LOWER DEAD RIVER WATERSHED MANAGEMENT PLAN

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Funded by the Michigan Department of Environment, Great Lakes, and Energy (Michigan EGLE)
Non-point Source Pollution Prevention Program and the
U.S. Environmental Protection Agency
Under the authority of Section 319 of the Clean Water Act

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1.0 INTRODUCTION

1.1 Lower Dead River Watershed Setting

People live, work, and recreate in areas of land known as "Watersheds". A watershed is best described as an area of land where surface water drains to a common location such as a stream, river, or lake. The source of groundwater recharge to streams, rivers, and lakes is also considered part of a watershed. Despite the simple definition for a watershed, they are complex systems with interaction between natural elements such as climate, surface water, groundwater, vegetation, and wildlife as well as human interactions. Agriculture, mineral exploration, timber harvesting and urban development produce polluted stormwater runoff, increase impervious surfaces thereby altering stormwater flows, and degrade or fragment natural areas. Other common names given to watersheds, depending on size, include basins, sub-basins, subwatersheds, and Subwatershed Management Units (SMUs).

The Lower Dead River (also known as Reany Creek-Dead River) watershed (12 Digit HUC: 040201050205) is in Michigan's Upper Peninsula in Marquette county (Figure 1). It is named for the Lower Dead River that drains into Lake Superior in the eastern portion of the watershed. The watershed is oblong and oriented west-east and drains into Lake Superior. Many small tributary streams in the watershed drain approximately 24.8 square miles (15,879 acres) of land surface. Municipalities found in the watershed include Marquette, Marquette Township, and Negaunee Township.

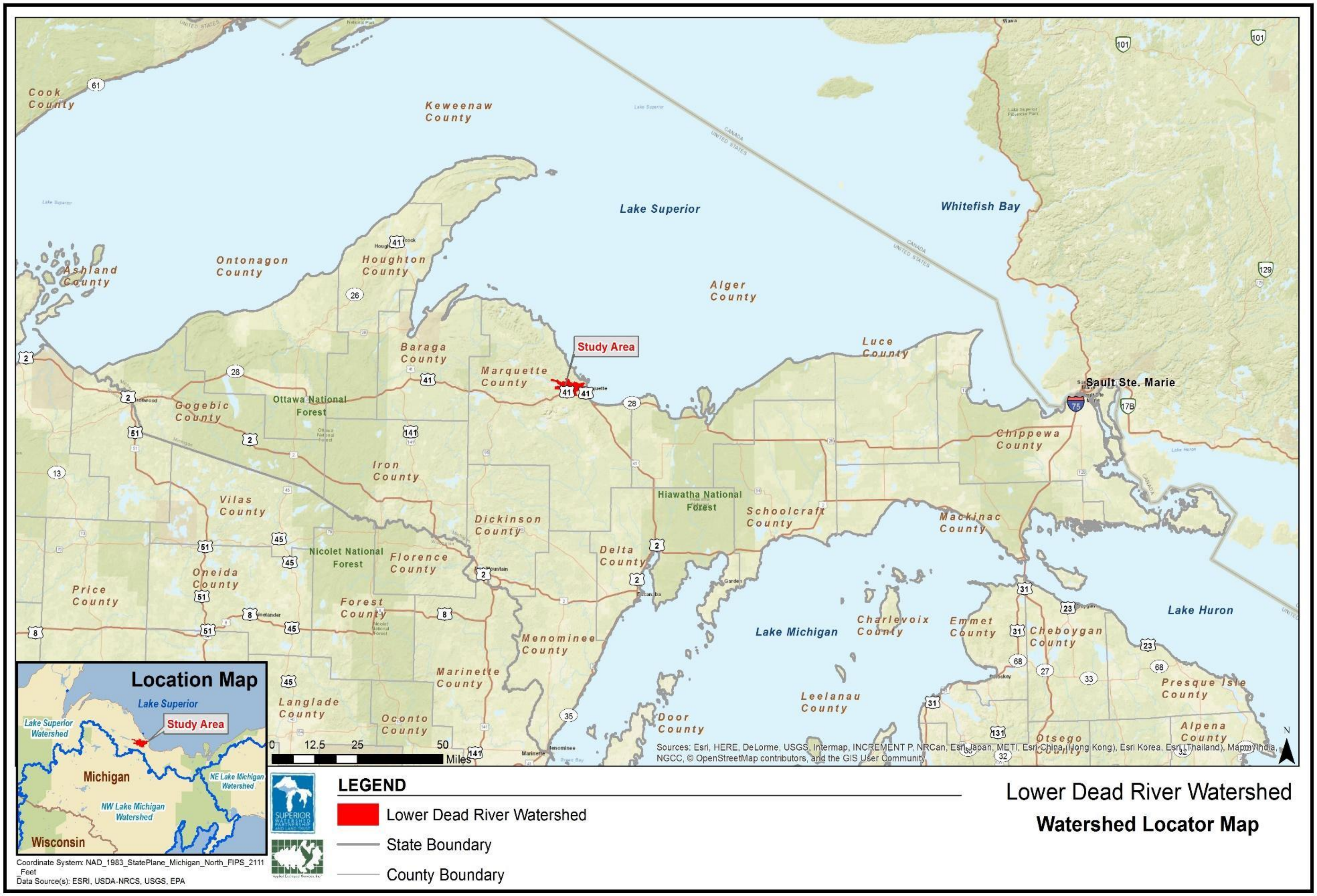
Prior to European settlement, the Lower Dead River watershed was ecologically intact, with clean water and a diversity of plant and wildlife populations. The steep topography was dominated by sugar maple-hemlock forests, with patches of aspen, birch and mixed conifer swamps communities, which were preserved by the cool moist climate along Lake Superior. During these times most of the water that fell as precipitation was absorbed in these forested and wetland communities or flowed over the exposed bedrock surfaces into the rivers. This portion of the Upper Peninsula was inhabited by the Ojibwe (Chippewa) Indian tribe until 1842 when the Treaty of La Pointe ceded the lands to the settlers and forced the Ojibwe from the region.

Hypothetical watershed setting (Source: USEPA)

The steep topography and dense forests of the region limited the landscape changes typically seen following European settlement in the mid-1800s. There were relatively few areas farmed, and the relatively few wetlands were in narrow floodplains, protecting them from drainage and filling. However, many ecological impacts were not eliminated. Drastic changes resulted from the rapid growth of the timber industry and early settlers cleared land in order to build their homes, use wood for fuel, and to sell to sawmills. Iron ore was discovered in the region around this time as well, bringing the Industrial Revolution to the area along with the ecological impacts brought by mining. Today, near Marquette, the most populated city in the region, the Lower Dead River watershed is occupied by residential areas and mixture of commercial /industrial centers, though the majority of the watershed remains forested.

"Traditional" development and landscape change in watersheds brings negative impacts to the environment. Impervious surfaces greatly reduce the ability of precipitation to infiltrate into the ground and instead cause stormwater runoff to quickly reach streams and tributaries resulting in downcutting, widening, and bank erosion, causing sediment and nutrient loading downstream. Meanwhile, invasive species established in adjacent floodplain wetlands can result in loss of wildlife habitat and reduced floodplain function. In addition, nutrients from residential lawn fertilizers negatively impact the watersheds. Additionally, discharged water from various sources that is not properly filtered is referred to as "non-point source pollution" and another source of degradation. Resource production activities such as mineral exploration and timber harvesting, can also pollute the watershed with sediment, contaminated groundwater, and the runoff of byproducts and other pollutants associated with these activities.

According to EGLE's Water Quality and Pollution Control in Michigan 2020 Sections 303(d), 305(b), and 314 Integrated Report (EGLE, 2020), all of the streams and rivers in the Lower Dead River watershed are fully supporting for the agriculture, navigation, and industrial water supply use designations. Holyoke Creek, Reany Creak, Brickyard Creek, Badger Creek, Midway Creek, Dead River and the impoundment of the Dead River west of Marquette upstream of Carrie Rd are fully supporting of the other indigenous aquatic and wildlife use designation. The Dead River is not supporting for fish consumption due to mercury found in fish tissue in three locations: 1.) Tourist Park Dam upstream to the powerhouse at west end of Forestville Reservoir (HUC040201050205 01), 2.) Dead River (HUC04020105020506), and 3.) McClure impoundment west of Marquette. A Total Maximum Daily Load Assessment completion date has not been established in the report. The Dead River was assessed as a warm water fishery, but insufficient information was found to make a determination; all other uses for all streams were not assessed. Additionally, the lakes within the Lower Dead River watershed were assessed only for the navigation, agriculture, and industrial water supply uses and all are fully supporting for these uses. Use designations for all waterbodies in the Lower Dead River watershed are summarized in Section 4.0 (EGLE, 2020).


Cook County
Keweenaw County
Lake Superior
Whitefish Bay
Ashland County
Ontonagon County
Houghton County
Alger County
Baraga County
Marquette County
Study Area
Luce County
Sault Ste. Marie
Gogebic County
Ottawa National Forest
Chippewa County
Iron County
Vilas County
Dickinson County
Hiawatha National Forest
Schoolcraft County
Mackinac County
Nicolet National Forest
Florence County
Delta County
Oneida County
Price County
Forest County
Lake Michigan
Charlevoix County
Emmet County
Cheboygan County
Lake Huron
Menominee County
Marinette County
Presque Isle County
Langlade County
Leelanau County
Oconto County
Door County
Otsego County
Alpena County
Location Map
Lake Superior
Lake Superior Watershed
Study Area
Michigan
NE Lake Michigan Watershed
NW Lake Michigan Watershed
Wisconsin
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Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community
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Coordinate System: NAD_1983_StatePlane_Michigan_North_FIPS_2111_Feet
Data Source(s): ESRI, USDA-NRCS, USGS, EPA
LEGEND
Lower Dead River Watershed
State Boundary
County Boundary
Lower Dead River Watershed
Watershed Locator Map

Figure 1- Location of Lower Dead River Watershed

Noteworthy- Watershed at a Glance

- The Lower Dead River watershed lies in an area covered by the most recent glacial event - the Late Wisconsin Glaciation.
- Sugar Maple-Hemlock forests covered the majority of the watershed during European settlement in the 1830s.
- The climate is cool to mild; Lake Superior reduces the heat of summer and buffers the cold of winter.
- Tributaries in the watershed drain 24.8 square miles of land in Marquette County, Michigan.
- The dominant land uses/land cover in 2015 included forested land, resource production, and various residential, commercial, and industrial development.
- Municipalities include Marquette, Marquette Township, and Negaunee Township.
- The watershed area is known for its steep, forested, topography beloved by outdoor enthusiasts.
- The population of the watershed in 2017 was estimated to be around 13,007 and is expected to remain stable.
- Water quality in tributaries is impacted by mercury and total suspended sediment; one of the samples showed elevated levels of total nitrogen and total phosphorus. Sampling data, however, was limited.
- There are 50.69 miles of streams within the watershed, mostly unnamed tributaries.
- There were 567 acres of wetlands prior to European settlement.
- Open space parcels comprise approximately 10,605 acres or 67% of the watershed.
- "Important Natural Areas" as defined by MDNR do not occur within the watershed.
- Shallow and deep groundwater aquifers provide the water supply for many private users and municipalities.

1.2 Project Scope & Purpose

The Superior Watershed Partnership and Land Conservancy is a 501(c)(3) award-winning Great Lakes nonprofit organization that has set national records for pollution prevention and implements innovative, science-based programs that achieve documented, measurable results. SWP hired Applied Ecological Services, Inc. (AES) to undertake a watershed planning effort and produce a comprehensive "Watershed-Based Plan" for the Lower Dead River watershed that meets requirements as defined by the United States Environmental Protection Agency (USEPA).

Ultimately, the intent is to develop and implement a Watershed-Based Plan designed to achieve water quality standards/criteria.

The watershed planning process is a collaborative effort involving voluntary stakeholders with the primary scope to restore impaired waters and protect unimpaired waters by developing an ecologically-based management plan for the Lower Dead River watershed that focuses on improving water quality by protecting green infrastructure, creating protection policies, implementing ecological restoration, and educating the public. Another important outcome is to improve the quality of life for people in the watershed for current and future generations.

The primary purpose of this plan is to spark interest and give stakeholders a better understanding of the Lower Dead River watershed to promote and initiate plan recommendations that will accomplish the goals and objectives of this plan. This plan was produced via a comprehensive watershed planning approach that involved input from SWP and analysis of complex watershed issues by watershed planners, ecologists, GIS specialists, water quality specialists, and environmental engineers. In addition, ideas and recommendations in this plan are designed to be updated through adaptive management that will strengthen the plan over time as additional information becomes available.

1.3 USEPA Watershed-Based Plan Requirements

In March 2008, the United States Environmental Protection Agency (USEPA) released watershed protection guidance entitled "Non-point Source Program and Grant Guidelines for States and Territories." The document was created to ensure that Section 319 funded projects make progress towards restoring waters impaired by non-point source pollution. Applied Ecological Services, Inc. consulted USEPA's "Handbook for Developing Watershed Plans to Restore and Protect Our Waters" (USEPA 2008) to create this watershed plan. Having a Watershed-Based Plan will allow Lower Dead River watershed stakeholders to access 319 Grant funding and other funding for watershed improvement projects recommended in this plan. Under USEPA guidance, "Nine Elements" are required in order for a plan to be considered a Watershed-Based Plan.

Noteworthy- USEI

Element A: Identification of the causes and sou
that will need to be controlled to :
estimated in the watershed-based

Element B: Estimate of the pollutant load redu
the management measures describ

Element C: Description of the BMPs (non-poir
expected to be implemented to achi
Element B above and an identificati
measures will be needed to impleme

Element D: Estimate of the amounts of technic
costs, and/or the sources and autl
the plan;

Element E: Public information/education comp
public understanding of the projec
participation in selecting, designing
source management measures that

Element F: Schedule for implementing the activ
measures the plan; identified in th

Element G: Description of interim, measurable
non-point source management me:
implemented;

Element H: Set of environmental or administra
whether loading reductions are be
progress is being made towards at

Element I: Monitoring component to evaluate
efforts over time.

1.4 Using the Watershed-Based Plan

The information provided in this Watershed-Based Plan is prepared so that it can be easily used as a tool by any stakeholder including elected officials, federal/state/county/municipal staff, and the general public to identify and take actions related to watershed issues and opportunities. The pages below summarize what the user can expect to find in each major "Section" of the Watershed-Based Plan.

Section 3.0: Watershed Resource Inventory
An inventory of the characteristics, problems, and opportunities in the Lower Dead River watershed is examined in Section 3.0. Resulting analysis of the inventory data can help develop a Management Measures Action Plan. Inventory results also help identify causes and sources of watershed impairment as required under USEPA's *Element A*.

Section 4.0: Water Quality & Pollutant Modeling Assessment
This section includes a detailed summary of physical, chemical, and biological data available for the Lower Dead River watershed. Water quality data combined with pollutant loading data provides information that sets the stage for developing pollutant reduction targets and identifying "Critical Areas".

<u>Watershed Resource Inventory Topics Included in the Plan</u>

- 3.1 Geology & Climate
- 3.2 Pre-European Settlement Landscape & Present Landscape
- 3.3 Topography, Watershed Boundary, Subwatersheds
- 3.4 Soils
- 3.5 Jurisdictions
- 3.6 Existing Policies
- 3.7 Demographics
- 3.8 Transportation Network
- 3.9 Existing & Future Land Use
- 3.10 Impervious Cover Impacts
- 3.11 Open Space & Green Infrastructure
- 3.12 Highly Productive Agricultural Land
- 3.13 Important Natural Areas
  - Natural Resource Management
- 3.14 Watershed Drainage System
  - Tributaries
  - Wetlands
  - Floodplain
- 3.15 Groundwater

1.6 Prior Studies & Projects

This planning document is an updated version of the Lower Dead River Watershed Management Plan approved in 2003. Since the initial plan came out, much work has been done to implement previously identified restoration projects and to continue to gather information for the Lower Dead River watershed. The Superior Watershed Partnership, with assistance from partners, continues to evaluate environmental conditions.

Superior Watershed Partnership has a legacy of water quality improvement implementation and monitoring efforts in the Lower Dead River watershed. Since 2003, the Superior Watershed Partnership and other partners have implemented a number of corrective actions and management strategies. On the ground restoration projects have consisted of improvements to road/stream crossings in Reany Creek and Midway Creek. In addition, a variety of means were used to inform and educate landowners, stakeholders, and the public about watershed issues and implementation progress. Public information and education efforts focused on land use management practices, conservation planning tools, and other methods to preserve and protect water quality and natural resources in the Lower Dead River watershed. A brief summary of projects completed along with other strategies implemented is provided.

A comprehensive three-year study, entitled Lake Superior: Urban and Rural Watershed Restoration, was prepared by the Model Forest Policy Program (MFPP) and Superior Watershed Partnership. The study identified aspects of the Lower Dead River watershed that could benefit from improved land management, including from riparian restoration, streamside and wellhead protection zones, and protection from the effects of metals and gravel mining (Hall, Margaret & Thaler, T., 2018). This collaborative project included social surveys, ecosystem services analysis, and curriculum development.

The watershed continues to be an ecological and community asset and provides a number of ecosystem services through the inherent capabilities of the landscape. A 2018 ecosystems services analysis by Key-Log Economics provided an assessment of Lower Dead River watershed ecosystem services which include aesthetics, climate regulation, air quality, cultural, passive use, energy resources, protection from extreme events, food, biodiversity, raw materials, medicine, recreation, soil formation, erosion control, waste assimilation, water supply, and pollination (Phillips 2018).

