threatened in the state along with natural communities native to Wisconsin. It includes species legally designated as "endangered" or "threatened." The DNR's Natural Heritage Conservation Program policy recommends that the **endangered** and **threatened** list should be reviewed every five years or earlier, as needed. Marathon County data is available at the county or township level and should be used for land management, master planning, community planning, conservation planning and review of public and private activities across the state in order to protect these threatened species and communities.

Source: https://dnr.wi.gov/topic/NHI/Data.asp

https://dnr.wi.gov/topic/NHI/documents/NHIWorkingList.pdf

## Agricultural Land Conditions

### *Agricultural Land*

According to the 2013 Marathon County Farmland Preservation Plan, agriculture in Marathon County, like the rest of Wisconsin, has experienced significant changes over the past 30 years. There are numerous reasons for these shifts in agricultural activities and practices including changes in economics, population growth, societal changes, operational practices, support services, and state and national policies. From 1987-2017 there has been a 19% decrease in acres of land in farms and a 27% decrease in the number of farm operations. Similar to most other farming areas in Wisconsin, remaining farm operations have tended to become larger with more livestock per farm (Figure 2-24), and more acres per farm—an 11% increase. There has also been a large decline in the number of dairy farms—a 68% decrease—(Figure 2-25) and a subsequent decrease in traditional perennial dairy forage crops such as alfalfa and grass hay, with a shift to more annual cash grain crops like corn and soybeans and more frequent tillage (Figure 2-26).

Along with this shift in crops has come an increase in soil erosion and its negative impacts on soil health and water quality. The soil erosion transect survey conducted by Marathon County CPZ indicates an increase in average county-wide cropland soil erosion from 1.6 tons/acre/year in 1999—the first year the survey was conducted—to 2.6 tons/acre/year in 2020, and a decrease in cropland fields meeting the Tolerable Soil Loss "T" erosion rate from 86% in 1999 to 75% in 2020.

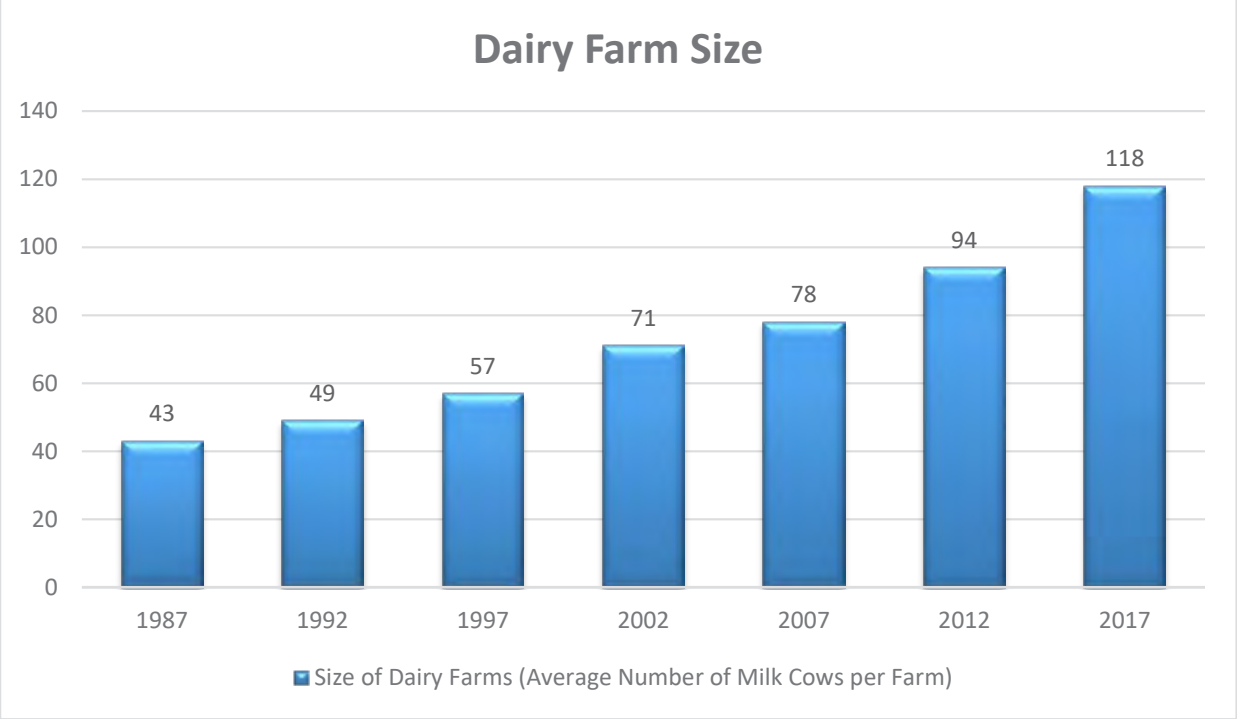



*FIGURE 2-24 Source National Agricultural Statistics Service*

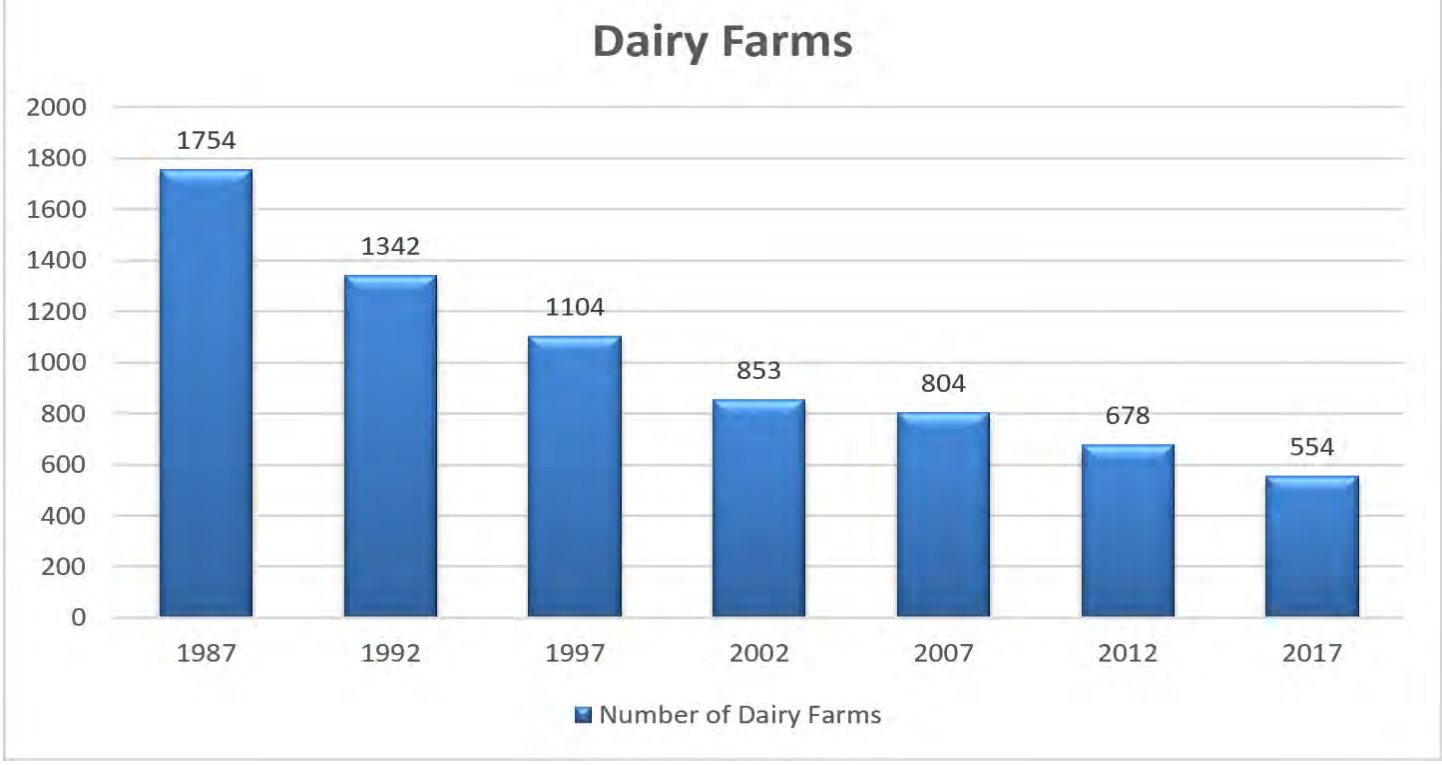



*FIGURE 2-25 Source National Agricultural Statistics Service*

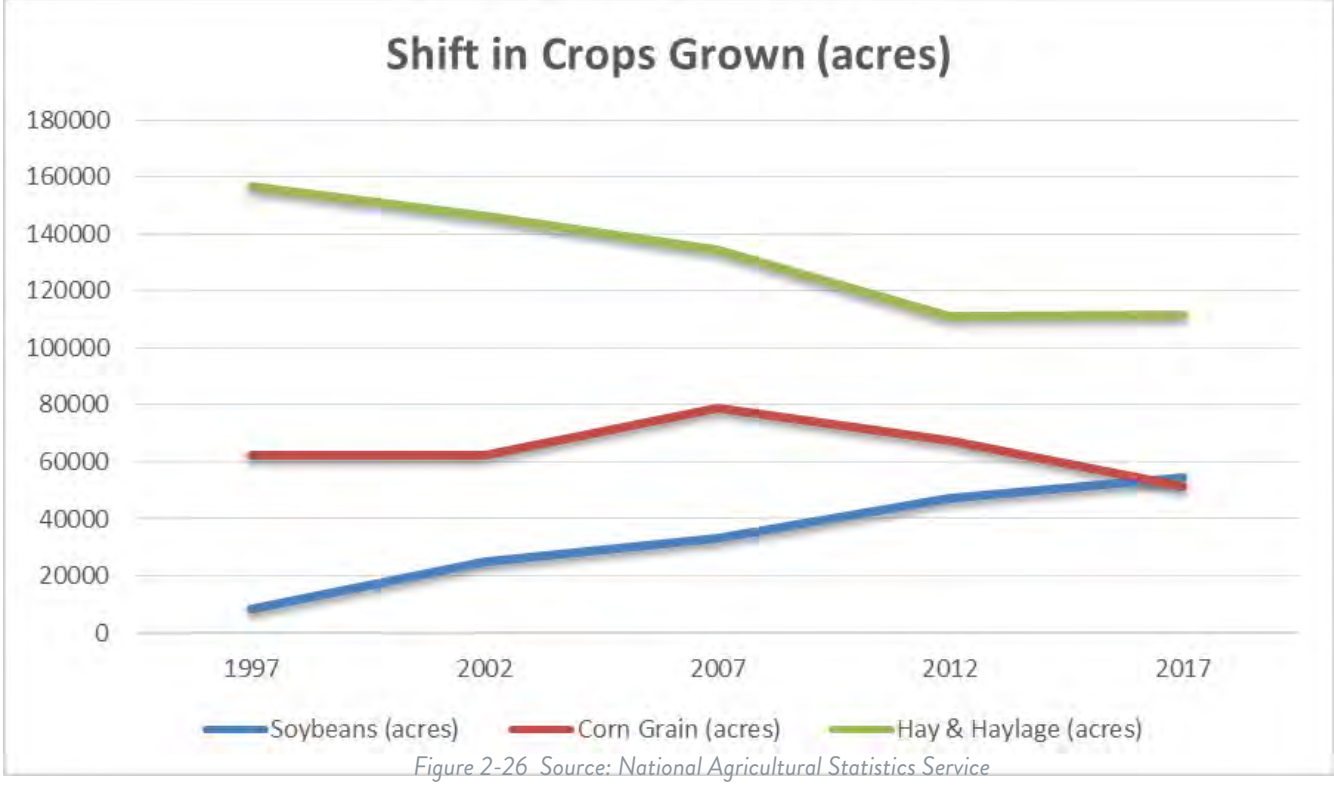



*Figure 2-26 Source: National Agricultural Statistics Service*

*Winter manure spreading*

To address resource concerns such as soil health and water quality, this LWRM Plan will continue to rely upon farm conservation programs and practices, both new and innovative and tried-and-true, such as the Farmland Preservation Program.

*Animal Waste Management*

According to the most recent WI DNR TMDL Watershed and 303(d) reports, phosphorus levels are increasing in streams and water bodies within the county. A new approach is needed that has the potential to lower phosphorus from manure spread during high risk times of the year (frozen, snow covered and saturated conditions). A primary goal of this plan will be to shift the application of manure outside of high risk times of the year over the next ten years. It has been estimated this will reduce phosphorus runoff on agricultural lands, by 250-360% during high risk times of the year (Peter A. Vadas USDA-ARS). The outcome of this new approach is to take steps to reach the goals of the Comprehensive Plan of Marathon County which identifies the reduction of agricultural nonpoint runoff to surface water (soil sediment, organics, and nutrients), in addition, the Strategic plan objective 5.2 and 6.3, and the Big Eau Pleine Strategic plan calls for the reduction and elimination of manure spread during high risk runoff conditons. Implementation of a much stronger strategy to eliminate manure spreading during high risk times is needed to reduce phosphorus runoff.

Currently, Marathon County is home to 145,000 head of cattle, 61,000 of which are milk cows and approximately 61,000 dairy replacement heifers. This is the second highest number of dairy livestock in the State. Livestock generate a large volume of manure each year, which is a great soil amendment but it is also rich in phosphorus. When properly managed, manure can be a great source of nutrients for growing crops, but when manure and its nutrients runs off of fields into local surface waters, it impairs local streams and significantly impacts water quality. The Wisconsin River TMDL study has now identified four main streams in the county as impaired from phosphorus, two of these are new additions in the last ten years. The chart (Figure 2-27) identifies the sources of phosphorus in the Big Eau Pleine watershed, which is reflective of most phosphorus impaired watersheds in the county. (Source: Wisconsin River TMDL study).

Unfortunately, the financial resources to address these problems from the State and Federal sources have continued to decrease over the last two decades. The county has continued to increase funding through the use of tax levy, program fees, and grants to address these problems, but overall financial resources have been decreasing. Eliminating or greatly restricting the spreading of manure when it is the highest risk time of the year is a strategy identified many times in various plans, but has yet to be implemented consistently at the county or state level.

The implementation of this strategy by the county will require a correct mix of regulation and voluntay efforts and will help to significantly reduce phosphorus during the highest time of the year for small and medium sized farms. DNR nonpoint source staf

fwill also play a critical role in this effort. A policy discussion by the Environmental Resources Committee on the correct mix of regulation and voluntary efforts is needed to address this large source of pollution.

Marathon County has attempted a variety of efforts to reduce runoff of manure during high risk times of the year. There has been over a sixty year effort to reduce both runoff of sediment and phosphorus from agricultural lands. Past efforts have included the following: Priority Watershed program, Animal Waste and Nutrient Management Ordinance, Livestock Facilities Licensing Ordinance, Nutrient management planning and cost sharing, Targeted Resource Management grants, Environmental Quality Incentive Program, Conservation Stewardship Program, Conservation Reserve Enhancement Program, Soil and Water Resource Management Program, and Managed Grazing. While these efforts have had local improvements and documented reductions, the gains have been lost to larger trends and the water resources slowly continue to degrade.

There are opportunities for new approaches to stem this tide of pollution. Conservation staff shall be directed to develop voluntary and regulatory options for county consideration with the intended outcome to greatly reduce the risk of runoff from manure during the high risk times of the year and through management changes which manure applications to move them to low risk times of the year.

By managing the amount of manure spread during high risk times, Marathon County can put in place a critical strategy to reduce phosphorus identified in the previously mentioned plans. The immediate goals of the Strategic Plan identifies the protection of surface and ground water as high priorities. Specifically Strategy B, the implementation of watershed plans, we can achieve improved water supplies that are not only safe for drinking but also for recreation, especially for fishable and swimmable waters with minimal cost.

If implemented, this new safeguard is estimated to reduce phosphorus runoff into the waters of Marathon County by up to 250-360% from farms that change their spreading practices each year.

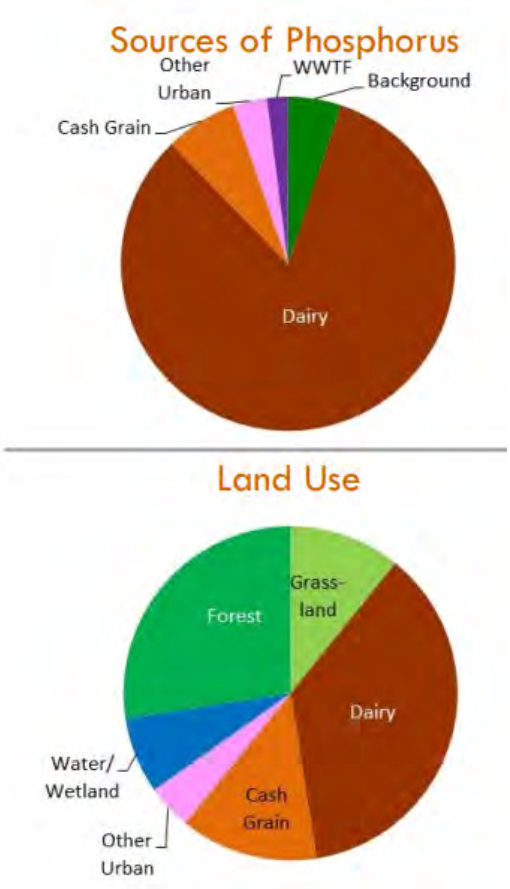



*FIGURE 2-27*
*phosphorus contributions in the Big Eau Pleine watershed*

## POPULATION

According to Demographic Services, Wisconsin Department of Administration and the United States Census Bureau (American Fact Finder), Marathon County had a population of 125,834 residents in 2000, and increased to 134,063 in 2010. In 2019, the population estimate has slowly increased to 136,517, and is projected to increase to an estimated population of 150,130 by 2030 with a percentage increase rate of 5.6. The Wausau urban area heavily influences the population growth and development patterns. Ten communities indicated a loss of population change while the majority saw a very modest increase of population ranging between 0 to 4.99 percent. Only three communities; the City of Marshfield, the Village of Kronenwetter, and the Town of Weston had a population increase over 5 percent.

According to the State of Wisconsin Department of Administration's Demographic Services Center, Marathon County population increased by 1.83 percent for the period 2010 – 2019 with a final population estimate of 136,517.

*historical farm field with small town in the background*

## IDENTIFICATION OF CONCERNS AND PRIORITIES

The Marathon County 2021-2030 Land & Water Resource Management Plan concentrates on updating resource data, incorporating information generated by the 2019 Wisconsin River Basin TMDL, review of goals, objectives, accomplishments, and implementation strategies to improve land and water natural resources. The LAC and Conservation staff reviewed goals, objectives, and existing water quality concerns to help align efforts to achieve the desired outcomes and goals over the 10-year planning period.

### *Marathon County Accomplishments (2010 – 2020)*

The County's highlights regarding our endeavors and accomplishments over the last 10 years are illustrated below to demonstrate significant achievements toward implementation of the 2010 LWRM Plan goals, and include the following:

## LWRM PLAN ACCOMPLISHMENTS

**2010**

- Led Conservation Observance Day for WI Conservation Farmers of the Year

**2011**

- Initiated Eastern Marathon County Lakes project

**2012**

- Awarded $400,000 US EPZ Brownfields Assessment Grant for Wausau River District remediation

**2013**

- Joined Heart of America's Dairyland and Antigo Flats Agricultural Enterprise areas

**2014**

- Adopted new Farmland Preservation Zoning District protecting over 111,000 acres from conversion to other uses

**2015**

- Completed closure of 150th idle or failing Waste Storage Facility as part of Safe Water project

**2016**

- Initiated Fendwood Creek Pilot Watershed project securing newarly $1,000,000 in grant funds

**2017**

- Provided Catalyst and Vision and secured initial funding for Eau Pleine Partership for Integrated conservation community-led watershed partnership

**2018**

- Developed Metallic Minng regulations to protect the environment of the county

**2019**

- Educated and qualified/requalified over 105 diiferent Marathon County farmers to develop their own Nutrient Management Plan

**2020**

- Completed and closed out the last of 21 Environmental Impact Fund projects

**Select Accomplishments by 2010 LWRM Plan Goal**

**Goal 1: Reduce Agricultural Nonpoint Runoff**

**Objective:** Reduce the discharge of soil sediment, organic materials, pesticides and nutrients into surface and ground waters. This runoff includes specific concerns about soil erosion rates on cropland and the loss of organic matter in the topsoil.

**Strategies** to address this resource concern include:

a. Reduce non-point runoff leaving the cropland; Accomplishment: Led efforts to educate farmers about the benefits of managed grazing, reduced and no-till farming methods to reduce runoff from cropland and increased implementation oncropland. Increased acreage of all three cropland practices over the last decade.

b. Improve nutrient management activities of livestock farms; Accomplishment: County cropland with a nutrient management plan increased from 45 % in 2010 to 57% in 2019, well above the state-wide percentages.

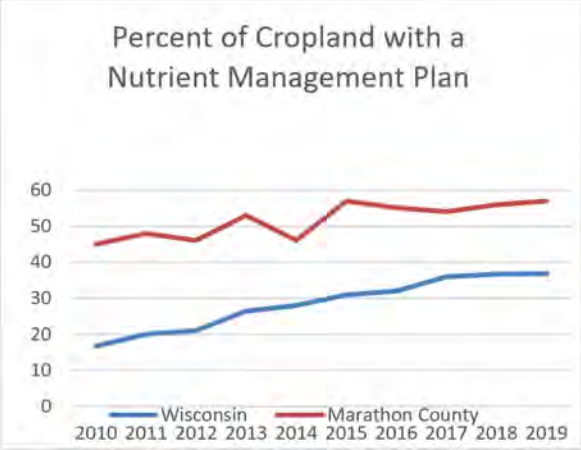



*FIGURE 2-28 Source: Wisconsin DATCP records*

c. Educate landowners about their compliance status with State Agricultural Performance Standards and best management practices, including enforcement strategies; Accomplishment: All Farmland Preservation participants, cost share recipients, and ordinance permittees were provided status reviews of their farms for compliance.

d. Minimize bare, unprotected soil during critical soil erosion periods; Accomplishment: Managed grazing is one of the most effective farming practices to keep soil covered with vegetation year-round. Land in the county planned for managed grazing increased from 23,602 acres in 2010 to 32,914 acres in 2019.

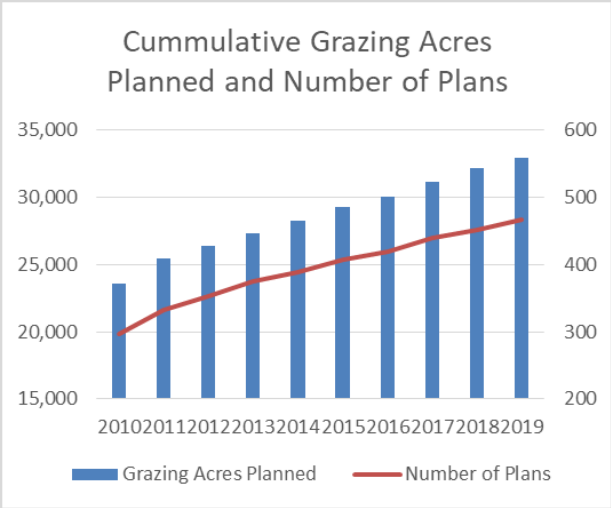
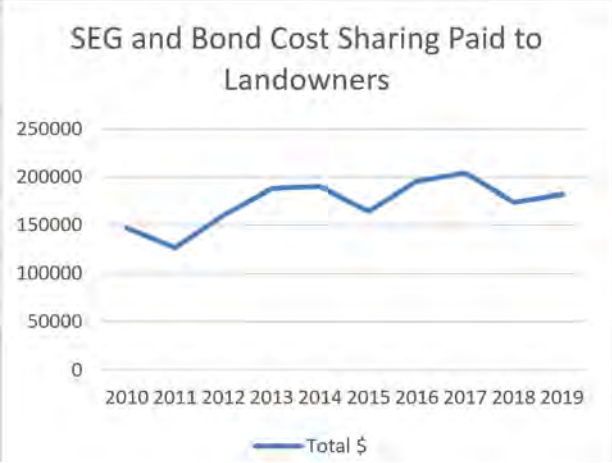



*FIGURE 2-29 Source: CPZ, Managed Grazing records*

e. Provide adequate program and financial incentives to implement best management practices; Accomplishment: CPZ provided county farmers between approximately $126,000 and $204,000 of DATCP-allocated cost share payments annually between 2010 and 2019. Secured just over $4,000,000 of DNR cost share funds that went directly to landowners to complete large projects.

f. Promote and educate landowners about new manure management technologies.




*FIUGRE 2-30 Source: CPZ, cost-sharing reecords*

**Outcomes:** Promote best management practices that lower the soil erosion rate on cropland. This includes managed grazing, residue management, and crop rotation.

- Reduce soil sedimentation delivery rates. Where upland treatment of cropland erosion is not adequate to protect water quality, promote the development of wetlands and sediment basins along field edges to collect sediment and minimize nutrient delivery to waters.

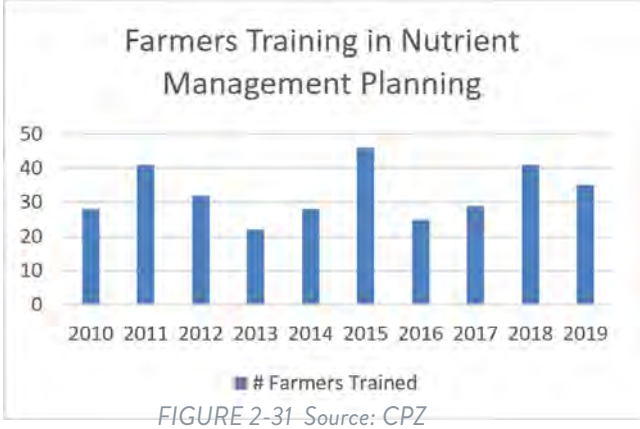



*FIGURE 2-31 Source: CPZ*

Increase nutrient management education and implementation efforts. This includes education relative to the profitability associated with best management practices such as Managed Grazing and nutrient management planning. Accomplishment: Trained 22-45 farmers per year to write or update their own nutrient management plans for their farm operation.

- Create a Farmer Advisory Group. This group representing diverse interests and program participation would provide suggestions and accountability to program delivery and effectiveness, as well as serve as ambassadors to the program outcomes. Accomplishment: In 2017, CPZ was a key catalyst, provided vision, and secured funding for the Eau Pleine Partnership for Integrated Conservation (EPPIC), Wisconsin's largest community-led watershed partnership.

- Develop new local ordinance authority to require winter spreading plans for manure applications in critical areas. The staffs would develop education and criteria for the development of winter spreading plans in critical watersheds where water quality is compromised by manure applications on frozen and snow-covered ground and spring runoff period. Accomplishment: Environmental Resources Committee (ERC) was provided with a policy paper on high risk manure spreading activities, and initial recommended changes. ERC chose not to discuss policy changes to current efforts.

**Goal 2: Groundwater (Quality and Quantity)**

**Objective:** A growing population and industrial base has led to a growing concern about both the supply and quality of our groundwater resources. Cropland irrigation and large livestock operations are high quantity agricultural water users, but urban centers need to reach farther and farther out into rural areas to access water. Industrial growth is now contingent upon access to outside-sourced water. Wellhead protection and infrastructure proposals to distribute water to rural communities are increasingly important.

**Strategies** to address this resource concern include:

a. Educate the public and users about groundwater use and challenges; Accomplishment: Enacted Metallic Mining Ordinance for Eastern Marathon County. Educated ERC on discharges of septage to surface water, ground water, bedrock. ERC took action to address all POWTS installed prior to 1980 with failing tanks and surface discharges. Established low interest revolving loan program to cover cost of replacement.

b. Maintain the current groundwater levels in our aquifers;

c. Increase the infiltration of rain and snowmelt to replenish aquifers; Accomplishment: Began soil health efforts on cropland which increase infiltration. Continued to protect wetlands and floodplains from development, which serve to recharge aquifers.

d. Maintain and improve the functioning of wetlands; and

e. Protect wellhead recharge areas from pollution. Accomplishment: Safe Water Project implemented to accelerate efforts to close idled waste storage facilities, to protect groundwater and surface water.

**A SAFE WATER PROJECT:**

**AN ACCELERATED EFFORT TO CLOSE LIVESTOCK WASTE STORAGE FACILITIES IN HIGH RISK ENVIRONMENTAL SITES**

January 2011

Prepared by:

Marathon County
Land Conservation & Zoning Committee

Excavator scraping grass mat off surface of an idle waste storage facility so manure/liquids can be agitated and pumped.

*Idle manure storage facilities are a safety hazard and a threat to surface and groundwater*

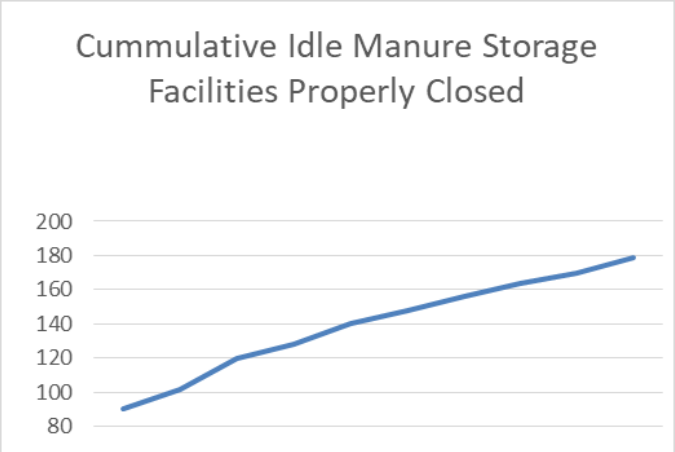



*FIGURE 2-32 Source: CPZ, Safe Water Program and GIS database*

Accomplishment: Adopted Wellhead Protection overlay zoning district to institute land use regulations to protect municipal water supplies in county-zoned towns, as part of the county's 2016 comprehensive zoning revision.

**Outcomes:**

- Develop education and incentive strategies to increase conservation of water in both urban and rural areas.

- Incorporate groundwater education and well sampling opportunities into farm visits by staff.

- Review and update Marathon County Groundwater Protection Plan (2001) Accomplishment: Marathon County has identified the need to update the plan. A timeline for plan completion has been developed and early steps have begun with a proposed

completion date of December 2022.

**Goal 3: Forestry**

**Objective:** There are approximately 400,000 acres of forest land use in Marathon County. Much of the management of these lands rests with private landowners. Forests need to be managed and promoted to provide large blocks of habitat and maintain sound watershed management, including maximizing groundwater recharge.

**Strategies** to address this resource concern include:

a. Reforestation of barren lands and idled cropland;

b. Maximize participation in Managed Forest Land program (MFL);

c. Keep large tracts of forest land;

d. Sustainable and healthy private and public forests;

e. Healthy school forest centers; and

f. Minimize invasive species.

**Outcomes:**

- Increase education and participation with local 4-H groups and schools to promote tree plantings (urban and rural). Includes promotion of planting projects for groups.

- Educate farmers about forest management and economic opportunities during farm visits.

- Officials and staff need to increase participation in regional and state program development and policy.

- Develop a strategy to identify and target land parcels that could benefits from woodland development. (Examples include fallow cropland and urban-rural transition areas). Promote tree planter use and planning for these landowners. Accomplishment: Marathon County continued providing tree planters as a cost-effective means for landowners to for woodland development. Rental of planters assisted in the planting of over 30,000 trees.

*Source: CPZ, Tree Planter*

Accomplishment: Worked with Golden Sands RC&D on forestry and deer management plans through the Cooperating for Woods and Wildlife program.

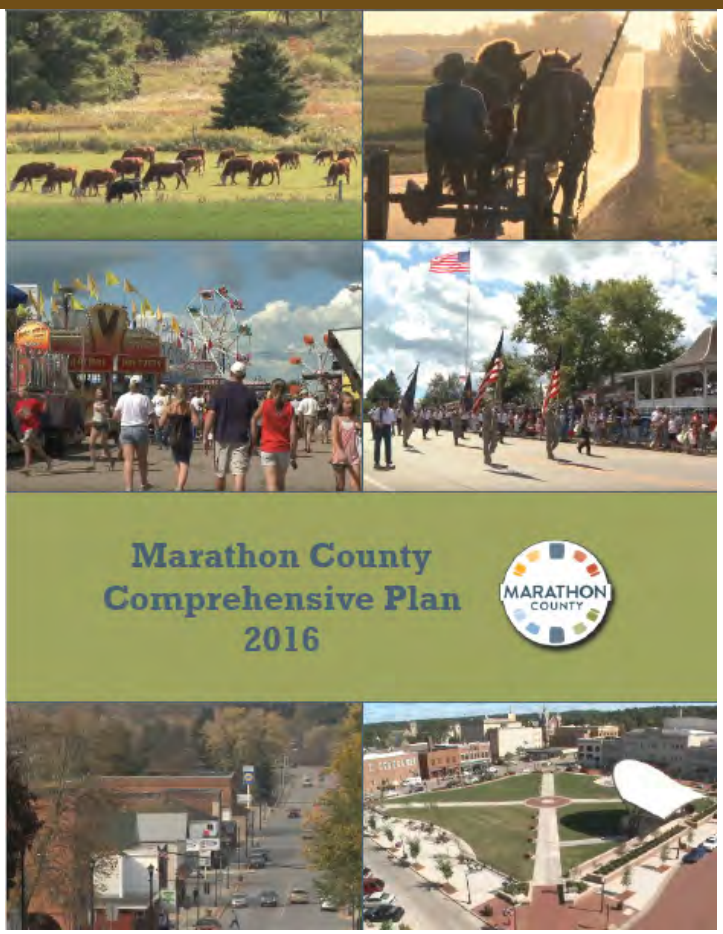
*Outreach in a forest unit*

**Goal 4: Land Conversion**

**Objective:** Conversion and fragmentation of agricultural cropland and woodlands from productive use is a continuing concern in Wisconsin and Marathon County. The protection of these cropland and woodland land uses are important to maintaining the rural and cultural integrity of our communities, but more importantly assure that the economic benefits of these sectors are realized. Sound land use requires policies that conserve resources and allow for the profitable use of the land.

**Strategies** to address this resource concern include:

a. Update Marathon County Comprehensive Plan to address the intent of the Working Lands Initiative and local implementation strategies; Accomplishment: 2016 update to Marathon County Comprehensive Plan included elements of the Working Lands Initiative as objectives and strategies of the plan.




*Marathon County Comprehensive Plan*

b. Maintain prime farmland in production

c. Minimize fragmentation of cropland by housing developments; and

d. Provide producers with viable opportunities to protect farmland from conversion.

**Outcomes:**

- County officials must be actively engaed in regional and statewide groups to provide leadership in this land use effort.

- Provide administrative and educational support to local municipal and Town officials in presenting initiatives through the Working Lands Initiative. Specifically, the County (staff and officials) must be available to discuss zoning ordinances, enterprise areas, and conservation easements. Accomplishments: Updated Farmland Preservation Plan, General Zoning Ordinance and Comprehensive Plan. Implemented strategies in these plans, all of which support a, b, and c above along with outcomes listed.

- Identify a tracking and selection process for location of Agricultural Enterprise Areas and conservation easements to maximize the effectiveness of the program opportunities. Accomplishment: Successfully petitioned and joined Heart of America's Dairyland and Antigo Flats Agricultural Enterprise Areas, designating 140,343 acres for landowner program opportunities including Farmland Preservation Program eligibility.

*Antigo Flats Agricultural Enterprise Area*

**Goal 5: Lake and Reservoir Management**

**Objective:** The management of our lake and reservoir resources is growing concern to the shore land residents, users, and local businesses. This resource concern encompasses the areas of wetland management and aquatic invasive species. There is a great participation by local landowners in securing information and resources to better protect our water resources.

**Strategies** to address this resource concern include:

a. Maintain existing wetlands;

b. Restore critical drained wetland areas along surface waters;

c. Keep sediments and nutrients out of wetlands to maintain function;

d. Improve awareness of public about the value and importance of wetlands; and

e. Develop a county-wide inventory and status report for aquatic invasive species. Accomplishment: Completed and implemented Aquatic Invasive Species plan.

*Aquatic Invasive Species*

**Outcomes:**

- Develop an Operation and Maintenance Plan for the aerator system at the Big Eau Pleine River Reservoir that assures the long-term operations and effectiveness of the equipment. Accomplishment: The Big Eau Pleine Aeration Task Force reviewed and updated the Big Eau Pleine Aerator System Operation Memorandum of Agreement. A new system was installed and is being operated when needed, through a diverse partnership.

- Develop a long-term strategy to minimize the agricultural nonpoint runoff contributions to the Big Eau Pleine River and Reservoir. Accomplishment: "Strategies for Reducing Fish Kills in the Big Eau Pleine Reservoir" strategic plan laid the groundwork for innovative strategies to address agricultural runoff in the Big Eau Pleine watershed, such as the EPPIC producer-led watershed group.

- Develop Lake Management Plan for the Eastern Lakes Project utilizing community contributions and assessment data gathered from the Eastern Lakes Project. Accomplishment: Completed and adopted eleven Eastern Marathon County Lake management plans utilizing leadership, technical assistance and grants acquired by CPZ staff.

*Source: BEPCO, Installation of the new Aeration system in the Big Eau Pleine Reservoir*

- Develop Lake Management Plan for Big Eau Pleine River and Reservoir from land use and water quality assessment data gathered by DNR, WVIC, and Marathon County. Accomplishment: Completed and began implementation of "Strategies for Reducing Fish Kills in the Big Eau Pleine Reservoir" strategic plan in partnership with Big Eau Pleine Citizens Organization.

- Educate landowners about the health of existing resources and efforts that the community can take to improve the concerns.

- Provide educational and technical support to lake residents and citizen groups in caring for lakes and reservoirs. Accomplishment: Created and filled a Water Resources Technician staff position to work with lake residents and citizens groups on implementing

*Source: UWSP, Big Eau Pleine Reservoir*

*lake located in eastern Marathon County*

the lake management plans, shoreland buffers and educational efforts that were developed as part of the Eastern Marathon County Lakes project.

*Source: Tyler Betry, Completed Shoreland buffer on public lands*

**Agricultural Performance Standards and Prohibitions Accomplishments**

Although compliance with the NR 151 APSP by farmers and other rural landowners was not a specific goal of the 2010 LWRM Plan. However, implementation of the various conservation practices and strategies designed to meet the five 2010 LWRM plan goals inherently led to progress toward meeting the APSP. Because meeting the APSP is, in fact, an integral part of achieving and meeting the specified goals of the 2020 LWRM Plan, following is a baseline analysis/status of compliance with the APSP in Marathon County over the 2010-2019 implementation period of the 2010 LWRM Plan, where data was available. This will serve as a benchmark to measure continued progress toward meeting the APSP during the implementation period of the 2021-2030 LWRM Plan.

**1. Cropland and Pasture Soil Erosion Control**

TABLE 2-1 Goal: 100% of cropland and pastureland meets Tolerable Soil Loss "T".

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| %* | 87 | - | 81 | - | 83 | - | 79 | -* | 78 | -* |

(Data Source: Marathon County Soil Erosion Transect Survey)

* No data available for odd number years.

**2. Cropland and Pasture Nutrient Management**

TABLE 2-2 Goal: 100% of cropland and (required) pastureland has a Nutrient Management Plan.

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| % | 45[1] | 48[1] | 46[1] | 53[1] | 46[2] | 57[2] | 55[2] | 54[2] | 56[2] | 57[3] |
| Acres* | 131,000 | 141,000 | 134,000 | 153,000 | 140,000 | 171,000 | 166,000 | 164,000 | 169,000 | 169,000 |

(Data Source: DATCP annual Wisconsin Nutrient Management Update publications)

* DATCP reported acres.

1 Based on 2007 NASS harvested cropland acres. 292,078 acres.
2 Based on 2012 NASS harvested cropland acres. 302,081 acres.
3 Based on 2017 NASS harvested cropland acres. 298,524 acres.

*Source: CPZ, Low-disturbance liquid manure injection*

**3. Cropland and Pasture Phosphorus Index (PI)**

TABLE 2-3 Goal: 100% of cropland, pastureland, and winter grazing areas meet PI of average of 6 or less over the accounting period, or 12 or less in any one year.

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| %* | 45 | 48 | 46 | 53 | 46 | 57 | 55 | 54 | 56 | 57 |

(Data Source: DATCP annual Wisconsin Nutrient Management Update publications)

* % listed is based upon % of harvested cropland acres under nutrient management plan. Actual % is likely much higher, but has not been inventoried at this time.

**4. Cropland Tillage Setback**

TABLE 2-4 Goal: 100% of tillage operations meet a minimum 5 foot setback from surface waters.

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| %* | 45 | 48 | 46 | 53 | 46 | 57 | 55 | 54 | 56 | 57 |

(Data Source: DATCP annual Wisconsin Nutrient Management Update publications)

* % listed is based upon % of harvested cropland acres under nutrient management plan. Actual % are likely very close to 100% due to topographic and hydrologic conditions in the county. I.e. Broad, wet river bottoms and riparian wetlands.

*Source: Unknown, Streambank protected with vegetative cover.*

**5. Manure Storage Facilities**

**a. New construction or substantial alterations meet standards**

TABLE 2-5 Goal: 100% of new construction and substantial alterations meet NRCS standards.

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| % | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

(Data Source: CPZ Animal Waste Storage Facility tracking)

*Source: CPZ, prepping for a new manure strorage facility*

**b. Closure within two years of becoming idle**

TABLE 2-6 Goal: 100% of idle manure storage facilities are safely closed according to standards.

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| %* | 60 | 68 | 80 | 85 | 64 | 68 | 71 | 75 | 78 | 82 |
| Closed | 90 | 102 | 120 | 128 | 140 | 148 | 156 | 164 | 170 | 179 |
| Idle | 61 | 49 | 31 | 23 | 79 | 71 | 63 | 55 | 49 | 40 |
| Idle + Closed | 151 | 151 | 151 | 151 | 219 | 219 | 219 | 219 | 219 | 219 |

(Data Source: CPZ Safe Water Project data; CPZ Animal Waste Storage GIS database)

* This % represents the % closed vs idle and still requiring closure.

*cleaning out contaminated soil during the abandonment of an idle storage pit*

**c. Failing or leaking facilities must be upgraded, replaced, or closed**

TABLE 2-7 Goal: 100% of failing or leaking manure storage facilities are upgraded, replaced, or closed.

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| %* | - | - | - | - | - | - | - | - | - | - |

(Data Source: None)

* CPZ does not currently have an inventory of this performance standard, therefore no data is available, but any identified failing or leaking facilities are brought into compliance with ordinance requirements within two years of awareness of violation.

**6. Clean Water Diversions for feedlots, barnyards, and storage manure in WQMA**

TABLE 2-8 Goal: 100% of feedlots, barnyards, and stored manure located in Water Quality Management Areas (WQMA) have clean water diversions.

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| #* | 18 | 22 | 24 | 27 | 25 | 25 | 25 | 30 | 30 | 55 |

(Data Source: CPZ Livestock Facility Licensing/TRM/NOD/CAFO tracking, and CPZ FPP GIS database)

*CPZ does not have a % in compliance, nor does it have a full county inventory.

**7. Process Wastewater Management**

TABLE 2-9 Goal: 100% of livestock producers shall have no significant discharge of process wastewater to waters of the state.

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| # | 20 | 25 | 27 | 31 | 29 | 31 | 33 | 40 | 43 | 50 |

(Data Source: CPZ Livestock Facility Licensing/TRM/NOD/CAFO tracking, and CPZ FPP GIS database)

**8. Manure Management Prohibitions**

**a. No overflow of manure storage facilities**

TABLE 2-10 Goal: 100% compliance by all livestock producers.

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| % | 99.4 | 99.2 | 99.7 | 100 | 99.7 | 99.7 | 100 | 99.5 | 99.8 | 99 |
| Actual Overflows | 2 | 3 | 1 | 0 | 1 | 1 | 0 | 2 | 1 | 4 |
| Active Storages | 339 | 351 | 358 | 361 | 377 | 393 | 404 | 409 | 411 | 417 |

(Data Source: CPZ Animal Waste Storage GIS database, Complaints GIS database, and CPZ FPP GIS database)

*Source: CPZ, Runoff from overflowing manure storage facility*

**b. No unconfined manure piles in a Water Quality Management Area**

TABLE 2-11 Goal: 100% compliance by all livestock producers.

