Watershed

February 2020

# Draft Kettle and Upper St. Croix River Watershed Restoration and Protection Strategy Report

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Location: Kettle River near the town of Kettle River, MN

**Commented [ST(1]:** Please share your watershed photos for the cover! Mine is just a placeholder




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# Contents

# Key terms and abbreviations

**Assessment Unit Identifier (AUID):** The unique waterbody identifier for each river reach comprised of the U.S. Geological Survey (USGS) eight-digit HUC plus a three-character code unique within each HUC.

**Aquatic life impairment:** The presence and vitality of aquatic life is indicative of the overall water quality of a stream. A stream is considered impaired for impacts to aquatic life if the fish Index of Biotic Integrity (IBI), macroinvertebrate IBI, dissolved oxygen, turbidity, or certain chemical standards are not met.

**Aquatic recreation impairment:** Streams are considered impaired for impacts to aquatic recreation if *E. Coli* bacteria standards are not met. Lakes are considered impaired for impacts to aquatic recreation if total phosphorus and either chlorophyll-a or Secchi disc depth standards are not met.

**Hydrologic Unit Code (HUC):** A HUC is assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the St. Croix River Basin is assigned a HUC-4 of 0703 and the Upper St. Croix River Watershed is assigned a HUC-8 of 07030001.

**Impairment:** Waterbodies are listed as impaired if water quality standards are not met for designated uses including aquatic life, aquatic recreation, and aquatic consumption.

**Index of Biotic Integrity (IBI):** A method for describing water quality using characteristics of aquatic communities, such as the types of fish and invertebrates found in the waterbody. It is expressed as a numerical value between 0 (lowest quality) to 100 (highest quality).

**Protection:** This term is used to characterize actions taken in watersheds of waters not known to be impaired to maintain conditions and beneficial uses of the waterbodies.

**Restoration:** This term is used to characterize actions taken in watersheds of impaired waters to improve conditions, eventually to meet water quality standards and achieve beneficial uses of the waterbodies.

**Source (or pollutant source):** This term is distinguished from 'stressor' to mean only those actions, places or entities that deliver/discharge pollutants (e.g., sediment, phosphorus, nitrogen, pathogens).

**Stressor (or biological stressor):** This is a broad term that includes both pollutant sources and non-pollutant sources or factors (e.g., altered hydrology, dams preventing fish passage) that adversely impact aquatic life.

**Total Maximum Daily Load (TMDL):** A calculation of the maximum amount of a pollutant that may be introduced into a surface water and still ensure that applicable water quality standards for that water are met. A TMDL is the sum of the wasteload allocation for point sources, a load allocation for nonpoint sources and natural background, an allocation for future growth (i.e., reserve capacity), and a margin of safety as defined in the Code of Federal Regulations.

# Executive summary

The Kettle River and Upper St. Croix River Watersheds are major watersheds located in east-central Minnesota, in the St. Croix River Basin and in the Northern Lakes and Forests ecoregion. Collectively, these watersheds drain approximately one million acres of land in portions of Carlton, Aitkin, Kanabec, and Pine counties. The dominant land cover in the Kettle and Upper St. Croix River Watersheds is forest and shrub, followed by wetlands. Pastureland, developed land, cultivated cropland, and open water each make up less than 10% of the watershed. Much of the watershed is undeveloped, but the watershed does contain multiple cities, including Sandstone, Moose Lake, and Hinckley.

The Kettle and Upper St. Croix River Watersheds contain approximately 1,700 miles of streams and rivers. Of these, 115 miles is designated as trout streams and 66 miles are considered exceptional use waters. There are 126 lakes larger than 10 acres located throughout both watersheds. Of these lakes, 17 produce wild rice, a unique resource that Minnesota produces more of than any other state. There are also two lakes (Hanging Horn and Little Hanging Horn) that are designated as cisco refuge lakes, and one lake, Grindstone Lake, that is a coldwater fishery for its ability to support trout populations.

From 2016 to 2018, Intensive Watershed Monitoring (IWM) was conducted by the Minnesota Pollution Control Agency (MPCA) to collect data across both watersheds for the purpose of assessing the quality of its natural water resources. Overall, the Kettle and Upper St. Croix River Watersheds have much healthier streams and lakes in comparison to most other watersheds in the state. Seventy of the 77 stream/river reaches that were assessed were found to fully support aquatic life, and six streams fully support aquatic recreation. Twenty-one streams do not support aquatic life and/or recreation, a majority of which (17 reaches) are in the Kettle River Watershed. Of those, 13 do not support aquatic life and 10 do not support aquatic recreation. The streams that do not support recreation are all located in the Kettle River Watershed and show chronically elevated bacteria concentrations. Thirty-one lakes across both watersheds were assessed as part of the IWM. Of the assessed lakes, 18 fully supported aquatic recreation and 13 did not support aquatic recreation.

Stressor Identification (SID) reports were completed for the stream aquatic life impairments (fish and macroinvertebrate communities) and a Total Maximum Daily Load (TMDL) Study was completed to address the stream and lake aquatic recreation impairments (*E. coli* and lake nutrients) in both watersheds. The SID reports identified infrastructure and altered hydrology as the most common stressors to biologic communities. Infrastructure stressors include dams, beaver activity, undersized culverts, and any other barriers that disrupt fish passage and connectivity. The primary altered hydrology stressor in these watersheds relates to historical ditching of peatlands, which was fairly common throughout this area, particularly the northwestern portion of the Kettle River Watershed. This ditching has caused and is causing subsequent stressors, including low dissolved oxygen (DO), water highly-stained with dissolved organic compounds, physical damage to the channel via increased erosion, and degradation of habitat by sedimentation and instability of channel features.

Priority areas for this watershed were determined based on input from local partners, XXXX, XXX, XXX, and XXX. Can also insert the list of priority resources and/or subwatersheds here.

Restoration strategies for addressing the identified issues in the Kettle and Upper St. Croix River SID and TMDL reports include: addressing culverts/dams and other fish passage barriers, restoring ditched

**Commented [ST(2]:** To be discussed in greater detail at the last LWG meeting; prioritization efforts were largely based on partner input and also built on existing work, especially in the Kettle watershed (KRWLSP, RAQ analysis).

wetlands and altered stream hydrology, livestock and manure management, addressing failing septic systems in shoreland areas, and investigating and managing internal loading in certain lakes. Strategies were also identified for lakes and streams that are currently meeting water quality to maintain and improve current conditions and protect these resources from becoming degraded or impaired. Some of the protection strategies presented in this report include: promoting shoreland protection, implementing programs for forest protection, aquatic invasive species (AIS) prevention and management, managing in-lake plant and fish communities, and expanded monitoring to better assess priority resources and track potential changes and trends over time. Specific locations of resource vulnerability are identified in this report and should be used to guide this process.

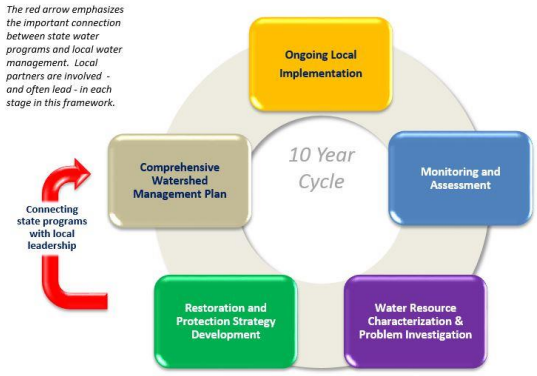
This Watershed Restoration and Protection Strategy (WRAPS) document is meant to serve as a foundation of technical information that can be used to assist in development of tools and prioritization of water quality efforts by local governments, landowners, and other stakeholder groups. The information can be used to determine what strategies will be best to make improvements and protect good quality water resources, as well as focus those strategies to targeted locations.

The topics of each chapter of this report are summarized below

- **Chapter 1** provides background information on the Kettle and Upper St. Croix River Watershed
- **Chapter 2** details watershed conditions based on results from intensive watershed monitoring (IWM), Stressor Identification (SID), and Total Maximum Daily Load (TMDL) calculations
- **Chapter 3** summarizes priority areas for targeting actions to improve water quality, and geographically locates where watershed restoration and protection actions should take place
- **Chapter 4** documents a monitoring plan necessary to assess conditions in both watersheds

## What is the WRAPS report?

Minnesota has adopted a watershed approach to address the health of aquatic ecosystems in the state's 80 major watersheds. The Minnesota watershed approach incorporates **water quality assessment, watershed analysis, public participation, planning, implementation, and measurement of results** into a 10-year cycle that addresses both restoration and protection.




Along with the watershed approach, the Minnesota Pollution Control Agency (MPCA) developed a process to identify and address threats to water quality in each of these major watersheds.

This process is called Watershed Restoration and Protection Strategy (WRAPS) development. The WRAPS reports have two parts: impaired waters have strategies for restoration, and waters that are not impaired have strategies for protection.

Waters not meeting state standards are listed as impaired and total maximum daily load (TMDL) studies are developed for them. The TMDLs are incorporated into the WRAPS reports. In addition, the watershed approach process facilitates a more cost-effective and comprehensive characterization of multiple water bodies and overall watershed health, including both protection and restoration efforts. A key aspect of this effort is to develop and utilize watershed-scale models and other tools to identify strategies for addressing point and nonpoint source pollution that will cumulatively achieve water quality targets. For nonpoint source pollution, the WRAPS report informs local planning efforts, but ultimately the local partners decide what work will be included in their local plans.

| | |
|---|---|
| Purpose | •Support local working groups and jointly develop scientifically-supported restoration and protection strategies to be used for subsequent implementation planning<br>•Summarize watershed approach work done to date including the following reports:<br>•*Kettle and Upper St. Croix River Watershed Monitoring and Assessments*<br>•*Kettle and Upper St. Croix River Watershed Biotic Stressor Identifications*<br>•*Kettle and Upper St. Croix River Watershed Total Maximum Daily Load* |
| Scope | •Impacts to aquatic recreation and impacts to aquatic life in streams<br>•Impacts to aquatic recreation in lakes |
| Audience | •Local working groups (local governments, SWCDs, watershed management groups, etc.)<br>•State agencies (MPCA, DNR, BWSR, etc.) |

# 1. Watershed background and description

The Kettle River and Upper St. Croix River Watersheds are adjacent watersheds located in east central Minnesota. The Kettle River Watershed is approximately 673,000 acres while the Upper St. Croix River Watershed is about half this size, at approximately 348,000 acres. Both watersheds are located in the Northern Lakes and Forest level III ecoregion, except a sliver of the Kettle River Watershed, which is located in the Northern Central Hardwood Forest level III ecoregion.

Both the Kettle River and Upper St. Croix River Watersheds drain south into the St. Croix River. The Kettle River Watershed consists of six HUC-10 subwatersheds that generally drain east and west into the Kettle River, which runs from north to south until its confluence with the St. Croix River. Main streams within the Kettle River Watershed, besides the Kettle River, include the Moose Horn River, the Willow River, the Pine River, and the Grindstone River. The watershed also contains 126 lakes greater than 10 acres, 12 of which are listed by the state as impaired for nutrients. The Kettle River Watershed is located mostly within Pine and Carlton Counties (53% and 34% of the watershed, respectively), with small portions in Aitkin and Kanabec Counties (10% and 3%, respectively). The watershed covers 44 townships, 13 cities, and 1 unorganized territory. Cities include Hinckley, Sandstone and Moose Lake. Interstate-35 roughly bisects the watershed.

The Upper St. Croix River Watershed consists of six HUC-10 subwatersheds that drain directly or almost directly into the St. Croix River. Main streams within the Upper St. Croix River Watershed include the Upper Tamarack River, the Lower Tamarack River, Crooked Creek, Sand Creek, Bear Creek, McDermott Creek, Hay Creek and Sucker Creek. The Upper St. Croix River Watershed is located entirely in Pine County and is predominately rural, draining only 19 townships and one city (Askov). The Nemadji and St. Croix State Forests are both located within the Upper St. Croix Watershed.

Land cover in both watersheds consists largely of wetlands and forest with some agricultural land. Both emergent and forested wetlands are abundant, although some have been ditched or altered. Forests contain a mixture of pine trees and hardwoods. Agricultural land is mostly hay fields for pasture, with some small fields of row crops. Feedlots are also scattered across the watershed. Prior to settlement in the area, the landscape consisted almost exclusively of forests, wetlands and lakes. However, most of the original, old-growth forests were cleared in the second half of the 19th century, when the timber industry made its way to the region, attracted by the abundant pine trees for which Pine County is named. Much of this harvested land has since been re-forested, but with obviously younger forests.

Several studies, reports and plans have been written on the Kettle River and Upper St. Croix River Watersheds. The MPCA has recently released monitoring reports for both watersheds: the Upper St. Croix River Monitoring and Assessment Report was released in May 2019 and the Kettle River Watershed Monitoring and Assessment Report was released in in October 2019. The Kettle River and Upper St. Croix River Watershed Stressor Identification Reports were also published in XXX 2020. The Kettle and Upper St. Croix River Watershed Total Maximum Daily Load study was completed in XXX 2020. In addition, the Kettle River Landscape Stewardship Plan was released in April 2014 by the Minnesota Forest Resources Council (Section 2.5).

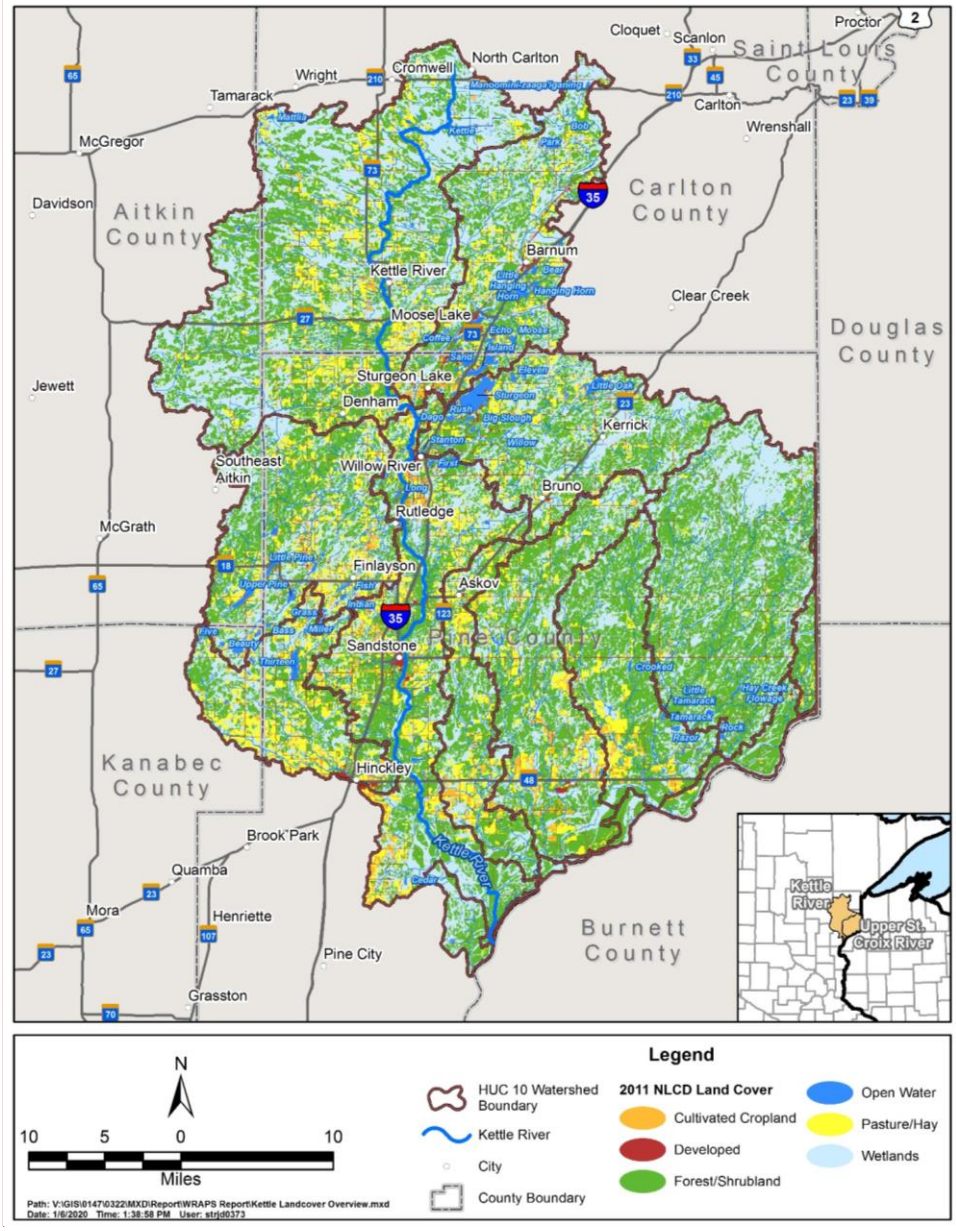



**Figure 1: Landcover in the Kettle and Upper St. Croix River Watersheds**

**Commented [ST(3]:** Lake names are a little difficult to read on this map. Also, could we update the data source to NLCD 2016?

## Additional Kettle and Upper St. Croix River watershed resources

Aitkin County Water Management Plan: https://aitkincountyswcd.org/PDF-Docs/WaterPlan6-24-09.pdf

Carlton County Comprehensive Local Watershed Management Plan: http://www.co.carlton.mn.us/ArchiveCenter/ViewFile/Item/58

Kanabec County Water Plan 2019-2028: http://www.kanabecswcd.org/wp-content/uploads/2019/02/2019-WP-draft-2-022619.pdf

Kettle River Watershed Landscape Stewardship Plan: https://mn.gov/frc/docs/KettleRiverWatershed_LSP_April2014.pdf

Kettle River Watershed Monitoring and Assessment Report: https://www.pca.state.mn.us/sites/default/files/wq-ws3-07030003b.pdf

Kettle and Upper St. Croix River Watershed Total Maximum Daily Load (TMDL) Study for Total Phosphorus, Total Suspended Solids, and Bacteria:

Kettle River Watershed Stressor Identification Report:

Lake Reports for Selected Lakes in Pine County (Upper Pine, Grace, Bass, Island, Long, Sturgeon, Oak, Big Pine, Tamarack, Grindstone, and county-wide watershed summary): https://www.pineswcd.com/?SEC=31A23F2C-06A5-4B4D-A15F-7F76BC375B83 (individual lakes), https://www.pineswcd.com/index.asp?SEC=207B7C60-44D4-4C0E-B24F-70C39200B2B9 (county-wide watershed summary)

Lake Reports for Selected Lakes in Carlton County (Bear, Eddy, Hanging Horn, Little Hanging Horn, Moosehead, Park, and county-wide watershed summary): https://carltonswcd.org/kettle-river-watershed

Minnesota Department of Natural Resources (DNR) Kettle River Watershed Context Report: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/context_report_major_35.pdf

Minnesota Department of Natural Resources (DNR) Upper St. Croix River Watershed Context Report: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/context_report_major_34.pdf

Minnesota Department of Natural Resources (DNR) Watershed Health and Assessment Framework (WHAF) Kettle River Watershed Report Card: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/ReportCard_Major_35.pdf

Minnesota Department of Natural Resources (DNR) Watershed Health and Assessment Framework (WHAF) Upper St. Croix River Watershed Report Card: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/ReportCard_Major_34.pdf

Minnesota Nutrient Planning Portal for Kettle River Watershed: https://mrbdc.mnsu.edu/mnnutrients/watersheds/kettle-river-watershed

Minnesota Nutrient Planning Portal for Upper St. Croix River Watershed: https://mrbdc.mnsu.edu/mnnutrients/watersheds/upper-st-croix-river-watershed

Pine County Local Water Management Plan: https://www.co.pine.mn.us/document_center/Departments/planning%20and%20zoning/Pine%20County%20Water%20Management%20Plan.pdf

Upper St. Croix River Monitoring and Assessment Report: https://www.pca.state.mn.us/sites/default/files/wq-ws3-07030001.pdf

Upper St. Croix River Stressor Identification Report:

# 2. Watershed conditions

Intensive watershed monitoring (IWM) was conducted in the Kettle River Watershed and Upper St. Croix River Watersheds in 2016 and 2017 to determine the overall health of water resources, identify impaired waters, and identify waters in need of additional protection. Data from this IWM was combined with other available data collected within the last 10 years and used to assess waterbody health. In general, IWM results showed that most of the lakes and streams in the Kettle River and Upper St. Croix River Watersheds are categorized as good to great. These results are summarized in the following sections, but more detailed results can be found in the *Kettle River Watershed Monitoring and Assessment Report* (MPCA 2019a) and the *Upper St. Croix River Watershed Monitoring and Assessment Report* (MPCA 2019b). The MPCA also developed biological stressor identification (SID) reports for both watersheds. Results from these SID reports were incorporated into this report to capture the existing condition of the watershed, as well as the primary stressors to watershed resources.

Both the Kettle River and Upper St. Croix River Watersheds have been divided into six HUC-10 subwatersheds in this WRAPS (Figure 2).

## 2.1 Condition status

This report addresses waters for protection or restoration of aquatic life uses based on the fishery, macroinvertebrate community, and DO concentration, and for aquatic recreation uses based on bacteria levels or nutrient levels and water clarity. Waters that are listed as impaired will be addressed through restoration strategies and a defined TMDL study. Waters that are not impaired will be addressed through protection strategies to help maintain water quality and recreation opportunities and reverse downward trends (see Section 3.3).

**Commented [ST(4]:** Potentially clarify to reflect that not all impairments will be addressed through a TMDL (like bio impairments)

Some of the waterbodies in the Kettle River Watershed and Upper St. Croix River Watershed are impaired by mercury; however, this WRAPS report does not cover mercury. For more information on mercury impairments, see the statewide mercury TMDL on the MPCA website at: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/special-projects/statewide-mercury-tmdl-pollutant-reduction-plan.html.

**Commented [ST(5]:** Discussion item:
What's the best way to approach the reaches within the watershed that are too high to be covered by the statewide Hg TMDL? Likely to be a concern by some partners.

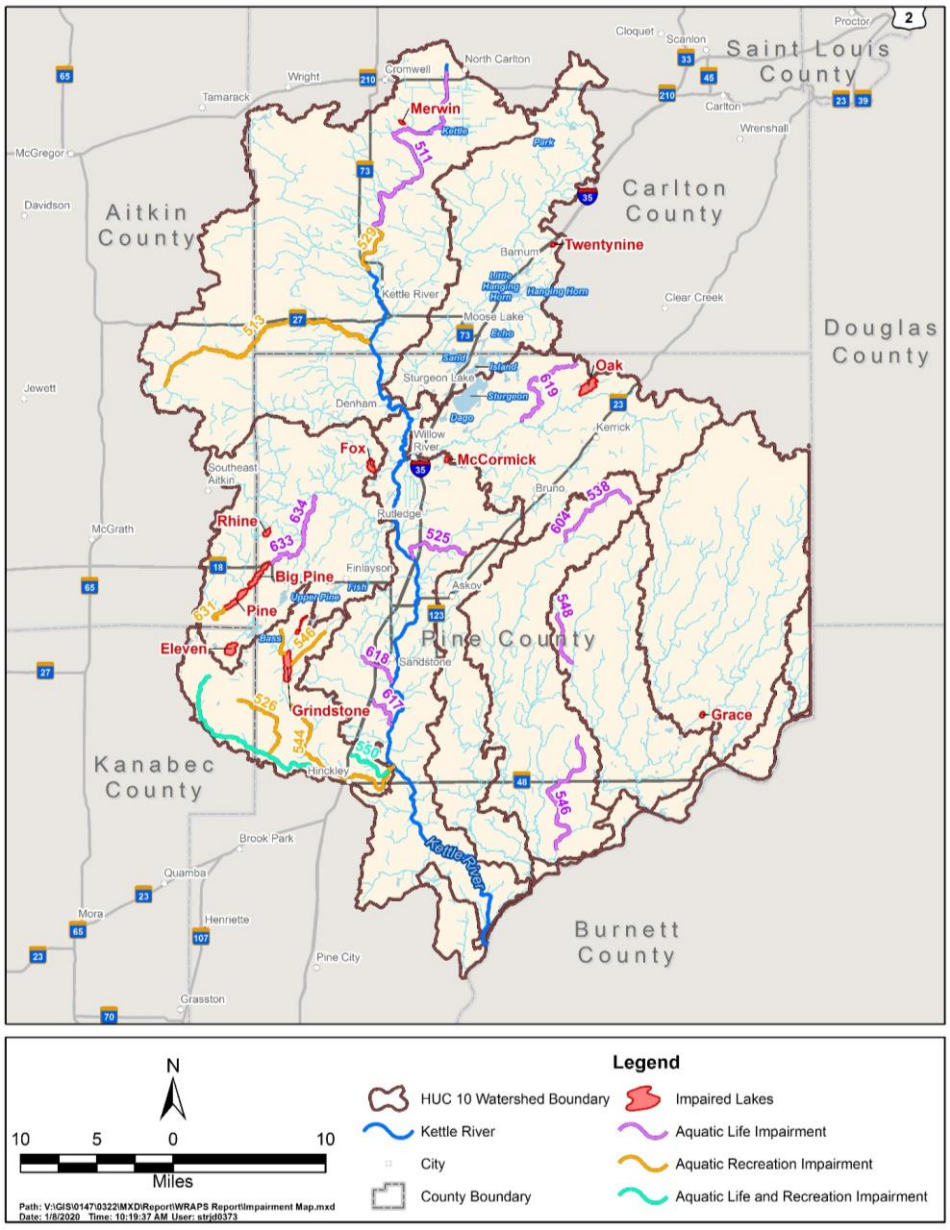



**Figure 2: Impairments in the Kettle and Upper St. Croix River Watersheds**

**Commented [ST(6]:** Same comment as above about individual lake names being difficult to read.

## Streams

Seventy-seven of the 203 stream/river reaches with unique watershed identification numbers (WIDs) in the Kettle and Upper St. Croix River Watersheds have been assessed through 2017 (Tables 1 and 2). Seventy stream/river reaches were found to fully support aquatic life, and six streams fully support aquatic recreation. Twenty-one streams do not support aquatic life and/or recreation, a majority of which (17 reaches) are in the Kettle River Watershed. Of those, 13 do not support aquatic life and 10 do not support aquatic recreation. The streams that do not support recreation are all located in the Kettle River Watershed and show chronically elevated bacteria concentrations.

The following tables provide a general summary of the assessment results for the Kettle and Upper St. Croix River Watersheds. A complete list of the results of the stream assessments, which includes all available data on the stream reaches within each watershed, can be found in the Watershed Monitoring and Assessment Reports (MPCA 2019a and MPCA 2019b).

**Table 1: Assessment status of river and stream reaches in the Kettle River Watershed, presented (mostly) from north to south.**

| HUC-10 Subwatershed | # Total WIDs | # Assessed WIDs | Aquatic Life Use | | Aquatic Recreation Use | | IF |
|---|---|---|---|---|---|---|---|
| | | | FS | NS | FS | NS | |
| Upper Kettle River | 36 | 11 | 10 | 1 | 0 | 2 | 1 |
| Moose River | 14 | 7 | 7 | 0 | 1 | 0 | 0 |
| Willow River | 9 | 5 | 9 | 1 | 1 | 0 | 0 |
| Pine River | 22 | 7 | 22 | 0 | 1 | 0 | 1 and 2 |
| Grindstone River | 19 | 6 | 19 | 1 | 0 | 6 | 4 |
| Lower Kettle River | 23 | 7 | 3 | 3 | 3 | 0 | 1 |

FS = fully supporting, i.e., found to meet the water quality standard; NS = not supporting, i.e., does not meet the water quality standard, and therefore, is impaired; IF = insufficient data, i.e., the data collected was insufficient to make a finding; NA = not assessed.

**Commented [ST(7]:** Numbers in the table below are taken from the Monitoring and Assessment Reports... They do not match up perfectly with the impairments included in Wenck's workplan/covered in the TMDL and Stressor ID reports. This discrepancy will be sorted out before the LWG meeting.

**Table 2: Assessment status of river and stream reaches in the Upper St. Croix River Watershed, presented (mostly) from west to east.**

| HUC-10 Subwatershed | # Total WIDs | # Assessed WIDs | Aquatic Life Use | | Aquatic Recreation Use | | IF |
|---|---|---|---|---|---|---|---|
| | | | FS | NS | FS | NS | |
| Bear Creek | 12 | 2 | 2 | 0 | 0 | 0 | 1 |
| Sand Creek | 36 | 11 | 7 | 3 | 0 | 0 | 2 |
| Crooked Creek | 32 | 9 | 6 | 1 | 0 | 0 | 3 |
| Lower Tamarack River | 14 | 9 | 7 | 0 | 0 | 0 | 5 |
| Upper Tamarack River | 3 | 2 | 2 | 0 | 0 | 0 | 1 |
| Chases Brook – St. Croix River | 5 | 1 | 1 | 0 | 0 | 0 | 0 |

FS = fully supporting, i.e., found to meet the water quality standard; NS = not supporting, i.e., does not meet the water quality standard, and therefore, is impaired; IF = insufficient data, i.e., the data collected was insufficient to make a finding; NA = not assessed.

## Lakes

Lakes are assessed for aquatic recreation uses based on ecoregion specific water quality standards for total phosphorus (TP), chlorophyll-a (chl-a) (i.e., the green pigment found in algae), and Secchi transparency depth. To be listed as impaired, a lake must fail to meet water quality standards for TP and either chl-a or secchi depth.

The Kettle and Upper St. Croix River Watersheds have several lakes with good to excellent water quality. All lakes were assessed against standards for aquatic recreation that are designed to protect lakes in the NLF Ecoregion; lakes with stream trout or lake trout populations (e.g. Grindstone Lake) were held to standards that are more stringent to protect those sensitive fish populations.

There are 126 lake basins in the Kettle and Upper St. Croix River Watersheds that have surface areas greater than 10 acres. Of these lake basins, 30 had enough water quality information to conduct a formal assessment of aquatic recreation. Eighteen lakes fully supported aquatic recreation and 12 did not support aquatic recreation (Tables 3 and 4). In the Upper St. Croix River Watershed, the impairment on Rock Lake was determined to be due to natural conditions and therefore was not included in the TMDL report.

Since 2013, the MPCA in coordination with the DNR has substantially increased the use of biological monitoring and assessment as a means to determine and report the condition of the state's lakes. This includes sampling fish communities of multiple lakes throughout a major watershed. The fish-based lake IBI (FIBI) utilizes data from trap net and gill net surveys, which focus on the gamefish community, as well as nearshore surveys which focus on the nongame-fish community. From this data, a FIBI score can be calculated, which provides a measure of overall fish community health. The DNR developed four FIBI tools to assess many different types of lakes throughout the state. More information on the FIBI can be found at the DNR Lake Index of Biological Integrity website. (http://www.dnr.state.mn.us/waters/surfacewater_section/lake_ibi/index.html).

When biological impairments are found, stressors to the aquatic community must be identified. Nine lakes were assessed by the DNR using the Fish IBI in the Kettle River Watershed. No lakes in the Upper St. Croix River Watershed have been assessed using the Fish IBI. Of the nine lakes assessed in the Kettle River Watershed, only one lake (Oak Lake) failed to meet the aquatic life standards.

Tables 3 and 4 below summarizes the ability of the assessed lakes to support aquatic recreation uses and aquatic life in the Kettle River and Upper St. Croix River Watersheds. A complete list of the results of the lake assessments can be found in the Watershed Monitoring and Assessment Reports (MPCA 2019a and MPCA 2019b).

**Table 3: Assessment status of the lakes in the Kettle River Watershed, presented generally from north to south.**

| HUC-10 Subwatershed | Lakes >10 Acres | Aquatic Life Use | | Aquatic Recreation Use | | IF |
|---|---|---|---|---|---|---|
| | | FS | NS | FS | NS | |
| Upper Kettle River | 9 | - | - | - | 1 | 3 |

| HUC-10 Subwatershed | Lakes >10 Acres | Aquatic Life Use | | Aquatic Recreation Use | | IF |
|---|---|---|---|---|---|---|
| | | FS | NS | FS | NS | |
| Moose River | 27 | 3 | - | 9 | 1 | 14 |
| Willow River | 22 | 1 | 1 | 3 | 1 | 3 |
| Pine River | 23 | 3 | - | 3 | 5 | 5 |
| Grindstone River | 16 | 1 | - | 1 | 2 | 3 |
| Lower Kettle River | 22 | - | - | - | 1 | 4 |

FS = fully supporting, i.e., found to meet the water quality standard; NS = not supporting, i.e., does not meet the water quality standard, and therefore, is impaired; IF = insufficient data, i.e., the data collected was insufficient to make a finding; NA = not assessed.

**Table 4: Assessment status of the lakes in the Upper St. Croix River Watershed, presented generally from west to east.**

| HUC-10 Subwatershed | Lakes >10 Acres | Aquatic Life Use | | Aquatic Recreation Use | | IF |
|---|---|---|---|---|---|---|
| | | FS | NS | FS | NS | |
| Bear Creek | 0 | -- | -- | -- | -- | -- |
| Sand Creek | 1 | 0 | 0 | 0 | 0 | 1 |
| Crooked Creek | 3 | 0 | 0 | 2 | 0 | 1 |
| Lower Tamarack River | 3 | 0 | 0 | 0 | 2 | 1 |
| Upper Tamarack River | 0 | -- | -- | -- | -- | -- |
| Chases Brook – St. Croix River | 0 | -- | -- | -- | -- | -- |

FS = fully supporting, i.e., found to meet the water quality standard; NS = not supporting, i.e., does not meet the water quality standard, and therefore, is impaired; IF = insufficient data, i.e., the data collected was insufficient to make a finding; NA = not assessed.

## 2.2 Water quality trends

Year-to-year weather variations affect water quality data; for this reason, analyzing long term data trends is important for gaining insight into changes occurring in a water body over time. In a 2014 MPCA statewide river monitoring report (MPCA 2014), Kettle River water chemistry data was analyzed for trends (Table 5) for both the long-term period of record (1967 through 2009) and recent trends (1995 through 2009). The long-term record indicates that there have been significant decreases in total suspended solids (TSS), total phosphorus (TP), ammonia, and biological oxygen demand, likely due to wastewater treatment upgrades. However, there have been increases in nitrates/nitrites ($NO_3$+$NO_2$) and chloride, although average concentrations of these parameters are quite low compared to other watersheds in the state, and the river still meets water quality standards.

**Table 5: Water quality trends of the Kettle River near Hinckley (bridge on MN-48).**
Note: Green values indicate an improving trend in water quality for that parameter while red values indicate a degrading trend in water quality for that parameter.

| Parameter | Long-term trend (1967-2009) | Recent trend (1995-2009) |
|---|---|---|
| Total suspended solids | Decrease (-58%) | No trend |
| Total phosphorus | Decrease (-45%) | No trend |
| Nitrite/Nitrate | No trend | Increase (+46%) |

| Parameter | Long-term trend (1967-2009) | Recent trend (1995-2009) |
|---|---|---|
| Ammonia | Decrease (-83%) | No trend |
| Biochemical oxygen demand | Decrease (-63%) | No trend |
| Chloride | Increase (+159%) | Little data |

In 2017, the MPCA switched to the Watershed Pollutant Load Monitoring Network (WPLMN). There are two long-term monitoring locations in the Kettle River Watershed. Users can access this data via the WPLMN browser, which shows the location of long-term monitoring sites throughout the state. It includes links to the MPCA's Environmental Data Access portal that contains all monitoring data for the entire period of record, including more recent data through 2019. When compared to the other basin and major watershed sites within the Saint Croix River Basin, the average annual TP flow-weighted mean concentrations (FWMCs) for the Kettle River are slightly elevated. Average annual TSS and $NO_3$+$NO_2$ FWMCs for the Kettle River are relatively low, as they are throughout the rest of the Saint Croix River Basin. When compared to other basin and major watershed sites throughout Minnesota, average annual TSS, TP, and $NO_3$+$NO_2$ FWMCs for the Kettle River are lower than most. See discussion on page 67 of the Kettle River Watershed Monitoring and Assessment Report for more information on results of the WPLMN for Kettle River.

The MPCA completes annual trend analysis on lakes and streams across the state based on long-term transparency measurements. The data collection for this work relies heavily on volunteers across the state and also incorporates any agency and partner data submitted to EQuIS. The calculated trends use a Seasonal Kendall statistical test for waters with a minimum of eight years of Secchi disk measurement in lakes and Secchi tube measurements in streams.

Citizen volunteer monitoring occurs at 23 stream locations and on 43 lakes in the Kettle and Upper St. Croix River Watersheds. There is strong evidence of a watershed-wide increasing trend in transparency based on stream measurements. Many volunteer-monitored lakes do not yet have enough data (or sufficient coverage) for watershed wide trend analysis, but individual lake analyses show that the number of increasing trends outnumber decreasing trends. Of the lake sites that are monitored by volunteers, seven show an improving trend, three show a declining trend, and 16 lakes show no long-term trend in observed in water clarity. Only 10 stream sites monitored by volunteers have long enough data records to evaluate trends. Of these sites, one site shows an improving trend, one shows a declining trend, and four show no long-term trends. See Table 6 for a list of lakes that demonstrate increasing and decreasing trends and Appendix A for a complete list of waterbodies investigated for trends.

**Table 6: Trends in stream and lake transparency in the Kettle River and Upper St. Croix River Watersheds.**
Note: Green values indicate an improving trend while red values indicate a degrading trend

| HUC-10 Subwatershed | Lake Name | ID | Trend |
|---|---|---|---|
| Moose River | Little Hanging Horn | 09003500 | Improving |
| Moose River | Eddy | 09003900 | Declining |
| Moose River | Moosehead | 09004100 | Declining |
| Willow River | Dago | 58007300 | Improving |
| Pine River | Rhine | 58013600 | Declining |

| HUC-10 Subwatershed | Lake Name | ID | Trend |
|---|---|---|---|
| Crooked Creek | Tamarack | 58002400 | Improving |

## 2.3 Stressors and sources

In order to develop appropriate strategies for restoring or protecting waterbodies, the stressors and/or sources impacting or threatening them must be identified and evaluated. Biological stressor identification (SID) is conducted for stream/river reaches with either fish or macroinvertebrate biota impairments, and encompasses the evaluation of both pollutant and non-pollutant-related (e.g., altered hydrology, fish passage, habitat) factors as potential stressors. Pollutant source assessments are done where a biological SID process identifies a pollutant as a stressor, as well as for the typical pollutant impairment listings. Section 3 provides further detail on stressors and pollutant sources.