Table 1 Lower Dead River Watershed Implementation Progress 2003-present.

2003
• Developed land use planning guide and CD for Marquette County including a resource inventory (GIS maps) • Developed a model riparian buffer ordinance for area townships and other local units of government.
2004
• Provided support to the Presque Isle Power Plant (City of Marquette) for a variance to install a mercury abatement facility, which resulted in a 90% reduction in mercury emissions.
2005

- Much of the watershed was photographed during a low altitude aerial survey conducted for development of the Superior Watershed Partnership "Shoreline Viewer" land use planning project.

2005-2008

- Lower Dead River Watershed Implementation Project funded by the Michigan Nonpoint Source Program – Implemented best management strategies to protect and restore water quality at 11 sites

2011

- Free Red Bucket program established for local businesses to curb cigarette litter.

2012

- Lake Superior Climate Adaptation, Mitigation and Implementation Plan written to address and mitigate the effects of climate change on local communities.

2018

- City of Marquette Stormwater Education Plan created to provide education on topics including: around the house stormwater management, lawn and garden care, pet waste, how to install a rain garden, water conservation techniques, reducing cigarette butt litter, and new community engagement opportunities. These educational articles are available on the city website (www.marquettemi.gov) and the SWP website (www.superiorwatersheds.org)
- Existing Stormwater Projects include:
    - Stormwater education materials mailed to city residents.
    - Informational public signs about stormwater and monitoring programs.
    - K-12 school programs regarding stormwater and Great Lakes stewardship.
    - Involving local artists and musicians with public outreach.
    - Improved social media and website education regarding stormwater.
    - Free Red Bucket program for local businesses to curb cigarette litter.
    - Rain Barrel cost-share program for city residents.
    - Informative posters on yard care, dog waste, car washing, etc.
    - Outreach regarding large green infrastructure projects.
    - Education regarding wetland restoration and stormwater benefits.
    - Technical assistance for rain garden design for city residents.
    - Installation assistance for BMP's from the Great Lakes Conservation Corps.
    - Volunteer events for dune restoration, tree planting and wetland restoration.

2020

- Raingarden challenge implemented in the City of Marquette with assistance from Great Lakes Conservation Corps, the Community Foundation of Marquette County, and other local partners
- Historic wetland restoration and enhancement along Hawley Street, adjacent to the Dead River and Lake Superior (12 acres)
- Hawley Street storm drain disconnection from Lake Superior and re-routed into newly restored wetlands (eliminate 7.5-9 million gallons of storm water from entering Lake Superior near public beaches each year)

2.0 MISSION, GOALS, AND OBJECTIVES

2.1 About Superior Watershed Partnership

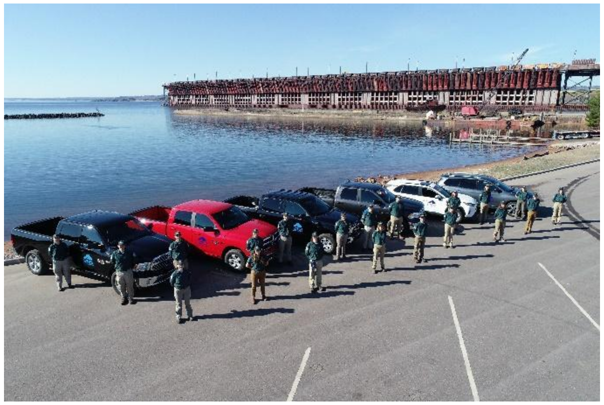
The Superior Watershed Partnership and Land Conservancy is a 501(c)(3) award-winning Great Lakes nonprofit organization that has set national records for pollution prevention and implements innovative, science-based programs that achieve documented, measurable results. The Superior Watershed Partnership implements a variety of conservation and public education projects including:

- Great Lakes habitat protection and restoration
- Community pollution prevention
- Climate change adaptation planning and implementation
- Invasive species removal and prevention
- Water Quality and Stormwater Management
- Native plant restoration
- Land protection
- Youth programs and public education
- Alternative energy and energy conservation
- UP community assistance

The Superior Watersheds Partnership also provides technical, educational, and monitoring assistance on a variety of Great Lakes protection initiatives with emphasis on Lake Superior, Lake Michigan, and Lake Huron. The Superior Watershed Partnership has received numerous state and national awards and has been recognized by former Michigan Governor Granholm, the US Environmental Protection Agency, Environment Canada and the Lake Superior Bi-national Program as a leader in watershed protection for the Lake Superior Basin and the headwaters region of the Great Lakes ecosystem.

2.2 Watershed Plan Goals and Objectives

The main goal of the Lower Dead River Watershed Management Plan is to promote and facilitate coordinated, collaborative action among stakeholders in order to improve and protect water quality and preserve the unique nature of the watershed. The watershed inventory and analysis identified and prioritized the causes and sources of pollution affecting or having the potential to affect water quality and designated and desired uses in the watershed. The following goals and management objectives provide guidance for implementation of actions that will reduce these affects and provide a basis for protection from further impacts. The goals and management objectives were developed in 2003 as strategies to address threats to water quality and designated and desired uses in the Lower Dead River watershed. They provide a basis for protection of significant natural resources and reflect the desires of stakeholders for the future state of the watershed. Goals and objectives for the watershed have not changed since 2003.



SWP's 2020 Great Lakes Conservation Corps Crews

Goals	Threatened Designated Us Addressed	
1. **Restoration:** Identify and improve areas of sedimentation, erosion, fish passage barriers, and **stormwater** runoff contributing to the decline of water quality and aquatic habitat in the Lower Dead River watershed	<u>Designated Uses:</u> Coldwater fishery Warm water fishery Other indigenous aquatic life an wildlife Public water supply	
2. **Monitoring and Prevention:** Create and/or continue watershed and land conservation programs and develop better stormwater management techniques that will help to protect the water quality and aquatic habitat in the Lower Dead River watershed	<u>Designated Uses:</u> Coldwater fishery Warm water fishery Other indigenous aquatic life an wildlife Public water supply	
3. **Planning:** Identify open space planning and low impact development practices in order to protect ecological resources while still supporting economic and social growth within the community	<u>Designated Uses:</u> Coldwater fishery Warm water fishery Other indigenous aquatic life an wildlife Public water supply Fish consumption	
4. **Align with Regional Vision:** Create a watershed management plan that assists in the realization of the vision for Lake Superior as defined by the Lake Superior Binational Forum	<u>Designated Uses:</u> Coldwater fishery Warm water fishery Other indigenous aquatic life and wildlife Public water supply	<u>D</u> Al

Table 2 Goals of the Lower Dead River watershed management plan: Threatened designated and desired uses and pollutants addressed.

Goal #1
Restoration
Identify and improve areas of sedimentation, erosion, fish passage barriers, and stormwater runoff contributing to the decline of water quality and aquatic habitat in the Lower Dead River watershed

Designated Uses:
Coldwater fishery, warm water fishery, other indigenous aquatic life and wildlife, public water supply

Desired Uses:
Restoration of the designated uses to the Lower Dead River watershed that includes physical improvements and quantifiable protection goals

Pollutants Addressed:
All

Objective 1:
Control and minimize sediment input to the Lower Dead River and its tributaries:

- Assess the condition of road/stream crossings to quantify erosion and sediment inputs
- Monitor stream margins to quantify erosion and sediment inputs
- Implement restoration improvements at prioritized degraded sites
- Utilize the well-established Great Lakes Conservation Corps (GLCC) program for 18-25-year-olds to provide career experience while implementing erosion control projects
- Work with partners to monitor the impact of land use practices and make improvements to recreational trails, river and lake public access points

Objective 2:
Protect and restore desirable habitat areas for fish and aquatic organisms in the Lower Dead River and its tributaries to preserve the biodiversity of aquatic communities

- Reduce sedimentation from priority sources
- Improve passage and connectivity for fish and aquatic organisms (road/stream crossings)
- Promote proper riparian land use practices including the use of buffers
- Support efforts to improve and maintain naturally reproducing native fish populations

Objective 3:
Discourage land use practices that have the potential to negatively impact water quality and aquatic habitat:

- Eliminate and/or minimize risks for surface and groundwater contamination by heavy metals, nutrients, and toxins through improved zoning and increased landowner education and stewardship
- Discourage development in sensitive areas (riparian corridors, wetlands, and areas with unsuitable soils, slope, etc.) through improved zoning and increased landowner education and stewardship

Goal #2
Monitoring and Prevention
Create and/or continue watershed and land conservation programs and develop better stormwater management techniques that will help to protect the water quality and aquatic habitat in the Lower Dead River watershed

Designated Uses Addressed:
Coldwater fishery, warm water fishery, other indigenous aquatic life and wildlife, and public water supply

Desired Uses Addressed:
Creation of better stormwater management techniques through education/demonstration sites and stormwater ordinances implemented by local municipalities

Pollutants Addressed:
All

Objective 1:
Create and/or utilize existing watershed programs in the Lower Dead watershed.

- Continue watershed monitoring, public education, regional outreach, and planning efforts
- Utilize the well-established Great Lakes Conservation Corps (GLCC) program for 18-25-year-olds to provide career experience, collect watershed monitoring data, and provide valuable boots-on-the-ground for project implementation

Objective 2:
Promote voluntary arrangements and regulatory incentives to help prevent degradation of water quality and aquatic habitat:

- Designate biologically important or sensitive areas within the watershed such as riparian corridors, recharge areas, wetlands, and slopes
- Provide detailed watershed information to landowners, land managers and decision makers
- Negotiate conservation easements where possible and applicable within the watershed
- Avoid development that encroaches on sensitive or biologically important areas
- Preserve high quality natural communities
- Protect critical riparian areas
- Properly manage working lands (forest lands)

Goal #3
Planning
Identify open space planning and low impact development practices in order to protect ecological resources while still supporting economic and social growth within the community

Designated Uses Addressed:
Coldwater fishery, warm water fishery, other indigenous aquatic life and wildlife, and public water supply

Desired Uses Addressed:
Limit development to areas outside the riparian corridor and promote sound land use practices

Pollutants Addressed:
All

Objective 1:
Create lines of communication:

- Communicate between the municipalities located within the Lower Dead River watershed
- Provide watershed information to allow for discussion and analysis of existing land use
- Discuss the impacts of future development

Objective 2:
Assist local units of government with open space planning

- Maintaining natural qualities within communities to protect vital natural resources and quality of life
- Use planning tools such as cluster development, conservation subdivision design, greenways, conservation corridors, and Planned Unit Developments (PUDs)
- Consider environmentally sensitive areas, such as unique forest stands or large wetland areas in open space planning.
- Maintain rural aesthetic, character, natural viewshed, and public access to natural resources.
- Prevent fragmentation of forest areas, loss of green space, and commercial sprawl

Objective 3:
Assist local units of government with master planning and zoning ordinances to protect water quality and sensitive areas

- Provide guidance and tools for planning, ordinance development, and zoning enforcement
- Provide detailed watershed information to local units of government
- Encourage the use of effective riparian buffers
- Encourage the use of land use restrictions in areas sensitive to environmental degradation
- Encourage appropriate provisions for water quality and sensitive areas in the approval process for new development or redevelopment
- Provide information on low-impact development such as reduced impervious surfaces, maintained natural drainages, minimized grading and proper stormwater controls

Goal #4
Align with Regional Vision
Create a watershed management plan that assists in the realization of the vision for Lake Superior as defined by the Lake Superior Lakewide Action and Management Plan

Designated Uses Addressed:
Coldwater fishery, warmwater fishery, other indigenous aquatic life and wildlife, and public water supply

Desired Uses Addressed:
All

Pollutants Addressed:
All

Objective 1:
Monitor and maintain coastal wetland, aquatic, and riparian biological communities in good ecological condition (LaMP Obj. 4)

- Monitor coastal wetland conditions to detect changes in water quality or biological communities
- Utilize land protection strategies, wetland-buffer ordinances, and tools to preserve coastal wetlands in good ecological condition
- Prioritize wetland protection for those with historic and current hydrologic connectivity to, and directly influenced by, the lake. Example species to benefit include Northern Pike, waterfowl, and many amphibians
- Use current ecological data to prioritize protection of habitats for threatened and endangered aquatic species

Objective 2:
Maintain coastal terrestrial habitats in good ecological condition (LaMP Obj. 6)

- Monitor coastal erosion and wave action influencing the shoreline
- Restore coastal habitat with native plantings, erosion control tools, and stabilization techniques
- Use current ecological data to prioritize protection of habitats for threatened and endangered coastal terrestrial species including shorebirds, bald eagles, and rare plants.

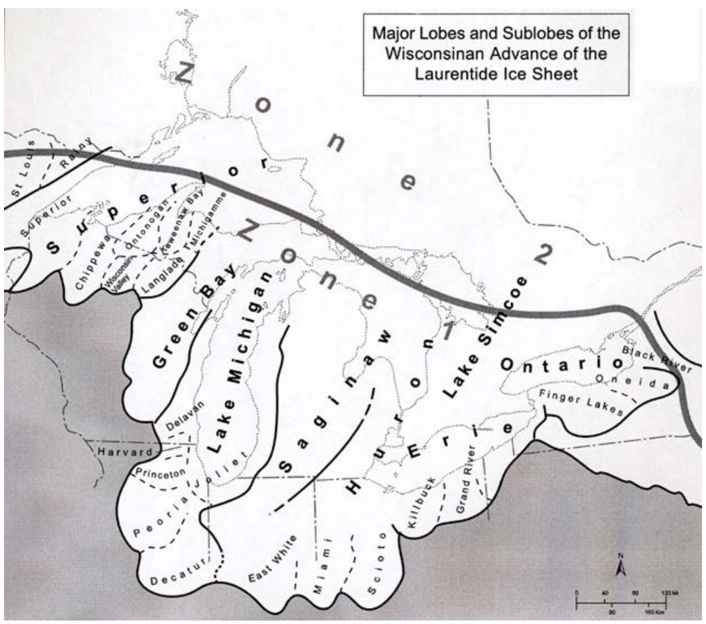
Objective 3:
Maintain tributaries and watersheds in good ecological condition (LaMP Obj. 7)

- Use baseline data in comparison with current data collection to analyze and monitor changes to ecosystem conditions
- Implement stream restoration projects and activities as prioritized by planning efforts and approved by local and state jurisdictions

3.0 WATERSHED RESOURCE INVENTORY

3.1 Geologic History & Climate

The terrain of the Midwestern United States was created over thousands of years as glaciers advanced and retreated during the Pleistocene Era or "Ice Age." Dr. Randall Schaetzl's "Geography of Michigan and the Great Lakes Region," observes that far earlier than that, more than a billion years ago, volcanic activity along the Lake Superior syncline lead to the formation of the Lake Superior basin and the deposition of the volcanic Pre-Cambrian geology that makes up the Keweenaw Peninsula, as well as forming the post-volcanic Cambrian and Ordovician sedimentary rock which makes up the bedrock of the watershed area. The area of the Upper Peninsula of Michigan where the



Lower Dead River watershed now lies was covered by the most recent glacial event known as the Late Wisconsin Glaciation that began approximately 30,000 years ago and ended around 9,500 years ago (Figure 2). This area was largely covered by the Superior lobe. The terrain of the Upper Peninsula was some of the last to experience deglaciation, with the Marquette re-advance occurring circa 10,000 years ago, burying exposed areas such as the Gribben Lake forest bed.

Around 9,500 years ago, the earth's temperature warmed and the ice slowly retreated leaving behind moraines and glacial ridges where it stood for long periods of time, some of which contributed to the topography in the watershed region (Figure 3).

The composition of the soil in Lower Dead watershed is also a remnant of the ancient ice movement. Above the bedrock and sedimentary deposits is a thin layer of poorly-sorted deposits left behind from the glaciers, consisting of largely mineral soils.

A combination of the thin mineral soils and somewhat tundra-like environment led to coniferous forest being the first ecological community to colonize after the glaciers retreated. As temperatures continued to rise, cool moist deciduous forests dominated by aspen and birch developed along Lake Superior coastal areas and beech, sugar maple, hemlock forests developed more inland. Jack pine-red pine forests, and hemlock-white pine forests, as well as small patches of mixed conifer swamp were also part of the landscape.

Climate

The Marquette, MI area climate can be described as temperate with cold winters and warm summers where great variation in temperature, precipitation, and wind can occur on a daily basis. Surges of polar air moving southward or tropical air moving northward causes daily and seasonal temperature fluctuations. The action between these two air masses fosters the development of low-pressure centers that generally move eastward and frequently pass over the study area, resulting in abundant rainfall. Prevailing winds are generally from the west but are more persistent and blow from a northerly direction during winter. Lake Superior significantly influences the study area as it reduces the heat of summer and buffers (warms) the cold of winter by several degrees on average.

The Weather Channel website (www.weather.com) provides an excellent summary of climate statistics including monthly averages and records for most locations in the Upper Peninsula. Data for Marquette was selected to represent the climate and weather patterns experienced in Lower Dead River watershed (Figure 4). The winter months are cold, averaging highs around 30° F while winter lows are around 17° F. Summers are warm with average highs around 71° F and summer lows around 56° F. The highest recorded temperature was 104° F in July 1977 while the lowest temperature was -33° F in February 1861.