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| # | 15 | 19 | 23 | 26 | 25 | 25 | 25 | 27 | 27 | 28 |

(Data Source: CPZ Livestock Facility Licensing/TRM/NOD/CAFO tracking) *CPZ does not have a % in compliance, nor does it have a full county inventory.)

*Source: CPZ, Unconfined manure pile flowing into wetland/stream*

**c. No direct runoff from a feedlot (barnyard) or stored manure into waters of the state**

TABLE 2-12 Goal: 100% compliance by all livestock producers.

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| # | 23 | 27 | 29 | 33 | 32 | 34 | 33 | 36 | 36 | 167 |

(Data Source: CPZ Livestock Facility Licensing/TRM/NOD/CAFO tracking) *CPZ does not have a % in compliance, nor does it have a full county inventory.)

**d. No unlimited livestock access to waters of the state without self-sustaining vegetation cover (streambank protection)**

TABLE 2-13 Goal: 100% compliance by all livestock producers.

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| # | 16 | 20 | 23 | 27 | 25 | 26 | 26 | 28 | 28 | 29 |

(Data Source: CPZ Livestock Facility Licensing/TRM/NOD/CAFO tracking) *CPZ does not have a % in compliance, nor does it have a full county inventory.)

*Source: CPZ, Uncontrolled cattle access to stream*

# CHAPTER 3 | GOALS, OBJECTIVES, STRATEGIES & OUTCOMES

## Approach Perspective

The foundation of the Land and Water Resource Management Plan for Marathon County is soil health. The role of soil health is critical for the capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans. The role of healthy of soil to improve infiltration, reduce flooding, temper droughts and improve base flow for streams and rivers is vastly underestimated. If we are to improve our environment from uncheck runoff it starts with healthy soils.

The importance of managing soils so they are resilient and sustaining for this and future generations cannot be overlooked. To do this, we need to consider soil as living organism that when provided the basic necessities for life performs functions required to produce food and fiber but also clean our environment. Only "living" things can have health, so we must consider soil as a living ecosystem. It is teaming with billions of bacteria, fungi, and other microbes that are the foundation of a symbiotic ecosystem. A healthy soil ecosystem provides nutrients for plant growth, absorbs and holds rainwater for use during dryer periods, filters and buffers potential pollutants from leaving our fields, which is the foundation for all agricultural and forest activities. If we were to measure only one criterion for healthy soils it would be the organic matter level. If organic matter levels are decreasing our soils are losing health, if they are increasing soil health increases. What is truly essential for soil health is covering our soils year round to improve infiltration, reduce erosion and nutrient loss. The agricultural practices most common for this are managed grazing, cover crops, conservation tillage, crop rotation, and perennial forages. This applies to not only agriculture but construction sites, shoreland riparian areas, buffer strips and other best management practices. We can no longer leave our soils exposed to the elements for long periods of time, especially from early October through mid-June if we want to have healthy soils along with clean surface and ground water.

### Plan Goals, Objectives, Strategies, Outcomes and Contributors

The overarching goal of the LWRM Plan is to support the county's following goal statement: **"Marathon County is the healthiest, safest, and most prosperous county in Wisconsin"**. Achieving this overarching goal will require many different small steps taken in concert in a coordinated effort across Marathon County as outlined in this chapter. The LWRM Plan is designed to align with Marathon County's Comprehensive and Strategic Plans to improve and protect land and water resources within the county.

The LAC reviewed and updated the goals, objectives, and strategies of the 2021-2030 LWRM Plan. For clarity, the goals, objectives, strategies, and measurable outcomes are defined to explain the differences among the three elements.

**Goals** are statements about Marathon County's aspirations in the topic area.

**Objectives** are vision statements which provide direction to the subtopics within the areas of each goal.

**Strategies** are key steps, which should be taken to meeting the objective and reaching the goal.

**Outcomes** are measures or targets to further define success with respect to goals and objectives.

## HEALTHIEST, SAFEST, MOST PROSPEROUS - WHY IS THIS IMPORTANT?

The future health and social well-being of Marathon County will be determined to a large extent by how the natural environment contributes to an individual's lifelong health and well-being. The social, economic, and physical environment in which a person lives shapes his or her individual characteristics and behaviors. And to that end, Marathon County is committed to being a strong supporter of the agriculture community while striving to achieve watershed restoration, and reducing nonpoint source pollution such as phosphorus. The reduction of phosphorus from watershed projects and practices will allow the county to assess progress toward improving water quality standards, and will align planning and decisions necessary to ensure continued progress.

Land Water Resource Management Plan GOALS:

1. Land resources are protected and improved and protected county-wide.
2. Surface water quality is protected and improved.
3. Groundwater is protected and improved.
4. Actively educate and engage all community stakeholders to develop an understanding of land, surface water, and . groundwater quality concerns.

## Plan Goals

**GOAL 1: LAND AND RESOURCES ARE PROTECTED AND IMPROVED COUNTY-WIDE.**

**Objectives:**

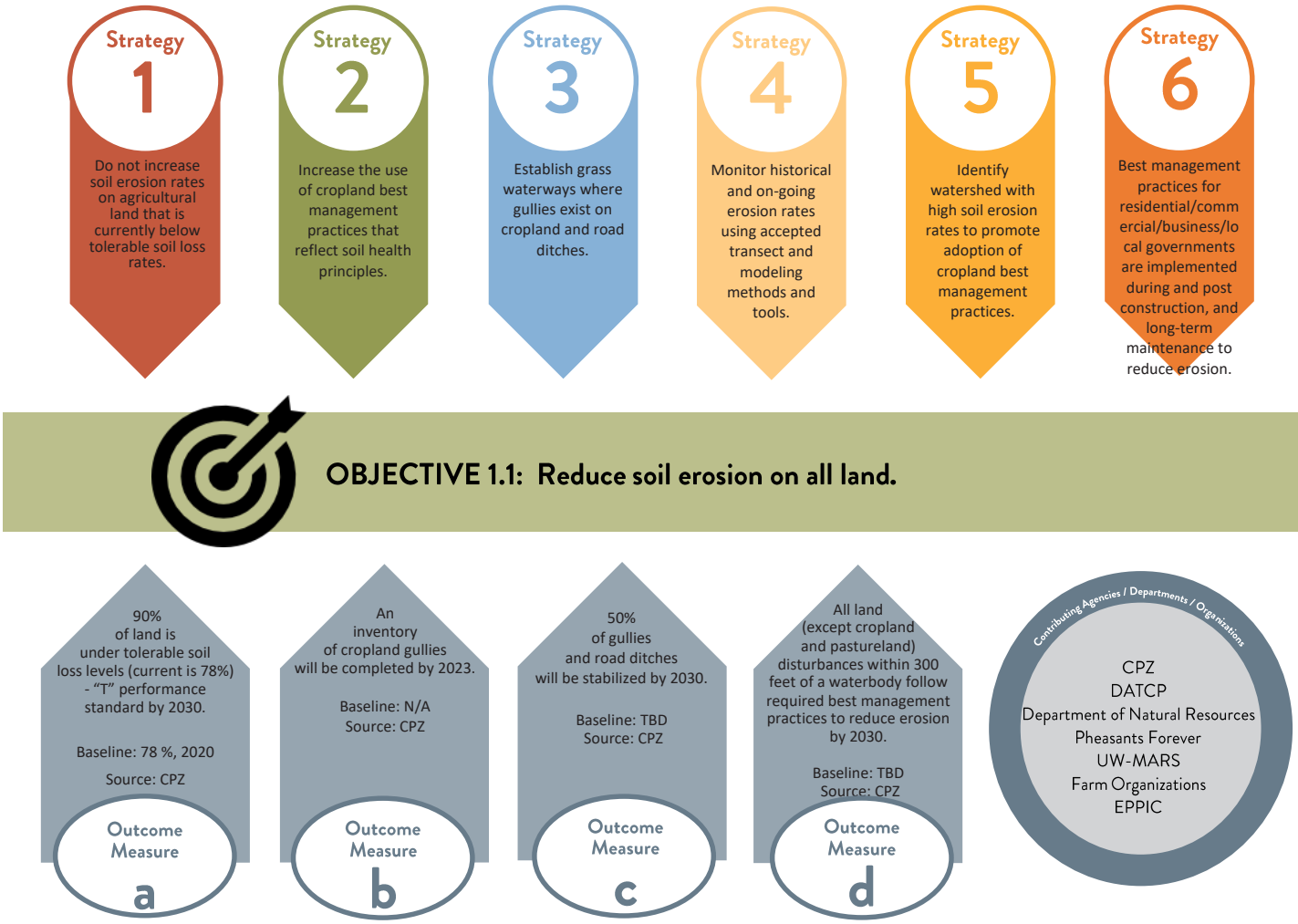
**1.1 Reduce soil erosion on all land.**

**Strategies:**

1. Do not increase soil erosion rates on agricultural land that is currently below tolerable soil loss rates.
2. Increase the use of cropland best management practices that reflect soil health principles.
3. Establish grass waterways where gullies exist on cropland and road ditches.
4. Monitor historical and on-going erosion rates using accepted transect and modeling methods and tools.
5. Identify watershed with high soil erosion rates to promote adoption of cropland best management practices.
6. Best management practices for residential/commercial/business/local governments are implemented during and post construction, and long-term maintenance to reduce erosion.

**Outcome Measures:**

a. 90% of land is under tolerable soil loss levels (current is 75%) - "T" performance standard by 2030.
b. An inventory of cropland gullies will be completed by 2023.
c. 50% of gullies and road ditches will be stabilized by 2030.
d. All land (except cropland and pastureland) disturbances within 300 feet of a waterbody follow required best management practices to reduce erosion by 2030.




*Infographic 3-1*

**1.2 Improve soil health.**

**Strategies:**

1. Monitor organic matter levels on agricultural land and utilize data to track trends in organic matter levels.
2. Increase organic matter on agricultural land.
3. Fully manage manure in a fashion where it benefits the health of the soil and productivity of the crops being grown.
4. Explore new soil testing methods to identify and improve soil health.
5. Increase soil health and productivity through newly adopted practices such as cover crops, small grains, reduced till and no-till farming, perennial forages, managed grazing and soil amendments.
6. Increase the number of farmers/owners utilizing new proven soil health testing methods.

**Outcome Measures:**

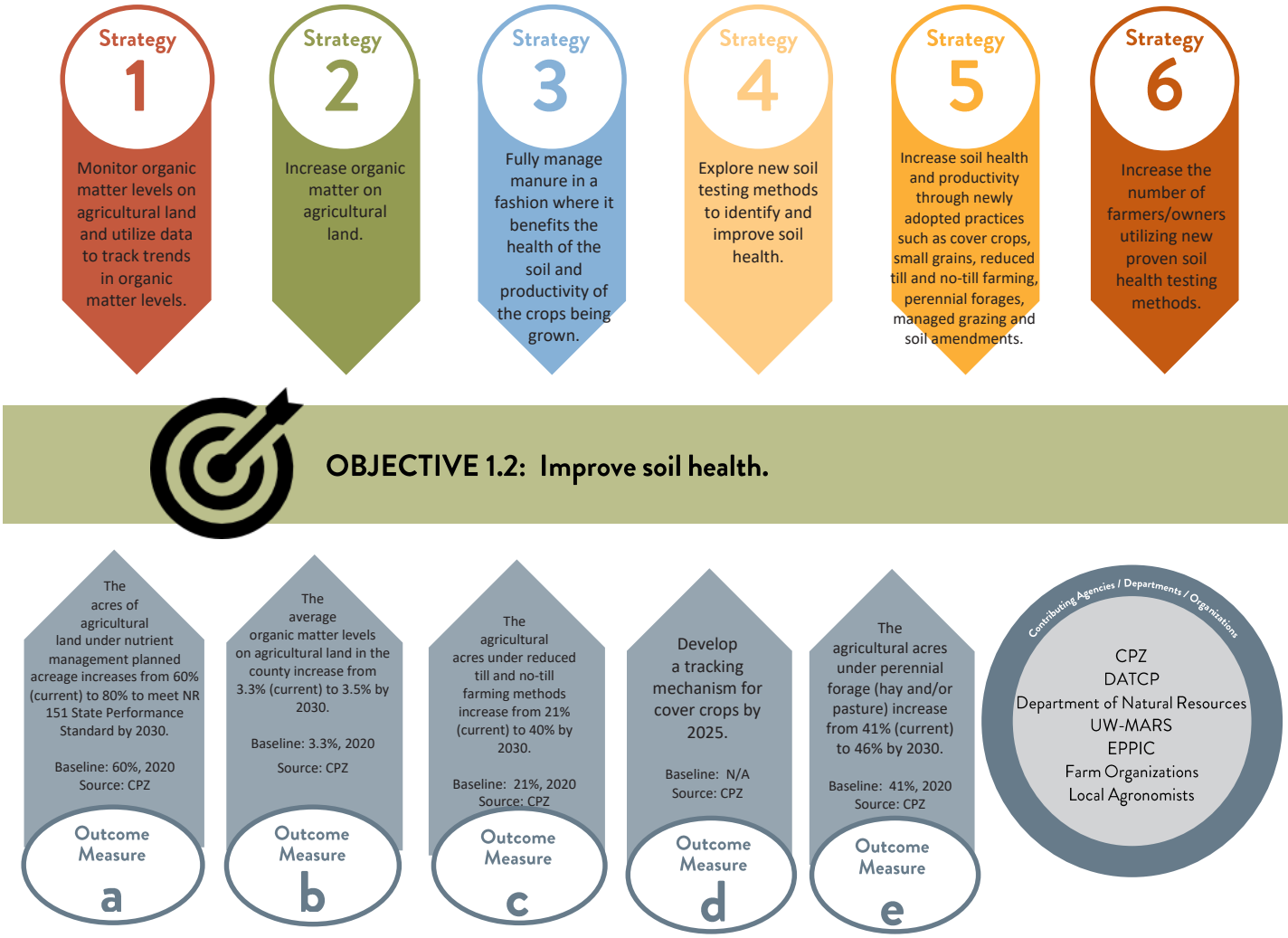
a. The acres of agricultural land under nutrient management planned acreage increases from 57% (current) to 80% to meet NR 151 State Performance Standard by 2030.

b. The average organic matter levels on agricultural land in the county increase from 3.3% (current) to 3.5% by 2030.

c. The agricultural acres under reduced till and no-till farming methods increase from 27% (current) to 40% by 2030.

d. Develop a tracking mechanism for cover crops by 2025.

e. The agricultural acres under perennial forage (hay and/or pasture) increase from 41% (current) to 46% by 2030.




*Infographic 3-2*

**1.3 Forest management - Private and public forest lands in Marathon County are well managed to support wildlife, recreation and timber harvest goals.**

**Strategies:**

1. Engage private landowners in land stewardship to participate in state and federal programs, including but not limited to the Managed Forest Law (MFL) program, the Deer Management Assistance Program (DMAP), and the Environmental Quality Incentives Program (EQIP).
2. Encourage private landowners to work together to align their own forest and wildlife habitat management objectives with landscape scale plans established by the state.
3. Provide education and best management practice options to reduce erosion during harvest.
4. Encourage forested pastures to be properly managed.
5. Encourage the establishment and/or maintenance of windbreaks for erosion control and energy conservation through working in partnership with the Central Wisconsin Windshield Partnership (CWWP).
6. Private forest lands are established and maintained as a viable land use.
7. Public forest lands in Marathon County are well managed to support wildlife, recreation and timber harvest goals as specified in the Marathon County Forest Comprehensive Land Use Plan.

**Outcome Measures:**

a. Establishment of a Demonstration Forest on a private landowner's property through Golden Sands RC&D's projects by 2023. This landowner will serve as a resource to other landowners looking to get involved in new land management programs.

b. Enroll at least 25 private landowners into the group forest stewardship and Deer Management Assistance Program (DMAP) cooperatives by 2023 through Golden Sands RC&D's efforts.

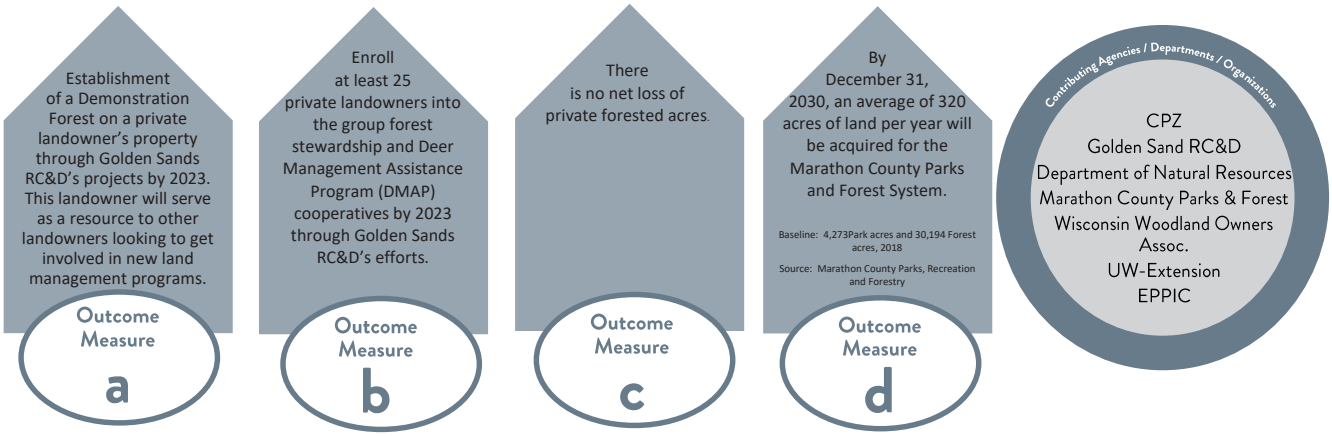
c. There is no net loss of private forested acres.

d. By December 31, 2030, an average of 320 acres of land per year will be acquired for the Marathon County Parks and Forest System.

Baseline: 4,273 Park acres and 30,194 Forest acres, 2018

Source: Marathon County Parks, Recreation and Forestry Department.

**OBJECTIVE 1.3: Forest management – Private and public forest lands in Marathon County are well managed to support wildlife, recreation and timber harvest goals.**




*Infographic 3-3*

**1.4 Protect and preserve prime agricultural lands.**

**Strategies:**

1. Preserve prime farm soils that are most vulnerable to conversion for non-farm land uses.
2. Expand the Farmland Preservation-Agricultural Enterprise Areas within the County.
3. Expand Farmland Preservation zoning to reduce fragmentation and protect prime farm soils.
4. Encourage the protection of a viable agricultural industry by continuing to advocate that towns participate in county zoning to protect land under general agricultural and farmland preservation zoning.
5. Improve funding mechanisms to provide technical assistance to farmers and landowners to develop nutrient management plans and meet basic agricultural performance standards and prohibitions.
6. Identify and financially support viable and environmentally superior farming systems.

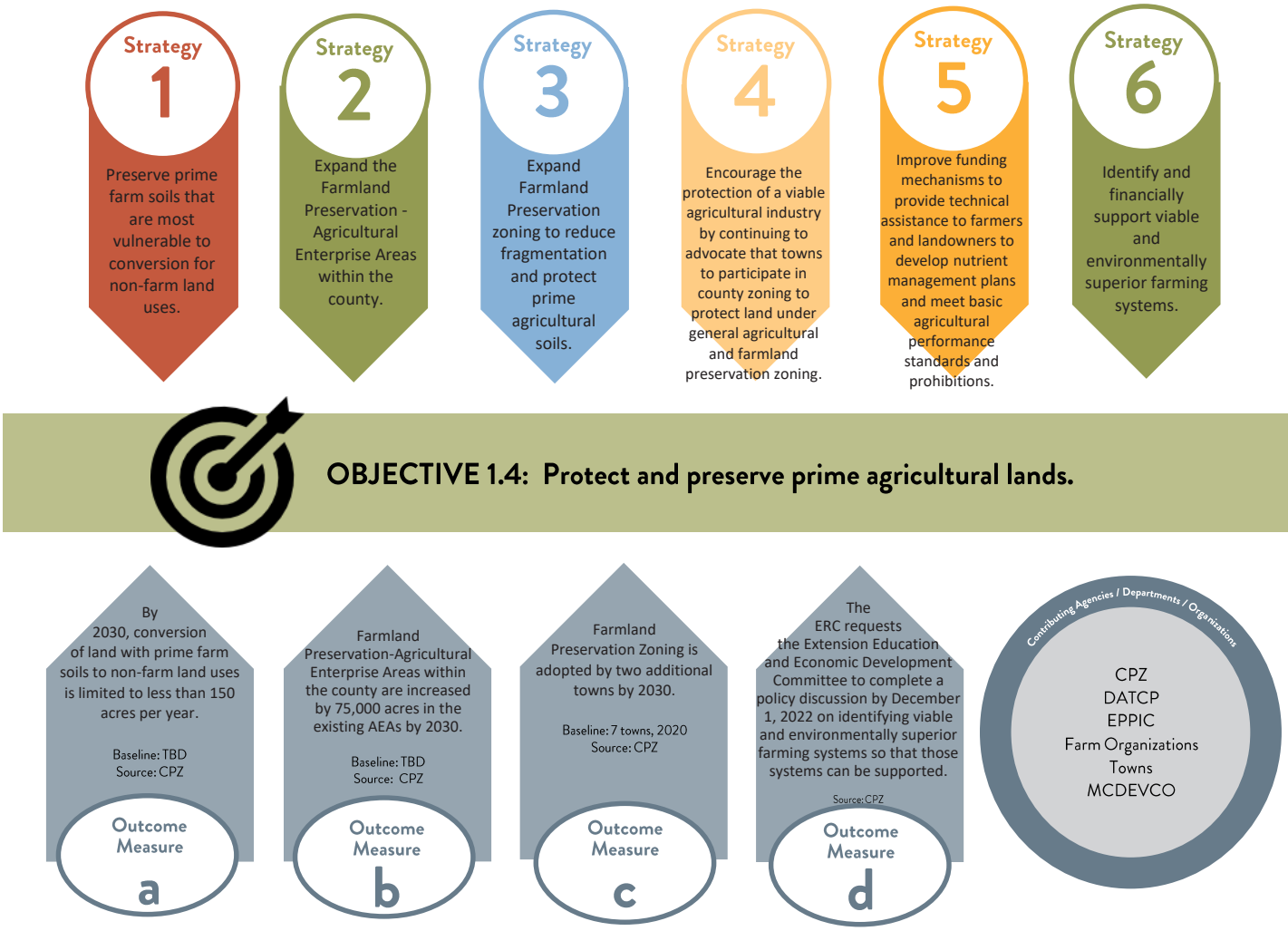
**Outcome Measures:**

a. Conversion of land with prime farm soils to non-farm land uses is limited to less than 150 acres per year.

b. Farmland Preservation-Agricultural Enterprise Areas within the county are increased by 75,000 acres in the existing AEAs by 2030.

c. Farmland Preservation Zoning is adopted by two additional towns by 2030.

d. The ERC requests the Extension Education and Economic Development Committee to complete a policy discussion by December 1, 2022 on identifying viable and environmentally superior farming systems so that those systems can be supported.




*Infographic 3-4*

**GOAL 2: SURFACE WATER QUALITY IS PROTECTED AND IMPROVED.**

**Objectives:**

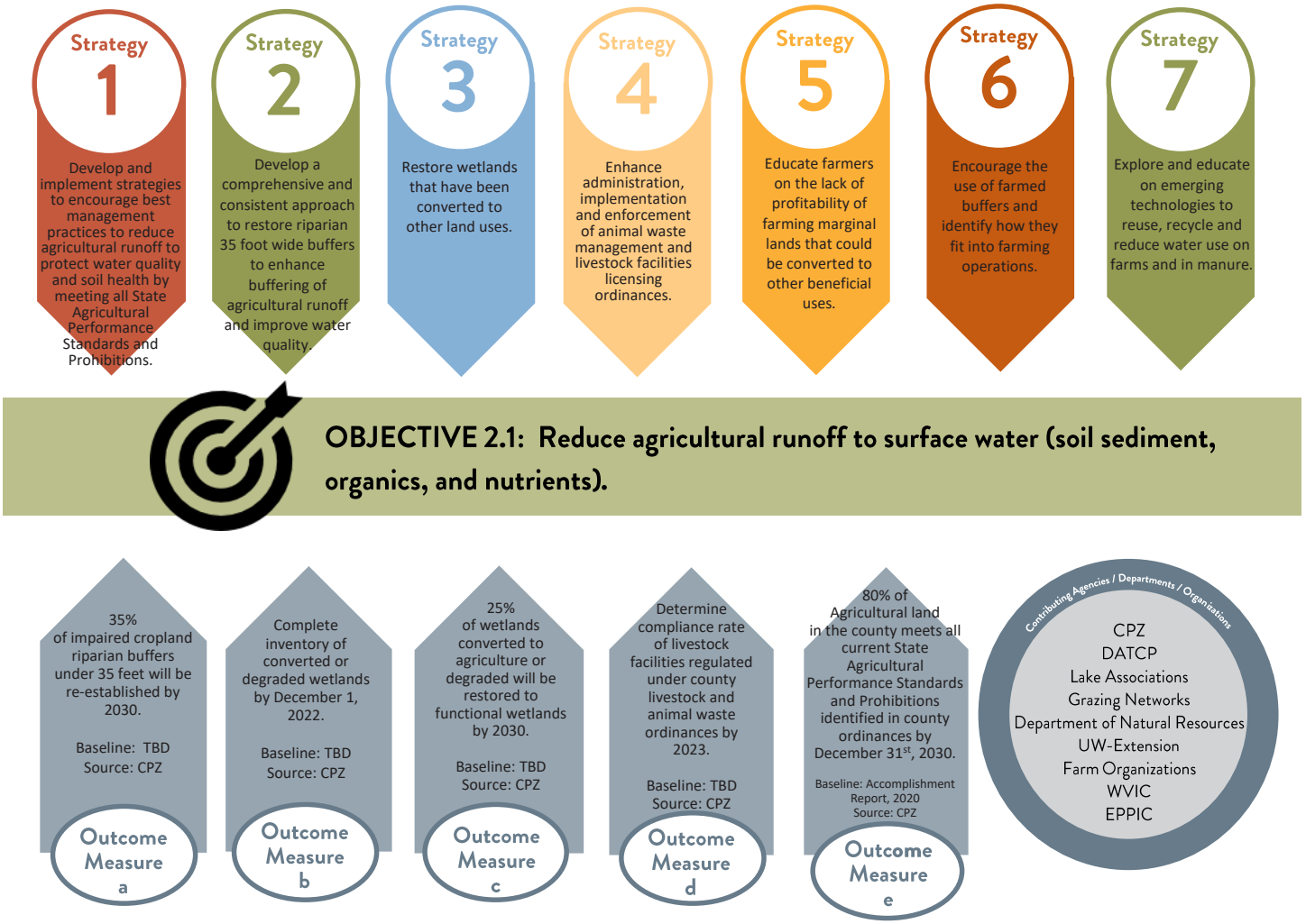
**2.1 Reduce agricultural runoff to surface water (soil sediment, organics, and nutrients).**

**Strategies:**

1. Develop and implement strategies to encourage best management practices to reduce agricultural runoff to protect water quality and soil health by meeting all State Agricultural Performance Standards and Prohibitions.
2. Develop a comprehensive and consistent approach to restore riparian 35 foot wide buffers to enhance buffering of agricultural runoff and improve water quality.
3. Restore wetlands that have been converted to other land uses.
4. Enhance administration, implementation and enforcement of animal waste management and livestock facilities licensing ordinances.
5. Educate farmers on the lack of profitability of farming marginal lands that could be converted to other beneficial uses.
6. Encourage the use of farmed buffers and identify how they fit into farming operations.
7. Explore and educate on emerging technologies to reuse, recycle and reduce water use on farms and in manure.

**Outcome Measures:**

a. 35% of impaired cropland riparian buffers under 35 feet will be re-established by 2030.
b. Complete inventory of converted or degraded wetlands by December 1, 2022.
c. 25% of wetlands converted to agriculture or degraded will be restored to functional wetlands by 2030.
d. Determine compliance rate of livestock facilities regulated under county livestock and animal waste ordinances by 2023.
e. 80% of Agricultural land in the county meets all current State Agricultural Performance Standards and Prohibitions identified in county ordinances by December 31st, 2030.




*Infographic 3-5*

**2.2 Work to implement the Wisconsin River Watershed and Upper Fox Wolf River Total Maximum Daily Load (TMDL) identified goals.**

**Strategies:**

1. Environmental Resource Committee (ERC) and County Board establishes the proper balance between voluntary/ regulatory approaches to:
    a. Establish targeted performance standards to meet water quality standards for phosphorus impaired watersheds.
    b. Reduce mechanically applied animal waste applications during snow covered, frozen or saturated conditions.
2. All surface waters, including intermittent streams, and existing wetlands will have a 35 foot tillage setback buffer.
3. All agricultural land will have Phosphorus Index (PI) levels at 2.5 pounds per acre or less.
4. Develop and support a coalition(s) of stakeholders to develop and implement action plan(s) to reduce phosphorus loading.
5. Complete implementation of the Fenwood Creek Watershed Plan and apply what was learned to future TMDL planning and implementation efforts, along with the Wisconsin River and Upper Fox Wolf River report to develop two more nine element watershed based plans in the county.
6. Seek new funding options and incentives outside of conventional government sources to implement soil health and conservation practices.

**Outcome Measures:**

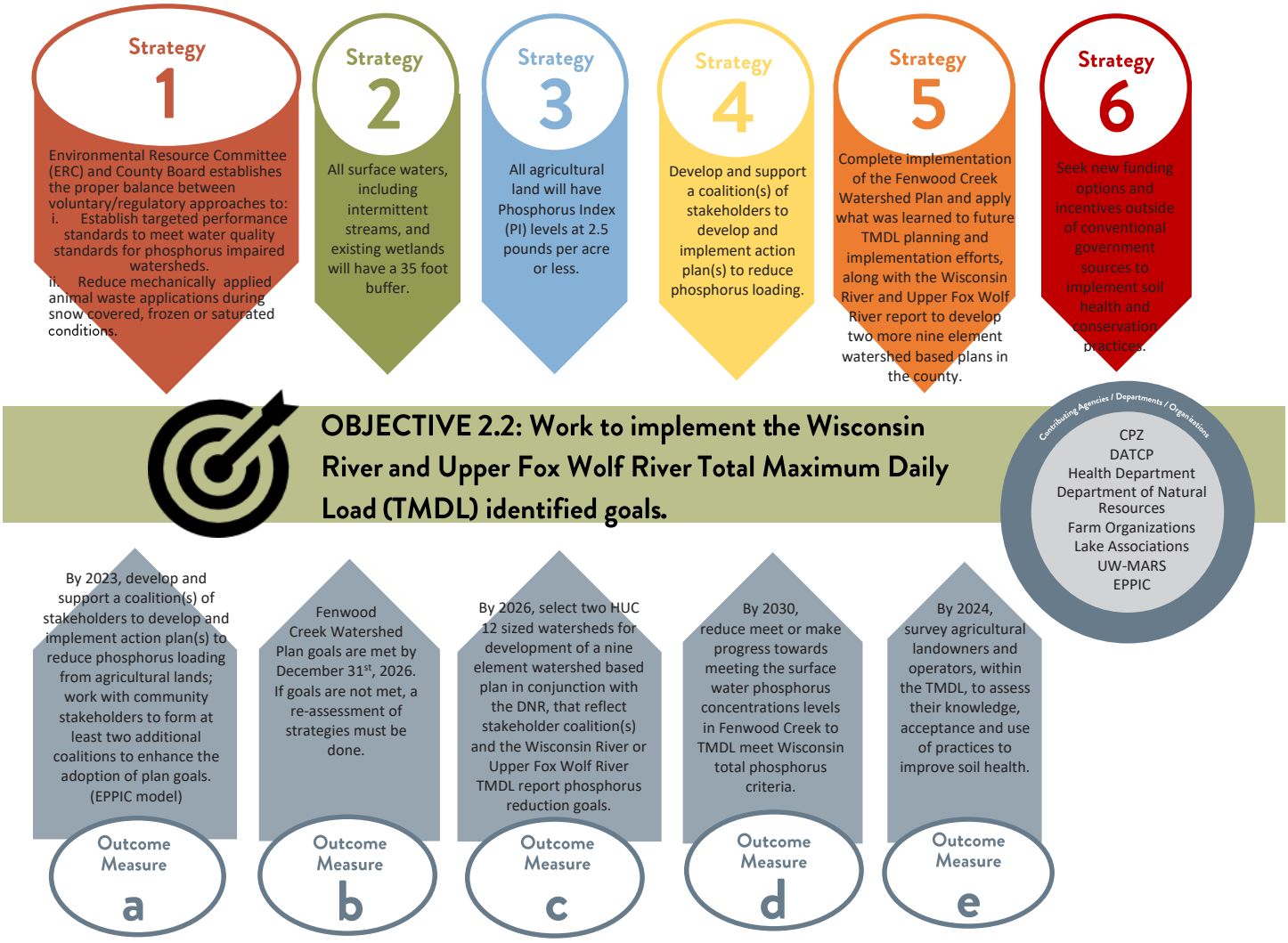
a. By 2023, develop and support a coalition(s) of stakeholders to develop and implement action plan(s) to reduce phosphorus loading from agricultural lands; work with community stakeholders to form at least two additional coalitions to enhance the adoption of plan goals. (EPPIC model)

b. Fenwood Creek Watershed Plan goals are met by December 31st, 2026. If goals are not met, a re-assessment of strategies must be done.

c. By 2026, select two HUC 12 sized watersheds for development of a nine element watershed based plan in conjunction with the DNR, that reflect stakeholder coalition(s) and the Wisconsin River or Upper Fox Wolf River TMDL report phosphorus reduction goals.

d. By 2030, reduce, meet, or make progress towards meeting the surface water phosphorus concentrations levels in Fenwood Creek to meet Wisconsin River TMDL total phosphorus criteria.

e. By 2024, survey agricultural landowners and operators within the TMDL watersheds to assess their knowledge, acceptance and use of practices to improve soil health.




*Infographic 3-6*

**2.3 Protect and enhance natural habitat areas along riparian corridors and wetlands.**

**Strategies:**

1. Promote conservation easements/programs along riparian corridors.
2. Conduct a riparian zone qualitative land cover analysis for watersheds in the county.
3. Develop and recommend a 35 foot buffer zone strategy for wetlands, outside of 303(d) impaired watersheds, by the end of 2024.
4. Support the development of lake and river management plans with key stakeholders.

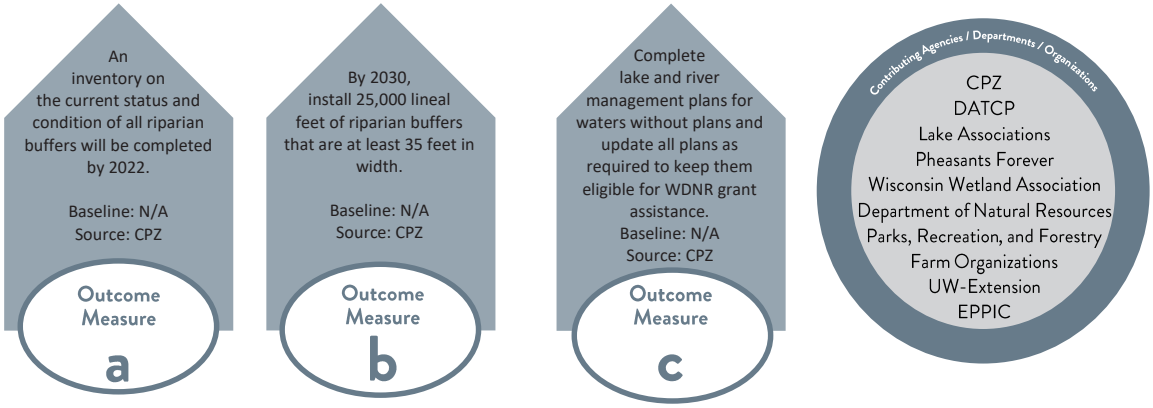
**Outcome Measures:**

a. An inventory on the current status and condition of all riparian buffers will be completed by 2022.

b. By 2030, install 25,000 lineal feet of riparian buffers that are at least 35 feet in width.

c. Complete lake and river management plans for waters without plans by 2030. Keep all plans updated, as required, to keep them eligible for WDNR grant assistance.

**OBJECTIVE 2.3: Protect and enhance natural habitat areas along riparian corridors and wetlands.**




*Infographic 3-7*

**2.4 Reduce runoff from non-agricultural sources to improve water quality.**

**Strategies:**

1. Implement the Private Onsite Wastewater Treatment System (POWTS) maintenance program to eliminate all surface discharge of septage.
2. Support implementation and enforcement of point source pollution regulations.
3. Shoreland owners will maintain existing buffers along waterbodies.
4. Shoreland owners will re-establish 35 foot buffers along waterbodies, where the buffer has been degraded.
5. Encourage the use of soil testing on non-agricultural land before fertilizer is applied near waterbodies.
6. Explore alternative methods for snow and ice removal from hard surfaces to reduce the impacts of salt on surface and groundwater.

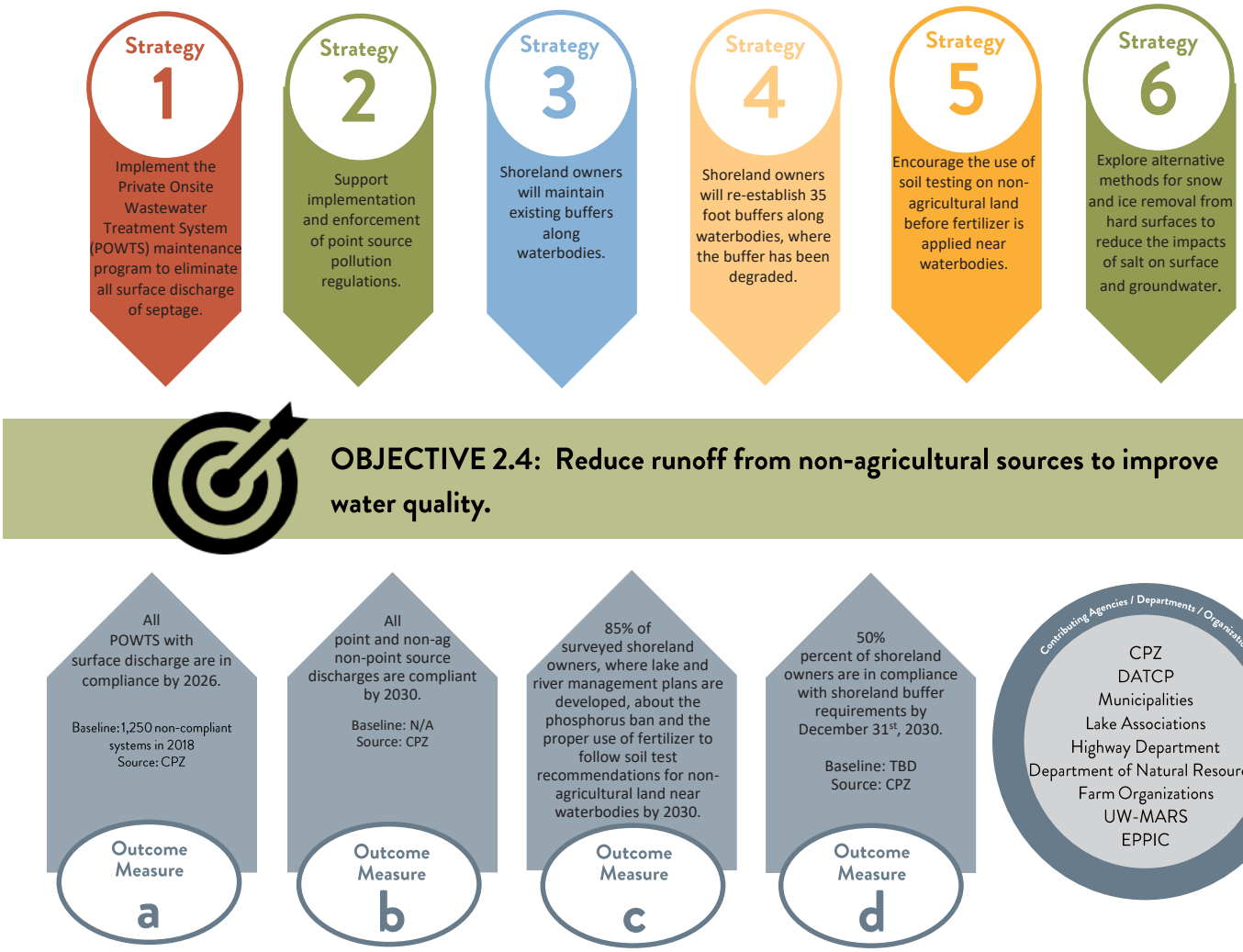
**Outcome Measures:**

a. All POWTS with surface discharge are in compliance by 2026.

b. All point and non-ag non-point source discharges are compliant by 2030.

c. 85% of surveyed shoreland owners, where lake and river management plans are developed, about the phosphorus ban and the proper use of fertilizer to follow soil test recommendations for non-agricultural land near waterbodies by 2030.

d. 50% percent of shoreland owners are in compliance with shoreland buffer requirements by December 31st, 2030.




*Infographic 3-8*

**2.5 Manage lake and stream resources to protect and improve the water quality and habitat.**

**Strategies:**

1. Continue to support the efforts of the WDNR, Lake Organizations, and Lake District associations to protect and improve the water quality and habitat of lakes.
2. Continue to mitigate aquatic invasive species by supporting WDNR projects and goals and provide services as outlined in the county AIS Network Partnership agreement. (AIS Network Partnership starts 2022 with planning in 2021)
3. Work with UW-Extension to provide information and education regarding Best Management Practices and other measures local municipalities and property owners can implement to improve water quality.
4. Coordinate water quality testing with Wisconsin Valley Improvement Corporation (WVIC) and other agencies.
5. Support healthy fisheries, wildlife and aquatic communities.
6. Provide technical assistance to protect and enhance waterfront properties to be in compliance with current Shoreland zoning requirements.

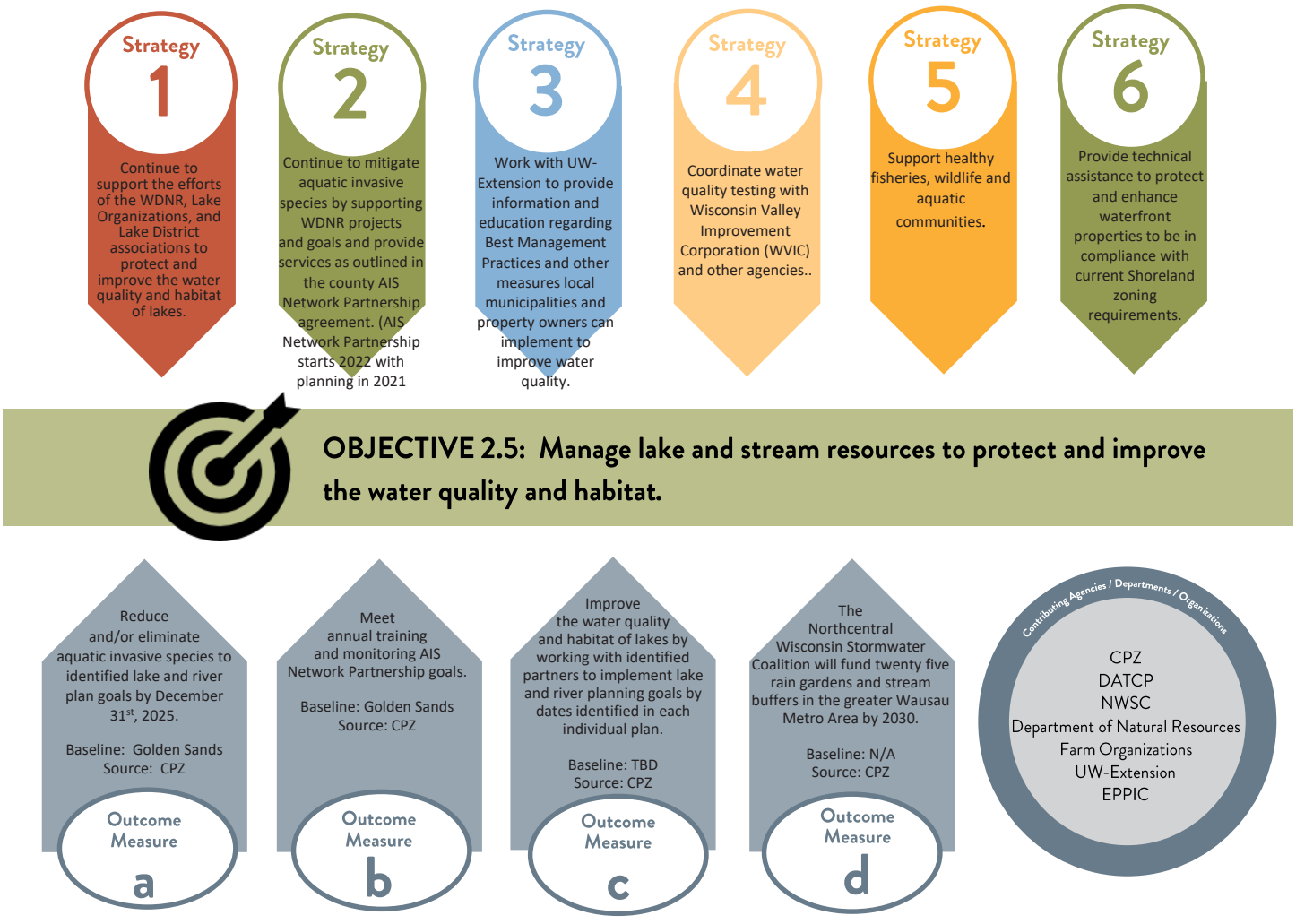
**Outcome Measures:**

a. Reduce and/or eliminate aquatic invasive species to identified lake and river plan goals by December 31st, 2025

b. Meet annual training and monitoring AIS Network Partnership goals.

c. Improve the water quality and habitat of lakes by working with identified partners to implement lake and river planning goals by dates identified in each individual plan.

d. The Northcentral Wisconsin Stormwater Coalition will fund twenty five rain gardens and stream buffers in the greater Wausau Metro Area by 2030.