### Stressors of biologically-impaired stream and river reaches

**Commented [ST(8]:** This section will be revisited and updated after both of the SID reports are finalized.

SID studies were completed in 2020 to identify the factors (i.e., stressors) that are causing the fish and macroinvertebrate community impairments in the Kettle Upper St. Croix River Watersheds (MPCA 2020a and MPCA 2020b). Nine Assessment Unit (AUID) reaches from eight different streams were included in the Kettle River Watershed SID process because they were determined to have substandard biological communities via the 2016-2017 IWM and the subsequent 2018 assessment phase of this WRAPS project. Four other biologically-impaired AUIDs were investigated in the Kettle River Watershed SID process but had recently changed warm/cold water designations, were determined by an assessment committee to be due to natural background conditions, or were labeled as inconclusive due to an abnormally-large rainfall event's potential effects on sampling. As such, they do not require a TMDL. Three AUID reaches from three different streams were included in the Upper St. Croix River Watershed SID report. Table 7 summarizes the primary stressors identified for each impaired reach covered in the SID studies.

**Commented [ST(9]:** I think this sentence is a little misleading because most of the SID work in the Kettle (and probably the same in USC) will likely not lead to TMDLs… Maybe for low DO, but even then, a TMDL may not provide much additional information.

**Commented [ST(10]:** USC SID work is not summarized in Table 7; see note, below.

The identified stressors were non-point source pollution, infrastructure, or naturally-occurring circumstances. No point source pollution was associated with the biological impairments. Infrastructure stressors included culverts that were installed such that fish passage is difficult or not possible (various reaches). The Grindstone Dam (a complete barrier to fish migration) is also a contributing stressor to the impairment of the fish community of South Branch Grindstone River. Also included in the infrastructure category are several legacy ditching projects, which in the early 1900s attempted to drain bog areas throughout much of the Kettle River Watershed. Although these ditch systems are not as long or extensive as those in adjacent watersheds to the north or west (e.g. around the cities of Cromwell, McGregor, Aitkin, Palisade, Hill City, and Floodwood), these ditches alter the hydrology downstream, and appear to have caused channel damage in some locations, leading to habitat loss. The ditches also likely contribute to low DO levels in streams due to the wetland-sourced water they convey to the streams. The natural stressors are low DO, due to the extensive wetlands, stagnant pools downstream of road crossings, and beaver dams, which have the potential to block fish passage and prevent fish movement in spring from downstream overwintering habitat.

There is one reach, Skunk Creek (AUID 618), impaired for fish IBI, that warrants additional discussion.. This reach is located within the City of Sandstone and has historic releases of creosote from the Former Kettle River Company Creosote Plant Site. The Minnesota Department of Agriculture (MDA) is currently

overseeing clean-up for this site/reach, which involves collection of sediment, surface water, groundwater, soil vapor, and air samples for the analysis of polycyclic aromatic hydrocarbons (PAHs) and/or volatile organic compounds (VOCs). In the spring of 2019, PAH and VOC data were used to complete a Preliminary Ecological Risk Assessment for Skunk Creek. The conclusion from the Preliminary Ecological Risk Assessment made a recommendation to conduct an advanced ecological assessment, which will be the next phase of this project. More information about this investigation and clean-up can be found on the MDA website.

**Table 7: Primary stressors to aquatic life in biologically impaired reaches in the Kettle River and Upper St. Croix River Watersheds.**

| HUC-10 Subwatershed | AUID (Last 3 digits) | River or Stream | Biological impairment | Primary stressor | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Dissolved oxygen | Phosphorus | TSS | Connectivity | Altered Hydrology | Channel Alteration | Habitat | Toxic chemicals |
| Upper Kettle River | 511 | Kettle River | Fish | • | | | | | • | • | |
| Willow River | 619 | Hay Creek | Fish | | | | | ♦ | • | • | |
| Pine River | 633 | Pine River | MI | • | | | | | | | |
| | 634 | Pine River | MI | • | | | | | | | |
| Grindstone River | 516 | S. Branch Grindstone River | Fish | • | | | • | | | | |
| | 550 | Spring Creek | Fish | | | | • | | | | |
| Lower Kettle River | 525 | Cane Creek | Fish, MI | | | | • | ◊ | | • | |
| | 617 | Friesland Ditch | Fish | | | | | ♦ | • | ? | |
| | 618 | Skunk Creek | Fish | | | | • | | | | ? |
| Sand Creek | 501 | Hay Creek | Fish, MI | | | | | | | | |
| | 503 | Sand Creek | Fish | | | | | | | | |
| Crooked Creek | 502 | Wolf Creek | MI | | | | | | | | |

MI = Macroinvertebrate

♦ A "root cause" stressor, which leads to consequences that become the direct stressors.

◊ Possible contributing root cause.

• Determined to be a direct stressor.

o A stressor, but anthropogenic contribution, if any, not quantified. Includes beaver dams as a natural stressor.

x A secondary stressor.

? Inconclusive

**Commented [ST(11]:** Sand Creek and Crooked Creek are not included in this table because the USC stressor summary table is undergoing revision. We are expecting a final draft very soon.

## Pollutant sources

This section summarizes the sources of pollutants (such as phosphorus, bacteria or sediment) to lakes and streams in the Kettle and Upper St. Croix River Watersheds, including point sources (such as sewage

treatment plants) or nonpoint sources (such as runoff from the land). HSPF model results were used to evaluate the relative magnitude of non-point versus point sources in both major watersheds as demonstrated in Table 8. In general, non-point source pollution represents the dominant pathway for nutrient export to the majority of streams and lakes throughout each major watershed. More information about the HSPF model is provided in Section 3.2 of this report.

**Table 8: HSPF estimated source contributions (percent of total) of total phosphorus for each major HUC-10 subwatershed in the Kettle River and Upper St. Croix River Watersheds**

| | Non-point Sources | | | | | |
|---|---|---|---|---|---|---|
| **HUC-10 Subwatershed** | **Forest and Wetland** | **Pasture and Grassland** | **Cropland** | **Developed** | **Stream Bed/ Bank** | **Point Sources** |
| Upper Kettle River | 29% | 48% | 12% | 7% | 1% | 2% |
| Moose River | 18% | 33% | 10% | 13% | 2% | 24% |
| Willow River | 27% | 35% | 9% | 12% | 17% | 0% |
| Pine River | 20% | 31% | 21% | 6% | 2% | 21% |
| Grindstone River | 10% | 31% | 29% | 7% | 6% | 18% |
| Lower Kettle River | 20% | 37% | 30% | 11% | 2% | 0% |
| ***Kettle River Watershed Total*** | **21%** | **37%** | **19%** | **9%** | **4%** | **10%** |
| Bear Creek | 22% | 45% | 19% | 7% | 1% | 7% |
| Sand Creek | 24% | 32% | 38% | 6% | 1% | 0% |
| Crooked Creek | 27% | 31% | 37% | 4% | 1% | 0% |
| Lower Tamarack River | 64% | 24% | 2% | 7% | 3% | 0% |
| Upper Tamarack River | 52% | 33% | 5% | 8% | 2% | 0% |
| Chases Brook | 40% | 34% | 8% | 13% | 4% | 0% |
| ***Upper St. Croix River Watershed Total*** | **34%** | **32%** | **24%** | **7%** | **2%** | **1%** |

The Kettle and Upper St. Croix River Watershed TMDL Study (MPCA 2020c) identified the relative contribution of point and non-point phosphorus sources to the watershed's impaired lakes. The TMDL study also identified point and non-point bacteria and sediment sources to the watershed's impaired streams. Below is a brief discussion of the major point and non-point sources that have been identified in these watersheds.

### Point Sources

Point sources are defined as facilities that discharge stormwater or wastewater to a lake or stream and have a National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit (Permit). There are nine permitted municipal wastewater treatment facilities (WWTF) and one industrial WWTF in the Kettle and Upper St. Croix River Watersheds (Table 9). There is only one NPDES/SDS permitted facility, Hinckley WWTP, whose surface discharge stations fall within an *E. coli* impaired stream subwatershed (Grindstone River Reach 501). An individual WLA was provided for this facility in the TMDL study, although it does not require any changes to the facility's discharge permit limits.

**Commented [ST(12]:** I don't see any figures showing permitted point sources… We should include one.

**Table 9: Point Sources in the Kettle River and Upper St. Croix River Watersheds.**

| HUC-10 Subwatershed | Name | Permit # | Type | Pollutant Reduction Required |
|---|---|---|---|---|
| Upper Kettle River | Kettle River WWTP | MNG580183 | Domestic | No |
| | Barnum WWTP | MNG580142 | Domestic | No |
| | Aitkin Agri-Peat Inc | MN0055662 | Industrial | No |
| Moose River | Sturgeon Lake WWTP | MN0067270 | Domestic | No |
| | Moose Lake WWTP | MN0020699 | Domestic | No |
| Pine River | Finlayson WWTP | MNG580203 | Domestic | No |
| Grindstone River | Hinckley WWTP | MN0023701 | Domestic | No |
| Lower Kettle River | Sandstone WWTP | MNG580213 | Domestic | No |
| Bear Creek | Askov WWTP | MNG580229 | Domestic | No |

### Non-Point Sources

Nonpoint sources of pollution, unlike pollution from industrial and municipal sewage treatment plants, come from many diffuse sources. Nonpoint source pollution is accumulated by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries natural and human-made pollutants, finally depositing them into lakes and streams. Common nonpoint pollutant sources in the Kettle and Upper St. Croix River Watersheds include:

- **Watershed runoff**: Erosion from agricultural fields and forests can deliver sediment to waterbodies that contains nutrients when soil is disturbed or exposed to wind and rain. Runoff from roads, parking lots and other impervious surfaces can also carry pollutants to lakes and streams. The HSPF model was used to estimate watershed runoff volumes and pollutant loads for all subwatersheds in the Kettle and Upper St. Croix River Watersheds. The HSPF model is based on land cover and soil type, and was calibrated using meteorological data from 1996 through 2009.
- **Wetlands**: Phosphorus export from wetlands is a well-known phenomenon in northern Minnesota wetlands (O'Brien et al. 2013; Fristedt 2004; Dillon and Molot 1997; Banaszuk et al. 2005). Several of the impaired lakes in the watershed are located in watersheds with wetland-dominated tributaries. At this time, it is not known if these wetlands are major contributors to downstream impairments. Monitoring of these wetland tributaries would help determine if they are exporting elevated levels of phosphorus and/or other pollutants.
- **Upstream lakes and streams**: A few of the impaired lakes receive a significant amount of their phosphorus load from upstream lakes and major stream reaches. For these lakes, restoration and protection efforts should focus on improving the water quality of the upstream lakes and streams.
- **Runoff from feedlots**: Fertilizer and manure contain high concentrations of phosphorus, nitrogen, and bacteria that can run off into lakes and streams when not properly managed.
- **Failing septic systems**: Septic systems that are not maintained or are failing near a lake or stream can contribute excess phosphorus, nitrogen, and bacteria.
- **Atmospheric deposition**: Atmospheric deposition represents the phosphorus that is bound to particulates in the atmosphere and is deposited directly onto surface waters.

- **Lake internal loading**: Lake sediments and macrophytes contain large amounts of phosphorus that can be released into the lake water through physical mixing or under certain chemical conditions or during the senescence of macrophytes. Internal loading of phosphorus can also occur through sediment resuspension by rough fish such as common carp and black bullheads.
- **Artificial drainage and stream morphometry**: An increase in artificial drainage combined with stream channelization can lead to streambank instability, reduced base flow, and longer periods of intermittent flow.
- **Timber harvesting**: Forest harvest has been and currently is a major activity within the Kettle and Upper St. Croix River Watersheds. Historical large-scale forest removal occurred in the watershed which may have created legacy effects still being experienced by streams and lakes today.

## 2.4 TMDL summary

A TMDL is a calculation of how much of a pollutant a lake or stream can receive before it does not meet state water quality standards. These standards define pollutant concentrations in terms of beneficial uses that a given water can support, which include aquatic recreation and aquatic life. TMDL studies are required by the Clean Water Act for all impaired lakes and streams. The Kettle and Upper St. Croix River Watershed TMDL Report was drafted in 2019 and 2020 in conjunction with this WRAPS document, and addresses 12 impaired lakes and 11 impaired streams throughout the Kettle and Upper St. Croix River Watersheds (Table 10). A majority of the impairments addressed in the TMDL study are located in the Pine River and Grindstone River HUC-10 Subwatersheds. For more details, refer to the TMDL document on the MPCA webpage (provide link here). See Appendix B for the existing pollutant loading, load/wasteload allocations, and the load reduction goals needed to meet water quality standards.

Impairments not caused by pollutants, for example aquatic life use impairment for macroinvertebrate IBI caused by degraded physical habitat, were not addressed through the TMDL process. Loading computations (TMDLs) are not required or appropriate for such impairments. The strategies in Section 3 of this report also cover streams and lakes with non-TMDL related impairments.

**Table 10: Summary of impaired lakes and streams with completed TMDLs in the Kettle River and Upper St. Croix River Watersheds.**

| HUC-10 Subwatershed | Stream or Lake Name | Reach AUID or Lake ID | Pollutant(s) |
|---|---|---|---|
| Upper Kettle River | Kettle River | 07030003-529 | *E. coli* |
| | Split Rock River | 07030003-513 | *E. coli* |
| | Merwin Lake | 09005800 | Excess Nutrients |
| Moose River | Twentynine Lake | 09002200 | Excess Nutrients |
| Willow River | Oak Lake | 58004800 | Excess Nutrients |
| Pine River | Pine River | 07030003-631 | *E. coli* |
| | Pine Lake | 01000100 | Excess Nutrients |
| | Big Pine Lake | 58013800 | Excess Nutrients |
| | Eleven Lake | 33000100 | Excess Nutrients |
| | Fox Lake | 58010200 | Excess Nutrients |
| | Rhine Lake | 58013600 | Excess Nutrients |

| HUC-10 Subwatershed | Stream or Lake Name | Reach AUID or Lake ID | Pollutant(s) |
|---|---|---|---|
| Grindstone River | N. Branch Grindstone River | 07030003-541 | *E. coli* |
| | Unnamed Creek | 07030003-546 | *E. coli* |
| | S. Branch Grindstone River | 07030003-516 | *E. coli* |
| | Judicial Ditch 1 | 07030003-526 | *E. coli* |
| | N. Branch Grindstone River | 07030003-544 | *E. coli* |
| | Spring Creek | 07030003-550 | *E. coli* |
| | Grindstone River | 07030003-501 | *E. coli* |
| | Elbow Lake | 58012600 | Excess Nutrients |
| | Grindstone Lake | 58012300 | Excess Nutrients |
| Lower Kettle River | McCormick Lake | 58005800 | Excess Nutrients |
| Sand Creek | Sand Creek | 07030003-538 | TSS |
| Lower Tamarack River | Grace Lake | 58002900 | Excess Nutrients |

**Commented [ST(13]:** Note to revisit this reach after natural background (4D) is advanced to the assessment group.

## 2.5 Protection considerations

Many of the lakes and streams in the Kettle and Upper St. Croix River Watersheds already meet or exceed water quality goals. Protecting water quality from degrading is typically more cost effective than trying to restore degraded waters. This section provides a brief discussion of some of the tools, reports, and information that is available to guide protection efforts in the Kettle and Upper St. Croix River Watersheds. All of the items highlighted below are based on input and work done by state agencies and local partners and were used to guide the identification and prioritization of strategies in Section 3.3.

### Stream Protection

The Kettle River is designated as a Minnesota State Wild and Scenic River. This program was established in 1973 to protect rivers which have outstanding natural, scenic, geographic, historic, cultural, and recreational values. As such, preservation and restoration of continuous natural vegetation within the Kettle River riparian corridor and preservation of floodplains is critical to protecting and preserving wildlife, water quality, flood abatement and the scenic nature of the river.

The Kettle River Watershed Landscape Stewardship Plan was developed to help private parties and public agencies to protect and enhance forest and water resources in the watershed. The key finding of the plan includes a focus on seven subwatersheds in the Kettle River watershed for future strategic landscape planning and project implementation that opportunities for improved water quality. The Kettle River Watershed Landscape Stewardship Plan is described in more detail later in this document.

Through the IWM process, 34 stream segments were assessed for aquatic life and/or aquatic recreation. Generally, it was found that the streams of the Upper St. Croix are among the most biologically intact, healthy and resilient of any watershed in Minnesota with aquatic life use (AQL) standards being met on 93% of streams that were assessed for fish and macroinvertebrates.

Further, the 2019 Kettle River Watershed Monitoring and Assessment Report states that water quality conditions throughout the Kettle River Watershed as generally categorized as good to great. Aquatic life

(AQL) use standards were met on 78% of the assessed stream reaches. Aquatic recreation (AQR) use standards were met on only 46% of stream reaches sampled for E. coli bacteria.

Recently, the MPCA, DNR, and other state agencies worked together to develop a Stream Protection and Prioritization Tool that can be used to generate a prioritized list of streams. This tool, and its application in the Kettle and Upper St. Croix River Watersheds, is discussed in more detail in Section 3.1.

## Lake Protection

As stated above, in 2016 the Minnesota Pollution Control Agency (MPCA) began the two-year IWM project in the Upper St. Croix River Watershed. The project was designed to assess the quality of the streams and lakes in the watershed through both biological and water chemistry monitoring. Overall, four lakes were assessed for aquatic life and/or aquatic recreation. Generally, it was found that the lakes within the Upper St. Croix River Watershed are among the most biologically intact, healthy and resilient of any watershed in Minnesota.

Further, the 2019 Kettle River Watershed Monitoring and Assessment Report states that water quality conditions throughout the Kettle River Watershed as generally categorized as good to great. Aquatic life (AQL) use standards are met on 61% of the lakes sampled for fish. However, mercury in fish tissue remains a concern, with 13 of the 16 tested lakes listed as impaired for high mercury. Of the 13 lakes, 9 have high enough levels for the Minnesota Statewide Mercury TMDL. Along with Mercury, fish tissues were tested for polychlorinated biphenyls (PCBs) at 7 lakes. None of these samples came back with a detectable level of PCB.

**Commented [ST(14]:** See comment in Executive Summary relating to Hg. (The other four lakes are not in the statewide Hg TMDL.)

Below is a list of studies, data, modeling tools, designations, local knowledge, and criteria that is available and should be considered when prioritizing lakes for protection in the Kettle and Upper St. Croix River Watersheds. Refer to Section 3 for information and details regarding the specific lakes that meet the protection criteria and categories listed below.

**Commented [JDS15]:** Note: this part could be moved down to the priorities section in Section 3 when that is written if it makes more sense

- Lakes with high recreational value/use identified by local stakeholders (XX lakes in Kettle; XX lakes in Upper St. Croix)
- Lakes barely meeting water quality standards and therefore have been identified as “vulnerable” by MPCA (6 lakes in Kettle)
- Lakes demonstrating decreasing trends in water clarity (2 lakes in Kettle)
- Lakes currently not meeting State standards for Lake Fish IBI and/or Plant IBI (4 lakes in Kettle; 2 lakes in Upper St. Croix)
- DNR Lakes of Biological Significance (16 lakes in Kettle; 7 lakes Upper St. Croix)
- DNR Lake Benefit:Cost Assessment Score (See Section 3.1 for more details) (5 lakes in Kettle scored in the “Higher” or “Highest” categories in terms of cost benefit)
- DNR Level 8 Subwatershed Habitat Strategy (33 lakes assessed in Kettle; 11 lakes assessed in Upper St. Croix)
- DNR designated Wild Rice Lakes – see discussion below (15 lakes in Kettle; 2 lakes in Upper St. Croix)
- DNR designated Cisco Refuge Lakes (2 lakes in Kettle)
- DNR designated Stream Trout Lakes (1 lake in Kettle)
- DNR designated Muskie Lake (1 lake in Kettle)

**Commented [ST(16]:** To be discussed at the LWG meeting; not a comprehensive list, but my initial thoughts:
Big Pine/Pine, Grindstone, Windemere Township lakes in Pine Co., Moose Lake area lakes

- MPCA-DNR Lake Phosphorus Sensitivity Analysis (See Section 3.1 for more details) (25 lakes in Kettle scored in the "Higher" or "Highest" categories for sensitivity; 2 lakes in Upper St. Croix scored in the "Higher" or "Highest" categories)
- MPCA-DNR Lake Protection and Prioritization Tool (See Section 3.1 for more details) (10 high priority lakes identified in Kettle; 1 high priority lake in Upper St. Croix identified)

## Watershed Protection Framework for Minnesota Lakes

Lake water quality depends largely on watershed land use. Agricultural and urban runoff contains significantly more nutrients such as phosphorus and nitrogen than undisturbed forests, grasslands, and wetlands. These nutrients increase algal growth, which is a primary driver for water quality in lakes. Catchments with undisturbed lands lie primarily in the forested ecoregions and generally provide good water quality.

In an effort to prioritize protection and restoration efforts of fishery lakes, the DNR has developed a ranking system by separating lakes into two categories, those needing protection and those needing restoration. Modeling by the DNR Fisheries Research Unit suggests that total phosphorus concentrations increase significantly over natural concentrations in lakes that have watershed with disturbance greater than 25%. Therefore, lakes with watersheds that have less than 25% disturbance need protection and lakes with more than 25% disturbance need restoration (Table 11). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land, public water, wetlands, or conservation easement.

**Table 11: Suggested approaches for watershed protection and restoration (source: DNR).**

| Watershed Disturbance (%) | Watershed Protection (%) | Management Strategy | Comments |
|---|---|---|---|
| < 25% | > 75% | Vigilance | Sufficiently protected -- Water quality supports healthy and diverse native fish communities. Keep public lands protected. |
| | < 75% | Protection | Excellent candidates for protection -- Water quality can be maintained in a range that supports healthy and diverse native fish communities. Disturbed lands should be limited to less than 25%. |
| 25% - 60% | n/a | Full Restoration | Realistic chance for full restoration of water quality and improve quality of fish communities. Disturbed land percentage should be reduced and BMPs implemented. |
| > 60% | n/a | Partial Restoration | Restoration will be very expensive and probably will not achieve water quality conditions necessary to sustain healthy fish communities. Restoration opportunities must be critically evaluated to assure feasible positive outcomes. |

The next step was to prioritize lakes within each of these management categories. DNR Fisheries identified high value fishery lakes, such as cisco refuge lakes. Ciscos (*Coregonus artedi*) can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. These watersheds with low disturbance and high value fishery lakes are excellent candidates for priority protection measures, especially those that are related to forestry and minimizing the effects of landscape disturbance. Forest stewardship planning, harvest coordination to

reduce hydrology impacts and forest conservation easements are some potential tools that can protect these high value resources for the long term.

Figure 3 shows the general management strategy for each HUC-12 subwatershed in the Kettle and Upper St. Croix River Watersheds using the DNR approach described above. A majority of the HUC-12 subwatersheds in the Kettle and Upper St. Croix fall into the "protection" management category. This suggests that primary strategies for both watersheds should focus on limiting human disturbance and enhancing and protecting un-disturbed land through forest stewardship plans, conservation easements, public land acquisition, and other tools discussed in Section 3.3.

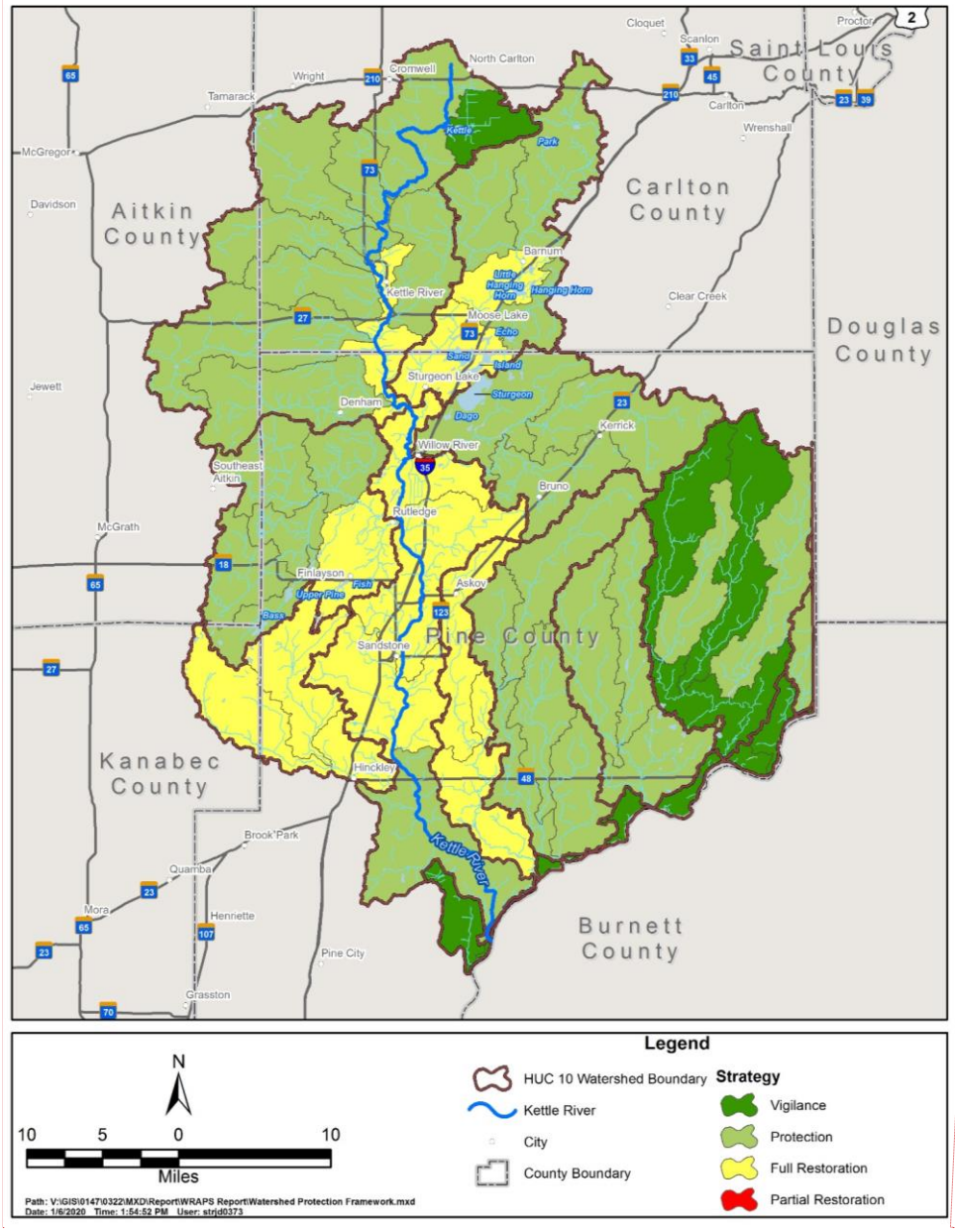



**Figure 3: Subwatershed restoration and protection strategies for the Kettle and Upper St. Croix River Watersheds**

**Commented [ST(17]:** Map legend doesn't include HUC12 boundaries

## Wild Rice and Tribal Lands

A relatively small portion of the Kettle River Watershed falls within the reservation lands of the Fond du Lac Band of Lake Superior Chippewa (Figure 4). This portion includes the northernmost extent of the Moose River HUC-10 subwatershed and a very small part (approximately 280 acres), of the northeastern Upper Kettle River subwatershed (Figure 12).

The Fond du Lac Band of Lake Superior Chippewa has federal Clean Water Act jurisdiction for Sections 106, 319, 303(c) and 401 for waters of the Reservation, and is active in watershed management and water quality restoration on the Reservation and in the 1854 Ceded Territory. The Fond du Lac Band has established water quality standards for its waters and implements a water quality monitoring, assessment, protection, and restoration program on the Reservation[1]. Waterbodies under jurisdiction of the Fond du Lac Band addressed in this WRAPS report include Manoomini-zaaga'iganing/Wild Rice Lake (AUID 09-0023-00) and the uppermost reach of the Moose Horn River (AUID 07030003-535).

**Commented [ST(18]:** Note to revisit this superscript when the report is closer to being published

Manoomini-zaaga'iganing/Wild Rice Lake is the headwaters of the Moose Horn River and listed as an Outstanding Reservation Resource Water by the Fond du Lac Band. The importance of the lake to the Fond du Lac Band is further codified through its wild rice cultural use designation. This cultural use designation is defined as "A stream, reach, lake or impoundment, or portion thereof, presently, historically or with the potential to be vegetated with wild rice" (Fond du Lac Band of Lake Superior Chippewa, Ordinance #12/98, as amended, 2001).

Wild rice, known as *manoomin* in Anishinaabemowin, is a significant and sacred spiritual and cultural resource to the Chippewa (also known as Ojibwe) people. Wild rice is part of the Ojibwe migration story, and Ojibwe and others have gathered wild rice for generations. Tribal rights to harvest wild rice are enshrined in treaties. Harvesting, preparing, sharing, and selling wild rice are important cultural, spiritual, and social activities to the Ojibwe people and other Native American groups in Minnesota. In addition to its immense importance to humans, wild rice is also an important food source for wildlife (Vennum 2004).

In addition to the Fond du Lac Band's Reservation lands, multiple Mille Lacs Band of Ojibwe trust lands are located throughout the Kettle River and Upper St. Croix River Watersheds (Figure 4). The Mille Lacs Band uses these lands for multiple purposes and they are important to tribal natural resource, economic, and environmental programs. Beyond lands directly affiliated with Tribal Nations, the entirety of both watersheds is ceded territory under two treaties between the United States government and signatory Ojibwe Bands—the Treaty of 1837 and the Treaty of 1854. These treaties secured the rights of Ojibwe people to hunt, fish, and gather within these ceded territories. The 1854 Treaty Authority is a tribal natural resources agency that manages off-reservation hunting, fishing and gathering in the 1854 Ceded Territory on behalf of the Bois Forte and the Grand Portage Band of Lake Superior Chippewa.

Wild rice grows in many waterbodies throughout the Kettle River and Upper St. Croix River watersheds (Figure 4). Given wild rice's significance to Native Americans, tribal organizations conduct research and monitoring on wild rice and are actively involved in wild rice management and restoration. Additional information on some of these efforts within the Kettle River and Upper St. Croix River watersheds can be found on the 1854 Treaty Authority's website: http://www.1854treatyauthority.org/wild-rice/wild-rice.html.

During the development of this WRAPS report, staff from the Fond du Lac Band's Office of Water Protection collaborated with MPCA staff to share data and develop strategies to protect and improve the water quality and associated designated uses of Manoomini-zaaga'iganing/Wild Rice Lake. Based on the Fond du Lac Band's 2018 assessment, Manoomini-zaaga'iganing/Wild Rice Lake fully supports the Band's wild rice cultural use designation from a water quality standpoint. The lake is listed as impaired for mercury under the Band's Wildlife Designated Use. At the time of this report's writing, the Fond du Lac Band was updating its Nonpoint Source Assessment Report and Management Plan, and Tribal staff indicated that Manoomini-zaaga'iganing/Wild Rice Lake will be classified as severely impaired from a nonpoint source standpoint in the updated report. Tribal staff have indicated that the wild rice population in Manoomini-zaaga'iganing/Wild Rice Lake has significantly declined over the past 20 years, and they attributed this decline in wild rice to high water levels in the lake.

Wild rice grows in shallow water from one to three feet deep and is sensitive to changing water levels (1854 Treaty Authority, http://www.1854treatyauthority.org/wild-rice/biology-of-wild-rice.html). A likely contributing factor to high water levels in Manoomini-zaaga'iganing/Wild Rice Lake is beaver activity in the low-gradient reach of the Moose Horn River downstream of the lake's outlet. In 2019, the Minnesota Department of Transportation (MNDOT) assessed the culvert under State Highway 210 that is directly downstream of Manoomini-zaaga'iganing/Wild Rice Lake and concluded that it is functioning properly. Using historic aerial photos, hydrologic models, state records on culvert maintenance at this location, and in-person observations, MNDOT and Fond du Lac Resource Management jointly concluded that the main reason for sustained high water in the lake is due to tailwater effects from a series of beaver dams downstream of the lake (personal communication; Fond du Lac Reservation 2004). Increased precipitation due to climate change is another potential contributing factor. Strategies to address the decline of wild rice in Manoomini-zaaga'iganing/Wild Rice Lake identified in discussion with tribal staff include improving hydrologic connectivity and potential water level management and are described in further detail strategy table for Moose River subwatershed (Table 15).

For more information, please see the following websites:

- Fond du Lac Band of Lake Superior Chippewa Resource Management, Water Quality: http://www.fdlrez.com/RM/waterquality.htm
- Water Quality Standards Regulations, EPA: https://www.epa.gov/wqs-tech/water-quality-standards-regulations-fond-du-lac-band-minnesota-chippewa-tribe
- The Fond du Lac Band of the Minnesota Chippewa Tribe Water Quality Standards: https://www.epa.gov/sites/production/files/2014-12/documents/chippewa-tribe.pdf

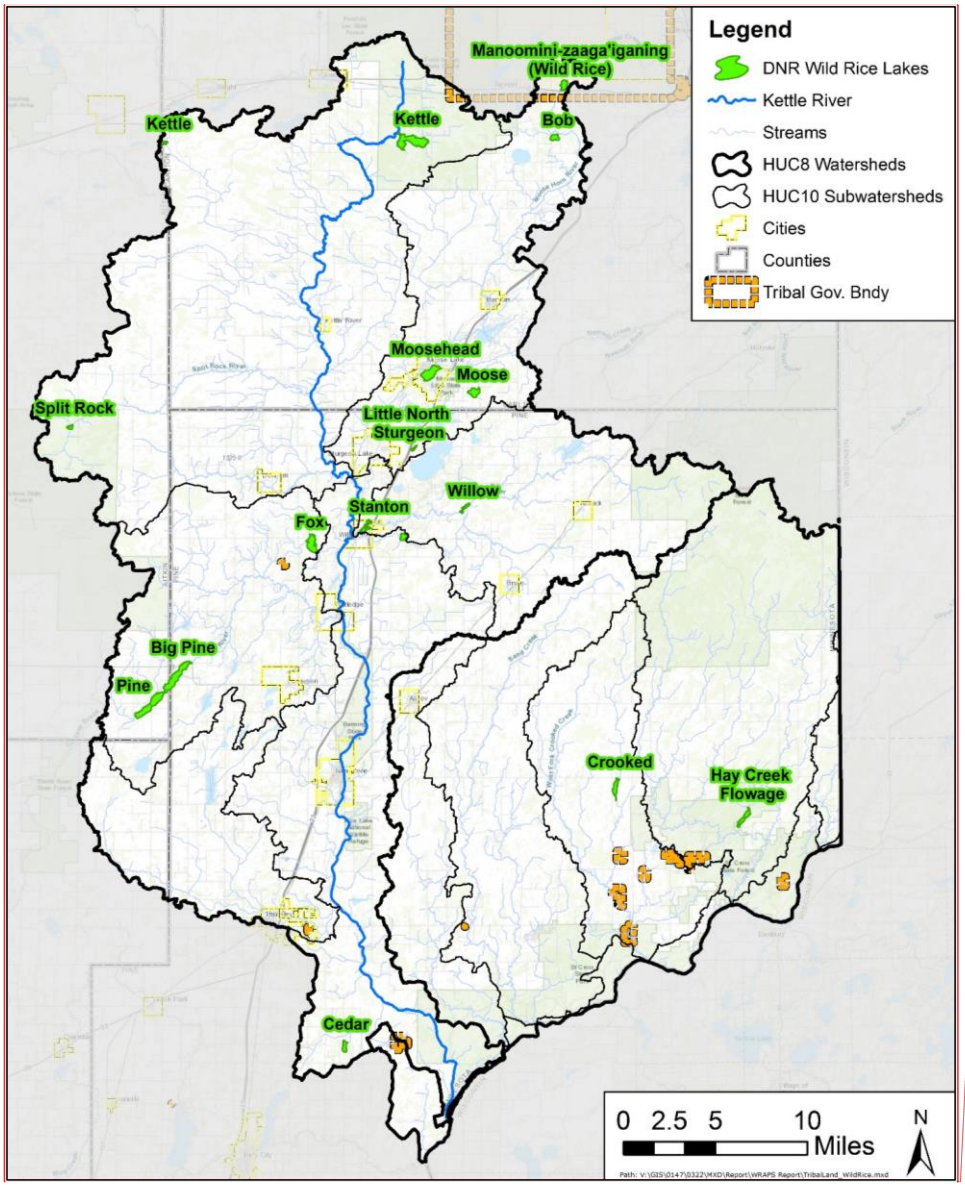



**Figure 4: Tribal land and wild rice lakes in the Kettle and Upper St. Croix River Watersheds**

**Commented [ST(19]:** We should show ceded territory under the Treaty of 1837 and the Treaty of 1854 here. (Should be able to add to the map easily enough as a background with relatively high transparency)

**Commented [ST(20R19]:** Data available from GLIFWC's (Great Lakes Indian Fish & Wildlife Commission) website: http://data.glifwc.org/ceded/downloads/ceded_territories_v2_1.zip (references/metadata/info is listed here: https://data.glifwc.org/ceded/)

## Groundwater and Drinking Water

Portions of the Kettle and Upper St. Croix River Watersheds are important for recharge of regional aquifers, including those serving the towns and small communities throughout the watershed. It is important to keep water on the land in these areas, and certain areas sensitive to groundwater pollution should not host pollutant-generating facilities.

The Environmental Health Division of the Minnesota Department of Health administers numerous programs of interest to local water management planning including drinking water protection and wellhead protection among others (link to more information).

The following table illustrates the number and size of Well Head Protection Areas (WHPAs) and Drinking Water Supply Management Areas (DWSMAs) within the 12 HUC-10 subwatersheds. The table also includes the area in acres that are vulnerable to groundwater contamination and identified karst areas in acres by subwatershed.