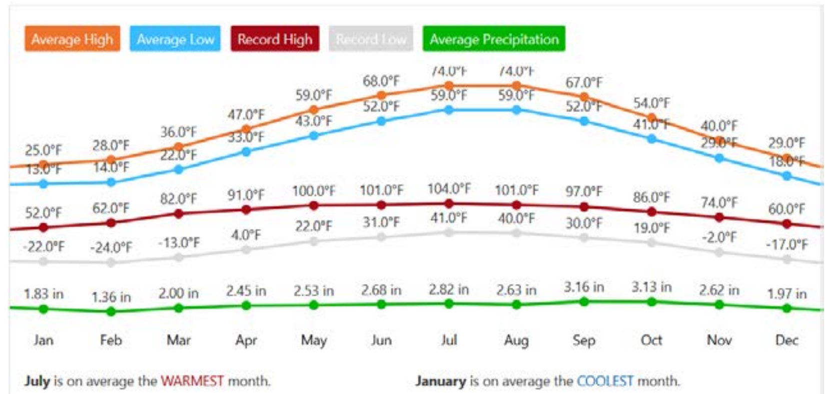


Figure 3- Regional Climate Trends

With a climate impacted by its northern latitude and proximity to Lake Superior, the Lower Dead River watershed consists of an average rainfall around 29 inches and snowfall around 119 inches. According to data collected in Marquette, the most precipitation on average occurs in September and October (3.2 inches) while January receives the least amount of precipitation with 1.3 inches on average.

According to Great Lakes Integrated Sciences and Assessments (GLISA), Michigan's climate is changing. On average, Michigan has become warmer and wetter over the past 60 years. Future projections for Michigan created by GLISA along with University of Michigan and Michigan State University suggest this trend will continue and increase considerably. By the latter half of the century, regional annual average temperatures are likely to warm by 5.5-6 ° F and precipitation will likely increase by 2-4 inches.

Climate Change

The variable effects of climate change are altering Northern Michigan forests and other ecosystems and can be attributed to changes in important cultural, economic, and environmental factors. In Michigan, the four heaviest rain events per year contain 35% more water than they did 50 years ago (US EPA 2016). These heavy rains lead to increased sedimentation, nitrates, phosphates, *E. coli*, and other pollutants entering waterways leading to beach closings and algae blooms. In addition, northern forest compositions are changing. In particular, the Upper Peninsula of Michigan may see declining paper birch, quaking aspen, balsam fir, and black spruce populations and increasing populations of oak, hickory, and pine trees (US EPA 2016). Furthermore, the central and eastern regions of the Upper Peninsula are projected to experience more extreme temperature changes than other parts of Michigan (GLISA 2014). The Climate Change Response Framework conducted a series of vulnerability assessments for the north woods region supported by 19 science and management experts from across the area aka the "Northwoods Framework." The experts agreed that current and anticipated climatic changes suggest the following main points for the Laurentian Mixed Forest Province of Northern Wisconsin and the Western Upper Peninsula (including Marquette County): 1). Increased precipitation 2). Increased daily maximum temperatures, particularly in winter 3). Potential increase in mean annual temperature of 2 to 9 ºF for the region 4). The most vulnerable forest communities in the assessment area include upland spruce-fir, lowland conifers, aspen-birch, lowland-riparian hardwoods, and red pine forests (Janowiak et al. 2014).

Projected climate trends anticipated for the next 100 years were determined using downscaled global climate model data. The suggested management implications in the Northwoods Framework report include (summarized) 1). Following state and federal guidance to protect and support wildlife, and specifically rare, threatened, and endangered species. 2). Replace water infrastructure such as culverts, bridges, and shoreline roads following 100-year flood plans. Use hydrologic modeling where possible to identify high runoff zones. 3). Prioritize the preservation of stream margins, as reduced shading could cause the effects of warming temperatures to compound with severe consequences for fish populations and other aquatic life. 4). Adapt fire and fuel policies specific to land use in particular regions to address ecosystem and human health concerns exacerbated by drought conditions. 5). Adapt forest harvest and management practices for anticipated changes in tree species diversity related to heat-stress and tolerance levels. 6). Adapt forest harvest and management practices for shorter seasons of frozen ground and reduced harvest windows. 7). Manage forests using strategies for increasing carbon storage with enhanced regeneration, competition control, fertilization, and superior stock (Janowiak 2012). 8). Manage forests for non-timber products such as food, medicine, and craft. In addition, protect cultural, archeological and historical resources. 9). Plan for increased infrastructure maintenance on trails, campsites, structures and hazard tree removal in wilderness areas due to increased storm events. 10). Plan to shift tourist and local recreational focus from winter-sports to warmer-weather activities. 11). Plan, adapt, and inform the public about regional increases in human diseases and vectors of transmission. 12). Plan, adapt to challenges and plant a variety of highly tolerant species at urban and community forest sites (Janowiak et al. 2014).

3.2 Pre-European Settlement Landscape Compared to Present Landscape

According to Michigan State University's "Michigan History," the Ojibwe (or Chippewa) peoples called this region home for many centuries before the arrival of European settlers. These people primarily hunted and fished in the region, subsisting themselves with the natural environment. This made them key allies to the French fur traders, until the decline of the fur trade and transfer of lands from French to British and eventually American ownership led to them being driven from the region around 1640. The final removal of the Ojibwe peoples from their native lands came with the signing of the Treaty of La Pointe in 1842, ceding the copper and iron rich lands. This treaty paved the way for European settlement in the area that began with surveys of the land. The original public land surveyors that worked for the office of U.S. Surveyor General in the early and mid-1800s mapped and described natural and man-made features and vegetation communities while creating the township, range, and section ("Rectangular Survey System") for mapping and sale of western public lands of the United States (Daly & Lutes et. al., 2011). Ecologists know by interpreting survey notes and hand drawn Federal Township Plats of Michigan (1833-1866) and from documents written by the earliest settlers in the area that a complex interaction existed between several ecological communities including coniferous and deciduous forests, and wetlands prior to European settlement in the 1830s (Figures 5 and 6).

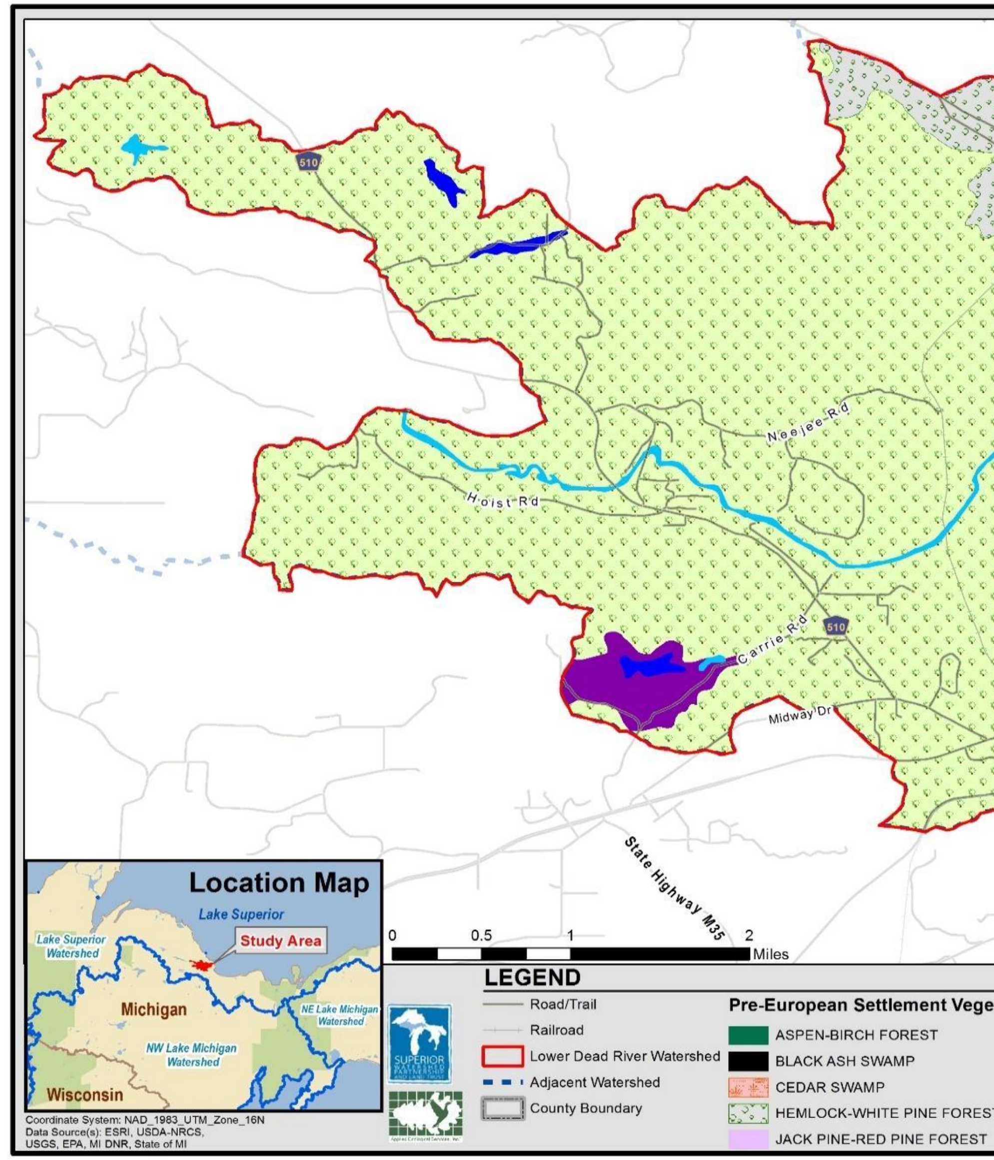
Mapping of Pre-European Settlement Vegetation for the Lower Dead River describes the region as dominated by a small number of upland species. Primarily, 85% of the Lower Dead River watershed was covered by sugar maple-hemlock forest. Isolated patches of aspen-birch forest cover the northeast portion of the watershed, and small portions of the lowland area are covered with cedar and mixed conifer species.

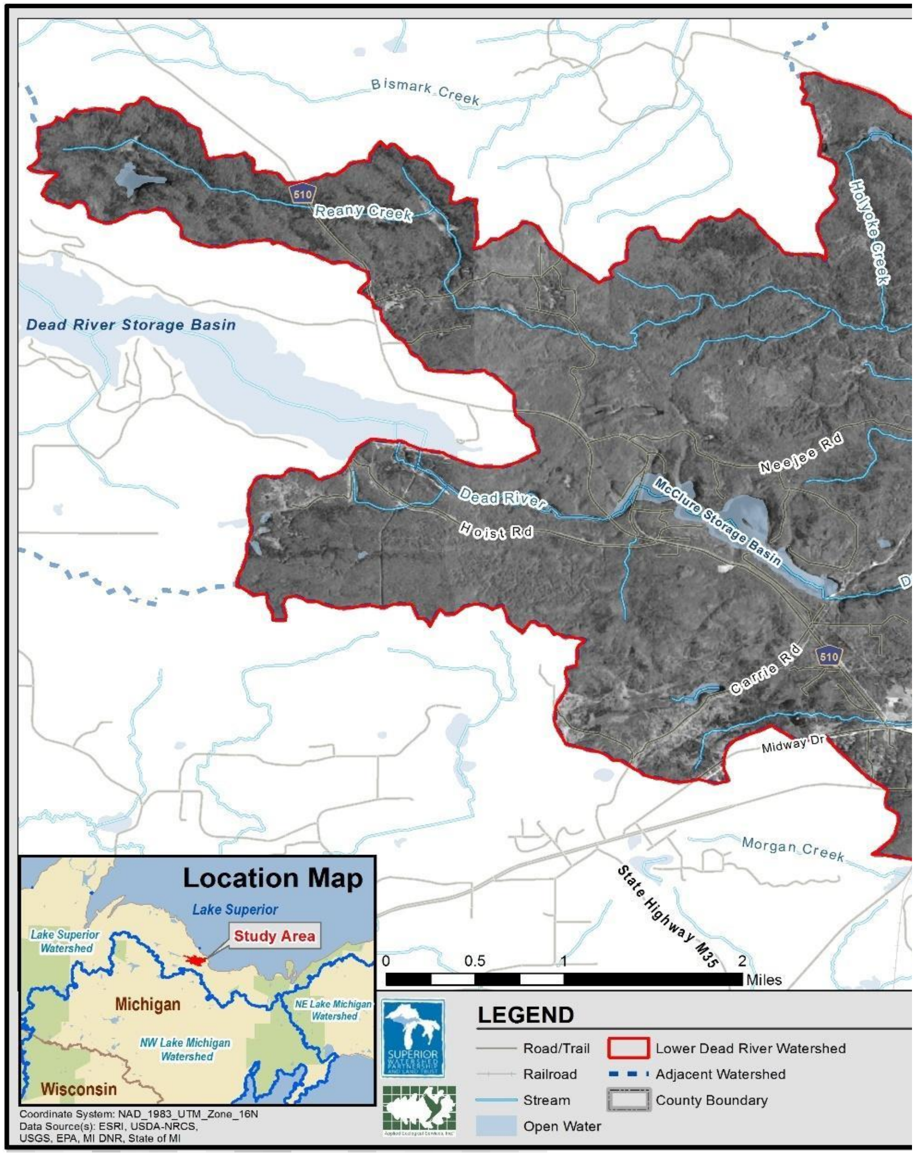
Though Europeans began settling in the area in the 1600s and earlier (and the Ojibwe far before them); European settlement beginning in the 1840s resulted in drastic changes to the fragile ecological communities as most of the old growth forests were cleared by settlers who used the wood for fuel, to build their homes, and sold it to sawmills. In 1849 following the settlement of Marquette by Amos Rogers Harlow and the discovery of iron ore a few years earlier; the Industrial Revolution came to the area. Iron ore mining and logging ebbed and flowed through the booms of the early 20th century and the bust of the Great Depression, persisting to this day though no longer with the dependency there once was. The earliest aerial photographs taken in 1953 depict the Lower Dead River watershed when logging and mining were the primary land use, along with the beginnings of the residential, commercial, and industrial development seen today.

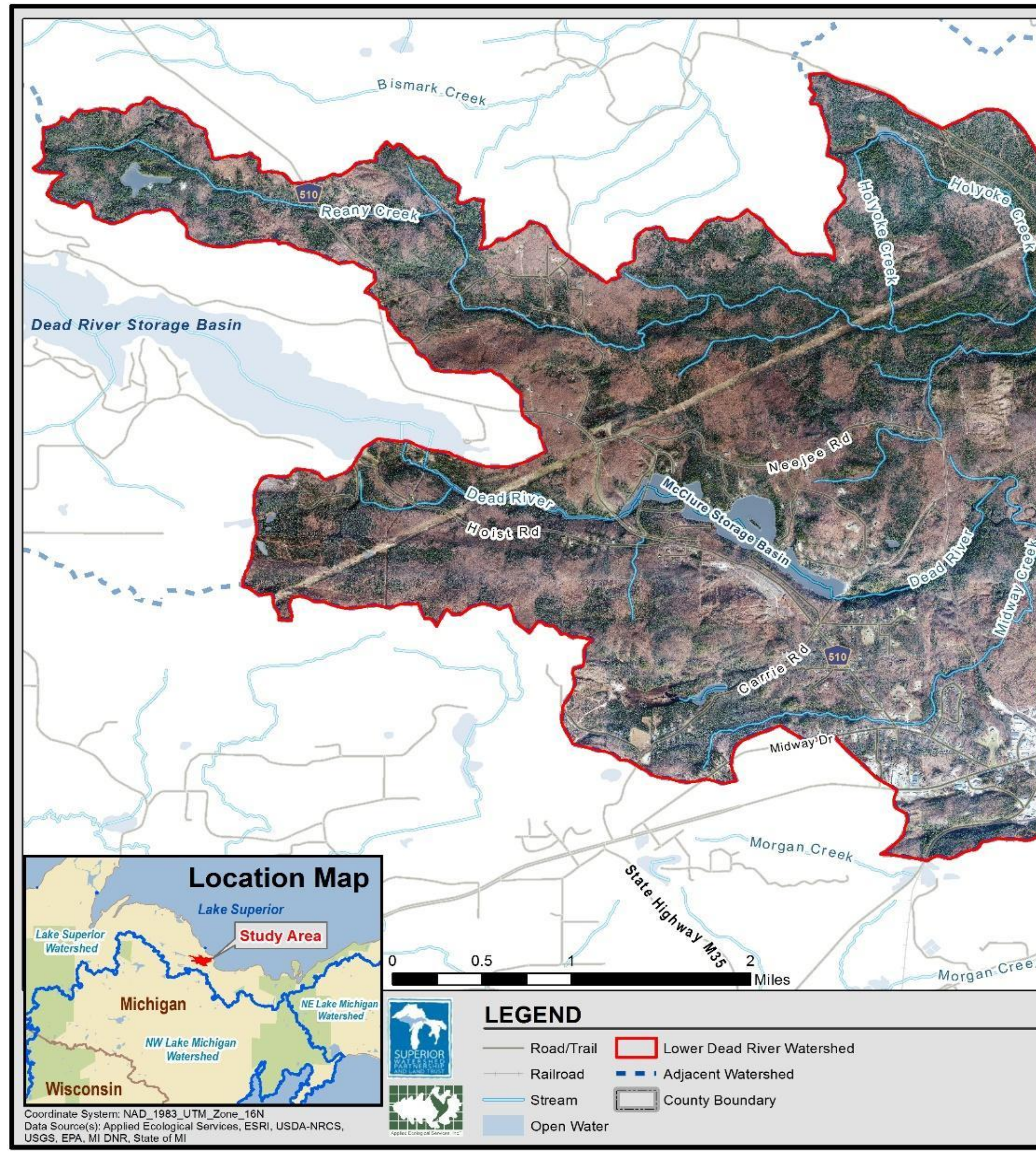
Over time, residential, commercial, and industrial development has expanded and continues to expand westward from Marquette into Marquette and Negaunee Townships. Most current development is occurring along US Highway 41. Outside of these areas, much of the watershed remains forested, with scattered residential development visible. Also, highly visible is tree clearing for utility easements connecting Presque Isle power plant to surrounding communities. Industrial and commercial land uses are common along Highway 41 for easy access to transportation routes.