*Infographic 3-9*

**GOAL 3: GROUNDWATER IS PROTECTED AND IMPROVED.**

**Objectives:**

**3.1 Protect and enhance the quantity and quality of groundwater resources.**

**Strategies:**

1. Update the 2001 County Groundwater Protection Plan, which will identify threats to groundwater quality and quantity.
2. Update county Geographic Information System (GIS) layer to properly identify municipal well recharge areas to be used for planning purposes and work to develop wellhead protection or source water protection plans for public drinking water systems within the county.
3. Continue to conduct tests and analysis of contaminants in public and private wells to develop a reliable data set which reflects the quality of water in the county.
4. Ensure all POWTS are working properly to protect groundwater.
5. Use the information from the updated groundwater plan to guide decisions on changes in land use approved by the county.
6. Amend wellhead or source water protection plans to meet EPA's nine key elements and submit to DNR and EPA for review and approval.

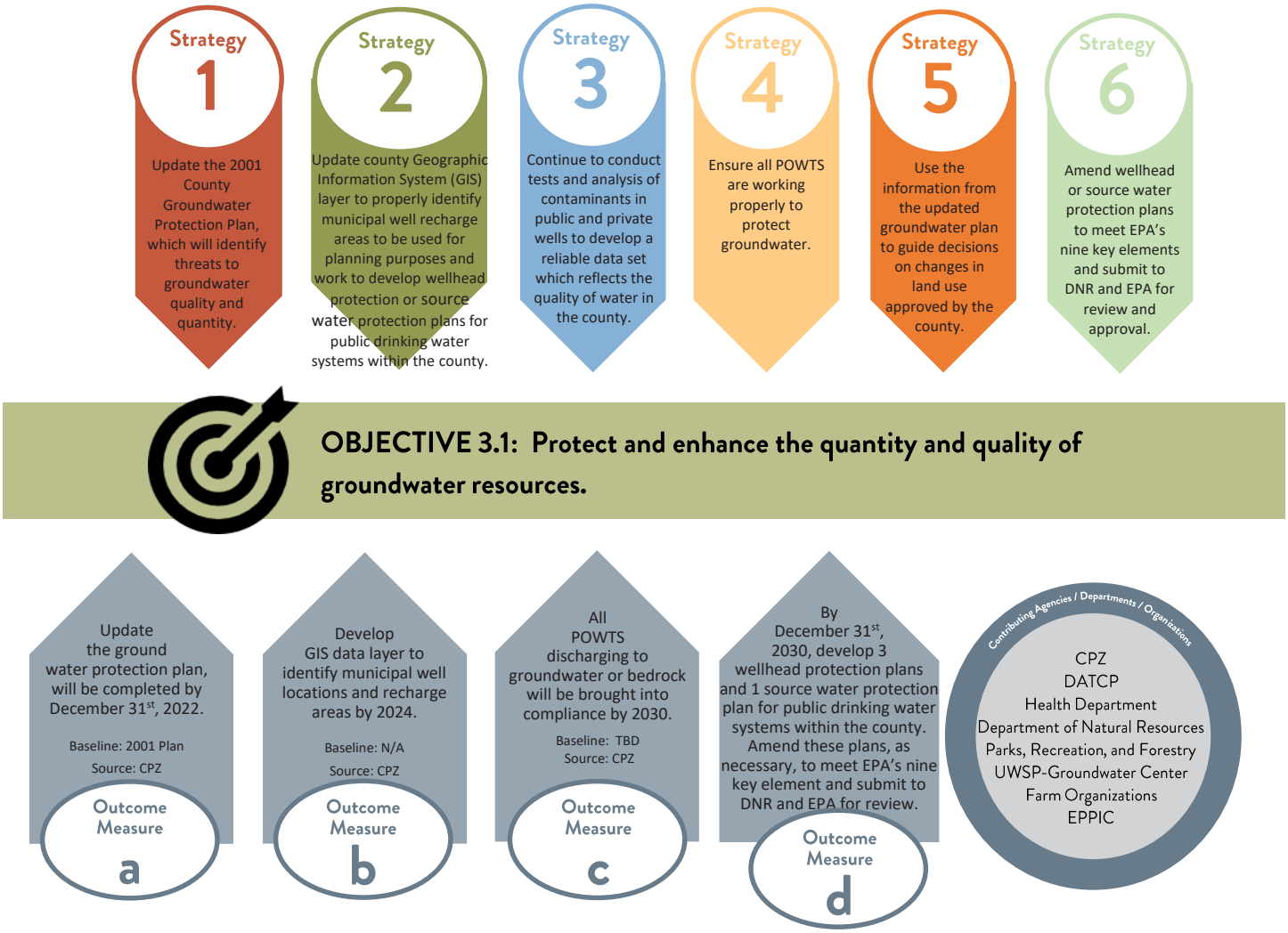
**Outcome Measures:**

a. Update of the ground water protection plan will be completed by December 31st, 2022.

b. Develop GIS data layer to identify municipal well locations and recharge areas by 2024.

c. All POWTS discharging to groundwater or bedrock will be brought into compliance by 2030.

d. By December 31st, 2030, develop 3 wellhead protection plans and 1 source water protection plan for public drinking water systems within the county. Amend these plans, as necessary, to meet EPA's nine key element and submit to DNR and EPA for review.




*Infographic 3-10*

**GOAL 4: ACTIVELY EDUCATE AND ENGAGE COMMUNITY STAKEHOLDERS TO DEVELOP AN UNDERSTANDING OF LAND, SURFACE WATER, AND GROUNDWATER QUALITY CONCERNS.**

**Objectives:**

**4.1 Improve public awareness and provide educational opportunities to enhance agricultural practices that protect land and water quality.**

**Strategies:**

1. Develop and implement strategies to educate farmers and landowners to implement best management practices.
2. Educate farmers and landowners about soil health.
3. Work with community coalitions to provide workshops, educational opportunities, and field tours to enhance agricultural practices while improving land and water quality.
4. Identify the benefits of conservation to farmers and landowners and engage them through educational activities to increase the adoption of conservation practices. This would include profitability, sustainability, natural resource protection, and soil health.
5. Provide coordinated access to information and educational materials through various sources including websites, newsletters, videos, local newspapers, public service announcements and social media.

**Outcome Measures:**

a. Organize and hold 15 on-farm educational demonstration days, per year, to show case how and why best management practices function properly and how they should be maintained. Conduct and hold five nutrient management farmer education courses per year.

b. Bi-annually conduct a survey of farmers to assess which forms they prefer to receive their information, program delivery, constraints and resistance to implementation of conservation practices.

**OBJECTIVE 4.1: Improve public awareness and provide educational opportunities to enhance agricultural practices that protect land and water quality.**

*Infographic 3-11*

**4.2 Conduct information and education activities as it relates to plan goals.**

**Strategies:**

1. Coordinate educational opportunities with the North Central Wisconsin Stormwater Coalition to inform key stakeholders.
2. Develop a clear understanding of land and water related concerns and relay the concerns in easily understood formats.
3. To develop a clear understanding of Wisconsin River and Upper Fox Wolf River TMDL reports and water quality related concerns that identify the concerns in easily understood formats.
4. Provide informational and educational opportunities to protect and enhance waterfront properties to improve water quality.
5. Coordinate educational activities based upon the importance of water quality to Schools County wide on an annual basis through environmental/agricultural teachers, 4-H, FFA, Water Action Volunteers (WAV) and environmental groups, including water quality sampling techniques.
6. Provide coordinated access to water, land and soil health information and educational materials through various sources including websites, newsletters, videos, local newspapers, public service announcements and social media.

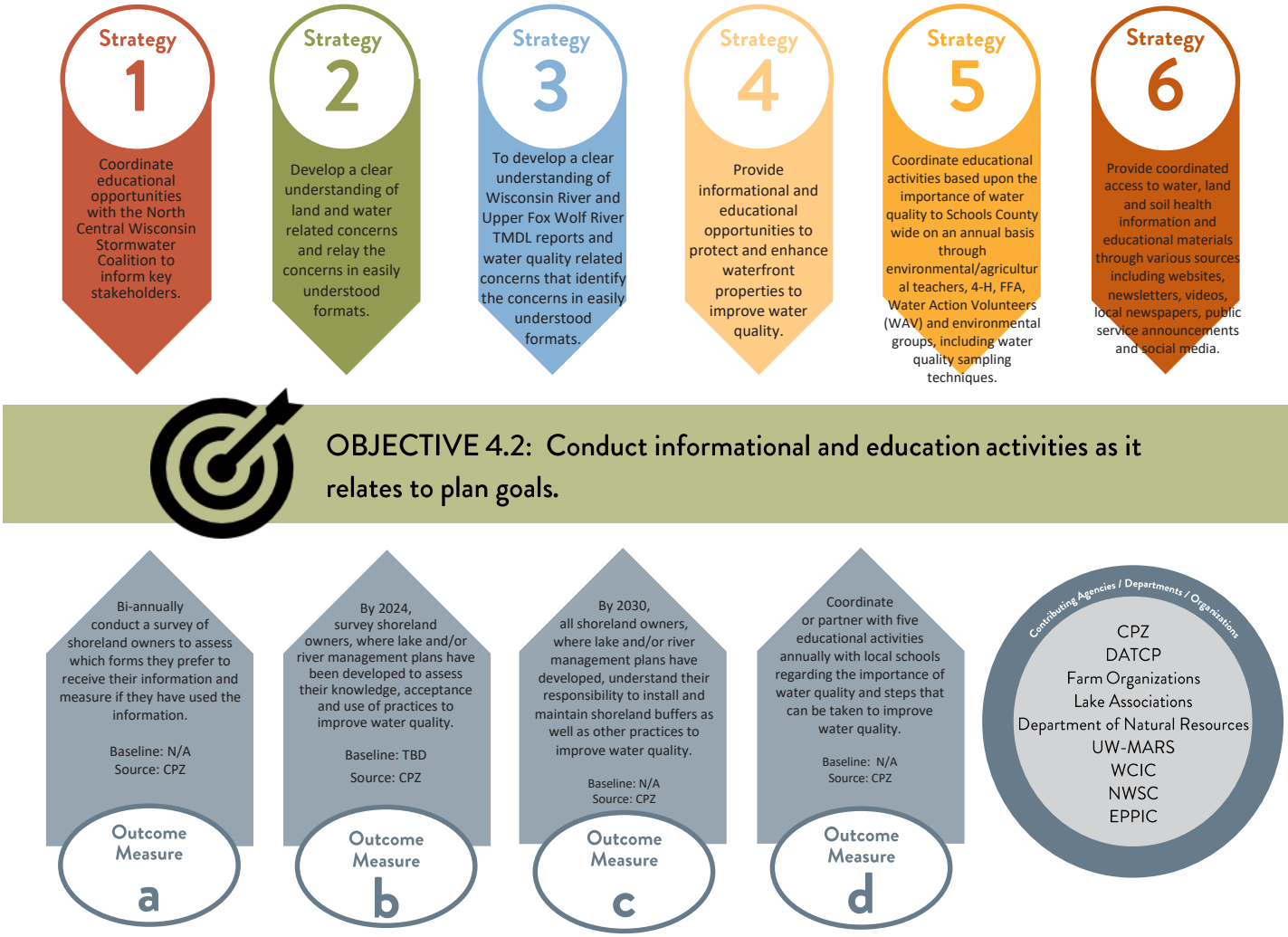
**Outcome Measures:**

a. Bi-annually conduct a survey of shoreland owners to assess which forms they prefer to receive their information and measure if they have used the information.

b. By 2024, survey shoreland owners, where lake and/or river management plans have been developed to assess their knowledge, acceptance and use of practices to improve water quality.

c. By 2030, all shoreland owners, where lake and/or river management plans have developed, understand their responsibility to install and maintain shoreland buffers as well as other practices to improve water quality.

d. Coordinate or partner with five educational activities annually with local schools regarding the importance of water quality and steps that can be taken to improve water quality.




*Infographic 3-12*

# CHAPTER 4 | PLAN IMPLEMENTATION & COORDINATION

Implementation of this LWRM Plan will be to continue education efforts, provide technical assistance, seek additional revenue streams to fund this plan, and grow compliance levels of landowners that meet the state performance standards and prohibitions. In addition, this Plan over the next ten-years will begin to focus on achieving and meeting water quality standards and lowering the phosphorus levels in the impaired watershed as specified in the Wisconsin and Fox-Wolf River Basin TMDL. Because of the complexity of the problems and multiple jurisdictions involved, most likely no one protective mechanism will solve the problem. More likely, a wide range of mechanisms will be necessary and, in many cases, may be preferred to give locally-based and supported initiatives maximum flexibility in achieving their protection goals and needs.

## Growing Community Engagement

It is imperative to recognize the need to develop and grow a committed groups of stakeholders at the watershed level, such as we have done with EPPIC. (see EPPIC videos on youtube https://www.youtube.com/channel/UCUgOVeQ-aqYyEdPLBtfuUsg ) A valuable lesson has been learned in the past that not just one or two groups can accomplish this task. A broad group of stakeholders need to be involved to achieve the outcome we desire, where a large percentage of people that control the land, implement conservation on their land to improve the land and water. Marathon County CPZ staff has and will continue to seek valuable input and coordinate with a diverse group of agencies, associations, private sector business, citizens, landowners, farmers and organizations involved in resource management and protection.

These agencies and groups include: United State Environmental Protection Agency, United States Department of Agriculture-( Natural Resource Conservation Service, Animal and Plant Health Inspection Service – Wildlife Services, and United States Forest Service), Wisconsin Department of Agriculture, Trade, and Consumer Protection, Wisconsin Department of Natural Resource staff (such as Water Resources Management Specialists, Fisheries Biologists, Water Regulations and Zoning Specialists, Water Program Management staff, Watershed Management staff), Army Corps of Engineers, University of Wisconsin Madison–Division of Extension; University of Wisconsin Stevens Point and Marshfield Agriculture Research Station, County Parks and Forestry, Land Records & Regulations, and the County Highway and Health Department.

*Public engagement*

Other organizations involved include the following: County Lake Associations/Districts, GrassWorks Inc., Big Eau Pleine Citizens Organization, Golden Sands Resource Conservation & Development Council, North Central Wisconsin Stormwater Coalition, Eau Pleine Partnership for Integrated Conservation, Lake Wausau Association, and the Wisconsin Valley Improvement Corporation. In addition, CPZ staff works actively with many regional organizations promoting resource conservation at both large and small-scale levels. Each agency, organization, association, and individual has its individual resource issues, programs, and plans; but cooperatively we can work together for the greater good of Marathon County's land and water resources.

## Nonpoint Source Pollution and Storm Water Managements

The threats to surface and groundwater resources are changing. Historically, point sources were viewed as the primary threat. Now, however, because of the successful implementation of point source controls, nonpoint runoff pollution is the primary threat to county water resources. Nonpoint problems are both water quality and quantity based. The increase of storm water runoff from poor soil conditions and increasing impervious surfaces are major threats to water resources. The solutions to these problems

are watershed-specific and therefore must be pursued using a watershed approach sometimes involving multiple government jurisdictions.

### Healthy Soil for Healthy Plants, Animals and People

Soil health can be defined as the capacity of a soil to function as a vital living ecosystem that sustains plants, animals, and humans. The importance of managing soil health to sustain agricultural productivity for this and future generations cannot be overlooked. We need to recognize that, when provided with the basic necessities of life, the living component of soil performs functions crucial to the production of food and fiber. We must consider and care for soil as a living ecosystem. It is teeming with billions of living bacteria, fungi, and other microbes that are the foundation of a stable ecosystem. This microbial component of the soil ecosystem: improves soil structure and stability; cycles nutrients for plant growth; increases rainwater infiltration and storage for use during drier periods; and prevents potential pollutants from leaving our fields. If we needed to measure soil health by only one criterion it would be organic matter. In general, if organic matter levels are decreasing our soil health is declining and if they are increasing our soil health is improving. The best management practices most commonly used to increase organic matter levels and improve soil health are managed grazing, cover crops, conservation tillage, no-till and perennial crops. In Marathon County, farmers can no longer leave soils exposed to the elements from early October through mid-June if the county is to have healthy soils and clean water. To improve soil health the following five principles need to be understood and followed by farmers in the county:

#### 1. Soil Cover

Keep plant residues on the soil surface -- a high percentage of soil must be protected by residue. Living or dead vegetation on the soil surface year round is the building block for soil health.

#### 2. Limit Disturbance of Soil

Minimize or eliminate tillage, this provides an opportunity for soil biology to start re-building soil aggregates, pore spaces, and organic matter.

#### 3. Increase Diversity

Mimic nature by incorporating a diversity of cool and warm season grasses and broad leaf plants into a management system, by utilizing three or more crops and cover crops in a rotation. Grassland and cropland plant diversity increases soil and animal health.

#### 4. Living Roots

Keep plants growing throughout the year to feed the soil. Cover crops and perennial forages add carbon to the soil via biomass and root exudates that feed and sustain soil micro-organisms.

#### 5. Integrate Livestock and animal manure

Managed grazing and properly applied animal manure from storage increases the soil biological activity on cropland, and improve nutrient cycling. Proper grazing techniques of managed pastures, cover crops and crop residue, increases livestock's level of nutrition.

**NR 151 Agricultural Performance Standards and Prohibitions Implementation:**
The specific roles and responsibilities of the county and state agencies in implementing these standards and prohibitions are well defined in NR 151 and ATCP 50. Under this program approach, CPZ staff will conduct status reviews of cropland and animal production areas for compliance with NR 151 Agricultural Performance Standards and Prohibitions as part of existing incentive, cost sharing, and permitting programs. In conducting the status review, staff may consult with DNR when determining which of the state standards and prohibitions apply to parcels being evaluated and determine the extent of compliance for each of the applicable standards and prohibitions. While conducting status reviews, staff use prescribed tools to determine compliance with applicable NR 151 performance standards and prohibitions. The information from the status review form is used to document the compliance status of parcels within the county. The status review results are tracked in the county's GIS, insuring current and future status of parcels and to create reports pertaining to overall NR 151 compliance throughout the county.

*cover crop between corn rows*

*goats grazing*

Upon completion of the status review, the landowner is provided a status report and provided an opportunity for review, comment, and appeal. In circumstances where full compliance has not yet been achieved, CPZ staff will work with the landowner to develop a timeline for compliance and secure technical assistance and cost-share funding when applicable and available. CPZ staff may also consult with DNR for select cases of NR 151 non-compliance.

*Farms subject to program requirements and/or regulatory enforcement of the state standards include:*

1. Property owners who require permits or enforcement under the County Animal Waste Management and/or Livestock Facilities Licensing Ordinances.
2. Lands enrolled in the Farmland Preservation Program in order to receive program tax credits.
3. Livestock operations which are new or expanding.
4. Operations which are subject to state jurisdiction under WI Stats. 281 and NR 243 or NR 151 that are found to be out of compliance with the NR 151 agricultural standards, as determined by a site evaluation conducted as part of routine permit monitoring or in response to a public complaint.
5. Farmers participating in the Multi-Discharger Variance Program.

6. Farmers entering into cost share agreements with the county.

**Priority Farm Strategy:**
There is a need to establish priorities because of limited time and financial resources. CPZ staff will follow the priority of services guidelines listed below to achieve LWRM Plan implementation. Currently there is high demand for administrative, technical, cost-sharing, and regulatory services administered through CPZ. The two highest priority objectives to meet plan goals are:

- Implementation of priority cropland Best Management Practices (BMPs) which support the five principles of soil health, listed above, include but are not limited to cover crops, no-till and conservation tillage, managed grazing, grassed waterways, clean water diversions, perennial forages, manure spreading during low risk times of the year, and implementing nutrient management plans.
- Implementation of NR 151 Agricultural Performance Standards and Prohibitions.

**High Priority for Services- Hierarchy of priority based on goals identified in Chapter 3**
To most efficiently and cost-effectively meet the demands for technical and financial assistance, while addressing the high resources concerns, CPZ staff will follow the priorities listed below based upon farm size, location, and programs:

- Fenwood Creek Watershed farms.
- Animal Waste Management Ordinance.
- Livestock operations with more than 500 animal units but not permitted by WI DNR as a Concentrated Animal Feeding Operation (CAFO).
- Manure application during high risk (frozen, snow coered or saturated) soil conditions.
- Farmland Preservation Program participants.
- Farms located within the impaired waters identified by the WI DNR, that want to advance their farms to superior levels of management by implementing the five principles of soil health.
- Status reviews for compliance with NR 151 Agricultural Performance Standards and Prohibitions on farms that receive cost sharing, permitting, or other programs that require compliance with one or more of the state standards:
- Livestock operations between 300 animal units and 500 animal units.
- Managed Grazing Program in Marathon and Lincoln County.
- Participants in other voluntary cost sharing programs outside of high priority locations, farm size, or program.
- Riparian and wetland buffer installation and maintenance.

*bedded pack barn*

*In responding to public complaints or staff observations, highest priority is assigned to:*

- Sites or farms identified above as high priority for services.
- Sites or farms where there is an immediate threat to fish, wildlife, and/or habitat.
- Sites or farms where resource impacts are evaluated to be severe, and compliance can be achieved.
- Technical and administrative support for local units of government undertaking initiatives to improve water quality.

**Medium Priority for Services**

- Farms located within watersheds of Outstanding and Exceptional Resource waters.
- Farms located within watersheds where TMDL reports or implementation plans are not yet prepared.

*In responding to public complaints or staff observations, medium priority is assigned to:*

- Sites or farms identified above as medium priority for services.
- Sites or farms where impacts are less severe.

**Low Priority for Services**

- All other operations

## Technical and financial assistance

Providing quality technical and financial assistance through CPZ and/or private service providers is an important part of achieving plan outcomes. This assistance is utilized in the following ways:

1. Implement best management practices by providing quality technical assistance and promoting and administering federal, state, and county cost share conservation programs to achieve LWRM plan priorities
2. Monitor and track conservation plans and practices and assess resource needs.
3. Provide training for farmer-developed nutrient management plans.
4. Plan review and permit issuance, ordinance implementation.

## Enforcement and compliance

Safeguards are a necessity at times to achieve plan goals and to protect the land and water of the county. Therefore, Marathon County has put into place fair and consistent ordinances and a defined enforcement policy for county ordinances administered by CPZ. These tools will be used and followed when enforcement and compliance with these ordinances is necessary. The relevant ordinances and enforcement process will be used when it comes the following situations:

1. Evaluating land parcels, notifying landowners of compliance status, offering cost sharing, providing technical assistance, and follow enforcement process to implement the cropland NR 151 Agricultural Performance Standards and Prohibitions.
2. Livestock Facilities Licensing Ordinance, and Animal Waste Management Ordinance in accordance with the priority farm strategy listed above.
3. Updating and implementing county ordinances related to land and water programs as needed or required by state statute or regulation.
4. Consider county stormwater and construction site erosion control incorporation into county land division, shoreland, and floodplain ordinances.

## Information and Education Strategy

Successful information and education strategies are essential to properly focus on the myriad of land and water goals of this LWRM Plan, along with Marathon County's conservation and planning programs, to achieve phosphorus reduction. Educational opportunities for local officials, land owners, farmers, and all citizens whether urban or rural, young or seniors, are paramount to share and generate a cohesive awareness about protecting and enhancing the land and water resources. In order to improve and protect these resources, collectively a change of culture by all those with a stake in these vital resources is required to be successful.

Information and education activities will be critical to reaching each plan goal. An information and education strategy is also a separate goal of this plan. Initial implementation of the information and education strategy is outlined in each one-year work plan. The strategy will be evaluated and modified along with other components of the work plan each year.

Citizen engagement through community stakeholder groups are critical components of the implementation of this LWRM Plan.

- A water resources technician along with dedicated conservation staff and partners provide focus to, and coordination of, natural resource educational efforts related to their program priorities.
- CPZ staff that deal directly with the public by answering the telephone or greeting clients are trained to distribute appropriate educational materials and refer clients to the appropriate staff person, department, or agency.
- The development and assessment of information and education strategies is imperative to ensure targeted audiences are reached and engaged, especially given the wide variety of communication platforms available today.

*stream in eastern Marathon County*

*Riparian and Wetland Tillage Setback Buffer*

Policy development and adoption of a Riparian and Wetland Protection buffer including a "Tillage Setback Policy' is required as part of this LWRM Plan, to protect existing vegetation in riparian corridors and work to restore the integrity of the natural resource areas. A riparian and wetland "Tillage Setback Policy" minimizes or prevents the alteration of the riparian zone along stream segments to ensure that functions provided by the riparian and wetland areas are protected. The riparian zone is an ecological term that refers to

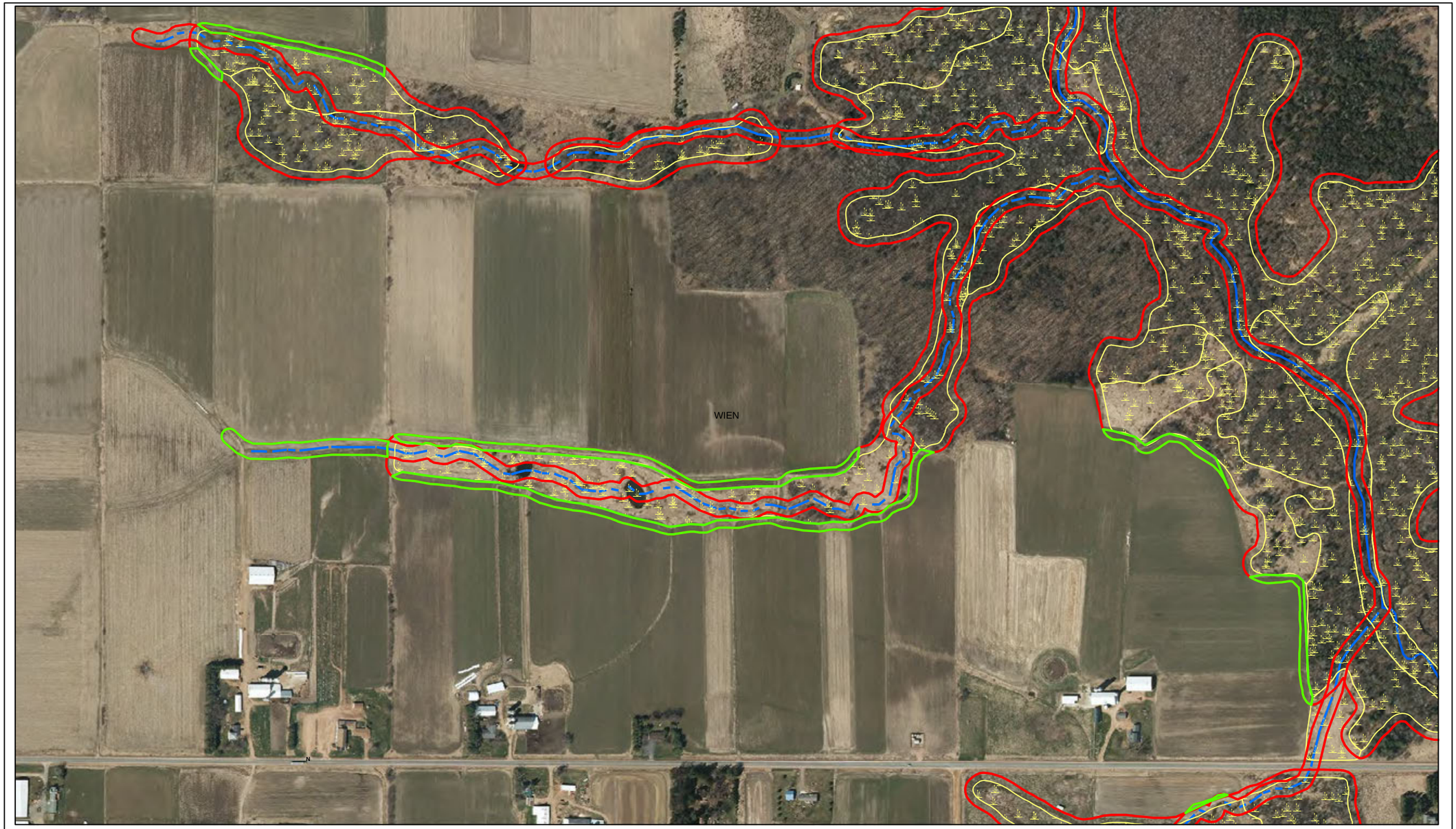



*FIGURE 4-1*

EXAMPLE TILLAGE SETBACK MAP
MARATHON COUNTY WI

the habitat adjacent to a river or stream that functions to support and enhance aquatic and terrestrial communities who are dependent on the river or stream. The riparian or wetland buffer refers to a "green corridor" along the banks of a river, stream or wetland that separates water bodies from tillage or developed land uses and is intended to provide protection from the harmful impacts of such uses on water quality. Research has indicated that these types of setbacks can range from 25 to 300 feet depending on the size and drainage area of the stream and quality of wetland; however at this time, such broad protection zones can only be encouraged on a voluntary basis. This plan does call for the county to consider the development and implementation a 35-foot buffer for surface water and wetland areas, which would be consistent with other state protections for property owners along shoreland areas. See Figure 4-1.

*Protection of Regionally Important Water Resources*

The need for careful judgment may be required to facilitate the management and protection of regionally important water resources, which are sensitive to local environmental impacts and yet provide important benefits to the residents of the region. These water resources can benefit from the strategies described in this LWRM Plan, which includes both legislative and administrative management recommendations. They also require cooperative efforts among the adjoining units of government that effect these waters. The development of management and protection strategies for regionally important water resources is based on existing information from the Wisconsin River Basin TMDL.

The identification of groundwater areas in need of protection is less defined than surface waters. One can pinpoint the locations of groundwater withdrawals for municipal and agricultural drinking water systems. Areas served by individual systems/wells are distributed over a broader area. It is important in groundwater protection to manage aquifer recharge areas. The delineation of aquifer recharge areas requires extensive subsurface geological information, which is often not readily available. Therefore, those areas, which are dependent on groundwater for a sizeable portion of water supply, are identified here in general terms only.

**Partners**

*Federal*

Section 303(d) of the Clean Water Act and Chapter 40 of the Code of Federal Regulations, Part 130 require states to develop total maximum daily loads (TMDLs) for waters not meeting designated uses under technology-based controls for pollution. The TMDL process quantitatively assesses the impairment factors so that states can establish water quality based controls to reduce pollution from both point and nonpoint sources, and to restore and protect the quality of their water resources.

*State Legislation*

This LWRM Plan recognizes legislation enacted in Wisconsin that established standards for the management of water quality standards and nonpoint source pollution, and provides a mechanism for local accountability to meet state minimum standards. However, it is clear from the deliberations of the LAC, charged with addressing the issues of land and water resource management recommendations for this plan, that the absence of adequate state statutory standards severely impedes adequate regulation to effectively achieve water quality standards and targets identified in the Wisconsin River TMDL and this Plan. These deficiencies need to be addressed by county board and proper recommendations sent to State leaders.

*State Agencies*

Improved linkages among different levels of government and existing protective mechanisms are needed. Actions taken by one level of government should be coordinated to maximize local, state, and federal investment and avoid long-term irreversible negative impacts on land and water resources.

*Marathon County*
CPZ staff will continue to work closely with a diverse group of agencies, associations, and organizations involved in resource management and protection and include the following: The Eau Pleine Partnership for Integrated Conservation (EPPIC), Big Eau Pleine Citizens Organization (BEPCO), Lake Wausau Association, various lake districts, Pheasants Forever, River Alliance of Wisconsin, Golden Sands, and Central Wisconsin River Graziers Network.

### Work Plan and Timeline

An annual work plan and timeline will be determined by the goals, objectives, strategies, and outcomes as identified in Chapter 3. The infographics clearly identify conservation staff activities to achieve the overall identified goals to be accomplished through specific objectives, activities and partnerships, with specific outcomes to accomplish within a specified timeframe. This model reflects the county's Comprehensive Plan and Strategic Plan format for continuity. Each year the conservation staff work plan and status will be evaluated to better inform and guide decisions towards education efforts, funding levels, staff directives, and efforts designed to preserve and protect land and water resources.

### Current and Future Potential Funding Sources

*Annual Fiscal Resource Projection*
The annual CPZ budget typically supports 7.7 full time equivalent staff positions whose primary focus is on LWRM Plan implementation. In 2010 there were 5 full time equivalent staff positions. Funding for these positions varies from year to year, but there is consistently on average over the last four years approximately $730,000 of county tax levy and $580,000 DATCP/DNR staffing and cost share grants which are relied upon to provide base funding for staff along with matching grant obligations for various staffing grants.

Annually there is an identified staffing budget shortfall of $190,000 and $730,000 cost share shortfall to meet the high priority objectives in the current and proposed Land Water Resource Management plan. This does not reflect any specific watershed plans or projects, which would need their own budget to be developed.

Despite a decrease in state funding over the last decade for staff and stable county tax levy, CPZ has been able to slowly increase staffing levels because of successful efforts to secure grants, provide stable revenue streams, and partnership agreements to boost the amounts of cost sharing and staff positions. In recent years CPZ has secured grants from the following sources to increase its current staff funding levels:

- *National Association of Conservation Districts-Technical Assistance Grant*
  $40,000 per year to support the managed grazing efforts.
- *National Association of Conservation Districts-Technical Assistance Grant*
  $35,000 per year to support the Farmland Preservation efforts.
- *Natural Resources Conservation Service-multiyear Cooperative Agreement*
  Provides $80,000 per year to support Conservation Specialist position working primarily in the Big Eau Pleine Watershed, which includes the Fenwood Creek.
- *DNR Lake Protection Grant*
  Multiyear grant supports Water Resources Technician position and Aquatic Invasive Species program partnership with Golden Sands RC&D.
- *Service fees* on cost share grants provide reliable funding to support staff expenses.

These grants and allocations have allowed CPZ to increase staff levels but they are not stable long term funding sources. A more sustainable approach is needed to secure additional County tax levy along with State base funding to fund staff positions and to pursue grants to provide cost sharing to farmers and landowners, which support State objectives. This approach is recommended to stabilize program efforts. To meet additional LWRM Plan goals and objectives along with desired outcomes, additional funding sources will need to be secured to achieve full plan objectives. Annual budgets will reflect county direction on plan implementation goals. Specific budgets will be developed to implement various goals within the plan. This plan is based upon current funding and staffing levels, with opportunities for new directions and initiatives if funding is provided.

### Grant Funding for Projects, Farmers and Landowners

Marathon County conservation programs have typically ranked well over the years in grant funding allocations supporting the work efforts aligned with conservation program implementation and practices to protect the soil and water resources within the county. For example, funding allocations for 2020 include the following:

- *Marathon County Total Funding allocation for 2020*
  Staffing funds and cost share funds totals $314,865. Marathon County has steadily risen and now ranks #1 in the state in highest total DATCP grant funding.
- *Marathon County Funding Allocation for Bond Cost Sharing*
  Annually, funds to be used for structural type conservation practices totals $75,850, and segregated fund revenues (SEG) cost sharing and funds to be used for "soft" practices such as nutrient management, no till, cover crops, etc. totals $95,000. Marathon County now ranks #1 in the state for total DATCP cost sharing for farmers compared to #26 in 2010.
- *Nutrient Management Farmer Education Training Grant*
  The annual multi county nutrient management farmer education program that Marathon County initiated 13 years ago received $53,350 of grant funds for 2020, with most of the funds going directly to participating farmers. This allocation is the highest in the state.

*classroom training fro farmers on Nutrient Management*

*growing money*

- *DNR Targeted Resource Management (TRM) grants*
  CPZ has been highly successful in securing grants to fund projects on farms. Both small and large scale grants have been secured over the last 10 years that have funded individual projects on farms along with watershed-scale projects such as the Fenwood Creek Watershed. These grants have varied annually from $50,000 to $800,000 with a ten year total of just over $4,000,000 that went directly to farmers. These types of grants will continue to be secured to fund conservation projects within the county.

- *Lake Grants*
  Marathon County has partnered with Lake Groups and associations to secure grants for Lake Plans, and now Lake Grants to aide in implementation of the plans that have been developed. CPZ will continue to grow this effort to secure grants to both develop new lake and river planning grants along with implementation grants to meet plan objectives.

- *Multi-Discharger Variance Program*
  These funds from the DNR are used in the Fenwood Creek Watershed as incentive payments to farmers. To be eligible, farmers must meet all State Agricultural Performance Standards and Prohibitions. Once eligible, farmers can earn incentive payments based on the amount of additional phosphorus reductions they make on their cropland. Funding ranges from $30,000-$40,000 per year.

According to the Wisconsin River Basin TMDL, the primary source of nonpoint pollution is from rural areas whose major land use is agriculture. As a result, agricultural stormwater runoff from fields carries animal waste, pesticides, nutrients, sediment, and phosphorus. The TMDL has identified phosphorus as the primary nonpoint source pollutant, and will be the focus of conservation staff and efforts.

The evaluation and monitoring of water quality and habitat along riparian and wetland areas will be critical to improving overall water quality in designated impaired watersheds within Marathon County, as well as coordinating with adjacent units of government where areas of impaired watersheds are located outside of the county. Land cover using the Wiscland 2.0 digital database will enable staff to examine GIS land cover data to further examine physical land cover attributes that may exacerbate nonpoint source pollution on a sub-basin scale and on a more refined analysis along riparian corridors.

The Marathon County LWRM Plan is intended to be a flexible document that will review progress toward goals, objectives, and measurable outcomes on an annual basis. CPZ staff will align annual work program efforts to ensure effective favorable progress.

## Agricultural Nonpoint Source and Farmland Preservation Program Monitoring and Tracking

1. *Agricultural Performance Standards and Prohibitions Monitoring and Evaluation*
   GIS technology, SnapPlus nutrient management planning software, remote sensing, and on-site evaluations are currently being used as tools to evaluate, track and monitor landowner compliance with the agricultural performance standards and prohibitions. Animal lot manure discharges are monitored using the BARNY runoff model.
2. *Soil Transect Survey*
   A biennial Soil Erosion Transect Survey conducted by conservation staff, farm-level soil conservation assessments via SnapPlus nutrient management planning software and use of satelite imagery are some main tools used to monitor the erosion of croplands within the county, along with changes in land use.
3. *Monitoring Soil Organic Matter Levels*
   Soil health is monitored by analyzing annual aggregate county-wide soil test data for organic matter levels based upon data from thousands of soil test results from various DATCP-approved labs and reported by the UW soil testing lab.
4. *Wetland monitoring through partners*
   The Wisconsin DNR provides, updates and maintains the official wetlands mapping of the State. CPZ depends on these maps along with site specific delineation when needed to identify wetlands.
5. *35 Feet Tillage Setback*
   This LWRM Plan calls for an inventory of 35 foot Shoreland buffers. This will begin an effort to track, evaluate and increase buffers along surface waters and wetlands of the county.
6. *Agricultural Runoff*
   The reduction of agricultural runoff to surface water is outlined in Objective 2.1 and success will be determined by monitoring the outcome measurements in chapter 3. Monitoring will be done with a variety of tools including site specific evaluation tools, watershed modeling , use ofstaelite imagery to estimate crop residue levels and monitoring by the WI DNR.
7. *Phosphorus*
   Phosphorus loading from agricultural croplands and pastures is currently modeled using the Wisconsin Phosphorus Index (PI) planning and assessment tool that is part of the SnapPlus nutrient management planning software program.

As part of tracking the outcomes over the life of this LWRM Plan, conservation staff will conduct a biennial survey of farmers to assess which forms they prefer to receive their information and measure if they have successfully used or implemented the information. Public awareness and educational opportunities to enhance agricultural practices will be promoted events through educational demonstrations such as on-farm field days, and through courses such as nutrient management farmer education classes.

## Surface Water Quality Monitoring

*Phosphorus loading*

The need for water quality monitoring and assessment for phosphorus loading is characterized by the data results found in the Wisconsin River Basin TMDL report. Clearly, the most significant element of this LWRM Plan is to achieve and reduce surface water phosphorus levels to recommended TMDL phosphorus criterion for 303(d) impaired waters in Marathon County. The county will rely upon the WI DNR for their prescribed role in water quality monitoring within the county. In addition, the Wisconsin Valley Improvement Company will continue to monitor various waterways within its control, and has agreed to share the data with CPZ. This includes monitoring the Fenwood Creek.

Additional water quality monitoring will include lakes and streams testing through volunteer efforts and the Wisconsin Valley Improvement Company (WVIC). Responsible agencies, local government, volunteer groups and WVIC will collaborate to monitor water resources.

*Lake Districts*

Marathon County in cooperation and partnership with citizens, communities and the University of Wisconsin Stevens Point developed 10 Management Plans and 11 Lake Studies to protect, enhance, and improve long-term water quality. Marathon County will continue to assist, promote and monitor the implementation of the plans.

*Aquatic Invasive Species*

Marathon County has entered into a working relationship with the Golden Sands Resource Conservation & Development Council to conduct ongoing inventories, monitoring and management of lakes and reservoirs.

## Citizen Monitoring

Raise public awareness, especially among the watersheds' residents, of the pollution sources and solutions in and out of Marathon County. Take a more proactive approach of Water Action Volunteers, citizens and citizen groups to monitor natural resources.

## Project Tracking

Conservation staff and partners will continue to meet annually over the next 10 years following plan adoption. Conservation staff will be responsible for demonstrating and assessing progress toward the stated goals, to allow both staff and partners to target projects and revise/amend the strategies if a realignment is required to better achieve the overall protection of natural resources.

## Overall Plan Evaluation

Important aspects of the LWRM Plan include tracking progress, maintaining contact with partner communities/organizations, and amending/updating the plan to reflect newly identified opportunities, needs, and gaps. It is planned that the partners will revisit goals, objectives, action steps, and outcomes annually to determine necessary program adjustments.

The partners will continue to meet following plan adoption over the life of this plan to assess progress toward the stated goals, to allow partners to better target projects and revise/amend the plan at its 5-year interval. The list of actions allows key stakeholders to assess progress in the following manner:

- Limited sampling is proposed along the Big Eau Pleine Reservoir and tributaries.
- Use of some BMPs assumes typical pollutant reduction and often does not involve monitoring. Conservation staff will document the amount, location, and type of BMPs installed relative to the plan items, which will allow pollutant load reductions to be modeled.

- Select projects will be monitored for effectiveness (e.g., pollutant reduction), as part of the project or as a separate monitoring effort.

These data will be compiled yearly. Partners will meet approximately quarterly to coordinate on projects and share results. Each year, partners will review progress and assess whether revised goals are needed.

*Plan Update/Annual Work Plan Revision*

To assess progress and update partners, conservation staff will:

- Track progress using summary tables;
- Hold meetings with partners and discuss plan progress, pending projects, and newly identified project needs at least four times a year or as appropriate to manage projects;
- Maintain contact with partners by telephone, e-mail, newsletter, or other methods; and
- Present updates at meetings, e.g. ERC, EPPIC, other pertinent groups.
- Consult annually with DNR nonpoint, TMDL and WQ monitoring staff to discuss/evaluate progress and opportunities for collaboration to implement TMDLs within selected watersheds.