**Table 12. Summary of groundwater and drinking water features in the Kettle and Upper St. Croix River Watersheds**

| HUC-10 Subwatershed | WHPAs / DWSMAs (count) | WHPA (acres) | DWSMA (acres) | Vulnerable Groundwater Areas (acres) | Karst Areas (acres) |
|---|---|---|---|---|---|
| Upper Kettle River | 1/1 | 34 | 120 | 20,621 | 0 |
| Moose River | 6/6 | 1,848 | 3,197 | 34,470 | 0 |
| Willow River | 1/1 | 8 | 33 | 37,297 | 23,313 |
| Pine River | 1/1 | 160 | 501 | 27,933 | 12,967 |
| Grindstone River | 2/1 | 445 | 855 | 28,520 | 13,437 |
| Lower Kettle River | 2/2 | 146 | 254 | 67,508 | 53,843 |
| Bear Creek | 1/1 | 297 | 589 | 12,161 | 11,522 |
| Sand Creek | 1/1 | 148 | 266 | 23,012 | 21,165 |
| Crooked Creek | 0/0 | -- | -- | 0 | 0 |
| Lower Tamarack River | 0/0 | -- | -- | 0 | 0 |
| Upper Tamarack River | 0/0 | -- | -- | 0 | 0 |
| Chases Brook | 0/0 | -- | -- | 0 | 0 |

Further, Figure 5 below depicts the geographic location and extent of the WHPAs, DWSMAs, vulnerable groundwater areas, and areas prone to development of karst features. Karst features like sinkholes are present within the watershed. Sinkholes are closed depressions in the landscape that act as direct conduits for surface waters to enter subsurface geological units. A Sinkhole Distribution study was conducted by the Department of Geology and Geophysics at the University of Minnesota in 2001. Approximately 245 sinkholes were mapped in north-central Pine County. The project began as a survey of sinkholes in Partridge Township but expanded northeast into Bruno Township and southwest into Sandstone Township. Protection strategies that should be considered for karst areas within these watersheds include:

- Further identifying karst features by expanding the existing inventory
- Increasing monitoring or targeting existing local monitoring in karst areas

- Increasing vegetative buffers around sinkholes, stream-sinks, karst outcroppings
- Managing for septic compliance, relating back to the larger watershed-wide theme/focus on septic issues
- Education and outreach to farmers and feedlot operators regarding nutrient management in karst areas and areas with vulnerable groundwater

MDA has developed the Groundwater Protection rule to minimize potential sources of nitrate pollution to the state's groundwater and protect drinking water. "The rule restricts fall application of nitrogen fertilizer in areas vulnerable to contamination, and it outlines steps to reduce the severity of the problem in areas where nitrate in public water supply wells is already elevated" (MDA 2020). More information can be found on the MDA website.

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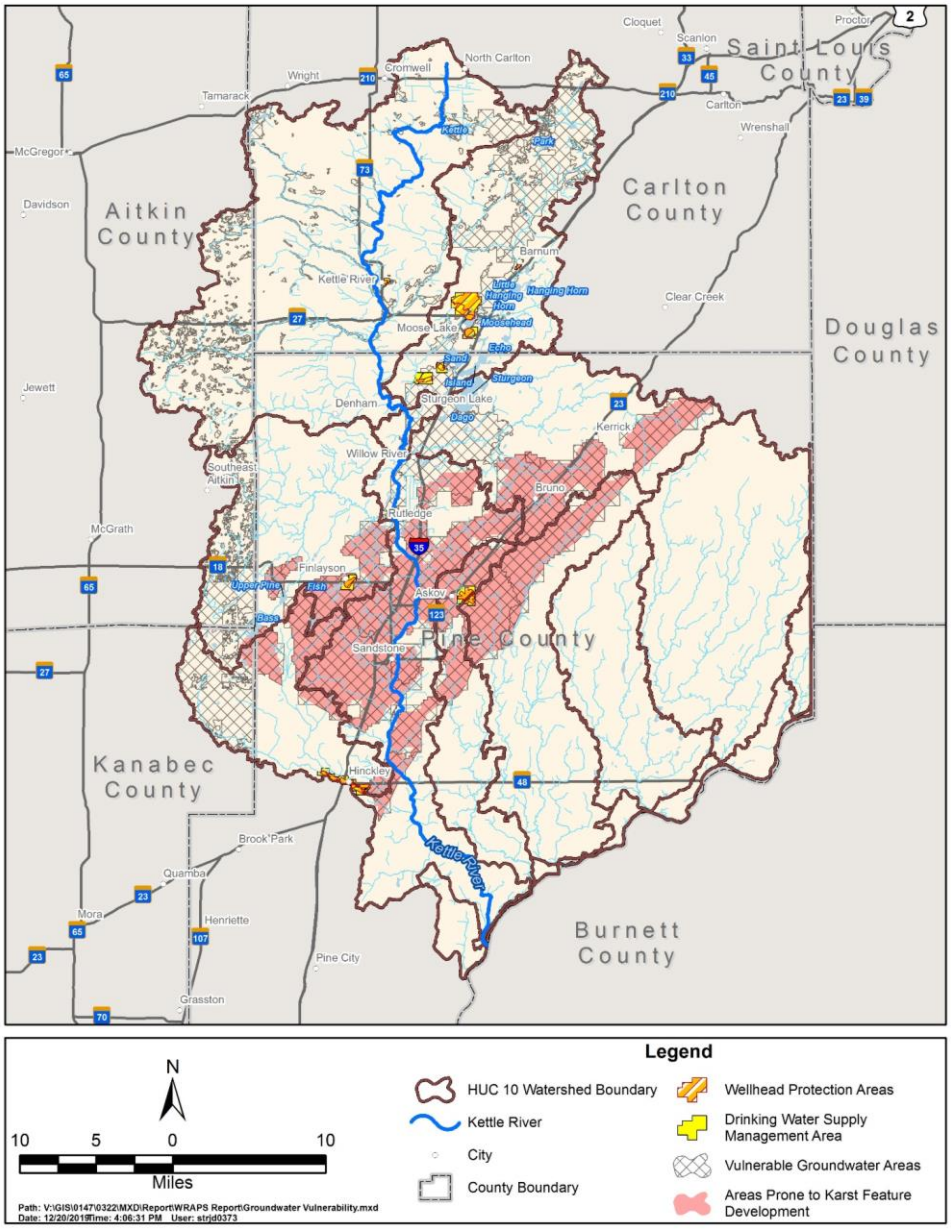
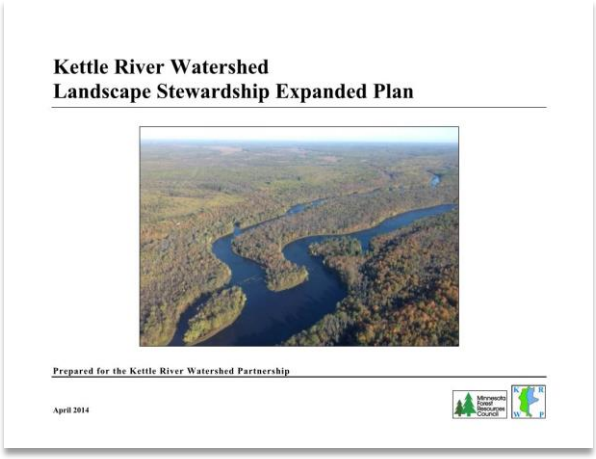



**Figure 5: Kettle and Upper St. Croix River WHPAs, DWSMAs, vulnerable groundwater areas and areas prone to karst**

## Kettle River Watershed Landscape Stewardship Plan

The Kettle River Watershed Landscape Stewardship Plan was developed to help private parties and public agencies to protect and enhance forest and water resources in the watershed. Key themes of the Plan focused on partners and partnerships, implementation programs and priorities, training and funding and engagement of communities and landowners within the watershed. A team of resource professionals was assembled to guide the development of the Plan. The team included a comprehensive array of professionals including: The Nature Conservancy, the Minnesota Forest Resources Council, Natural Resource Conservation Service, United States Forest Service, WIDNR, MNDNR, county and SWCD staff, members of the St. Croix Tribe and the St. Croix River Association among others.

The primary focus of landscape stewardships plans is forest resources. However, the framework of this Plan recognized the critical connection of management of forest resources with the management of water resources and recreational resources. The Plan outlines desired future conditions that include the protection and improvement of water quality the protection and improvement of forest resources, and attractive and engaging recreational resources across the watershed.




The Plan included a detailed subwatershed assessment for seven subwatersheds; the Lower Kettle River, Grindstone River, Pine River, Willow River, Moose River, Upper Kettle River and the Headwaters Kettle River. All of these subwatersheds are aligned with the HUC-10 subwatersheds used in this report, except for the "Upper Kettle River" and the "Headwaters Kettle River", which consist of two aggregated HUC-12 subwatersheds of what is just the Upper Kettle River subwatershed in this report. The subwatershed assessments included physical descriptions, key findings, and an overall subwatershed risk assessment ranking. The assessments were further summarized to help draw conclusions for management priorities.

The following goals and objectives pertaining to water and forest resources were borne from the process:

**Water Resources**:

- Protect healthy water systems and features,
- protect forested riparian corridors,
- protect undeveloped shorelands,
- advocate and support the implementation of protection BMPs,

- improve impaired water resources,
- implement projects to restore and improve native vegetation,
- work with partners and stakeholders to implement shoreland restoration projects,
- build coordination and share knowledge to advance water and forest resource management,
- work with counties and other partners to develop and implement forest management practices into County Water Plans, and
- work with counties and other partners to develop and implement lake management plans to include forest management practices, and monitor water quality.

**Forest Resources:**

- Protect healthy forest ecosystems,
- support the protection and maintenance of public forestlands using assessment criteria established in the subwatershed analyses,
- implement projects that protect and maintain private forestlands using priorities established in the subwatershed analyses,
- support and participate in programs and projects that promote proactive forest health practices,
- increase and restore native forest land cover,
- support the implementation of forest restoration projects on priority sites within each subwatershed,
- support efforts to prevent and manage invasive species,
- design and implement forest and other land-based restoration projects to maximize utilization of removed undesirable woody plant material,
- build coordination and share knowledge related to forest resources and management to protect and restore water quality and quantity,
- actively educate partners in the watershed about the watershed/forest land cover connection and its role in promoting water quality and quantity,
- support the expansion and effectiveness of local conservation groups, and
- advocate for sound land-use planning and recognition of forest resources in local planning and regulatory processes.

# 3. Prioritizing and implementing restoration and protection

The Clean Water Legacy Act (CWLA) requires that WRAPS reports summarize priority areas for targeting actions to improve water quality, and identify point sources and nonpoint sources of pollution with sufficient specificity to prioritize and geographically locate watershed restoration and protection actions. In addition, the CWLA requires including an implementation table of strategies and actions that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint sources.

This section of the WRAPS report provides the results of such prioritization and strategy development. Because many of the nonpoint source strategies outlined in this section rely on voluntary implementation by landowners, land users, and residents of the watershed, it is imperative to create social capital (trust, networks, and positive relationships) with those who will be needed to voluntarily implement best management practices (BMPs). Thus, effective ongoing civic engagement is fully a part of the overall plan for moving forward.

The implementation strategies, including associated scales of adoption and timelines, provided in this section are the result of watershed modeling efforts and professional judgment based on what is known at this time and, thus, should be considered approximate. Furthermore, many strategies are predicated on needed funding being secured. As such, the proposed actions outlined are subject to adaptive management—an iterative approach of implementation, evaluation, and course correction.

## 3.1 Targeting of geographic areas

The following section describes the information and tools gathered throughout the Kettle and Upper St. Croix River WRAPS project to develop restoration and protection strategies for the lakes and streams throughout each watershed. Follow-up field reconnaissance will be the next part of the process to validate the identified areas potentially needing work.

It is understood that management needs for the Kettle and Upper St. Croix River Watersheds exceed available resources, and therefore prioritization and focus is necessary to achieve goals in high priority areas. The following subsections provide several methods of prioritizing geographic areas. Later in the report, tables of management strategies were drafted to include those management approaches deemed most important. While this information provides substantial direction, it is expected that local water management authorities will further define the highest priority projects and geographic areas based on scientific, social, political, and financial considerations.

### Hydrologic Simulation Program-FORTRAN (HSPF)

HSPF is a large-basin, watershed model that simulates non-point source runoff and water quality in urban and rural landscapes. The Kettle and Upper St. Croix River HSPF model incorporates real-world meteorological data and is calibrated to real-world stream flow data. HSPF model development includes the addition of point source data in the watershed, including both domestic and industrial WWTFs.

HSPF was used to predict the relative magnitude of runoff, TSS, TP, and Total Nitrogen (TN) pollution generated in each subwatershed of both watersheds. The HSPF model was also used to evaluate the

extent of contributions from point, nonpoint, and atmospheric sources where necessary. Development of the HSPF model helps to better understand existing water quality conditions and predict how water quality might change under different land management practices and/or climatic changes at the subwatershed scale. HSPF also provides a means to evaluate the impacts of alternative management strategies to reduce these loads and improve water quality conditions. Runoff, TSS, TP, and TN yields predicted from the HSPF model in the Kettle and Upper St. Croix River Watersheds are mapped in Figure 6.

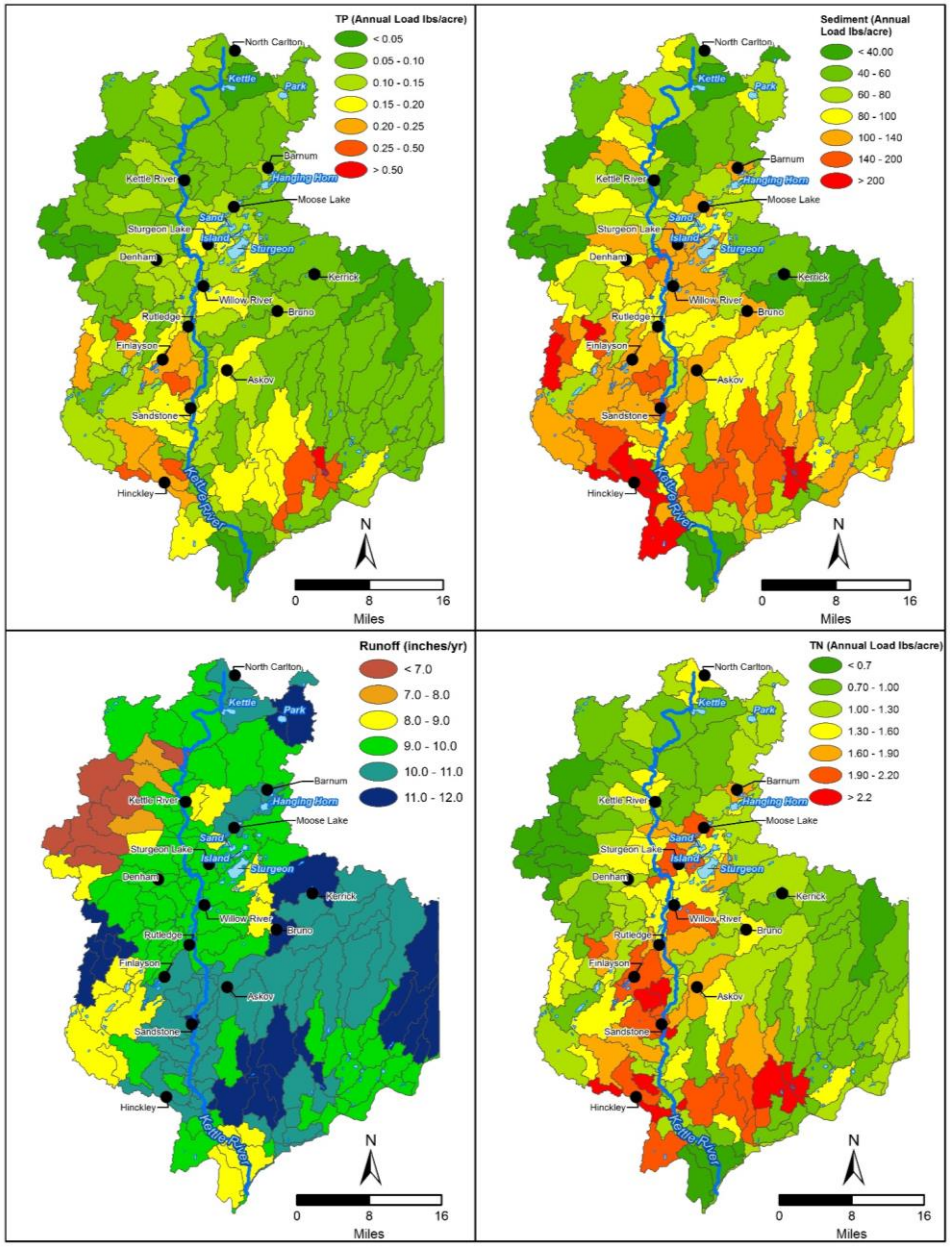



**Figure 6: Kettle and Upper St. Croix River Watershed HSPF-predicted runoff and pollutant loading by HUC-12 subwatershed**

## Stream Protection and Prioritization Tool

The MPCA, DNR, and other state agencies worked together to develop a Stream Protection and Prioritization Tool that can be used to generate a prioritized list of streams. The list is based on the results of water quality assessments, the level of risk posed from near shore areas, the level of risk posed from the contributing watershed, and the level of protection already in place in the watershed. The tool utilizes state-wide coverages; therefore, additional local information must be weighed including factors such as forest management practices, potential development trends and mining impacts.

The process is limited to streams that have water quality assessments that include fish and/or macroinvertebrates (bugs) and the streams must be meeting water quality standards – i.e., they are considered to be fully supporting of aquatic life. The first step considers how close these communities are to being impaired or degraded.

The second step looks at near shore (riparian) risks to healthy stream communities. In developing the tool, the following parameters were considered: the presence of steep slopes, percent altered streams, percent wetland loss, road density, population density, population change, feedlots, septic system density, and a variety of land use categories (percent agriculture, percent row crop, percent impervious surface, percent undeveloped). This analysis indicates that road density and disturbed land use (cultivated and urban uses) can best predict impacts or changes in stream biological health. These same risks are then also evaluated for the larger, upstream watershed.

The third step looks at how well protected the near shore areas and upstream watershed already are. To complete this step, analysis of lands in public ownership or with public easements is conducted.

A prioritized list of streams is then generated for the entire watershed. The list may then be further prioritizing by splitting out, or separately considering, modified streams (ditches), general use streams (good biology and habitat), and exceptional streams (best biological communities and habitat).

| Risk Factors | Impairment Risk Level | Rank |
|---|---|---|
| Road Density - Riparian<br>% Disturbed Land – Riparian | Low road density<br>Low % disturbed<br>Low Risk → High Risk | RIPARIAN RISK<br>(low) 3 2 1 (high) |
| Road Density – Watershed<br>% Disturbed Land – Watershed | Low road density<br>Low % disturbed<br>Low Risk → High Risk | WATERSHED RISK<br>3 2 1 |
| **Protective Factors** | | + |
| Current Protection – Riparian<br>Current Protection –Watershed | High % current riparian protection<br>High % current watershed protection<br>Low Risk → High Risk | CURRENT PROTECTION<br>3 2 1 |
| **IBI Threshold Proximity Factor** | | × |
| Number of communities close to IBI Impairment threshold | Neither Community / One / Both<br>Low Risk → High Risk | IBI THRESHOLD PROXIMITY<br>3 2 1 |
| **PROTECTION PRIORITY** | **Priority Level** | = |
| High Risk = High Priority Rank<br>Low Risk = Low Priority Rank | **Lower Priority** → **Higher Priority** | PROTECTION PRIORITY RANK<br>(lower priority) C B A (higher priority)<br>(low rank) 27 14 3 (high rank) |

**Figure 7: Stream protection and prioritization tool matrix**

The Stream Protection and Prioritization Tool was applied (where applicable) to non-impaired stream reaches throughout the Kettle and Upper St. Croix River Watersheds. Once all of the non-impaired stream reaches in each watershed were ranked and prioritized, they were grouped into priority categories by splitting the list into thirds; the top third are high (A) priority, the next third medium (B) priority, and the final third are low (C) priority. Thirty-two stream reaches in the Kettle River Watershed had the required data and information for assessment using the tool (Figure 9). Of these stream reaches, seven were identified as Priority A (highest priority for protection) since they are near the tipping point towards one or more impairments. The Priority A streams include four Exceptional Use streams: Little Pine Creek (560), the west branch of the Moose Horn River (628), Pine River (624) and Kettle River (505). Additionally, three General Use streams, the Grindstone River (501), the Moose Horn River (521), and Larson's Creek (548) also scored as high priority for protection efforts. The tool also identified 19 Priority B and six Priority C stream reaches.

Twenty-five stream reaches in the Upper St. Croix River Watershed had the required data and information for assessment using the tool. Of these reaches, two were identified as Priority A, nine as Priority B, and 14 as Priority C. The higher priority stream reaches include five Exceptional Use streams: Little Sand Creek, Bangs Brook, Sand Creek, Crooked Creek, and the Upper Tamarack River. In addition, one General Use stream, Kenney Brook, scored as high priority for protection efforts. While these streams currently meet standards, work done to maintain current condition is important to prevent future impairment. A detailed list of protection streams can be found in Appendix A.

## Lake Protection and Prioritization Tool

The MPCA and other state agencies have also developed a Lake Protection and Prioritization Tool to generate a prioritized list of protection lakes in each major watershed throughout the State. The analysis is based on water quality assessment results, the amount of clarity lost if phosphorus is added, the amount of land use disturbance, lake size, as well as what is known about current trends in water quality.

The process is limited to lakes that have completed water quality assessments and that are currently meeting water quality standards – i.e., they are considered fully supporting for aquatic recreation. The first step considers how much lake clarity would be lost with an increase of 100 pounds of phosphorus to the lake. This is also known as the lake's phosphorus sensitivity.

The second step considers the significance of this sensitivity – i.e., the likelihood that this increase in phosphorus would occur. Factors considered include the percentage of disturbed land use (cultivated and urban uses), the amount of surface area of the lake, the


**Figure ~~8~~7. Lake Protection and Prioritization Tool Framework**

current phosphorus concentration and loading to the lake, and the proximity of the lake to the impairment threshold. Any information on declining trends in water quality are also considered.

The third step for lakes results in a prioritized list of lakes, each with a load reduction goal. The goal is calculated as a 5% reduction in predicted phosphorus loading (pounds/year) for any given lake. The goal is not regulatory; it is intended to give local groups a value to aim for, in lieu of just maintaining current phosphorus levels. This provides a way to measure progress over time for a given lake; estimated load reductions in phosphorus can be tracked as new practices are implemented.

Once all of the non-impaired lakes in the watershed have been ranked and prioritized, they are grouped into priority categories. The top 25$^{th}$ percentile is the high (A) priority, 50 to 75$^{th}$ percentile is medium (B) priority, and the bottom half of the lakes are the lower (C) priority. Forty-three lakes in the Kettle River Watershed had the required data and information for assessment using the Lake Protection and Prioritization Tool (Figure 9). Of these lakes, 10 were identified as Priority A (highest priority for protection), 18 Priority B and 15 Priority C. Priority A lakes in the Kettle River Watershed include: Bear, Little Hanging Horn, Eddy Oak, Island, Sturgeon, Dago, Sand, Rhine, and Bass Lakes.

**Commented [ST(22]:** Nine lakes listed here; 10 priority A lakes in total

Thirteen lakes in the Upper St. Croix River Watershed had the required data and information for assessment using the tool (Figure 9). Of these lakes, one was identified as Priority A (Lena Lake), two as Priority B (Rock and Greigs), and 10 as Priority C. A detailed list of the priority protection lakes can be found in Appendix A.

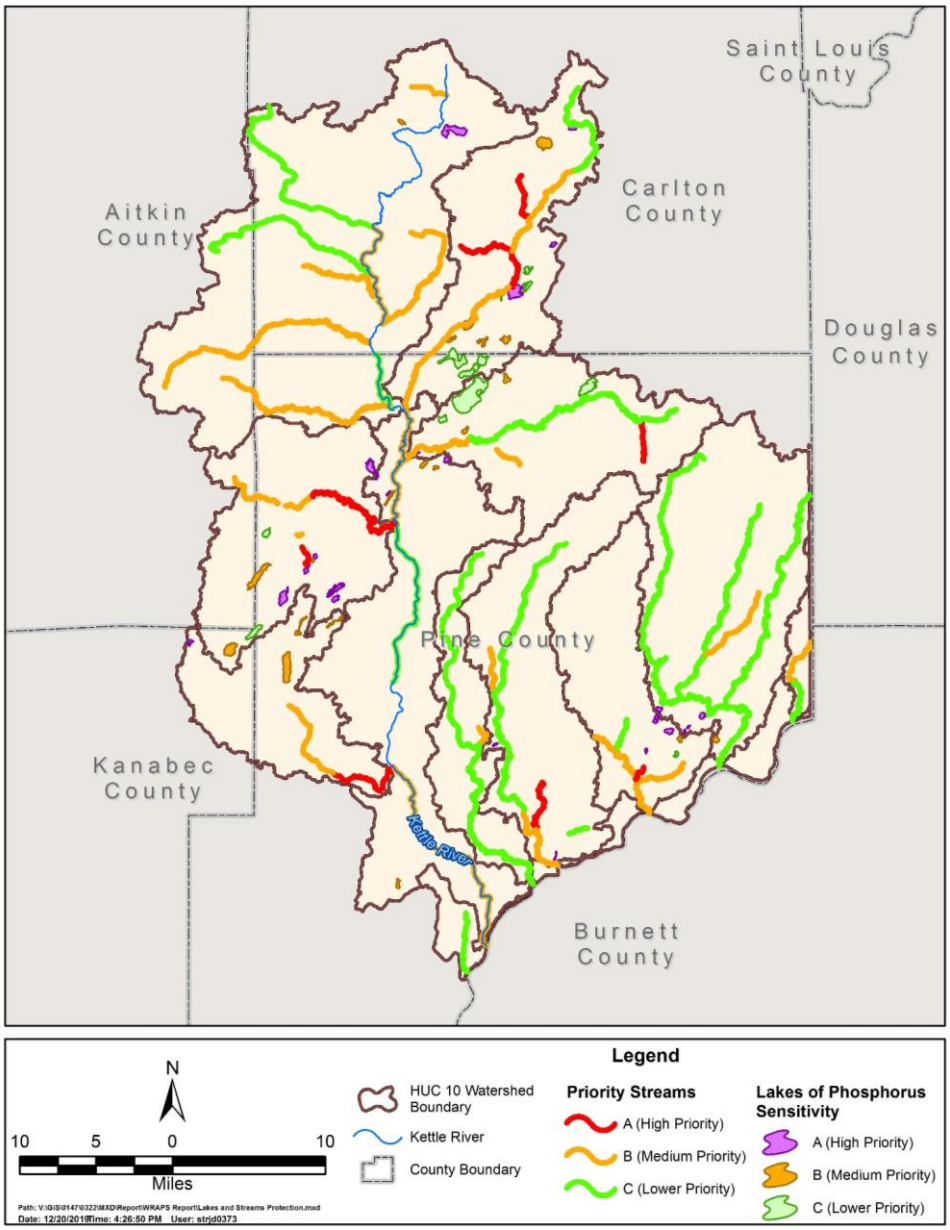
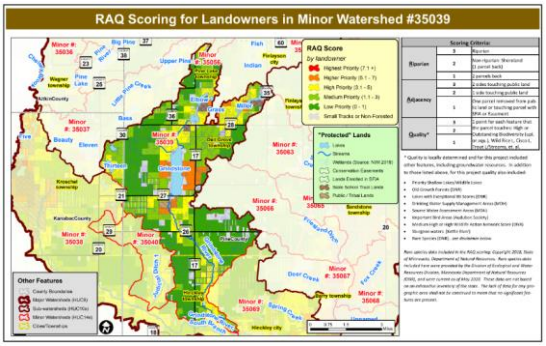



**Figure 9: Priority streams and lakes in the Kettle and Upper St. Croix River Watersheds identified using the MPCA Stream and Lake Protection and Prioritization Tools.**

## Riparian Adjacency Quality (RAQ) Tool

A methodology and GIS tool for targeting specific large tracts of forested land for protection strategies has been developed and referred to as RAQ, Riparian Adjacency Quality. This conservation-based analysis and subsequent scoring model places an emphasis on the forest-water interface. This forest-water interface, and the protection strategies that can be implemented to protect it, are critical for influencing water quality, habitat and other public benefits. The RAQ tool scores each private forested parcel on a 0-3 scale for each of common characteristics; "Riparian"--the parcels proximity to water, "Adjacency"--the parcels location in relation to contiguous tracts of protected/managed land in preference to parcels scattered across the landscape, knowing that a forest community is healthier and more diverse with less fragmentation, and "Quality"--the most subjective of the three characteristics. Quality is defined by the local technical team within their realm of expertise, such as the presence of wild rice, cisco, or other outstanding or unique biological resources, both terrestrial or aquatic. The greatest risk for development and fragmentation is riparian private forest lands. The three individual Riparian, Adjacency and Quality scores are added together to make a composite RAQ score.

| Scoring Criteria: | | |
|---|---|---|
| Riparian | 3 | Riparian |
| | 2 | Non-riparian: Shoreland (1 parcel back) |
| | 1 | 2 parcels back |
| Adjacency | 3 | 2 sides touching public land |
| | 2 | 1 side touching public land |
| | 1 | One parcel removed from public land or touching parcel with SFIA or Easement |
| Quality* | 3 | 1 point for each feature that the parcel touches: High or Outstanding Biodiversity (upl. or aqu.), Wild Rice L, Cisco L, Trout L/Streams, et. al. |
| | 2 | |
| | 1 | |




The higher the total RAQ score, the higher priority the parcel should have to implement protection strategies.

The RAQ tool has been developed for the entire Kettle River Watershed and includes a series of RAQ maps for each major HUC-10 subwatershed: Upper Kettle River, Lower Kettle River, Moose River, Willow River and Grindstone River. The tool prioritizes private parcels adjacent to state or federal lands (protected lands in the model). The RAQ tool will be a helpful tool for land and water managers in the Kettle River Watershed to aid in future planning efforts to target areas where public investments will have the most benefit. To date, the RAQ tool has not been developed for the Upper St. Croix River Watershed. Development of the RAQ tool to advance the ongoing work of local partners in the watershed has been identified as a strategy in this report.

**Commented [ST(23]:** No love for USC… Watershed-wide strategy to conduct RAQ analysis for USC?

**Commented [ST(24R23]:** This strategy will be added to the report/tables after talking with Pine Co. SWCD at the LWG meeting

## Watershed Health Assessment Framework (WHAF)

The DNR developed the Watershed Health Assessment Framework (WHAF), which provides a comprehensive overview of the ecological health of Minnesota's watersheds. The WHAF is based on a "whole-system" approach that explores how all parts of the system work together to provide a healthy watershed. The WHAF divides the watershed's ecological processes into five components: biology, connectivity, geomorphology, and hydrology and water quality. A suite of watershed health index scores have been calculated that represent many of the ecological relationships within and between the five components. These scores have been built into a statewide GIS database that is compared across Minnesota to provide a baseline health condition report for each of the 80 major watersheds in the state. The DNR has applied the condition report to larger (HUC-8) watersheds, as well as smaller (HUC-12) subwatersheds. Thus, the WHAF is a helpful resource and targeting tool for future restoration and protection planning and implementation in the Kettle and Upper St. Croix River Watersheds (see Figure 10 for example).

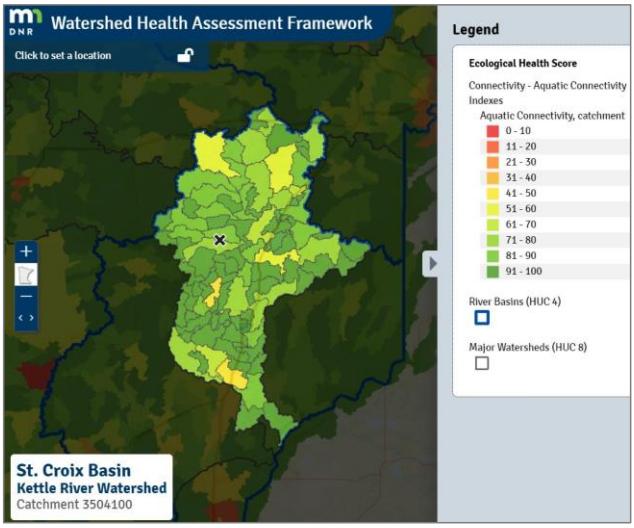



**Figure 10: Aquatic connectivity analysis by individual catchment for the Kettle River Watershed using the DNR's online WHAF tool**

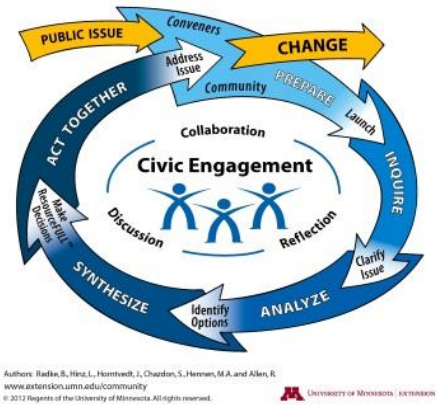
## Other Available Tools and Models

Table 13 below summarizes several other state-wide databases, analyses, tools and models that can be used to help prioritize and target waterbodies and/or upland areas for restoration and protection in the Kettle and Upper St. Croix River Watersheds.

**Table 13: State-wide databases, analyses, tools, and models**

| Tools | Description | Link to information and data |
|---|---|---|
| **Lake Phosphorus Sensitivity Significance Index** | Index tool developed by MPCA to predict how much water clarity would be reduced with additional phosphorus loading to a given lake. The index is a function of phosphorus sensitivity, lake size, lake TP concentration, proximity to MPCA's phosphorus impairment thresholds, and watershed disturbance. Results are used to help prioritize lakes as they relate to MPCA's policy objective of focusing on high quality, unimpaired lakes at greatest risk of becoming impaired. This index tool was also used as one of the key metrics in the Lake Protection and Prioritization Tool described above | MN Geospatial Commons |
| **Lake Benefit: Cost Assessment** | Analysis performed by DNR to rank lakes as they relate to the state's priority of focusing on high-quality, high-value lakes that likely provide the greatest return on investment. For each lake, a benefit: cost assessment priority score was calculated. This score is a function of phosphorus sensitivity, lake size, and catchment disturbance. Lakes were then grouped based on this score and assigned a priority rating. | MN Geospatial Commons |
| **Ecological ranking tool (Environmental Benefit Index - EBI)** | This dataset consists of three Geographic Information System (GIS) raster data layers including soil erosion risk, water quality risk, and habitat quality. The 30-meter grid cells in each layer contain scores from 0-100. The sum of all three scores is the EBI score (max of 300). A higher score indicates a higher priority for restoration or protection. | BWSR<br>MPCA Web Map<br>MPCA download |
| **Restorable wetland inventory** | A GIS data layer that shows potential wetland restoration sites across Minnesota. Created using a compound topographic index (CTI) (10-meter resolution) to identify areas of ponding, and U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) soils with a soil drainage class of poorly drained or very poorly drained. | Restorable Wetlands |
| **National Hydrography Dataset (NHD) and Watershed Boundary Dataset (WBD)** | The NHD is a vector GIS layer that contains features such as lakes, ponds, streams, rivers, canals, dams, and stream gages, including flow paths. The WBD is a companion vector GIS layer that contains watershed delineations. | USGS |
| **Light Detection and Ranging (LiDAR)** | Elevation data in a digital elevation model (DEM) GIS layer. Created from remote sensing technology that uses laser light to detect and measure surface features on the earth. | MGIO |

## 3.2 Civic engagement




A key prerequisite for successful strategy development and on-the-ground implementation is meaningful civic engagement. This is distinguished from the broader term 'public participation' in that civic engagement encompasses a higher, more interactive level of involvement. The MPCA has coordinated with the University of Minnesota Extension Service implementing civic engagement approaches and efforts for the watershed approach. Specifically, the University of Minnesota Extension's definition of civic engagement is "Making 'resourceFULL' decisions and taking collective action on public issues through processes that involve public discussion, reflection, and collaboration." Extension defines a resourceFULL decision as one based on diverse sources of information and supported with buy-in, resources (including human), and competence. Further information on civic engagement is available on the University of Minnesota Extension website at: https://extension.umn.edu/community-development/leadership-and-civic-engagement.

### Accomplishments and future plans

The MPCA partnered with two local governmental units in the Kettle River and Upper St. Croix River Watersheds (Carlton Soil and Water Conservation District and Pine County Soil and Water Conservation District) to directly advance civic engagement throughout the watersheds for much of the duration of this project. Through the partnership, the MPCA provided grant funds for the local partners to engage directly with watershed residents and landowners on a variety of water quality topics. These projects were successful in helping local watershed partners connect with watershed residents to build relationships that will be integral in implementing the strategies described in this report. The work began under these projects will continue as implementation continues throughout both watersheds.

### Public notice for comments

An opportunity for public comment on the draft WRAPS report was provided via a public notice in the *State Register* from [XXX] to [XXX].

## 3.3 Restoration and protection strategies

**Commented [ST(25]:** Missing information about strategy to inventory feedlots smaller than requirement for MPCA registration; also manure management at smaller feedlots (<300 AUs). This will be added to the report after discussions at the LWG meeting.

### Watershed-Wide Strategies

The following watershed-wide strategies were identified by the local partners as priority strategies during this WRAPS process and/or the during the development of the Kettle River Watershed Landscape Stewardship Plan.

#### Shoreland Protection

Minnesota's buffer law requires perennial vegetative buffers along public ditches, and DNR designated shoreland of lakes, rivers, and streams. Buffers along lakes, rivers, and streams must be at least 50 feet in width on each bank, and buffers along public ditches must be at least 16.5 feet wide on each back as well. Vegetative buffers help filter out phosphorus, nitrogen, and sediment. Buffers are critical to protecting and restoring water quality and healthy aquatic life, natural stream functions and aquatic habitat due to their immediate proximity to the water. Further, maintained vegetative buffers provide needed filter strips that can limit runoff into streams during manure application in fields.

The law provides some flexibility for landowners to install alternative practices if they provide equal or better water quality benefits. An example of an alternative practice could be a narrower buffer if the land slopes away from the water body. This is not uncommon with some ditches, rivers, and streams. Alternative practices must be approved by the local governmental unit that implements the buffer law. It should be noted that this law defines a buffer as any type of perennial cover, including turf grass. However, buffers that are most effective at protecting water quality and habitat are characterized by native, deep-rooted vegetation.