With degraded ecological conditions comes the opportunity to implement ecological restoration to improve the condition of the Lower Dead River watershed. Present day knowledge of how pre-European settlement ecological communities formed and evolved provides a general template for developing present day natural area restoration and management plans and projects. One of the primary goals of this watershed plan is to identify, protect, restore, and manage remaining natural areas.

Mouth of Lower Dead River with Presque Isle Power Plant in the foreground, Marquette in the background. Source: Superior Watershed Partnership




Bismark Creek
510
Reany Creek
Holyoke Creek
Dead River Storage Basin
Neejee Rd
Dead River
Hoist Rd
McClure Storage Basin
Carrie Rd
510
Midway Dr
Morgan Creek
State Highway M35
Location Map
Lake Superior
Lake Superior Watershed
Study Area
Michigan
NE Lake Michigan Watershed
NW Lake Michigan Watershed
Wisconsin
0
0.5
1
2
Miles
LEGEND
Road/Trail
Railroad
Stream
Open Water
Lower Dead River Watershed
Adjacent Watershed
County Boundary
Coordinate System: NAD_1983_UTM_Zone_16N
Data Source(s): ESRI, USDA-NRCS, USGS, EPA, MI DNR, State of MI


Bismark Creek
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Reany Creek
Holyoke Creek
Holyoke Creek
Dead River Storage Basin
Neejee Rd
Dead River
Hoist Rd
McClure Storage Basin
Dead River
Midway Creek
Carrie Rd
510
Midway Dr
Morgan Creek
State Highway M35
Morgan Cree
Location Map
Lake Superior
Lake Superior Watershed
Study Area
Michigan
NE Lake Michigan Watershed
NW Lake Michigan Watershed
Wisconsin
0
0.5
1
2
Miles
LEGEND
Road/Trail
Railroad
Stream
Open Water
Lower Dead River Watershed
Adjacent Watershed
County Boundary
Coordinate System: NAD_1983_UTM_Zone_16N
Data Source(s): Applied Ecological Services, ESRI, USDA-NRCS, USGS, EPA, MI DNR, State of MI

3.3 Topography, Watershed Boundary, & Subwatershed Management Units

Topography & Watershed Boundary

The effects of the Pleistocene ice age can be seen in the varying topography throughout the Lower Dead River watershed. This variety includes relatively flat areas, gently rolling hills, and very steep slopes, particularly adjacent to stream and river corridors (Godby and Suppnick 2001, CUPPAD 1998). In Marquette Township nearly 25% of the township has slopes greater than 15% (Sundberg et al. 1995).

This varied topography can be a determining factor in the pattern of development in the watershed. Current construction techniques and the market's strong desire to take advantage of long views and attractive vistas exerts significant development pressure on these fragile areas. However, when development occurs near steep slopes there is an increased risk of erosion, sedimentation, and damage to aquatic habitat. In their comprehensive development plans, both Marquette and Negaunee Townships discourage high-density development on moderate slopes (15%-25%), preferring such development be located on areas with less relief (Sundberg et al. 1995, CUPPAD 1998). According to Marquette Township's development plan, improper planning as it relates to the area's topography can result in not only the destruction of an aesthetic feature, but also "soil stability disturbances, altering of established drainageways, elimination of natural windscreens (vegetation), land slippage, and rapid erosion which adds silt and sediment to downstream waterways" (Sundberg et al. 1995).

The Lower Dead River watershed boundary used in this study is sourced from the United States Geologic Survey (USGS) database. The watershed boundary and available elevation data from Michigan Open GIS database was then input into a GIS model (ArcSWAT) that generated a Digital Elevation Model (DEM) of the watershed (Figure 9).

The Lower Dead River watershed is 15,879 acres or 24.8 square miles in size. The entire watershed drains from west to east and eventually to Lake Superior. Elevation within the watershed ranges from a high of 502 meters above mean sea level (AMSL) to a low of 186 meters AMSL along the Lake Superior coast for a total relief of 316 meters (Figure 9). The highest point is found in the northwest corner of the watershed near the headwaters of Reany Creek.

An interesting feature is the large relatively flat zone in the central portion of the watershed downstream of the McClure Storage Basin. Being one of the few flat areas in the watershed, this area has relatively hydric soils and, according to the original public land survey conducted in the mid-1800s, harbored mixed conifer swamp in the largest contiguous swampland in the watershed. Most of the wetlands that once existed on the plateau have been drained. This area is still minimally developed.

Table 3- Subwatershed Management Unit Acreage

SMU #	Subwatershed/Creek Names	Total Acres	Total Square Miles
SMU 1	Reany Creek	1,814.9	2.8
SMU 2	Unnamed Creek	523.6	0.8
SMU 3	Unnamed Creek	970.0	1.5
SMU 4	Unnamed Creek	904.2	1.4
SMU 5	Unnamed Creek	923.7	1.4
SMU 6	Midway Creek	1,085.9	1.7
SMU 7	Unnamed Creek	258.6	0.4
SMU 8	Unnamed Creek	564.9	0.9
SMU 9	Brickyard Creek	391.4	0.6
SMU 10	Unnamed Creek	1,049.5	1.6
SMU 11	Holyoke Creek	724.2	1.1
SMU 12	Unnamed Creek	399.8	0.6
SMU 13	Unnamed Creek	848.1	1.3
SMU 14	Unnamed Creek	276.6	0.4
SMU 15	Unnamed Creek	406.4	0.6
SMU 16	Brickyard Creek	543.0	0.8
SMU 17	Unnamed Creek	570.3	0.9
SMU18	Wolner Creek	715.9	1.1
SMU19	Badger Creek	838.3	1.3
SMU 20	Unnamed Creek	507.5	0.8
SMU 21	Unnamed Creek	342.8	0.5
SMU 22	Backyard Creek	296.1	0.5
SMU 23	Raney Creek	307.7	0.5
SMU 24	Unnamed Creek	338.9	0.5
SMU 25	Unnamed Creek	277.2	0.4
Totals		**15,879**	**24.8**

Subwatershed Management Units (SMUs)

The Center for Watershed Protection (CWP) is a leading watershed planning agency and has defined watershed and subwatershed sizes appropriate to meet watershed planning goals. In 1998, the CWP released the "Rapid Watershed Planning Handbook" (CWP 1998) as a guide to be used by watershed planners when addressing issues within urbanizing watersheds. The CWP defines a watershed as an area of land that drains anywhere from 10 to 100 square miles. Broad assessments of conditions such as soils, wetlands, and water quality are generally evaluated at the watershed level and provide some information about overall conditions. The Lower Dead River watershed is about 25 square miles and therefore this plan allows for a detailed look at watershed characteristics, problem areas, and management opportunities. However, an even more detailed look at smaller drainage areas must be completed to find site specific problem areas or "Critical Areas" that require immediate attention.

A watershed can be divided into subwatersheds called Subwatershed Management Units (SMUs) to address issues at a smaller scale. The Lower Dead watershed was delineated into 25 SMUs using a combination of the Digital Elevation Model (DEM) (Table 3; Figures 9 and 10). All SMUs within the watershed are connected as tributaries to the main branch of the Dead River which eventually drains to Lake Superior. Information obtained at the SMU scale allows for detailed analysis and better recommendations for site specific "Management Measures" otherwise known as Best Management Practices (BMPs). Delineation into SMUs also allows for better identification of areas contributing to water quality problems as summarized in Section 4.0.

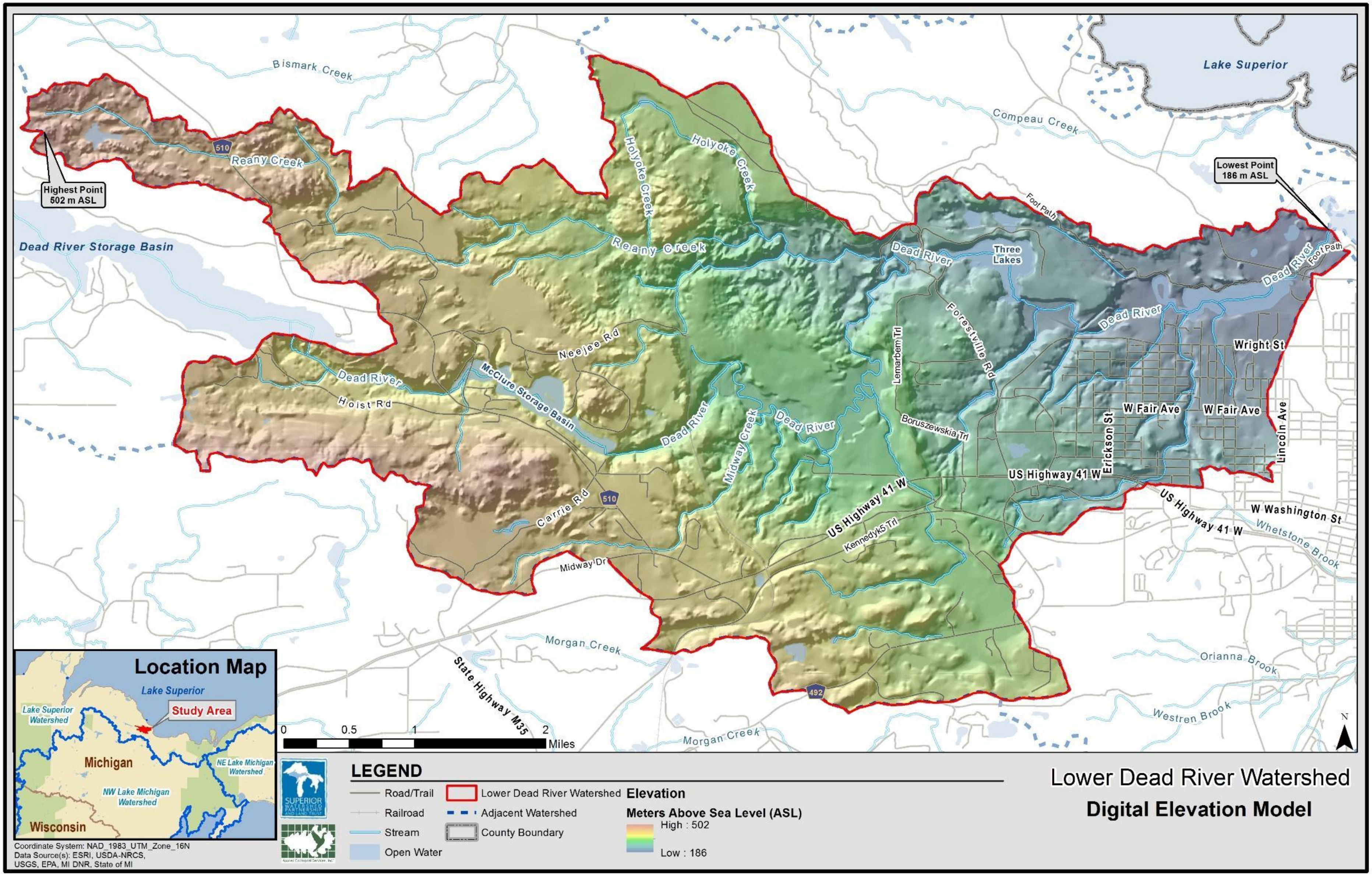
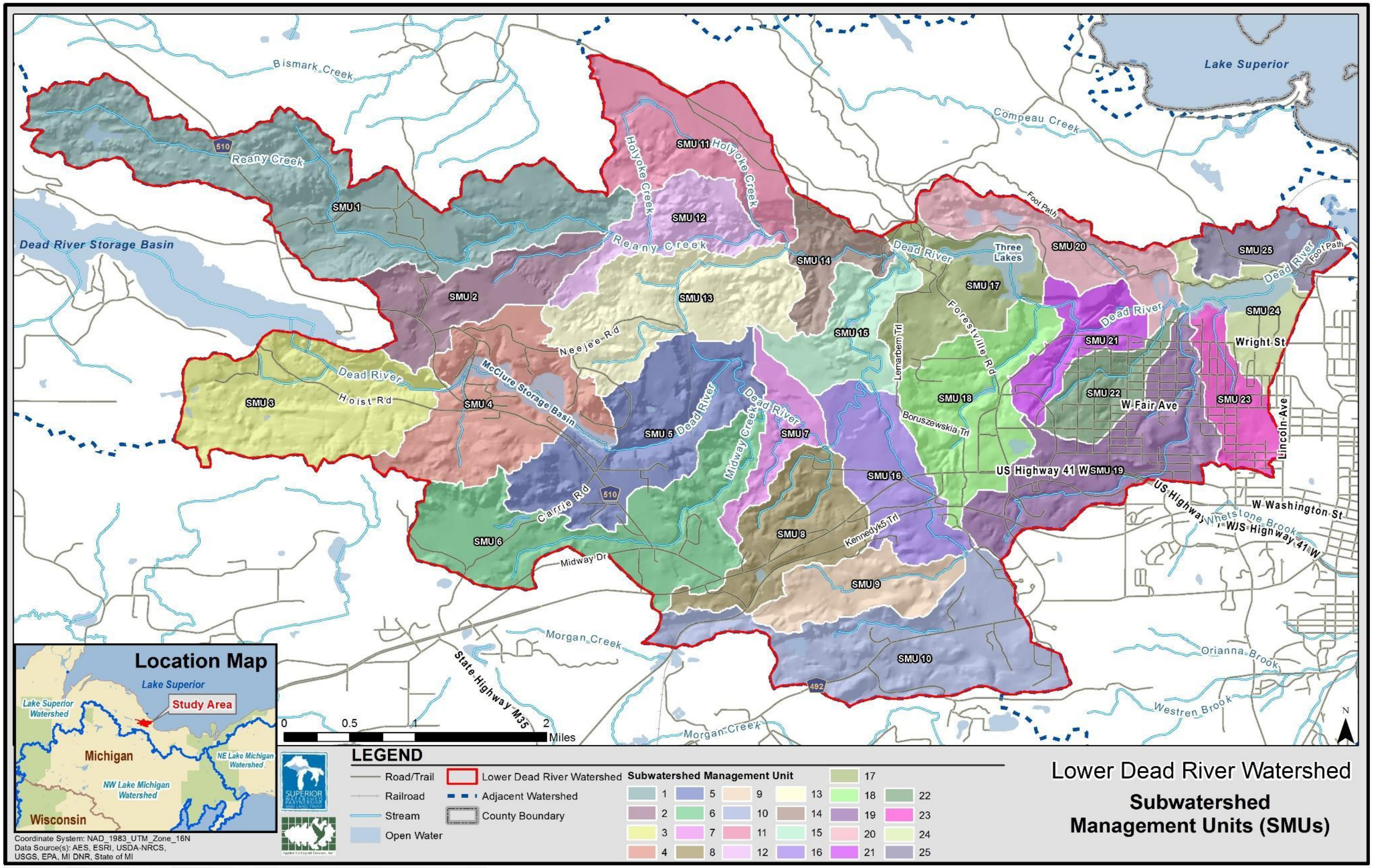


*Figure SEQ Figure * ARABIC 7- Digital Elevation Model*


Lower Dead River Watershed
Subwatershed Management Units (SMUs)
LEGEND
Road/Trail
Railroad
Stream
Open Water
Lower Dead River Watershed
Adjacent Watershed
County Boundary
Subwatershed Management Unit
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Location Map
Lake Superior
Study Area
Lake Superior Watershed
Michigan
Wisconsin
NW Lake Michigan Watershed
NE Lake Michigan Watershed
0 0.5 1 2 Miles
Coordinate System: NAD_1983_UTM_Zone_16N
Data Source(s): AES, ESRI, USDA-NRCS, USGS, EPA, MI DNR, State of MI
Dead River Storage Basin
Lake Superior
Bismark Creek
Reany Creek
Compeau Creek
Holyoke Creek
Dead River
Three Lakes
Foot Path
McClure Storage Basin
Hoist Rd
Neejee Rd
Carrie Rd
Midway Dr
Midway Creek
Kennedyk5 Trl
Lemarbem Trl
Forestville Rd
Boruszewskia Trl
US Highway 41 W
W Fair Ave
Wright St
Lincoln Ave
W Washington St
Whetstone Brook
WJS Highway 41 W
Orianna Brook
Westren Brook
Morgan Creek
State Highway M35
SMU 1
SMU 2
SMU 3
SMU 4
SMU 5
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SMU 10
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SMU 12
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SMU 14
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SMU 16
SMU 17
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SMU 19
SMU 20
SMU 21
SMU 22
SMU 23
SMU 24
SMU 25

3.4 Hydric Soils, Soil Erodibility, & Hydrologic Soil Groups

Soils

The U.S. Department of Agriculture Natural Resources Conservation Service Soil Survey Geographic (SSURGO) database for Marquette County, Michigan was used to identify soil types within the boundary of the Lower Dead River watershed. This dataset was used to identify hydric soils, hydrologic soil groups, and soil erodibility.