CPZ will retain the LWRM Plan document and use its web page to post updates, information, discussion materials, upcoming events/coordination, and contact information.

# APPENDIX A

# APPENDIX A

## MARATHON COUNTY ADMINISTRATOR THROUGH THE AUTHORITY PROVIDED IN CHAPTER 2- THE GOVERNING BODY HEREBY CREATES A LOCAL ADVISORY COMMITTEE FOR THE ENVIRONMENT AL RESOURCES COMMITTEE FOR THE PURPOSE DEVELOPING A LAND AND WATER RESOURCE MANAGEMENT PLAN

**WHEREAS**, Wisconsin State Statute 92.10 and ATCP 50.12(3) require the Environmental Resources Committee (ERC) to prepare a land and water resource management plan that, at a minimum, does the following:

- Develops an assessment of water quality and soil erosion throughout the County
- Specifies water quality objectives for each priority watershed and priority lake
- Identifies best management practices to achieve water quality objectives and to achieve tolerable erosion levels
- Identifies applicable performance standards and prohibitions related to the control of pollution from nonpoint sources
- Describes multi-year plan of activities and priorities for any activities related to land and water resource protection
- Describes a monitoring program with performance measurements
- Provides for education and information of soil and water resource management
- Strategy to coordinate activities with programs of other local, state and federal agencies. and

**WHEREAS**, the Environmental Resource Committee is required to actively solicit public participation in the planning and evaluation of soil and water conservation programs through a local advisory committee as specified in ATCP 50.12(3), and

**WHEREAS**, the Environmental Resources Committee values citizen involvement land and water resource management, and

**WHEREAS**, the Environmental Resources Committee supports the efforts of the Citizens and Technical Advisory members in the development of the land and water resource management, and

**WHEREAS**, the development of the land and water resource management plan will serve to guide local, state and federal programming in protecting and conserving resources, and

**WHEREAS**, DNR consultation and involvement in land and water resource management planning will provide for a more complete plan, and

**NOW, THEREFORE BE IT RESOLVED** that the County Administrator of the County of Marathon does hereby resolve to authorize the local Advisory Committee (membership as attached) to provide advice and assist in development of recommendations for inclusion in the Land and Water Resources Plan.

**AND FURTHER IT BE RESOLVED**, that the Environmental Resources Committee approves of the appointment of advisory members.

Jacob Langenhahn, Chair

Dated this 6 day of June, 2019

Marathon County Environmental Resource Committee

**Local Advisory Members:**

Randy Fifrick
Marathon County Board Supervisor District 15
Environmental Resources Committee member
1555 Greenwood Drive, Kronenwetter, WI 54455

Mary Kate Riordan
Maple Ridge Farms, Owner, Marketing
Lake Wausau Association Board
212 Rainbow Lane, Wausau, WI 54401

Peter Arnold
Dairy Farmer-Grazing Based midsized farm
2009 WI Conservation Farmer of the Year
226512 County Road E, Edgar, WI 54426

Meldon Maguire
Dairy Farmer-family sized dairy
Woodland Owner-Wisconsin Woodland Owners Board of Directors
Town Chair-Town of Emmet
211651 Eau Pleine Park Road, Mosinee, WI 54455

Tom Mueller
Dairy farmer-Large Scale farm Owner and Operator
Miltrim Farms
115315 Township Road, Athens, WI 54411

LeeAnn Podruch
President Pike Lakes Sportsman Club/Wi Lake Leaders
Graduate Eastern Lakes Representative
214900 County Road Z, Wausau, Wi, 54403

Wayne Breitenfeldt
Dairy farmer, No-till cash crops
160400 County Road Z, Wausau, Wi 54403

Technical advisors shall include representatives from the following agencies:

Wisconsin DNR

Wisconsin Valley Improvement Company

USDA- Natural Resources Conservation Service

UW-Extension/Marshfield Agricultural Research Station

# APPENDIX B

# APPENDIX B

# APPENDIX C

# APPENDIX C

# APPENDIX D

# APPENDIX D

## OUTSTANDING AND EXCEPTIONAL WATERS REPORT: MARATHON COUNTY

| WADRS ID | LOCAL WATERBODY NAME | WBIC | ERW/ ORW | ERW/ ORW ID | START MILE | END MILE | MILEAGE |
|---|---|---|---|---|---|---|---|
| 12512 | Big Cain Creek | 1471300 | ERW | 253 | 0 | 6.45 | 6.45 |
| 10375 | Camp F Creek | 290900 | ERW | 990 | 0 | 4.28 | 4.28 |
| 1492908 | Comet Creek | 285600 | ERW | 868 | 12.24 | 26.63 | 14.39 |
| 9751 | Un Creek (T27n-R10e-S02) | 308900 | ORW | 1067 | 0 | 0.36 | 0.36 |
| 316189 | Flume Creek | 286600 | ERW | 899 | 13.44 | 24.17 | 10.73 |
| 12379 | Fourmile Creek | 1436200 | ERW | 228 | 7.8 | 11.11 | 3.31 |
| 12491 | Grass Creek | 1461300 | ERW | 250 | 0 | 6.38 | 6.38 |
| 10372 | Holt Creek | 289200 | ORW | 957 | 0.63 | 8.56 | 7.93 |
| 1458906 | Creek 35-8 T27n R10e | 986406717 | ERW | 49 | 0 | 0.23 | 0.23 |
| 12513 | Little Cain Creek | 1471400 | ERW | 254 | 0 | 5.31 | 5.31 |
| 18371 | Little Trappe River | 1470800 | ERW | 252 | 0 | 8.46 | 8.46 |
| 201391 | Little Wolf River | 272400 | ERW | 817 | 64.73 | 66.99 | 2.26 |
| 12425 | Mole Brook | 1439400 | ERW | 229 | 0 | 6.53 | 6.53 |
| 12400 | Noisy Creek | 1429700 | ERW | 227 | 0 | 6 | 6 |
| 314375 | S Br Embarrass River | 309700 | ORW | 1070 | 0.47 | 9.49 | 9.02 |
| 9755 | Norrie Creek | 309700 | ORW | 1070 | 0 | 0.47 | 0.47 |
| 1459093 | Plover River | 1402800 | ORW | 213 | 49.86 | 60.86 | 11 |
| 18372 | Prospect Creek (Cain Creek) | 1472000 | ERW | 255 | 0 | 4.72 | 4.72 |
| 314425 | Embarrass River-S. Branch | 305600 | ORW | 1051 | 14.79 | 34.79 | 20 |
| 1485521 | Spranger Creek | 308500 | ORW | 1065 | 2.03 | 10.6 | 8.57 |
| 9748 | Spranger Creek | 308500 | ERW | null | 0 | 2.03 | 2.03 |
| 12431 | Spring Brook Creek | 1440800 | ERW | 230 | 0 | 10.27 | 10.27 |
| 1459514 | Creek 32-12 (T26n, R9e) | 1404750 | ERW | 216 | 0 | 0.06 | 0.06 |
| 1459521 | Creek 30-15 T26n R9e | 5014474 | ERW | 218 | 0 | 0.6 | 0.6 |
| 1459527 | Creek 25-15c T28n R9e | 1407550 | ERW | 225 | 0 | 0.21 | 0.21 |
| 1459550 | Creek 2-14 (T29n, R4e) | 1458400 | ERW | 247 | 0 | 5.41 | 5.41 |
| 1459556 | Creek 25-11 T30n R3e | 5009527 | ERW | 248 | 0 | 0.8 | 0.8 |
| 1486233 | Norrie Brook Tributary | 309900 | ERW | 1071 | 0 | 2.38 | 2.38 |
| 9750 | Un Creek 118 (T27n-R10eS11) | 308800 | ERW | 1066 | 0 | 1.65 | 1.65 |
| 1493687 | Creek 27-13 T27n R10e | 286500 | ERW | 892 | 0 | 1.13 | 1.13 |
| 1458622 | Creek 25-15d T28n R9e | 1407250 | ERW | 26 | 0 | 0.08 | 0.08 |
| 1493681 | Creek 15-3? | 290800 | ERW | 988 | 0 | 0.81 | 0.81 |
| 1458640 | Creek 27-13 T27n R10e | 3000158 | ERW | 29 | 0 | 0.53 | 0.53 |
| 1458030 | Creek 21-14 T30n R3e | 3000157 | ERW | 16 | 0 | 1.03 | 1.03 |
| 12480 | Unnamed Creek 2114(T30n, R4e, S2, Nwse, 37) | 1459900 | ERW | 249 | 0 | 3.15 | 3.15 |
| 316308 | Un Creek 8-2 (T26n-R10eS08 | 291000 | ERW | 992 | 0 | 2.98 | 2.98 |
| 316294 | Un Creek (T26n-R10eS15 | 290700 | ERW | 988 | 0 | 1.35 | 1.35 |
| 316281 | Un Creek 22-13 (T26nR10e-S22 | 290300 | ERW | 979 | 0 | 0.95 | 0.95 |
| 18360 | Unnamed Creek 25-11 (T30n, R3e, S25, Swsw, 37) | 1459200 | ERW | 248 | 0 | 1.49 | 1.49 |
| 18359 | Unnamed Creek 2-13 (T29n, R4e, S2, Nwse, 37) | 1458300 | ERW | 246 | 0 | 3.22 | 3.22 |
| 12345 | Unnamed Creek 53t28n, R10e, S5, Swne) | 1407800 | ERW | 226 | 0 | 0.37 | 0.37 |
| 12344 | Unnamed Creek 18-9 (T28n, R10e, S18, Nesw) | 1407500 | ERW | 224 | 0 | 0.41 | 0.41 |
| 12343 | Unnamed Creek 19-3 R10e,S19,Sw ne) | 1407400 | ERW | 223 | 0 | 2.96 | 2.96 |
| 12342 | Unnamed Creek 25-12 (T28n, R9e, S25, Sesw) | 1407300 | ERW | 222 | 0 | 0.92 | 0.92 |
| 12341 | Unnamed Creek (T28n, R9e, S36, Swne)(Creek 36-3) | 1407100 | ERW | 221 | 0 | 0.46 | 0.46 |
| 12340 | Unnamed Creek 11-12 (T27n, R9e, S11, Sesw) | 1406800 | ERW | 220 | 0 | 0.87 | 0.87 |
| 12337 | Unnamed Creek 26-6 (T27n, R9e, S26, Nwnw) | 1406000 | ERW | 219 | 0 | 1.76 | 1.76 |
| 10374 | Un Creek 209 (T26n-R10eS20) | 290100 | ERW | 974 | 0 | 0.98 | 0.98 |
| 12334 | Unnamed Creek (T26n,R9e,S3 1,Sese)(Cree k 31-15) | 1404700 | ERW | 215 | 0 | 1.99 | 1.99 |
| 12335 | Unnamed Creek 32-6 (T26n, R9e, S32, Nwnw) | 1404900 | ERW | 217 | 0 | 1.91 | 1.91 |

# APPENDIX E

# APPENDIX E

## SECTION 303(D) LISTED IMPAIRED WATER RESOURCES

| Local Waterbody Name | Water Type | Date Listed | Pollutant | Impairment Indicator |
|---|---|---|---|---|
| Beaver Creek | RIVER | 4/1/2016 | Unknown Pollutant | Elevated Water Temperature |
| Big Bass Lake | LAKE | 4/1/2002 | Mercury | Contaminated Fish Tissue |
| Big Rib River | RIVER | 4/1/1998 | Mercury | Contaminated Fish Tissue |
| Creek 2-14 (T29n, R4e) | RIVER | 4/1/2014 | Unknown Pollutant | Degraded Biological Community |
| Mayflower Lake | LAKE | 4/1/1998 | Mercury | Contaminated Fish Tissue |
| Unnamed Creek 2-13 (T29n, R4e, S2,Nwse, 37) | RIVER | 4/1/2016 | Unknown Pollutant | Elevated Water Temperature |
| Lost Lake | LAKE | 4/1/2018 | Total Phosphorus | Water Quality Use Restrictions |
| Big Eau Pleine Flowage | IMPOUNDMENT | 4/1/1998 | Total Phosphorus | Low DO, Eutrophication, Excess Algal Growth |
| Big Eau Pleine River | RIVER | 4/1/1998 | Total Phosphorus | Low DO |
| Big Eau Pleine River | RIVER | 4/1/1998 | Total Phosphorus | Low DO |
| Big Eau Pleine River | RIVER | 4/1/1998 | Total Phosphorus | Low DO |
| Black Creek | RIVER | 4/1/2014 | Total Phosphorus | Impairment Unknown |
| Black Creek | RIVER | 4/1/2014 | Total Phosphorus | Impairment Unknown |
| Dill Creek | RIVER | 4/1/2014 | Total Phosphorus | Water Quality Use Restrictions |
| E Br Big Eau Pleine River | RIVER | 4/1/2014 | Total Phosphorus | Water Quality Use Restrictions |
| Fenwood Creek | RIVER | 4/1/2014 | Total Phosphorus | Impairment Unknown |
| Fenwood Creek | RIVER | 4/1/2012 | Total Phosphorus | Impairment Unknown |
| Hamann Creek | RIVER | 4/1/2014 | Total Phosphorus | Impairment Unknown |
| Raeder Creek | RIVER | 4/1/2012 | Total Phosphorus | Impairment Unknown |
| Randall Creek | RIVER | 4/1/2014 | Total Phosphorus | Water Quality Use Restrictions |
| Randall Creek | RIVER | 4/1/2014 | Total Phosphorus | Water Quality Use Restrictions |
| Scotch Creek | RIVER | 4/1/2014 | Total Phosphorus | Impairment Unknown |
| Scotch Creek | RIVER | 4/1/2014 | Total Phosphorus | Impairment Unknown |
| Scotch Creek | RIVER | 4/1/2014 | Total Phosphorus | Impairment Unknown |
| Wild Creek | RIVER | 4/1/2014 | Total Phosphorus | Water Quality Use Restrictions |

Source: Wisconsin Department of Natural Resources

# APPENDIX F

# APPENDIX F

## WISCONSIN RIVER BASIN TMDL

### MARATHON COUNTY - ROW CROP TOTAL PHOSPHORUS TARGETS

*Wisconsin River Basin (WRB) = 279,882 Total row crop acres | Source: Wisconsin Department of Natural Resources*

| HUC12 Name | Row Crop Acres | Translated TMDL Allocations | | | | |
|---|---|---|---|---|---|---|
| | | TP Baseline (lb/ac/yr) | Current Criteria | | Recommended SSC | |
| | | | Reduction Needed | TP Target (lb/ac/yr) | Reduction Needed | TP Target (lb/ac/yr) |
| Middle and South Forks of the Copper River | 0 | - | - | - | - | - |
| Devil Creek | 892 | 3 | 79% | 0.6 | 63% | 1.1 |
| Prospect Creek-Trappe River | 2,104 | 2.8 | 79% | 0.6 | 63% | 1.0 |
| Little Trappe River-Trappe River | 4,516 | 3.1 | 79% | 0.6 | 63% | 1.1 |
| Beaver Creek-Black Creek | 8,186 | 3 | 79% | 0.6 | 63% | 1.1 |
| Drewek Creek-Black Creek | 11,004 | 3.3 | 79% | 0.7 | 67% | 1.1 |
| McGinnis Creek | 2,817 | 3.3 | 79% | 0.7 | 63% | 1.2 |
| Baldwin Creek-Big Rib River | 3,483 | 3.8 | 79% | 0.8 | 63% | 1.4 |
| West Fork of the Little Rib River-Rib River | 11,276 | 3.6 | 79% | 0.7 | 63% | 1.3 |
| Little Brook-Little Rib River | 6,560 | 3.7 | 79% | 0.8 | 63% | 1.3 |
| Scotch Creek | 15,982 | 3.2 | 79% | 0.7 | 65% | 1.1 |
| Pine Creek-Big Rib River | 10,464 | 3.6 | 79% | 0.7 | 63% | 1.3 |
| Kennedy Creek-Big Rib River | 8,335 | 3.5 | 79% | 0.7 | 63% | 1.3 |
| Elmwood Cemetery-Spring Brook | 727 | 2.3 | 79% | 0.5 | 63% | 0.9 |
| Oldens Creek-Eau Claire River | 1,361 | 2.4 | 79% | 0.5 | 63% | 0.9 |
| Mole Brook-Eau Claire River | 4,876 | 2.9 | 79% | 0.6 | 63% | 1.1 |
| Prahl Creek-Big Sandy Creek | 8,433 | 3 | 79% | 0.6 | 63% | 1.1 |
| Little Sandy Creek-Big Sandy Creek | 3,760 | 2.3 | 79% | 0.5 | 63% | 0.8 |
| Silver Creek-Eau Claire River | 858 | 2.7 | 79% | 0.6 | 63% | 1.0 |
| County Line Creek-Wisconsin River | 3,146 | 2.9 | 79% | 0.6 | 63% | 1.1 |
| Jim Moore Creek-Wisconsin River | 5,149 | 2.8 | 79% | 0.6 | 63% | 1.0 |
| Eau Claire Flowage | 504 | 3.6 | 79% | 0.7 | 63% | 1.3 |
| East Branch of the Big Eau Pleine River | 7,005 | 2.7 | 84% | 0.4 | 84% | 0.4 |
| West Branch of the Big Eau Pleine River | 4,886 | 2.3 | 84% | 0.4 | 84% | 0.4 |
| Randall Creek | 11,722 | 3 | 84% | 0.5 | 84% | 0.5 |
| Dill Creek | 12,474 | 2.9 | 85% | 0.4 | 85% | 0.4 |
| Porky Creek-Big Eau Pleine River | 8,496 | 3.2 | 84% | 0.5 | 84% | 0.5 |
| Hamann Creek | 9,407 | 3.3 | 84% | 0.5 | 84% | 0.5 |
| Noisy Creek-Big Eau Pleine River | 9,118 | 3 | 84% | 0.5 | 84% | 0.5 |
| Rock Creek-Big Eau Pleine River | 7,184 | 3.2 | 84% | 0.5 | 84% | 0.5 |
| Fenwood Creek | 12,809 | 3.2 | 84% | 0.5 | 84% | 0.5 |
| Freeman Creek | 6,961 | 3.7 | 84% | 0.6 | 84% | 0.6 |
| Lake Dubay | 7,083 | 3.6 | 84% | 0.6 | 84% | 0.6 |
| Carlson Creek-Little Eau Pleine River | 7,695 | 2.7 | 84% | 0.4 | 84% | 0.4 |
| McMillan Marsh-Little Eau Pleine River | 4,937 | 2.5 | 80% | 0.5 | 78% | 0.6 |
| Squaw Creek/Scheuer Creek | 3,770 | 2.6 | 79% | 0.5 | 77% | 0.6 |
| Wild Creek-Little Eau Pleine River | 12,671 | 2.6 | 81% | 0.5 | 74% | 0.7 |
| Bear Creek | 125 | 1.9 | 79% | 0.4 | 67% | 0.6 |
| Honey Island Flowage-Little Eau Pleine River | 5,895 | 2.6 | 79% | 0.5 | 68% | 0.8 |
| Townline Reservoir-Little Eau Pleine River | 225 | 1.5 | 79% | 0.3 | 63% | 0.5 |
| Fourmile Creek | 3,206 | 3.9 | 79% | 0.8 | 63% | 1.4 |
| Bull Junior Creek | 840 | 1 | 79% | 0.2 | 63% | 0.4 |
| Mosinee Flowage-Wisconsin River | 1,021 | 2.8 | 79% | 0.6 | 63% | 1.0 |
| Hog Creek | 1,937 | 2.8 | 79% | 0.6 | 63% | 1.0 |
| Little Eau Claire River | 3,818 | 1.2 | 79% | 0.2 | 63% | 0.4 |
| Johnson Creek | 1,287 | 1.4 | 79% | 0.3 | 63% | 0.5 |
| Lake Dubay-Wisconsin River | 3,237 | 1.4 | 79% | 0.3 | 63% | 0.5 |
| Headwaters of the Plover River | 3,602 | 2.1 | 79% | 0.4 | 63% | 0.8 |
| Pike Lake-Plover River | 7,499 | 1.5 | 79% | 0.3 | 63% | 0.5 |
| Jordan Pond-Plover River | 1,580 | 0.8 | 79% | 0.2 | 63% | 0.3 |
| Hay Meadow Creek | 82 | 0.8 | 79% | 0.2 | 63% | 0.3 |
| Headwaters of the Yellow River | 2,663 | 3.2 | 73% | 0.9 | 73% | 0.9 |
| East Branch of the Yellow River-Yellow River | 2,214 | 2.1 | 73% | 0.6 | 73% | 0.6 |

# Upper Fox-Wolf River Basin TMDL

## Marathon County - Row Crop Total Phosphorus Targets

Upper Fox-Wolf River Basin (UFWRB) = 17,254 Total row crop acres

| HUC12 Name | Row Crop Acres | Translated TMDL Allocations | | | | | |
|---|---|---|---|---|---|---|---|
| | | TP | | | TSS | | |
| | | TP Baseline (lb/ac/yr) | Reduction Needed | TP Target (lb/ac/yr) | TP Baseline (tons/ac/yr) | Reduction Needed | TP Target (tons/ac/yr) |
| Spranger Creek-South Branch Embarrass River | 6,639 | 3.25 | 83% | 0.55 | 2.10 | 35% | 1.36 |
| Packard Creek-Middle Branch Embarrass River | 624 | 2.52 | 83% | 0.43 | 1.71 | 35% | 1.11 |
| Holt Creek-Little Wolf River | 5,706 | 1.87 | 83% | 0.32 | 1.45 | 45% | 0.79 |
| Flume Creek | 424 | 2.53 | 83% | 0.43 | 1.85 | 47% | 0.99 |
| Comet Creek | 2,805 | 2.38 | 83% | 0.41 | 1.65 | 46% | 0.89 |
| Bradley Creek-Little Wolf River | 1,056 | 2.09 | 83% | 0.36 | 1.57 | 47% | 0.84 |

Source: Wisconsin Department of Natural Resources

# APPENDIX G

| PRACTICE or ACTIVITY | ATCP 50 Reference | Fund Source | Units of Measurement |
|---|---|---|---|
| Pesticide Management Plans | 50.79 | | |
| 1. Management Plans | 50.79(1) | No Funds Available | Number |
| 2. Structures (as described in the plan for structure's design) | 50.79(2) | Bond | Number |
| Prescribed Grazing | 50.80 | | |
| 1. Management Plan | 50.80(1) | No Funds Available | Number |
| 2. Fencing (not permanent) | 50.80(2) | No Funds Available | Linear Ft. |
| 3. Fencing (permanent) | 50.80(3) | Bond | Linear Ft. |
| 4. Establish Permanent Pasture (seeding) | 50.80(4) | Bond | Acres |
| Relocating or abandoning animal feeding operations | 50.81 | Bond | Number |
| Residue Management | 50.82 | SEG [1] | Acres |
| Riparian Buffers | 50.83 | | |
| 1. Installation (including land out of production and first 10 years of maintenance) | 50.83(1) | Bond | Acres |
| 2. Mowing and maintenance beyond initial 10 year period | 50.83(2) | No Funds Available | Acres |
| Roofs | 50.84 | Bond | Number |
| Roof Runoff Systems | 50.85 | Bond | Number |
| Sediment Basins | 50.86 | Bond | Number |
| Sinkhole Treatment | 50.87 | Bond | Number |
| Stream Bank and Shoreline Protection | 50.88 | Bond | Linear Ft. |
| Stream Crossing | 50.885 | Bond | Linear Ft. |
| Strip-Cropping | 50.89 | SEG [1] | Acres |
| Subsurface Drains | 50.90 | Bond | Number |
| Terrace Systems | 50.91 | Bond | Linear Ft. |
| Underground Outlet | 50.92 | Bond | Number |
| Waste Transfer Systems | 50.93 | Bond | Number |
| Wastewater Treatment Strips | 50.94 | Bond | Linear Ft. |
| Water and Sediment Control Basins | 50.95 | Bond | Number |
| Waterway Systems | 50.96 | Bond | Acres |
| Well Decommissioning | 50.97 | Bond | Number |
| Wetland Restoration | 50.98 | Bond | Acres |
| Engineering services provided in connection with a completed cost-share practice for which bond revenue may be used (also refer to 50.40(7)). | 50.34(4) | Bond | |
| Other practices with DATCP's written approval | 50.40(3)(a) | | |

A completed form must indicate whether the reimbursement request involves practices installed to achieve compliance with NR 151 performance standards and prohibitions. Not all practices are installed for the purpose of achieving compliance with NR 151 (see below for examples). If no compliance is achieved, the "00" code should be used on the form. Where compliance is achieved, staff completing the form should use their professional judgment to identify the specific NR 151 standard or prohibition that was met, and then insert the code number that corresponds to that NR 151 standard or prohibition (The code numbers in the form match the sections in NR 151 where the standard or prohibition are referenced). The following chart can help you complete this part of the form.

| NR 151 Code | Compliance Achieved through Practice Installation |
|---|---|
| 02 | Control soil erosion (sheet, rill and wind) to meet tolerable soil loss (T) calculated by RUSLE 2 (now includes pastures) |
| 03 | Tillage setback of 5 to 20 feet |
| 04 | Phosphorous Index |
| 05 | Construct, maintain and close manure storage facilities to prevent manure overflows and leaks. |
| 055 | Process Wastewater discharge to waters of the State |
| 06 | Divert clean water from feedlots, manure storage areas and barnyard areas within a water quality management area. |
| 07 | Apply manure and fertilizer in conformance with a nutrient management plan to control nutrient runoff into water of the state. |
| 08 | No overflow from manure storage facilities. |
| 08 | No unconfined manure stacks within the Water Quality Management Area. |
| 08 | No direct runoff from feedlots and manure storage facilities. |
| 08 | No unlimited access of livestock to waters of the state that prevents maintenance of adequate sod or self- sustaining cover. |

**Guidance on Compliance Determinations involving Specific Practices**

To receive 70% cost-sharing, the practices listed below must be associated with a NR 151 performance standard. If a NR 151 performance standard code is not assigned to the practice, then the project will only receive funding at a 50% cost-share rate. This table lists possible codes that might be associated with a particular practice to receive the higher cost-share rate.

| Practice | NR 151 Code Options |
|---|---|
| Access Roads (50.65) | 05, 08 |
| Roof Runoff Systems (50.85) | 05, 055, 06, 08 |
| Stream Bank and Shoreline Protection (50.88) | 03, 08 |
| Stream Crossing (50.885) | 02, 03, 08 |
| Wetland Restoration (50.98) | 02, 07 |

MARATHON COUNTY

Marathon County's goal is to be the healthiest, safest and most prosperous county in Wisconsin.

Marathon County: Land & Water Resource Management Plan

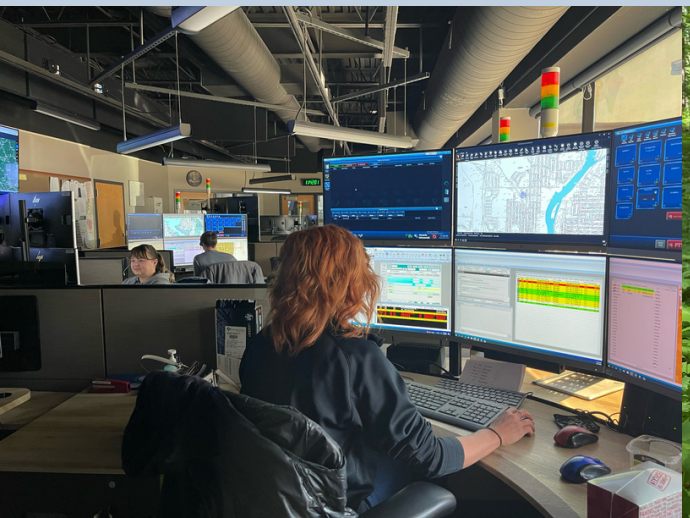
www.co.marathon.wi.us

Back photo by Roger Zimmermann

# Appendix E:4

# Marathon County Strategic Plan
## 2023-2024 REVISION & EXTENSION

MARATHON COUNTY



# MEASURING OUR PROGRESS...

Welcome! We'd like to share with you our efforts and successes since 2018 to become the healthiest, safest, and most prosperous county in Wisconsin.

In 2023, the Marathon County Board of Supervisors approved an extension and revision of the 2018–2022 Strategic Plan. This extension was in large part due to the delays that occurred as a result of efforts being redirected during the COVID-19 pandemic.

The effort to revise the Strategic Plan was led by the County Board Vice-Chair and supported by community partnerships.

As our work to achieve the objectives and their associated outcome measures as outlined in this plan continues, Marathon County is dedicated to aligning County resources to meet the needs of the community and our residents in order to become the most vibrant county in the state, where people prefer to live, work, visit, and do business.

# 2023-2024 REVISION & EXTENSION

**#R-16-23 Updates to Marathon County Strategic Plan**

WHEREAS, in 2018, the Marathon County Board of Supervisors adopted a Strategic Plan for Marathon County to serve as both a guiding policy document and a metric by which to measure Marathon County's progress on defined strategic goals related to the County's broader Comprehensive Plan. The current Strategic Plan, including updates adopted in 2020, was adopted as a five-year plan for the years 2018 through 2022 and identified twelve important issues to be addressed and measured over that period; and

WHEREAS, the 2018-2022 Strategic Plan identified 12 specific objectives from the Marathon County 2016 Comprehensive Plan, clarified which broad objectives were most important over the next 5 years, and linked the Comprehensive Plan to the County's annual budget and work plans; and

WHEREAS, the Strategic Plan embodies the partnership between the elected County Board Supervisors, who are entrusted with setting policy for the County, and county staff, who are charged with carrying out operations in support of those policies; and

WHEREAS, in 2022 and 2023, the Marathon County Board of Supervisors and its Standing Committees, led by the Vice-Chair of the Marathon County Board of Supervisors, reviewed the existing Strategic Plan to identify completed goals, categorize new or updated goals, and remove outdated or unwanted strategies; and

WHEREAS, on April 11, 2023, the Executive Committee approved the attached additions and changes to the Marathon County Strategic Plan to serve as an updated policy document to continue through December 31, 2024 and forwarded the recommended additions and changes to the Marathon County Board for consideration.

NOW, THEREFORE, BE IT RESOLVED that the Board of Supervisors of the County of Marathon does hereby adopt the additions and changes to the Marathon County Strategic Plan to serve as an updated Strategic Plan and policy document to continue through December 31, 2024.

Dated the 25th day of April, 2023.
Executive Committee

**For a comprehensive list of changes, including the strategies and outcomes that have been deemed complete, please click here.**

# HEALTHIEST

Health is not merely restored at the doctor's office, but instead starts in our families, in our schools and workplaces, in our playgrounds and parks, and in the air we breathe and the water we drink. We recognize that health and well-being are lifelong pursuits and that our communities can support positive, healthy lifestyles.

**OBJECTIVE 3.3: Ensure that every person makes it to adulthood with health, stability, and growth opportunities.**

STRATEGIES

**OBJECTIVE 3.7: Ensure that every person has local access to effective mental health treatment.**

STRATEGIES

**OBJECTIVE 5.2: Promote sound land use decisions that conserve and preserve natural resources in decisions with economic development and growth.**

STRATEGIES

**OBJECTIVE 6.3: Protect and enhance the quantity and quality of potable groundwater and potable surface water supplies.**

STRATEGIES

| STRATEGY A | STRATEGY B | STRATEGY C | STRATEGY D | STRATEGY E | STRATEGY F |
|---|---|---|---|---|---|
| Provide resources to reduce childhood trauma. | Create a trauma-informed care system. | Develop a framework for building resilient children and providing parent resources. | Develop a plan to address how to support persons of all ages with disabilities and the changing demographics of persons with disabilities. | Continue work towards reducing truancy. | Develop policies that support affordable, high-quality childcare. |

## OBJECTIVE 3.3: Ensure that every person makes it to adulthood with health, stability, and growth opportunities.

**Outcome Measure 1**
By December 31, 2024, there will be an increase in graduation rates to 93% or above in Marathon County.

**Outcome Measure 2**
By December 31, 2024, out of home care placement days will decrease with an emphasis on reducing the most restrictive and expensive placement types in favor of more family-like placement settings.

**Outcome Measure 3**
By December 31, 2024, the capacity to deliver affordable, high-quality childcare to children in Marathon County will increase.

**Departments Contributing:**

Clerk of Courts
County Administration
Corporation Counsel
Health
Library
Parks, Recreation, and Forestry
Sheriff's Office
Social Services
UW-Extension

| STRATEGY A | STRATEGY B | STRATEGY C | STRATEGY D | STRATEGY E | STRATEGY F |
|---|---|---|---|---|---|
| Develop a continuum of services within a therapeutic community. | Attract and retain qualified treatment providers and behavioral educators. | Develop more mechanisms to ensure access to treatment across the County. | Develop a more comprehensive approach to crisis prevention and serving people (adults and children in crisis). | Develop comprehensive mental health treatment options for criminal justice populations and others with criminogenic treatment needs. | Conduct a Community Needs Assessment and create a plan to address identified gaps in service. |

## OBJECTIVE 3.7: Ensure that every person has local access to effective mental health treatment.

**Outcome Measure 1**
By December 31, 2024, the number of Chapter 51.15 Emergency Detentions in Marathon County will decrease.

**Outcome Measure 2**
By December 31, 2024, the percentage of LIFE Report community survey respondents who reported not seeing a mental health provider when needed will be less than 20% and barriers to mental health care will be reduced.

**Outcome Measure 3**
By 2024, the annual number of deaths by suicide will decrease (baseline 2021 - 21 suicides).

**Departments Contributing:**

- Clerk of Courts
- County Administration
- Corporation Counsel
- District Attorney
- Emergency Management
- Health
- North Central Health Care
- Sheriff's Office
- Social Services
- Veterans

| STRATEGY A | STRATEGY B | STRATEGY C | STRATEGY D | STRATEGY E | STRATEGY F |
|---|---|---|---|---|---|
| Update existing land use policies to address sprawl and natural resource protection. | Promote infastructure development that protects natural resources. | Identify and preserve unique regional areas for natural resource protection and environmental remediation. | Develop a Land Capability Index. (Deprioritized) | Develop a comprehensive approach to redevelopment and revitalization of older housing stock and older buildings. | Acquire land for public park and forest use to retain natural landscapes and resources. |

## OBJECTIVE 5.2: Promote sound land use decisions that conserve and preserve natural resources in decisions with economic development and growth.

**Outcome Measure 1**
By December 31, 2024, phosphorus from cropland and farmsteads in the Fenwood Creek Watershed will be reduced by 20% or 14,016 pounds.

**Outcome Measure 2**
By December 31, 2024, Marathon County will hold one continuing education event per year for all towns, to better educate them on sound land use development options.

**Outcome Measure 3**
By December 31, 2024, an average of 320 acres of land per year will be acquired for the Marathon County Parks and Forest System.

**Departments Contributing:**

Central WI Airport
Highway
Conservation, Planning & Zoning
Corporation Counsel
Parks, Recreation, and Forestry
Solid Waste
UW-Extension

| STRATEGY A | STRATEGY B | STRATEGY C | STRATEGY D | STRATEGY E |
|---|---|---|---|---|
| Update the 2001 Groundwater Protection Plan. | Continue to develop and implement watershed management plans and Targeted Management plans to minimize the impacts on water quality. | Evaluate the County's role in conducting tests and analysis of contaminants in private wells and in evaluating whether such tests should be mandatory instead of voluntary. | Explore alternative methods for snow and ice removal from hard surfaces to reduce the impacts of salt on surface water and groundwater. | Create new partnerships with agencies and organizations to further efforts to protect surface water and groundwater. |

## OBJECTIVE 6.3: Protect and enhance the quantity and quality of potable groundwater and potable surface water supplies.

**Outcome Measure 1** By December 31, 2024, the Marathon County Board of Supervisors will adopt a Groundwater protection plan that provides state outcome measures of groundwater quality and quantity.

**Outcome Measure 2** By December 31, 2024, the number of failing POWTS will be reduced by 750 systems or more.

**Outcome Measure 3** By December 31, 2024, an inventory of wellhead protection areas, their associated land use, and delineation of their recharge areas will be compiled. Marathon County will reach out to each municipality to educate them on potential groundwater contamination sources and how to prevent the contamination of its wells.

**Departments Contributing:**

Central WI Airport
Conservation, Planning & Zoning
Emergency Management
Health
Highway
Parks, Recreation, and Forestry
Solid Waste

# SAFEST

Safety starts in our families, in our schools and workplaces, and in our communities. Safety in Marathon County means living in confidence, without undue fear of crime, disorder, danger, injury, or harm, and knowing that you will receive the right response from the right person or entity if needed. Our communities proactively plan and have systems in place to ensure our safety.

**OBJECTIVE 7.1: Provide cost-effective and high-quality public safety services.** STRATEGIES

**OBJECTIVE 7.2: Mitigate the impacts of drug and alcohol abuse in Marathon County through evidence-based practices.** STRATEGIES

**OBJECTIVE 8.7: Strive to provide affordable, reliable, high-speed internet access throughout the County.** STRATEGIES

| STRATEGY A | STRATEGY B | STRATEGY C | STRATEGY D | STRATEGY E |
|---|---|---|---|---|
| Continue to consider the potential to consolidate emergency service agencies. | Reduce recidivism by creating a mechanism to respond to "high-utilizers" of our justice, mental health, and social service systems. | Report every 2 years on the response time with advice for municipalities (ex: consolidation, realignment, or targeted education) | Seek out funding partners to develop and implement the proposed Marathon County Forensic Science Center. | The Public Safety Committee will consider the reported feedback from municipal leaders (elected or appointed) on safety concerns on county highway and multimodal transportation systems following quarterly safety meetings. |

## OBJECTIVE 7.1: Provide cost-effective and high-quality public safety services.

**Outcome Measure 1**

By December 31, 2024, emergency response times for public safety (law enforcement, fire, and emergency medical services) will decrease.

**Outcome Measure 2**

By December 31, 2023, the Public Safety Committee will issue a white paper for consideration by the Marathon County Board of Supervisors that identifies strategies to address the shortage of state public defenders and attorneys accepting public defender appointments in Marathon County.

**Departments Contributing:**

- Central WI Airport
- Corporation Counsel
- County Administration
- Emergency Management
- Finance
- Library
- North Central Health Care
- Sheriff's Office
- Social Services

| STRATEGY A | STRATEGY B | STRATEGY C |
|---|---|---|
| Develop a comprehensive approach to address use of drugs and alcohol in the children and young adults of Marathon County. | Identify and advance public policy and programs that would support the mitigation and prevention of drug and alcohol misuse and abuse among residents of Marathon County. | Identify and track data points to measure the impact of drug and alcohol misuse and abuse among residents of Marathon County. |

## OBJECTIVE 7.2: Mitigate the impacts of drug and alcohol abuse in Marathon County through evidence-based practices.

**Outcome Measure 1**
By December 31, 2024, an outcome measure will be established to measure the quality of life for all people in counseling, mental health, or AOD-related treatment programs seen at North Central Health Care.

**Outcome Measure 2**
By December 31, 2024, 3% or less of high school students in Marathon County will report having taken prescription drugs without a doctor's prescription one or more times in the past 30 days.

**Outcome Measure 3**
By December 31, 2024, the rate of overdose deaths among residents in Marathon County will hold steady or decrease.

**Departments Contributing:**

Clerk of Courts
Corporation Counsel
County Administration
District Attorney
Health
North Central Health Care
Sheriff's Office

| STRATEGY A | STRATEGY B | STRATEGY C | STRATEGY D | STRATEGY E |
|---|---|---|---|---|
| Support the Broadband Task Force in executing continued comprehensive approach to delivering county-wide high-speed internet access, including fiber, copper, powerline, cellular, Wi-Fi, new radio frequencies, satellite, and other emerging technologies, with a particular focus on addressing underserved areas. | Promote partnerships between carriers/providers and government. | Develop financial incentives to encourage carriers/providers to commit to helping accomplish this objective in Marathon County. | Establish a dig-once policy for county roadway reconstruction and bridge projects that engages providers in a discussion about whether to include conduit for fiber. | Assist Marathon County citizens by providing information regarding available carriers within their general areas of the county. |

## OBJECTIVE 8.7: Strive to provide affordable, reliable, high-speed internet access throughout the county.

**Outcome Measure 1**
By December 31, 2024, develop an improved data inventory relative to internet service speeds available through the county.

**Outcome Measure 2**
By December 31, 2023, ensure 85% of households have access to high-speed internet (50 MBPS/ 10 MBPS)

**Departments Contributing:**

City-County IT Commission
County Administration
Highway
Library
Sheriff's Office

# MOST PROSPEROUS

HOME | HEALTHIEST | SAFEST

Prosperity is not a function of what or how much we possess or consume. Nor is prosperity a function of net worth. Instead, prosperity is realized when our future is marked with opportunity and when we see ourselves as part of a larger community. Every individual can belong, participate, and thrive. Prosperous communities are committed to "one table" where public, non-profit, philanthropic, and business entities come together to focus on people, place, and opportunity.

**OBJECTIVE 10.6: Ensure the future availability of a skilled and flexible workforce prepared to meet the needs of both existing and emerging industries and technologies.**

STRATEGIES

**OBJECTIVE 10.8: Encourage development and redevelopment of key employment centers in areas that possess strong market potential, provide good transportation access for workers, and promote the efficient movement of goods.**

STRATEGIES

**OBJECTIVE 10.10: Create an innovative atmosphere to foster an entrepreneurial-supportive environment.**

STRATEGIES

**OBJECTIVE 10.12: Maintain infrastructure to support economic growth.**

STRATEGIES

**OBJECTIVE 12.3: Promote cost-effective and high-quality public services.**

STRATEGIES

| STRATEGY A | STRATEGY B | STRATEGY C | STRATEGY D | STRATEGY E |
|---|---|---|---|---|
| Work with the North Central Wisconsin Workforce Development Board, (NCWWDB) to ensure a well-trained workforce. | Seek out additional opportunities to partner with local education providers (secondary and post-secondary). | Develop policies that support affordable, high-quality child care to enhance workforce availability. | Develop policies that promote a variety of safe and affordable housing options to enhance workforce availability. | Explore and implement recruiting strategies aimed at population centers with significant linkage to Marathon County. |

## OBJECTIVE 10.6: Ensure the future availability of a skilled and flexible workforce prepared to meet the needs of both existing and emerging industries and technologies.

**Outcome Measure 1** By December 31, 2024, the number and percentage of self-sufficient households in Marathon County will increase or remain the same.

**Outcome Measure 2** By December 31, 2024, the number of unfilled job openings within Marathon County will be reduced.

**Outcome Measure 3** By August 31, 2023, with input from non-EEED Supervisors and other Marathon County Stakeholders, the EEED Committee will prepare recommendations for Marathon County Government's role in supporting affordable high-quality childcare.

**Outcome Measure 4** By August 31, 2023, with input from non-EEED Supervisors and other Marathon County Stakeholders, the EEED Committee will prepare recommendations for Marathon County Government's role in supporting safe and affordable housing options.

**Departments Contributing:**

- Conservation, Planning & Zoning
- Corporation Counsel
- County Administration
- Emergency Management
- Library
- Marathon County Development Corporation
- Parks, Recreation, and Forestry

## STRATEGY A

Support efforts to engage the public and private sectors to provide leadership for county economic development efforts.

## STRATEGY B

Engage local municipalities on how county infrastructure development can contribute to business and industrial park growth.

# OBJECTIVE 10.8: Encourage development and redevelopment of key employment centers in areas that possess strong market potential, provide good transportation access for workers, and promote the efficient movement of goods.

**Outcome Measure 1**

Maintain a 5-8 year inventory of developable land within the municipal business and industrial parks.

**Outcome Measure 2**

By December 31, 2024, the number of private sector full-time and part-time employee positions in Marathon County will increase or be maintained.

**Departments Contributing:**

Conservation, Planning & Zoning
Corporation Counsel
County Administration
Highway
Marathon County Development Corporation

| STRATEGY A | STRATEGY B | STRATEGY C |
|---|---|---|
| Respond to changing economic conditions and opportunities through periodic review and updating of economic development strategies, policies, investments, and programs. | Work with MCDEVCO* to support a low-interest loan fund to finance new farmer startups and adoption of new technology by existing farmers. | Enhance awareness of MCDEVCO* as the primary point of contact for business expansion and startup information. |

## OBJECTIVE 10.10: Create an innovative atmosphere to foster an entrepreneurial-supportive environment.

**Outcome Measure 1**
By December 31, 2024, the number of businesses will increase.

**Outcome Measure 2**
By December 31, 2024, 90% of businesses that receive assistance from Marathon County Development Corporation will be sustained for 3 years.