Within the Kettle and Upper St. Croix River Watershed, most of the private lands are well vegetated with forests, grasslands, and wetlands. Most of the privately owned lands are managed for wildlife habitat, forest management, or recreational purposes. These lands are almost always covered by permanent vegetation. The buffer requirement is sometimes not met on agricultural lands, depending on the current crop or tillage methods. The majority of lands where buffers are not in place are being used for agricultural purposes—either livestock or crop production. As it pertains to karst features, there is consensus to increase vegetative buffers around identified sinkholes, stream-sinks and karst outcroppings.

Buffer compliance is referenced as a priority in all the County Local Water Plans. The Kettle River Watershed Landscape Stewardship Plan identifies the action item of protecting forested riparian corridors in the Plan. The Plan goes further to identify a few specific priority management strategies by subwatershed. Please be apprised that the Kettle River Watershed Landscape Stewardship Plan was completed in 2014 and therefore may not account for vegetative buffer improvements since publication. Nonetheless, the following are specific buffer related recommendations from the Plan:

- Upper Kettle River Subwatershed – riparian buffers strips along drainage ditches in Birch Creek and Split River Rock minor watersheds.
- Moose River Subwatershed – protect riparian areas along designated trout streams.
- Willow River Subwatershed – riparian buffers along Sturgeon Lake and along the streams upstream from Big Slough Lake.
- Pine River Subwatershed – protect and restore riparian buffers along Pine River downstream of Big Pine Lake and around Bass Lake.
- Lower Kettle River Subwatershed – restore and protect riparian forests along tributaries of concern.
- Grindstone River Subwatershed – protect and restore riparian buffers along lakes and tributaries of concern.

### Forest Protection

Water quality in this watershed is overall good, its quality derived from well-managed forestlands, grasslands, and agricultural lands. Forestland ranks among the best land cover in providing clean water by absorbing rainfall and snow melt, slowing storm runoff, recharging aquifers, sustaining stream flows, filtering pollutants from the air and runoff before they enter the waterways, and providing critical habitat for fish and wildlife. In addition, forested watersheds provide abundant recreational opportunities, help support local economies, provide an inexpensive source of drinking water, and improve the quality of our lives.

As stated previously, the Kettle River Watershed Landscape Stewardship Plan was developed to help private parties and public agencies to protect and enhance forest and water resources in the watershed. Key themes of the Plan are focused on partners and partnerships, implementation programs and priorities, training and funding and engagement of communities and landowners within the watershed. Specific forest management protection strategies outlined in the Plan include:

- Upper Kettle River subwatershed – protect forests that extend outward from Solana State Forest and the State owned/County administered lands.
- Moose River subwatershed – protect forests upstream from Hanging Horn and Little Hanging Horn Lakes as they are high quality Tullibee (Cisco) lakes.
- Willow River subwatershed – restore forests east of Sturgeon Lake. Extend protected forest land to the east of General C.C. Andrews State Forest.
- Pine River subwatershed – Restore forests in the Big Pine Lake and Medicine Creek – Pine River minor watersheds. Extend protected areas south of Solana State Forest in the Big Pine Lake minor subwatershed.
- Lower Kettle River subwatershed – restore and protect riparian forests along tributaries of concern.
- Grindstone River subwatershed – protect an additional 1,860 acres of upland forest (to maintain stable spring snow melts); start with areas near state forest lands in the headwaters that are located in Kroschel Township.

Further, the Kanabec County Water Plan identifies the Grindstone River subwatershed as high priority for protection and restoration, particularly regarding forest management.

The Kettle River Watershed Landscape Stewardship Plan incorporated robust engagement of agencies, organizations and stakeholders. The Plan identifies a number of coordination strategies to help implement elements of the Plan. The details of the Kettle River Watershed Landscape Stewardship Plan go beyond the scope of this WRAPS. However, the coordination strategies are bulleted here.

1. Convene, support and sustain the Coordination/Implementation Committee
2. Hire a Project Coordinator
3. Form the Kettle River Watershed Partnership (KRWP)
4. Grow Coordination through partnerships in the watershed
5. Synchronize watershed priorities with Federal, State, regional and local priorities
6. Integrate service provider training
7. Collaborate on funding development using this Plan as a guide
8. Maintain an inventory of available resources for implementation
9. Systematic and comprehensive landowner outreach

**Commented [ST(26]:** These sections are maybe a little too Kettle-centric in my opinion. I know the KRWLSP is the source for this material, but much of what is being said here also could apply well to USC… How should we best integrate that?

**Commented [ST(27]:** I question how relevant this section is to the WRAPS report overall. I think we could delete it. While it's always a good idea to take stock of where things have been, I don't know really know what value this adds to the report overall.

The Kettle River Watershed Landscape Stewardship Plan stresses the importance of private forest management. When outlining coordination and implementation strategies for forest resource management plans, it is important to consider the entire range of options available to resource managers. The following is a range of options in the implementation tool box as outlined in the Plan. As one moves down the list, the costs and benefits generally increase in cost, permanence and social benefit.

- Technical Advice and Assistance – information, site visits, tree sales, equipment
- Forest Stewardship Plans – individual, cluster, common
- Cost Share Programs – Federal, State, local
- Property Tax Programs – credit, deferral
- Forest Economic Development – coops, forest banks
- Conservation Easements – donated, purchased
- Land Trades and Exchanges – public, industrial
- Fee Title Acquisition – Federal, State, local.

The DNR Forest Stewardship webpage provides an excellent resource for private forest management including education, management plan development, cost-share programs, and other grant and program opportunities: https://www.dnr.state.mn.us/foreststewardship/index.html

**Septic System Improvements**

Failing septic systems can export high levels of bacteria, nutrients, and other pollutants to both surface and groundwater. Straight pipe systems and cesspools pose a greater pollution threat and are considered imminent threats to public health (ITPH) because they can cause significant harm to both people and the environment. Failing subsurface sewage treatment systems (SSTS) were identified in the lake and bacterial TMDLs for the watersheds as potential sources of bacteria and phosphorus to surface waters. However, at this time, the exact location, condition and number of potentially failing SSTS is largely unknown. In order to properly assess the level of influence failing SSTS have on the impairments of the Kettle and Upper St. Croix River Watersheds, further planning will be required.

There are a number of administrative and programmatic approaches local units of government that administer SSTS programs can pursue. Typical approaches include inventories of SSTS file materials, education and outreach, ordinance amendments requiring SSTS compliance inspection upon property sale or transfer, compliance inspection triggers as a condition of building permits, and systematic and prioritized site inspections based local need. Three of the four counties within the Kettle River and Upper St. Croix watersheds require SSTS compliance inspections at time of property transfer. Those three counties are Aitkin, Kanabec and Pine. In Carlton County, SSTS compliance inspections are required at the time of property transfer or permit application for SSTS located in shoreland zoning areas.

**Commented [TAB28]:** Please consider asking the counties if they want to also include any acknowledgment if any of them also include SSTS compliance inspections as part of any permit. Some counties require that within more sensitive areas such as DNR designated shoreland. If any of them do, we can add a sentence.

**Commented [ST(29R28]:** To be discussed at the LWG

The following includes some funding sources local units of government have access to pertaining to administering a SSTS program.

Natural Resource Block Grant funds

Each Minnesota County receives Natural Resource Block Grant (NRBG) funds from the Board of Water and Soil Resources (BWSR) to help administer certain county programs that influence water quality. Those NRBG funds cover the following programs; a shoreland program, an SSTS program, a feedlot

program (typically distributed to SWCDs), a Wetland Conservation Act (WCA) program, and a local water planning program. NRBG funds associated with SSTS are limited, and often help support the cost of staffing an employee to manage an SSTS program. However, some jurisdictions use the funds to supplement existing SSTS administrative functions funded through the County. The BWSR webpage provides details regarding county grants including the NRBG program: https://bwsr.state.mn.us/nrbg

Unsewered Communities

The MPCA maintains a database of communities that are unsewered, meaning wastewater is managed in a manner other than that of a centralized wastewater treatment plant. Unsewered communities therefore manage their wastewater through community systems or SSTS. There are several unsewered communities or geographically identified locations listed within the Kettle River and Upper St. Croix watersheds. Those unsewered communities include: XXXX An unsewered community listed does not mean septic systems are failing, rather, that the location is not served by a centralized wastewater treatment plant.

SSTS Assessments

There are state-sponsored funding programs available for community-wide septic system assessments. The Public Facilities Authority (PFA) administers the Small Community Wastewater Treatment Program, which provides grants of up to $60,000 to local government units to "conduct preliminary site evaluations and prepare feasibility reports, provide advice on possible SSTS alternatives, and help develop the technical, managerial, and financial capacity to build, operate, and maintain SSTS systems" (PFA website). These studies assess current SSTS compliance status as well as potential future individual and/or community SSTS solutions.

The PFA Small Community Wastewater Program offers grant and loan packages of up to $2,000,000 for the construction of publicly-owned community SSTS. The PFA webpage provides an excellent resource in providing financial and technical resources for a variety of wastewater projects: https://mn.gov/deed/pfa/

Also, BWSR and the MPCA has provided grant opportunities in the past to local governments for large-scale SSTS compliance inspection projects. These projects typically involve riparian communities on impaired waterbodies.

Many Counties and SWCDs offer their own low interest loan programs for SSTS upgrades or replacement.

SSTS Upgrades/Replacement process

When a straight pipe system or other Imminent Threat to Public Health (ITPH) location is confirmed, the local SSTS LGU will send a Notice of Non-compliance to the owner that includes a replacement or repair timeline. State rules mandate a 10-month deadline for the system to be brought into compliance, but an LGU can choose to set a more restrictive timeline.

An SSTS does not need to be a straight pipe or other ITPHS to be a threat to surface water quality. Leaking tanks or a drainfield without adequate separation from groundwater can result in the transport of pathogens or excess nutrients to nearby surface waters through the groundwater. This is of particular concern for water-front properties.

**Commented [ST(30]:** This section will be updated…
A couple of maps will be developed for this section and shared at the LWG meeting. The unsewered areas will not be mapped directly, as the dataset is of low quality. The maps will show the populated areas of the watershed and the location of WWTPs and have a discussion about STSS to hopefully assist people to better understand where potential issues related to STSS may be located in the watershed.

**Commented [ST(31]:** County staff, I know we've talked about this previously, but please let me know if you have specific areas with STSS issues that you want identified in this section.

**Commented [ST(32]:** To be discussed at the LWG meeting. Do any counties/SWCDs in the watershed offer loans for STSS upgrades/replacement.

**Commented [ST(33]:** Potentially rephrase to: "Properties in shoreland areas?"

SSTS Maintenance and Education

The most cost-effective BMP for managing loads from SSTS is regular maintenance. USEPA recommends that septic tanks be pumped every three to five years depending on the tank size and number of residents in the household (USEPA, 2002). When not maintained properly, SSTS can cause the release of pathogens and excess nutrients into surface water. Annual inspections, in addition to regular maintenance, ensure that systems function properly. Compliance with state and county code is essential to reducing *E. coli* and phosphorus loading from SSTS. SSTS are regulated under Minnesota Statutes §§ 115.55 and 115.56. Counties must enforce ordinances in Minn. R. ch. 7080 to 7083.

Education is another crucial component of reducing pollutant loading from SSTS. Education can occur through public meetings, routine SSTS service provider home visits, mass mailings, and radio and television advertisements. An inspection program can also help with public education because inspectors can educate owners about proper operation and maintenance during inspections.

The University of Minnesota Onsite Sewage Treatment Program website offers workshops, training, and licensure for SSTS professionals and property owner maintenance and education materials: https://septic.umn.edu/

### Legacy Ditches

A large part of the northwestern area of the Kettle River Watershed is flat and contains various wetland/peatland, low-gradient streams with soft bottoms, and darkly stained tannins. Ditching projects were common in the early 1900s throughout this part of the watershed, as well as other locations in the Kettle River Watershed, in order to drain many of these bog areas (Figure 11). The ditches are likely a major contributor to low DO levels in downstream streams due to the wetland-sourced water they convey to the streams. It is also believed that these ditches are impacting downstream hydrology, however, the extent of these impacts are unclear are still being studied (Holden et al., 2004). Some of the biotic impaired reaches in the Kettle River Watershed that are located downstream of ditched peatland appear to have channel damage in some locations, which has led to habitat loss.

**Figure 11: Example of ditched peatland system in the Upper Kettle River Subwatershed located just west of Kettle Lake**

In order to better understand the hydrologic impacts of these legacy ditches, paired flow monitoring stations could be established both upstream (i.e. in the peatland) and downstream of the altered peatland systems. Such a study would improve knowledge of how hydrology is quantitatively altered in these systems, and how that alteration has affected water quality in and downstream of these peatlands. Restoring hydrology in these systems is a complex task, and a standard template of peatland restoration does not exist (Price et al. 2003). Efforts to restore natural hydrology to stream channels by restoring upstream peatland hydrology should be done in consultation with experienced hydrologists, and it should be realized that attempts at the current time are not guaranteed to succeed since peatland hydrology and impacts of ditching are still being researched.

### Culvert Replacement and other Barriers

As discussed in Section 2.3, infrastructure stressors, which include dams and perched and undersized culverts, can make fish passage difficult or impossible and lead to negative impacts and impairments to biological communities. Problem culverts and dams were identified as primary stressors for several of the biotic impaired reaches in the Kettle and Upper St. Croix Watershed Stressor ID Reports. In 2019, the DNR completed Stream Crossing Inventory and Prioritization Reports for the Kettle and Upper St. Croix River Watersheds. For these reports, a total of 398 stream crossings (245 in Kettle; 153 in Upper St. Croix) were identified and assessed for fish passage. The DNR uses a set of criteria to determine complete (Level 1) and significant (Level 2) barriers such as water/culvert slopes, headloss, degree of perching and the sizing ratio. These barriers were then prioritized using upstream drainage area, natural stream miles, rare features, and professional judgement points. Results of the assessments indicate there are 72 total barriers (45 in Kettle; 27 in Upper St. Croix) throughout both watersheds, which includes: eight dams, two Level 1 (complete) barriers, and 62 Level 2 (significant) barriers. Figure 11 shows the locations of the priority barriers for the Kettle River Watershed. In this figure, priority scores of 1-10 are the highest priority sites based on the prioritization criteria described above. High priority sites will need a full site assessment to determine if restoration is necessary and/or possible. The priority barrier locations for both watersheds are also shown in the HUC-10 subwatershed maps (Figures 13 through 23) that proceed the individual restoration and protection tables later in this section.

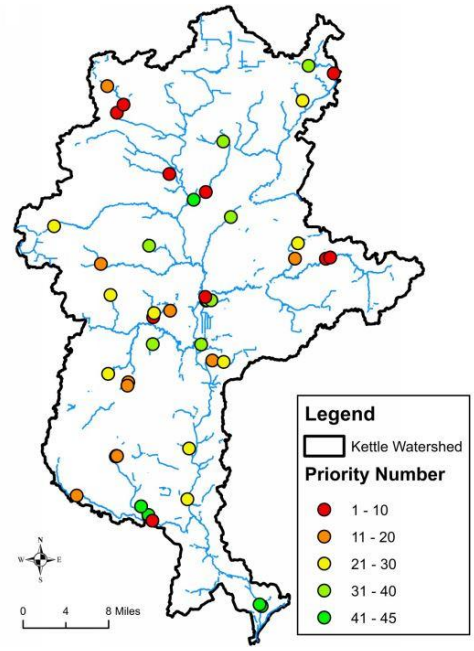



**Figure 1211: Priority barriers for the Kettle River Watershed**

Beaver activity was also identified as a likely stressor for a number of the biotic impaired reaches in the Kettle and Upper St. Croix River Watersheds. Beaver dams can act as partial or in some cases complete barriers by blocking fish passage and preventing repopulation of streams in spring from downstream overwintering habitat. Beaver dams also have the potential to impound and slow streamflow which leads to longer residences times, increased temperatures, and decreases in dissolved oxygen. The biotic impaired reaches with known beaver activity are noted in the Stressor ID Reports and the individual strategies tables below.

### Funding Sources

There are a variety of funding sources to help cover some of the cost to implement practices that reduce pollutants from entering surface waters and groundwater. Below are several programs that contain web

links to the programs and contacts for each entity. The contacts for each grant program can assist in the determination of eligibility for each program, as well as funding requirements and amounts available.

- Agriculture BMP Loan Program (MDA)
- Agricultural Water Quality Certification Program (MDA)
- Clean Water Fund Grants (BWSR)
- Clean Water Partnership Loans (MPCA)
- Environment and Natural Resources Trust Fund (Legislative-Citizen Commission on Minnesota Resources)
- Environmental Assistance Grants Program (MPCA)
- Phosphorus Reduction Grant Program (Minnesota Public Facilities Authority)
- Clean Water Act Section 319 Grant Program (MPCA)
- Small Community Wastewater Treatment Construction Loans & Grants (Minnesota Public Facilities Authority)
- Source Water Protection Grant Program (Minnesota Department of Health)
- Surface Water Assessment Grants (MPCA)
- Wastewater and storm water financial assistance (MPCA)
- Conservation Partners Legacy Grant Program (DNR)
- Environmental Quality Incentives Program (Natural Resources Conservation Service)
- Conservation Reserve Program (USDA)
- Clean Water State Revolving Fund (EPA)

**Climate protection co-benefit of strategies**

Many agricultural BMPs that reduce the load of nutrients and sediment to receiving waters also act to decrease emissions of greenhouse gases (GHGs) to the air. Agriculture is the third-largest emitting sector of GHGs in Minnesota. Important sources of GHGs from crop production include the application of manure and nitrogen fertilizer to cropland, soil organic carbon oxidation resulting from cropland tillage, and carbon dioxide ($CO_2$) emissions from fossil fuel used to power agricultural machinery or in the production of agricultural chemicals. Reduction in the application of nitrogen to cropland through optimized fertilizer application rates, timing, and placement is a source reduction strategy; while conservation cover, riparian buffers, vegetative filter strips, field borders, and cover crops reduce GHG emissions as compared to cropland with conventional tillage.

The USDA Natural Resources Conservation Service (NRCS) has developed a ranking tool for cropland BMPs that can be used by local units of government to consider ancillary GHG effects when selecting BMPs for nutrient and sediment control. Practices with a high potential for GHG avoidance include: conservation cover, forage and biomass planting, no-till and strip-till tillage, multi-story cropping, nutrient management, silvopasture establishment, other tree and shrub establishment, and shelterbelt establishment. Practices with a medium-high potential to mitigate GHG emissions include: contour buffer strips, riparian forest buffers, vegetative buffers and shelterbelt renovation. A longer, more detailed assessment of cropland BMP effects on GHG emission can be found at NRCS, *et al*., "COMET-Planner: Carbon and Greenhouse Gas Evaluation for NRDC Conservation Practice Planning http://comet-planner.nrel.colostate.edu/COMET-Planner_Report_Final.pdf.

## Watershed Priorities

XXXXX

## HUC-10 Subwatershed Strategies

This section provides detailed tables identifying restoration and protection strategies for individual lakes and streams in each HUC-10 subwatershed. The subwatershed-based implementation strategy tables outline the strategies and actions that are capable of cumulatively achieving the needed pollution load reductions for point and non-point sources, as well as watershed and in-stream improvements to decrease stressors on biological communities throughout the watershed. The tables were developed by reviewing results of the TMDL studies, Stressor ID reports, the Kettle River Watershed Landscape Stewardship Plan, HSPF and other modeling tools, specific conditions affecting each subwatershed, and input and feedback from the Kettle River Watershed technical group and local citizen groups.

**Commented [JDS34]:** This may be a good place to include a discussion and list of "priorities" identified by the local work group for this WRAPS project. There are a variety of tools, models listed above, along with the Landscape Stewardship Plan, that can help with prioritization, but this is where the local input would be needed to develop a final list. See Miss. Grand Rapids WRAPS and other recent WRAPS for examples on how they set a list of priority resources. To simplify things for the purposes of this WRAPS, this could be a list of priority waterbodies and/or subwatersheds to work in and focus on over the next 10 years (until the next WRAPS cycle, at which point defined priorities will be reassessed) (Note: creating a priority list doesn't exclude working on other waterbodies or subwatersheds in the watershed)

Based on the conversations and meetings to date, some of the common "priority" resources and subwatersheds appear to be:

- Pine Lake and Big Pine Lake - restoration
- Grindstone Lake – restoration
- Grindstone Subwatershed as a whole – restoration and protection
- **Are there other priority subwatersheds for restoration or protection?**
- Cisco lakes - protection (Hanging Horn and Little Hanging Horn)
- Windmere Twp. Lakes - protection (Sand, Sturgeon, Island)
- Wild Rice Lakes – protection (are there certain ones?)
- Trout streams and streams exhibiting exceptional use fish and IBI scores - protection (are there certain ones?)
- Groundwater protection areas – protection (are there certain specific areas/locations?)

What others are missing or should be IDd as priority? For each priority identified in the report, we will want to explain why this was identified as a priority resource (close to meeting WQ standards, willing landowners, high recreational value, rare/sensitive species, etc.) and/or any models/tools used in the prioritization process.

**Commented [ST(35R34]:** Moose River subwatershed? Development pressure on lakes near Moose Lake per discussion with Carlton SWCD

**Commented [ST(36R34]:** Note to include language here that explains what wild rice/DNR priority shallow lakes/lakes of biological significance/etc. are and why they are considered priorities.

**Commented [ST(37R34]:** Wild Rice Lake/Manoomini-zaaga'iganing on the FDL Reservation?

## Upper Kettle River HUC-10

***Subwatershed Characteristics***

- Size: 224,693 acres
- HUC-12 subwatersheds: Headwaters Kettle River, Kettle Lake, Heikkila Creek-Kettle River, West Branch River, Dead Moose River, Silver Creek, Gillespie Brook, City of Kettle River-Kettle River, Split Rock River, Birch Creek
- Towns/Cities: Cromwell (pop. 231) (partially in the Mississippi River-Grand Rapids major watershed), Kettle River (pop. 180) and Denham (pop. 35)
- Point Source Dischargers: Kettle River WWTP and Barnum WWTP
- Landcover: wetlands (45%), forest/shrubland (38%), hay/pasture (12%), developed (2%), cropland (1%), open water (1%), and barren/mining (<1%)
- Forested Land Protection: 36% (30,816 acres) public ownership, 64% (54,903 acres) privately owned
- WHPAs: Kettle River (34 acres) (see Figure 5)
- DWSMAs: Kettle River (120 acres) (see Figure 5)

***Streams***

- Streams: 378 miles
- Stream Types
    - Natural: 195 miles
    - Altered: 133 miles
    - Impounded: <1 mile
    - No definable channel: 49 miles
- Public Watercourses: 158 miles
- Tiered Aquatic Life Use Classes
    - Exceptional use: 0 miles
    - General use: 107 miles
    - Modified use 0 miles
- DNR Designated Trout Streams: None
- Cold Water Streams: None
- Stream Protection & Prioritization Tool (see Figure 9 and Appendix A)
    - Priority A: 0 reaches
    - Priority B: 7 reaches (69 miles)
    - Priority C: 3 reaches (37 miles)
- Stream Crossing Inventory and Prioritization
    - Top 10: 4 barriers
    - Rank 11-19: 1 barrier
    - Rank 20-29: 2 barriers
    - Rank 30-39: 1 barrier
    - Rank 40-45: 2 barriers

***Lakes***

- Lakes >10 acres: Kettle (2), Little Kettle, Mattlia, Merwin, School, Section One, Split Rock, Walli
- Lakes >100 acres: Kettle
- Impaired Lakes: Merwin
- Nearly/Barely Impaired Lakes: none

- Lakes of Biological Significance
  - Outstanding: Kettle, Little Kettle
  - High: none
  - Moderate: Mattlia
- DNR Priority Shallow Lakes: Kettle
- DNR Wild Rice Lakes: Kettle and Split Rock
- DNR Cisco Refuge Lakes: none
- DNR Stream Trout Lakes: none
- DNR Muskie Lakes: none
- Fish IBI scores: none
- Lake Protection & Prioritization Tool (see Figure 9)
  - Priority A: none
  - Priority B: none
  - Priority C: Kettle
- Lake Benefit: Cost Assessment Tool:
  - Highest: none
  - Higher: none
  - High: Kettle and Merwin

***Subwatershed Priorities Identified in Kettle River Watershed Landscape Stewardship Plan***

- Overall Subwatershed Risk Assessment: Low
- Minor Subwatershed Priorities: West Branch River, Birch Creek, Split Rock River,
- Lakes and Tributaries of Concern: West Branch River
- Priority Management Strategies:
  - Protect areas along West Branch River between State Owned/County Administered lands and around Fond Du Lac State Forest
  - Riparian buffer strips along drainage ditches in Birch Creek and Split Rock River minor watersheds
  - Protect forests that extend outward from Solana State Forest and the State Owned/County Administered lands
- 10-year Demonstration Projects:
  - Birch Creek to Moose Horn River Reach: Funding applied for 3 small projects focused on riparian areas (Carlton SWCD)
  - Northwest State/County Forest Block: Protect these blocks from fragmentation and parcelization (MN DNR Forestry and Carlton Co Land Dep't)
  - West Branch Kettle River: Protect riparian areas. Consists of mostly 40-acre parcels owned by a variety of private non-industrial landowners (Carlton SWCD)
  - Fond Du Lac State Forest: Re-meandering of drainage ditches (MN DNR Forestry)

**Commented [JDS38]:** Note: these are the "priority" subwatersheds identified in the Kettle River LSP. Do these match what the local work group identifies as priorities? We can remove these from this section if they are not relevant.

**Commented [JDS39]:** Note: these are also from the Kettle River LSP. Are these projects still relevant and priorities for the local work group? Currently they are not included in the strategies tables, but they can be added to the tables if they are still relevant projects.

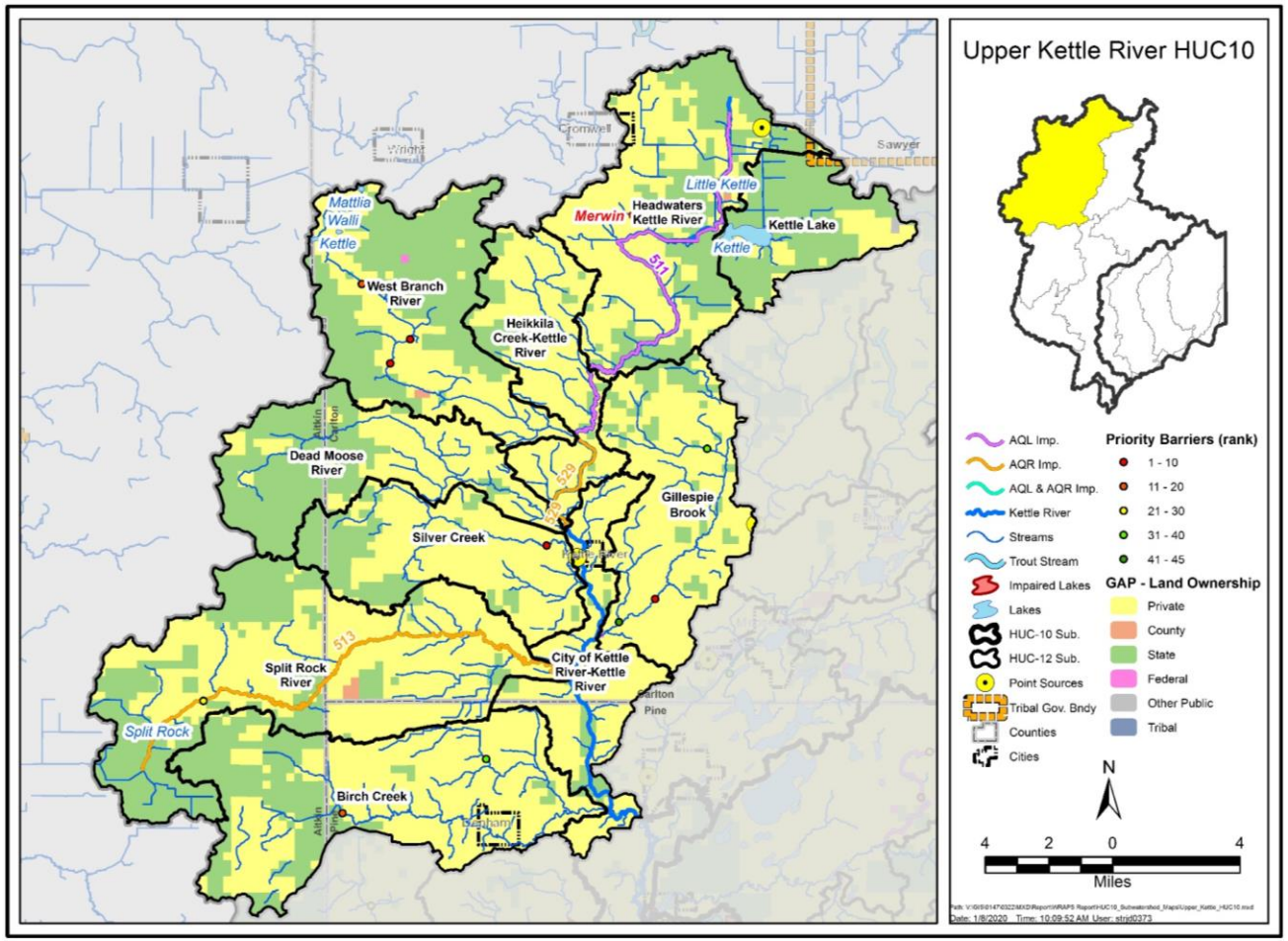



**Figure 13: Upper Kettle River HUC-10 Subwatershed**

**Table 14: Strategies and actions proposed for the Upper Kettle River HUC-10 Subwatershed.**

**Moose River HUC-10**

***Subwatershed Characteristics***

- Size: 90,326 acres
- HUC-12 subwatersheds: Hanging Horn Lake-Moose Horn River, Moose Horn River, Moose River, Portage River, Portage River
- Towns/Cities: Sturgeon Lake (pop. 2,447), Moose Lake (pop. 2,001), Barnum (pop. 646)
- Point Source Dischargers: Moose Lake WWTP and Sturgeon Lake WWTP
- Landcover: wetlands (40%), forest/shrubland (35%), hay/pasture (13%), developed (6%), open water (5%), cropland (1%), and barren/mining (<1%)
- Forested Land Protection: 13% (4,042 acres) public ownership, 87% (27,306 acres) privately owned
- WHPAs: Barnum (41 acres), Moose Lake (1,370 acres), Minnesota Correctional Facility - Moose Lake (216 acres), Sturgeon Lake (133 acres), and Sun Bay Mobile Home Park and Campground (89 acres) (see Figure 5)
- DWSMAs: Minnesota Correctional Facility - Moose Lake (436 acres), Sturgeon Lake (208 acres), Moose Lake (1,870 acres), Barnum (92 acres), and Sun Bay Mobile Home Park and Campground (243 acres) (see Figure 5)

***Streams***

- Streams: 160 miles
- Stream Types
  - Natural: 119 miles
  - Altered: 12 miles
  - Impounded: 2 miles
  - No definable channel: 27 miles
- Public Watercourses: 75 miles
- Tiered Aquatic Life Use Classes
  - Exceptional use: 7 miles
  - General use: 38 miles
  - Modified use 0 miles
- DNR Designated Trout Streams: 15 miles
- Cold Water Streams: 2 streams (15 miles)
- Stream Protection & Prioritization Tool (see Figure 9 and Appendix A)
  - Priority A: 3 reaches (12 miles)
  - Priority B: 3 reaches (22 miles)
  - Priority C: 1 reach (11 miles)
- Stream Crossing Inventory and Prioritization
  - Top 10: 1 barrier
  - Rank 11-19: No barriers
  - Rank 20-29: 1 barrier
  - Rank 30-39: 2 barriers
  - Rank 40-45: No barriers

***Lakes***

- Lakes >10 acres: 16 lakes
- Lakes >100 acres: Echo, Little Hanging Horn, Moose, Moosehead, Park, Hanging Horn, Sand, and Island

- Impaired Lakes: Twentynine
- Nearly/Barely Impaired Lakes: Eddy, Moosehead, Hanging Horn, and Island
- Lakes of Biological Significance
    - Outstanding: Manoomini-zaaga'iganing (Wild Rice), Moosehead, and Hanging Horn
    - High: Lords
    - Moderate: None
- DNR Priority Shallow Lakes: Spring and Wild Rice
- DNR Wild Rice Lakes: Little North Sturgeon, Manoomini-zaaga'iganing (Wild Rice), Bob, Moose, and Moosehead
- DNR Cisco Refuge Lakes: Hanging Horn and Little Hanging Horn
- DNR Stream Trout Lakes: none
- DNR Muskie Lakes: Island
- Fish IBI scores
    - Exceptional: Echo and Hanging Horn
    - At or Above Impairment: Bear and Island
    - Below Impairment Threshold: Sand
- Lake Protection & Prioritization Tool (see Figure 9)
    - Priority A: Eddy, Bear, Little Hanging Horn, Sand, and Island
    - Priority B: Coffee, Echo, Moose, Moosehead, and Park
    - Priority C: Twentynine, Bob, and Hanging Horn
- Lake Benefit: Cost Assessment Tool:
    - Highest: none
    - Higher: Sand and Island
    - High: Eddy, Bear, Little Hanging Horn, Coffee, Echo, Moose, Moosehead, Park, Twentynine, Bob, and Hanging Horn

***Subwatershed Priorities Identified in Kettle River Watershed Landscape Stewardship Plan***

- Overall Subwatershed Risk Assessment: High
- Minor Subwatershed Priorities: Moose River
- Lakes and Tributaries of Concern: Moosehead Lake, Sand Lake, Island Lake, Hanging Horn Lake, Little Hanging Horn Lake
- Priority Management Strategies:
    - Shoreland restoration with lakeshore owners around lakes of concern in Moose River HUC 12.
    - Urban Forestry in the City of Moose Lake.
    - Protect Riparian areas along designated trout streams
    - Protect forests upstream from Hanging Horn and Little Hanging Horn Lakes (high quality Tullibee (Cisco) Lakes).
- 10-year Demonstration Projects:
    - City of Sturgeon Lake: Urban and community forestry, parkland, important areas for stormwater runoff, Moose Horn River run through, meets Kettle river on southwest corner.
    - Hanging Horn Drainage: Part of the Clean Water Legacy Tullibee Lakeshed Stewardship Project, which gives possibility of multiple benefits for projects.
    - King Creek: Designed trout stream, meanders past several agricultural fields, possible areas for some buffer expansion.
    - Moose Horn River Headwaters: : Designed trout stream, meanders past several agricultural fields, possible areas for some buffer expansion, but judging from aerial imagery mostly flows through a mix of floodplain shrubs and forests.

**Commented [JDS40]:** Note: these are the "priority" subwatersheds identified in the Kettle River LSP. Do these match what the local work group identifies as priorities? We can remove these from this section if they are not relevant.

**Commented [JDS41]:** Note: these are also from the Kettle River LSP. Are these projects still relevant and priorities for the local work group? Currently they are not included in the strategies tables, but they can be added to the tables if they are still relevant projects.

- City of Moose Lake: Urban and community forestry, parkland, important areas for stormwater runoff, next to Moosehead Lake, which is part of the Moose Horn River.