Hydric Soils

Wetland or "Hydric Soils" generally form over poorly drained clay material associated with wet prairies, marshes, and other wetlands and from accumulated organic matter from decomposing surface vegetation. Hydric soils are important because they indicate the presence of existing wetlands or drained wetlands where restoration may be possible. There has not been significant wetland loss in the western Upper Peninsula primarily due to not many wetlands existing in the first place. This is largely due to the steep topography, especially around riparian systems, where water doesn't stand long enough to develop a significant organic layer.

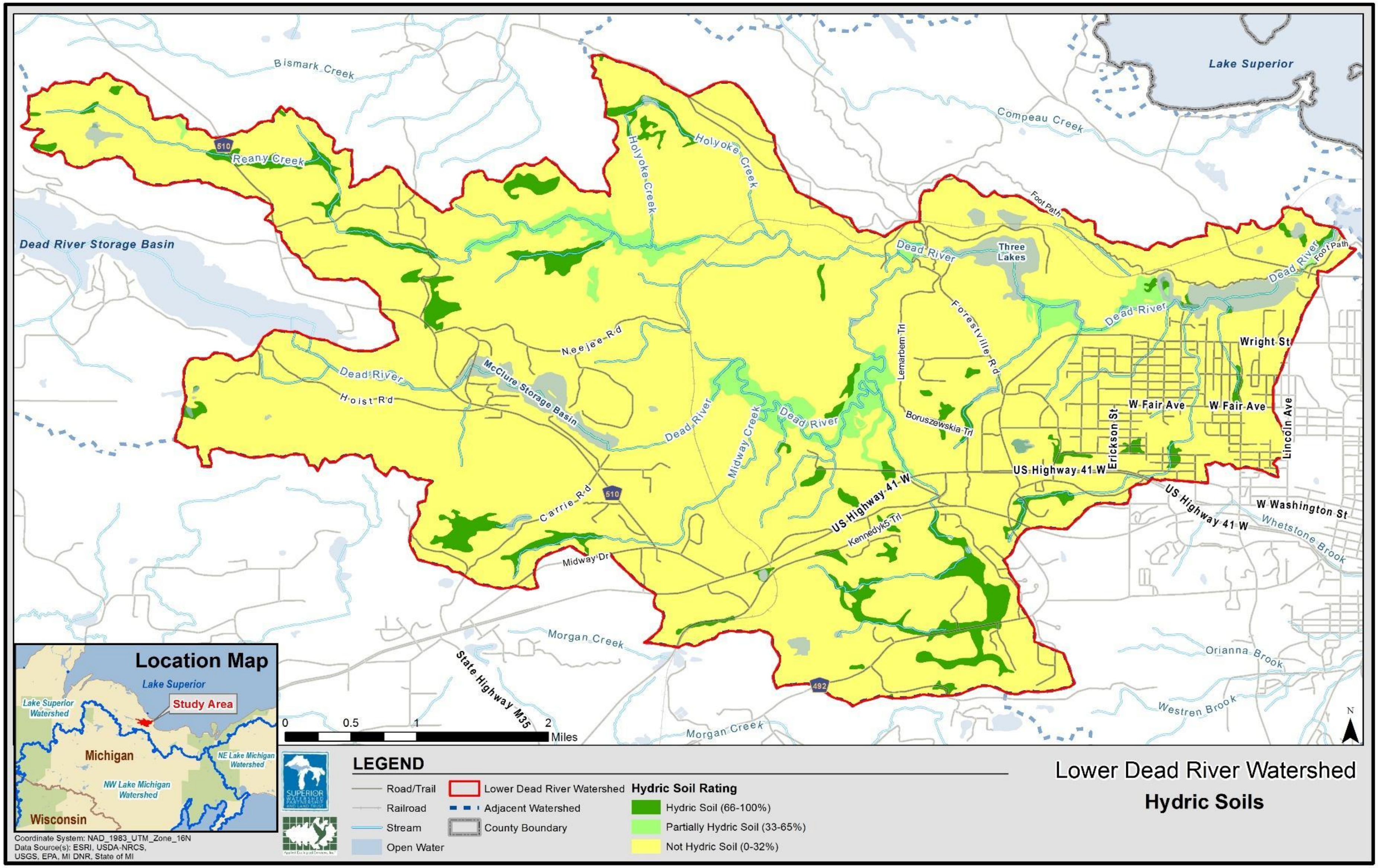
Hydric soils comprise 756 acres or 4.8% of the watershed. Most of these soils are located on the relatively flat headwater areas around the tributaries. Early vegetation mapping suggests these areas contained much of the same hemlock-sugar maple forests as the rest of the watershed.

543 acres or 3,4% of the watershed is comprised of partially hydric soils which exhibit some, but not all, of the characteristics of hydric soils. These soils are scattered throughout the watershed but again, they are concentrated in the relatively flat floodplain areas throughout the watershed. These soils likely did not support true wetland communities.

Approximately 14,580 acres (91.8%) are not hydric.

Table 4- Acreage of Hydric, Partially Hydric, and Non-Hydric Soils

Soil	Total Area (acres)	Percentage of Watershed
Hydric Soil	756	4.8
Partially Hydric Soil	543	3.4
Non-Hydric Soil	14,580	91.8
Totals	**15,879**	**100.0**


Lake Superior
Bismark Creek
Compeau Creek
Reany Creek
Holyoke Creek
Dead River Storage Basin
Dead River
Three Lakes
Foot Path
Neejee Rd
Hoist Rd
McClure Storage Basin
Midway Creek
Lemarbem Trl
Forestville Rd
Boruszewski Trl
Wright St
W Fair Ave
Erickson St
Lincoln Ave
US Highway 41 W
W Washington St
Whetstone Brook
Carrie Rd
Midway Dr
Kennedy Trl
Morgan Creek
Orianna Brook
Westren Brook
State Highway M35
Location Map
Lake Superior Watershed
Study Area
Michigan
NE Lake Michigan Watershed
NW Lake Michigan Watershed
Wisconsin
0 0.5 1 2 Miles
Coordinate System: NAD_1983_UTM_Zone_16N
Data Source(s): ESRI, USDA-NRCS, USGS, EPA, MI DNR, State of MI
LEGEND
Road/Trail
Railroad
Stream
Open Water
Lower Dead River Watershed
Adjacent Watershed
County Boundary
Hydric Soil Rating
Hydric Soil (66-100%)
Partially Hydric Soil (33-65%)
Not Hydric Soil (0-32%)
Lower Dead River Watershed
Hydric Soils

Soil Erodibility

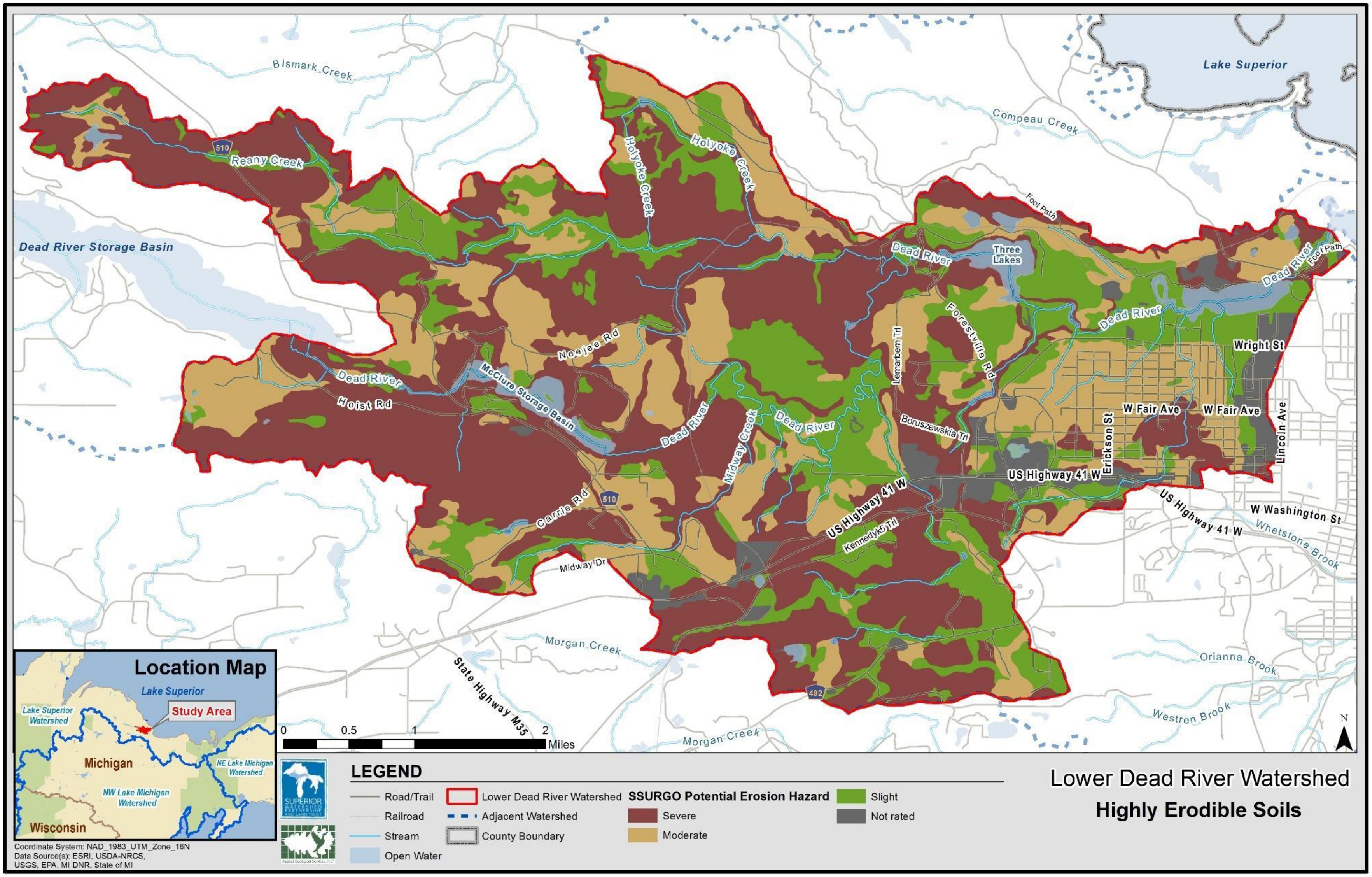
Soil erosion is the process whereby soil is removed from its original location by flowing water, wave action, wind, and other factors. Sedimentation is the process that deposits eroded soils on other ground surfaces or in bodies of water such as streams and lakes. Soil erosion and sedimentation reduces water quality by increasing total suspended solids (TSS) in the water column and by carrying attached pollutants such as phosphorus, nitrogen, and hydrocarbons. When soils settle in streams and lakes they often blanket rock, cobble, and sandy substrates needed by fish and aquatic macroinvertebrates for habitat, food, and reproduction.

A highly erodible soils map was created based on soil information provided by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) (Figure 12). Highly erodible soils have attributes that when located on slopes are susceptible to erosion. It is important to know the location of highly erodible soils because these areas have the highest potential to degrade water quality during mining, forestry, farm tillage, development, or other land usage. Based on mapping, 7,382 acres or about 46.5% of the soils in the watershed are "Severely Erodible," 3,871 acres or 24.4% of soils are "Moderately Erodible," 3,589 (22.6%) acres are "Slightly Erodible,", and the remaining 1,037 acres (6.5%) are not rated. (Table 5).

Highly erodible areas are currently stabilized by existing land uses/cover. However, land use, especially timber harvesting, can increase the risk of erosion, through the loss of land cover and exposure to increased truck traffic. These impacts on riparian systems can be mitigated as much as possible, by ensuring that best management practices prescribed through forestry management plans are followed (see section 3.13.1).

Table 5- Acreage of Severely Erodible, Moderately Erodible, and Slightly Erodible Soils

Soil Erodibility	**Total Area (acres)**	**Percentage of Watershed**
Severely Erodible	7,382	46.5
Moderately Erodible	3,871	24.4
Slightly Erodible	3,589	22.6
Not Rated	1,037	6.5
Totals	**15,879**	**100.0**


Lower Dead River Watershed
Highly Erodible Soils
LEGEND
Road/Trail
Railroad
Stream
Open Water
Lower Dead River Watershed
Adjacent Watershed
County Boundary
SSURGO Potential Erosion Hazard
Severe
Moderate
Slight
Not rated
Location Map
Lake Superior
Study Area
Michigan
Wisconsin
Lake Superior Watershed
NE Lake Michigan Watershed
NW Lake Michigan Watershed
Coordinate System: NAD_1983_UTM_Zone_16N
Data Source(s): ESRI, USDA-NRCS, USGS, EPA, MI DNR, State of MI
0 0.5 1 2 Miles
Lake Superior
Dead River Storage Basin
McClure Storage Basin
Dead River
Bismark Creek
Reany Creek
Holyoke Creek
Compeau Creek
Midway Creek
Morgan Creek
Orianna Brook
Westren Brook
Whetstone Brook
Three Lakes
Neejee Rd
Hoist Rd
Carrie Rd
Midway Dr
Forestville Rd
Lemanbem Trl
Boruszewski Trl
Kennedy Trl
US Highway 41 W
State Highway M35
Erickson St
Lincoln Ave
W Fair Ave
Wright St
W Washington St
Foot Path
510
492

Hydrologic Soil Groups

Table 6- Hydrologic Soil Groups and Acreages

Hydrologic Soil Group	Area (acres)	Percent of Watershed
A	10,988	69.2
A/D	907	5.7
B	576	3.6
B/D	1,653	10.4
C	1,005	6.3
C/D	84	0.5
D	140	0.9
Unknown	527	3.3
Totals	**15,879**	**100.0**

Soils also exhibit different infiltration capabilities and have been classified to fit what are known as "Hydrologic Soil Groups" (HSGs). HSGs are based on a soil's infiltration and transmission (permeability) rates and are used by engineers and planners to estimate stormwater runoff potential. Knowing how a soil will hold water ultimately affects the type and location of recommended infiltration management measures such as wetland restorations and detention basins. More importantly however is the link between hydrologic soil groups and groundwater recharge areas. Groundwater recharge is discussed in detail in Section 3.14.

HSG's are classified into four primary categories; A, B, C, and D, and three dual classes, A/D, B/D, and C/D. Figure 13 depicts the location of each HSG in the watershed. The HSG categories and their corresponding soil texture, drainage description, runoff potential, infiltration rate, and transmission rate are shown in Table 7 while Table 6 summarizes the acreage and percent of each HSG. Group A and A/D soils are together dominant throughout the watershed at about 75% (11,895 acres) coverage and are found in most upland areas. Group B and B/D soils together make up another 2,228 acres or 14% of the watershed. Group C and C/D soils make up 1,089 acres (6.8 %). Group D soils comprise 140 acres or another 0.9% of the watershed. Group B/D and D soils generally line up with areas exhibiting hydric to partially hydric soils adjacent to tributaries in the watershed.

HSG	Soil Texture	Drainage Description	Ru
A	Sand, Loamy Sand, or Sandy Loam	Well to Excessively Drained	
B	Silt Loam or Loam	Moderately Well to Well Drained	
C	Sandy Clay Loam	Somewhat Poorly Drained	High
D	Clay Loam, Silty Clay Loam, Sandy Clay Loam, Silty Clay, or Clay	Poorly Drained	High

Table 7- Description of Hydrologic Soils Groups

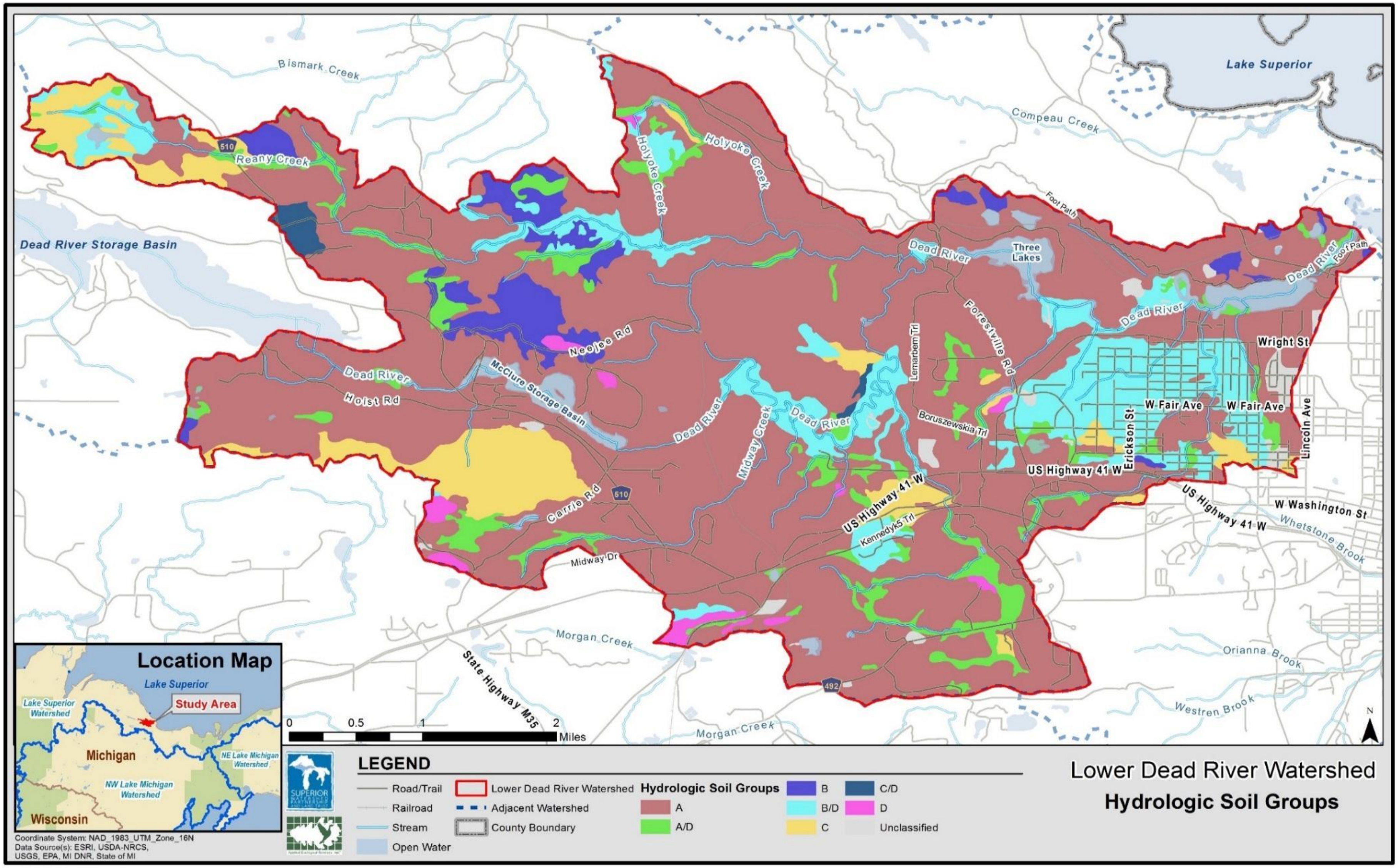


*Figure SEQ Figure * ARABIC 11- Hydrologic Soils Groups*

3.5 Jurisdictions, Roles & Protections

The Lower Dead River watershed is in Marquette county and spans one city and two townships (Table 8, Figure 14). The largest municipality is the City of Marquette, spanning 1,322 acres (8.3%) within the watershed boundaries. The townships of Marquette Township (5,503 ac, 34.7%) and Negaunee Township (9,054 ac, 57.0%) make up the remaining acreage of the watershed. There are no large state or federally owned nature/forest preserves or parks in the watershed.