**Outcome Measure 3**
By December 31, 2023, add one or more MCDEVCO informational pages to the "Work" section of the Marathon County website.

**Departments Contributing:**

Central WI Airport
Corporation Counsel
County Administration
Conservation, Planning & Zoning
Education & Entrepreneurial Center
Library
Marathon County Development Corporation

* Marathon County Development Corporation

| STRATEGY A | STRATEGY B | STRATEGY C | STRATEGY D | STRATEGY E | STRATEGY F |
|---|---|---|---|---|---|
| Maintain a safe highway network to provide access to all communities in the County. | Support technology in the workplace and at home, particularly through access to broadband. | Provide appropriate access for trucks and employees for all business and industrial park sites. | Secure state and federal funding to maintain and/or develop infrastructure-including multimodal transportation features- and support economic growth. | Maintain an updated County Highway Safety Plan. | Maintain the partnership between Portage and Marathon Counties to support and strengthen Central Wisconsin Airport as a regional airport. |

## OBJECTIVE 10.12: Maintain infrastructure to support economic growth.

**Outcome Measure 1**
Maintain a county highway overall Pavement Surface Evaluation and Rating Score average annual rating of 7.0.

**Outcome Measure 2**
Implement at least three Federal Highway Administration Safety Countermeasures based on information from the 2021 Marathon County Roadway Safety Plan, or its successor, on an annual basis.

**Outcome Measure 3**
Staff report to Infrastructure Committee relative to feedback from municipal leaders (elected or appointed) on safety concerns on the county highway and multimodal transportation systems following quarterly safety meetings.

**Departments Contributing:**

Central WI Airport
City-County IT Commission
Conservation, Planning & Zoning
County Administration
Facilities & Capital Management
Highway

| STRATEGY A | STRATEGY B | STRATEGY C | STRATEGY D | STRATEGY E | STRATEGY F |
|---|---|---|---|---|---|
| Continue to support efforts by local municipalities to establish cooperative service and joint facility arrangements. | Continue to enhance E-911 dispatch services for all police, fire, and EMS agencies in Marathon County. | Work with local municipalities and other government agencies to explore opportunities to share costs and/or consolidate public services. | Address solid waste management issues on a regional basis, cooperating with other counties. | Implement a plan to increase the number and nature of services accessible to the public online and identify achievable measures to track our progress at engaging the public. | County Board adopt, maintain, and fund employee class compensation plans and government policies that prioritize the retention and recruitment of the high-quality, skilled workforce needed to deliver government services. |

## OBJECTIVE 12.3: Promote cost-effective and high-quality public services.

**Outcome Measure 1**

Reduce to and maintain a county employee resignation turnover rate of 15% or lower by December 31, 2024.

**Departments Contributing:**

County Administration

All Marathon County Government Departments

Marathon County's goal is to be the healthiest, safest, and most prosperous county in Wisconsin.

Marathon County Strategic Plan: 2023-2024 Revisions & Extension

Information about the 2018-2022 Strategic Plan is available online at www.marathoncounty.gov/about-us/strategic-plan

# Appendix E:5

# STRATEGIES FOR REDUCING FISH KILLS IN THE BIG EAU PLEINE RESERVOIR

*VISION*

*Water quality and recreation on the Big Eau Pleine Reservoir are enhanced and a flourishing fishery is sustained which is not harmed by manmade events.*

# Strategies for Reducing Fish Kills in the Big Eau Pleine Reservoir

2017

The authors would like to acknowledge the commitment and enthusiasm of the Big Eau Pleine Citizens Organization (BEPCO), land owners in the Big Eau Pleine watershed, and participants in the Community Conversations.

This plan was prepared in 2017 by Nancy Turyk, Center for Watershed Science and Education at the University of Wisconsin – Stevens Point. Along with the Community Conversation participants, the following individuals and organizations contributed to the content of this plan.

**Big Eau Pleine Technical Advisory Committee**

Tim Garrigan and John Kennedy, BEPCO Board

Jim Arch and Matt Zoschke, Clark County Land Conservation Dept.

Keith Foye, Dept. Agriculture, Trade, and Consumer Protection

Tom Meronek, Al Niebur, Buzz Sorge, Dept. of Natural Resources

John Small, Marathon City

Sandy Cihlar, Marathon County Board

Diane Hanson and Andy Johnson, Marathon County CPZ

Matt Krueger, River Alliance of Wisconsin

Ben Stanfley, Taylor County Land Conservation Dept.

Amy Neigum, UDSA Natural Resource Conservation Service

Aaron Thompson and Kris Tiles, Univ. Wisconsin-Extension

Nancy Turyk, Univ. Wisconsin-Stevens Point

Ben Niffenegger, Wisc. Valley Improvement Company

**Big Eau Pleine Dissolved Oxygen Technical Committee**

Ken Dorshorst and John Kennedy, BEPCO Board

Tom Meronek, Pat Oldenburg, Buzz Sorge, Dept. of Natural Resources

Andy Johnson , Marathon County CPZ

Matt Krueger, River Alliance of Wisconsin

Kurt Schoen, Schoen Engineering

Dr. Paul McGinley and James Brodzeller, Univ. Wisconsin-Stevens Point

Ben Niffenegger, Wisc. Valley Improvement Company

Lead persons and resources are given under each objective of this plan. These individuals and organizations are able to provide information, suggestions, or services to achieve goals. The following table lists organization names and their common acronyms used in this plan. This list should not be considered all-inclusive – assistance may also be provided by other entities, consultants, and organizations.

| Resource | Acronym or Truncated Name |
|---|---|
| Big Eau Pleine Citizens Organization | BEPCO |
| Clark County Land Conservation Dept. | Clark County LCD |
| Marathon County Board of Supervisors & professional staff | Marathon County CPZ |
| River Alliance of Wisconsin | River Alliance |
| Taylor County Land Conservation Department | Taylor County LCD |
| University of Wisconsin - Extension | UWEX |
| USDA Natural Resources Conservation Service | NRCS |
| Walleyes for Tomorrow | WFT |
| Wisconsin Department of Agriculture, Trade and Consumer Protection | DATCP |
| Wisconsin Department of Natural Resources | WDNR |
| Wisconsin Valley Improvement Company | WVIC |

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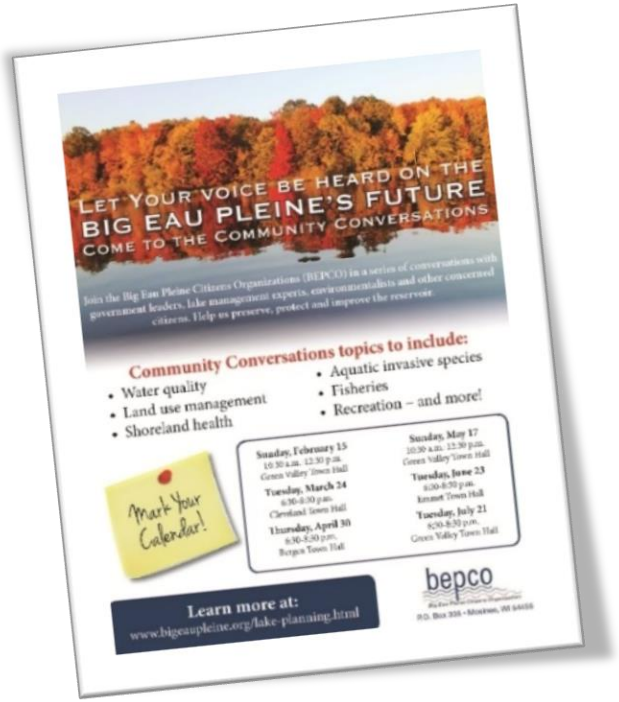
## VISION FOR THE BIG EAU PLEINE RESERVOIR

***Water quality and recreation on the Big Eau Pleine Reservoir are enhanced and a flourishing fishery is sustained which is not harmed by manmade events.***

### Plan Development

**Who created the strategic plan?**

This plan is the result of a stakeholder-driven effort which involved many partners combining insight, knowledge, and expertise throughout the process. More than 112 participants gathered at a series of community conversations which provided opportunities to learn from one another and make suggestions about the fishery, water quality, habitat, and land management in the Big Eau Pleine watershed. The Big Eau Pleine Citizens Organization (BEPCO) hosted the meetings at venues throughout the watershed between February and July, 2015.




An advisory committee provided guidance for the content of the community conversations, the planning process, and plan refinements. Committee members will continue to meet to ensure the goals in this plan are achieved. The committee includes representatives from BEPCO, Clark, Marathon and Taylor counties, USDA Natural Resources Conservation Service, Wisconsin Dept. of Agriculture, Trade and Consumer Protection, Wisconsin Dept. of Natural Resources, and Wisconsin Valley Improvement Company. Plan development was guided by staff from UW-Stevens Point, River Alliance of Wisconsin, and UW-Extension. Descriptions of these organizations can be found in the "Meet the Partners" section in this document. Funding to create this plan was provided to BEPCO from the Wisconsin Dept. of Natural Resources.

**How were the opinions of those not attending the meetings considered?**

A total of 625 households were contacted using a mail survey in early 2015 to understand the priorities of landowners. Two unique surveys were designed to obtain opinions from 375 agricultural producers and 250 waterfront landowners. The return rate was high: 42% (150) of the agricultural surveys and 72.6% (167) of the riparian surveys were received. The results of both surveys are incorporated throughout this plan and can be found in the appendices.

## The Problem

Periodically, winter fish kills occur in the Big Eau Pleine Reservoir. Multiple factors within the BEP reservoir and watershed lead to conditions which result in low oxygen levels in the water, asphyxiating the more sensitive fish species.

### Challenges within the watershed

Too many nutrients (fertilizers, often from agricultural land) move off the landscape during rains and snowmelt, and flow downstream to the BEP reservoir. The nutrients feed algae and aquatic plants. During the winter, microbes that are decomposing algae consume oxygen in the water. This results in less oxygen being available to fish, which can lead to fish kills.

### Weather

The amount and timing of precipitation play significant roles in the problem. Years with heavy rain or snow lead to more nutrients getting into the BEP system. Summers and falls with less than normal amounts of rain lead to low water levels in the BEP reservoir in early winter. Temperature can also play a role, with warmer water leading to nutrient release from sediments.

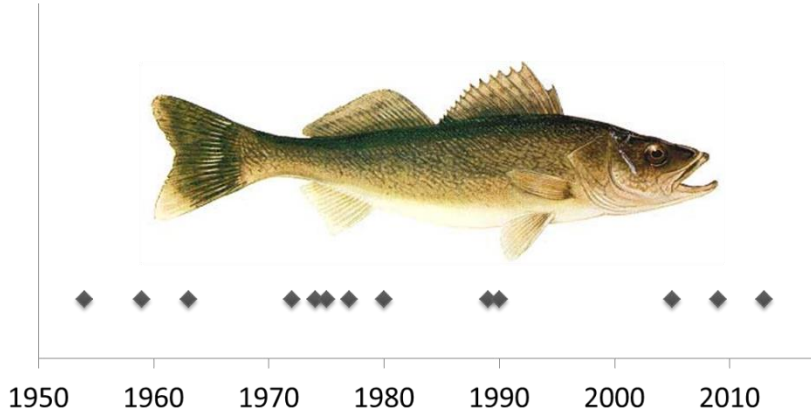
### Water levels

During some years, low water levels can affect the amount of oxygen available during the winter. This is particularly important when the levels are low at the beginning of a long winter. Simply put, more water holds more oxygen.

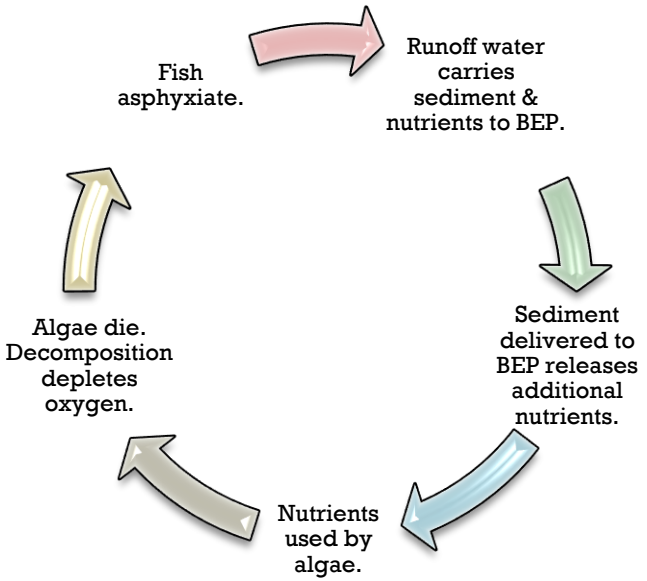
***Survey of Shoreland Owners Revealed …***

Based on their experiences living near the BEP, more than 60% of landowners feel the quality of fishing has declined in recent years. Additionally, nearly 1 in 3 believe property values have decreased as a result of changes to the quality of fishing.

Years with reported winter fish kills.




Note: The fish kills in 1989, 1990, and 2005 were considered small.



## BEP Basics

### River or Lake?

The Big Eau Pleine Reservoir (BEP) comprises a surface area of 6,677 acres with a maximum depth of 46 feet (Brodzeller & McGinley, 2015). The reservoir was created in 1937 by the construction of a dam on the Big Eau Pleine River. The Wisconsin Valley Improvement Company (WVIC) created reservoirs, including the BEP, to help provide uniform flow in the Wisconsin River for the generation of power by storing surplus water in reservoirs for release when water flow is low. This is done to improve the usefulness of the rivers for all public purposes and to reduce flood damage. This is achieved by storing water in the reservoirs and releasing it to the Wisconsin River during periods of lower flow.

### Multiple interests

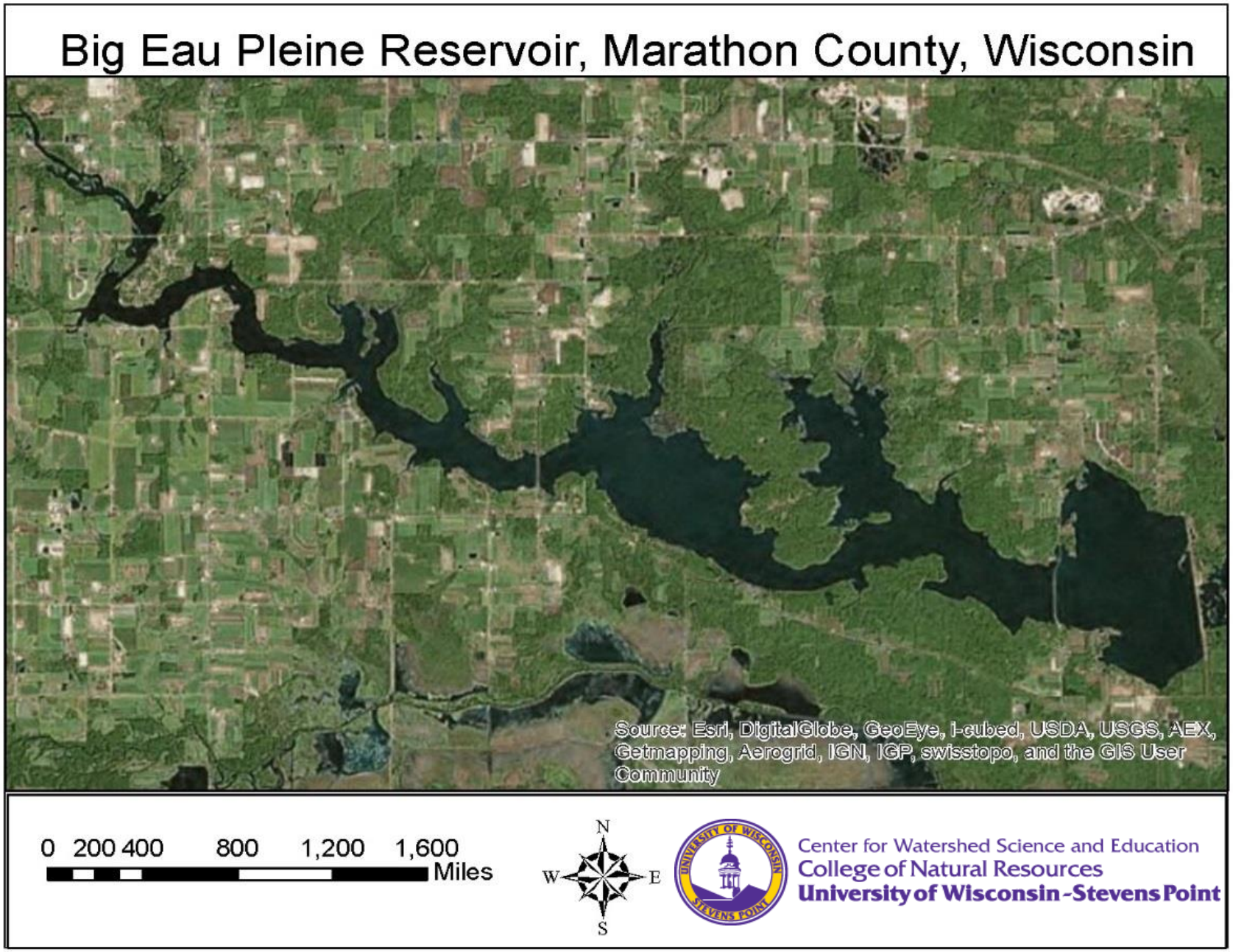
In addition to providing water storage for energy production, the BEP provides a lake-like setting capable of supporting a healthy fishery, habitat for waterfowl and other wildlife, and recreational activities such as boating and snowmobiling. The variety of uses can lead to differing ideas about how the reservoir should be managed, particularly its water levels; therefore, working together and finding common ground is especially important to achieving shared goals for the BEP.

Survey results show the majority of individuals believe the BEP vastly adds to the beauty of the community and its surroundings. Respondents feel strongly that time spent on the BEP is relaxing because the lake is quiet and not overcrowded. Most enjoy the natural, scenic shorelines and are not looking for the suburban backyards found on other lakes. They actively recreate on the BEP, rather than choosing to go to other nearby lakes.

Additionally, they see excellent fishing opportunities on the BEP and feel safe eating fish caught there. Survey responses showed overall agreement that the greatest threat to fish populations in the BEP is the decline in the water level during winter months.

### Challenges with reservoirs

A dam on the river slows the water, allowing sediment to fall out of the water and build up in the reservoir. This sediment, from its agriculturally dominated watershed, is rich in nutrients, which provides food for aquatic plants and algae. Since it is difficult for rooted aquatic plants to thrive in the BEP due to its abundance of carp, light limitations from algal blooms, and fluctuating water levels, algae will use the available nutrients to flourish. While some algal growth is normal, an overabundance of algae can produce poor conditions for recreation and, in some cases, can even be a health hazard for people and wildlife.


Big Eau Pleine Reservoir, Marathon County, Wisconsin
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
0 200 400 800 1,200 1,600
Miles
N
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S
Center for Watershed Science and Education
College of Natural Resources
University of Wisconsin-Stevens Point

# Goal 1.

# Sustain and Improve the Fishery of the BEP Reservoir

Primary Partners:

BEPCO

WDNR Fisheries Biologists

WVIC

# OXYGEN, FISH KILLS, AND THE BEP

## Understanding Oxygen Challenges in the BEP

During some winters, maintaining sufficient oxygen in the water to support the sport fishery (muskellunge, walleye, and northern pike) in the BEP has been a challenge since the reservoir's creation. As described in Goal 2, the agricultural nature of the BEP watershed and its management as a WVIC-owned storage reservoir creates challenges for maintaining a healthy fishery, due to fish kills.

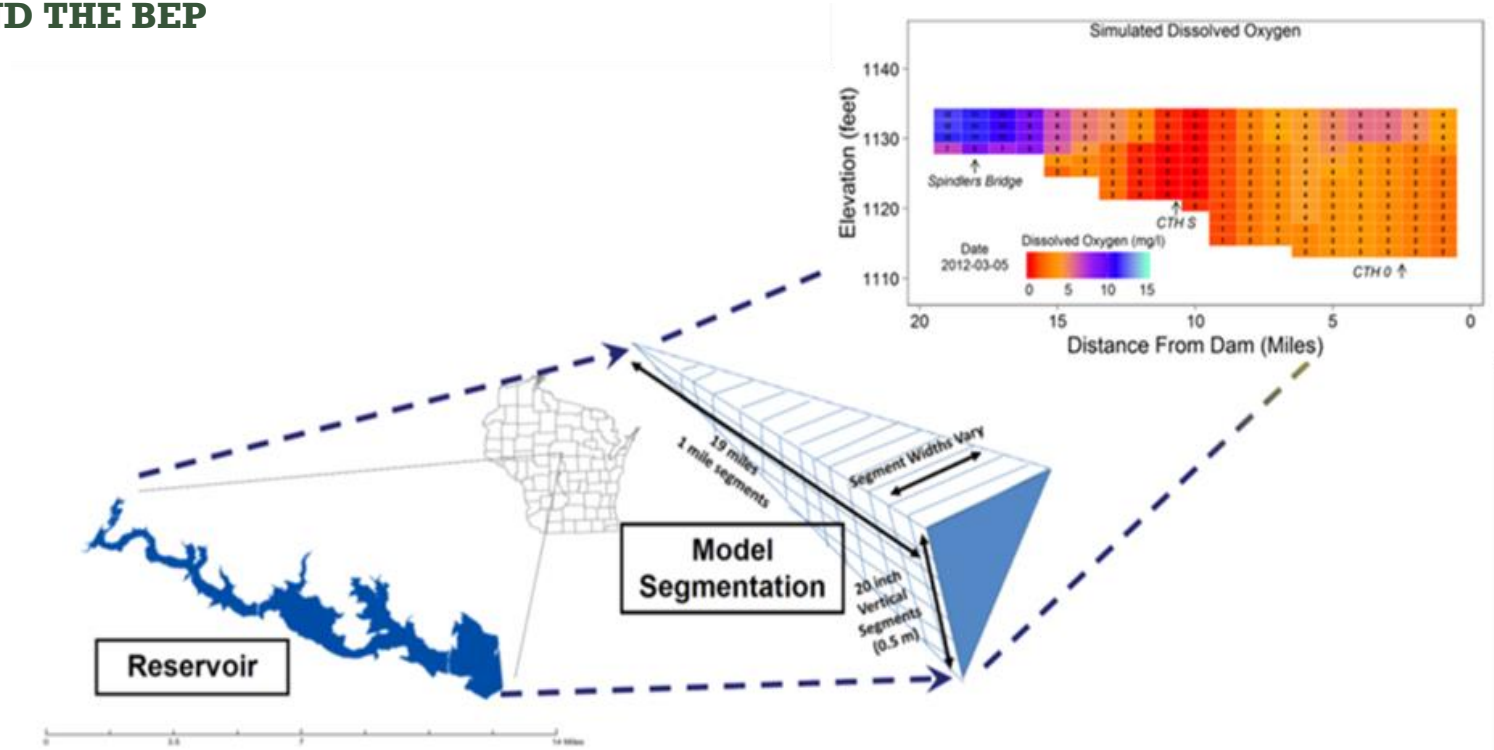



Figure 1. Illustration of how the BEP Dissolved Oxygen Model simulates the shape of the reservoir and calculates a dissolved oxygen concentration in the reservoir profile.

To better understand the dynamics and availability of dissolved oxygen for gamefish during the winter, in 2014 BEPCO obtained WDNR funding to support Dr. Paul McGinley's staff at the UW-Stevens Point to develop a model to understand the dynamics associated with oxygen depletion in the BEP. The Dissolved Oxygen Technical Committee reviewed and commented on their modeling efforts, meeting monthly from Jan 2014 to Aug 2016.

Excerpts from the work of both Dr. McGinley, and the Committee that supported his work are featured throughout this chapter.

**What was considered in the model?**

The BEP Dissolved Oxygen Model uses size and shape of the reservoir, weather, river flow, and water level in a computer simulation to project how oxygen concentrations vary under the ice in the BEP. Eighteen years of monitoring in the BEP was incorporated into the Model. Figure 1 shows how the model segments the reservoir and calculates the dissolved oxygen concentration throughout the reservoir.

**Why was the model developed?**

The ***Model*** was used to understand oxygen concentrations under the ice during the winter because the BEP has had problems with winter fish kills since it was created in the 1930s. The model allows for analysis of the importance of individual factors on winter oxygen concentrations. It is important to note that while the model uses a state-of-the-art computer simulation tool, it simplifies the many and complex processes that occur in the reservoir.

Figure 2 shows a typical yearly pattern of water ice formation, water level lowering, and dissolved oxygen depletion. The study showed the importance of ***winter length*** or the time between ice formation and the spring flush that replaces much of the water in the reservoir on oxygen concentration. In many years, the spring flush occurred by early March. In a few years, the spring flush occurs much later. In 2013, that flush did not occur until March 30.

**What was learned from the model?**

Oxygen is used under the ice by bacteria decomposing organic material that has accumulated in the sediments. This ***sediment oxygen demand*** is very high in the BEP. This is consistent with the large quantity of nutrients that flow in from the watershed, the resulting high concentration of phosphorus in the reservoir, and the conversion of that phosphorus to algae in the reservoir.

***Oxygen depletion*** during the winter follows warming of the water in the reservoir. During the winter, heat stored in the sediment during the summer warms the water from the bottom. This accelerates the upward propagation of low oxygen water during the winter. In reservoirs like the BEP, the high sediment area and the high sediment oxygen demand can rapidly deplete oxygen in the water under the ice.

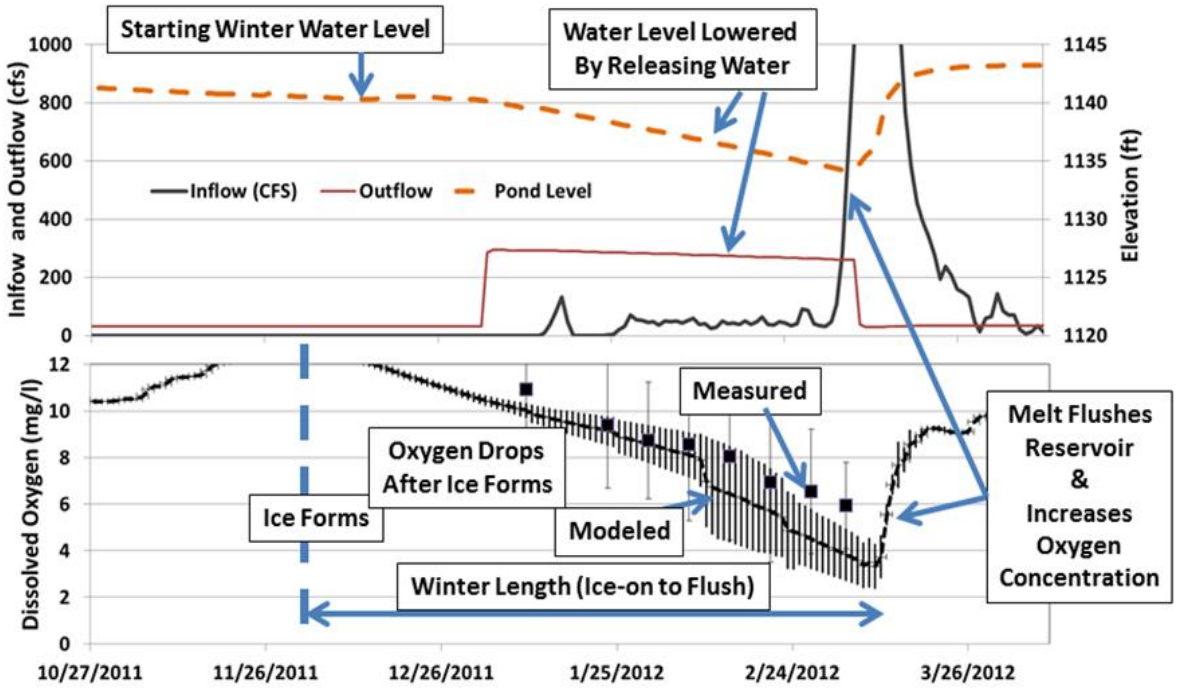



**Figure 2. Comparison of water level operation (above) and dissolved oxygen concentrations (below) during a typical winter in the BEP.**

The ***water level in the reservoir*** is important to how the oxygen concentrations drops during the winter. The model can be used to estimate how different water levels would have affected the oxygen concentrations. For example, the graph to the right shows how, using characteristics of the 2013 winter, higher water levels at the start of winter decreases the number of days that the oxygen concentrations are low. As an illustration, starting the winter at 60% full (approx. 15 days), would result in 15 days with oxygen less than 2 mg/L or almost 10 more days where the dissolved oxygen would be less than 2 mg/L than starting at 45% full, which would have approximately 25 days of low oxygen.

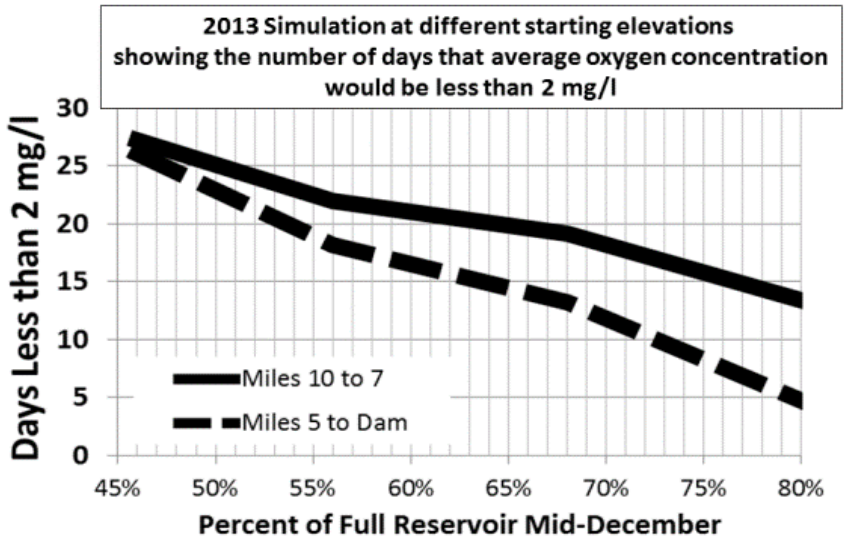
The model can be used to examine the combined effect of water level and winter length. As the graph to the right shows, for the very long winter length in 2013, although the duration of lower oxygen levels was shorter as the starting elevation increased, the model projected some days of low oxygen under all the starting water elevations shown.

The study shows how reductions in sediment oxygen demand (SOD) will benefit the reservoir. Options for reductions are discussed in the Goal 2 section of this plan. Similar to higher starting elevations, a reduction in SOD leads to more days during the winter that the oxygen concentration is higher. The model projects that a 10% reduction in SOD would add another week where the average oxygen would be above 2 mg/L near the dam.

The ***aerator*** was also examined in the model. It uses mixing to create an opening in the ice that allows oxygen to transfer from the atmosphere to the water. The result is that the aerator can provide a zone of higher oxygen concentrations. The model suggests this zone will not travel far in low-flow winters but that it should be able to overcome the oxygen demand in the vicinity of the aerator.

The full report *CE-QUAL-W2 Model for Dissolved Oxygen in the Big Eau Pleine Reservoir, Wisconsin to Understand and Manage Winter Anoxia* J. Brodzeller & P. McGinley, 2016 is available at

http://www.uwsp.edu/cnr-ap/watershed/Documents/BEP_FinalReport_Draft_July11_2016.pdf



**Reviewing the scientific understanding over time**

Over the last 40 years, several recommendations have been made to reduce the likelihood of winter oxygen depletion and fish kills in the BEP.

Shaw (1979) and Sullivan (1982) suggested that higher water levels in the BEP in early winter would reduce the impact of SOD on oxygen concentrations. Shaw also recommended a minimum pool of 25 to 30% of full volume at the end of the winter. Coon (1998) described how water levels in the BEP, streamflow and drawdown timing were all important to the movement of upstream oxygen depleted water into the BEP. He suggested a flexible management strategy using the three factors to control the development and movement of the oxygen depleted zone.

BEPCO (2011) analyzed 40 years of reservoir data and observed there were **no fish kill**s when the reservoir was both 60% full at the start of winter and 20% full at the end of winter. In the years where fish kills were reported, one or both of those criteria were not met, primarily the former.

While all these studies suggested a relationship between water levels and oxygen depletion in the BEP, the extent to which streamflow, weather, runoff and other factors combine with water level to contribute to the depletion of oxygen was not fully understood.

The purpose of Dr. McGinley's study was to develop a computer simulation model to improve the understanding of winter oxygen concentrations in the BEP and evaluate management actions to prevent oxygen depletion. While the sources of winter oxygen depletion were understood, the extents to which site-specific conditions and year-to-year variations in runoff, water level, air temperature, and ice cover determine oxygen concentrations were not well understood.

## Aeration

**The role of aeration**

Oxygen in the water can be limited during the winter. Ice cover restricts contact with the atmosphere and oxygen production from algae and aquatic plants is minimal. In addition, oxygen in the water is consumed by microbes and other organisms.

In the BEP, aeration can help to guard against massive fish kills by maintaining sufficient oxygen in the water to support the nearby fishery, creating a zone of refuge. The **zone of refuge** is the area located between BEP Reservoir Miles 5-6. This area was chosen because of the narrowing of the reservoir which allows for nearly shore to shore coverage as well as excellent access through the BEP county park and proximity to WDNR owned property.

**Why is aeration important to the BEP?**

Currently, all of the factors leading to oxygen problems in the BEP cannot be controlled, so there are years when oxygen levels in the BEP are insufficient to support the fishery. It will take time for improvements on the landscape to result in better water quality in the BEP (see Chapter 2), and during some years, there will not be enough precipitation in the fall and winter to replenish the water released from the BEP to the Wisconsin River.

**Who is involved in the operation of the BEP aeration system?**

Following a large fish kill, in 2009, the BEP Task Force was organized as a result of a resolution by the Marathon Co Board of Supervisors. It includes representation by WDNR, WVIC, Marathon County, and BEPCO. This group entered into a memorandum of agreement (MOA) for the operation of the BEP aeration system. The MOA specifies responsibilities associated with monitoring to determine the need for an aeration system, and

the safety, maintenance, operation, and expenses of running the aeration system. A copy of the agreement can be found in the appendices.

**The Challenges**

Studies indicate aeration should be operated over a longer period of time during some years. A strategy needs to be developed for safe deployment of the aeration prior to ice-on, as well as how to inform the public where ice will be unsafe and/or open water will exist.

- A longer period of operation will increase operational costs, particularly related to power.
- In addition to operational costs, there will be maintenance and replacement costs for the aeration system.

## Managing Flow and Water Levels in the BEP

**Who manages flow and water levels in the BEP?**

WVIC is responsible for outflow and water levels in the BEP, which is one of the reservoirs created on Wisconsin River tributaries to provide more uniform flow in the Wisconsin River. Privately owned by dam owners and member companies along the Wisconsin River and its tributaries, WVIC was founded in 1907 by the State Legislature. According to its charter, WVIC is to provide "*nearly a uniform flow of water as practicable in the Wisconsin and Tomahawk rivers by storing in reservoirs surplus water for discharge when the water supply is low to improve the usefulness of the rivers for all public purposes and to reduce flood damage*." In total, 21 reservoirs make up the WVIC system. As part of licensing requirements, WVIC has many management plans related to the BEP including Operations, Land Resource Management, Recreation, Fish and Wildlife Management, and Historic Resource Management. More information about WVIC may be found on its website: http://www.wvic.com/

**What guides WVIC management decisions?**

The Federal Energy Regulatory Commission (FERC) is the agency responsible for licensing hydropower dams and storage reservoirs such as the BEP. A FERC license provides the structure needed to guide the operation of a reservoir or system of reservoirs. The most recent FERC license for the Wisconsin River reservoir system, which included the BEP, was issued to WVIC in 1996. The license has a 30-year term.

**Can the FERC license for the BEP be changed?**

A process involving many studies and public input is laid out by FERC for licensing, relicensing, and periodic review of elements of the license. The license period for the BEP is currently 30 years and was last renewed in 1996. It is scheduled to be renewed in 2026. The FERC license and periodic review processes are designed to create a balance between the generation of power and the public interest. There are opportunities for input from the public and agencies during review periods, which occur every 5 years.

**Be Informed**
**Share Your Opinions**
**Do Your Part**
**Support Improvements**

# Share Your Ideas

***Informed community members, agency staff, and elected officials can provide suggestions about improvements to the license for the BEP.***

**Learn the basics of the FERC license for the BEP held by WVIC.**

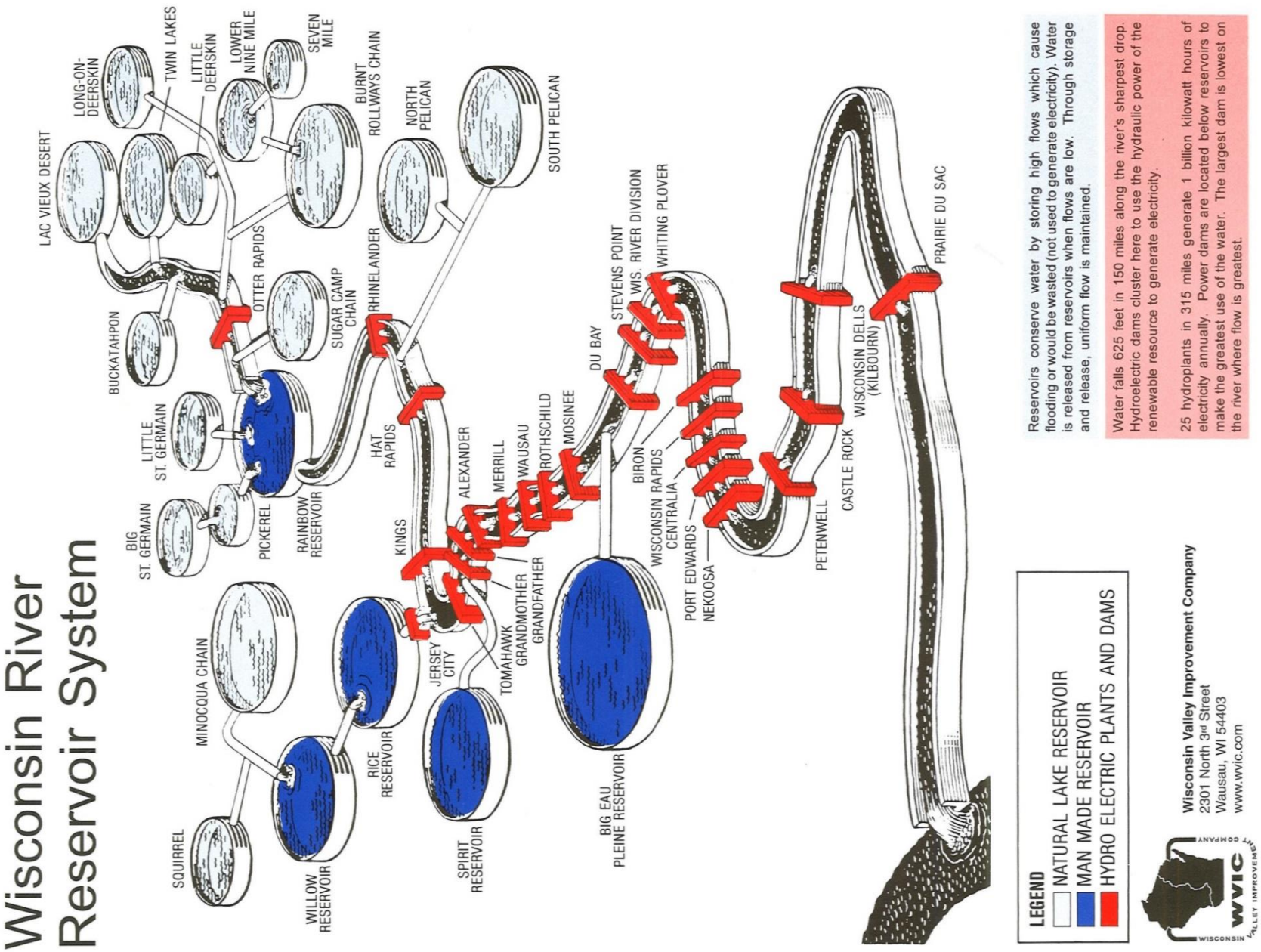
Timeline: Ongoing.

**Sign up for a FERC e-subscription to learn details related to license P-2113.** https://www.ferc.gov/docs-filing/esubscription.asp

**Know the schedule for comment-periods related to the BEP FERC license.**

Timeline: 2021 and every 5 years.

**When there are comment periods - share your opinions about strategies for the management of the BEP that are identified in the FERC license.**


Wisconsin River
Reservoir System
LAC VIEUX DESERT
LONG-ON-DEERSKIN
TWIN LAKES
LITTLE DEERSKIN
LOWER NINE MILE
SEVEN MILE
BURNT ROLLWAYS CHAIN
NORTH PELICAN
SOUTH PELICAN
BUCKATAHPON
OTTER RAPIDS
SUGAR CAMP CHAIN
RHINELANDER
LITTLE ST. GERMAIN
BIG ST. GERMAIN
PICKEREL
RAINBOW RESERVOIR
HAT RAPIDS
KINGS
ALEXANDER
MERRILL
WAUSAU
ROTHSCHILD
MOSINEE
DU BAY
STEVENS POINT
WIS. RIVER DIVISION
WHITING PLOVER
BIRON
WISCONSIN RAPIDS
CENTRALIA
PORT EDWARDS
NEKOOSA
PETENWELL
CASTLE ROCK
WISCONSIN DELLS (KILBOURN)
PRAIRIE DU SAC
MINOCQUA CHAIN
SQUIRREL
WILLOW RESERVOIR
RICE RESERVOIR
JERSEY CITY
TOMAHAWK
GRANDMOTHER
GRANDFATHER
SPIRIT RESERVOIR
BIG EAU PLEINE RESERVOIR
LEGEND
NATURAL LAKE RESERVOIR
MAN MADE RESERVOIR
HYDRO ELECTRIC PLANTS AND DAMS
Reservoirs conserve water by storing high flows which cause flooding or would be wasted (not used to generate electricity). Water is released from reservoirs when flows are low. Through storage and release, uniform flow is maintained.
Water falls 625 feet in 150 miles along the river's sharpest drop. Hydroelectric dams cluster here to use the hydraulic power of the renewable resource to generate electricity.
25 hydroplants in 315 miles generate 1 billion kilowatt hours of electricity annually. Power dams are located below reservoirs to make the greatest use of the water. The largest dam is lowest on the river where flow is greatest.
Wisconsin Valley Improvement Company
2301 North 3rd Street
Wausau, WI 54403
www.wvic.com
WVIC
WISCONSIN VALLEY IMPROVEMENT COMPANY

## Drought Contingency Plan

**What is WVIC's drought contingency plan (DCP)?**

In 2011, WVIC updated the DCP, as required by their license. The strategies in the DCP are complex and require balancing the needs in the BEP while allowing for sufficient flow in the Wisconsin River.

Since the conditions leading to a drought can vary, there is no single approach that will serve to meet the needs of the BEP and the Wisconsin River. Some of the variability depends upon how widespread the drought is in the upper Wisconsin River basin, the predicted duration of the drought, the time of year, and other measures of severity.

**When is the drought contingency plan activated?**

The following circumstances serve as triggers to enact the DCP.

1) If the 24-month running average cumulative precipitation deficit reaches 6 inches.

2) If after two consecutive weeks, the natural river flow in the Wisconsin River is less than 900 cubic feet per second at Merrill or 1,300 cubic feet per second at Wisconsin Rapids.

3) If the index level in any of the five large reservoirs (Rainbow, Willow, Rice, Spirit, or Eau Pleine) falls below "level 3" during the period of June through November. In the BEP, level 3 elevations are set by month; 3,182 June – August, and 1,854 September to November. See DCP in the appendix for more details.

**Summary of the drought contingency plan**

Once the need to enact the DCP has been demonstrated, WVIC will begin consultation with staff from the WDNR, U.S. Fish and Wildlife Service, and FERC. Although not required, a representative from BEPCO may also be included in the consultation.