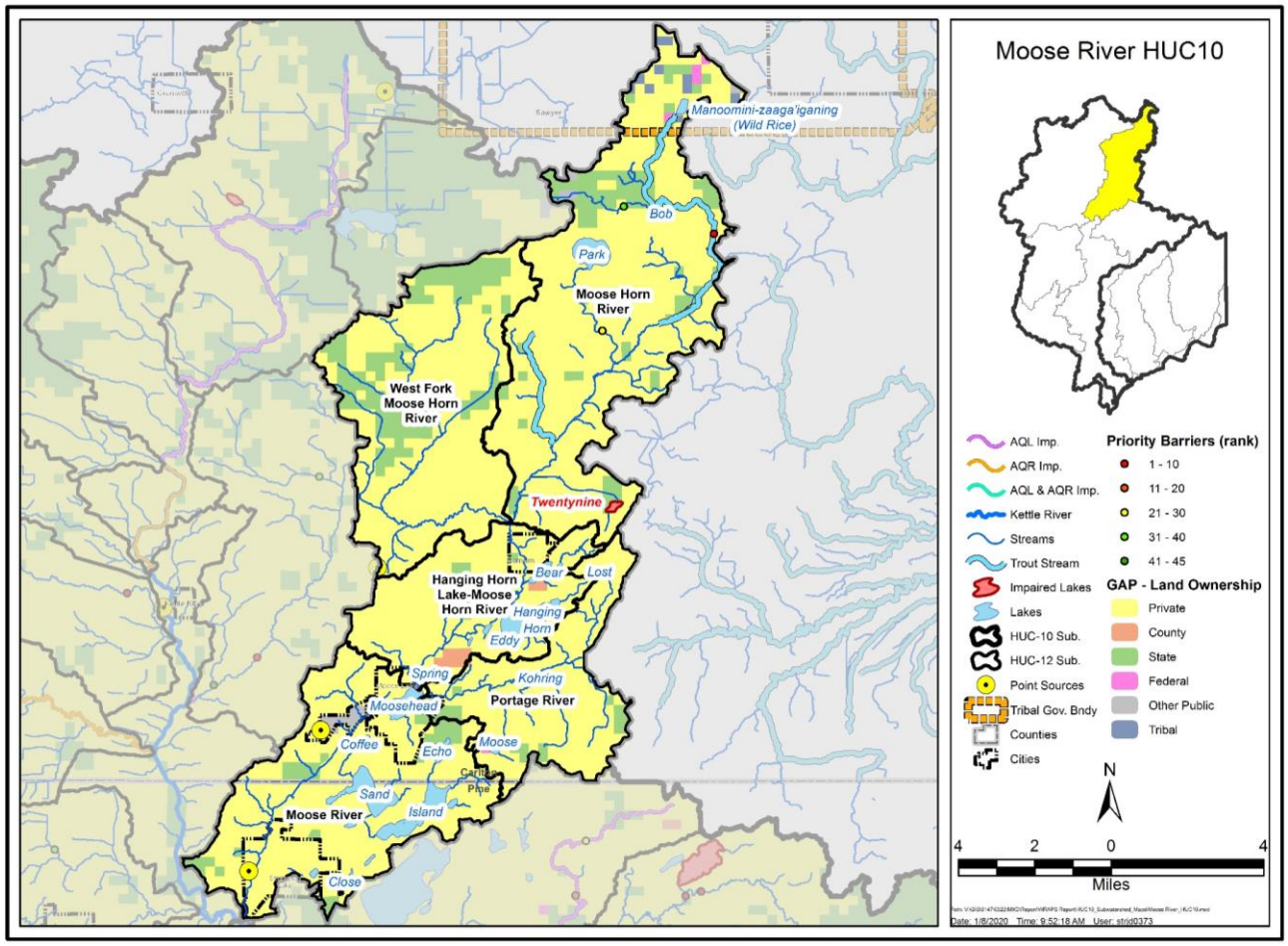



**Figure 14: Moose River HUC-10 Subwatershed**

**Table 15: Strategies and actions proposed for the Moose River HUC-10 Subwatershed.**

**Willow River HUC-10**

***Subwatershed Characteristics***

- Size: 85,750 acres
- HUC-12 subwatersheds: Little Willow River, Oak Lake-Willow River, Sturgeon Lake-Willow River
- Towns/Cities: Willow River (pop. 1,229), Kerrick (pop. 641), Bruno (pop. 639)
- Point Source Dischargers: None
- Landcover: wetlands (40%), forest/shrubland (40%), hay/pasture (10%), developed (4%), open water (4%), cropland (1%), and barren/mining (<1%)
- Forested Land Protection: 26% (9,020 acres) public ownership, 74% (25,610 acres) privately owned
- WHPAs: Willow River (8 acres) (see Figure 5)
- DWSMAs: Willow River (33 acres) (see Figure 5)

***Streams***

- Streams: 114 miles
- Stream Types
    - Natural: 83 miles
    - Altered: 16 miles
    - Impounded: <1 mile
    - No definable channel: 14 miles
- Public Watercourses: 63 miles
- Tiered Aquatic Life Use Classes
    - Exceptional use: 8 miles
    - General use: 29 miles
    - Modified use 0 miles
- DNR Designated Trout Streams: 3 miles
- Cold Water Streams: 1 stream (3 miles)
- Stream Protection & Prioritization Tool (see Figure 9 and Appendix A)
    - Priority A: 1 reach (3 miles)
    - Priority B: 2 reaches (10 miles)
    - Priority C: 1 reach (24 miles)
- Stream Crossing Inventory and Prioritization
    - Top 10: 3 barriers
    - Rank 11-19: 1 barrier
    - Rank 20-29: 1 barrier
    - Rank 30-39: No barriers
    - Rank 40-45: No barriers

***Lakes***

- Lakes >10 acres: 14 lakes
- Lakes >100 acres: Eleven, Dago, Oak, and Sturgeon
- Impaired Lakes: Oak
- Nearly/Barely Impaired Lakes: Eleven
- Lakes of Biological Significance
    - Outstanding: none
    - High: Turtle
    - Moderate: Big Slough

- DNR Priority Shallow Lakes: Stanton
- DNR Wild Rice Lakes: Willow and Stanton
- DNR Cisco Refuge Lakes: none
- DNR Stream Trout Lakes: none
- DNR Muskie Lakes: none
- Fish IBI scores
    - Exceptional: none
    - At or Above Impairment: Sturgeon
    - Below Impairment Threshold: Oak
- Lake Protection & Prioritization Tool (see Figure 9)
    - Priority A: Dago, Oak, Sturgeon
    - Priority B: Passenger and Eleven
    - Priority C: Stanton
- Lake Benefit: Cost Assessment Tool:
    - Highest: Sturgeon
    - Higher: Dago
    - High: Oak, Passenger, Eleven, and Stanton

***Subwatershed Priorities Identified in Kettle River Watershed Landscape Stewardship Plan***

- Overall Subwatershed Risk Assessment: Moderate
- Minor Subwatershed Priorities: Sturgeon Lake – Willow River
- Lakes and Tributaries of Concern: Sturgeon Lake
- Priority Management Strategies:
    - Riparian Buffers around Sturgeon Lake and along streams upstream from Big Slough Lake.
    - Restore upland forests east of Sturgeon Lake
    - Extend protected forest lands to the east of General C.C Andrews State Forest.
- 10-year Demonstration Projects:
    - Larson's Creek: Designed trout stream, larger block of contiguous forest, surrounded by the Nemadji State Forest, DNR Forestry land, Trust land, and Misc. County land. In the northeast corner of the junction of Kerrick Road and Larson Creek, a landowner has several tree plantings - possible private partner.

**Commented [JDS42]:** Note: these are the "priority" subwatersheds identified in the Kettle River LSP. Do these match what the local work group identifies as priorities? We can remove these from this section if they are not relevant.

**Commented [JDS43]:** Note: these are also from the Kettle River LSP. Are these projects still relevant and priorities for the local work group? Currently they are not included in the strategies tables, but they can be added to the tables if they are still relevant projects.

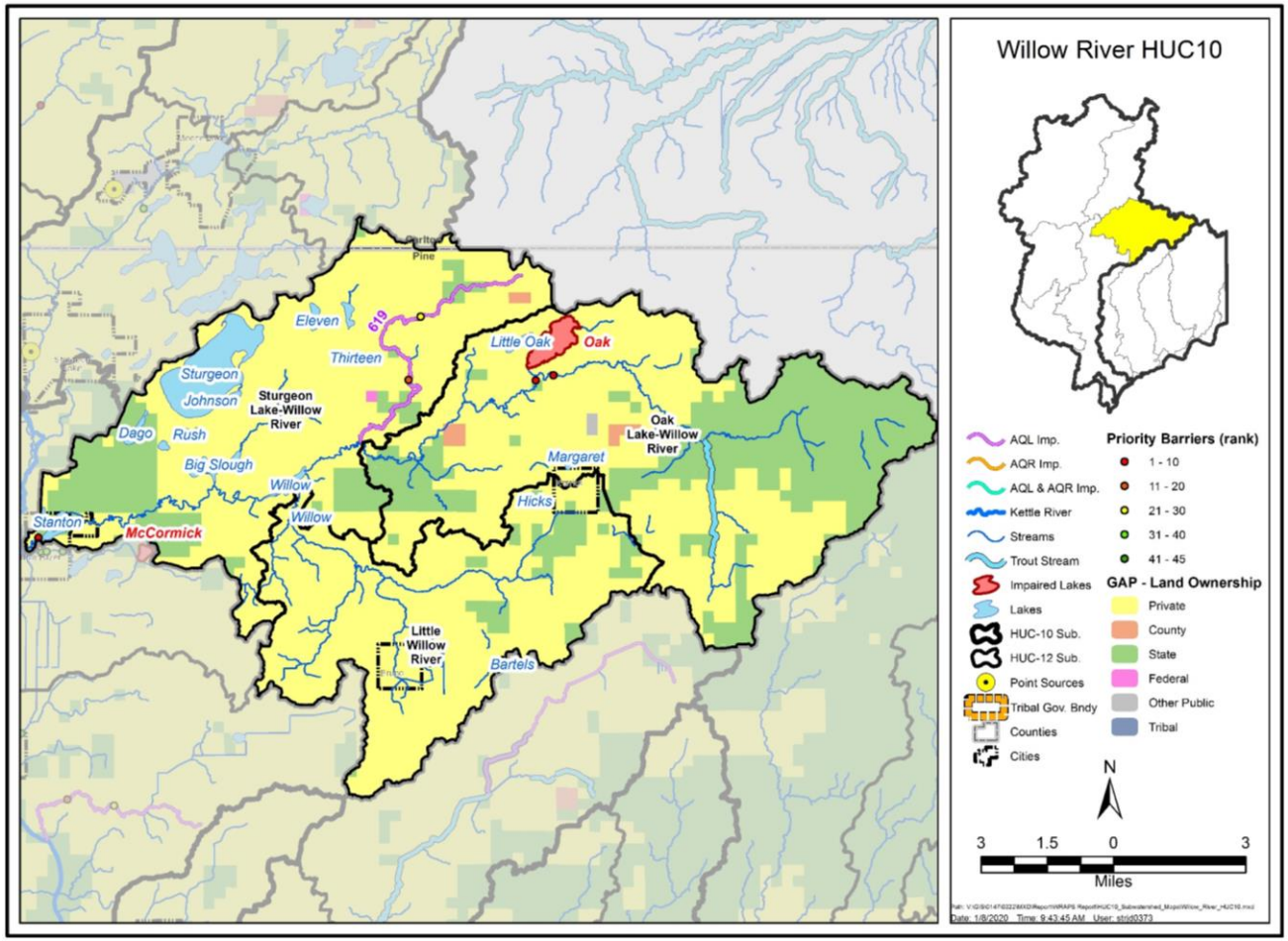



**Figure 15: Willow River HUC-10 Subwatershed**

**Table 16: Strategies and actions proposed for the Willow River HUC-10 Subwatershed.**

**Pine River HUC-10**

***Subwatershed Characteristics***

- Size: 92,127 acres
- HUC-12 subwatersheds: Big Pine Lake, Bremen Creek, Fox Lake-Pine River, Little Pine Creek, Medicine Creek-Pine River, Rhine Lake-Pine River
- Towns/Cities: Rutledge (pop. 1,933) Finlayson (pop. 1,870)
- Point Source Dischargers: Finlayson WWTP
- Landcover: forest/shrubland (40%), wetlands (35%), hay/pasture (15%), developed (4%), open water (4%), cropland (2%), and barren/mining (<1%)
- Forested Land Protection: 20% (7,425 acres) public ownership, 80% (29,496 acres) privately owned
- WHPAs: Finlayson (160 acres) (see Figure 5)
- DWSMAs: Finlayson (501 acres) (see Figure 5)

***Streams***

- Streams: 170 miles
- Stream Types
    - Natural: 126 miles
    - Altered: 15 miles
    - Impounded: 5 miles
    - No definable channel: 23 miles
- Public Watercourses: 81 miles
- Tiered Aquatic Life Use Classes
    - Exceptional use: 15 miles
    - General use: 8 miles
    - Modified use 0 miles
- DNR Designated Trout Streams: None
- Cold Water Streams: None
- Stream Protection & Prioritization Tool (see Figure 9 and Appendix A)
    - Priority A: 2 reaches (15 miles)
    - Priority B: 3 reaches (69 miles)
    - Priority C: 0 reaches
- Stream Crossing Inventory and Prioritization
    - Top 10: 1 barrier
    - Rank 11-19: 3 barriers
    - Rank 20-29: 3 barriers
    - Rank 30-39: 1 barrier
    - Rank 40-45: No barriers

***Lakes***

- Lakes >10 acres: Clear, Little, Little Bass, Mud, Cemetery, Bass (58012800), Loon, Beauty, Indian, Little Pine, and Grass
- Lakes >100 acres: Rhine, Fish, Fox, Bass (58013700), Upper Pine, Eleven, Pine, Big Pine
- Impaired Lakes: Rhine, Fox, Eleven, Pine, and Big Pine
- Nearly/Barely Impaired Lakes: Pine and Big Pine
- Lakes of Biological Significance
    - Outstanding: none

    - High: Eleven
    - Moderate: Bass (58013700)
- DNR Priority Shallow Lakes: Grass, Fox, Upper Pine, and Eleven
- DNR Wild Rice Lakes: Fox, Pine, and Big Pine
- DNR Cisco Refuge Lakes: none
- DNR Stream Trout Lakes: none
- DNR Muskie Lakes: none
- Fish IBI scores
    - Exceptional: none
    - At or Above Impairment: Fox, Upper Pine, Eleven, and Big Pine
    - Below Impairment Threshold: Pine and Bass (58013700)
- Lake Protection & Prioritization Tool (see Figure 9)
    - Priority A: Rhine
    - Priority B: Little Bass, Eleven, and Big Pine
    - Priority C: Upper Pine, Fox, Fish, Little Pine, and Indian
- Lake Benefit: Cost Assessment Tool:
    - Highest: none
    - Higher: Bass
    - High: Pine, Upper Pine, Fox, Fish, Little Pine, Indian, Big Pine, Eleven, Little Bass, Bass (58013700), and Rhine

***Subwatershed Priorities Identified in Kettle River Watershed Landscape Stewardship Plan***

- Overall Subwatershed Risk Assessment: High
- Minor Subwatershed Priorities: Big Pine Lake, Rhine Lake - Pine River, Medicine Creek – Pine River
- Lakes and Tributaries of Concern: Pine Lake and Big Pine Lake, Pine River downstream of Big Pine Lake, Bass Lake.
- Priority Management Strategies:
    - Protect and restore riparian buffers along Pine River Downstream from Big Pine Lake and Around Bass Lake.
    - Restore upland forests in the Big Pine Lake and Medicine Creek – Pine River minor watersheds.
    - Extend protected areas south of Solana State Forest in the Big Pine Lake Minor watershed.
- 10-year Demonstration Projects:
    - Hinckley-Finlayson School Forest. The school has two 80-acre parcels connected diagonally, one of which has been used for many years for outdoor environmental education. Little Pine Creek bisects one of the parcels and connects Upper Pine Lake and Little Pine Lake. Prior to 2003, some trail improvements were made to the forest with help from the Pine County Ruffed Grouse Society and the Finlayson-Giese Sportsmen's Club. Need to include a Forestry Stewardship Plan, interpretive signs, invasive species identification, or seedlings. Pine County SWCD.

**Commented [JDS44]:** Note: these are the "priority" subwatersheds identified in the Kettle River LSP. Do these match what the local work group identifies as priorities? We can remove these from this section if they are not relevant.

**Commented [JDS45]:** Note: these are also from the Kettle River LSP. Are these projects still relevant and priorities for the local work group? Currently they are not included in the strategies tables, but they can be added to the tables if they are still relevant projects.

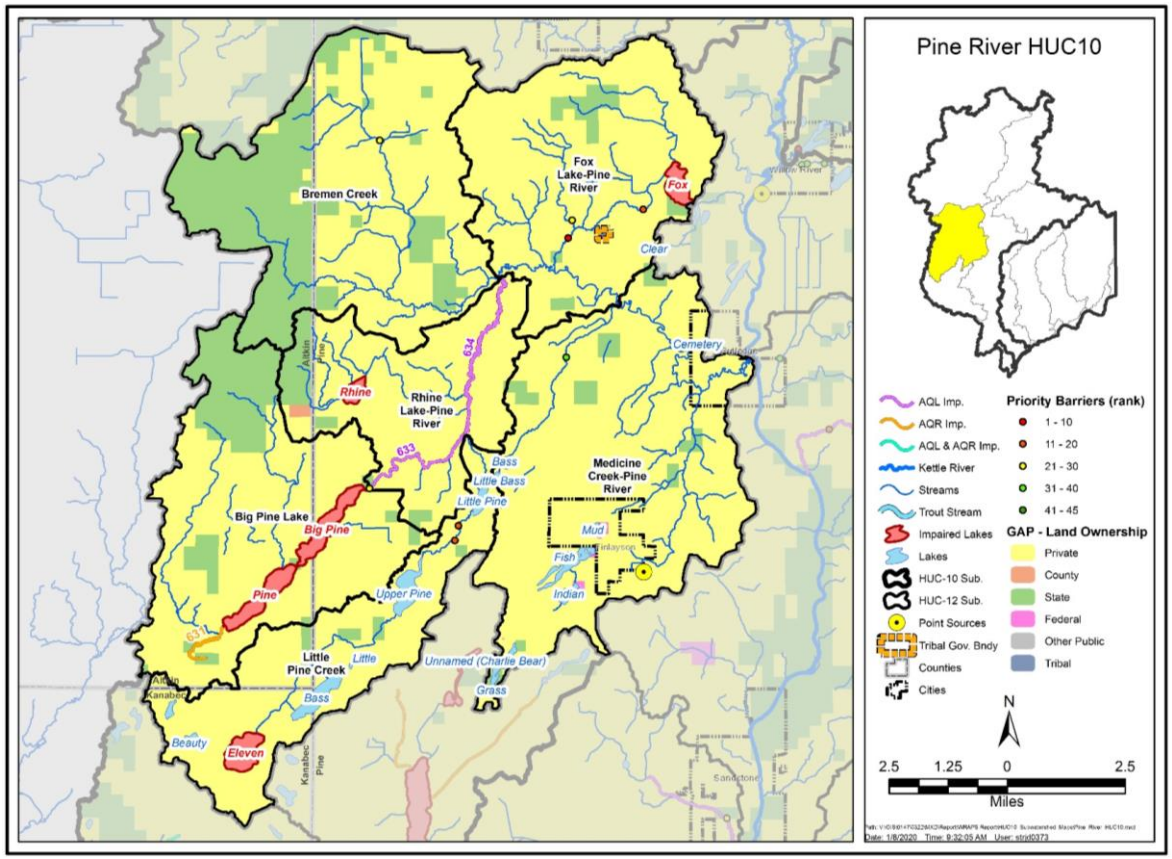



**Figure 16: Pine River HUC-10 Subwatershed**

**Table 17: Strategies and actions proposed for the Pine River HUC-10 Subwatershed.**

**Grindstone River HUC-10**

***Subwatershed Characteristics***

- Size: 55,558 acres
- HUC-12 subwatersheds: Grindstone River, North Branch Grindstone River, South Branch Grindstone River
- Towns/Cities: Hinckley (pop. 1,868)
- Point Source Dischargers: Hinckley WWTP
- Landcover: forest/shrubland (34%), wetlands (29%), hay/pasture (25%), developed (5%), cropland (4%), open water (3%), and barren/mining (<1%)
- Forested Land Protection: 9% (1,774 acres) public ownership, 91% (17,329 acres) privately owned
- WHPAs: Hinckley (445 acres) (see Figure 5)
- DWSMAs: Hinckley (855 acres) (see Figure 5)

***Streams***

- Streams: 77 miles
- Stream Types
    - Natural: 42 miles
    - Altered: 20 miles
    - Impounded: 6 miles
    - No definable channel: 9 miles
- Public Watercourses: 42 miles
- Tiered Aquatic Life Use Classes
    - Exceptional use: 0 miles
    - General use: 14 miles
    - Modified use 0 miles
- DNR Designated Trout Streams: 6 miles
- Cold Water Streams: None
- Stream Protection & Prioritization Tool (see Figure 9 and Appendix A)
    - Priority A: 1 reach (7 miles)
    - Priority B: 1 reach (7 miles)
    - Priority C: 0 reaches
- Stream Crossing Inventory and Prioritization
    - Top 10: 1 barrier
    - Rank 11-19: 3 barriers
    - Rank 20-29: 1 barrier
    - Rank 30-39: 1 barrier
    - Rank 40-45: 2 barriers

***Lakes***

- Lakes >10 acres: McMuller, Charlie Bear, Featherbed, Twelve, White Lily, Long, Five, Thirteen, Miller, and Elbow
- Lakes >100 acres: Grindstone
- Impaired Lakes: Elbow and Grindstone
- Nearly/Barely Impaired Lakes: none
- Lakes of Biological Significance
    - Outstanding: Grindstone

    - High: Thirteen
    - Moderate: none
- DNR Priority Shallow Lakes: Miller
- DNR Wild Rice Lakes: none
- DNR Cisco Refuge Lakes: none
- DNR Stream Trout Lakes: Grindstone
- DNR Muskie Lakes: none
- Fish IBI scores
    - Exceptional: Grindstone
    - At or Above Impairment: none
    - Below Impairment Threshold: none
- Lake Protection & Prioritization Tool (see Figure 9)
    - Priority A: none
    - Priority B: Elbow, Grindstone, and Miller
    - Priority C: Five
- Lake Benefit: Cost Assessment Tool:
    - Highest: none
    - Higher: none
    - High: Five, Elbow, Grindstone, and Miller

***Subwatershed Priorities Identified in Kettle River Watershed Landscape Stewardship Plan***

- Overall Subwatershed Risk Assessment: Very High
- Minor Subwatershed Priorities: Grindstone, South Branch, North Branch (all minors)
- Lakes and Tributaries of Concern: Grindstone Lake, tributaries to Grindstone Lake, South Branch of the Grindstone River – west of Hinckley to Kroschel Township.
- Priority Management Strategies:
    - Protect and restore riparian buffers along lakes and tributaries of concern.
    - Protect an additional 1,860 acres of upland forest (to maintain stable spring snow melts); start with areas near state forest lands in the headwaters area located in Kroschel Township.
    - Urban forestry in the City of Hinckley.
- 10-year Demonstration Projects:
    - Spring Creek: Designed trout stream that runs through several agriculture and grassland cover types but is surrounded by a good sized forest buffer.
    - City of Hinckley: Urban and community forestry, parkland, important areas for stormwater runoff; Grindstone River runs through.
    - Grindstone Lake: Audubon Center, potential interested landowner w/ 300 acres, designed trout stream. Water quality monitoring, particularly temperature/dissolved oxygen profiles monthly through open water season, compare with charge in land use upstream (which has 2—60% disturbance).

**Commented [JDS46]:** Note: these are the "priority" subwatersheds identified in the Kettle River LSP. Do these match what the local work group identifies as priorities? We can remove these from this section if they are not relevant.

**Commented [JDS47]:** Note: these are also from the Kettle River LSP. Are these projects still relevant and priorities for the local work group? Currently they are not included in the strategies tables, but they can be added to the tables if they are still relevant projects.

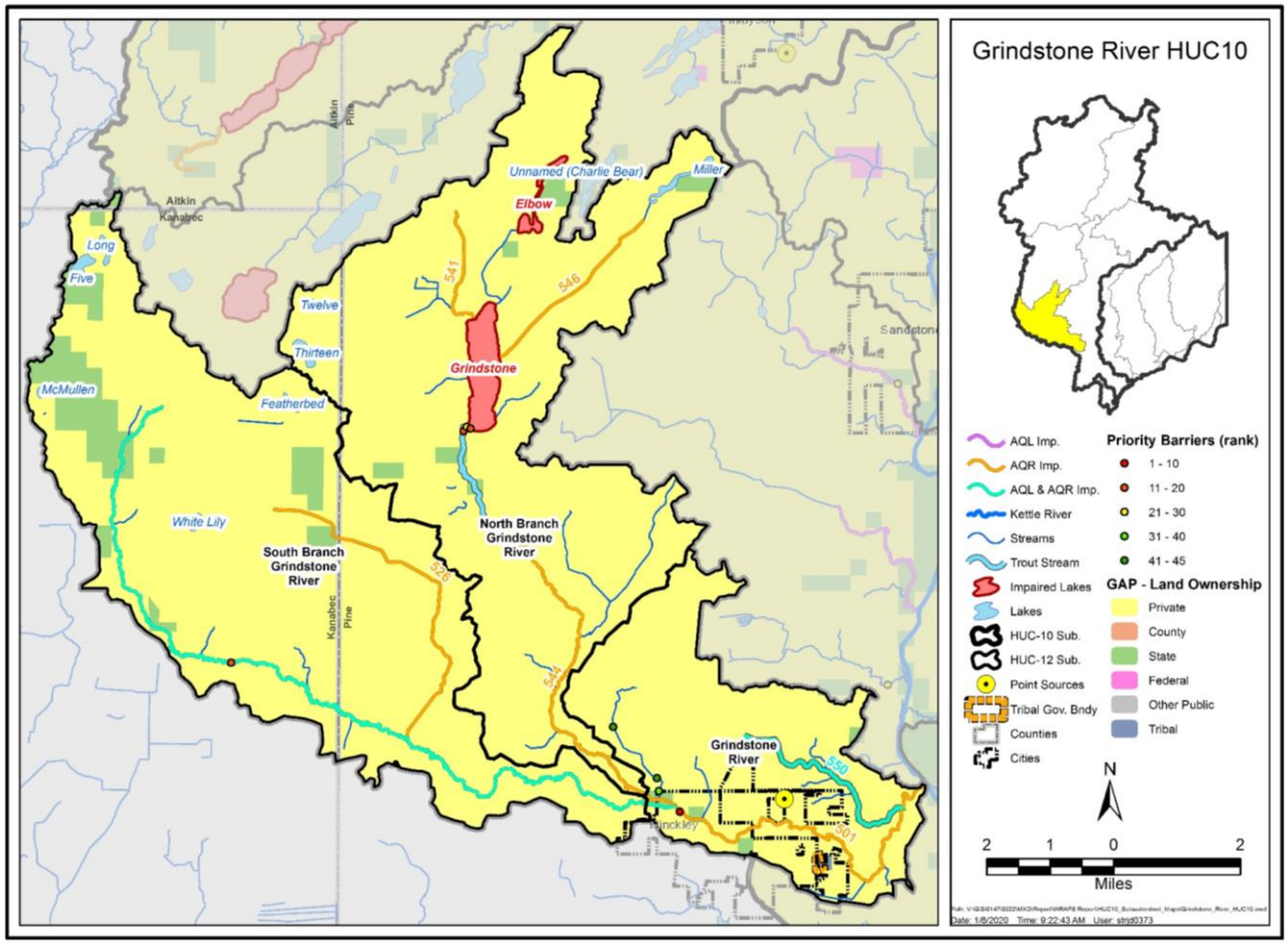



**Figure 17: Grindstone River HUC-10 Subwatershed**

**Table 18: Strategies and actions proposed for the Grindstone River HUC-10 Subwatershed.**

**Lower Kettle River HUC-10**

***Subwatershed Characteristics***

- Size: 124,403 acres
- HUC-12 subwatersheds: City of Sandstone-Kettle River, City of Willow River-Kettle River, Friesland Ditch-Kettle River, Kettle River
- Towns/Cities: Sandstone (pop. 3,466), Sturgeon Lake (pop. 2,447), Rutledge (pop. 1,933), Hinckley (pop. 1,868), Willow River (pop. 1,229)
- Point Source Dischargers: Sandstone WWTP and Willow River WWTP
- Landcover: forest/shrubland (42%), wetlands (30%), hay/pasture (16%), developed (5%), cropland (4%), open water (2%), and barren/mining (<1%)
- Forested Land Protection: 31% (16,203 acres) public ownership, 69% (36,326 acres) privately owned
- WHPAs: Willow River (6 acres), and Hinckley (141 acres) (see Figure 5)
- DWSMAs: Willow River (11 acres) and Hinckley (8242 acres) (see Figure 5)

***Streams***

- Streams: 235 miles
- Stream Types
    - Natural: 143 miles
    - Altered: 61 miles
    - Impounded: 1 mile
    - No definable channel: 29 miles
- Public Watercourses: 102 miles
- Tiered Aquatic Life Use Classes
    - Exceptional use: 10 miles
    - General use: 30 miles
    - Modified use 0 miles
- DNR Designated Trout Streams: 3 miles
- Cold Water Streams: None
- Stream Protection & Prioritization Tool (see Figure 9 and Appendix A)
    - Priority A: 2 reaches (<1 mile)
    - Priority B: 5 reaches (27 miles)
    - Priority C: 1 reaches (12 miles)
- Stream Crossing Inventory and Prioritization
    - Top 10: No barriers
    - Rank 11-19: 1 barrier
    - Rank 20-29: 2 barriers
    - Rank 30-39: 5 barriers
    - Rank 40-45: 2 barriers

***Lakes***

- Lakes >10 acres: Skunk, Mud (58009000), Shoemaker, Little Mud, Mud (58010300), Clear, Stevens, Second, McCormick, Long, Cedar, and First
- Lakes >100 acres: none
- Impaired Lakes: McCormick
- Nearly/Barely Impaired Lakes: Long
- Lakes of Biological Significance
    - Outstanding: none

    - High: none
    - Moderate: Clear, Long, and Second
- DNR Priority Shallow Lakes: none
- DNR Wild Rice Lakes: McCormick and Cedar
- DNR Cisco Refuge Lakes: none
- DNR Stream Trout Lakes: none
- DNR Muskie Lakes: none
- Fish IBI scores
    - Exceptional: none
    - At or Above Impairment: none
    - Below Impairment Threshold: none
- Lake Protection & Prioritization Tool (see Figure 9)
    - Priority A: Rhine
    - Priority B: Cedar, First, Long, and Second
    - Priority C: Little Mud, McCormick, and Mud (58010300)
- Lake Benefit: Cost Assessment Tool:
    - Highest: none
    - Higher: none
    - High: Cedar, First, Long, Second, Little Mud, McCormick, and Mud (58010300)

***Subwatershed Priorities Identified in Kettle River Watershed Landscape Stewardship Plan***

- Overall Subwatershed Risk Assessment: Moderate
- Minor Subwatershed Priorities: None identified
- Lakes and Tributaries of Concern: Pelkey Creek and Cane creek.
- Priority Management Strategies:
    - Protect and restore riparian forests along tributaries of concern.
    - Extend protection around state park lands.
    - Urban forestry in the City of Sandstone.
- 10-year Demonstration Projects:
    - Pelkey Creek: Designed trout stream, large block of continuous forest stretching northwest from public lands including School Trust lands, misc. County land, Chengwatana State Forest, and St. Croix State Park.
    - City of Sandstone: Urban and community forestry, parkland, important areas for stormwater runoff; Kettle River runs through it.
    - Kettle River Streambank Erosion – Banning State Park. Approximately 500 feet of streambank erosion located downstream of Highway 23 bridge within Banning State Park.
    - East Central High School Property. The East Central High School is built on an 80-acre parcel. There is a large wetland and forest on the back part of the property. I know they talked in the past about using area for classes.
    - Cane Creek: larger block of contiguous forest, edged by Banning State Park, County miscellaneous land, Rutledge WMA, and School Trust land. Appears to have highly varied land cover.

**Commented [JDS48]:** Note: these are the "priority" subwatersheds identified in the Kettle River LSP. Do these match what the local work group identifies as priorities? We can remove these from this section if they are not relevant.

**Commented [JDS49]:** Note: these are also from the Kettle River LSP. Are these projects still relevant and priorities for the local work group? Currently they are not included in the strategies tables, but they can be added to the tables if they are still relevant projects.

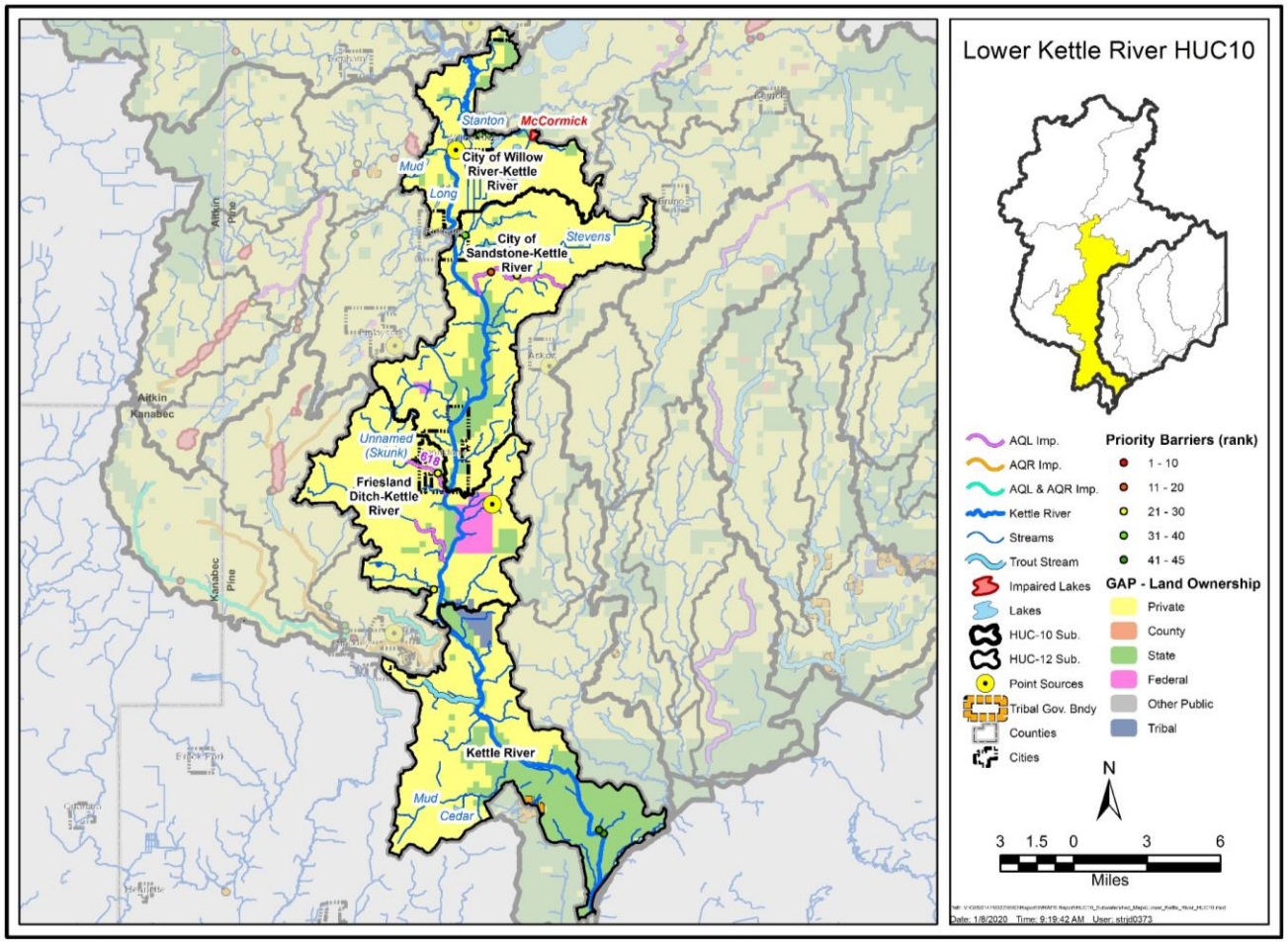



**Figure 18: Lower Kettle River HUC-10 Subwatershed**

**Table 19: Strategies and actions proposed for the Lower Kettle River HUC-10 Subwatershed.**

**Bear Creek HUC-10**

***Subwatershed Characteristics***

- Size: 42,898 acres
- HUC-12 subwatersheds: Lower Bear Creek, Upper Bear Creek
- Towns/Cities: Askov (pop. 816)
- Point Source Dischargers: Askov WWTP
- Landcover: forest/shrubland (43%), wetlands (30%), hay/pasture (20%), cropland (4%), developed (3%), open water (<1%), and barren/mining (<1%)
- Forested Land Protection: 26% (4,769 acres) public ownership, 74% (13,790 acres) privately owned
- WHPAs: Askov (297 acres) (see Figure 5)
- DWSMAs: Askov (589 acres) (see Figure 5)

***Streams***

- Streams: 74 miles
- Stream Types
    - Natural: 40 miles
    - Altered: 28 miles
    - Impounded: <1 mile
    - No definable channel: 7 miles
- Public Watercourses: 49 miles
- Tiered Aquatic Life Use Classes
    - Exceptional use: 0 miles
    - General use: 41 miles
    - Modified use 0 miles
- DNR Designated Trout Streams: 2 miles
- Cold Water Streams: None
- Stream Protection & Prioritization Tool (see Figure 9 and Appendix A)
    - Priority A: 0 reaches
    - Priority B: 1 reach (2 miles)
    - Priority C: 1 reach (40 miles)
- Stream Crossing Inventory and Prioritization
    - No priority barriers

***Lakes***

- Lakes >10 acres: none
- Lakes >100 acres: none
- Impaired Lakes: none
- Nearly/Barely Impaired Lakes: none
- Lakes of Biological Significance
    - Outstanding: none
    - High: none
    - Moderate: none
- DNR Priority Shallow Lakes: none
- DNR Wild Rice Lakes: none
- DNR Cisco Refuge Lakes: none
- DNR Stream Trout Lakes: none

- DNR Muskie Lakes: none
- Fish IBI scores
    - Exceptional: none
    - At or Above Impairment: none
    - Below Impairment Threshold: none
- Lake Protection & Prioritization Tool (see Figure 9)
    - Priority A: none
    - Priority B: none
    - Priority C: none
- Lake Benefit: Cost Assessment Tool:
    - Highest: none
    - Higher: none
    - High: none

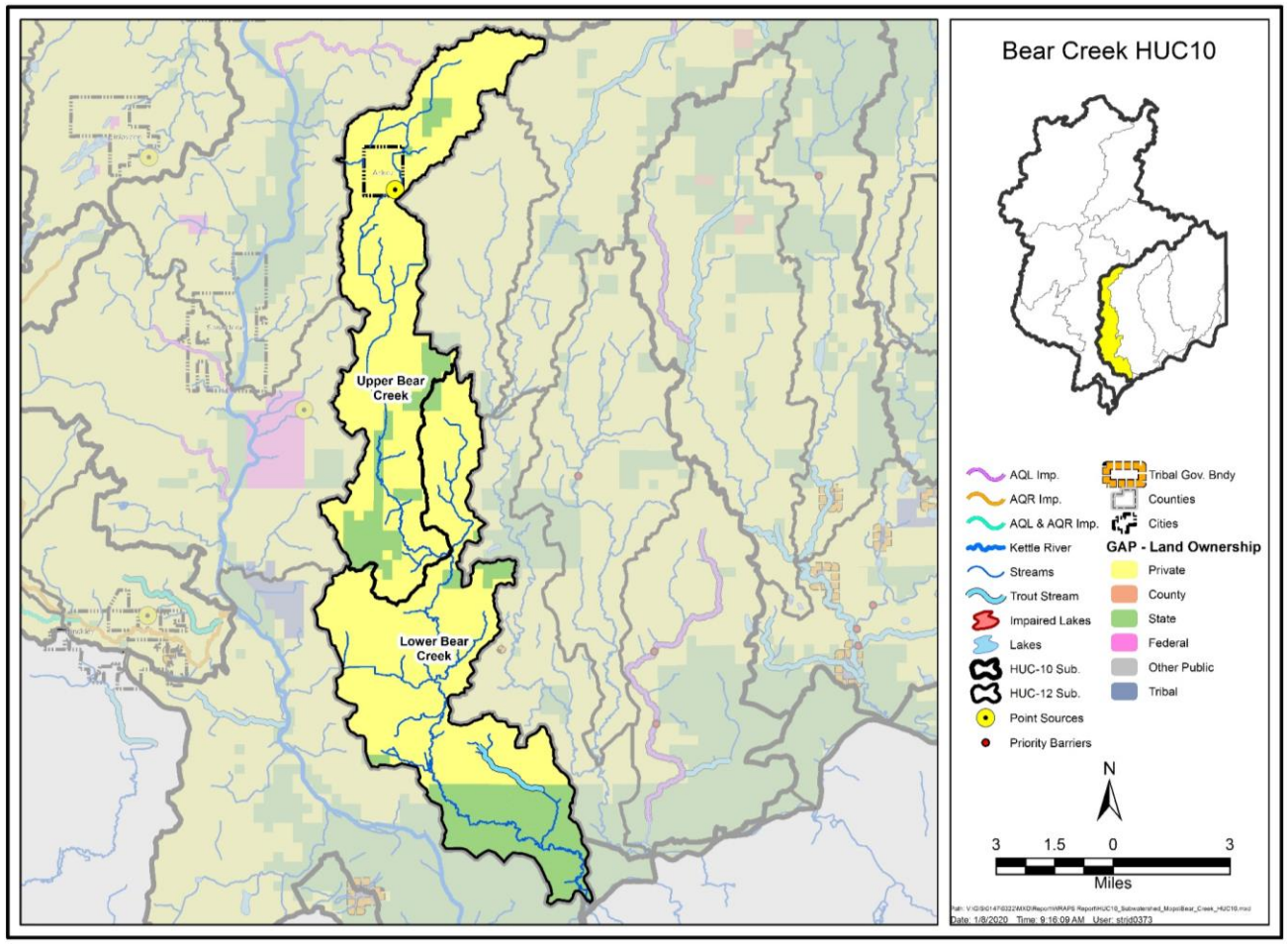



**Figure 19: Bear Creek HUC-10 Subwatershed**

**Table 20: Strategies and actions proposed for the Bear Creek HUC-10 Subwatershed**

## Sand Creek HUC-10

***Subwatershed Characteristics***

- Size: 89,860 acres
- HUC-12 subwatersheds: Hay Creek-Sand Creek, Little Sand Creek, Lower Sand Creek, Partridge Creek, Upper Sand Creek
- Towns/Cities: None
- Point Source Dischargers: None
- Landcover: forest/shrubland (48%), wetlands (32%), hay/pasture (12%), cropland (4%), developed (3%), open water (1%), and barren/mining (<1%)
- Forested Land Protection: 28% (12,210 acres) public ownership, 72% (31,092 acres) privately owned
- WHPAs: Askov (148 acres) (see Figure 5)
- DWSMAs: Askov (266 acres) (see Figure 5)