Table 8- Watershed Jurisdictions

Jurisdiction	Area (acres)	% of Watershed
County		
Marquette	14,557	91.7%
Township		
Marquette Township	5,503	34.7%
Negaunee Township	9,054	57.0%
Municipalities		
City of Marquette	1,322	8.3%
Total	**15,879**	**100.0%**

Source: State of MI

Jurisdictional Roles and Protections

Water quality and land protection throughout the United States are supported to some degree under federal, state, and/or local laws and regulations.

Water Quality Protection

At the federal level, the Clean Water Act (CWA) is the strongest tool in protecting water resources. Within the state of Michigan, the authority to administer the provisions of the CWA has been delegated to the Michigan Department of Environment, Great Lakes, and Energy (EGLE). Section 402 of the CWA establishes the National Pollution Discharge Elimination System (NPDES), while Section 319 Nonpoint Source Management Program was created in order to further support state and local nonpoint pollutant source efforts not addressed by NPDES permits. Section 319 permits states to receive grant money towards activities such as technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of nonpoint pollutant source implementation projects. Section 303 of the CWA requires states to catalogue impaired waters, prioritize them, and calculate Total Maximum Daily Loads (TMDLs) of pollutants a waterbody can receive and still safely meet water quality standards.

The Safe Drinking Water Act also plays a role in protecting surface and groundwater resources. In Michigan, the Wellhead Protection Program includes both mandatory and voluntary initiatives aimed at protecting groundwater resources. As such, EGLE oversees protection of around 10,000 non-community and 1,400 community water supplies.

In 1985, the Michigan Legislature created the Office of the Great Lakes under the Great Lakes Protection Act. The Office houses the Areas of Concern Program, Coastal Management Program, and the Great Lakes Coordination Program with a mission of collaborating with groups locally and federally to protect and restore the Great Lakes. In 2016 Michigan released the Michigan Water Strategy, a 30-year vision for the protection, restoration, and sustainable management of Michigan's water resources. (MDNR, 2016)

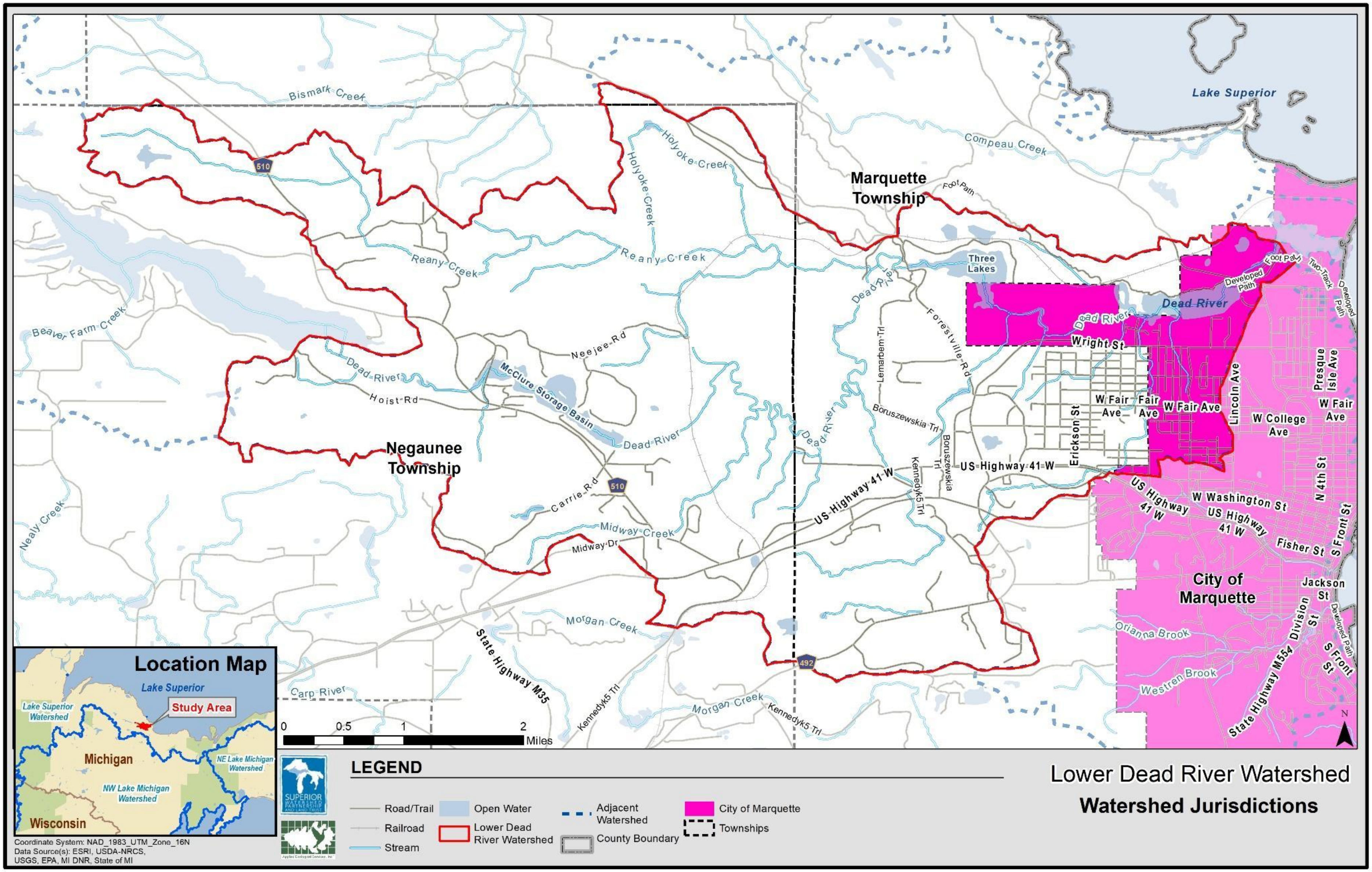


*Figure SEQ Figure * ARABIC 12- Watershed Jurisdictions*

Additionally, Michigan is part of three interstate compact agreements that also have jurisdiction over Lake Superior. The first is the Great Lakes Basin Compact which established the Great Lakes Commission and gave it the authority to research and make recommendations regarding water use and development in the Great Lakes. The Council of Great Lakes Governors established the Great Lake Protection Fund to finance projects used to protect and restore the Great Lakes. Finally, the Great Lakes Charter, signed by the Council of Great Lakes Governors, regulates water transfers out of the Great Lakes Drainage basin in excess of 100,000 gallons per day.

The Michigan Coastal Management Program was established under the Federal Coastal Zone Management Act in 1978. It serves to protect Michigan's coastline by supporting healthy and productive coastal ecosystems and sustainable coastal communities.

Land Protection

The U.S. Fish and Wildlife Service (USFWS) and MI DNR protect various dedicated natural areas and threatened and endangered species. Local conservation groups such as the Superior Watershed Partnership and Yellow Dog Watershed Preserve also serve in a similar capacity by working to protect and restore natural areas, along with many other watershed groups and land conservancies throughout the state.

The U.S. Army Corps of Engineers (USACE), with approval of MI DNR, regulates wetlands through Sections 401 and 404 of the Clean Water Act (CWA). Land development affecting water resources (rivers, streams, lakes, wetlands, and floodplains) is regulated by the USACE when "Waters of the U.S." are involved. These types of waters include any wetland or stream/river that is hydrologically connected to navigable waters. The USACE primarily regulates filling activities and requires buffers or wetland mitigation for developments that impact jurisdictional wetlands. The Lower Dead River watershed falls within USACE's Detroit District of the Great Lakes & Ohio River Division.

Land development in the watershed is regulated by ordinances developed by planning commissions at the county and municipal level (including townships). Only townships who choose not to develop their own planning commission and set of ordinances fall under the county's zoning ordinances. In addition, Marquette County has drainage ordinances giving the county Drain Commissioner jurisdiction over all established drains in the county, new drain construction, maintenance of existing drains, and establishment of water management districts.

Beyond county-level regulations, each municipality has their own applicable regulations. Municipalities in the watershed may or may not provide additional watershed protection above and beyond existing local municipal codes. Most municipal codes provide ordinances covering businesses regulations, building regulations, zoning regulations, new subdivision regulations, stormwater management, streets, utilities, landscaping/restoration, tree removal, etc.

Municipal codes and ordinances include:

- *City of Marquette* Land development is regulated by Land Development Code Chapter 54 Code of Ordinances adopted February 11, 2019. Dedicated ordinances include Subdivision Controls, Environmental Performance

Standards including stormwater management, riparian buffers, wetland protection, steep slopes and ridge lines, and woodland protection and tree mitigation.

- *Marquette Township*: Zoning Codes regulate development within Charter Township of Marquette. Largely regulates allowed land use, open space preservation, subdivision, buffer requirements. Stormwater regulation falls under County Drainage Commission.

- *Negaunee Township*: Regulated by Negaunee Township Zoning Ordinance. Regulation includes natural resource extraction, wellhead protection, and open space preservation.

Other governments and private entities with watershed jurisdictional or technical advisory roles include the Federal Emergency Management Agency (FEMA), the USDA's Natural Resources Conservation Service (NRCS), and Central Upper Peninsula Planning and Development Regional Commission (CUPPAD). County Boards are also important because they oversee decisions made by respective county governments and therefore have the power to override or alter policies and regulations.

Noteworthy- Stormwater Management O

The Michigan Department of Environment, Great Lakes, and Energy (EGLE) oversees th
(MS4) for urbanized areas in the state; defined by the US Census Bureau as consisting of 5
federal Clean Water Act to reduce pollutants to the nation's waters. This program requires
industrial effluent; and 3) stormwater from MS4's and construction sites.

As none of the municipalities within the Lower Dead River watershed fall under the defini
the National Pollutant Discharge Elimination System (NPDES) requirements of being per
bodies, both public and private, cooperate to manage stormwater in such a way that protec
pollution.

Drainage regulations, such as those established by Marquette County, do a good job of layi
identifying typical sources of flood risk and pollutant sources and seeking to mitigate these
resource protection. These regulations provide guidelines on the specifications for sewer d
detention/retention facilities. Similar ordinances are established for the City of Marquette,

While these ordinances are useful for regulation in stormwater management, developing a
opportunity for local communities to reevaluate how best to make use of their water resou

- By adopting a long-term approach to planning, communities can provide for plan
within other community development plans such as capital improvement plans an
- Managing stormwater close to where precipitation falls, such as with retention or a
effective stormwater control method.
- Innovative technologies, including green infrastructure, are important tools that ca
quality to cost savings to more community amenities. They also may be fundamen
- The voluntary approach to long-term planning can be a useful part of the larger e
over multiple permit cycles). For example, a regulated municipal separate storm se
EPA and/or the state to consider how the plan can help satisfy the requirements o

USEPA, October 2016

Planning, Policy and Regulation

Planning, policy, and regulation are the foundation of watershed protection, because the process sets the minimum standards for development that occurs or is proposed to occur in the vicinity of water resources. It is hoped that recommendations from this watershed plan will be referenced in future comprehensive plans and implemented in ordinances. In many cases, municipal codes also lay the foundation for the types of trees that can be removed from sites as well as what types of plant communities and species can be replanted. County stormwater ordinances are the primary preventative measure that can be used to standardize the requirements that proposed developments must meet. Monitoring and enforcement of implemented municipal codes and county regulations falls in the hands of local municipalities or County agencies. It is up to these enforcing bodies to effectively communicate and review problems with how ordinance language is interpreted and institute amendments that may help clarify certain regulations.

Planning/zoning guidance provides another level of watershed and natural resource protection. Most planning and zoning guidance is in the form of local floodplain or zoning ordinances that regulate onsite land use practices to ensure adequate floodplain, wetland, stream, lake, pond, conservancy soil, and other natural resource protection. Zoning ordinances and overlay districts in particular define what type of development is allowed and where it can be located relative to natural resources. For example, the City of Marquette's Land Development Code contains a section related to "Environmental Performance Standards." Other examples of planning/zoning resource protection include riparian and wetland buffers, impervious area reduction, open space/greenway dedication, steep slope and ridge line, and stormwater protection.

To improve the impact of planning/zoning guidance on water resource protection, there needs to be improved coordination and communication between county and local government. Watershed development regulations should be made very clear to local enforcement officers; local planners and zoning boards should consider revisions to local ordinances that address watershed, subwatershed, and/or site-specific natural resource issues. For example, communities with less impervious development should revise their zoning ordinances sooner rather than later in order to adequately prevent the types of development that contribute to flooding, degrade wildlife habitat, and reduce water quality.

3.6 Existing Policies and Ordinance Review

Protection of natural resources during future growth is important for the future health of a watershed. To assess how future growth might further impact the watershed, an assessment of local municipal ordinances is recommended to determine how development is regulated in each municipality. In this way, potential improvements to local ordinances can be identified. As a future measure, it is recommended that municipal governments compare their local ordinances against model policies outlined by the Center for Watershed Protection (CWP) in a publication entitled "*Better Site Design: A Handbook for Changing Development Rules in Your Community*" (CWP 1998).

This assessment process begins by reviewing local municipal zoning and other ordinances like those in the City of Marquette, Marquette Township, and Negaunee Township.

CWP's recommended ordinance review process involves assessments of three general categories including "Residential Streets & Parking Lots," "Lot Development" and "Conservation of Natural Areas." Various questions with point totals are examined under each category. The maximum score is 100. CWP also provides general rules based on scores. Scores between 60 and 80 suggest that it may be advisable to reform local development ordinances. Scores less than 60 generally mean that local ordinances are not environmentally friendly and serious reform may be needed. This assessment is meant to serve as a tool for local communities to help guide development of future ordinances.

Fortunately, the municipalities within the watershed are making good steps in preventing damage to natural resources by implementing zoning ordinances like riparian buffers and open space requirements and the development of stormwater management plans. However, it is highly recommended that the CWP review process be implemented to identify areas for improvement.

3.7 Demographics

Among other planning reports, the Central Upper Peninsula Planning and Development Regional Commission (CUPPAD) provides Upward 2025, an economic development strategy for Alger, Delta, Dickinson, Marquette, Menominee, and Schoolcraft Counties. The Regional Prosperity Initiative was developed by the State of Michigan and was implemented in 2014 for the areas within CUPPAD region. This was produced with the mission of encouraging regional collaboration in the application of public funds with the objective of cleaning up disparate service areas, reducing overlapping responsibilities, and enhancing public-private cooperation. (CUPPAD, 2015)

In an area where populations are sparsely concentrated the presence of a regional planning body provides a window into demographic trends. Though the RPI 2025 plan does not provide projections for future changes in population, housing, and employment, it provides records of demographic trends in the region for the past century. Data from CUPPAD as well as from a 2017 American Community Survey was used to assemble estimated total population, estimated total employed population, and estimated total housing units. These data are highly useful for predicting trends regarding where land use changes will be focused.

Table 9 includes 2017 American community survey results for estimated total population (Figure 15), estimated total employed population (Figure 16), and estimated total housing units (Figure 17). These data are generated by census block group, which are the most precise data available for the area. Block groups which are contacting the watershed boundary are included within the watershed boundary. As there is no reliable way to divide the block group into portions that are solely within the watershed, these estimates tend to overestimate the populations actually occurring within the watershed bounds.

On the regional level, CUPPAD's RPI 2025 plan data shows that since peaking in 1980 the Central Upper Peninsula region has seen a decline in overall population, with Marquette county experiencing modest growth of 0%-4.9% between 2000 and 2010. For comparison, the Upper Peninsula as a whole has seen a similar trend with diminishing populations since 1980, while the general population of Michigan has largely continued to trend upward. By applying this trend to the watershed region, we can assume that the Lower Dead River Watershed area will experience population change in the range from stagnation to modest growth. As seen in Table 9 and Figure 15, the watershed population is around 13,007 people and is largely concentrated within the City of Marquette and in Negaunee Township.