- The consultation is intended to develop a response to the specified drought.
- A minimum release of water from the BEP is required; however, when water levels in the BEP drop below the specified minimum water elevation, resource agencies may require WVIC to release less water than the minimum-required release. The minimum-water release and water elevations are defined in the FERC license.
- The minimum flows were set using criteria that included protecting water quality, vegetation and cover for fish and wildlife, areas for spawning, feeding, and nursery, aquatic invertebrates (insects), recreation (esp. fishing and canoeing), and aesthetics.

Additional details associated with the DCP can be found in the appendices.

### Strategies

***Avoid or reduce fish kills in the BEP during drought by enacting the drought contingency plan (DCP).***

**Enact the DCP and initiate consultation with WDNR and USFWS when trigger levels for defining drought in the BEP watershed are met.**

Timeline: As needed.

## Reducing Oxygen Problems in the BEP to Protect the Fishery

The Dissolved Oxygen Technical Committee developed and unanimously agreed upon the following set of management recommendations to protect the fishery of the BEP, particularly during winter when the fishery is most susceptible to fish kills.

The Committee acknowledges that focusing on enhancing dissolved oxygen in the zone of refuge is part of the best short-term approach to protecting the fishery of the BEP. However, due to the size of the reservoir, it is important to note that this approach will not protect all fish in the reservoir.

### Risk Factors that Influence the Possibility of a Fish kill

Factors of significance that influence fish kills were identified during the development of Model. These factors provided sound basis for the management recommendations and are presented in a matrix of options in this plan.

- **Air temperatures** during the preceding summer (June-Aug) which can increase water and soft sediment temperatures prior to wintertime.
- **Severity of winter**, specifically duration of ice cover.
- **Seasonal distribution of precipitation**. Heavy rainfall events in the spring and fall can negatively impact winter fish survival through increased nutrient loadings, while increased summer precipitation can be protective by increasing the volume of water available for winter storage.
- **Reservoir elevation/water level** prior to the formation of ice cover.
- **Timing and duration of mechanical aeration**.

**Understanding the matrix risk factors and critical indicators**

***Predicted Winter Severity*** – Of the risk factors identified in the Matrix, predicted winter severity as measured by ice cover duration is of significant importance for winter oxygen depletion. The Committee did not apply a particular weight to this factor in the Matrix, but it appears to be a significant driver of winter oxygen depletion, and should be treated as such.

The Model indicates winters with ice cover longer than 90 days have a greater likelihood of fish kills. Therefore, if a severe winter is predicted (with increased likelihood of ice cover lasting over 90 days), a high risk for low oxygen conditions is indicated in the Matrix. Dec 1 is the average date that ice covers the BEP. An increasingly high risk for winter oxygen problems exists for every day that ice cover is present prior to Dec 1.

***Water Level*** – Water levels at the start of winter are important to the time it takes for oxygen depletion and are of significant importance. Based on the 2013 simulation, the Model suggests a winter starting volume of 60% of full pool would provide 10 additional days of oxygen above 2 mg/L, compared to a starting winter volume of 45% of full pool. This is supported by a statistical analysis of historical records (1981 to present) performed by BEPCO which showed that during this period there had never been a fish kill when the water level in the BEP was above 60% at ice over. This study showed that in 6 of the 13 years (46%) that winter started with levels in BEP below 60%, a reported fish kill occurred.

***Preceding Summer Temperatures*** – Warmer-than-average summer (June-Aug) temperatures increase the bottom sediment temperatures in the BEP. During winter, oxygen depletion of the water occurs at the sediment-water interface. Warmer sediment temperatures warm the oxygen-depleted bottom water, causing it to rise thus increasing the rate of oxygen depletion in the water column above. Therefore, if preceding summer temperatures are warmer than the mean, an increased risk of low oxygen in the BEP exists.

The best weather station to utilize for the BEP is the National Weather Service—Wausau ASOS (Wausau Airport) as it closely matches precipitation data at Stratford, and provides a historical record for comparison and prediction. To retrieve recent data, visit http://w2.weather.gov/climate/index.php?wfo=grb then select *1. Product* and then *Preliminary Monthly Climate Data (CF6)*. Next, select *2. Location* and *Wausau*, and finally, select *3. Timeframe*, followed by *Archived Data* and the appropriate dates.

***Preceding Spring Rainfall*** – Above-average precipitation in the months of the preceding spring (March - May) can negatively influence winter oxygen in the BEP. Excess rainfall and storm events can wash nutrients and sediment from farm fields at a vulnerable time, when the root systems of crops (which can hold soil in place) are not fully established. Most of the nutrients and sediment that wash into the BEP will remain, and can contribute to oxygen depletion the following winter. Preceding spring rainfall amounts greater than the mean creates a risk for oxygen depletion.

***Preceding Fall Rainfall*** – Similar to spring precipitation, above-average rainfall in the preceding fall (Sept - Nov) can influence oxygen in the BEP by washing nutrients and sediment from farm fields at a vulnerable time, when crops have been harvested from farm fields and bare soil is exposed. Most of the nutrients and sediment that wash into the BEP will remain, and can contribute to oxygen depletion the next winter. Preceding fall rainfall greater than the mean creates a risk for low oxygen in the winter.

## Aeration Decision Matrix

| | Risk factor | Low Risk | High Risk | Critical Indicator | Resource for assessing risk |
|---|---|---|---|---|---|
| **Predicted winter severity** | The predicted duration of winter is… | Less than 90 days | Greater than 90 days | 90 days | http://www.cpc.ncep.noaa.gov/products/CFSv2/CFSv2seasonal.shtml |
| | The date that ice covers the BEP is… | Later than Dec. 1 | Earlier than Dec. 1 | Dec. 1 | Ice-cover data is collected by Wisconsin Valley Improvement Company |
| **Water level** | The Dec. 1 BEP water level/elevation is… | Above 1139.3 ft. | Below 1139.3 ft. | 61.7% full pool (1139.3 feet elev.) | Wisconsin Valley Improvement Company water level reports http://www.wvic.com/WaterReports/Water_Level_Report.cfm |
| **Preceding summer temperatures** | Recorded air temperatures for the preceding June-Aug were… | Cooler than the mean | Warmer than the mean | Mean temp. of 67.2 degrees F | National Weather Service - Wausau Airport station 1. Preliminary Monthly Climate Data (CF6) 2. Location – Wausau 3. Archived Data http://w2.weather.gov/climate/index.php?wfo=grb |
| **Preceding spring and fall rainfall** | Precipitation for the preceding March-May was… | Less than the mean | Greater than the mean | Mean precip. of 7.97 inches | National Weather Service - Wausau Airport station 1. Preliminary Monthly Climate Data (CF6) 2. Location – Wausau 3. Archived Data http://w2.weather.gov/climate/index.php?wfo=grb |
| | Precipitation for the preceding Sept-Nov was… | Less than the mean | Greater than the mean | Mean precip. of 8.84 inches | National Weather Service - Wausau Airport station 1. Preliminary Monthly Climate Data (CF6) 2. Location – Wausau 3. Archived Data http://w2.weather.gov/climate/index.php?wfo=grb |

**Example of Matrix application**

If a severe winter is predicted and ice cover is established on the BEP at or near Dec 1, managers should consider initiating aeration earlier in the winter. Note: Both of these situations are High Risk factors.

If multiple risk factors are present but a severe winter is not predicted, early winter oxygen monitoring should be closely watched, and if depletion of oxygen is indicated, the aeration system should be turned on. This decision should factor in the two-week "lag time" before an increase in oxygen occurs as a result of aeration.

This is a dynamic process and adaptions should be made upon annual review of monitoring data and aeration operation schedule of the preceding year or years.

**Dissolved Oxygen Committee Management Recommendations**

1) Convene the parties named in the BEP Aerator System Memorandum of Agreement (MOA) and any other relevant parties to discuss the framework and commitments of a new MOA.

BEPCO, Marathon County, WDNR, and WVIC are the parties named in the current MOA, set to expire in 2017. These parties should convene to consider, and come to consensus on, actions related to the following:

a. Update the Reservoir Monitoring and Operation section to include the use of an Aeration Decision Matrix to evaluate the need and timing of aerator operations (see Recommendation #3).

b. Identify strategies to adaptively manage aeration operations to maximize the wintertime zone of refuge downstream of the aerator, while addressing recreational safety concerns (see Recommendation #4).

c. Develop a comprehensive, year-round monitoring strategy that complements existing monitoring conducted by WVIC (see Recommendation #7).

d. Identify and expand funding sources to allow for earlier startup of the aeration system.

e. Identify new partners to be added to the MOA (i.e. Greater Wausau Area representation from the tourism sector).

2) Maintain BEP water levels as high as is practical and for as long as possible in advance of the winter drawdown, within the constraints of WVIC's FERC license, particularly as it relates to maintaining flows in the Wisconsin River.

According to the Model, starting the winter at a higher water level leads to higher average oxygen concentrations at the surface near the dam late in the winter which decreases the likelihood of oxygen depletion near the surface before spring runoff but does not guarantee adequate oxygen near the surface during a very long winter. At the onset of most winters (Dec 1), greater volume equates to more oxygen to support the fishery throughout the winter, prolonging the onset of oxygen depletion.

Also, holding the starting elevation longer into the winter could delay reaching low oxygen concentrations in the *metric regions*. The intended outcome behind recommending a higher Dec 1 water level is to limit the number of days dissolved oxygen concentrations in the metric regions fall under the threshold of 2 mg/L, below which gamefish populations are stressed and the likelihood of fish kills increases. Metric regions are two focal areas—BEP Miles 10-7, and 5-0 which the model used as reference points for dissolved oxygen concentrations.

3) Develop an Aeration Decision Matrix that identifies and weights the risk factors that contribute to wintertime dissolved oxygen depletion in the Big Eau Pleine, to serve as a guide for managers to initiate mechanical aeration.

According to the modeling results, increased and earlier mechanical aeration (before Feb 15, the average aeration start date in the years that aeration has been necessary) could result in a greater chance of providing a greater the zone of refuge and protecting the fishery through the winter. However, earlier and longer operation of the aerator leads to increased operational expenses and potential safety concerns due to thin or non-existent ice. These and other concerns mentioned in Recommendation #1 should be considered prior to altering aeration regimes.

The Committee identified several risk factors that are potential predictors of winter oxygen depletion—predicted winter severity, water levels on Dec 1, and air temperature and rainfall amounts that occurred from the preceding March through November. If any of these factors fall under a critical indicator of risk (identified in the Matrix), there is increased chance of oxygen depletion, at which point the Committee recommends aeration should be considered. The Matrix is the Committee's best attempt to identify key risk factors and associated indicators of risk; however, the Committee acknowledges that more data is necessary to further refine these indicators and make the Matrix more operational as a predictive tool for anoxic conditions on the BEP.

Considerations for aeration start up after ice fully covers the BEP:

- depending on thickness of ice cover, there can be a two-week or more delay between when the aeration system is turned on, and when full benefits of aeration are realized.
- the initial process of starting the aerator re-suspends bottom sediments full of oxygen-consuming material, which, if occurring during ice-covered conditions, likely actually consumes rather than generates oxygen.

4) Adaptively manage aerator operations to determine and optimize which operational practices maximize the zone of refuge for fish within and downstream of the aeration system.

a. The Model shows that turning on the aerator earlier can increase the winter oxygen in the zone of refuge downstream of the aerator by preventing ice formation, which in turn can increase the chances of fish survival. To the extent possible, the Committee recommends evaluating the economics, safety, and environmental benefit of an earlier start date for the aeration system, consistent with Wis. Stat. § 167.26.

b. Determine if additional holes could be drilled in the aerator blower lines, without impacting the efficacy of the aeration system. This may expedite connection of the holes in the ice (created by the aerator) which could lead to a larger open water area, which would provide oxygen to the zone of refuge.

c. Evaluate a staggered aerator blower operation rather than operating both blowers at the same time. One blower could be turned on a few weeks in advance of the other, to begin opening up holes in the ice sooner. This could provide oxygen to the zone of refuge earlier and without increased electrical operation expenses.

d. Develop a monitoring plan related to aeration, to determine and quantify the net effect of the aerator's influence within and immediately downstream of the aeration zone.

5) Conduct a fish movement study in the BEP using acoustic technology.

Improve the understanding of how, where, and when fish move within the reservoir and river during the winter. WDNR fish survey data have shown that even in major fish kill years, some fish survive. For instance, many of the first-year walleye survived the extreme 2009 fish kill, the largest fish kill recorded since 1980. Conversely, in some winters not characterized as extreme fish kills, a percentage of fish die, presumably due to low oxygen.

The results of a 1988-89 WVIC-sponsored radio telemetry study showed extensive movement of walleye over the winter period; however, questions remain on how they survive periods of winter where conditions aren't favorable for survival. These questions include: Where do fish find oxygen during the winter outside the zone of refuge created by the aerator? Will fish move, and how far

will they move to seek out the zone of refuge? Why were young walleye less susceptible than adult fish to the 2009 fish kill?

6) Develop a BEP Watershed Manure Advisory System to warn agricultural producers of the threat for winter oxygen problems in the BEP, as described in the Aeration Decision Matrix and by monitoring dissolved oxygen.

The Model clearly describes sediment-oxygen demand (SOD) as a driver of oxygen in the BEP. SOD results from nutrient-rich runoff entering the BEP from watershed sources during melt and storms. The runoff can contain manure, fertilizer, and phosphorus-rich soil.

The Model shows that if SOD is reduced, there is a direct benefit on winter availability of oxygen in the BEP. When conditions are present that threaten of the onset of winter oxygen problems and/or fish kills, agricultural producers should be notified along with guidance on winter spreading of manure and other discharge practices. The advisory could use a similar model as the Wisconsin Manure Advisory System.

7) Develop and implement a summer and fall monitoring strategy incorporating phosphorus, algal blooms, and water temperature, to better predict how and when oxygen will be depleted in the winter.

The Model suggests that processes occurring in the watershed and BEP in the summer influence the availability of oxygen the following winter. Monitoring phosphorus and algal blooms in the summer will provide data that could be used as a predictor of winter oxygen depletion, and an indicator of the need for earlier and prolonged aeration. Summer water temperatures are an indicator of winter sediment temperatures.

8) Continue the winter monitoring efforts for dissolved oxygen and ice cover currently being conducted by WVIC.

The monitoring data provided by WVIC used in the Model was critical. To continue to have the best available science to guide management decisions on the BEP, WVIC's data collection should continue.

9) Support development and implementation of measures that reduce nutrient and organic matter loading to the BEP.

Until nutrient runoff from the surrounding lands is reduced, the BEP will continue to be challenged by winter oxygen problems and fish kills. Ongoing efforts by the WDNR (Wisconsin River TMDL), Marathon County, DATCP, and NRCS (non-point source pollution reduction programs), and municipalities (phosphorus compliance efforts such as watershed adaptive management and water quality trading) will all contribute toward reducing nutrient loading to the BEP. These, and other similar efforts, should be supported, and implemented where possible, by all affected parties.

# ENHANCING FISH HABITAT

## Spawning Habitat

Different species of fish prefer different types of spawning habitat. Walleyes favor gravel beds. Walleyes for Tomorrow, BEPCO, WDNR, and WVIC have partnered on projects to improve spawning habitat in the BEP by constructing several extensive gravel beds similar to the one displayed right.

## Shelter and Other Habitat

Due to lack of aquatic plants, the BEP does not provide as much habitat as other water bodies in central Wisconsin. Typically, aquatic plants support fish and other species by providing habitat and shelter, especially for young fish and their food. With the absence of plants, woody structure in shallow water can offer shelter for fish, opportunities for turtles to warm themselves, and places for birds to perch and fish.

***Survey of Shoreland Owners Revealed ...***

*Where do 'riparian' stakeholders agree?*

Agree

Providing better habitat for fish and wildlife on the lake motivates me to support efforts to improve the BEP.

**"Let it Fall" or Add Fish Sticks**

Adding fish sticks to the BEP can be beneficial; however, the locations should be carefully identified so logs don't float downstream and block the dam. Back bays provide shelter from the primary flow of the river and therefore are good sites for the addition of fish sticks. Consultation with the WDNR Fisheries Biologist is recommended during project development to ensure chosen sites will be beneficial to fish, and the techniques proposed to secure the wood in place are sufficient. For more information visit the WDNR website:

http://dnr.wi.gov/topic/fishing/outreach/fishsticks.html

Enhancement of fishery habitat using fish sticks and other woody structure is recommended.
Projects will be most successful in back bays such as those indicated by pink circles on the map.

## GOAL 1. SUSTAIN AND IMPROVE THE FISHERY OF THE BEP RESERVOIR

**Outcome 1.1 – Operate the aeration system in the BEP to reduce the likelihood of winter fish kills while ensuring safety.**

**Who**: BEPCO, Marathon County, WDNR and WVIC (BEP Task Force)

**What**: The BEP Aeration operation group will review and update the aeration system plan and memorandum of agreement (MOA). For purposes of broader ownership, the aeration operation group should consider adding new representatives to the group.

- In winter 2016-17, the BEP Aeration operation group will review and update plans for the aeration system in the BEP Aerator System Operation Memorandum of Agreement (MOA).
- Updates to aeration operations should consider recommendations from the DO Technical Modeling Committee, timing and duration of operation, safety of deployment, and public safety during operation.
- The BEP Aeration operation group should develop a governance structure for inclusion in the MOA which addresses leadership roles and responsibilities related to financial contributions, maintenance and operation, monitoring, safety considerations, points of contact, and processes for calling meetings, distributing information, decision-making, and changes to the MOA.

**When**: 2017 and every 5 years thereafter.

**Indicators of success**: An updated MOA by October 1, 2017 for operations in 2018.

**What**: Sustainable funding is identified to assure the maintenance and operation of the aeration system.

- In 2017, BEPCO and WDNR will convene a meeting of the BEP Task Force, towns, local businesses, sports, conservation and agricultural groups, Wausau Area Visitor's Bureau, and others to identify cost estimates and sustainable funding sources for the operation of the aerator.
- BEPCO should engage with UWEX Lakes to explore options for the formation of a Lake District to help with funding for the aeration system.

**Indicators of success**: A sustainable funding strategy is identified that will cover maintenance and operational costs for the aeration system. The funding strategy is initiated by Jan 1, 2018.

## GOAL 1. SUSTAIN AND IMPROVE THE FISHERY OF THE BEP RESERVOIR

**Outcome 1.2. - Enact the Drought Contingency Plan (DCP) and initiate consultation with WDNR and the U.S. Fish and Wildlife Service when trigger levels for defining drought are met.**

**Who will take the lead**: WVIC

**What:** See DCP in Appendix for details.

**When**: As needed, when triggers of the DCP are met.

**Indicators of success**: The DCP is enacted when trigger levels defining drought conditions are met.

MOA participants understand the DCP prescribed activities and know the definitions of drought conditions/indicators that trigger implementation of the DCP.

The actions taken and plans enacted as a result of the required consultation prevents a fish kill during the following winter.

**Outcome 1.3 – Obtain information related to gamefish movement that can assist with maximizing habitat improvements, aeration operation, and overall management of the fishery.**

**Who:** WDNR, WVIC, Marathon County, UWSP Fisheries Faculty and Students

**What**: Conduct a gamefish movement study on the BEP using acoustic technology.

- Design a gamefish movement study using acoustic technology that outlines materials, tasks, methods, performance measures reporting etc. Identify study duration.
- Apply for Marathon County Environmental Impact Grant Funds to purchase the necessary materials and equipment, and hire the staff needed to implement the study.
- Continue collecting dissolved oxygen and temperature profiles during the winter months which can be analyzed relative to gamefish movement/distribution and aerator operation.

**When:** Submit application for funding to the Marathon County Environmental Impact Fund by June 1, 2017. Funding would be available in 2018.

**Indicators of success:** A study is designed and implemented that provides a better understanding of how, where, and when gamefish move within the reservoir throughout the year and particularly during the winter when dissolved oxygen

## GOAL 1. SUSTAIN AND IMPROVE THE FISHERY OF THE BEP RESERVOIR

**Outcome 1.4 – The fishery will be improved by increasing fish habitat in the BEP reservoir.**

**Who:** Shoreland property owners

**What:** Improve fish habitat in the BEP.

- Learn about the importance of the addition of fish habitat to the BEP reservoir and which permits are necessary to ensure it is safely deployed. WDNR Fishery Biologists can provide technical assistance.
- WDNR Fishery Biologist will work with stakeholders to develop a habitat development plan to identify and prioritize important habitat needs for major gamefish and panfish in the BEP.
- Over the next 3 years, shoreland property owners and fishing clubs will work together to improve fish habitat in the BEP. WDNR Fishery Biologists can provide technical assistance.
- BEPCO or Walleyes for Tomorrow can apply for Healthy Lakes Grants (WDNR) to offset funding for "Fish Sticks" projects.

**When:** 2017

**Indicators of success**: WDNR fish surveys show improvement in fish reproduction and size structure.

**Outcome 1.5 – The status of the fishery, including community and population, will be known. This information can be used as a measure of this plan's success and to adjust approaches in this plan.**

**Who:** WDNR, WVIC (as needed), community members (as needed)

**What**:

- Monitor the fishery. Monitoring will be conducted by the WDNR Fishery Biologists following WDNR standardized lake assessment protocol to determine the survival and health of the fish community in the BEP.
  - An annual spring electrofishing transect will be completed to assess the spawning adult walleye population along with a fall electrofishing transect to monitor walleye recruitment.
  - A comprehensive survey will be conducted on a 7-year rotational basis, which will include spring fyke netting, spring electrofishing and fall electrofishing to assess the status of the entire fishery.
  - Primary fish metrics to monitor the fishery would include catch per unit effort (CPUE) and proportional and relative stock density indexes.
- If needed, WVIC staff can assist with surveys.
- Make survey results with interpretation and comparison to prior surveys available to BEPCO and other interested stakeholders.

## GOAL 1. SUSTAIN AND IMPROVE THE FISHERY OF THE BEP RESERVOIR

**Outcome 1.6 – Understand the economic benefits from a healthy fishery and the negative impacts to the economy from fish kills in the BEP. Maintain the BEP's reputation for a healthy fishery, which is especially important following fish kills, when it is assumed the whole fishery was harmed.**

**Who:** BEPCO, Marathon County, WDNR, Walleyes for Tomorrow, other fishing clubs

**What**:

- Hire an economist to conduct an economic assessment to determine the benefits of the BEP including property values, business, municipal, and industrial benefits, and a healthy fishery. Request recommendations about the economic issues that should be addressed.
- Obtain economic information related to the International Ice Fishing Championships from the Wausau/Central Wisconsin Convention and Visitors Bureau.

**When**: 2019

**Indicators of success**: The economic impacts of the BEP to the economy in central Wisconsin and the extent of negative impacts of fish kills will be understood.

**Who**: BEPCO, Walleyes for Tomorrow, other fishing clubs

**What**:

- Following a fish kill, once the health of the fishery has been established, make a splash about the fishery by submitting news articles, contacting the local media, and posting on Lake_Link.com and other fishing sites.
- Following a fish kill, host an event that brings fishers back to the BEP.

**When**: As needed.

**Indicators of success:** The reputation for the BEP is that it has an excellent fishery.

# Goal 2.

# Improve Water Quality in the BEP Reservoir and Watershed

**Primary Partners**

Shoreland and Watershed Property Owners

Conservation and Farmers Groups

Clark, Marathon, and Taylor Counties

Wisconsin Dept. of Agriculture, Trade and Consumer Protection

United States Dept. of Agriculture – NRCS

United States Environmental Protection Agency

# WATER QUALITY IN THE BEP

## Improving the Water helps the Fishery

The water quality goal for the BEP to decrease nutrient levels (phosphorus) which would decrease the frequency of algal blooms, improve water clarity and reduce fish kills related to oxygen depletion. To achieve these goals, the water quality standard for phosphorus in the BEP is 30 ppb (parts per billion) during the summer. Reducing the current levels in the BEP is essential for the long- term reduction of winter fish kills and reducing summer algae blooms.

Achieving the water quality goals for the BEP will be accomplished by the BEP community working together to place a high community value on sustaining the fishery and improving the water quality in the BEP and its watershed. Monitoring and modeling has been conducted in the BEP and its watershed which identified the amount of phosphorus coming into the BEP that must be controlled to improve water quality. This process, a TMDL, is described later in this chapter. Based on monitoring results and modeling, the majority of phosphorus entering the BEP is from agricultural land. Achieving the needed phosphorus reductions from agricultural lands will require the greater BEP community to support the agricultural community in a meaningful way in order to reduce the amount of nutrients and runoff from agricultural lands.

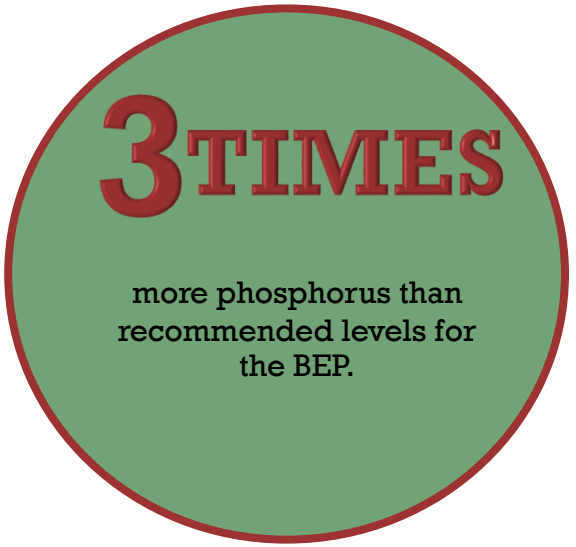
## What We Know about Water Quality in the BEP

Water quality in the BEP is the result of natural characteristics such as geology, slope, soil type, native vegetation, wetlands, the amount of land that drains to the reservoir, and climatic factors. The water quality is heavily impacted by human activity including land management in the watershed, and the dam slowing the flow and allowing sediment and nutrients to settle out in the BEP.

Changes in the land use, and intensive land management practices, such as fertilizing, draining and ditching wetlands, discharge of municipal and industrial wastewater, spreading livestock manure and solids from human waste treatment on land, and soil erosion can have negative effects on water quality.

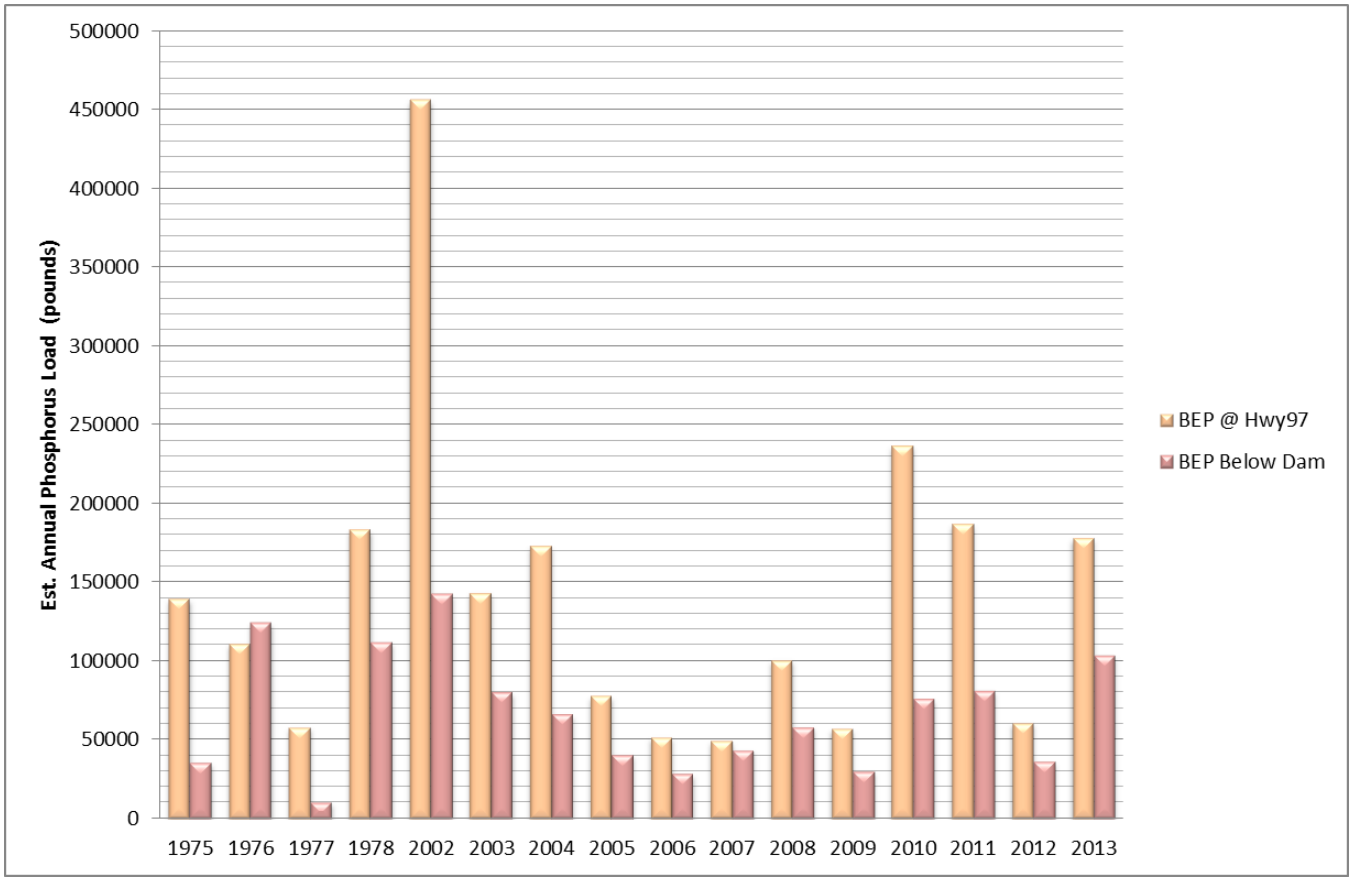
Water quality has been monitored in the BEP for over 40 years. Many studies have been conducted in the water and in the watershed to help the community understand the conditions leading to algal growth and oxygen depletion that leads to fish kills in the BEP.

Water samples collected 2010-2013 indicated median phosphorus concentrations in the BEP were **above 100 ppb.** While this sounds like a small amount, this is more than three times the acceptable level of phosphorus for good water in the BEP. Most of the phosphorus enters the BEP from the BEP River, Fenwood Creek, and Freeman Creek, which all have water with high levels of phosphorus.



**Some of the phosphorus entering the BEP remains in the BEP**

During most years, more phosphorus enters the BEP than exits. This means phosphorus has been accumulating in the sediments since the BEP River was dammed in 1937. This "internal" phosphorus load will continue to fuel algal growth for many years. Therefore, changes on the landscape are not likely to result in immediate improvements in the BEP. Regardless, making changes now is critical to ensure that improvements in the BEP occur, including reductions in the frequency and intensity of algal blooms and fish kills.



## Societal Guidance and Rules Related to Water Quality

Wisconsin and the United States have developed guidance to identify the levels of phosphorus and other pollutants that are allowable in our groundwater, lakes, and streams. When a waterbody exceeds these thresholds, specific steps are required to address the problem. For the phosphorus problem in the BEP, the Clean Water Act (CWA), signed into law in 1972 by President Nixon, directs the state to address the problem.

### The Clean Water Act, TMDL, and the BEP

Because of its high phosphorus concentrations, the BEP was identified by the WDNR and the U.S. Environmental Protection Agency (EPA) as a water body that is degraded and does not meet the phosphorus water quality standards. The CWA requires that a Total Maximum Daily Load (TMDL) be determined for the BEP.

According to the EPA's website, *A TMDL is a pollution budget and includes a calculation of the maximum amount of a pollutant that can occur in a waterbody and allocates the necessary reductions to one or more pollutant sources. A TMDL serves as a planning tool and potential starting point for restoration or protection activities with the ultimate goal of attaining or maintaining water quality standards.*

The WDNR monitored water quality and used WVIC, citizen acquired, and other water quality data to develop a phosphorus budget for the BEP. The TMDL is being prepared by staff from the WDNR working with experts from the U.S. Army Corps of Engineers, U.S. Geologic Survey, and UW-Stout.

### How will the phosphorus reductions be achieved?

Once the BEP phosphorus budget and allocations to reduce phosphorus are known, the next step is for community members to work together to develop a specific strategy to the reduce phosphorus from the landscape of the BEP. This strategy is called a 9 key element plan. The first element of the BEP 9 key element plan has been accomplished and the second element is underway.

The 9 elements are:

1. Identify the causes and sources
2. Estimate pollutant loading into the watershed and the expected load reductions
3. Describe management measures that will achieve load reductions and targeted critical areas
4. Estimate the amounts of technical and financial assistance and the relevant authorities needed to implement the plan
5. Develop an information/education component
6. Develop a project schedule
7. Develop the interim, measurable milestones
8. Identify indicators to measure progress and make adjustments
9. Develop a monitoring component

## Get Involved!

***9 Key Element Plan***

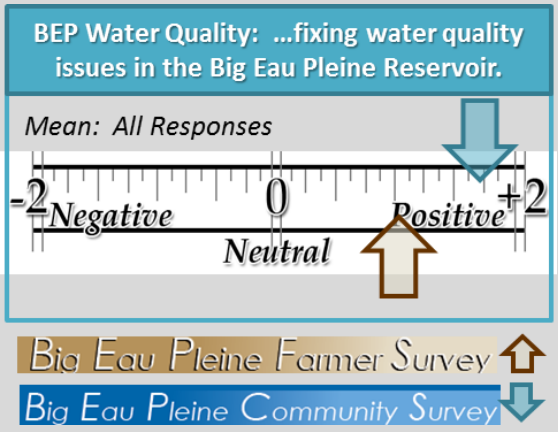
The community will work together to develop strategies for clean water in the BEP. Participate in the events and public input sessions for the development of the BEP 9 Key Element Plan. Discussions about how to achieve the pollutant budget in the BEP watershed will be coordinated by Marathon County CPZ and is anticipated to begin in 2017.

## Water Quality: Working Together to Achieve Goals

Achieving water quality improvements will require commitment by the community to make good water quality a focus and priority. Community partnerships and relationships are imperative; partnerships have occurred for many years. In addition, the conversations that have taken place over the past 3 years have helped to expand and solidify relationships. The conversations must continue, partnerships and commitments need to be affirmed, leaders (and their replacements) must be identified, and additional community members should be sought and welcomed.

### Agreement among land owners

In the survey, improving the BEP's water quality was supported by the shoreland and agricultural landowners. Survey results indicated that **the average shoreland owner 'strongly agrees' with the goal of improving water quality in the BEP**. On average, agricultural landowners also 'agree' with this priority, but to a lesser degree than the shoreland owners.




Scale: Strongly Disagree (-2) to Strongly Agree (+2)

### Disagreement among shoreland owners

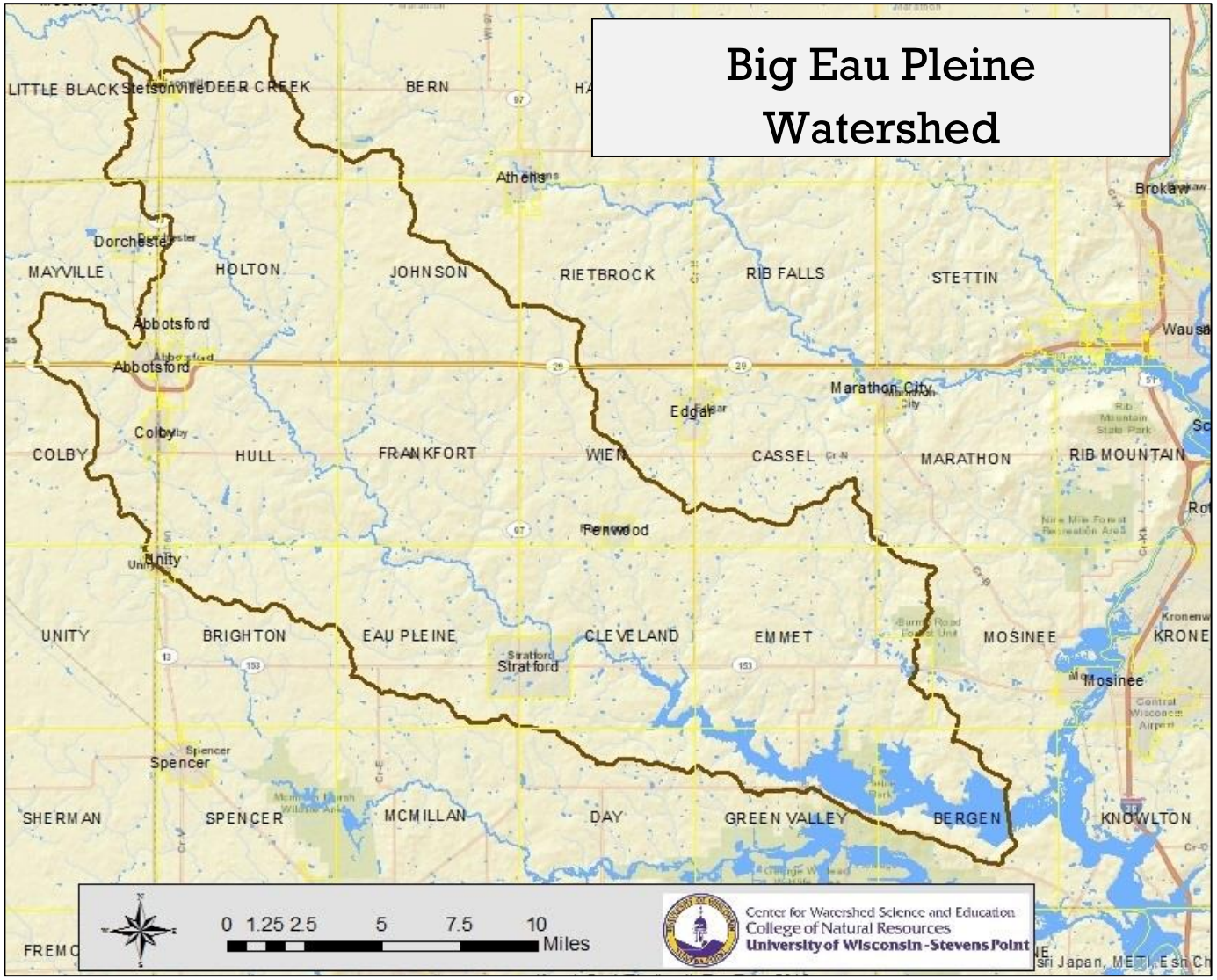
When asked if *spending time on the reservoir was less enjoyable due to unclear water*, many respondents disagreed; however, nearly 1 in 5 survey respondents indicated they see the BEP as a water body in decline, and indicated 'strong agreement' that *algae blooms have made the BEP unsafe for the types of lake activities they enjoy most*. For a subset of shoreland owners, this was less important - it was clear their recreational enjoyment is tied more to the relative solitude and lack of overcrowding.

Clearly, the BEP community can find common ground, and the survey results are a way to identify where community members can agree and come together to make water quality improvements in the BEP a community priority. Additional details about community perception and partnerships can be found in the Goal 3 chapter.

## THE BEP WATERSHED AND LAND USE

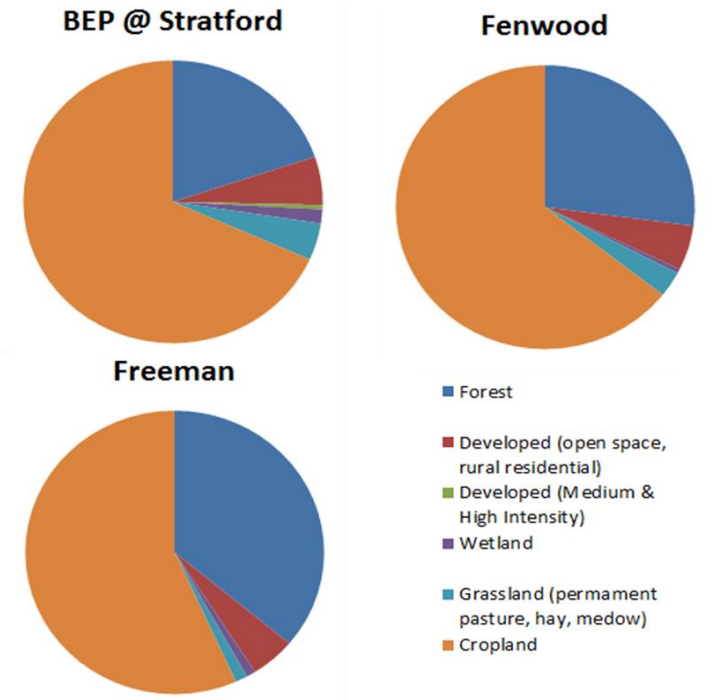
Water quality and land use management are intimately tied to one another. Therefore, developing strategies to improve land management practices is an essential part of addressing water quality problems in the BEP.

*Approximately 238,000 acres of land in Marathon, Taylor, and Clark counties are included in the BEP watershed.*



## Land Use in the BEP Watershed

A large proportion of the land in the BEP watershed is agricultural cropland (60%). In the sub-watersheds that drain to the Big Eau Pleine River at Highway 97 in Stratford, Fenwood Creek, and Freeman Creek, nearly two-thirds of the land use is agricultural. Agricultural lands contribute the largest source of phosphorus to the BEP; therefore, it is critical to look for changes that can be made on these lands to reduce the movement of phosphorus and soil from the landscape to the water.



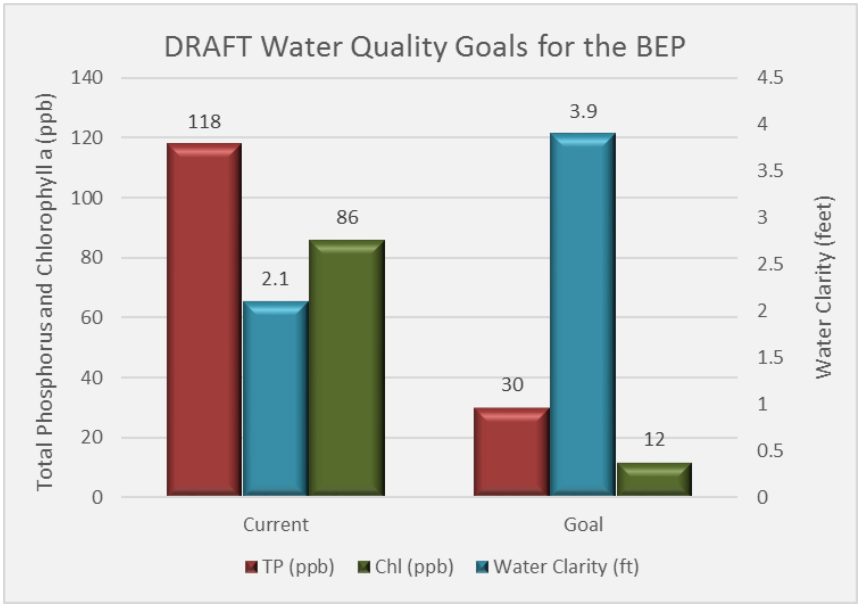

Graphic: Pat Oldenburg

**Land use categories in three BEP sub-watersheds.**

**How good can the water quality get in the BEP?**

Water quality goals for the BEP are being developed as a part of the BEP TMDL. The goal will be identified for total phosphorus. Reductions in phosphorus lead to reductions in chlorophyll *a*, a measure of algae, and increases in water clarity. Preliminary models estimate that if phosphorus can be reduced from an average of 118 ppb to 30 ppb, algae will be reduced by about 74 ppb, which would equate to a two-foot increase in water clarity in the BEP.

To achieve these water quality goals, it will be necessary to reduce the phosphorus contributions from the landscape.