***Streams***

- Streams: 143 miles
- Stream Types
    - Natural: 98 miles
    - Altered: 29 miles
    - Impounded: 2 miles
    - No definable channel: 15 miles
- Public Watercourses: 92 miles
- Tiered Aquatic Life Use Classes
    - Exceptional use: 14 miles
    - General use: 34 miles
    - Modified use 0 miles
- DNR Designated Trout Streams: 24 miles
- Cold Water Streams: 3 reaches (7 miles)
- Stream Protection & Prioritization Tool (see Figure 9 and Appendix A)
    - Priority A: 1 reach (6 miles)
    - Priority B: 2 reaches (12 miles)
    - Priority C: 4 reaches (30 miles)
- Stream Crossing Inventory and Prioritization
    - 3 priority barriers
    - T106 culvert
    - Private Culvert
    - T777 Culvert

***Lakes***

- Lakes >10 acres: Bartels, Clayton, Wallace, Wilbur
- Lakes >100 acres: none
- Impaired Lakes: none
- Nearly/Barely Impaired Lakes: none
- Lakes of Biological Significance
    - Outstanding: none
    - High: none
    - Moderate: none

- DNR Priority Shallow Lakes: none
- DNR Wild Rice Lakes: none
- DNR Cisco Refuge Lakes: none
- DNR Stream Trout Lakes: none
- DNR Muskie Lakes: none
- Fish IBI scores
    - Exceptional: none
    - At or Above Impairment: none
    - Below Impairment Threshold: none
- Lake Protection & Prioritization Tool (see Figure 9)
    - Priority A: none
    - Priority B: none
    - Priority C: Clayton and Wallace
- Lake Benefit: Cost Assessment Tool:
    - Highest: none
    - Higher: none
    - High: Clayton and Wallace

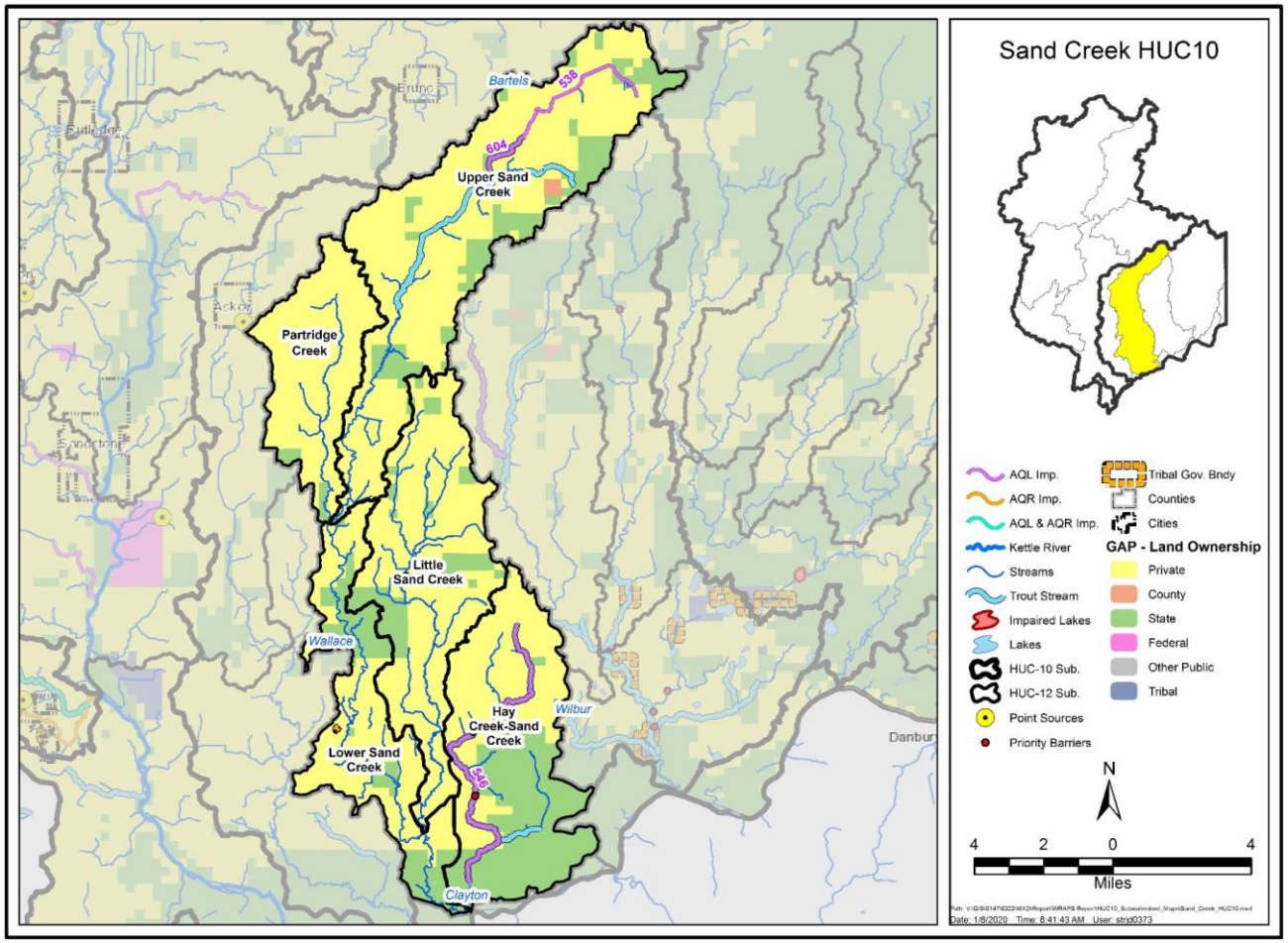



**Figure 20: Sand Creek HUC-10 Subwatershed**

**Table 21: Strategies and actions proposed for the Sand Creek HUC-10 Subwatershed**

## Crooked Creek HUC-10

***Subwatershed Characteristics***

- Size: 64,158 acres
- HUC-12 subwatersheds: Crooked Creek, East Fork Crooked Creek, West Fork Crooked Creek
- Towns/Cities: None
- Point Source Dischargers: None
- Landcover: forest/shrubland (57%), wetlands (28%), hay/pasture (9%), cropland (3%), developed (2%), open water (2%), and barren/mining (<1%)
- Forested Land Protection: 42% (15,265 acres) public ownership, 58% (21,287 acres) privately owned
- WHPAs: None (see Figure 5)
- DWSMAs: None (see Figure 5)

***Streams***

- Streams: 97 miles
- Stream Types
    - Natural: 90 miles
    - Altered: 3 miles
    - Impounded: 1 mile
    - No definable channel: 4 miles
- Public Watercourses: 81 miles
- Tiered Aquatic Life Use Classes
    - Exceptional use: 7 miles
    - General use: 13 miles
    - Modified use 0 miles
- DNR Designated Trout Streams: 34 miles
- Cold Water Streams: 4 reaches (16 miles)
- Stream Protection & Prioritization Tool (see Figure 9 and Appendix A)
    - Priority A: 1 reach
    - Priority B: 4 reaches (16 miles)
    - Priority C: 1 reach (3 miles)
- Stream Crossing Inventory and Prioritization
    - 4 Priority barriers
    - MN48 bridge
    - T1348 culvert
    - T381 culvert
    - CSAH32 culvert

***Lakes***

- Lakes >10 acres: 15 lakes
- Lakes >100 acres: none
- Impaired Lakes: none
- Nearly/Barely Impaired Lakes: none
- Lakes of Biological Significance
    - Outstanding: Crooked
    - High: Razor
    - Moderate: Alma, Tamarack and Greigs

- DNR Priority Shallow Lakes: Crooked
- DNR Wild Rice Lakes: Crooked
- DNR Cisco Refuge Lakes: none
- DNR Stream Trout Lakes: none
- DNR Muskie Lakes: none
- Fish IBI scores
    - Exceptional: none
    - At or Above Impairment: none
    - Below Impairment Threshold: none
- Lake Protection & Prioritization Tool (see Figure 9)
    - Priority A: Lena
    - Priority B: Greigs
    - Priority C: McGowan, Tamarack, and Razor
- Lake Benefit: Cost Assessment Tool:
    - Highest: none
    - Higher: none
    - High: Lena, Greigs, McGowan, Tamarack, and Razor

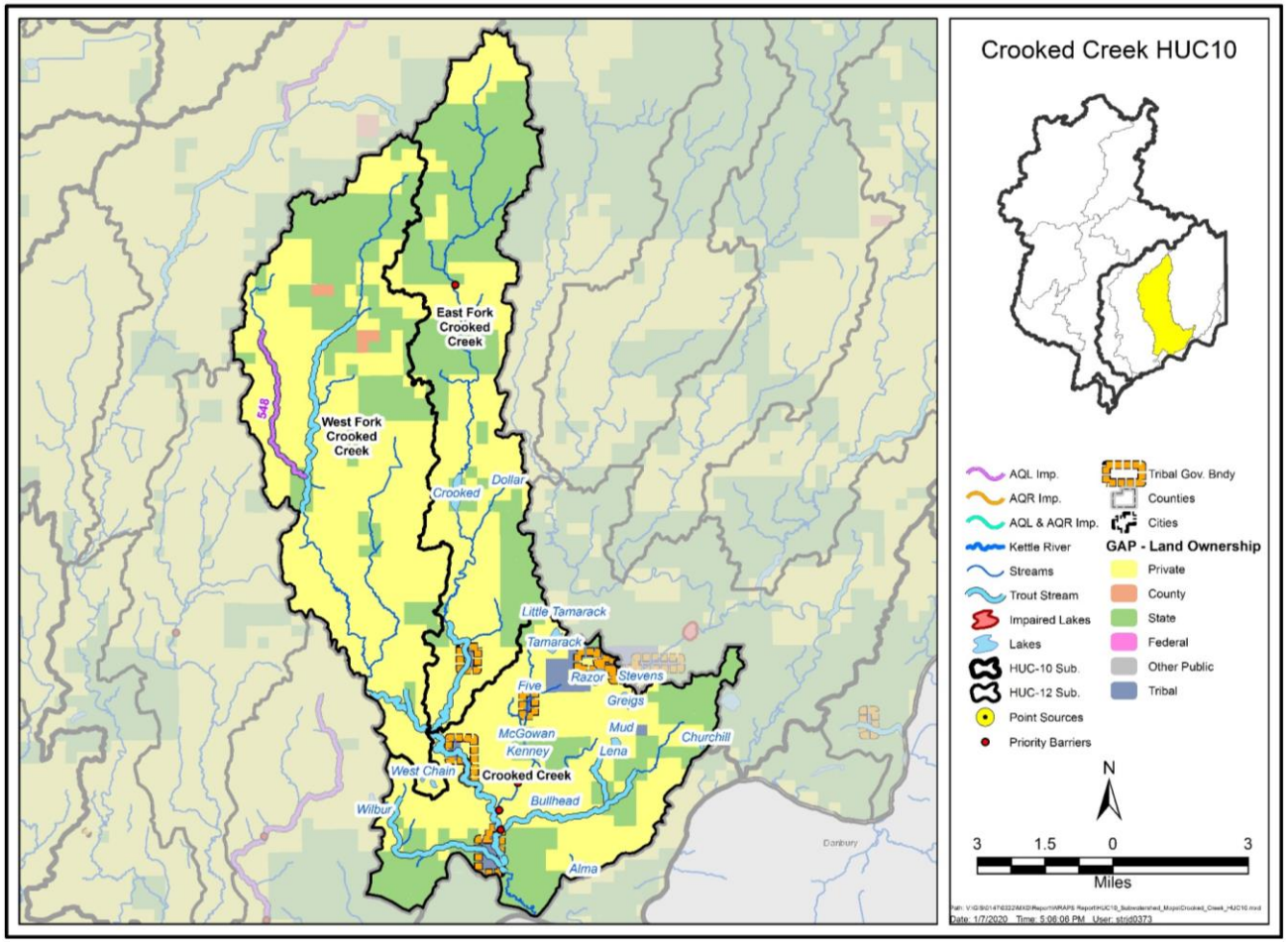



**Figure 21: Crooked Creek HUC-10 Subwatershed**

**Table 22: Strategies and actions proposed for the Crooked Creek HUC-10 Subwatershed**

**Lower Tamarack River HUC-10**

***Subwatershed Characteristics***

- Size: 118,453 acres
- HUC-12 subwatersheds: Hay Creek-Lower Tamarack River, Headwaters Lower Tamarack River, Keene Creek, Lower Tamarack River, McDermott Creek
- Towns/Cities: None
- Point Source Dischargers: None
- Landcover: forest/shrubland (55%), wetlands (41%), hay/pasture (2%), developed (1%), open water (1%), cropland (<1%), and barren/mining (<1%)
- Forested Land Protection: 61% (39,552 acres) public ownership, 39% (25,153 acres) privately owned
- WHPAs: None (see Figure 5)
- DWSMAs: None (see Figure 5)

***Streams***

- Streams: 178 miles
- Stream Types
  - Natural: 170 miles
  - Altered: 2 miles
  - Impounded: 1 mile
  - No definable channel: 4 miles
- Public Watercourses: 125 miles
- Tiered Aquatic Life Use Classes
  - Exceptional use: 0 miles
  - General use: 87 miles
  - Modified use 0 miles
- DNR Designated Trout Streams: 5 miles
- Cold Water Streams: None
- Stream Protection & Prioritization Tool (see Figure 9 and Appendix A)
  - Priority A: 0 reaches
  - Priority B: 1 reach (6 miles)
  - Priority C: 6 reaches (81 miles)
- Stream Crossing Inventory and Prioritization
  - 1 Priority barrier
  - T918 culvert

***Lakes***

- Lakes >10 acres: Grace, Hay Creek Flowage, Little Tamarack, Rock, and Stevens
- Lakes >100 acres: none
- Impaired Lakes: Grace
- Nearly/Barely Impaired Lakes: none
- Lakes of Biological Significance
  - Outstanding: Grace and Hay Creek Flowage
  - High: none
  - Moderate: none
- DNR Priority Shallow Lakes: Rock, Grace, and Hay Creek Flowage
- DNR Wild Rice Lakes: Hay Creek Flowage

- DNR Cisco Refuge Lakes: none
- DNR Stream Trout Lakes: none
- DNR Muskie Lakes: none
- Fish IBI scores
    - Exceptional: none
    - At or Above Impairment: none
    - Below Impairment Threshold: none
- Lake Protection & Prioritization Tool (see Figure 9)
    - Priority A: none
    - Priority B: Rock
    - Priority C: Grace, Hay Creek Flowage, Little Tamarack, and Stevens
- Lake Benefit: Cost Assessment Tool:
    - Highest: none
    - Higher: none
    - High: Grace, Hay Creek Flowage, Little Tamarack, Rock, and Stevens

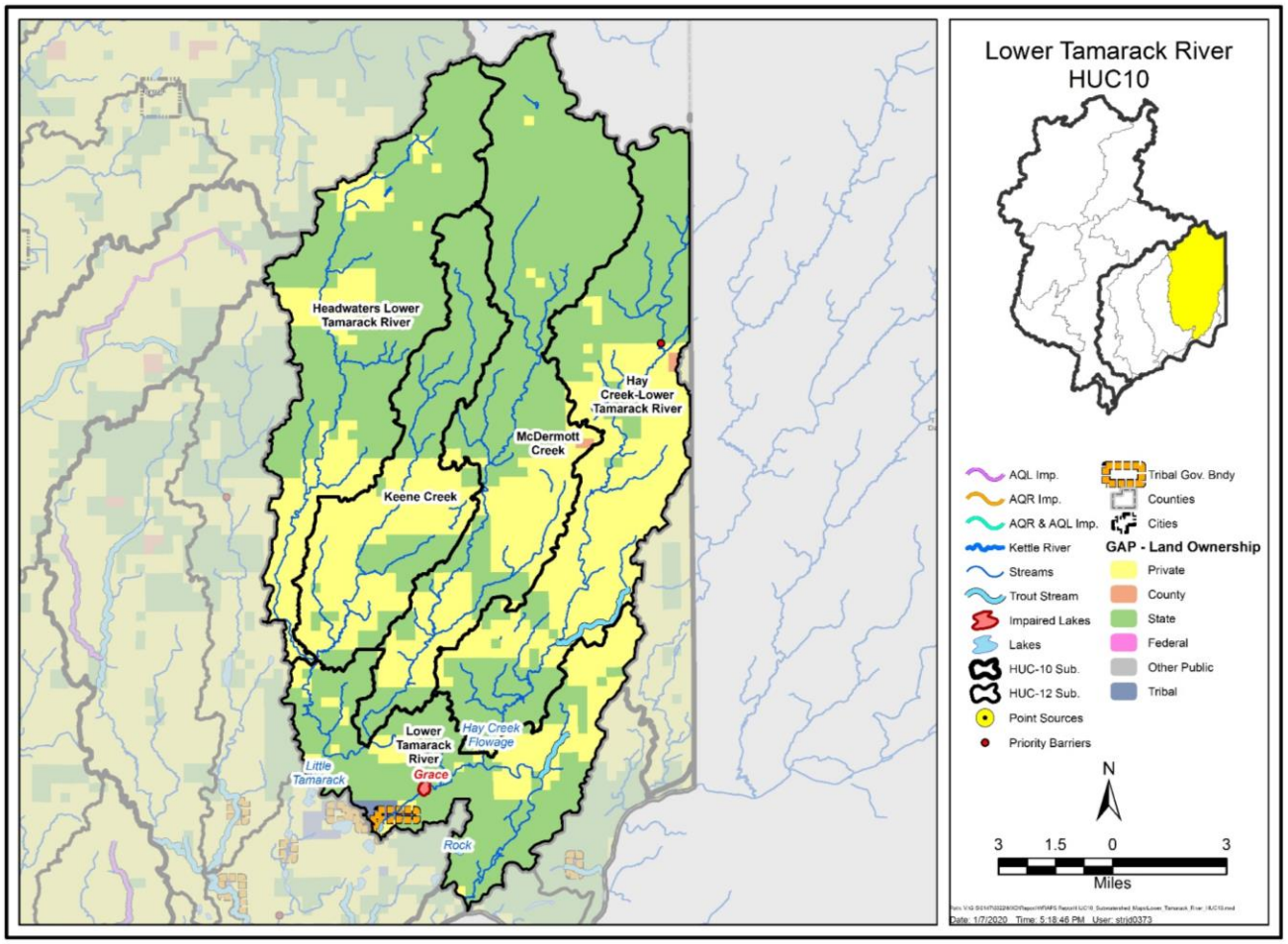



**Figure 22: Lower Tamarack River HUC-10 Subwatershed**

**Table 23: Strategies and actions proposed for the Lower Tamarack River HUC-10 Subwatershed**

**Upper Tamarack River HUC-10**

***Subwatershed Characteristics***

- Size: 6,879 acres
- HUC-12 subwatersheds: Spruce River, Upper Tamarack River
- Towns/Cities: None
- Point Source Dischargers: None
- Landcover: forest/shrubland (64%), wetlands (26%), hay/pasture (5%), developed (3%), cropland (2%), open water (<1%), and barren/mining (<1%)
- Forested Land Protection: 15% (646 acres) public ownership, 85% (3,759 acres) privately owned
- WHPAs: None (see Figure 5)
- DWSMAs: None (see Figure 5)

***Streams***

- Streams: 16 miles
- Stream Types
    - Natural: 11 miles
    - Altered: <1 miles
    - Impounded: 0 miles
    - No definable channel: 4 miles
- Public Watercourses: 8 miles
- Tiered Aquatic Life Use Classes
    - Exceptional use: 4 miles
    - General use: 4 miles
    - Modified use 0 miles
- DNR Designated Trout Streams: None
- Cold Water Streams: None
- Stream Protection & Prioritization Tool (see Figure 9 and Appendix A)
    - Priority A: 0 reaches
    - Priority B: 1 reach (4 miles)
    - Priority C: 1 reach (4 miles)
- Stream Crossing Inventory and Prioritization
    - No priority barriers

***Lakes***

- Lakes >10 acres: none
- Lakes >100 acres: none
- Impaired Lakes: none
- Nearly/Barely Impaired Lakes: none
- Lakes of Biological Significance
    - Outstanding: none
    - High: none
    - Moderate: none
- DNR Priority Shallow Lakes: none
- DNR Wild Rice Lakes: none
- DNR Cisco Refuge Lakes: none
- DNR Stream Trout Lakes: none
- DNR Muskie Lakes: none
- Fish IBI scores

    - Exceptional: none
    - At or Above Impairment: none
    - Below Impairment Threshold: none
- Lake Protection & Prioritization Tool (see Figure 9)
    - Priority A: none
    - Priority B: none
    - Priority C: none
- Lake Benefit: Cost Assessment Tool:
    - Highest: none
    - Higher: none
    - High: none

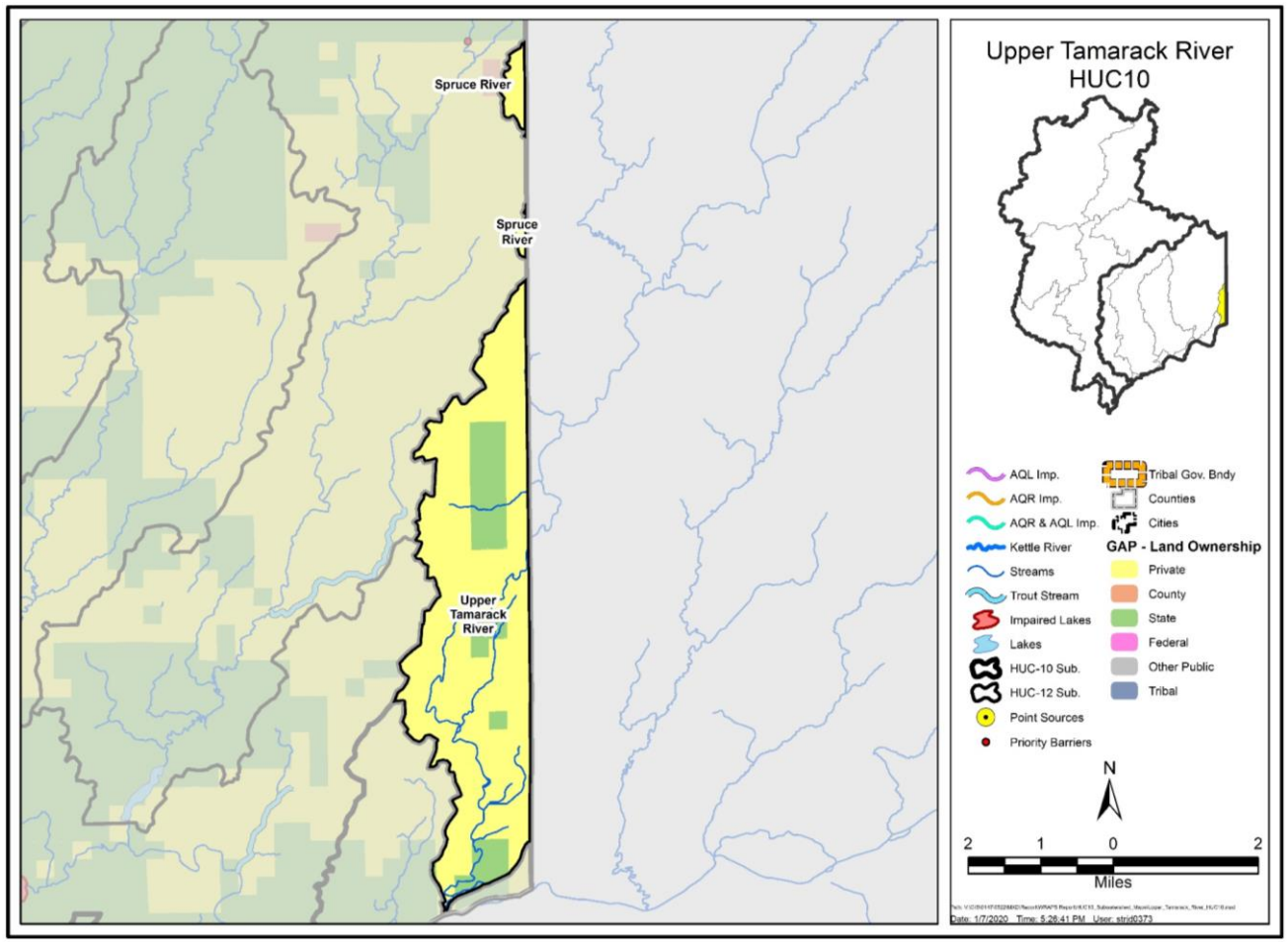



**Figure 23: Upper Tamarack River HUC-10 Subwatershed**

**Table 24: Strategies and actions proposed for the Upper Tamarack River HUC-10 Subwatershed**

**Commented [ST(50]:** Chases Brook-St Croix River HUC-10 is missing from this section and an implementation table has not been developed yet. More to come here…

# 4. Monitoring plan

The collection of current land and water data is an important component to both assess progress and inform management and decision-making. For improved watershed management to work in the Kettle and Upper St. Croix River Watersheds, there needs to be reliable data collected and analyzed. Monitoring of both land management and water resources is needed to inform and calibrate watershed models, evaluate progress towards defined goals, and desired outcomes. Section 7 of the Kettle and Upper St. Croix River TMDL report includes more information on monitoring.

It is the intent of the implementing organizations in this watershed to make steady progress in terms of pollutant reduction. The response of the lakes and streams will be monitored and subsequently evaluated as management practices are implemented. The management approach to achieving the goals should be adapted as new monitoring data is collected and evaluated (i.e. adaptive management approach, Figure 24). Continued monitoring and "course corrections" responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in these watersheds. Management activities will be changed or refined to efficiently meet the TMDL and lay the groundwork for de-listing the impaired water bodies.

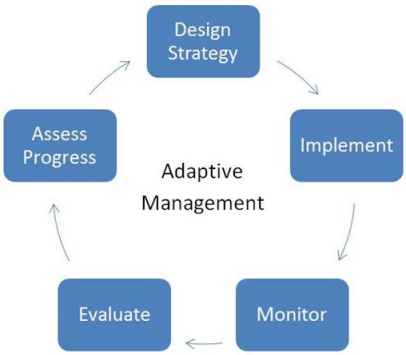



**Figure 24: Adaptive management framework**

The overall schedule for implementation of this TMDL and WRAPS project is 2020 through 2040. During this time period, it is expected that on average, water quality pollutant concentrations will decline each year equivalent to approximately 3% of the starting (i.e., long-term) pollutant load reduction for the *E. coli* impairments and 2% for the lake TP impairments. This progress benchmark will generally result in meeting water quality standards by 2040 the majority of the waterbodies.

Again, this is a general guideline. Factors that may mean slower progress include limits in funding or landowner acceptance, challenging fixes (e.g., restoring large peatlands, invasive species, lake internal load management) and unfavorable climatic factors. Conversely, there may be faster progress for some impaired waters, especially where high-impact fixes are slated to occur.

Data from numerous monitoring programs will continue to be collected and analyzed throughout the Kettle and Upper St. Croix River Watersheds. Monitoring is conducted by local, state and federal entities, and also special projects as described below.

### Intensive Watershed Monitoring

Through the State of Minnesota's Watershed Approach, the MPCA collects water quality and biological data for two years every 10 years at established stream and lake monitoring stations within every major watershed in the State (link to MPCA website). The first round of intensive watershed monitoring for the Kettle and Upper St. Croix River Watersheds was completed in 2016 and 2017. These efforts are summarized in the monitoring and assessment reports (MPCA 2019a and MPCA 2019b). The MPCA, with assistance from LGUs, will re-visit and re-assess these monitoring stations, as well as have capacity to

visit new sites in areas with BMP implementation activity, scheduled to begin in 2026. It is expected that funding for monitoring and analysis will be available through the MPCA.

### Watershed Pollutant Load Monitoring Network (WPLMN)

The WPLMN, which includes state and federal agencies, Metropolitan Council Environmental Services, state universities, and local partners, collects data on water quality and flow in Minnesota to calculate pollutant loads in rivers and streams (link to WPLMN website). Data is collected at 199 sites around the state. Each year, approximately 25 to 35 water quality samples are collected at each monitoring site, either year-round or seasonally depending on the site. Water quality samples are collected near gaging stations, at or near the center of the channel. Samples are collected more frequently when water flow is moderate and high, when pollutant levels are typically elevated and most changeable. Pollutant concentrations are generally more stable when water flows are low, and fewer samples are taken in those conditions. This staggered approach generally results in samples collected over the entire range of flows.

Data collected through WPLMN is used to assist in watershed modeling, determine pollutant source contributions, evaluate trends, develop reports, and measure water quality restoration efforts. There are two WPLMN sites within the Kettle River Watershed (see discussion in Section2.2).

### Citizen Stream and Lake Monitoring Program

The MPCA's Citizen Stream and Lake Monitoring Program (link to website) relies on a network of private citizen volunteers who make monthly stream and lake measurements annually. Data collected through these efforts can provide a continuous record of waterbody transparency throughout much of the basin. There is currently a limited number of citizens doing monitoring within the Kettle and Upper St. Croix River Watersheds. The MPCA and local units of government have sought and will continue to seek more citizen monitors to track trends of water quality transparency for impaired waters within the basin.

### County and Lake Association Monitoring

XXXX

**Commented [JS51]:** Are there any counties and/or lake associations in the watersheds that have routine monitoring programs that we could highlight here? Or if not, is this a objective of any of these groups to implement a program?

I know in Tim's notes from meetings with LWG, there are requests for a tool-kit that Counties and Lake Association could use to develop monitoring plans. Should we expand upon that here or introduce that idea? What would that look like and include?

**Commented [ST(52R51]:** I am going to solicit input about monitoring programs from the LWG, but I know that Pine/Carlton SWCDs have done monitoring before—unsure about Aitkin and Kanabec; Big Pine Lake Association has also done monitoring before too, but I don't know if that effort is ongoing. Windemere Township Lakes Association has expressed interest in monitoring and will be participating in CLMP+ starting this year.

### Diagnostic and Targeted Monitoring

The Kettle and Upper St. Croix River Watershed Stressor ID reports, TMDL allocations, and source assessment exercises were developed using available monitoring data, surveys, assessments, and models. For many of the impairments, it is recommended that additional targeted data and information be collected prior to investing significant money and resources into restoring these waterbodies. Collecting additional diagnostic and targeted monitoring data will help calibrate and/or validate modeling results, refine the TMDL source assessments, pinpoint geographic locations of problem areas, and provide baseline data prior to project implementation. Several targeted monitoring activities were identified in the Kettle and Upper St. Croix River Watershed SID and TMDL reports. Many of these activities have been incorporated into the individual strategies tables in this WRAPS and include the following:

- Microbial source tracking in all bacteria impaired streams to identify sources of fecal contamination
- Longitudinal (upstream to downstream) *E. coli* monitoring surveys in all bacteria impaired streams to evaluate potential locations of elevated bacteria loading
- Additional dissolved oxygen and flow monitoring within ditched peatlands

- Inventory/assessment of streambank and riparian conditions along the main-stem Kettle River to identify and prioritize bank stabilization, stream restorations, and other riparian improvement projects
- Collect flow and water quality (e.g. TP) in major tributaries and wetlands flowing to impaired lakes. Compare monitoring results to HSPF and lake response models for validation and/or re-calibration
- Collect sediment cores and evaluate phosphorus release from sediment within selected impaired lakes and compare to TMDL model predictions
- Collect targeted water quality measurements and sediment data within lakes and streams that have been identified as having potential legacy loading impacts (e.g. historic paper mills, logging, trout farms, etc.)
- Conduct/update fish and/or vegetation surveys according to DNR methodology for lakes that have never been surveyed or have limited or outdated survey data

# 5. References


Banaszuk, P., A. Wysocka-Czubaszek, P. Kondratiuk. 2005. Spatial and temporal patterns of groundwater chemistry in the river riparian zone. Agriculture Ecosystems and Environment 107:167-179.

Dillon, P.J. and L.A. Molot. 1997. Effect of landscape form on export of dissolved organic carbon, iron, and phosphorus from forested stream catchments. Water Resources Research 33(11):2591-2600. http://onlinelibrary.wiley.com/doi/10.1029/97WR01921/pdf

Fond du Lac Reservation. 2004. Fond du Lac Reservation Tribal Nonpoint Source Assessment Report and Management Program, September 2004, pages 24 and 34

Fristedt, A. 2004. Phosphorus distribution, forms and dynamics of riparian zone peat wetland in Kristianstad district, Southern Sweden. Department of Soil Sciences. Uppsala, Sweden, Swedish University of Agricultural Sciences. Masters: 66 pp. http://www.vattenriket.kristianstad.se/examensarbete/pdf/050415_Phosphorus_distribution.pdf

Holden, J., P.J. Chapman, and J.C. Labadz. 2004. Artificial drainage of peatlands: hydrological and hydrochemical process and wetland restoration. Progress in Physical Geography 28(1): 95-123

MDA 2020. Groundwater Protection Rule. https://www.mda.state.mn.us/nfr

MPCA 2014. Water Quality Trends for Minnesota Rivers and Streams at Milestone Sites. https://www.pca.state.mn.us/sites/default/files/wq-s1-71.pdf

MPCA 2019a. Kettle River Watershed Monitoring and Assessment Report. https://www.pca.state.mn.us/sites/default/files/wq-ws3-07030003b.pdf

MPCA 2019b. Upper St. Croix River Monitoring and Assessment Report. https://www.pca.state.mn.us/sites/default/files/wq-ws3-07030001.pdf

MPCA 2020a. Kettle River Watershed Stressor Identification Report. <provide link when available>

MPCA 2020b. Upper St. Croix River Watershed Stressor Identification Report. <provide link when available>

MPCA 2020c. Kettle and Upper St. Croix River Watershed Total Maximum Daily Load. <provide link when available>

O'Brien, H.D., M.C. Eimers, S.A. Watmouth, and N.J. Casson. 2013. Spatial and temporal patterns in total phosphorus in south-central Ontario streams: the role of wetlands and past disturbance. Canadian Journal of Fisheries and Aquatic Sciences 70:766-774.

Price, J., A. Heathwaite, and A. Baird. 2003. Hydrological processes in abandoned and restored peatlands: An overview of management approaches. Wetlands Ecology and Management 11(1): 65-83.

Vennum, T. 2004. *Wild Rice and the Ojibway People*; Minnesota Historical Society Press: St. Paul, 2004.