The total labor force in the Central Upper Peninsula has decreased in the past ten years as well, with the unemployment rate remaining relatively steady. This is an indication of the decrease in overall residents in the region and indicates that there won't be much industrial expansion within the watershed region in the upcoming years. The employed population in 2017 was estimated at 7,258 people with these concentrated in the City of Marquette and Negaunee Township.

Households in the watershed area are concentrated in the City of Marquette and Negaunee Township with the estimated total housing units in 2017 being 6,585. The general demographic trend in the region indicates that there will not be an increase in housing development in the coming years.

Table 9-American Community Survey 2017

Data Category	
Estimated Total Population 2017	13,007
Estimated Total Employed Population 2017	7,258
Estimated Total Housing Units 2017	6,585

Source: American Community Survey 2017

Socioeconomic Status

The CUPPAD Upward 2025 economic development report and community profiles developed by Marquette County provide useful insight on the socioeconomic status of the watershed. The region within the Lower Dead River Watershed has been extensively developed, especially near the Marquette, and Negaunee. Nearby cities offer amenities such as parks, shopping, conservation areas, beaches, libraries, and are in close proximity to interstate highway access.

Though populations in the U.P. are steadily declining, the trend is less so in the region surrounding the city of Marquette. Populations in Marquette peaked in 1980, but townships have been increasing in recent years. Median ages in Marquette and Negaunee Township are 27.7 and 36.9 respectively. Marquette County is comprised of a mostly white population (>93%). The median household income in 2013 was about $45,622 which is about a 5.1% decrease from what it was in 2000. In Marquette County 2014, nearly 15.4% of the population was below poverty level, though that is roughly the same as the U.S. as a whole (CUPPAD 2015).

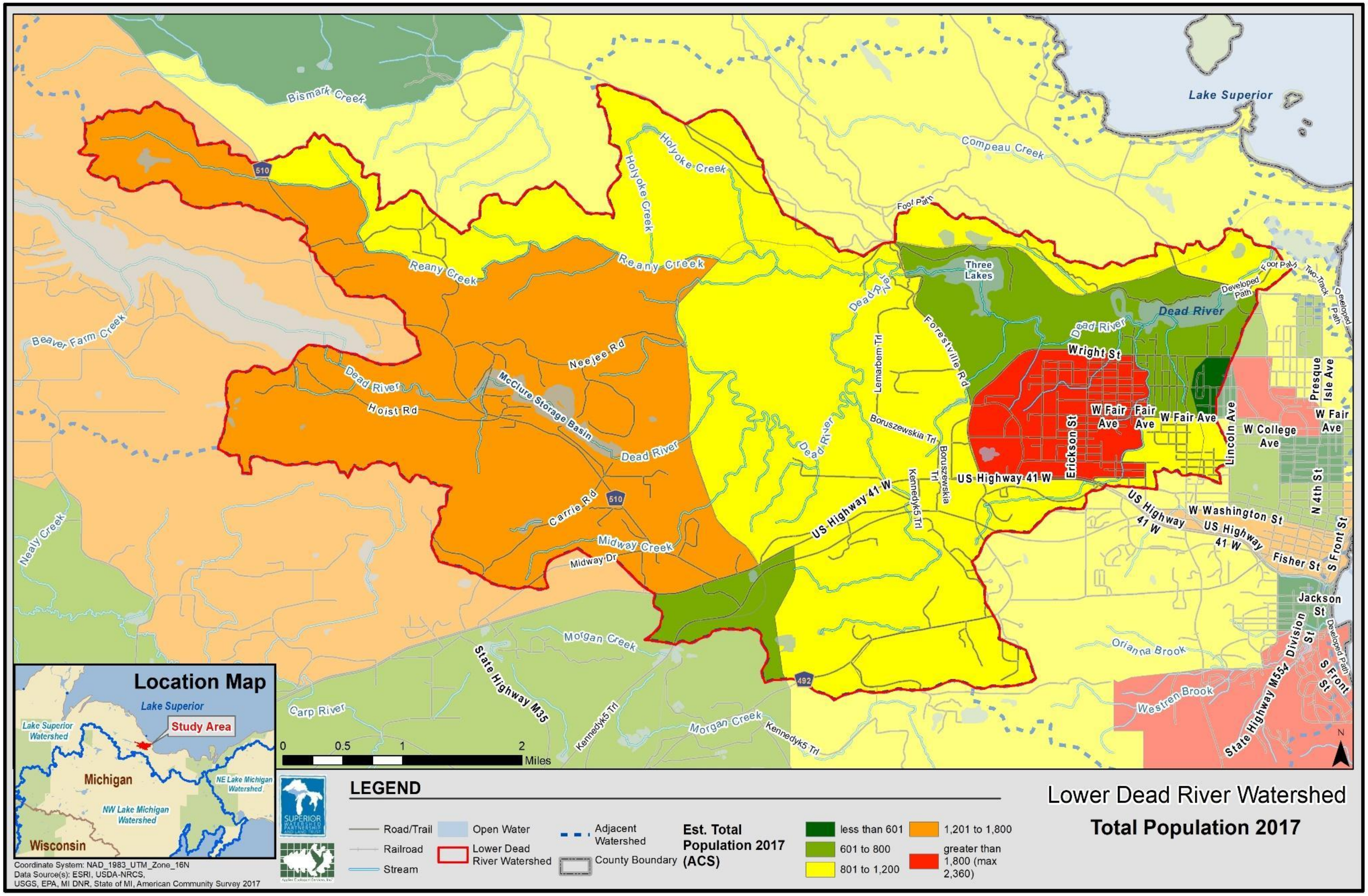

Lower Dead River Watershed
Total Population 2017
Location Map
Lake Superior
Study Area
Lake Superior Watershed
Michigan
Wisconsin
NE Lake Michigan Watershed
NW Lake Michigan Watershed
LEGEND
Road/Trail
Railroad
Stream
Open Water
Lower Dead River Watershed
Adjacent Watershed
County Boundary
Est. Total Population 2017 (ACS)
less than 601
601 to 800
801 to 1,200
1,201 to 1,800
greater than 1,800 (max 2,360)
0 0.5 1 2 Miles
Coordinate System: NAD_1983_UTM_Zone_16N
Data Source(s): ESRI, USDA-NRCS, USGS, EPA, MI DNR, State of MI, American Community Survey 2017
Lake Superior
Dead River
Bismark Creek
Compeau Creek
Holyoke Creek
Reany Creek
Beaver Farm Creek
Nealy Creek
Midway Creek
Morgan Creek
Carp River
Orianna Brook
Westren Brook
McClure Storage Basin
Three Lakes
Neejee Rd
Hoist Rd
Carrie Rd
Midway Dr
Lemarbem Trl
Forestville Rd
Boruszewskia Trl
Kennedyk5 Trl
US Highway 41 W
State Highway M35
State Highway M554
Wright St
W Fair Ave
Erickson St
Lincoln Ave
W College Ave
Presque Isle Ave
N 4th St
W Washington St
Fisher St
S Front St
Jackson St
Division St
Foot Path
Two-Track
Developed Path

Figure 13- Total Population

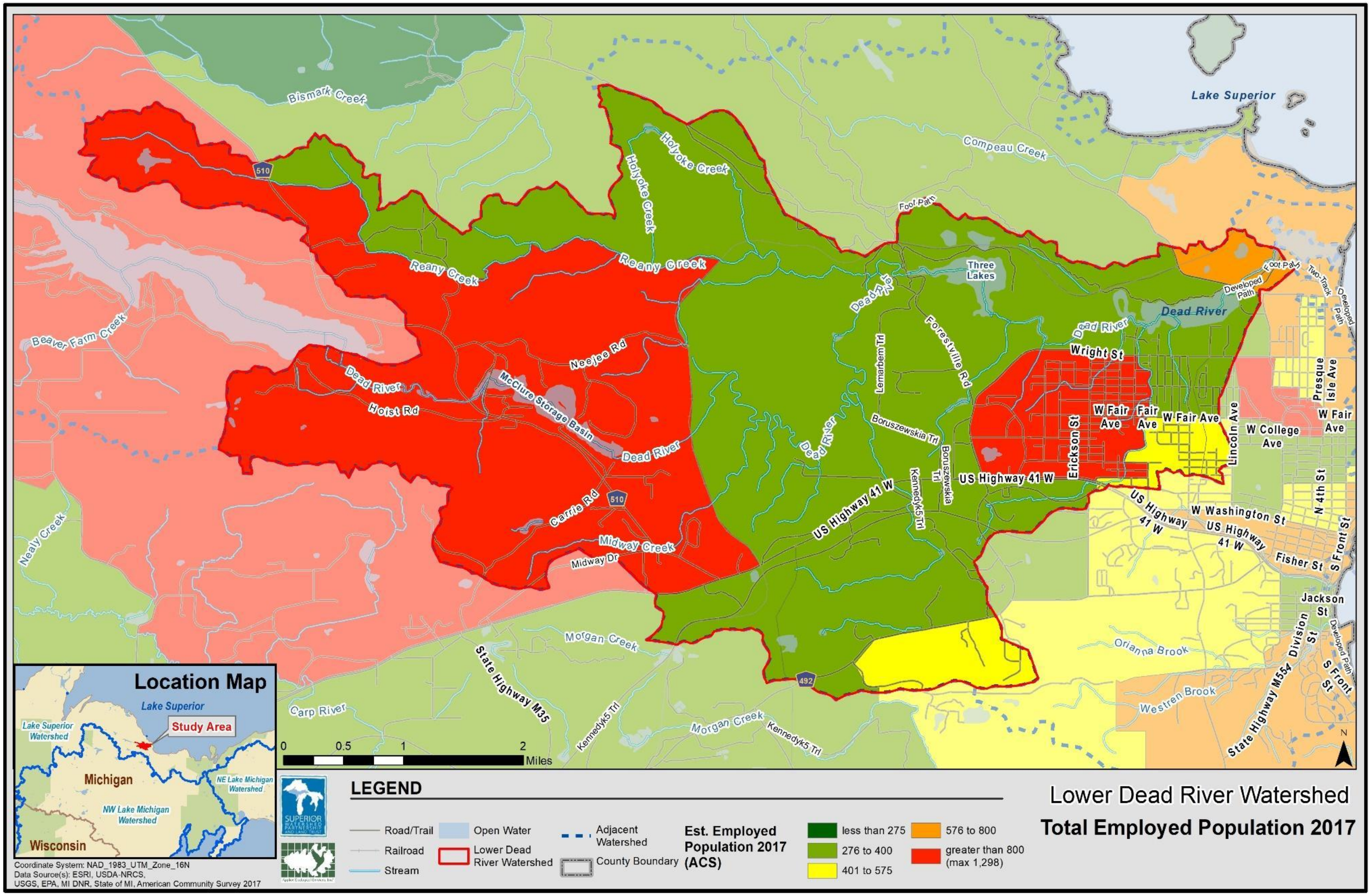


Figure 14- Total Employed Population

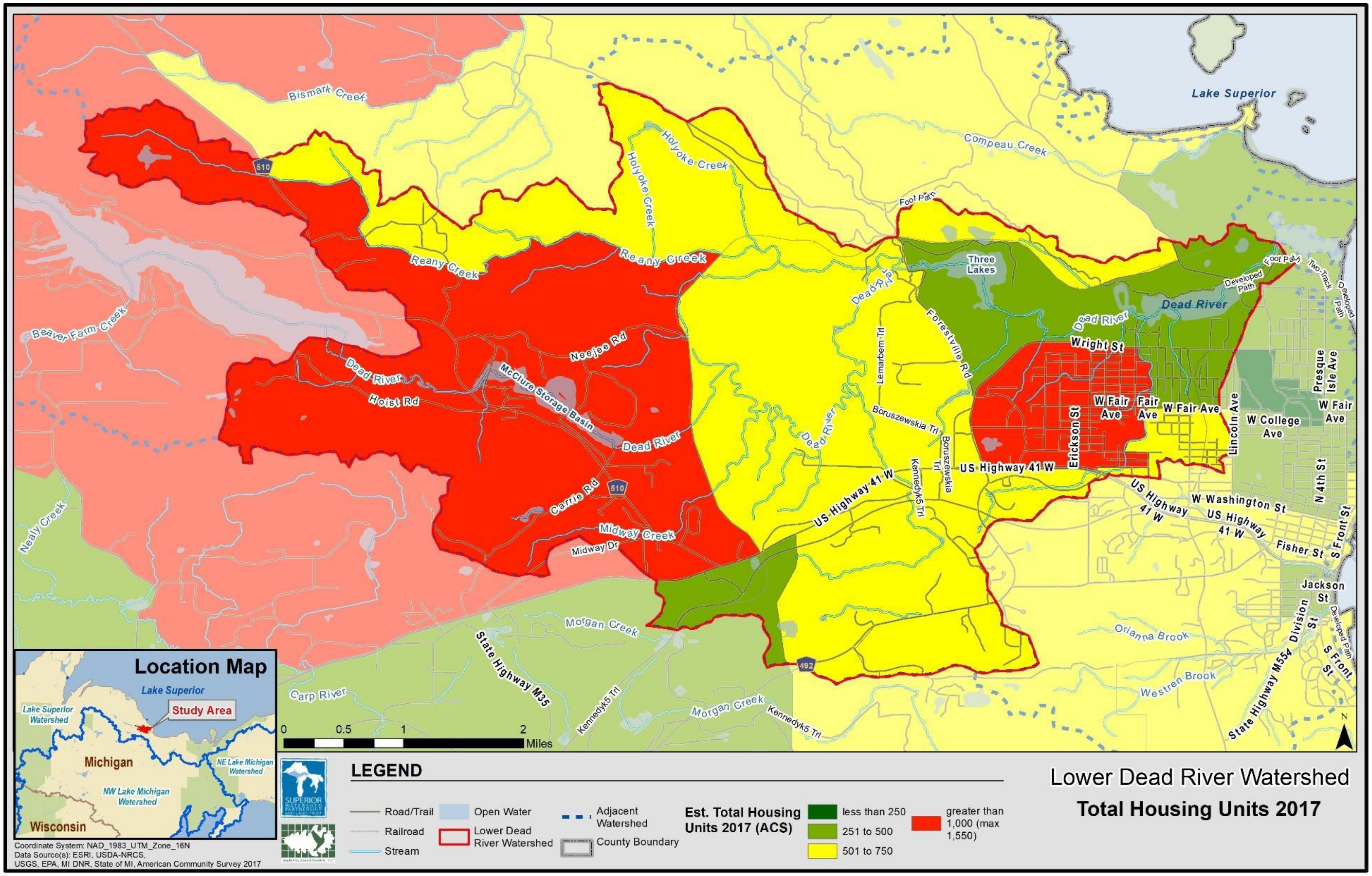


Figure 15- Total Housing Units

3.8 Transportation Network

Roads

A limited network of roads traverses the Lower Dead River watershed (Figure 18). US Route 41(running concurrently in the region with M28) is the major road in the watershed, running north-south from the Keweenaw Peninsula to Miami, FL. It runs through the southern lobe of the watershed into downtown Marquette. Another major regional road is County Road 492, which winds through the watershed around the City of Marquette and County Road 550 (Big Bay Rd) which runs north connecting Marquette and Powell Township, MI. There are various major secondary roads that generally run around and between the branches of the Dead River.

Lake Superior Ishpeming Railroad crossing Lower Dead River at Trestle Falls (Source: Waterfalls of the Keweenaw- Trestle Falls)

Railroads

Lake Superior and Ishpeming Railroad (LSI) operates throughout the Upper Peninsula as an independent railroad headquartered in Marquette. Since its organization in 1893, the railroad's primary business is the transport of iron ore to the docks in Marquette from the nearby iron mines. In modern times, the railroad operates as a short line from the Tilden Mine south of Ishpeming as well as the now-defunct Empire Mine to the docks in Marquette. This rail line crosses the Dead River once at Trestle Falls where the rail trestle is 104 feet high over the river.

Airports

There are no air fields, public or private, within the boundaries of the watershed.

Harbors

Located at the mouth of the Dead River is the Lake Superior and Ishpeming dock. This serves as a functioning ore dock to transfer iron ore from train cars operating on the LSI railroad to freighters in the lake.

To the immediate north of this dock is the Presque Isle Marina, a small craft marina providing a harbor for seasonal crafts and a boat launch.

Trails/Bike Paths

With beautiful natural scenery of forests and exciting topography, the Upper Peninsula is an area many consider a destination for exploration. Within the Lower Dead River watershed area, hikers may explore the Noquemanon North Trails, or the North Country Trail. The North Country Trail is part of a larger trail system spanning from Vermont to North Dakota; it travels six miles through the watershed. On the more urban side, the Marquette City Multi-Use Path travels about 12 miles through the City of Marquette. The Marquette Tourist Park, Presque Isle Park, and Clark Lambros' Beach Park access paths are directly within the watershed crossing over the Dead River and running along the Upper Harbor. In addition to pedestrian paths, people

travel from all over to explore the Upper Peninsula via snowmobile. The Big Bay/550 Snowmobile Club trail covers 114 miles in the region connecting Marquette with Big Bay.