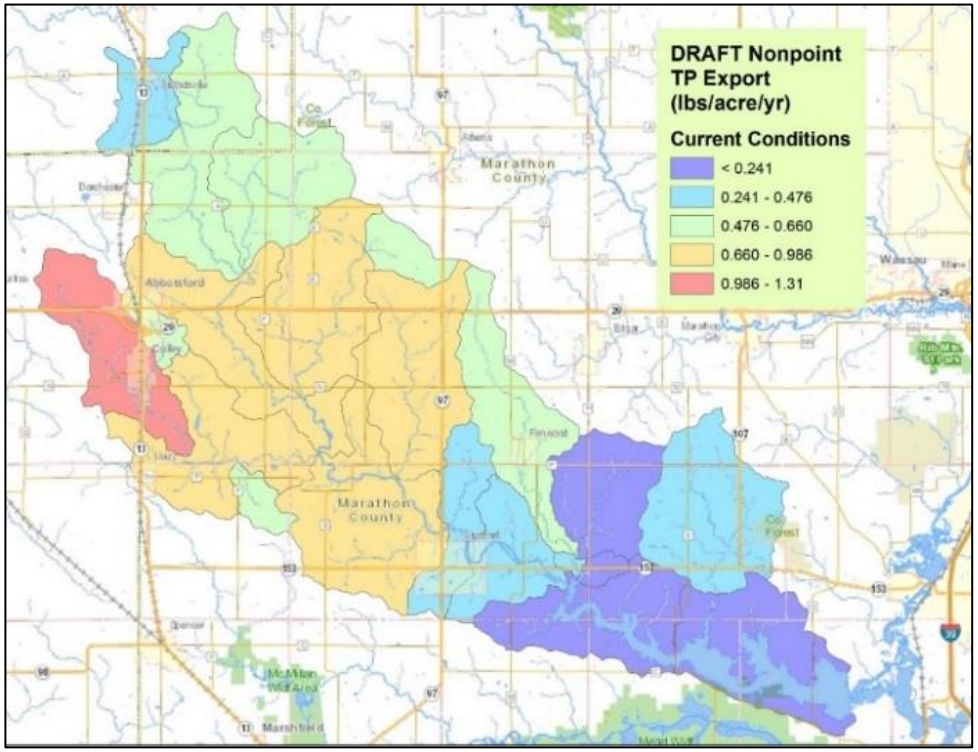
**Phosphorus in the BEP watershed**

To evaluate the amount of phosphorus coming off the landscape from different parts of the BEP watershed, a model called SWAT was developed. The SWAT model used soil type, land use, crop types, and slope to replicate estimates for the current conditions in the watershed, below left. The model was adjusted for a goal of obtaining phosphorus reductions needed to meet water quality goals. The resulting map displays the **draft** phosphorus contributions, below right. Most of the improvements would need to occur in the parts of the watershed nearest the BEP. The map showing the percent of the phosphorus reduction used in the draft phosphorus reduction exercise is shown in the Appendix. **It is important to note that these results are not the final TMDL results.** It is anticipated the final results will become available in 2017.

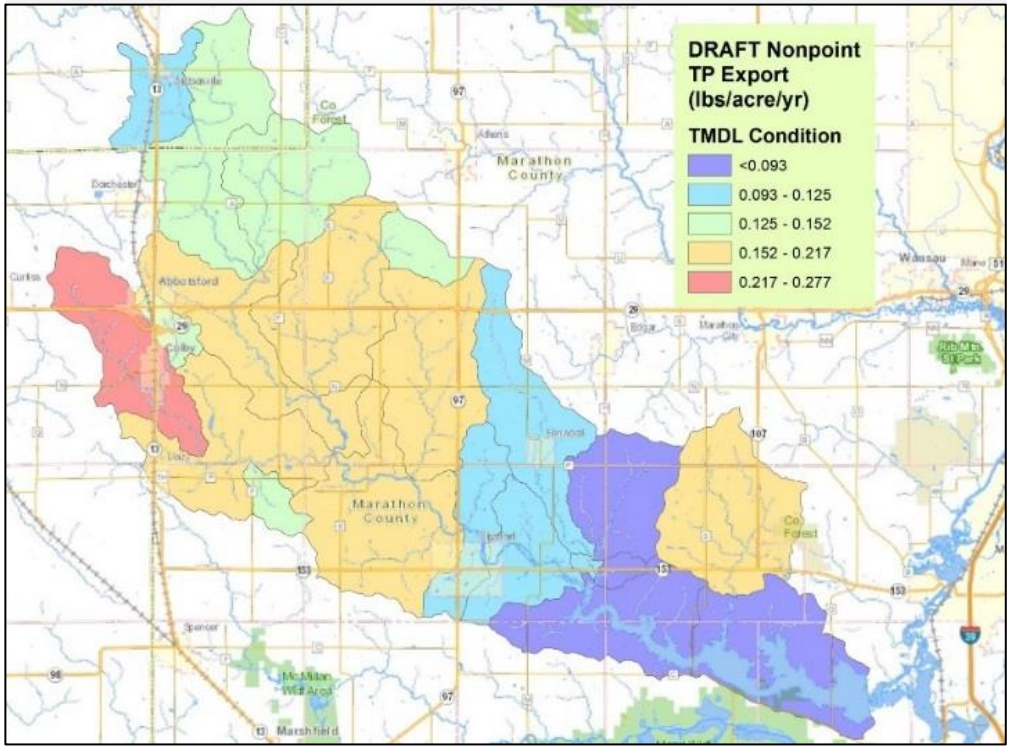
**Options for phosphorus reduction**

The next section of the plan will describe some of the options that could be applied to reduce the movement of phosphorus from the landscape to the water.

Estimated phosphorus contributions from the BEP watershed.
CURRENT SCENARIO




Estimated phosphorus contributions from the BEP watershed.
MEETING WATER QUALITY GOALS SCENARIO



## How the Land is Managed Matters!

Wastewater, animal waste, and fertilizers used on lawns, gardens and crops can contribute nutrients, especially phosphorus, to the BEP that increases the growth of algae.

**Where is the agricultural phosphorus coming from?**

In the BEP watershed, the primary sources of phosphorus from agricultural land include manure, phosphorus-containing fertilizers, and soil erosion. Phosphorus reaching the BEP was not used by the crops for which it was intended, resulting in problems within the BEP and economic waste.

**Strategies to reduce excessive phosphorus**

There are many management practices that can be used to reduce phosphorus loads to the BEP. Selecting phosphorus reduction strategies depends on the setting and can vary with the type and size of the farm, slope of the landscape, proximity to water, available equipment, economics, and the capabilities of the manager. However, the basics are the same for all farms: 1) keep the soil covered, 2) apply only the amount of nutrients a crop needs, 3) improve soil health, and 4) limit the amount of runoff coming off the landscape.

**1. Keep soil in place - where it is useful!**

Retaining soil on the landscape and not in the water is beneficial from a number of perspectives. Healthy soil grows crops requiring less fertilizer, pesticides, and irrigation compared to crops grown in poor quality soil. It can also increase the amount of water that soaks into the ground.

A number of practices can be employed to prevent soil erosion. Vegetation helps to keep soil in place. Permanently covering soil with hay, alfalfa, pasture, or other perennial vegetation is one of the best ways to minimize soil erosion. On fields with annual crops, cover crops can be planted to retain vegetative cover while a crop is not being grown. Depending upon the crop, beneficial cover crops may be interspersed among row crops.

Reduced tilling, using no-till cropping, and leaving crop residuals on the landscape are commonly used practices. Reduced tilling can increase soil health and limit soil erosion by allowing the soil to form clods instead of individual particles that are easily carried by wind or water. No-till cropping allows the field to remain covered by crops and cover crop residuals at all times. Crop residuals (leftovers after harvest) remaining on the field help reduce soil erosion and provide organic materials to the soil.

Vegetation can be intentionally managed on a farm near wetlands and waterways to slow runoff and remove pollutants before they enter the water.

**2. Nutrient management planning: Budget nutrients and reduce costs!**

Nutrient budgets should be developed for the farmland. This concept is similar to calculating and managing a household budget. A phosphorus budget includes an inventory of all of the sources of phosphorus added to the soil, as well as amounts already existing in the soil. To achieve a balance and avoid accumulating excess phosphorus in the soil, the amount of available phosphorus should balance with and not exceed the needs of the crop. Understanding how much phosphorus already exists in the soil, a first step to understanding the true application/crop needs, can be assessed by a routine series of soil tests across a field.

Alterations in the amount, timing, and type of application of fertilizers, manure, and crop residue can help to reduce the amount of phosphorus reaching the waterways in the BEP watershed.

**3. Improve Soil Health**

Contributed by NRCS (Smith et. al, 2016)

Only "living" things can have health, so viewing soil as a living ecosystem reflects a fundamental shift in the way we care for our nation's soils. Soil is not an inert growing medium; it is teaming with billions of bacteria, fungi, and other microbes that are the foundation of an elegant symbiotic ecosystem. Soil is an ecosystem that can be managed to provide nutrients for plant growth, absorb and hold rainwater for use during dryer periods, filter and buffer potential pollutants from leaving our fields, serve as a firm foundation for agricultural activities, and provide habitat for soil microbes to flourish and diversify to keep the ecosystem running smoothly.

"Soil health management systems" are one way to try to offset the effects of projected climate changes on crops and cropland and to improve short-term drought tolerance and, potentially, ground-water recharge. These systems can increase infiltration, reduce evaporation, moderate soil temperature changes, increase rooting depth, increase nutrient uptake, and improve the water-holding capacity for most soils. These improvements lead to better crop resilience during drought. In some circumstances, they also provide for ground-water recharge. Additionally, increased infiltration rates decrease runoff, thereby reducing sediment and nutrient loading to streams as well as reducing flood volumes.

**More runoff carries more pollutants**

Land use and land management practices within the BEP watershed can affect the water quality in streams and the BEP. Forests, grasslands, wetlands, and some land with healthy farmland soils allow a fair amount of rainfall to soak into the ground. These land uses can help to recharge groundwater, filter nutrients, and improve water quality.

In contrast, agricultural, industrial, municipal, and residential land uses may result in more runoff and less groundwater recharge. Increased runoff promotes the delivery of nutrients and sediment into surface water. Specifically, conventional soil tillage, as well as manmade drainage systems (ditches, tiles, and "waterways") and alterations to vegetation on the landscape may increase the amount of pollutants leaving the landscape. Impervious (hard) surfaces such as roads, rooftops, and compacted soil prevent rainfall from soaking into the ground, which may result in more runoff carrying more pollutants, including phosphorus to the BEP.

*Best management practices* can be utilized to reduce the amount of runoff from the landscape. Depending upon the setting, practices may include routing runoff to depressions, "buffering" areas with vegetation, collecting and storing wastewater and manures for improved application timing, and routing runoff through areas with permanent groundcover vegetation before it enters a stream.

**Eroding soil can carry nutrients to streams and the BEP**

Areas of land with exposed soil can produce soil erosion. Soil entering the BEP or its streams can make the water cloudy and cover fish spawning beds. Soil also contains nutrients that increase the growth of algae in the BEP and its tributaries.

## Land Use Management: How Do We Get There?

***Approach 1: Create opportunities for cooperation and emphasize co-learning and communication with partners.***

*Recommendation:* Experts working collaboratively with landowners is central to the success of this preferred approach. Efforts need to build on presenting stakeholders with options for inviting in different experts for discussions that provide opportunities for small group interaction.

*Recommendation:* Create forums for clarifying rules and regulations about what is expected of rural landowners AND demonstrate what these practices (such as reservoir-friendly farming) look like when correctly installed and maintained. This is intended to address a perception that not everyone is equally treated by existing rules, and to prepare non-farm stakeholders (such as shoreland owners) to appreciate when actions are being taken by producers that will have a direct benefit on water quality.

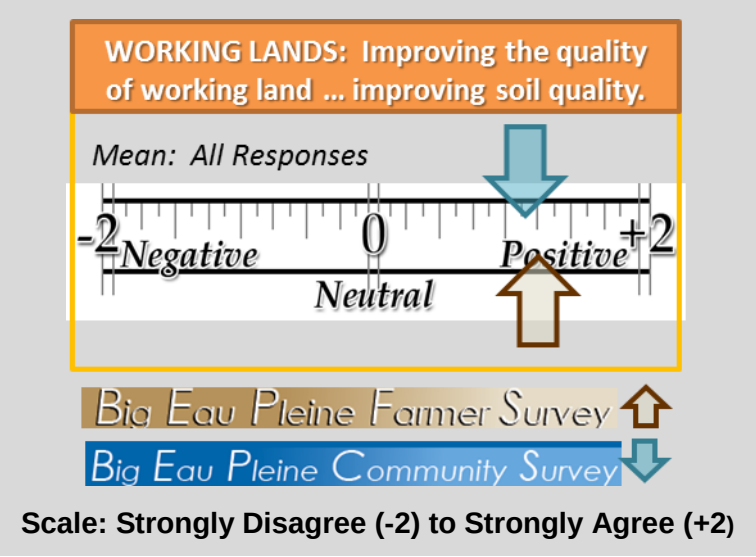
***Approach 2: Focus on improving working lands and identify strategies that protect priority areas*.**

*Recommendation:* Soil health and farm profitability have become part of the message for conservation practice adoption in Wisconsin. The survey revealed a top goal of farmers in the BEP watershed is improving the quality of working lands, which suggests that approaches emphasizing soil health benefits and/or outreach that provide cost and benefit information (such as yield impact) would be appropriate in the BEP watershed.

*Recommendation:* Working with multiple partners (county, agricultural producers, and BEPCO), identify high priority project areas within the BEP watershed. This is a large watershed and there is support from shoreland and agricultural landowners for focusing efforts on priority areas (such as lands near existing streams, wetlands, and the BEP).

***Approach 3: Focus efforts on willing partners first. The path to success begins with mobilizing supporters in the agriculture community to show what can be done.***

*Recommendation:* Focus in the lower portion of the BEP watershed. This group of property owners clearly separated itself from other respondents with positive environmental attitudes characterized by strong support for statements such as *good farming results from placing equal importance in managing both the agricultural and natural areas of my farm*.




**Scale: Strongly Disagree (-2) to Strongly Agree (+2)**

# BEP SHORELANDS

## The Importance of Shoreland Vegetation

**Land closest to the streams and the BEP has the most direct effect on water quality and habitat**

Healthy shoreland vegetation can help improve the quality of the runoff flowing across the landscape towards a stream or the BEP. It also provides habitat for many aquatic and terrestrial animals including birds, frogs, turtles, and many small and large mammals.

Shorelands include adjacent wetlands, which also serve the BEP by allowing contaminants to settle out, providing shelter and food for fish and wildlife, and decreasing the hazard of shoreline erosion by providing a barrier from waves and wind.

Shoreland vegetation prevents erosion

The deep roots of native flowers, grasses, shrubs and trees create a network of plant material that helps to keep soil in place. This is particularly beneficial during periods of low water in the BEP.

When the water is low, shorelands lacking vegetation or comprised of shallowly-rooted plants (such as bluegrass) can be prone to erosion. Soil delivered to the BEP can eventually blanket gravel and rocks needed for fish spawning and aquatic insect habitat. Eroded soil also carries nutrients into the BEP, adding to the already high nutrient load.

***Survey of Shoreland Owners Revealed …***

Most shoreland owners enjoy the natural, scenic shorelines and are not looking for the suburban backyards found on other lakes.

**Making good management choices**

Water quality is altered by the cumulative effect of management choices. Even if the size of a property is small compared to the overall BEP watershed, changes made by one property owner can serve as an example to others. When neighbors see improvements being made, they are more likely to make better management choices themselves.

## What You Can Do

***Shoreland property owners can make informed decisions about the management of their land.***

**Shoreland property owners can lead the way by:**

- **understanding what a healthy shoreland means**
- **maintaining shorelands that are already healthy**
- **making strides to improve disturbed shorelands**

**Learn from each other through demonstration sites on public land, shoreland open houses, and talking with neighbors and others in the watershed.**

**Identify incentives and funds to help people with their efforts (WDNR Lake Protection Grant, WDNR Healthy Lakes Grant, contests, reduced taxes/dues, other incentives)**

**If you are a shoreland property owner, do not disturb exposed habitat when water levels are low.**

## Healthy Shorelands: How Do We Get There?

***Approach 1: Set an example.***

*Recommendation:* Use public spaces, such as boat launches and parks, to provide settings for examples of healthy shoreland practices and give a municipality a way to show it shares a stake in the health of the BEP. Practices may include the diversion of runoff from boat ramps, access roads, and parking lots; rain gardens to capture water from buildings; and, shoreland vegetation restorations.

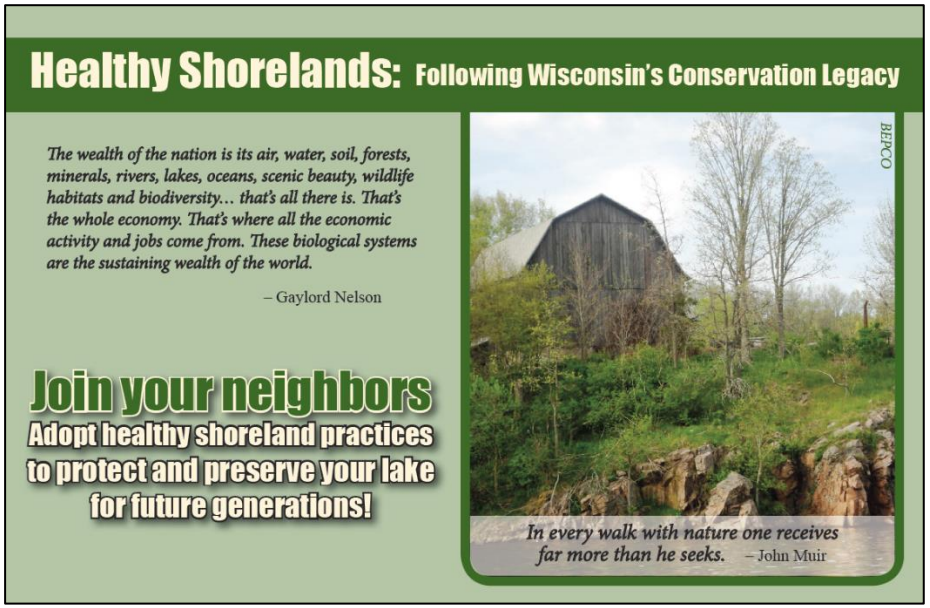
Acknowledging that public spaces are intended to provide access to the BEP, shoreland restorations can be designed in ways that don't impede access but still provide benefits and examples for others to view and learn from. Signage describing the benefits of the restoration is another way to disseminate information.

***Approach 2: Spread the word.***

*Recommendation:* There are a variety of written materials and websites that provide information about healthy shorelands. Many creative ways can also be used to get the word out and have some fun.

Example: During summer 2015, neighbor-to-neighbor conversations were initiated at 28 out of 76 BEP properties visited by volunteers. During these conversations, volunteers gathered information about their community's lake-related interests. Overall, a majority of property owners expressed interest in healthy shorelands, and no residents conveyed disinterest.

The volunteers participating in this project reported they were well-received by neighbors in subdivisions along a portion of the western side of the BEP. This approach allowed them to have conversations with people who may not attend meetings or other gatherings or read newsletters. Conversations can create a less intimidating first step in talking about the importance of shorelands and can also strengthen the BEP community. A successful informational campaign should include plans for follow-up by offering assistance to interested landowners. This could be accomplished by the county or BEPCO. Future efforts should include a handbill/brochure describing the benefits of maintaining the shoreland vegetation and good habits (not cleaning up woody habitat, not driving on the exposed lake bed during periods of low water levels, etc.).



## GOAL 2. IMPROVE WATER QUALITY IN THE BEP RESERVOIR AND WATERSHED: OUTCOMES AND ACTIONS

**Outcome 2.1 -- BEP community members will develop and host educational and celebration events, as well as take actions that lead to elevating clean water to a community value.**

Desired outcomes could include advocacy for local policies to improve clean water, clean water conservation demonstrations on working farmlands and shorelands, collaboration between agricultural and conservation organizations, and participating in local agency and governmental meetings and workgroups that develop policies and strategies to improve water quality in the BEP watershed.

**Who**: Waterfront property owners, landowners and agricultural producers in the BEP watershed, including BEPCO, Marathon County Chapter of Farm Bureau. Farmers Union, and Grazing Groups.

**What:**

- School-based events
- Results of water quality and fishery monitoring
- BMP demonstrations
- Community gatherings

**When:** Ongoing

**Indicators of success**: The community values clean water by providing support for clean water initiatives and property owners manage their land in ways that lead to clean water.

- The community will understand how they can individually and collectively support clean water initiatives.
- Property owners and agricultural producers will actively manage their land in ways that lead to clean water.
- Additional resources for individuals, organizations and institutions to improve water quality.

## GOAL 2. IMPROVE WATER QUALITY IN THE BEP RESERVOIR AND WATERSHED: OUTCOMES AND ACTIONS

**Outcome 2.2 – Conservation and agricultural organizations, property owners, and agencies will seek opportunities to increase and maintain conservation efforts on shoreland and rural lands that contribute runoff to the BEP.**

This could include demonstration projects which improve habitat and reduce phosphorus runoff, as well as implementing conservation provisions into leases for rented agricultural land.

**A. Who**: Clark, Marathon, and Taylor Counties, NRCS, Marathon County Chapter of Farm Bureau. Farmers Union, and Grazing Groups.

**What**:

- Apply for and utilize DATCP funding through the Soil and Water Resource Management Program and Nutrient Management Farmer Education Program to promote proper timing, rates, and methods to apply manure and other nutrients. The grant applications for calendar year 2018 are due in April 2017. Identify funding opportunities. Apply for WDNR Targeted Runoff Management and SWRM Bond funds for the watershed for engineered practices.
- By 2018, Marathon County, DATCP and National Weather Service will generate manure spreading advisory strategies to alert farmers to risky spreading situations (scale of 1.5 square miles).
- Marathon County and WDNR will prepare a report on any "significant" cropland runoff events to quantify the impacts of erosion and nutrient loading to water quality in the BEP watershed. The information can be used to inform the community of resource concerns and to provide information for the aeration implementation decision matrix.
- Marathon County, NRCS, and WDNR will collaborate to maximize funding for farmers to improve conservation practices.
- The installation of 2 learning, or demonstration, sites will be established by UWEX, Marathon County, BEPCO, NRCS, Marathon County Farm Bureau, and Farmers Union working in conjunction with willing landowners within 3 years for the purpose of informing landowners about best practices to protect water quality within the BEP.

**When**: Ongoing or as noted.

**Indicators of success**: Property owners will install the demonstrated conservation practices on their farmland.

- By Dec 31, 2028, phosphorus loading from agricultural lands will be reduced by 50%.
- By Dec 31, 2022, shoreland and storm water BMP's will be installed on all public lands along the BEP.

## GOAL 2. IMPROVE WATER QUALITY IN THE BEP RESERVOIR AND WATERSHED: OUTCOMES AND ACTIONS

**Outcome 2.2 – Conservation and agricultural organizations, property owners, and agencies will seek opportunities to increase and maintain conservation efforts on shoreland and rural lands that contribute runoff to the BEP.**

**B. Who**: BEPCO

**What:** Create a watershed-wide culture of conservation by supporting and recognizing farmers that successfully implement conservation measures.

**When**: Ongoing

**Indicators of success**:

- Boat tours of the BEP, hosted by BEPCO and attended by "upstream" farmers
- Participation in any efforts to organize a watershed council in Fenwood Creek
- Recognition of BEP "conservation farmers" in BEPCO communications and at meetings

**C. Who**: BEPCO

**What:** Create a watershed-wide culture of conservation by engaging waterfront property owners on best landscape management practices to protect the BEP

**When**: Summer 2017

**Indicators of success**:

- Advocating for/working with Marathon County to construct a demonstration "healthy shorelands" rain garden at Big Eau Pleine County Park.
- Sharing via BEPCO communications and at meetings what was learned about healthy shorelands and their relationship to a healthy fishery by BEPCO members who participated in neighbor-to-neighbor shoreland outreach.
- Developing a section on the BEPCO website with resources for members about healthy shorelands.

## GOAL 2. IMPROVE WATER QUALITY IN THE BEP RESERVOIR AND WATERSHED: OUTCOMES AND ACTIONS

**Outcome 2.3 – Within Marathon County, the Marathon County CPZ Staff and Committee will have the governmental leadership role in developing projects, programs and policies in collaboration with the BEP community and agricultural groups that reduce polluted runoff, improve soil health, and improve water quality.**

**Who**: Agricultural groups such as Marathon County Farm Bureau and Farmers Union, municipalities, property owners, local businesses, BEPCO, and conservation groups.

**What**: Develop strategies to address clean water improvements in the BEP.

- The series of discussions about how to achieve the pollutant goals in the BEP watershed will be coordinated by the Marathon County CPZ and is anticipated to begin in 2017. The community will work together to develop strategies for clean water in the BEP by participating in the events and requests for public input related to the development of the 9-Key Element Plan for the BEP watershed.
- Taylor and Clark Counties will assist with the development of the 9-Key Element Plan for the BEP watershed.
- Marathon County will provide support to a producer-led watershed council. BEPCO representatives will be invited to participate on this council. The next round of applications for Producer Led Watershed Protection Grants for 2018 will be available from DATCP in August/September 2017.

**When**: Ongoing

**Indicators of success:**

- Community supported guidance for the improvement of water quality in the BEP will be laid out in the 9-Key Element plan.
- Marathon County internal collaboration between UWEX, NRCS, and CPZ will be strong, demonstrated by coordination of education and technical program integration.

## GOAL 2. IMPROVE WATER QUALITY IN THE BEP RESERVOIR AND WATERSHED: OUTCOMES AND ACTIONS

**Outcome 2.4 – Continue to monitor water quality to evaluate the success of the efforts and identify changes. Phosphorus goals identified for the BEP in the TMDL should be met or exceeded.**

**Who:** WDNR, WVIC, Taylor County, Volunteer monitors

**What**:

- WDNR will lead the water quality monitoring effort in the BEP. At a minimum, measurements of water quality should include dissolved oxygen, phosphorus, nitrogen, chlorophyll a, pH, specific conductance, and temperature. Some agricultural pesticides have also been shown to effect algal growth.
- WVIC will continue to collect water quality data in accordance with its Water Quality Monitoring Plan including collecting bi-monthly D.O. and temperature profiles at the Eau Pleine Dam throughout the year; Trophic State Index data in June, July, August and during fall overturn for 3 consecutive years out of every 10 years. Additional sampling parameters (alkalinity, BOD, color, conductivity, D.O. pH, phosphorus, Secchi depth, temperature and turbidity) collected seasonally as part of WVIC's *Man-Made Quarterly Monito*ring during the same years. Winter D.O. and temperature profiles will be collected at each reservoir mile.
- Over the next 3-10 years, Taylor County Land Conservation staff will continue to monitor four sites in the BEP River from May to October for total phosphorus, conductivity, dissolved oxygen, and temperature.
- Volunteer citizen monitoring near demonstration sites in the BEP and/or tributaries could be beneficial. Monitoring strategies and protocol will be developed based on the site and purpose. Grants may be needed to purchase equipment or analyses.

**When**: Ongoing

**Indicators of success**:

- A robust dataset is available to describe conditions in the BEP, identify problems, and determine if goals are being met.
- Resource management plan(s) outcomes are monitored and reported to community groups to demonstrate success of education and BMP activities.
- Farmers and landowners are recognized for positive improvements to water quality.
- Farmers and landowners understand the connection between land use activities and water quality.

# Goal 3.

# Develop, Engage & Sustain Partnerships Necessary to Implement this Plan for Reducing Fish Kills in the BEP

## ACHIEVING GOALS THROUGH PARTNERSHIPS

The actions outlined in this plan will have the greatest chance of being implemented if the partnership of those involved remains strong. Understanding who the partners are and what their roles may be can help to clarify expectations and responsibilities.

### Meet the Partners

Many individuals, agencies, and municipalities manage or play a role in the management of the BEP reservoir. Active participants have included:

Agricultural Producers and Landowners in the Watershed

Big Eau Pleine Citizens Organization (BEPCO) Local residents and businesses formed this 501(c)(3) organization. Their mission is to preserve, protect, and improve the Big Eau Pleine Reservoir.

Clark County Land Conservation Dept. (LCD) It is the mission of the LCD to promote and assist in wise land use decisions that preserve, protect, and enhance the natural resources of Clark County.

Marathon County Board of Supervisors and professional staff The mission for the Conservation, Planning, and Zoning Dept. (CPZ) is to "Protect our community's land and environment". The county board is the governing body of the county and functions as the policymaking and legislative branch of county government. Through its decisions, the Marathon County Board of Supervisors directs the work and funding for the CPZ.

River Alliance of Wisconsin Advocates for the protection, enhancement and restoration of Wisconsin's rivers and watersheds, and helps citizen advocacy groups work toward clean and plentiful water.

Shoreland Property Owners Property owners adjacent to the BEP and its streams can have some of the greatest impacts (positive or negative) to the BEP from the land management choices that they make. They have the ability to set examples for other property owners in the BEP watershed.

Taylor County Land Conservation Department (LCD) Their mission is to work with Taylor County citizens and local, state, and federal agencies and organizations to provide information, technical assistance, and financial aid for the conservation and protection of natural resources throughout Taylor County.

University of Wisconsin - Extension (UWEX) provides statewide access to university resources and research so the people of Wisconsin can learn, grow and succeed at all stages of life.

USDA Natural Resources Conservation Service (NRCS) NRCS is an agency committed to "helping people help the land". Their mission is to provide resources to farmers and landowners to aid them with conservation. Ensuring productive lands in harmony with a healthy environment is their priority.

Walleyes for Tomorrow (WFT) The mission of WFT is to work with other clubs, agencies, and the WDNR to improve the quality of walleye and sauger fishing. WFT is a project-oriented organization with the goal of increasing the population of walleye in the waters where habitat projects are undertaken.

Wisconsin Department of Agriculture, Trade and Consumer Protection (WI DATCP) Their mission is to partner with all the citizens of Wisconsin to grow the economy by promoting quality food, healthy plants and animals, sound use of land and water resources, and a fair marketplace.

Wisconsin Department of Natural Resources (WDNR) The WDNR is dedicated to working with the citizens and businesses of Wisconsin while preserving and enhancing the natural resources of Wisconsin. In partnership with individuals and organizations, WDNR staff manage fish, wildlife, forests, parks, air and water resources while promoting a healthy, sustainable environment and a full range of outdoor opportunities.

Wisconsin Valley Improvement Company (WVIC) WVIC's mission is to operate the Big Eau Pleine Reservoir as part of the Wisconsin River Reservoir System to maintain as uniform a flow as practicable in the Wisconsin River and a reasonable balance among the benefits the water resource provides including water conservation, flood control, low flow augmentation, hydroelectric generation, water quality, wildlife and recreation.

## Working Together: How Do We Get There?

**Audience 1: BEP supporters**

Survey results demonstrate shoreland owners have both a high level of awareness about BEPCO and strong support for its mission; however, there is a gap between awareness/support and membership in the organization. Responding to the short and long term needs identified in the watershed planning process will require a volunteer management strategy.

*Recommendation:* Trusted facilitators such as County Extension, River Alliance of Wisconsin, and others should assist BEPCO in developing implementation capacity that emphasizes expanding outreach to shoreland owners and lake users who support this work, but aren't involved. Understand why these individuals aren't joining or participating and identify new pathways to gain their involvement.

**Audience 2: Stewardship-focused agricultural producers**
There is an overall lack of awareness by the agricultural community about BEPCO's presence and objectives in the landscape.

*Recommendation:* For BEPCO, it may be possible to create an informational campaign about the BEP watershed management plan that emphasizes positive messaging about the link between good land stewardship and productive agricultural landscapes. Emphasis should be on recognizing the efforts of farmers and sharing conservation success stories within the watershed.

*Recommendation:* Work with Marathon County staff with support from other organizations (such as UWEX) to develop programming to support awareness of options for achieving conservation on rented agricultural land. This could be in the form of workshops that introduce non-farming households to available conservation programs or more advanced sessions that discuss changing lease agreements to ensure conservation goals are achieved.

## ECONOMIC IMPORTANCE OF THE BEP

The BEP has economic value to property owners, business owners, Marathon County, WVIC, and others in the region who benefit from tourism.

During the planning process, participants expressed concerns about reduced property values, loss of revenue to local businesses, and diminished willingness to invest in new businesses such as bait shops, boat rental facilities, fishing tours, restaurants and taverns. Most people linked these concerns to low water levels during the summer that limit boating and other recreational activities. In addition, the reputation of the BEP fishery is perceived to be damaged when fish kills occur, with the bad reputation lingering for years. Some of the concerns about economic impacts may be genuine, while other concerns may not be as damaging as they are perceived.

***Survey of Shoreland Owners Revealed ...***

*Where do 'riparian' stakeholders agree?*

Agree

Local funding to revitalize the lake is a great investment in our future.

## Strategies

***Understand the economic impacts of the BEP to the economy in central Wisconsin and the extent of negative impacts of fish kills.***

Hire an economist to conduct an economic assessment to determine the benefits of the BEP and make recommendations about the economic issues that should be addressed.

***Reduce the negative impacts to the economy from fish kills in the BEP.***

The reputation of the BEP as a healthy fishery may be diminished following fish kills; however, much of the fishery may still remain even after bigger fish kills.

After a fish kill, once the health of the fishery has been established, make a splash about the fishery by submitting news articles, contacting the local media, and posting on Lake_Link.com and other fishing sites.

Host an event that brings fishers back to the BEP.

## Economics: What Do People Think?

### Economic and recreational characteristics

One of the reasons for undertaking the shoreland owner survey was to determine current levels of recreational use on the BEP reservoir. Respondents were asked whether or not they participate in seven recreational activities on or around the BEP, including: canoeing or kayaking, motor boating, fishing (spring-fall), ice fishing, hunting, wildlife viewing, and biking or walking. The key findings (listed below and to the right) for the economic and recreational characteristics include:

**The average respondent reported:**

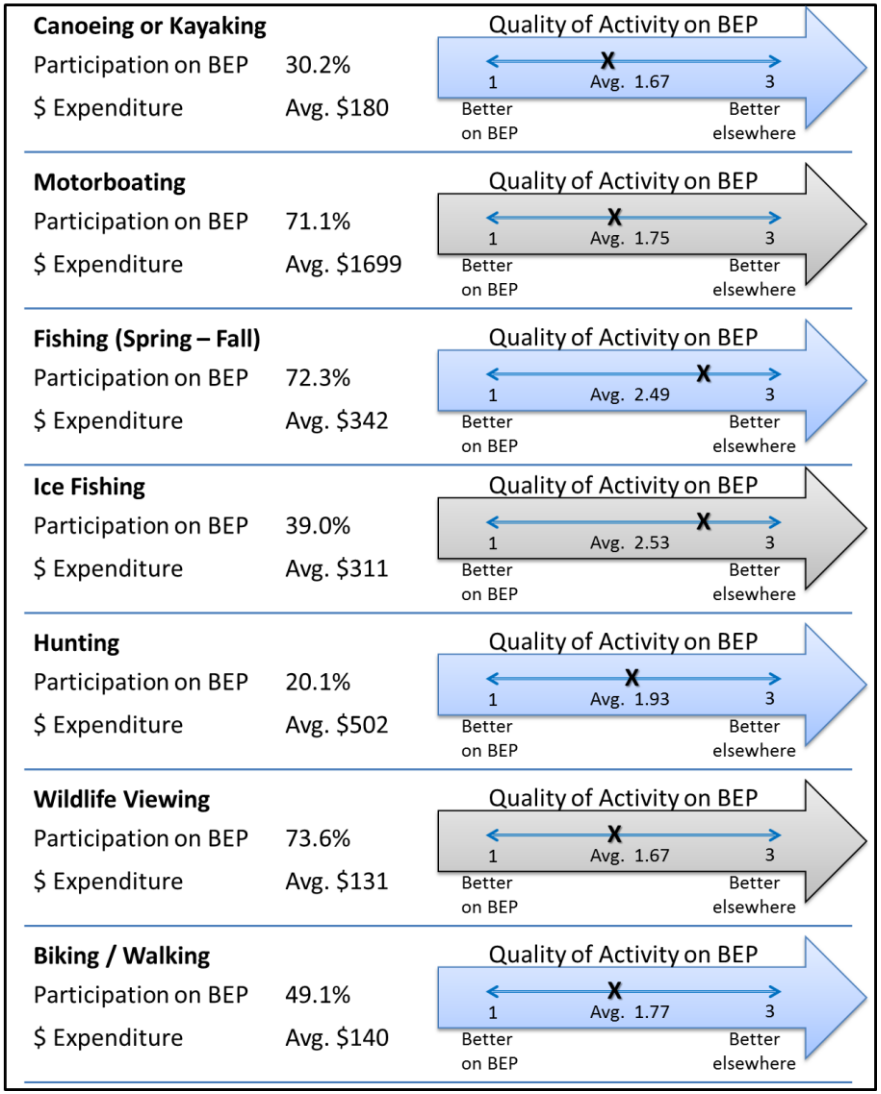
- Participation in 3-4 different activities out of the 7, with the highest participation rates for motor boating, fishing (spring-fall), and wildlife viewing.
- An average annual expenditure of $1,850 per household for all recreational activities.

Total recreational expenditures for these 7 recreational activities exceeded $225,000 per year based on reports from 123 survey respondents. As shown in the figure to the right, the cost and perceived quality varied significantly among activities.

***Survey of Shoreland Owners Revealed …***

As a result of changes to the quality of fishing, nearly 1 in 3 believe property values have decreased.

Recreational Activities: Riparian Users



## GOAL 3. DEVELOP, ENGAGE & SUSTAIN PARTNERSHIPS NECESSARY TO IMPLEMENT THIS PLAN FOR REDUCING FISH KILLS IN THE BEP: OUTCOMES AND ACTIONS

**Outcome 3.1 – Improved coordination of water quality enhancement activities within the BEP watershed.**

**Who**: BEPCO, representatives of Clark, Marathon, and Taylor counties, NRCS, River Alliance of Wisconsin, UW-Extension (UWEX), DATCP, WVIC, WDNR and agricultural groups such as Marathon County Farm Bureau and Farmers Union.

**What**:

- Marathon County and UWEX, with support from other partners, will host at least 2 community listening sessions annually (one with an agricultural focus and one with a shoreland focus) to solicit input about current conditions and to collect suggestions for strategies to engage the community in efforts to improve water quality in the BEP watershed.
- Ensure informed community outreach occurs between all partners.
  - A meeting soliciting the participation of all BEP watershed partners will be convened by Marathon County and BEPCO, with support from other partners, at least biannually to provide an update from all partners on efforts occurring to improve water quality in the BEP watershed.
  - WDNR, with support from other partners, will provide a discussion and training for response to water quality or fish related problematic events such as fish kills, algal blooms, etc. Training topics may include: working with local media, preparing a narrative to describe your current efforts, and the basic science of fish kills / water quality /dissolved oxygen to ensure that all organizations are providing a response based on a common understanding of the BEP facts.
- Within 2 years, WDNR, River Alliance, and UW-Extension convene a leadership team consisting of equal representation of appropriate community and agency partners, who will initially be tasked with developing a civic governance strategy for the BEP watershed.
- At least twice per year, Clark, Marathon, Taylor County Land Conservation Staff and NRCS will meet to discuss current projects and future plans and coordinate efforts, as appropriate.

**Indicators of success**:

- Increased transparency and coordination between all partners regarding implementation of elements of BEP Lake Management Plan.
- Increased participation (numbers and diversity) by community members.

## GOAL 3. DEVELOP, ENGAGE & SUSTAIN PARTNERSHIPS NECESSARY TO IMPLEMENT THIS PLAN FOR REDUCING FISH KILLS IN THE BEP: OUTCOMES AND ACTIONS

**Outcome 3.2 –Increase the capacity for BEPCO to respond to the challenge of enhancing water quality in the watershed.**

**A. Who**: BEPCO

**What**:

- Conduct a two-year outreach campaign designed to increase overall membership and effectiveness of BEPCO. Should focus on non-member waterfront property owners. Could feature house parties; door-to-door recruitment efforts; solicitation for participation on BEPCO work groups/committees; events that members can participate in.
- When: beginning 2017
- Indicators of success: membership increase of 25%, 1-2 new volunteers to support BEPCO leadership or take a leadership role.

**B. Who**: BEPCO

**What**: Expand communications efforts to let the BEP community (members and non-members alike) know what progress is being made to improve water quality and enhance BEPCO as an organization. Could be an update linked to the BEPCO annual meeting, and shared with every property owner on the BEP, each town board within the watershed, appropriate county committees, and state legislators.

**When**: Summer 2018

**C. Who**: BEPCO

**What**: Create opportunities to build watershed-wide support for the BEP, by engaging new partners in the community. Could include hosting an annual event co-sponsored by at least one other community organization (not a county, state, or local agency) to promote awareness of water quality issues in the BEP; or providing opportunities for community organizations to speak about their goals and priorities for the BEP at BEPCO's membership meetings.

**When**: 2017

**Indicators of success**:

- At least one community event is co-hosted with a partner organization
- At least one partner organization presents at a BEPCO membership meeting each year.
- Identification of and a shared dialogue with other community organizations that may be potential partners in the protection of the BEP.
- BEPCO board members will pledge to participate in a minimum of 8 hours of leadership training annually.

## GOAL 3. DEVELOP, ENGAGE & SUSTAIN PARTNERSHIPS NECESSARY TO IMPLEMENT THIS PLAN FOR REDUCING FISH KILLS IN THE BEP: OUTCOMES AND ACTIONS

**Outcome 3.3 – Improve communication between the organizations in the BEP which have common interest in improving water quality.**

**Who**: BEPCO, Marathon County Farm Bureau, etc. Marathon County CPZ staff and Committee Members, Marathon City, UWEX.

**What**:

- Share meeting agendas, define opportunities to collaborate on water quality improvement projects, pool resources to improve water quality, conduct learning events collaboratively.

- Engage the UWEX Center for Land Use Education to complete a comprehensive community capacity assessment to identify community stakeholders, formal and informal communication networks, assess the current capacity of existing and potential partners, and develop a community capacity building strategy for supporting efforts to improve water quality within the basin.

**When**: Ongoing

**Indicators of success**: Examples of collaborations that have led to improved water quality

## GOAL 3. DEVELOP, ENGAGE & SUSTAIN PARTNERSHIPS NECESSARY TO IMPLEMENT THIS PLAN FOR REDUCING FISH KILLS IN THE BEP: OUTCOMES AND ACTIONS

**Outcome 3.4: Informed community members will participate in public processes that are associated with the BEP.**

**Who**: BEPCO, community members, agency staff

**What**:

- Informed community members and agency staff will provide suggestions about improvements to the FERC license for the BEP to ensure a healthy fishery is maintained. Learn the basics of the FERC license for the BEP, including time periods for public comment.
- Community members will share ideas related to the development of the 9-key element plan and natural resource management plans.

**When**: Ongoing

**Indicators of success**:

- FERC licensing processes receive and respond to informed comments about the BEP during public comment periods.
- BEPCO and community partners contribute constructively to resource plans, FERC licensing activities, recreational improvement of the reservoir, and water quality.

**Outcome 3.5: This plan will be implemented and updated by partners in the BEP.**

**Who**: Partners listed in this plan.

**What**:

- By Feb 2017, develop a BEP implementation team and governance structure including the lead and meeting frequency.
- Implementation team will develop annual goals and strategies. Share accomplishments and keep records of the accomplishments. The first meeting will be organized by Marathon County.
- The BEP Implementation Team will update this plan every 2 years. Append the list of accomplishments and track changes made to each revision.

**Indicators of success**: The BEP Implementation Team will coordinate to ensure implementation occurs efficiently and on time. This plan will be kept current so partners are working on the most relevant actions.

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## APPENDICES

**BIG EAU PLEINE AERATOR SYSTEM**
**MEMORANDUM OF AGREEMENT**

**THIS MEMORANDUM OF AGREEMENT, ("MOA")** is entered into as of the date and year below and in consideration of the mutual promises, obligations and benefits provided herein, the receipt and adequacy of which is hereby acknowledged, the parties hereto agree as follows:

## I. PARTIES

The parties to this MOA are the State of Wisconsin Department of Natural Resources ("DNR" or "Department"), Wisconsin Valley Improvement Company ("WVIC"), Marathon County, and the Big Eau Pleine Citizens Organization ("BEPCO").

## II. PURPOSE

First installed in 1981, the aerator system on the Big Eau Pleine Reservoir had an estimated 10-year life span but continued operation into 2009 when it began failing. The efficiency of the system declined as equipment and aerator lines aged. The original 1981 aeration system on the Big Eau Pleine Reservoir was re-designed and upgraded in 2009 by WVIC, DNR and the Army Corps of Engineers ("ACOE") to improve performance and reliability over the original aeration system. The ACOE provided valuable assistance with design specifications and the evaluation of various operating/engineering scenarios. The new aeration system was funded by Marathon County, BEPCO, WVIC, and DNR and installed in January, 2010. The new aeration system began operation in February, 2010.

When nutrient laden water from the Big Eau Pleine watershed is impounded, the decomposition of the organic material depletes dissolved oxygen in the Big Eau Pleine Reservoir. The Big Eau Pleine Reservoir is susceptible to winter fish kills during periods of extreme low dissolved oxygen conditions. The aerator system helps to mitigate fish kills by creating 30-60 acres of open water and oxygen exchange.