# Appendix A: Lake and Stream Protection and Prioritization Results

| HUC-10 Subwatershed | Lake ID | Lake Name | Mean TP (ug/L) | Secchi Trend | % Disturbed Land Use | Load Reduction Goal (TP lbs/year) | Priority |
|---|---|---|---|---|---|---|---|
| Grindstone River | 58-0123-00 | Grindstone | 19.5 | No evidence of trend | 12% | 83 | B |
| | 58-0126-00 | Elbow | 40.9 | Insufficient data | 13% | 23 | B |
| | 58-0135-00 | Miller | 35.5 | Insufficient data | 11% | 7 | B |
| | 33-0003-00 | Five | 24.3 | Insufficient data | 5% | 2 | C |
| Lower Kettle River | 58-0083-00 | Second | 28.0 | Insufficient data | 12% | 2 | B |
| | 58-0089-00 | Cedar | 38.0 | Insufficient data | 8% | 11 | B |
| | 58-0099-00 | First | 39.0 | Insufficient data | 27% | 30 | B |
| | 58-0107-00 | Long | 29.6 | Insufficient data | 13% | 10 | B |
| | 58-0058-00 | McCormick | 34.5 | Insufficient data | 9% | 21 | C |
| | 58-0103-00 | Mud | 80.0 | Insufficient data | 3% | 15 | C |
| | 58-0106-00 | Little Mud | 54.5 | No data provided | 3% | 8 | C |
| Moose River | 09-0034-00 | Bear | 25.6 | No evidence of trend | 44% | 7 | A |
| | 09-0035-00 | Little Hanging Horn | 17.2 | Improving trend | 15% | 5 | A |
| | 09-0039-00 | Eddy | 22.3 | **Declining trend** | 10% | 121 | A |
| | 58-0062-00 | Island | 31.5 | No evidence of trend | 22% | 39 | A |
| | 58-0081-00 | Sand | 17.9 | No evidence of trend | 20% | 35 | A |
| | 09-0029-00 | Park | 16.5 | No evidence of trend | 4% | 8 | B |
| | 09-0041-00 | Moosehead | 35.9 | **Declining trend** | 61% | 378 | B |
| | 09-0043-00 | Moose | 24.0 | No data provided | 7% | 8 | B |
| | 09-0044-00 | Echo | 16.0 | No data provided | 13% | 5 | B |
| | 09-0045-00 | Coffee | 19.9 | Insufficient data | 28% | 30 | B |
| | 09-0022-00 | Twentynine | 53.4 | No data provided | 11% | 8 | C |
| | 09-0026-00 | Bob | 17.6 | Insufficient data | 4% | 9 | C |

| HUC-10 Subwatershed | Lake ID | Lake Name | Mean TP (ug/L) | Secchi Trend | % Disturbed Land Use | Load Reduction Goal (TP lbs/year) | Priority |
|---|---|---|---|---|---|---|---|
| | 09-0038-00 | Hanging Horn | 25.5 | No evidence of trend | 10% | 276 | C |
| Pine River | 58-0136-00 | Rhine | 62.0 | **Declining trend** | 6% | 31 | A |
| | 58-0137-00 | Bass | 16.7 | Insufficient data | 16% | 4 | A |
| | 33-0001-00 | Eleven | 38.9 | Insufficient data | 10% | 22 | B |
| | 58-0127-00 | Little Bass | 35.1 | No evidence of trend | 15% | 1 | B |
| | 58-0138-00 | Big Pine | 35.9 | No evidence of trend | 12% | 129 | B |
| | 58-0102-00 | Fox | 52.1 | Insufficient data | 7% | 52 | C |
| | 58-0128-00 | Bass | 23.5 | No evidence of trend | 7% | 1 | C |
| | 58-0129-00 | Little Pine | 67.0 | Insufficient data | 11% | 118 | C |
| | 58-0130-00 | Upper Pine | 24.2 | No evidence of trend | 7% | 43 | C |
| | 58-0131-00 | Fish | 69.0 | Insufficient data | 18% | 23 | C |
| | 58-0132-00 | Indian | 27.0 | Insufficient data | 9% | 14 | C |
| | 01-0001-00 | Pine | 36.8 | No evidence of trend | 7% | 109 | NA |
| Upper Kettle River | 09-0058-00 | Merwin | 39.3 | No data provided | 9% | 7 | B |
| | 09-0049-00 | Kettle | 28.9 | Insufficient data | 1% | 53 | C |
| Willow River | 58-0048-00 | Oak | 32.8 | No evidence of trend | 12% | 24 | A |
| | 58-0067-00 | Sturgeon | 14.0 | No evidence of trend | 17% | 27 | A |
| | 58-0073-00 | Dago | 16.1 | Improving trend | 21% | 3 | A |
| | 58-0068-00 | Eleven | 24.6 | No evidence of trend | 8% | 3 | B |
| | 58-0076-00 | Passenger | 12.3 | No data provided | 11% | 1 | B |
| | 58-0111-00 | Stanton | 41.0 | No data provided | 27% | 394 | C |
| Crooked Creek | 58-0018-00 | Lena | 32.0 | Insufficient data | 15% | 2 | A |
| | 58-0013-00 | Greigs | 27.0 | Insufficient data | 16% | 2 | B |
| | 58-0010-00 | Razor | 15.0 | Insufficient data | 3% | 3 | C |
| | 58-0024-00 | Tamarack | 20.4 | Improving trend | 3% | 2 | C |
| | 58-0012-00 | McGowan | 41.0 | Insufficient data | 0% | 24 | C |
| Lower Tamarack River | 58-0007-00 | Rock | 35.1 | Insufficient data | 3% | 3 | B |
| | 58-0028-00 | Little Tamarack | 26.0 | Insufficient data | 5% | 4 | C |

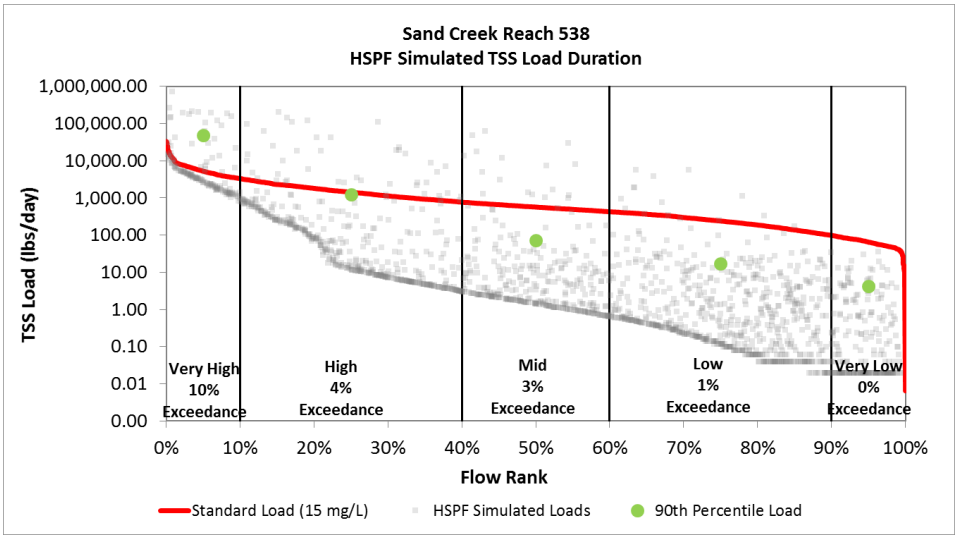
| HUC-10 Subwatershed | Lake ID | Lake Name | Mean TP (ug/L) | Secchi Trend | % Disturbed Land Use | Load Reduction Goal (TP lbs/year) | Priority |
|---|---|---|---|---|---|---|---|
| | 58-0009-00 | Stevens | 63.0 | Insufficient data | 7% | 4 | C |
| | 58-0029-00 | Grace | 70.3 | Insufficient data | 3% | 31 | C |
| | 58-0005-00 | Hay Creek Flowage | 75.3 | No data provided | 3% | 340 | C |
| Sand Creek | 58-0054-00 | Wallace | 32.0 | No data provided | 5% | 4 | C |
| | 58-0040-00 | Clayton | 55.0 | No data provided | 3% | 106 | C |

| HUC-10 Subwatershed | WID | Stream Name | TALU | Cold/ Warm | Community Nearly Impaired | Riparian Risk | Watershed Risk | Current Protection Level | Protection Priority Class |
|---|---|---|---|---|---|---|---|---|---|
| Grindstone River | 07030003-501 | Grindstone River | General | warm | one | high | med/high | med/low | A |
| | 07030003-544 | Grindstone River, North Branch | General | warm | neither | medium | medium | med/low | B |
| Lower Kettle River | 07030003-501 | Grindstone River | General | warm | one | high | med/high | med/low | A |
| | 07030003-502 | Kettle River | General | warm | one | low | medium | medium | B |
| | 07030003-503 | Kettle River | Exceptional | warm | neither | med/high | medium | med/low | B |
| | 07030003-505 | Kettle River | Exceptional | warm | one | medium | medium | medium | B |
| | 07030003-528 | Kettle River | General | warm | neither | medium | medium | med/high | C |
| Moose River | 07030003-521 | Moose Horn River | General | warm | one | high | med/high | med/low | A |
| | 07030003-547 | King Creek | General | cold | one | med/low | medium | low | A |
| | 07030003-628 | Moose Horn River, West Branch | Exceptional | warm | one | med/high | medium | med/low | A |
| | 07030003-531 | Moose Horn River | General | warm | neither | medium | med/high | medium | B |
| | 07030003-629 | Moose Horn River | Exceptional | warm | neither | med/high | med/high | medium | B |
| | 07030003-630 | Moose Horn River | General | warm | neither | medium | med/high | medium | B |
| | 07030003-535 | Moose Horn River | General | cold | neither | med/low | medium | medium | C |
| Pine River | 07030003-560 | Little Pine Creek | Exceptional | warm | both | high | med/high | low | A |
| | 07030003-624 | Pine River | Exceptional | warm | one | medium | medium | med/low | A |
| | 07030003-568 | Bremen Creek | General | warm | neither | med/high | med/low | medium | B |
| | 07030003-609 | Rhine Creek | General | warm | neither | high | medium | med/low | B |
| | 07030003-620 | Bremen Creek | General | warm | one | med/low | low | med/high | B |
| Upper Kettle River | 07030003-509 | Gillespie Brook | General | warm | neither | med/low | medium | med/low | B |
| | 07030003-510 | Kettle River | General | warm | neither | medium | medium | medium | B |
| | 07030003-513 | Split Rock River | General | warm | neither | medium | medium | medium | B |
| | 07030003-514 | Birch Creek | General | warm | neither | medium | medium | medium | B |
| | 07030003-529 | Kettle River | General | warm | neither | med/high | medium | med/low | B |
| | 07030003-592 | Silver Creek | General | warm | neither | med/low | medium | med/low | B |
| | 07030003-615 | Unnamed ditch | General | warm | one | med/low | medium | medium | B |

| HUC-10 Subwatershed | WID | Stream Name | TALU | Cold/ Warm | Community Nearly Impaired | Riparian Risk | Watershed Risk | Current Protection Level | Protection Priority Class |
|---|---|---|---|---|---|---|---|---|---|
| | 07030003-512 | Kettle River, West Branch | General | warm | neither | medium | med/low | medium | C |
| | 07030003-537 | Dead Moose River | General | warm | neither | med/low | medium | medium | C |
| | 07030003-552 | Kettle River | General | warm | neither | med/low | medium | medium | C |
| Willow River | 07030003-548 | Larsons Creek | General | cold | both | low | low | medium | A |
| | 07030003-575 | Little Willow River | General | warm | neither | med/low | medium | low | B |
| | 07030003-622 | Willow River | Exceptional | warm | neither | med/high | medium | medium | B |
| | 07030003-621 | Willow River | General | warm | neither | low | medium | medium | C |
| Bear Creek | 07030001-581 | Little Bear Creek | General | warm | neither | med/high | medium | low | B |
| | 07030001-518 | Bear Creek | General | warm | neither | med/low | medium | medium | C |
| Chases Brook-St. Croix River | 07030001-541 | Crooked Creek | Exceptional | warm | one | low | med/low | med/high | B |
| | 07030001-618 | Sand Creek | Exceptional | warm | one | medium | medium | medium | B |
| | 07030001-519 | Redhorse Creek | General | warm | neither | medium | med/low | high | C |
| Crooked Creek | 07030001-562 | Kenney Brook | General | warm | one | med/high | medium | med/low | A |
| | 07030001-522 | Crooked Creek | General | cold | one | medium | med/low | medium | B |
| | 07030001-537 | Crooked Creek, West Fork | General | cold | neither | med/high | med/low | medium | B |
| | 07030001-541 | Crooked Creek | Exceptional | warm | one | low | med/low | med/high | B |
| | 07030001-545 | Bangs Brook | Exceptional | cold | one | medium | medium | medium | B |
| | 07030001-533 | Crooked Creek, East Fork | General | cold | neither | medium | med/low | medium | C |
| Lower Tamarack River | 07030001-528 | Squib Creek | General | warm | one | med/low | med/low | medium | B |
| | 07030001-510 | Lower Tamarack River | General | warm | neither | med/low | low | med/high | C |
| | 07030001-511 | Hay Creek | General | warm | neither | med/low | low | medium | C |
| | 07030001-512 | Lower Tamarack River | General | warm | neither | low | low | high | C |
| | 07030001-513 | McDermott Creek | General | warm | neither | low | low | high | C |

| HUC-10 Subwatershed | WID | Stream Name | TALU | Cold/ Warm | Community Nearly Impaired | Riparian Risk | Watershed Risk | Current Protection Level | Protection Priority Class |
|---|---|---|---|---|---|---|---|---|---|
| | 07030001-514 | Lower Tamarack River | General | warm | neither | med/low | low | med/high | C |
| | 07030001-532 | Keene Creek | General | warm | neither | med/high | low | medium | C |
| Sand Creek | 07030001-554 | Little Sand Creek | Exceptional | warm | one | medium | med/low | low | A |
| | 07030001-553 | Partridge Creek | General | warm | neither | med/low | medium | med/low | B |
| | 07030001-618 | Sand Creek | Exceptional | warm | one | medium | medium | medium | B |
| | 07030001-605 | Sand Creek | General | cold | neither | med/low | med/low | medium | C |
| | 07030001-606 | Sand Creek | General | cold | neither | medium | med/low | med/high | C |
| | 07030001-617 | Sand Creek | General | warm | neither | med/low | medium | medium | C |
| | 07030001-902 | Little Hay Creek | General | cold | neither | med/low | medium | med/high | C |
| Upper Tamarack River | 07030001-613 | Upper Tamarack River | Exceptional | warm | one | med/low | low | low | B |
| | 07030001-614 | Upper Tamarack River | General | warm | neither | low | low | med/low | C |

# Appendix B: Stream and Lake TMDL Summaries

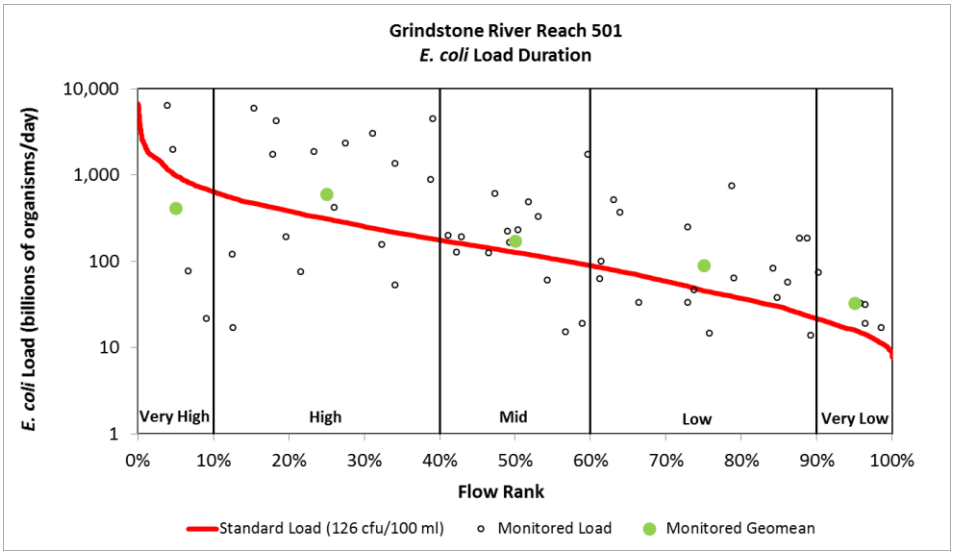



**Creek Reach 538 TSS LDC and HSPF simulated TSS loads and exceedances.**

**TSS TMDL summary for Sand Creek Reach 538.**

| Total Suspended Solids | | Flow zones* | | | | |
|---|---|---|---|---|---|---|
| | | Very high | High | Mid-range | Low | Very low |
| Sources | | TSS load (pounds/day) | | | | |
| Wasteload | Construction/Industrial SW | 3 | 0.9 | 0.4 | 0.2 | 0.04 |
| | **Total WLA** | **3** | **0.9** | **0.4** | **0.2** | **0.04** |
| Load | **Total LA** | **4,689** | **1,285** | **512** | **215** | **58** |
| | **MOS** | **521** | **143** | **57** | **24** | **6** |
| | **Total load** | **5,213** | **1,429** | **569** | **239** | **64** |
| **Existing 90th percentile concentration (mg/L)**** | | -*** | | | | |
| **Overall estimated percent reduction**** | | -*** | | | | |

* Model simulated flow for HSPF reach 764 (2000-2017) was used to develop the flow zones and LCs for this reach
** The impairment listing for this reach is based on Secchi Tube data (see Table 7 and Figure 4) as no TSS data has been collected for this reach. Therefore, reductions are based on HSPF simulated TSS loads/concentrations
*** This impairment was originally listed based on Secchi Tube data. No TSS has been collected for this reach and therefore it is not possible to estimate a monitored TSS load reduction target at this time. The MPCA will reevaluate the reach in the next impairment assessment for this watershed.



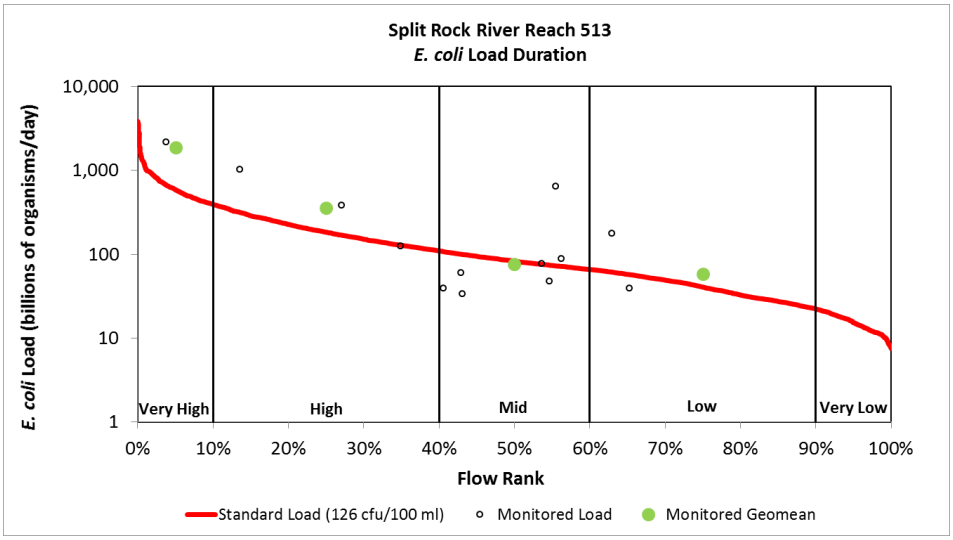

**Grindstone River Reach 501 *E. coli* LDC and monitored loads.**

***E. coli* TMDL summary for Grindstone River Reach 501.**

| *E. coli* | | Flow zones* | | | | |
|---|---|---|---|---|---|---|
| | | Very high | High | Mid-range | Low | Very low |
| Sources | | *E. coli* load (billions of org/day) | | | | |
| Wasteload | Hinckley WWTP (MN0023701) | 3 | 3 | 3 | 3 | 3 |
| | **Total WLA** | **3** | **3** | **3** | **3** | **3** |
| Load | **Total LA** | **880** | **277** | **111** | **38** | **11** |
| | **MOS** | **98** | **31** | **13** | **5** | **2** |
| | **Total load** | **981** | **311** | **127** | **46** | **16** |
| **Existing Concentration Apr-Oct (org/100 mL)**** | | **202** | | | | |
| **Maximum Monthly Geometric Mean (org/100mL)**** | | **606** | | | | |
| **Overall Estimated Percent Reduction***** | | **79%** | | | | |

* Model simulated flow for HSPF reach 627 from April-October (2000-2017) was used to develop the flow zones and LCs for this reach

** Water quality monitoring station(s) used to estimate reductions: S001-270 (years 2007-2009, 2016 and 2017)



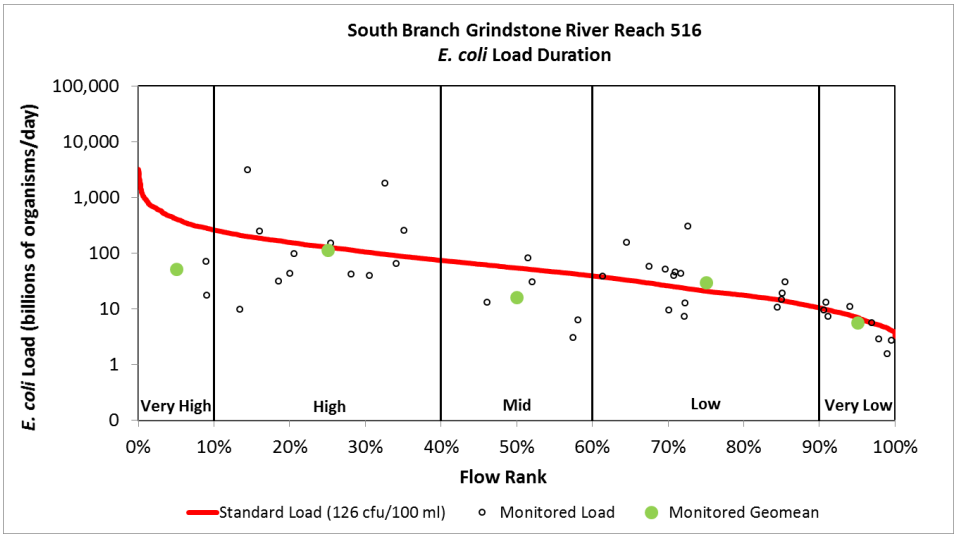

**Split Rock River Reach 513 *E. coli* LDC and monitored loads.**

***E. coli* TMDL summary for Split Rock River Reach 513.**

| *E. coli* | | Flow zones* | | | | |
|---|---|---|---|---|---|---|
| | | Very high | High | Mid-range | Low | Very low |
| Sources | | *E. coli* load (billions of org/day) | | | | |
| Wasteload | Total WLA | -- | -- | -- | -- | -- |
| Load | Total LA | 526 | 165 | 74 | 37 | 14 |
| | MOS | 58 | 18 | 8 | 4 | 2 |
| | Total load | 584 | 183 | 82 | 41 | 16 |
| | Existing Concentration Apr-Oct (org/100 mL)** | 172 | | | | |
| | Maximum Monthly Geometric Mean (org/100mL)** | 329 | | | | |
| | Overall Estimated Percent Reduction** | 62% | | | | |

* Model simulated flow for HSPF reach 467 from April-October (2000-2017) was used to develop the flow zones and LCs for this reach

** Water quality monitoring station(s) used to estimate reductions: S008-823 (years 2016 & 2017)



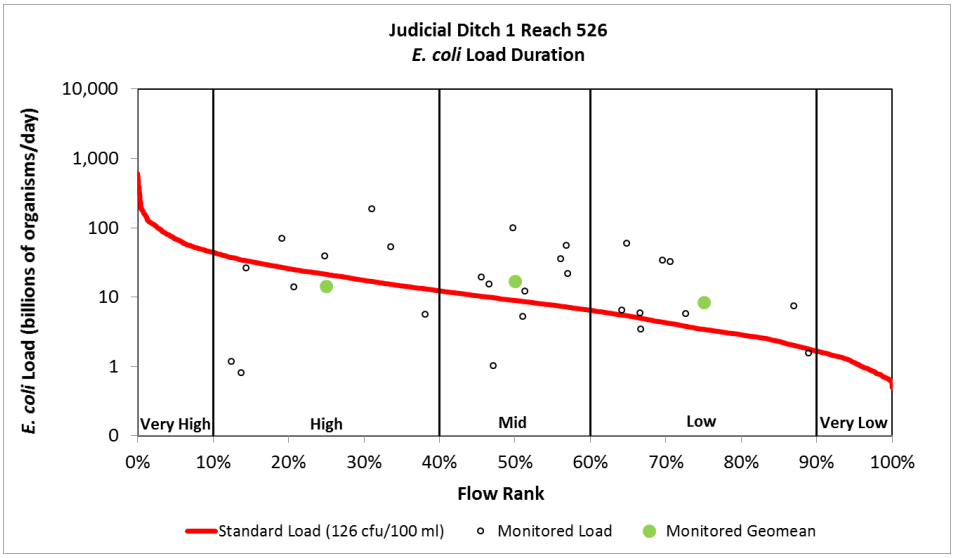

**South Branch Grindstone River Reach 516 *E. coli* LDC and monitored loads.**

***E. coli* TMDL summary for South Branch Grindstone River Reach 516.**

| *E. coli* | | Flow zones* | | | | |
|---|---|---|---|---|---|---|
| | | Very high | High | Mid-range | Low | Very low |
| Sources | | *E. coli* load (billions of org/day) | | | | |
| Wasteload | Total WLA | -- | -- | -- | -- | -- |
| Load | Total LA | 367 | 115 | 49 | 19 | 6 |
| | MOS | 41 | 13 | 5 | 2 | 0.7 |
| | Total load | 408 | 128 | 54 | 21 | 7 |
| | Existing Concentration Apr-Oct (org/100 mL)** | 104 | | | | |
| | Maximum Monthly Geometric Mean (org/100mL)** | 217 | | | | |
| | Overall Estimated Percent Reduction** | 42% | | | | |

* Model simulated flow for HSPF reach 624 from April-October (2000-2017) was used to develop the flow zones and LCs for this reach

** Water quality monitoring station(s) used to estimate reductions: S001-263 (years 2007 through 2009)



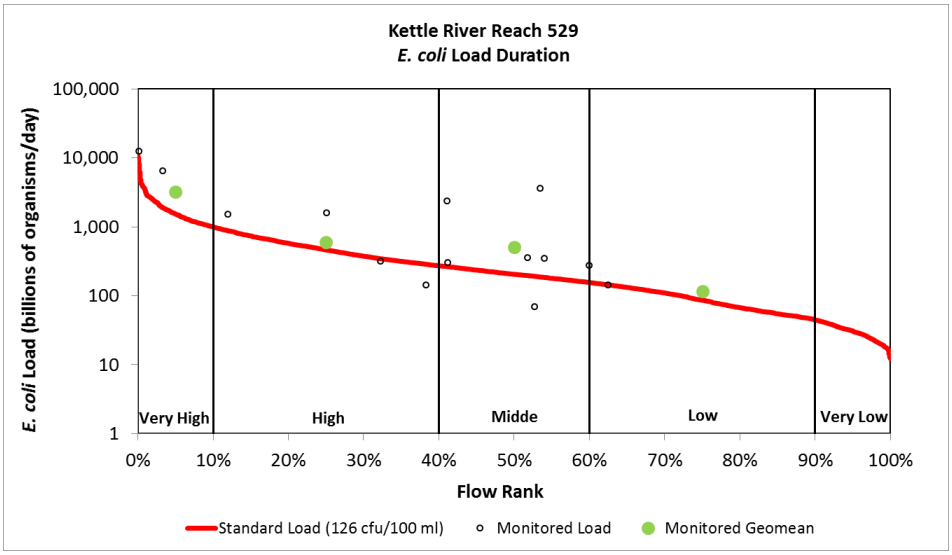

**Judicial Ditch #1 Reach 526 *E. coli* LDC and monitored loads.**

***E. coli* TMDL summary for Judicial Ditch #1 Reach 526.**

| *E. coli* | | Flow zones* | | | | |
|---|---|---|---|---|---|---|
| | | Very high | High | Mid-range | Low | Very low |
| Sources | | *E. coli* load (billions of org/day) | | | | |
| Wasteload | Total WLA | -- | -- | -- | -- | -- |
| Load | Total LA | 62 | 19 | 8 | 3 | 1 |
| | MOS | 7 | 2 | 0.9 | 0.3 | 0.1 |
| | Total load | 69 | 21 | 9 | 3 | 1 |
| | Existing Concentration Apr-Oct (org/100 mL)** | 185 | | | | |
| | Maximum Monthly Geometric Mean (org/100mL)** | 624 | | | | |
| | Overall Estimated Percent Reduction** | 80% | | | | |

* Model simulated flow for HSPF reach 622 from April-October (2000-2017) was used to develop the flow zones and LCs for this reach

** Water quality monitoring station(s) used to estimate reductions: S004-894 (years 2008 through 2010)



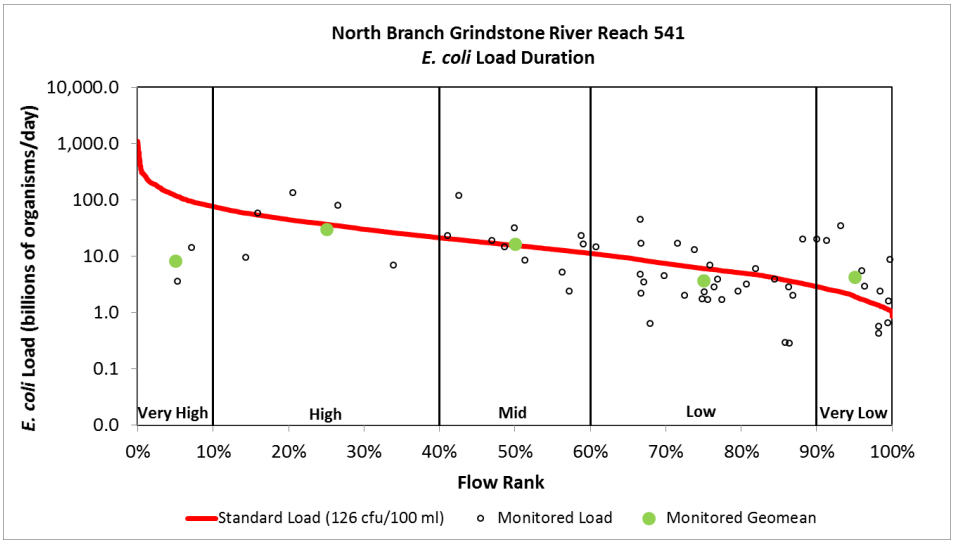

**Kettle River Reach 529 *E. coli* LDC and monitored loads.**

***E. coli* TMDL summary for Kettle River Reach 529.**

| *E. coli* | | Flow zones* | | | | |
|---|---|---|---|---|---|---|
| | | Very high | High | Mid-range | Low | Very low |
| Sources | | *E. coli* load (billions of org/day) | | | | |
| Wasteload | Total WLA | -- | -- | -- | -- | -- |
| Load | Total LA | 1,377 | 416 | 184 | 78 | 27 |
| | MOS | 153 | 46 | 20 | 9 | 3 |
| | Total load | 1,530 | 462 | 204 | 87 | 30 |
| | Existing Concentration Apr-Oct (org/100 mL)** | 232 | | | | |
| | Maximum Monthly Geometric Mean (org/100mL)** | 529 | | | | |
| | Overall Estimated Percent Reduction** | 76% | | | | |

* Model simulated flow for HSPF reach 430 from April-October (2000-2017) was used to develop the flow zones and LCs for this reach

** Water quality monitoring station(s) used to estimate reductions: S008-822 (years 2016 & 2017)



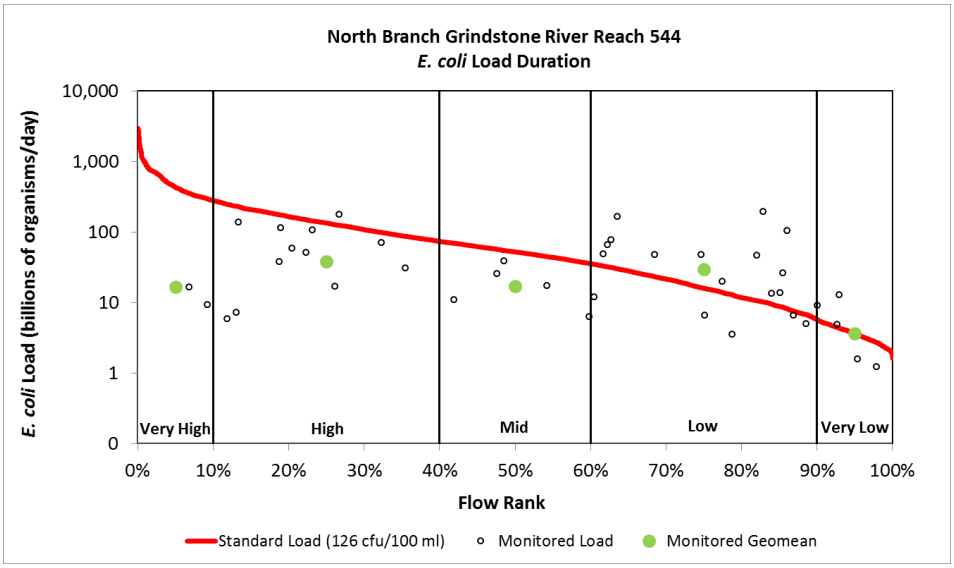

**North Branch Grindstone River Reach 541 *E. coli* LDC and monitored loads.**

***E. coli* TMDL summary for North Branch Grindstone River Reach 541.**

| *E. coli* | | Flow zones* | | | | |
|---|---|---|---|---|---|---|
| | | Very high | High | Mid-range | Low | Very low |
| Sources | | *E. coli* load (billions of org/day) | | | | |
| Wasteload | Total WLA | -- | -- | -- | -- | -- |
| Load | Total LA | 107 | 33 | 14 | 5 | 2 |
| | MOS | 12 | 4 | 2 | 0.6 | 0.2 |
| | Total load | 119 | 37 | 16 | 6 | 2 |
| | Existing Concentration Apr-Oct (org/100 mL)** | 105 | | | | |
| | Maximum Monthly Geometric Mean (org/100mL)** | 210 | | | | |
| | Overall Estimated Percent Reduction** | 40% | | | | |

* Model simulated flow for HSPF reach 625 from April-October (2000-2017) was used to develop the flow zones and LCs for this reach

** Water quality monitoring station(s) used to estimate reductions: S004-891 (years 2006-2009, 2016 and 2017)



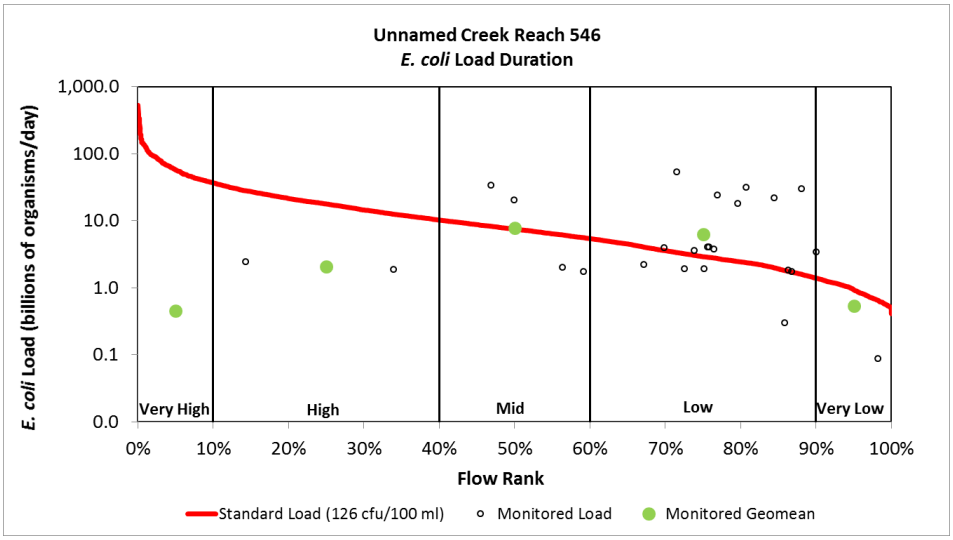

**North Branch Grindstone River Reach 544 *E. coli* LDC and monitored loads.**

***E. coli* TMDL summary for North Branch Grindstone River Reach 544.**

| *E. coli* | | Flow zones* | | | | |
|---|---|---|---|---|---|---|
| | | Very high | High | Mid-range | Low | Very low |
| Sources | | *E. coli* load (billions of org/day) | | | | |
| Wasteload | Total WLA | -- | -- | -- | -- | -- |
| Load | Total LA | 386 | 121 | 47 | 14 | 3 |
| | MOS | 43 | 13 | 5 | 2 | 0.4 |
| | Total load | 429 | 134 | 52 | 16 | 3 |
| | Existing Concentration Apr-Oct (org/100 mL)** | 86 | | | | |
| | Maximum Monthly Geometric Mean (org/100mL)** | 279 | | | | |
| | Overall Estimated Percent Reduction** | 55% | | | | |

* Model simulated flow for HSPF reach 626 from April-October (2000-2017) was used to develop the flow zones and LCs for this reach

** Water quality monitoring station(s) used to estimate reductions: S001-262 (years 2007 through 2009)



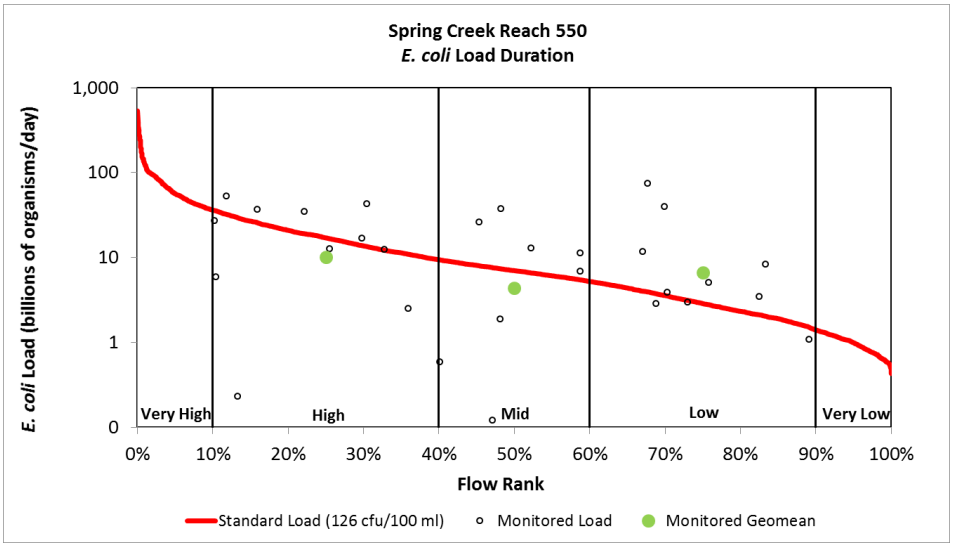

**Unnamed Creek Reach 546 *E. coli* LDC and monitored loads.**

***E. coli* TMDL summary for Unnamed Creek Reach 546.**

| *E. coli* | | Flow zones* | | | | |
|---|---|---|---|---|---|---|
| | | Very high | High | Mid-range | Low | Very low |
| Sources | | *E. coli* load (billions of org/day) | | | | |
| Wasteload | Total WLA | -- | -- | -- | -- | -- |
| Load | Total LA | 52 | 16 | 7 | 3 | 0.8 |
| | MOS | 6 | 2 | 0.8 | 0.3 | 0.09 |
| | Total load | 58 | 18 | 8 | 3 | 0.9 |
| | Existing Concentration Apr-Oct (org/100 mL)** | 140 | | | | |
| | Maximum Monthly Geometric Mean (org/100mL)** | 530 | | | | |
| | Overall Estimated Percent Reduction** | 76% | | | | |