This MOA is intended to describe the tasks and responsibilities of the parties hereto to operate and maintain ("O&M") the new aerator system. The O&M cost estimates include routine maintenance and potential capital replacement costs. The maintenance history and hours of operation of the two 40 hp electric motors and associated blowers are set forth on Attachment A.

## III. RESERVOIR MONITORING & OPERATION

A. WVIC will monitor dissolved oxygen ("DO"), biological oxygen demand ("BOD"), and temperature in the Big Eau Pleine Reservoir during the winter period (January 1st of each year to ice out on the Big Eau Pleine Reservoir) to characterize oxygen conditions, identify DO sags and coordinate operation of the aeration system with the DNR, pursuant to and in strict conformance with the requirements of its 1996 FERC license in Articles 411 and 413.

B. WVIC has the primary responsibility to operate the Big Eau Pleine Reservoir pursuant to and in conformance with the requirements of its 1996 FERC license including the requirements set forth in Article 421.

## IV. WINTER SAFETY FENCE

A. The DNR will coordinate installation of the on-ice winter safety fence and warning signs with assistance from local volunteers. The installation date will be determined at the discretion of the DNR taking into consideration safe ice conditions in the channel.

B. The DNR will coordinate removal of the winter safety fence and warning signs after ice-out.

C. The DNR will store and maintain the winter safety fence.

## V. AERATOR OPERATION

A. WVIC in consultation with the DNR shall review reservoir monitoring data, (Section III) to determine if the aeration system needs to be operated to help mitigate low dissolved oxygen conditions.

B. DNR owns the aerator system and will have primary responsibility for operation of the aerator system including winter season start up, equipment monitoring, routine maintenance, record keeping, and seasonal shut down.

C. DNR shall have the responsibility to identify any major repairs or preventive maintenance needs of the mechanical aeration system. DNR will bring major repair needs to the attention of the parties hereto.

D. DNR shall prepare aerator lines to prevent winter freezing. This includes operating the shallow "bubbler line" to keep the shoreline area ice-free where the aerator lines enter the water and to de-ice the aerator lines early in the winter and just prior to aerator start-up.

E. WVIC shall have the primary responsibility for other off-season routine maintenance of aerator lines including raising line sections for repair and moving lines if displaced. WVIC

will bring major repair needs to the attention of the parties hereto.

F. DNR shall identify a person to appoint as back up operator for the aeration system. The lead operator will train the backup operator on routine operation of the aerator system.

## VI. O&M EXPENSES

A. DNR and WVIC shall share equally annual routine maintenance expenses. These expenses are estimated at $400 annually and include maintenance such as drive belts, air filters, grease, oil and de-icing line compounds.

B. WVIC, DNR, Marathon County, and BEPCO, agree that all future capital expenses related to the 40 hp. electric motors and blowers shall be paid for by each party hereto in proportion to those sums as the parties shall agree. WVIC, DNR, Marathon County, and BEPCO shall collectively decide whether to invest in any other capital expenses and if so how to fund such expenses. Potential future capital expenses are outlined in Attachment B.

C. Nothwithstanding anything to the contrary herein, Marathon County shall contribute the sum of $500 per calendar year for the term of this MOA.

## VII. POINTS OF CONTACT

All notices, certificates or other communications hereunder shall be sufficiently given and be deemed given when hand delivered or when mailed to the official addresses of each of the parties hereto as follows:

DNR: Bob Hujik
NR Region Program Manager
P.O. Box 4001
Eau Claire, WI 54702
Telephone (715) 839-3731
Email Robert.Hujik@wi.gov.

Marathon County:
Bill Duncanson
Director of Parks, Recreation & Forestry
212 River Drive, Ste. 2
Wausau, WI 54403
Telephone (715) 261-1554

WVIC: Cathy Wendt
Director Of Environmental Affairs
2301 North 3rd Street
Wausau, WI 54403
Telephone (715) 848-2976 Ext. 310;
Email wendt@wvic.com.

BEPCO: Tim Garrigan
President, BEPCO
P.O. Box 335
Mosinee, WI 54455
Telephone (715) 687-4773

The parties shall notify each other as soon as practical of any changes to the contact information in this Section.

## VIII. APPLICABLILITY

A. Nothing in this MOA creates any right or obligation, either substantive or procedural, enforceable by any third party.

B. All parties reserve any rights each may have to commence an action against the other for failing to carry out the duties or obligations under this MOA.

C. The invalidity of any one or more phrases, sentences, clauses or sections in this MOA shall not affect the remaining portions of this MOA or portions thereof.

## IX. FUNDING

All obligations on the part of the parties hereto shall be subject to and dependent on the appropriation, allocation, and allotment of sufficient funds for such purposes by the parties hereto.

## X. LIABILITY

To the extent allowed by law, the parties hereby mutually agree to hold each other harmless and indemnify the other from and against all claims, costs and liability of every kind and nature, for injury or damage received or sustained by any person or entity in connection with, or on account of the performance of obligations under this MOA caused by the other or their agents, employees or any third party from whom said party is responsible.

## XI. EFFECTIVE DATE, DURATION, MODIFICATION, AND REVOCATION

A. This MOA shall take effect on the date the last party signs the same.

B. This MOA shall remain in effect for a period of five years from the date of execution by all the parties hereto unless modified, renewed, or revoked as provided in this Section.

C. This MOA may only be modified by the written agreement of all parties hereto.

D. This MOA contains the entire understanding of the parties as set forth herein and supersedes all prior written and/or verbal agreements of the parties hereto.

## XII. AGREED TO BY

The parties, by their signatures, certify that they have been duly and properly authorized by their respective entities to make the commitments contained herein, intending them to be binding upon their respective entities and to execute this MOA on their behalf.

Dated at Wausau, Wisconsin, this 19th day of Dec., 2012.

WISCONSIN VALLEY IMPROVEMENT COMPANY

By: Thomas Kipp, President

Dated at Madison, Wisconsin, this 13th day of August 2012.

STATE OF WISCONSIN,
DEPARTMENT OF NATURAL RESOURCES

for By: Cathy Stepp, Secretary

Dated at Wausau, Wisconsin, this 10th day of Dec., 2012.

MARATHON COUNTY

By: Brad Karger, Administrator

Dated at Mosinee, Wisconsin this 12th day of Dec, 2012.

BEPCO

By: Tim Garrigan

**Attachment A**

**Eau Pleine Reservoir Winter Aerator Hours Of Operation**
**1981 - 2011**

| Year | Date Aerator Turned On | Date Aerator Turned Off | Total No. Days | Total Hours for Each Motor & Blower |
|---|---|---|---|---|
| 1981 | Feb. 7 | Mar. 17 | 38 | 912 |
| 1982 | Feb. 11 | Mar. 26 | 43 | 1,032 |
| 1983 | Mar. 1 | Mar. 6 | 5 | 120 |
| 1984 | Feb 27 | Mar. 23 | 25 | 600 |
| 1985 | Feb. 13 | Mar. 21 | 36 | 864 |
| 1986 | Mar. 5 | Mar. 26 | 21 | 504 |
| 1987 | Feb. 10 | Mar. 30 | 48 | 1,152 |
| 1988 | Mar. 7 | Mar. 26 | 19 | 456 |
| 1989 | Feb. 13 | Mar. 27 | 42 | 1,008 |
| 1990 | Jan. 29 | Mar. 16 | 46 | 1,104 |
| 1991 | Mar. 18 | Mar. 27 | 9 | 216 |
| 1992 | Jan. 28 | Apr. 10 | 73 | 1,752 |
| 1993 | Feb. 22 | Apr. 8 | 45 | 1,080 |
| 1994 | Feb. 23 | Mar. 24 | 29 | 696 |
| 1995 | Mar. 6 | Apr. 7 | 32 | 768 |
| 1996 | Feb. 26 | Apr. 10 | 44 | 1,056 |
| 1997 | Feb. 10 | Mar. 31 | 49 | 1,176 |
| 1998 | Feb. 12 | Mar. 27 | 43 | 1,032 |
| 1999 | Not Operated | | 0 | 0 |
| 2000 * | Jan. 19 | Mar. 3 | 44 | 1,056 |
| 2001 | Mar. 12 | Apr. 6 | 25 | 600 |
| 2002 * | Not Operated | | 0 | 0 |
| 2003 | Not Operated | | 0 | 0 |
| 2004 | Feb. 25 | Mar. 11 | 15 | 360 |
| 2005 | Feb. 21 | Mar. 29 | 36 | 864 |
| 2006 | Not Operated | | 0 | 0 |
| 2007 | Feb. 23 | Mar. 20 | 25 | 600 |
| 2008 | Feb. 20 | Apr. 8 | 48 | 1,152 |
| 2009 | Jan. 14 | Mar. 20 | 65 | 1,560 |
| 2010 | Feb. 17 | Mar. 26 | 37 | 888 |
| 2011 | Mar. 7 | Apr. 11 | 35 | 840 |
| | | TOTAL = | 977 | 23,448 hrs |

*** Note: The East 40 hp motor was rebuilt by Linder Electric, Wausau in 2000 and had 16,464 hrs and since has 6,864 hrs.**
**The West 40 hp motor rebuilt by Linder Electric, Wausau in 2002 and had 17,064 hrs and since has 6,264 hrs.**
**The rebuild for both mortors included rewinding, new seals and bearings.**
**The blowers have not required any other non-routine maintenance to date.**

File: ENV/Water quality: EP3 Ops Aerator hrs 1981-2011.xls

**Attachment B**

**Eau Pleine Reservoir Aerator: Potential Capital Expenses**

The aerator system is composed of two electric motors that drive one blower each to deliver surface air through the fourteen 2-inch aerator lines located on the bottom of the reservoir. Each blower delivers air into a manifold which contains seven 2-inch ports to which the aerator lines are connected. Each 2-inch aerator line has two drilled orifices 3/8 inch in diameter (orifices drilled through both sides of the 2 inch line). On each aerator line, one orifice is located approximately 6 ft from the outer end of the line and the second orifice is located at a mid-point area that coincides with maximum reservoir depth in the area of each specific line. The electric motors and blowers are housed in a cement block building owned by the DNR.

The specifications for the electric motors and blowers and associated capital replacement costs are given below:

**Electric Motors**

40 hp electric 3-phase, 1800 rpm, 240 volt, 326T-Frame

Option 1. Purchase new motor = $1,800/motor per Linder Electric, Wausau, WI (New motor can be delivered w/in 24 hrs) (Hyundai motor w/ 2 yr warranty; Worldwide Electric motor w/ 3 yr warranty – both are highly rated motors)

Option 2. Rewind and replace bearings and seals = $1,800 per motor Linder Electric, Wausau, WI

**Gardner Denver Blowers**

Model: 5CDL13F GD Cycloblower (serial #'s 35031 & 35032)

Overhaul kit (GD P/N: 8508096) = $2,400 (2011 costs) + labor install = $2,600 = Total $5,000/blower. Factory lead time is 4-6 weeks ARO.

New replacement blower (GD Model # 5CDL13P drop in replacement for F version) = $11,727/blower (2011 cost). Factory lead time is 6-8 weeks ARO.

The above blower cost estimates are from:

Air Process Systems Co.
%Dan Geoghegan
774 Burr Oak Drive
Westmont, IL 60659

Ph: 630-887-0700 Fax: 630-887-0771
Email: dang@airprocesssystems.com

## APPENDIX B: WVIC DROUGHT CONTINGENCY PLAN

WVIC 2016 - Article 409

Summary

Requires that a Drought Contingency Plan (DCP) be developed in consultation with the resource agencies within one year of license issuance. Plan is to include procedures to define drought conditions and modify minimum reservoir releases and downstream target flows during a drought.

Status

The original DCP was developed in cooperation with the resource agencies and submitted to FERC on July 17, 1997. FERC approved the plan on August 5, 1997. A revised plan was submitted to FERC in July 2011. FERC approved the revised DCP on August 1, 2014.

The revised plan set trigger levels for defining drought conditions and set up a consultation process with the resource agencies when drought conditions are expected. The revised plan also outlines possible actions to be taken during drought conditions, but specifies that the final decision for implementing these actions will be made on a case-by-case basis.

Based on the requirements of the DCP, the following consultations occurred during the 2011-2015 period.

Wisconsin River Low Flow Triggers

During August and September 2012, the Wisconsin River experienced low flows because of a hot, dry summer and low groundwater levels (hence low base flows) that was a carry-over from the 2003-2012 drought. Prior to the consultation meeting, in late August, WVIC reduced target river flows to the allowable minimums prescribed in its FERC license. Despite lowering flows to these Q(7,10) levels, there was not sufficient reservoir storage to maintain these flows through the winter. WVIC proposed to lower the target flows from 900 to 750 cfs at Merrill and from 1,300 to 950 cfs at Wisconsin Rapids in order to conserve reservoir storage for the winter.

During a consultation meeting on October 5, 2012, previous reductions in target flows were discussed. Similar consultations resulted in lowered target flows in 2009 and similar flow reductions had also occurred in 1976 and 1988-89. Under WVIC's old license, consultation with the agencies was not required at that time.

The resource agencies expressed concerns that further lowering of the target flows may adversely affect Wisconsin River water quality and may be harmful to mussel populations. Minimum flow reductions at WVIC's Rainbow and Spirit Reservoirs at the same ratios as the main Wisconsin River cuts were also discussed to conserve storage in those reservoirs due to their Index Levels being the lowest of the five reservoirs.

No final decisions were made during the meeting as not all parties were able to attend. However, soon after, runoff events occurred and consultation was no longer required.

Decreasing Minimum Releases

Consultations were completed relating to reducing minimum releases out of the Long-on-Deerskin project numerous times during the reporting period and the results of those consultations were discussed under Article 404. Consultation also occurred in September 2013 as the water level at South Pelican was approaching minimum resulting in no changes in operations being requested. Soon after, runoff occurred and the water level rose.

Trigger for consultation on index levels of the five large reservoirs

In August 2013 a consultation meeting was held because 4 of the 5 large reservoirs (Rainbow, Willow, Rice and Spirit) had index levels below level 3. Because the index levels would change dramatically on September 1st based on the formulas in the license, it was determined that there was no need to start discussions on reducing flow goals on the Wisconsin River earlier than normal. In addition, WVIC felt that there was enough water in the reservoirs to handle another month or so of no rainfall. The outcome of the meeting was that if by the end of September no rains had occurred, discussions on reducing flows would be required. No further review was necessary as runoff producing rainfalls occurred.

During the summer of 2015, both the Willow and Spirit reservoirs were below index level 3 as both projects had water levels being held significantly below the maximum to relieve pressures on the dam structures. All agencies were notified of the reasons for low water levels and no concerns were identified.

Index levels improved in the fall based on the formulas in the license.

Review

WVIC has reviewed the three triggers added to the Drought Contingency Plan that were approved on August 1, 2014 and recommend that they be revised as follows:

From:

• WVIC will track the cumulative precipitation departure from normal. If the cumulative precipitation deficit reaches 15 inches, WVIC will consult with WDNR and USFWS to consider reducing flow goals to Q(7,10) earlier than specified. During this consultation process, WVIC and the resource agencies will also consider limiting winter drawdowns in all WVIC reservoirs to facilitate a more complete spring refill. Any changes in flow goals or reservoir drawdowns will remain in effect until all parties agree they can be lifted. It is estimated that consultation for this trigger event will occur approximately once every 25 years.

• WVIC will track the natural flows of the Wisconsin River at Merrill and Wisconsin Rapids. Natural flow is defined as the river flow that would occur without reservoir storage or release. If the natural river flow falls below 900 cfs at Merrill or 1,300 cfs at Wisconsin Rapids, WVIC will consult with WDNR and USFWS to consider reducing flow goals earlier than specified.

• If the index level in any of the five large reservoirs (Rainbow, Willow, Rice, Spirit, or Eau Pleine) falls below level 3 during the period June through November, WVIC will consult with WDNR and USFWS to consider reducing flow goals earlier than specified.

To:

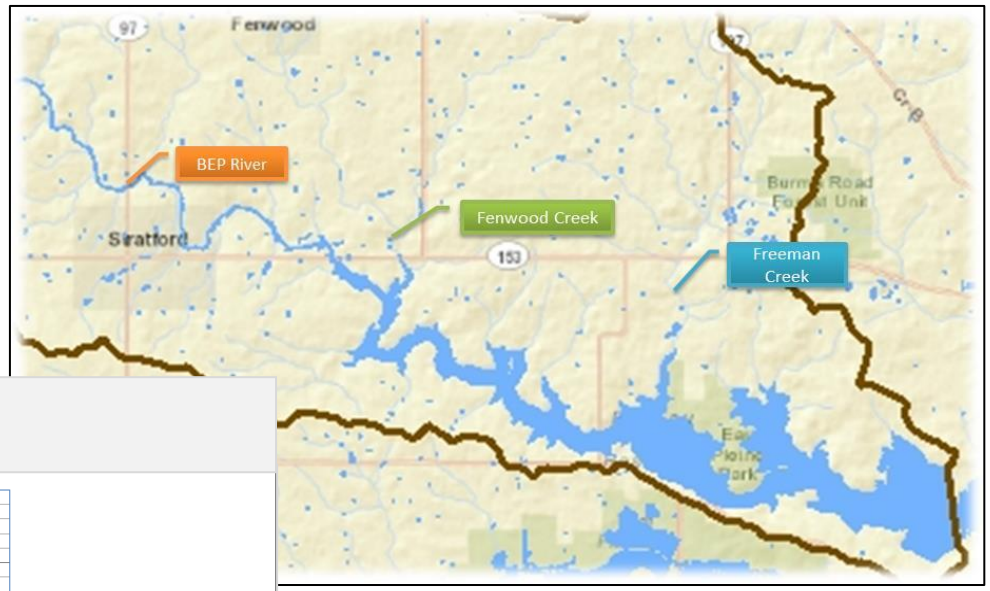
• WVIC will track the cumulative precipitation departure from normal. If the 24-month running average cumulative precipitation deficit reaches 6 inches, WVIC will consult with WDNR and USFWS to consider reducing flow goals to Q(7,10) earlier than specified. During this consultation process, WVIC and the resource agencies will also consider limiting winter drawdowns in all WVIC reservoirs to facilitate a more complete spring refill. Any changes in flow goals or reservoir drawdowns will remain in effect until all parties agree they can be lifted.

• WVIC will track the natural flows of the Wisconsin River at Merrill and Wisconsin Rapids. Natural flow is defined as the river flow that would occur without reservoir storage or release. If after two consecutive weeks the natural river flow falls below 900 cfs at Merrill or 1,300 cfs at Wisconsin Rapids, WVIC will consult with WDNR and USFWS to consider reducing flow goals earlier than specified.

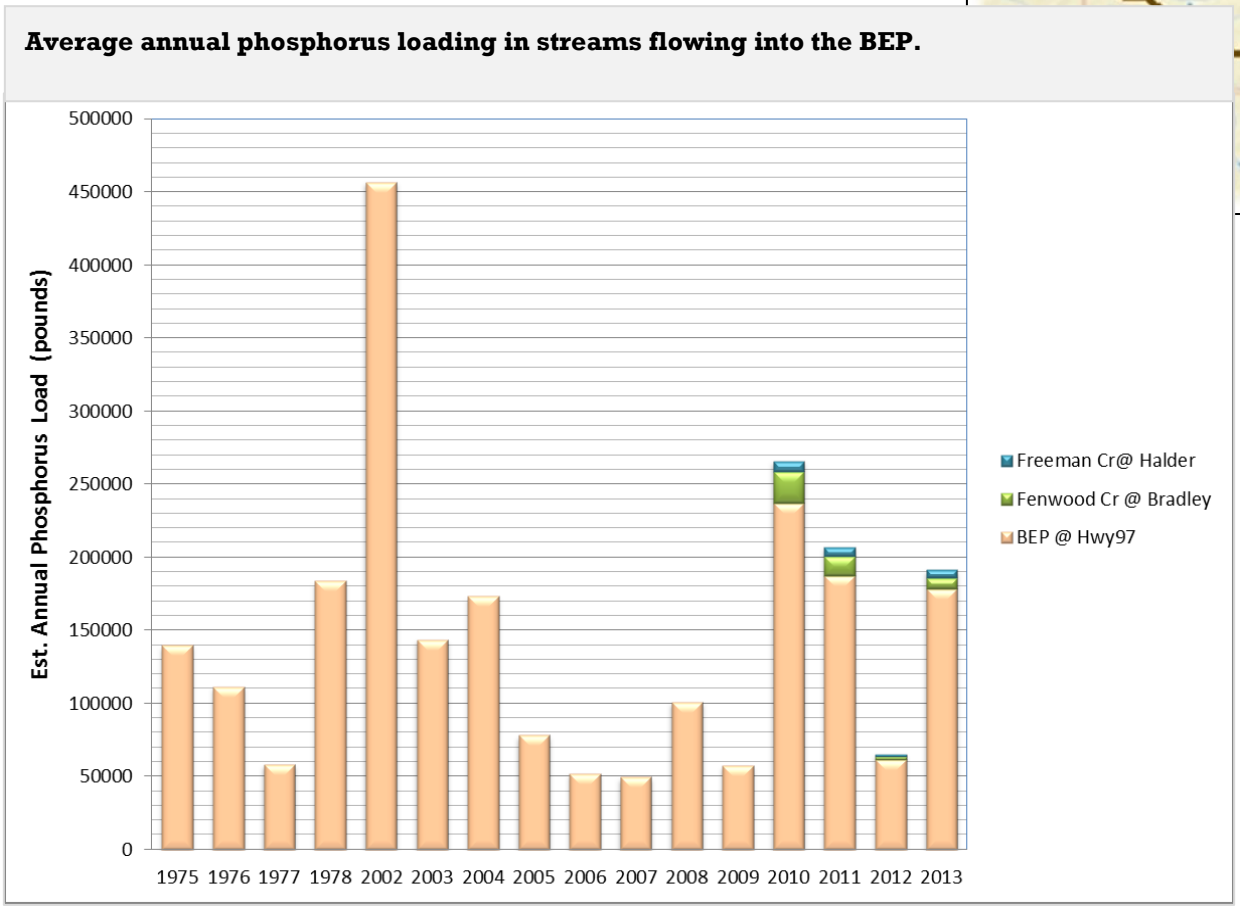
• If the index level in any of the five large reservoirs (Rainbow, Willow, Rice, Spirit, or Eau Pleine) falls below level 3 during the period June through November, WVIC will consult with WDNR and USFWS to consider reducing flow goals earlier than specified.

## APPENDIX C: WATER QUALITY OVER TIME

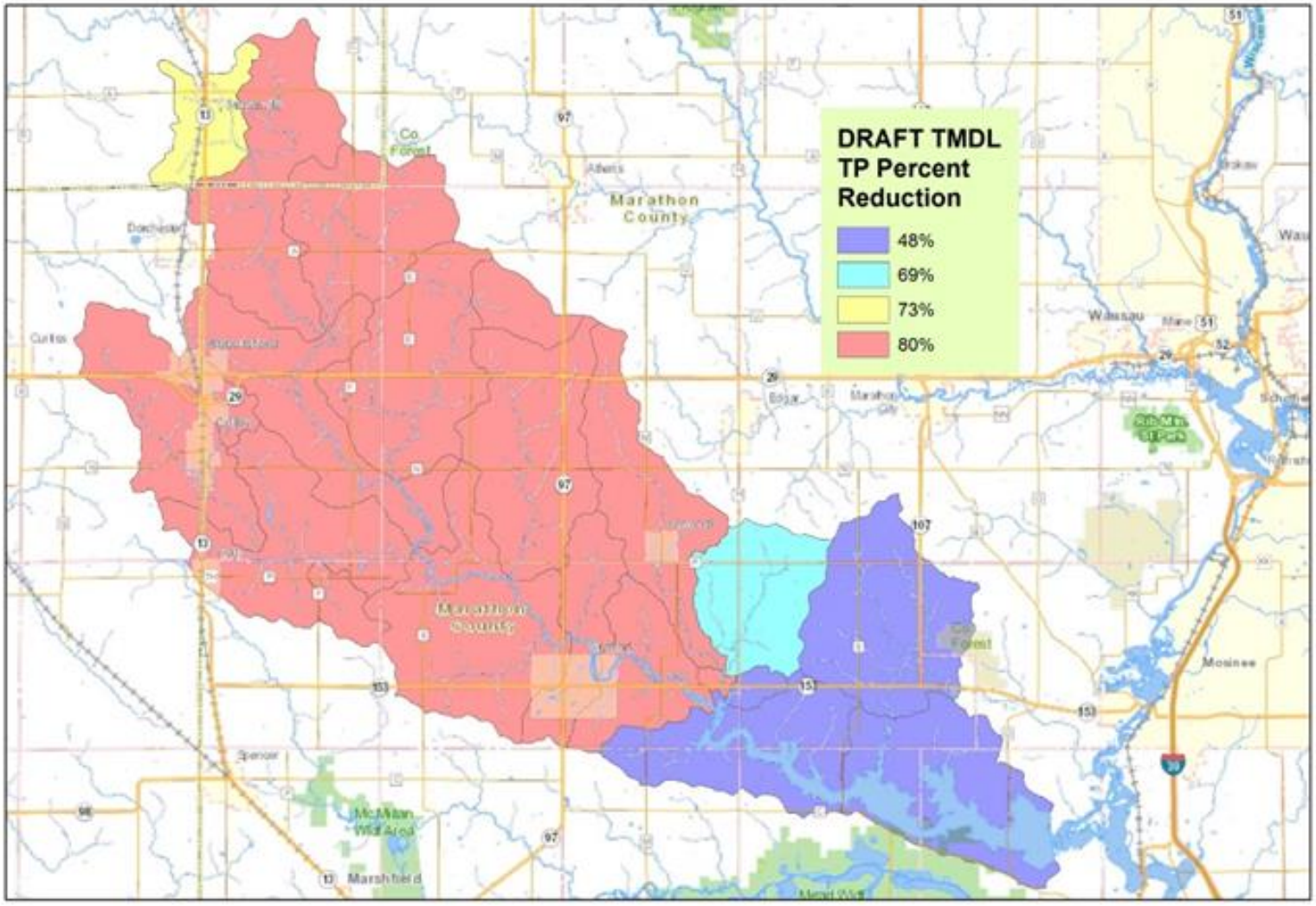
Since the BEP River is the greatest source of water to the BEP, monitoring the water quality in the Big Eau Pleine River has occurred periodically since the mid-1970s. To estimate the pounds of phosphorus in the BEP River, Fenwood Creek, and Freeman Creek, phosphorus concentrations and flow measurements were combined for each year. Results are shown in the chart below.




**Average annual phosphorus loading in streams flowing into the BEP.**



## APPENDIX D: PERCENT PHOSPHORUS REDUCTION NEEDED TO ACHIEVE THE TMDL IN THE BEP.



# Appendix E:6

# Management Recommendations from Big Eau Pleine Dissolved Oxygen Modeling Technical Committee

August 11, 2016

## *Committee Members:*

James Brodzeller (University of Wisconsin Stevens-Point)
Ken Dorshorst (Big Eau Pleine Citizens Organization)
Andy Johnson (Marathon County Conservation, Planning, and Zoning Department)
John Kennedy (Big Eau Pleine Citizens Organization)
Matt Krueger (River Alliance of Wisconsin)
Paul McGinley (UW-Stevens Point Center for Watershed Science)
Tom Meronek (Wisconsin Department of Natural Resources)
Ben Niffenegger (Wisconsin Valley Improvement Company)
Pat Oldenburg (Wisconsin Department of Natural Resources)
Kurt Schoen (Schoen Engineering Solutions)
Buzz Sorge (Wisconsin Department of Natural Resources)

## *Background:*

The following recommendations and findings were generated over the course of the Dissolved Oxygen Modeling Technical Committee's meetings and discussions from January 2014 to August 2016 in support of the University of Wisconsin-Stevens Point's Center for Watershed Science and Education's development of the *CE-QUAL-W2 Model for Dissolved Oxygen in the Big Eau Pleine Reservoir, Wisconsin to Understand and Manage Winter Anoxia.* (The report can be found online at https://www.uwsp.edu/cnr-ap/watershed/Pages/Reports.aspx.) The goal of the study was to develop a computer simulation model to improve the understanding of winter oxygen concentrations in the Big Eau Pleine Reservoir and evaluate management actions to prevent anoxia (depletion of dissolved oxygen). From the modeling results generated by project lead Dr. Paul McGinley, the Committee has developed and unanimously agreed upon the management recommendations identified below, the goal of which is to protect the fishery of the Big Eau Pleine Reservoir, particularly through the wintertime, when anoxic conditions can kill fish. These recommendations are intended to aide development of management decisions that will protect the fishery of the Big Eau Pleine.

## *Acknowledgements:*

The Committee acknowledges that some of these recommendations address water level management and the operation of an aeration system to protect the fishery, which is a short-term solution to the larger and more long-term challenge of reducing polluted runoff from the Big Eau Pleine watershed that largely influences wintertime anoxia.

The Committee also acknowledges with these recommendations that focusing on enhancing dissolved oxygen in the "zone of refuge"—the local area between reservoir Miles 5-6, downstream of the aeration system—is part of the best short-term approach to protecting the fishery of the Big Eau Pleine at this time. However, due to the sheer size of the reservoir, it's important to note that this approach will not protect all fish in the reservoir.

Lastly, the Committee acknowledges that through the CE-QUAL-W2 modeling process, the risk factors identified in the bulleted list below annually influence the possibility of a fish kill occurring on the Big Eau Pleine, and some more than others—the influence of each will vary from year-to-year. It's also important to note that the Aeration Decision Matrix (see Recommendation #3) which incorporates these factors is meant to be an adaptive tool, to be refined, monitored, and updated with increasing availability of data.

<u>Risk factors that influence the possibility of a fish kill</u>

- Air temperatures during the preceding summer (June-Aug) which can increase water and soft sediment temperatures prior to wintertime.
- Severity of winter, specifically duration of ice cover.
- Temporal distribution of precipitation. Heavy rainfall events in the spring and fall can negatively impact winter fish survival through increased nutrient loadings, while increased summer precipitation can be protective by increasing the volume of water available for winter storage.
- Reservoir elevation/water level prior to the formation of ice cover.
- Timing and duration of mechanical aeration.

## *Recommendations:*

1) **Convene the parties named in the "*Big Eau Pleine Aerator System Memorandum of Agreement (MOA)*" and any other relevant parties to discuss the framework and commitments of a new MOA.**

   The Big Eau Pleine Citizens Organization (BEPCO), Marathon County, Wisconsin Department of Natural Resources, and Wisconsin Valley Improvement Company (WVIC) are the parties named in the current MOA, set to expire in 2017. These parties should convene to consider, and come to consensus on, actions related to the following:

   a. Update the Reservoir Monitoring and Operation section to include the use of an Aeration Decision Matrix to evaluate the need and timing of aerator operations (see Recommendation #3).
   b. Identify strategies to adaptively manage aeration operations to maximize the wintertime zone of refuge downstream of the aerator, while addressing recreational safety concerns (see Recommendation #4).
   c. Develop a comprehensive, year-round monitoring strategy that complements existing monitoring conducted by WVIC (see Recommendation #7).
   d. Identify and expand funding sources to allow for earlier startup of the aeration system.

e. Identify new partners to be added to the MOA (i.e. Greater Wausau Area representation from the tourism sector).

**2) Maintain Big Eau Pleine Reservoir water levels as high as is practical and for as long as possible in advance of the winter drawdown, within the constraints of WVIC's FERC license, particularly as it relates to maintaining flows in the Wisconsin River.**

According to the CE-QUAL-W2 modeling results, "starting the winter at a higher water level leads to a higher average dissolved oxygen concentration at the reservoir surface near the dam late in the winter" and will "decrease the likelihood of surface anoxia before spring runoff but not guarantee adequate dissolved oxygen near the surface during a very long winter." At the onset of most winters (December 1), greater volume equates more dissolved oxygen to support the fishery throughout the winter, prolonging the onset of anoxia. Also, "holding the starting elevation longer into the winter could also delay reaching lower average dissolved oxygen concentrations in the metric regions." The intended outcome behind recommending a higher December 1 water level is to limit the number of days dissolved oxygen concentrations in the "metric regions" fall under the threshold of 2 mg/L, below which gamefish populations are stressed and likelihood of fish kills increases. ("Metric regions" are two focal areas—miles 10-7, and 5-0—that the model used as reference points for dissolved oxygen concentrations.)

**3) Develop an Aeration Decision Matrix that identifies and weights the risk factors that contribute to wintertime dissolved oxygen depletion in the Big Eau Pleine, to serve as a guide for managers to initiate mechanical aeration.**

According to the modeling results, increased and earlier mechanical aeration (beyond February 15, the average aeration start date in years aeration has been necessary) provides a greater chance of enhancing the zone of refuge and protecting the fishery through the wintertime. However, the earlier and potentially longer operation of the aerator leads to increased operational expenses and potential safety concerns due to thin or non-existent ice. These and other concerns, as mentioned in Recommendation #1, should be considered prior to any altered aeration regimes.

The Committee identified several risk factors that are potential predictors of wintertime oxygen depletion—predicted winter severity, water levels on December 1, and air temperature and rainfall amounts for the months March through November preceding winter. If any of these factors fall under a critical indicator of risk (identified in the Matrix), there is increased chance of anoxic conditions, at which point the Committee recommends aeration should be considered. The Matrix is the Committee's best attempt to identify key risk factors and associated indicators of risk; however, the Committee acknowledges that more data is necessary to further refine these indicators and make the Matrix more operational as a predictive tool for anoxic conditions on the Big Eau Pleine.

A note about the process of initiating aeration once ice fully covers the Big Eau Pleine: there is approximately a two-week delay between when the aeration system is turned on, and when full benefits of aeration are realized. Furthermore, the initial process of starting the aerator re-suspends bottom sediments full of oxygen-consuming matter, which, if occurring during ice-covered conditions, likely actually consumes rather than generates oxygen. This delay between aerator start-up and resulting ice holes being opened, and "oxygen sag" post-startup, should be considered in assessing when to start the aerator.

Matrix risk factors and critical indicators, explained

*Predicted Winter Severity* – Winter severity, particularly as it relates to ice cover duration, has a significant influence on dissolved oxygen in the Big Eau Pleine. According to the model, winters with ice cover extending beyond 90 days have a greater probability of fish kills, due to sediment-driven oxygen consumption expanding into the zone of refuge downstream of the aerator. Therefore, if a severe winter is predicted (increasing the likelihood that ice cover will last longer than 90 days), the Matrix indicates a high risk for anoxic conditions. December 1 is the average expected date at which ice covers the Big Eau Pleine. Every day earlier than December 1 that ice cover is present creates an increasingly high risk for wintertime anoxic conditions.

*Water Level* – Reservoir pool elevation at the start of winter is important to the time it takes for the surface waters to become anoxic. Based on a 2013 simulation, the model suggests a winter starting volume of 60% full pool would provide ten additional days of oxygen above 2 mg/L (a critical threshold for protecting gamefish), compared to a starting winter volume of 45%.

*Preceding Summer Temperatures* – Warmer-than-average summer (June-August) temperatures heat the bottom sediments in the Big Eau Pleine more than normal. During winter, oxygen depletion of the water occurs at the sediment-water interface. Warmer sediment temperatures warm this oxygen-depleted water more quickly, causing it to rise. This increases the rate of oxygen depletion in the water column above. In this way, warmer sediment more quickly uses up dissolved oxygen as the model shows. Therefore, if preceding summer temperatures are warmer than the mean, the Matrix indicates an increased risk of anoxic conditions in the Big Eau Pleine. The National Weather Service—Wausau ASOS (Wausau Airport) station is the best weather resource to utilize for the Big Eau Pleine Reservoir weather, as it closely matches precipitation data at Stratford, and provides a historical record for comparison and prediction. To retrieve recent data, visit http://w2.weather.gov/climate/index.php?wfo=grb, select "1. Product" and then "Preliminary Monthly Climate Data (CF6)." Next, select "2. Location" and "Wausau," and finally, select "3. Timeframe," followed by "Archived Data" and the appropriate dates.

*Preceding Spring Rainfall* – Above-average precipitation in the months of the preceding spring (March through May) can negatively influence wintertime dissolved oxygen in the Big Eau Pleine. Excess rainfall and storm events can wash nutrients and sediment from farm fields at a vulnerable time, when the root systems of planted crops (which hold soil in place) have not yet fully established. Most of the nutrients and sediment that wash into the reservoir will remain, and can

contribute to oxygen depletion in the winter following. Preceding spring rainfall amounts greater than the mean creates a risk for anoxic wintertime conditions.

*Preceding Fall Rainfall* – Similar to spring precipitation, above-average rainfall in the preceding fall (September through November) can influence dissolved oxygen in the Big Eau Pleine. Excess rainfall and storms can wash nutrients and sediment from farm fields at a vulnerable time, when crops have been harvested from farm fields and bare soil is exposed. Most of the nutrients and sediment that wash into the reservoir will remain, and can contribute to oxygen depletion in the winter following. Preceding fall rainfall greater than the mean creates a risk for anoxic wintertime conditions.

Example of Matrix application

Of the risk factors identified in the Matrix, predicted winter severity as measured by ice cover duration is of significant importance for wintertime oxygen depletion. The Committee did not apply a particular "weight" to this factor in the Matrix, but it appears to be a significant driver of wintertime oxygen depletion, and should be treated as such. (Water levels also appear to be significant.) If a severe winter is predicted and ice cover is established on the Big Eau Pleine Reservoir at or near December 1, managers should consider initiating aeration earlier in the winter season. If multiple other identified risk factors are present but a severe winter is not predicted, early winter dissolved oxygen monitoring should be watched closely, and if depletion of oxygen is indicated, the aeration system should be turned on. This decision should factor in the "lag time" (described above) in seeing an actual benefit from aeration in the form of oxygen. This is a dynamic process and adaptions should be made upon annual review of monitoring data and aeration operation schedule of the preceding year or years.

| Aeration Decision Matrix | | | | | |
|---|---|---|---|---|---|
| | **Risk factor** | **Low Risk** | **High Risk** | **Critical Indicator** | **Resource for assessing risk** |
| **Predicted winter severity** | The predicted duration of winter is… | Less than 90 days | Greater than 90 days | 90 days | http://www.cpc.ncep.noaa.gov/products/CFSv2/CFSv2seasonal.shtml |
| | The date that ice covers the BEP is… | Later than Dec. 1 | Earlier than Dec. 1 | Dec. 1 | Ice-cover data is collected by Wisconsin Valley Improvement Company |
| **Water level** | The Dec. 1 BEP water level/elevation is… | Above 1139.3 ft. | Below 1139.3 ft. | 61.7% full pool (1139.3 feet elev.) | Wisconsin Valley Improvement Company water level reports http://www.wvic.com/WaterReports/Water_Level_Report.cfm |
| **Preceding summer temperatures** | Recorded air temperatures for the preceding June-Aug were… | Cooler than the mean | Warmer than the mean | Mean temp. of 67.2 degrees F | National Weather Service - Wausau Airport station 1. Preliminary Monthly Climate Data (CF6) 2. Location – Wausau 3. Archived Data http://w2.weather.gov/climate/index.php?wfo=grb |
| **Preceding spring and fall rainfall** | Precipitation for the preceding March-May was… | Less than the mean | Greater than the mean | Mean precip. of 7.97 inches | National Weather Service - Wausau Airport station 1. Preliminary Monthly Climate Data (CF6) 2. Location – Wausau 3. Archived Data http://w2.weather.gov/climate/index.php?wfo=grb |
| | Precipitation for the preceding Sept-Nov was… | Less than the mean | Greater than the mean | Mean precip. of 8.84 inches | National Weather Service - Wausau Airport station 1. Preliminary Monthly Climate Data (CF6) 2. Location – Wausau 3. Archived Data http://w2.weather.gov/climate/index.php?wfo=grb |

4) **Adaptively manage aerator operations to determine and optimize which operational practices best maximize the wintertime zone of refuge for fish within and downstream of the aeration zone.**

   a. The model shows that turning on the aerator earlier can increase the wintertime dissolved oxygen in the zone of refuge downstream of the aerator by preventing ice formation, which in turn can increase the chances of protecting fish. To the extent possible, this Committee recommends evaluating the economics, safety, and environmental benefit of an earlier start date for the aeration system, consistent with Wis. Stat. § 167.26.
   b. Evaluate whether additional holes could be drilled in the aerator blower lines, without impacting the efficacy of the aeration system, to potentially expedite "connecting" the holes in the ice (created by the aerator), opening up a larger open water area, which provides dissolved oxygen to the zone of refuge.
   c. Evaluate staggered aerator blower operation rather than operating both blowers at the same time, as is the current practice. One blower could be turned on a few weeks in advance of the other, to begin opening up holes in the ice sooner, thus providing dissolved oxygen to the zone of refuge earlier, and without increased electrical operation expenses.
   d. Develop a monitoring plan related to aeration, to determine and quantify the net effect of the aerator's influence within and immediately downstream of the aeration zone.

5) **Conduct a fish movement study on the Big Eau Pleine Reservoir using acoustic technology.**

   There is unanimous agreement among all stakeholders that fish kills should be reduced on the Big Eau Pleine Reservoir; in order to achieve that, a better understanding is needed of how, where, and when fish move within the reservoir and river during the winter. DNR fish survey data has shown that even in major fish kill years, some percentage of fish survive. For instance, many of the first-year walleye survived the extreme 2009 fish kill, the largest fish kill recorded since 1980. Conversely, in some years not characterized as extreme fish kills, some percentage of fish die, presumably due to anoxia.

   The results of a 1988-89 WVIC-sponsored radio telemetry study showed extensive movement of walleye over the winter period, however, questions remain on how specifically they survive periods of winter where conditions aren't favorable for survival. (These questions include: Where do fish find oxygen during the winter outside the zone of refuge created by the aerator? Will fish move, and how far will they move to seek out the zone of refuge created by the aerator? Why were young walleye less susceptible than adult fish to the extreme 2009 fish kill?)

6) **Develop a Big Eau Pleine Watershed Manure Advisory System to warn agricultural producers of the threat for wintertime anoxia in the Big Eau Pleine, as described in the Aeration Decision Matrix and actual DO measurements.**

The model unequivocally describes sediment-oxygen demand (SOD) as a driver of anoxia in the Big Eau Pleine. SOD is a proxy for nutrient-rich runoff that leaves the Big Eau Pleine watershed during rain storms and is deposited in the reservoir. Due to the high agricultural use in the watershed, this runoff can contain manure, fertilizer, and phosphorus-rich sediment.

The model shows that if SOD is reduced, there is a direct benefit on wintertime availability of dissolved oxygen in the Big Eau Pleine. When conditions are present that threaten of the onset of wintertime anoxia and/or fish kills, agricultural producers should be notified along with guidance on wintertime spreading of manure and other potential discharge practices. This advisory could be modeled after the Wisconsin Manure Advisory System.

7) **Develop and implement a summer and fall monitoring regime that incorporates phosphorus, algae blooms, and water temperatures, to better predict how and when wintertime dissolved oxygen will be depleted.**

The model suggests that processes occurring in the watershed and reservoir in the summer will influence the availability of dissolved oxygen the following winter. Monitoring phosphorus and algal blooms in the summer will provide data that could be yet another valuable predictor of wintertime anoxia, and an indicator of the need for earlier and prolonged mechanical aeration. Summer water temperatures are a surrogate for winter sediment temperatures. The model shows that warmer sediment temperatures are a causative factor relating to dissolved oxygen depletion rates, and lead to earlier anoxia in the winter.

**8) Continue the wintertime monitoring efforts (dissolved oxygen, ice cover, etc.) currently conducted by Wisconsin Valley Improvement Company.**

The monitoring data provided by WVIC to inform this modeling effort was critical, and a valuable contribution to the overall results. To continue to put the best available science toward management decisions on the Big Eau Pleine, WVIC's data collection should continue.

9) **Support development and implementation of measures that reduce nutrient and organic loading to the Big Eau Pleine Reservoir.**

Until nutrient runoff from the surrounding lands is reduced, the Big Eau Pleine will continue to be challenged by winter anoxia and fish kills. Ongoing efforts by the Wisconsin DNR (Wisconsin River Total Maximum Daily Load), Marathon County (non-point source pollution reduction programs), and municipalities (phosphorus compliance efforts such as watershed adaptive management and water quality trading) will all contribute toward reducing nutrient loading to the Big Eau Pleine. These, and other similar efforts, should be supported, and implemented where possible, by all affected parties.