* Model simulated flow for HSPF reach 624 from April-October (2000-2017) was used to develop the flow zones and LCs for this reach

** Water quality monitoring station(s) used to estimate reductions: S002-245 (years 2008 and 2009)



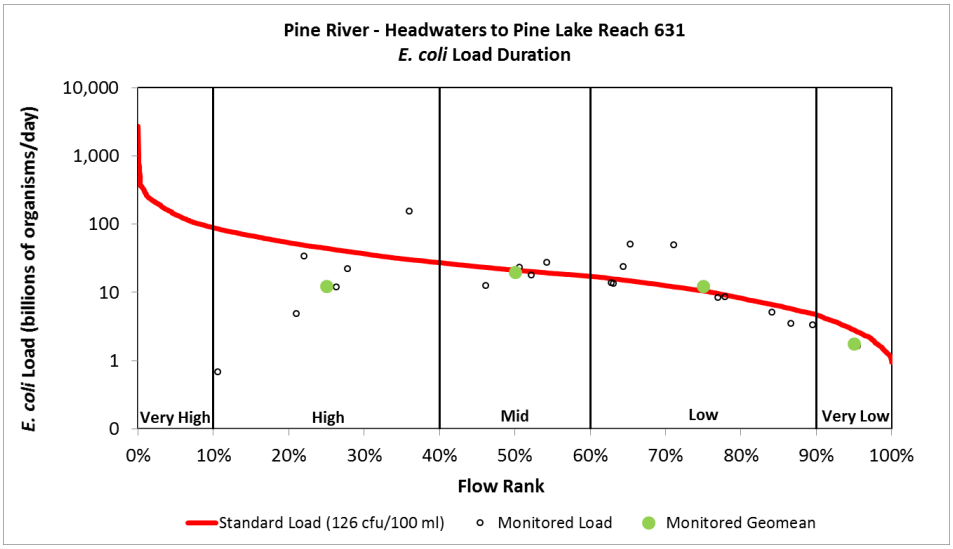

**Spring Creek Reach 550 *E. coli* LDC and monitored loads.**

***E. coli* TMDL summary for Spring Creek Reach 550.**

| *E. coli* | | Flow zones* | | | | |
|---|---|---|---|---|---|---|
| | | Very high | High | Mid-range | Low | Very low |
| Sources | | *E. coli* load (billions of org/day) | | | | |
| Wasteload | Total WLA | -- | -- | -- | -- | -- |
| Load | Total LA | 50 | 15 | 6 | 3 | 0.9 |
| | MOS | 6 | 2 | 0.7 | 0.3 | 0.1 |
| | Total load | 56 | 17 | 7 | 3 | 1 |
| | Existing Concentration Apr-Oct (org/100 mL)** | 121 | | | | |
| | Maximum Monthly Geometric Mean (org/100mL)** | 603 | | | | |
| | Overall Estimated Percent Reduction** | 79% | | | | |

* Model simulated flow for HSPF reach 628 from April-October (2000-2017) was used to develop the flow zones and LCs for this reach

** Water quality monitoring station(s) used to estimate reductions: S004-895 (years 2008 through 2010)




**Pine River Reach 631 *E. coli* LDC and monitored loads.**

***E. coli* TMDL summary for Pine River Reach 631.**

| *E. coli* | | Flow zones* | | | | |
|---|---|---|---|---|---|---|
| | | Very high | High | Mid-range | Low | Very low |
| Sources | | *E. coli* load (billions of org/day) | | | | |
| Wasteload | Total WLA | -- | -- | -- | -- | -- |
| Load | Total LA | 124 | 40 | 19 | 9 | 3 |
| | MOS | 14 | 4 | 2 | 1 | 0.3 |
| | Total load | 138 | 44 | 21 | 10 | 3 |
| | Existing Concentration Apr-Oct (org/100 mL)** | 90 | | | | |
| | Maximum Monthly Geometric Mean (org/100mL)** | 194 | | | | |
| | Overall Estimated Percent Reduction** | 35% | | | | |

* Model simulated flow for HSPF reach 521 from April-October (2000-2017) was used to develop the flow zones and LCs for this reach

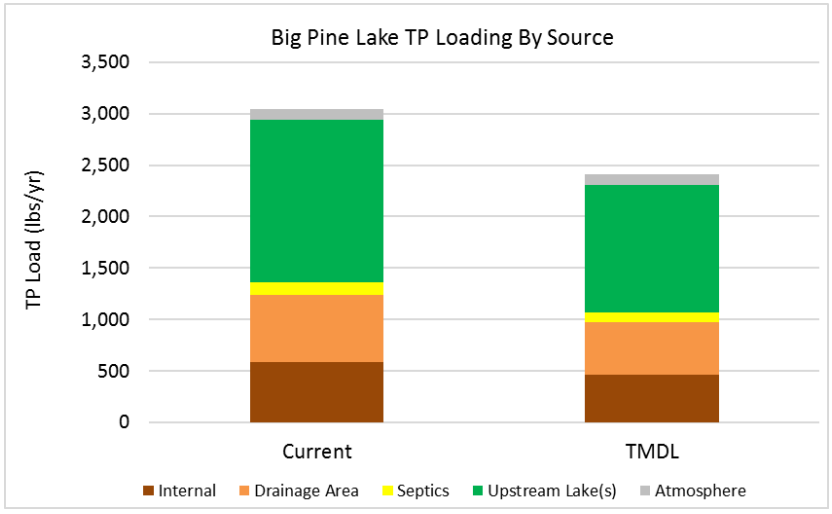
** Water quality monitoring station(s) used to estimate reductions: S004-889 (years 2008-2010)

**Big Pine Lake (58-0138-00) phosphorus TMDL.**

| Phosphorus Sources | | Existing TP load* | | Allowable TP load | | Estimated load reduction | |
|---|---|---|---|---|---|---|---|
| | | lbs/yr | lbs/day | lbs/yr | lbs/day | lbs/yr | % |
| **Wasteload** | **Total WLA** | **0.8** | **0.002** | **0.8** | **0.002** | **0** | **0%** |
| | Construction/Industrial SW | 0.8 | 0.002 | 0.8 | 0.002 | 0 | 0% |
| **Load** | **Total LA** | **3,045** | **8.3** | **2,407** | **6.7** | **638** | **23%** |
| | Atmosphere | 103 | 0.3 | 103 | 0.3 | 0 | 0% |
| | Drainage Area | 653 | 1.8 | 512 | 1.4 | 141 | 22% |
| | Upstream Lakes (Pine) | 1,584 | 4.3 | 1,239 | 3.4 | 345 | 22% |
| | Septics | 119 | 0.3 | 94 | 0.3 | 25 | 21% |
| | Internal Load | 586 | 1.6 | 459 | 1.3 | 127 | 22% |
| **MOS** | | | | **268** | **0.7** | | |
| **Total load** | | **3,046** | **8.3** | **2,676** | **7.4** | **638**** | **21%** |

* Model calibration year(s): 2008, 2009, 2014, 2015, 2016, 2017

** Net reduction from current load to TMDL is 370 lbs/yr, but the gross load reduction from all sources must also accommodate the MOS and is therefore 370 + 268 = 638 lbs/yr.



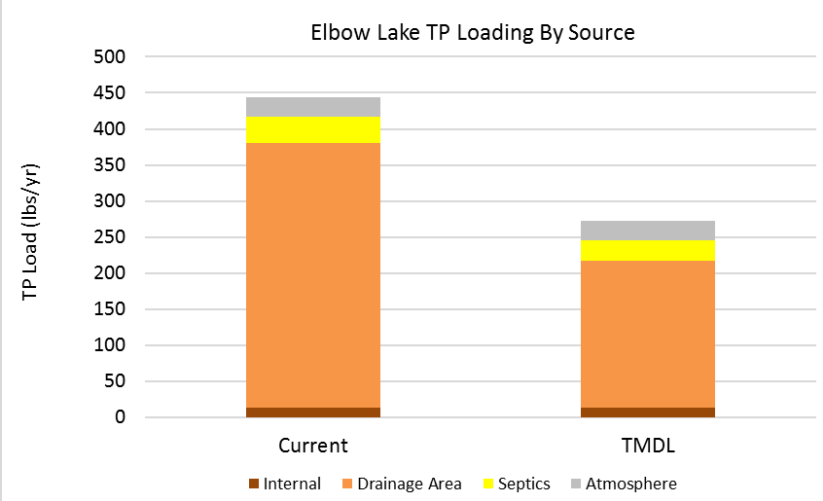

**Pine Lake phosphorus source reductions to meet TMDL.**

**Elbow Lake (58-0126-00) phosphorus TMDL.**

| Phosphorus Sources | | Existing TP load* | | Allowable TP load | | Estimated load reduction | |
|---|---|---|---|---|---|---|---|
| | | lbs/yr | lbs/day | lbs/yr | lbs/day | lbs/yr | % |
| **Wasteload** | **Total WLA** | **0.5** | **0.001** | **0.5** | **0.001** | **0** | **0%** |
| | Construction/Industrial SW | 0.5 | 0.001 | 0.5 | 0.001 | 0 | 0% |
| **Load** | **Total LA** | **444** | **1.2** | **272** | **0.8** | **172** | **42%** |
| | Atmosphere | 27 | 0.1 | 27 | 0.1 | 0 | 0% |
| | Drainage Area | 367 | 1.0 | 203 | 0.6 | 164 | 45% |
| | Septics | 36 | 0.1 | 28 | 0.1 | 8 | 22% |
| | Internal Load | 14 | 0.04 | 14 | 0.04 | 0 | 0% |
| **MOS** | | | | **30** | **0.1** | | |
| **Total load** | | **445** | **1.2** | **303** | **0.9** | **172**** | **39%** |

* Model calibration year(s): 2011, 2012

** Net reduction from current load to TMDL is 142 lbs/yr , but the gross load reduction from all sources must also accommodate the MOS and is therefore 142 + 30 = 172 lbs/yr.



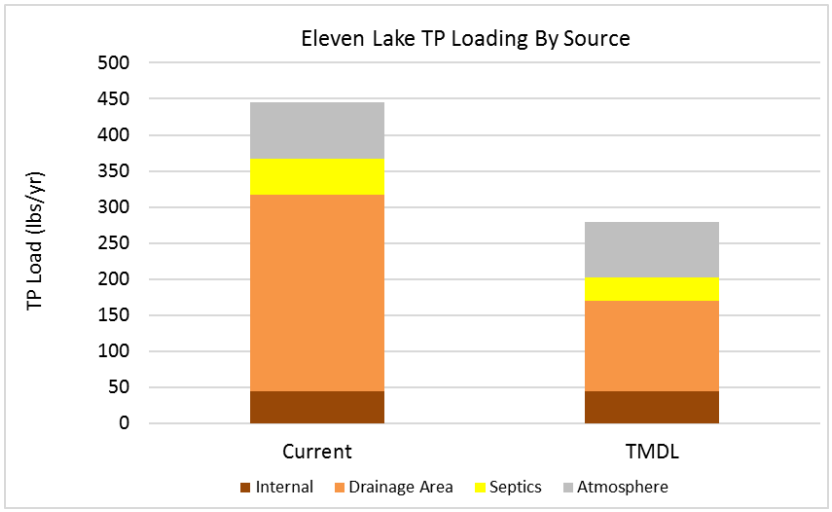

**Elbow Lake phosphorus source reductions to meet TMDL.**

**Eleven Lake (33-0001-00) phosphorus TMDL.**

| Phosphorus Sources | | Existing TP load* | | Allowable TP load | | Estimated load reduction | |
|---|---|---|---|---|---|---|---|
| | | lbs/yr | lbs/day | lbs/yr | lbs/day | lbs/yr | % |
| **Wasteload** | **Total WLA** | **0.3** | **0.0009** | **0.3** | **0.0009** | **0** | **0%** |
| | Construction/Industrial SW | 0.3 | 0.0009 | 0.3 | 0.0009 | 0 | 0% |
| **Load** | **Total LA** | **444** | **1.2** | **279** | **0.7** | **165** | **37%** |
| | Atmosphere | 78 | 0.2 | 78 | 0.2 | 0 | 0% |
| | Drainage Area | 273 | 0.8 | 125 | 0.3 | 148 | 54% |
| | Septics | 49 | 0.1 | 32 | 0.1 | 17 | 35% |
| | Internal Load | 44 | 0.1 | 44 | 0.1 | 0 | 0% |
| **MOS** | | | | **31** | **0.1** | | |
| **Total load** | | **444** | **1.2** | **310** | **0.8** | **165**** | **37%** |

* Model calibration year(s): 2008, 2010, 2015, 2016

** Net reduction from current load to TMDL is 134 lbs/yr, but the gross load reduction from all sources must also accommodate the MOS and is therefore 134 + 31 = 165 lbs/yr.



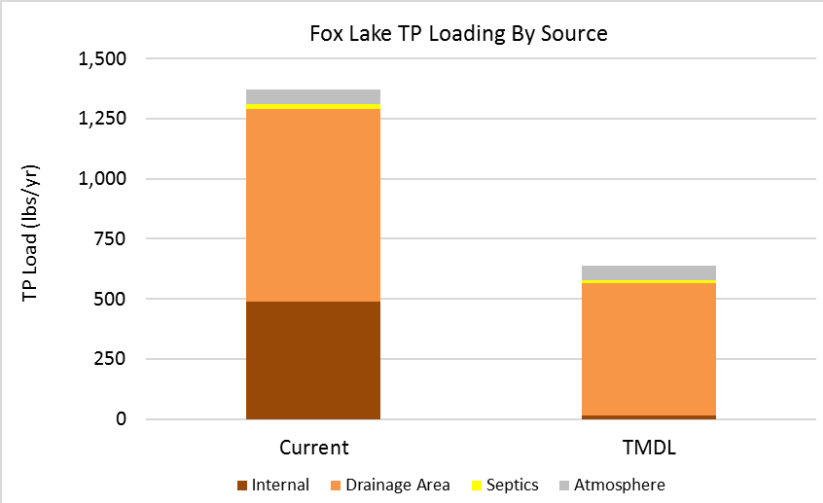

**Eleven Lake phosphorus source reduction to meet TMDL.**

**Fox Lake (58-0102-00) phosphorus TMDL.**

| Phosphorus Sources | | Existing TP load* | | Allowable TP load | | Estimated load reduction | |
|---|---|---|---|---|---|---|---|
| | | lbs/yr | lbs/day | lbs/yr | lbs/day | lbs/yr | % |
| **Wasteload** | **Total WLA** | **1** | **0.003** | **1** | **0.003** | **0** | **0%** |
| | Construction/Industrial SW | 1 | 0.003 | 1 | 0.003 | 0 | 0% |
| **Load** | **Total LA** | **1,370** | **3.8** | **636** | **1.8** | **734** | **54%** |
| | Atmosphere | 59 | 0.2 | 59 | 0.2 | 0 | 0% |
| | Drainage Area | 801 | 2.2 | 547 | 1.5 | 254 | 32% |
| | Septics | 20 | 0.1 | 14 | 0.04 | 6 | 28% |
| | Internal Load | 490 | 1.3 | 16 | 0.04 | 474 | 97% |
| **MOS** | | | | **71** | **0.2** | | |
| **Total load** | | **1,371** | **3.8** | **708** | **2.0** | **734**** | **54%** |

* Model calibration year(s): 2016, 2017

** Net reduction from current load to TMDL is 663 lbs/yr, but the gross load reduction from all sources must also accommodate the MOS and is therefore 661 +71 = 734 lbs/yr.



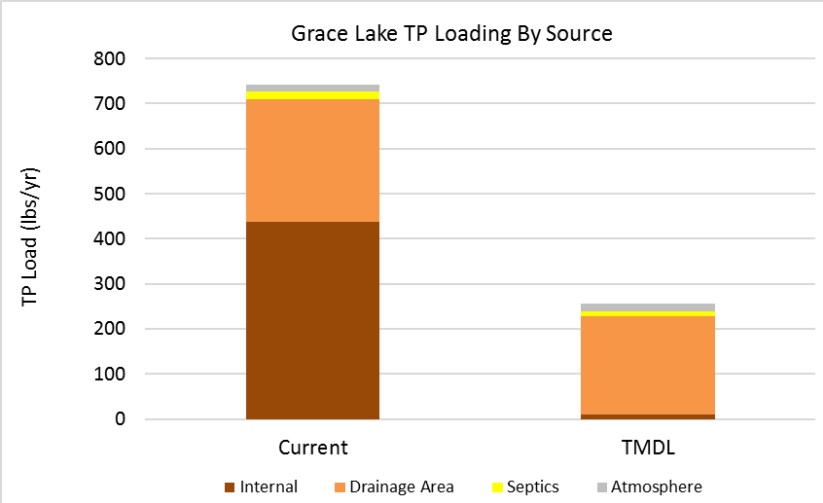

**Fox Lake phosphorus source reductions to meet TMDL.**

**Grace Lake (58-0029-00) phosphorus TMDL.**

| Phosphorus Sources | | Existing TP load* | | Allowable TP load | | Estimated load reduction | |
|---|---|---|---|---|---|---|---|
| | | lbs/yr | lbs/day | lbs/yr | lbs/day | lbs/yr | % |
| **Wasteload** | **Total WLA** | **0.2** | **0.0005** | **0.2** | **0.0005** | **0** | **0%** |
| | Construction/Industrial SW | 0.2 | 0.0005 | 0.2 | 0.0005 | 0 | 0% |
| **Load** | **Total LA** | **742** | **2.0** | **255** | **0.7** | **487** | **66%** |
| | Atmosphere | 16 | 0.04 | 16 | 0.04 | 0 | 0% |
| | Drainage Area | 272 | 0.7 | 217 | 0.6 | 55 | 20% |
| | Septics | 17 | 0.05 | 12 | 0.03 | 5 | 29% |
| | Internal Load | 437 | 1.2 | 10 | 0.03 | 427 | 98% |
| **MOS** | | | | **28** | **0.1** | | |
| **Total Load** | | **742** | **2.0** | **283** | **0.8** | **487**** | **66%** |

* Model calibration year(s): 2016, 2017

** Net reduction from current load to TMDL is 459 lbs/yr, but the gross load reduction from all sources must also accommodate the MOS and is therefore 459 + 28 = 487 lbs/yr.



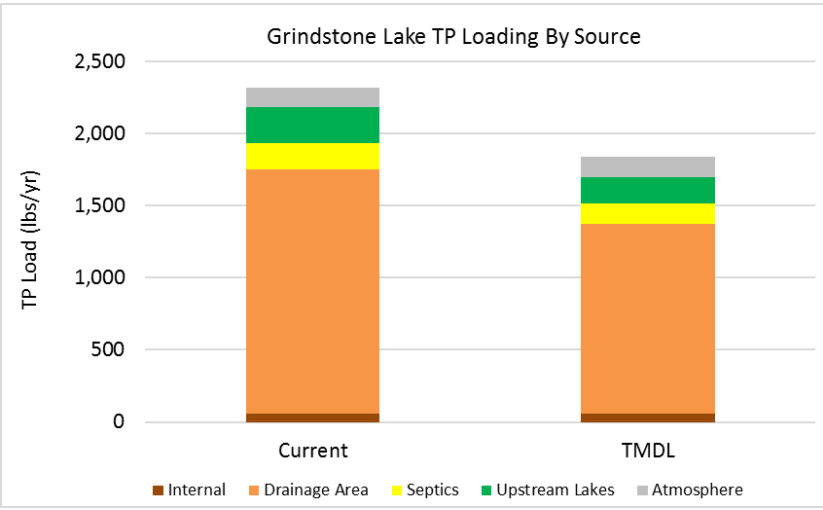

**Grace Lake phosphorus source reductions to meet TMDL.**

**Grindstone Lake (58-0123-00) phosphorus TMDL.**

| Phosphorus Sources | | Existing TP load* | | Allowable TP load | | Estimated load reduction | |
|---|---|---|---|---|---|---|---|
| | | lbs/yr | lbs/day | lbs/yr | lbs/day | lbs/yr | % |
| **Wasteload** | **Total WLA** | **2** | **0.006** | **2** | **0.006** | **0** | **0%** |
| | Construction/Industrial SW | 2 | 0.006 | 2 | 0.006 | 0 | 0% |
| **Load** | **Total LA** | **2,319** | **6.4** | **1,836** | **5.1** | **483** | **21%** |
| | Atmosphere | 137 | 0.4 | 137 | 0.4 | 0 | 0% |
| | Drainage Area | 1,695 | 4.6 | 1,315 | 3.6 | 380 | 22% |
| | Upstream Lakes (Elbow) | 250 | 0.7 | 184 | 0.5 | 66 | 27% |
| | Septics | 180 | 0.5 | 143 | 0.4 | 37 | 20% |
| | Internal Load | 57 | 0.2 | 57 | 0.2 | 0 | 0% |
| **MOS** | | | | **204** | **0.6** | | |
| **Total Load** | | **2,321** | **6.4** | **2,042** | **5.7** | **483**** | **21%** |

* Model calibration year(s): 2008, 2016, 2017

** Net reduction from current load to TMDL is 279 lbs/yr, but the gross load reduction from all sources must also accommodate the MOS and is therefore 279 + 204 = 483 lbs/yr.



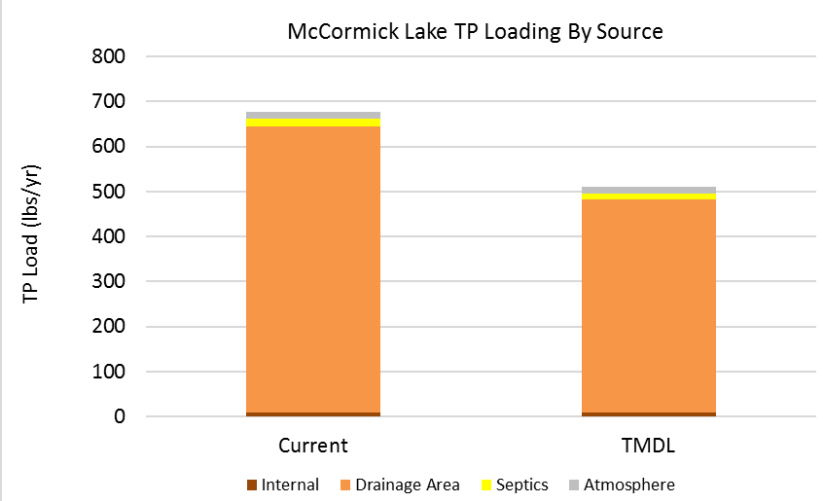

**Grindstone Lake phosphorus source reductions to meet TMDL.**

**McCormick Lake (58-0058-00) phosphorus TMDL.**

| Phosphorus Sources | | Existing TP load* | | Allowable TP load | | Estimated load reduction | |
|---|---|---|---|---|---|---|---|
| | | lbs/yr | lbs/day | lbs/yr | lbs/day | lbs/yr | % |
| **Wasteload** | **Total WLA** | **0.8** | **0.002** | **0.8** | **0.002** | **0** | **0%** |
| | Construction/Industrial SW | 0.8 | 0.002 | 0.8 | 0.002 | 0 | 0% |
| **Load** | **Total LA** | **677** | **1.8** | **509** | **1.4** | **168** | **25%** |
| | Atmosphere | 16 | 0.04 | 16 | 0.04 | 0 | 0% |
| | Drainage Area | 633 | 1.7 | 471 | 1.3 | 162 | 26% |
| | Septics | 18 | 0.05 | 12 | 0.03 | 6 | 29% |
| | Internal Load | 10 | 0.03 | 10 | 0.03 | 0 | 0% |
| **MOS** | | | | **57** | **0.2** | | |
| **Total load** | | **678** | **1.8** | **567** | **1.6** | **168**** | **25%** |

* Model calibration year(s): 2016, 2017

** Net reduction from current load to TMDL is 111 lbs/yr, but the gross load reduction from all sources must also accommodate the MOS and is therefore 111 + 57 = 168 lbs/yr.



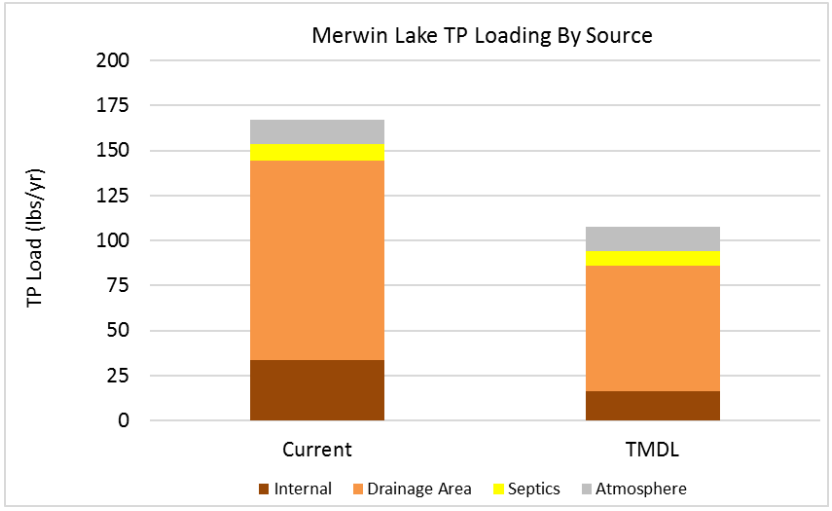

**McCormick Lake phosphorus source reductions to meet TMDL.**

**Merwin Lake (09-0058-00) phosphorus TMDL.**

| Phosphorus Sources | | Existing TP load* | | Allowable TP load | | Estimated load reduction | |
|---|---|---|---|---|---|---|---|
| | | lbs/yr | lbs/day | lbs/yr | lbs/day | lbs/yr | % |
| **Wasteload** | **Total WLA** | **0.1** | **0.0004** | **0.1** | **0.0004** | **0** | **0%** |
| | Construction/Industrial SW | 0.1 | 0.0004 | 0.1 | 0.0004 | 0 | 0% |
| **Load** | **Total LA** | **167** | **0.5** | **108** | **0.3** | **59** | **36%** |
| | Atmosphere | 14 | 0.04 | 14 | 0.04 | 0 | 0% |
| | Drainage Area | 110 | 0.3 | 70 | 0.2 | 40 | 37% |
| | Septics | 9 | 0.03 | 8 | 0.02 | 1 | 16% |
| | Internal Load | 34 | 0.1 | 16 | 0.04 | 18 | 52% |
| **MOS** | | | | **12** | **0.03** | | |
| **Total load** | | **167** | **0.5** | **120** | **0.3** | **59**** | **35%** |

* Model calibration year(s): 2016, 2017

** Net reduction from current load to TMDL is 47 lbs/yr, but the gross load reduction from all sources must also accommodate the MOS and is therefore 47 + 12 = 59 lbs/yr.



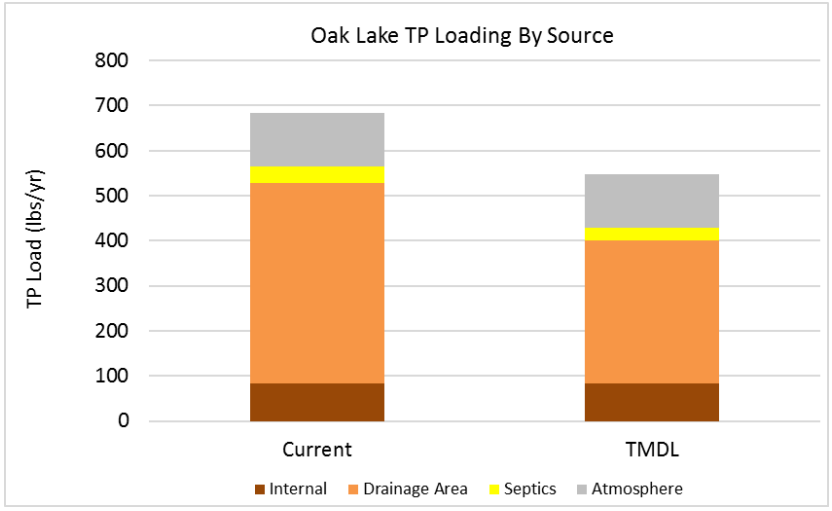

**Merwin Lake phosphorus source reductions to meet TMDL.**

**Oak Lake (58-0048-00) phosphorus TMDL.**

| Phosphorus Sources | | Existing TP load* | | Allowable TP load | | Estimated load reduction | |
|---|---|---|---|---|---|---|---|
| | | lbs/yr | lbs/day | lbs/yr | lbs/day | lbs/yr | % |
| **Wasteload** | **Total WLA** | **0.6** | **0.002** | **0.6** | **0.002** | **0** | **0%** |
| | Construction/Industrial SW | 0.6 | 0.002 | 0.6 | 0.002 | 0 | 0% |
| **Load** | **Total LA** | **683** | **1.8** | **547** | **1.5** | **136** | **20%** |
| | Atmosphere | 118 | 0.3 | 118 | 0.3 | 0 | 0% |
| | Drainage Area | 444 | 1.2 | 316 | 0.9 | 128 | 29% |
| | Septics | 37 | 0.1 | 29 | 0.1 | 8 | 21% |
| | Internal Load | 84 | 0.2 | 84 | 0.2 | 0 | 0% |
| **MOS** | | | | **61** | **0.2** | | |
| **Total load** | | **684** | **1.8** | **609** | **1.7** | **136**** | **20%** |

* Model calibration year(s): 2011, 2012, 2016

** Net reduction from current load to TMDL is 75 lbs/yr, but the gross load reduction from all sources must also accommodate the MOS and is therefore 75 + 61 = 136 lbs/yr.



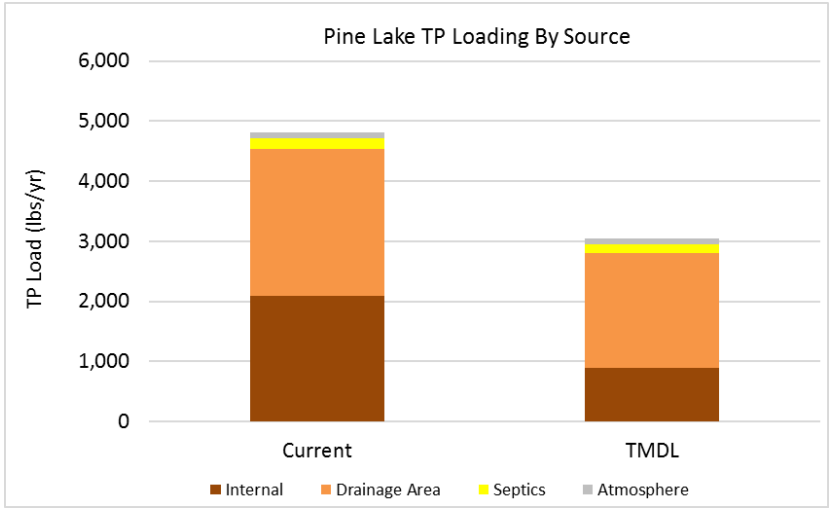

**Oak Lake phosphorus source reductions to meet TMDL.**

**Pine Lake (01-0001-00) phosphorus TMDL.**

| Phosphorus Sources | | Existing TP load* | | Allowable TP load | | Estimated load reduction | |
|---|---|---|---|---|---|---|---|
| | | lbs/yr | lbs/day | lbs/yr | lbs/day | lbs/yr | % |
| **Wasteload** | **Total WLA** | **3** | **0.008** | **3** | **0.008** | **0** | **0%** |
| | Construction/Industrial SW | 3 | 0.008 | 3 | 0.008 | 0 | 0% |
| **Load** | **Total LA** | **4,812** | **13.2** | **3,046** | **8.3** | **1,766** | **37%** |
| | Atmosphere | 98 | 0.3 | 98 | 0.3 | 0 | 0% |
| | Drainage Area | 2,442 | 6.7 | 1,917 | 5.2 | 525 | 22% |
| | Septics | 175 | 0.5 | 143 | 0.4 | 32 | 18% |
| | Internal Load | 2,097 | 5.7 | 888 | 2.4 | 1,209 | 58% |
| **MOS** | | | | **339** | **0.9** | | |
| **Total load** | | **4,815** | **13.2** | **3,388** | **9.2** | **1,766**** | **37%** |

* Model calibration year(s): 2008, 2009, 2014, 2015, 2016, 2017

** Net reduction from current load to TMDL is 1,427 lbs/yr, but the gross load reduction from all sources must also accommodate the MOS and is therefore 1,427 + 339 = 1,766 lbs/yr.



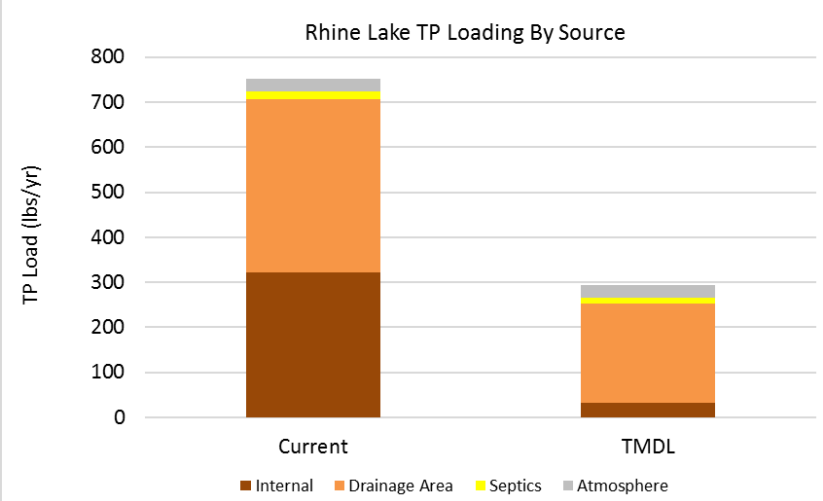

**Pine Lake phosphorus source reductions to meet TMDL.**

**Rhine Lake (58-0136-00) phosphorus TMDL.**

| Phosphorus Sources | | Existing TP load* | | Allowable TP load | | Estimated load reduction | |
|---|---|---|---|---|---|---|---|
| | | lbs/yr | lbs/day | lbs/yr | lbs/day | lbs/yr | % |
| **Wasteload** | **Total WLA** | **0.5** | **0.001** | **0.5** | **0.001** | **0** | **0%** |
| | Construction/Industrial SW | 0.5 | 0.001 | 0.5 | 0.001 | 0 | 0% |
| **Load** | **Total LA** | **752** | **2.1** | **294** | **0.8** | **458** | **61%** |
| | Atmosphere | 29 | 0.1 | 29 | 0.1 | 0 | 0% |
| | Drainage Area | 385 | 1.1 | 220 | 0.6 | 165 | 43% |
| | Septics | 16 | 0.04 | 13 | 0.04 | 3 | 20% |
| | Internal Load | 322 | 0.9 | 32 | 0.1 | 290 | 90% |
| **MOS** | | | | **33** | **0.1** | | |
| **Total load** | | **753** | **2.1** | **328** | **0.9** | **458**** | **61%** |

* Model calibration year(s): 2011, 2012

** Net reduction from current load to TMDL is 425 lbs/yr, but the gross load reduction from all sources must also accommodate the MOS and is therefore 425 + 33 = 458 lbs/yr.



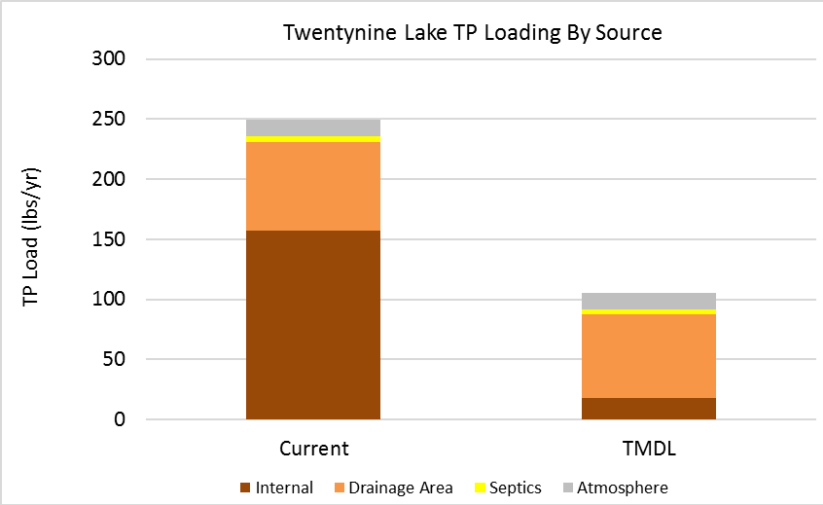

**Rhine Lake phosphorus source reductions to meet TMDL.**

**Twentynine (09-0022-00) phosphorus TMDL.**

| Phosphorus Sources | | Existing TP load* | | Allowable TP load | | Estimated load reduction | |
|---|---|---|---|---|---|---|---|
| | | lbs/yr | lbs/day | lbs/yr | lbs/day | lbs/yr | % |
| **Wasteload** | **Total WLA** | **0.09** | **0.0003** | **0.09** | **0.0003** | **0** | **0%** |
| | Construction/Industrial SW | 0.09 | 0.0003 | 0.09 | 0.0003 | 0 | 0% |
| **Load** | **Total LA** | **249** | **0.7** | **104** | **0.3** | **145** | **58%** |
| | Atmosphere | 13 | 0.04 | 13 | 0.04 | 0 | 0% |
| | Drainage Area | 74 | 0.2 | 70 | 0.2 | 4 | 5% |
| | Septics | 5 | 0.01 | 4 | 0.01 | 1 | 20% |
| | Internal Load | 157 | 0.4 | 17 | 0.05 | 140 | 89% |
| **MOS** | | | | **12** | **0.03** | | |
| **Total load** | | **249** | **0.7** | **116** | **0.3** | **145**** | **58%** |

* Model calibration year(s): 2016, 2017

** Net reduction from current load to TMDL is 133 lbs/yr, but the gross load reduction from all sources must also accommodate the MOS and is therefore 132 + 12 = 145 lbs/yr.




**Twentynine Lake phosphorus source reductions to meet TMDL.**