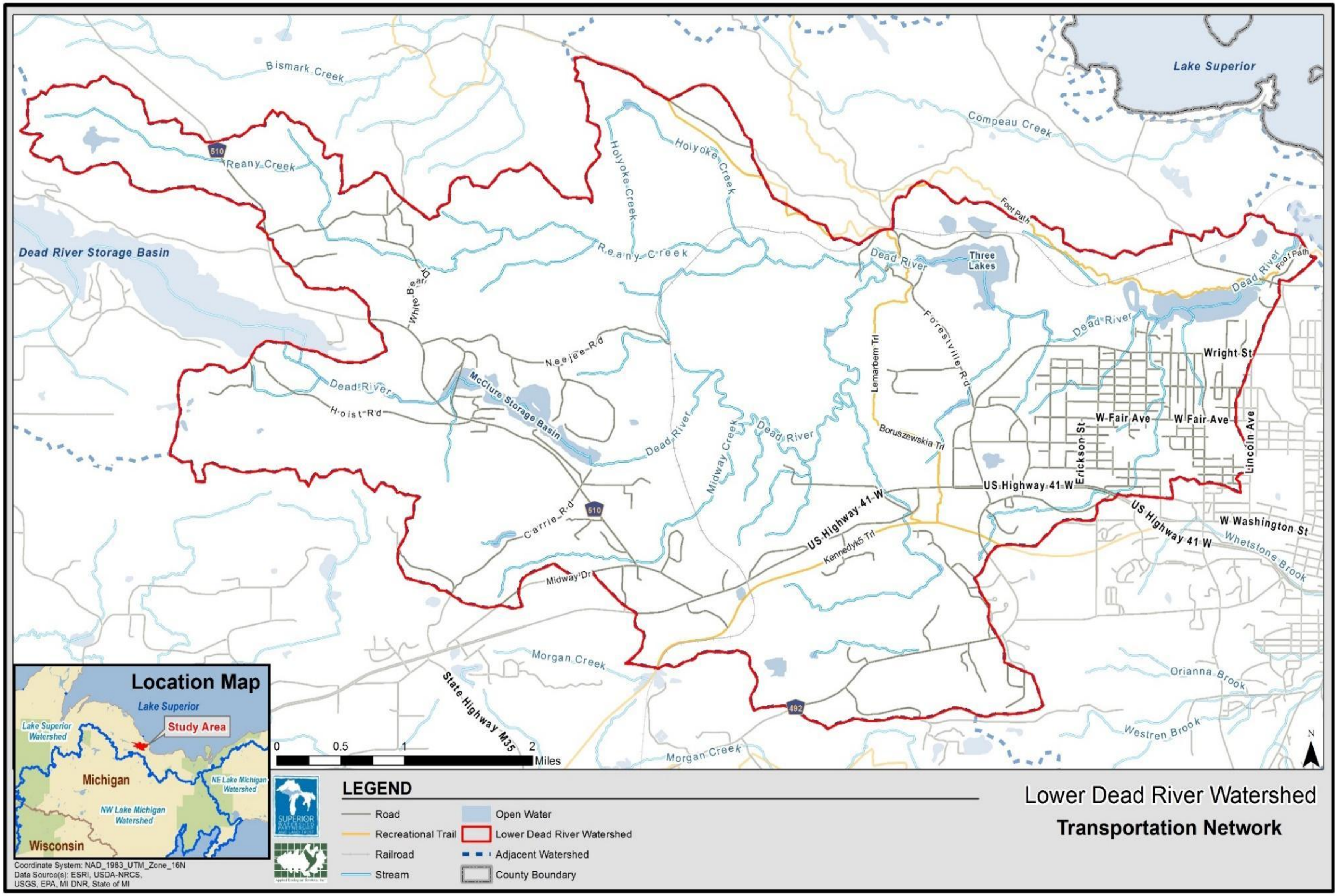

Lake Superior
Bismark Creek
Reany Creek
Dead River Storage Basin
Holyoke Creek
Compeau Creek
Foot Path
Dead River
Three Lakes
White Bear Rd
Neejee Rd
McClure Storage Basin
Hoist Rd
Forestville Rd
Lemarbern Trl
Boruszewskia Trl
Wright St
W Fair Ave
Erickson St
Lincoln Ave
US Highway 41 W
W Washington St
Whetstone Brook
Midway Creek
Carrie Rd
Kennedy Trl
Midway Dr
Morgan Creek
State Highway M35
Orianna Brook
Westren Brook
510
492
0 0.5 1 2 Miles
Location Map
Lake Superior
Study Area
Lake Superior Watershed
Michigan
NE Lake Michigan Watershed
NW Lake Michigan Watershed
Wisconsin
Coordinate System: NAD_1983_UTM_Zone_16N
Data Source(s): ESRI, USDA-NRCS, USGS, EPA, MI DNR, State of MI
LEGEND
Road
Recreational Trail
Railroad
Stream
Open Water
Lower Dead River Watershed
Adjacent Watershed
County Boundary
Lower Dead River Watershed
Transportation Network

Figure 16- Transportation Network

3.9 Existing Land Use/Land Cover

2015 Land Use/Land Cover

Land use/land cover data was produced for the Lower Dead River watershed using a combination of sources. Marquette County zoning data, compiled from a number of local governments including the City of Marquette and various township zoning designations, served as the base layer and was then overlaid with 2015 land cover mapping to fill in gaps where data was missing. The 2015 land use/land cover data and map for Lower Dead River watershed is included in Table 10 and depicted in Figure 19.

Table 10- 2015 Land Use/Land Cover

Land Use	Area (acres)	% of Watershed
Business District	370	2.3%
Conservation & Recreation	667	4.2%
Development District	525	3.3%
Forested	6,591	41.5%
General Business District	373	2.4%
Industrial/Manufacturing	126	0.8%
Mixed Use	0	0.0%
Multi-Family Residential	32	0.2%
Residential	1,267	8.0%
Resource Production	2,085	13.1%
Rural Residential	3,382	21.3%
Transportation	461	2.9%
Total	**15,879**	**100.0%**

Forested areas are the most abundant land use in the watershed and comprise 6,591 acres or 41.5% of the watershed. The forested lands are generally concentrated in the northwestern portion of the watershed.
Residential land uses combined make up the next largest land use category. This includes 3,382 acres (21.3%) of rural residential, 1,267 acres (8.0%) of single-family residential, and 32 acres (0.2%) of multi-family residential land uses.

The Resource Production land use is an important land use within the watershed, covering 2,085 acres or 13.1% of the land base within the watershed. This is land designated as important for careful use of resources, such as conservation of minerals. Conservation and Recreation areas comprise approximately another 4.2% or 667 acres of the watershed and the remaining acres are divided among the various remaining land use categories, such as business uses, industrial and manufacturing, development districts, and transportation.

Noteworthy: Local Power Plant

What remains of the Presque Isle Power Plant is located right outside the Lower Dead River watershed on 65 acres of land on the shore of Lake Superior in Marquette, MI. Now closed and in the process of being decommissioned, the plant was owned by We Energies and was a coal-based power plant with a total net generating capacity of 359 megawatts. In 2020 the plant was replaced by two new natural gas-fueled power plants in Marquette and Baraga counties owned and operated by Upper Michigan Energy Resources Corp.

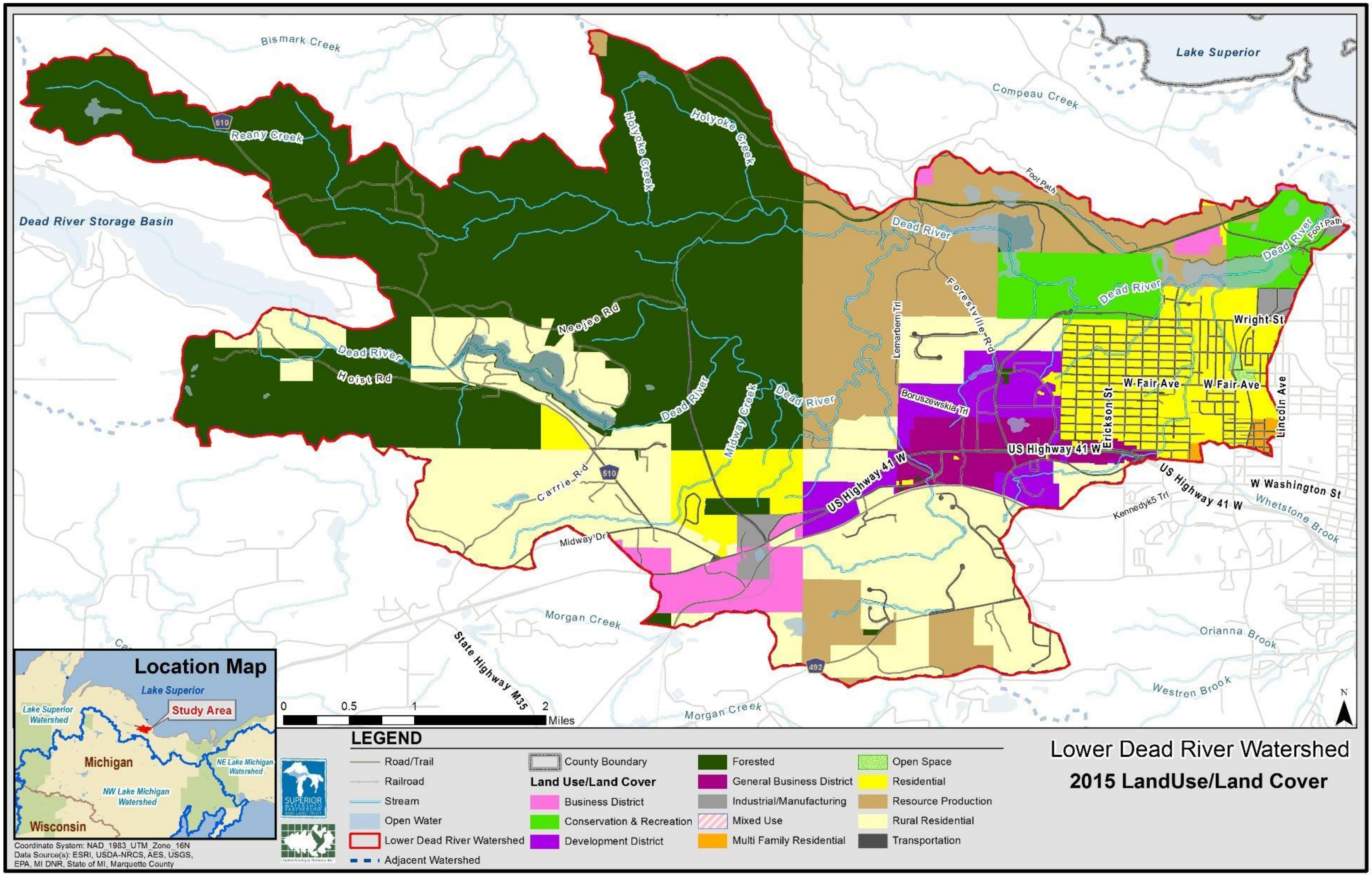


Figure 17- 2015 Land Use/Land Cover

Noteworthy-Land Use/

Business District: Land use that includes food and drug stores, eating an
estate offices, doctors' offices, personal services, business services, shoppi
Conservation & Recreational: Established and maintained for recreatio
and rivers, which because of their natural characteristics, accessibility, and
development than the Lake-Shore and River District and intended for rec
provided on a year-round basis or may not be provided at all.
Development District: The Development District is intended to accomn
where planning studies and future land use maps have indicated, where in
location of this district will most naturally occur between the General Bus
Forested: Land cover generally consisting of remnant or second growth f
General Business District: Intended to serve as a focal point for the co
Township of Marquette and the surrounding areas. The General Business
supporting intense development. The standards prescribed for the Distric
Industrial/Manufacturing: Land use that includes manufacturing and p
extraction, associated parking areas, truck docks, etc. It is the intent of the
industrial uses in the city in such a way as to prevent the deterioration of t
to exert a minimum nuisance on adjacent uses within this district.
Mixed Use: The Mixed Use district is intended to encourage and facilitat
Master Plan. The non-residential uses in the M-U district are intended to s
reducing the number of car trips required to these areas.
Multi-family Residential: Land use that includes multifamily residences
townhouse units, apartment complexes, condominiums, and associated pa
Open Space: Open space is any open piece of land that is undeveloped (
accessible to the public. Open space can include: green space (land that is
Residential: A residential area is a land used in which housing predomina
single-family housing of varying density. Zoning for residential use may p
and industry.
Resource Production: This District is intended to provide for a variety
standards are intended to provide flexible utilization of the Township's na
provides for the conservation of minerals from wasteful use, and assures
Rural Residential: Established to preserve and protect large tracts of lan
development located on private roads.
Transportation: Land use that includes railroads and associated stations,
transportation.

Future Land Use/Land Cover Predictions

Population trends based on the Central Upper Peninsula Planning and Development (CUPPAD) Regional Commission's *Upward 2025: A Framework For Prosperity* (CUPPAD, 2016) show that the Central Upper Peninsula has been consistently losing population since the 1980's. This suggests, that it is unlikely that the land use/land cover of the Lower Dead River watershed will change much in the immediate future, as existing infrastructure can already support larger populations. Therefore, further examinations of future land use changes are unnecessary for this planning process.

Figure 18- Relationship between impervious surfaces, evapotransporation, & infiltration. Source: The Federal Interagency Stream Restoration Working Group, 1998 (Rev. 2001).

Category	% Imperviou s	Stream Condition within Subwatershed
Sensitive	<10%	Stable stream channels, excellent habitat, good water quality, and diverse biological communities
Impacted	>10% but <25%	Somewhat degraded stream channels, altered habitat, decreasing water quality, and fair-quality biological communities.
Non-Supp orting	>25%	Highly degraded stream channels, degraded habitat, poor water quality, and poor-quality biological communities.

Table 11- Impervious category & corresponding stream condition via the Impervious Cover Model. Source: (Zielinski 2002).

3.10 Impervious Cover Impacts

Impervious cover is defined as surfaces of an urban landscape that prevent infiltration of precipitation (Scheuler 1994). Imperviousness is an indicator used to measure the impacts of urban land uses on water quality, hydrology and flows, flooding/depressional storage, and habitat related to streams (Figure 20). Based on studies and other background data, Scheuler (1994) and the Center for Watershed Protection (CWP) developed an Impervious Cover Model used to classify streams within subwatersheds into three quality categories: Sensitive, Impacted, and Non-Supporting (Table 11). In general, Sensitive subwatersheds have less than 10% impervious cover, stable stream channels, good habitat, good water quality, and diverse biological communities. Impacted subwatersheds have between 10% and 25% impervious cover, somewhat degraded streams, altered habitat, and decreasing water quality. Non-Supporting subwatersheds generally have greater than 25% impervious cover, highly degraded streams, degraded habitat, poor water quality, and poor-quality biological communities. In addition, runoff over impervious surfaces collects pollutants and warms the water before it enters a stream resulting in negative biological impacts.

The following paragraphs describe the implications of increasing impervious cover:

Water Quality Impacts

Imperviousness affects water quality in streams and lakes by increasing pollutant loads and water temperature. Impervious surfaces accumulate pollutants from the atmosphere, vehicles, roof surfaces, lawns and other diverse sources. During a storm event, pollutants such as nutrients (nitrogen and phosphorus), metals, oil/grease, and bacteria (*E. coli*) are delivered to streams and lakes. According to monitoring and modeling studies, increased imperviousness is directly related to increased urban pollutant loads (Schueler 1994). Furthermore, impervious surfaces can increase stormwater runoff temperature as much as 12 degrees compared to vegetated areas (Galli, 1990). Water temperatures exceeding 90°F (32.2°C) can be lethal to aquatic fauna and can generally occur during hot summer months.

Hydrology and Flow Impacts

Higher impervious cover translates to greater runoff volumes thereby changing hydrology and flows in streams. If unmitigated, high runoff volumes can result in higher floodplain elevations (Schueler 1994). In fact, studies have shown that even relatively low percentages of imperviousness (5% to 10%) can cause peak discharge rates to increase by a factor of 5 to 10, even for small storm events. Impervious areas come in two forms: 1) disconnected and 2) directly connected. Disconnected impervious areas are represented primarily by rooftops, so long as the rooftop runoff does not get funneled to impervious driveways or a stormsewer system. Significant portions of runoff from disconnected surfaces usually infiltrate into soils more readily than directly connected impervious areas such as parking lots that typically end up with stormwater runoff directed to a stormsewer system that discharges directly to a waterbody.

Flooding and Depressional Storage Impacts
Flooding is an obvious consequence of increased flows resulting from increased impervious cover. As stated above, increased impervious cover leads to higher water levels, greater runoff volumes, and high floodplain elevations. Higher floodplain elevations usually result in more flood problem areas. Furthermore, as development increases, wetlands and other open space decrease. A loss of these areas results in increased flows because wetlands and open space typically soak up rainfall and release it slowly via groundwater discharge to streams and lakes. Detention basins can and do minimize flooding in highly impervious areas by regulating the discharge rate of stormwater runoff, but detention basins do not reduce the overall increase in runoff volume.

Habitat Impacts
A threshold in habitat quality exists at approximately 10% to 15% imperviousness (Booth and Reinelt 1993). When a stream receives more severe and frequent runoff volumes compared to historical conditions, channel dimensions often respond through the process of erosion by widening, downcutting, or both, thereby enlarging the channel to handle the increased flow. Channel instability leads to a cycle of streambank erosion and sedimentation resulting in physical habitat degradation (Schueler 1994). Streambank erosion is one of the leading causes of sediment suspension and deposition in streams leading to turbid conditions that may result in undesirable changes to aquatic life (Waters 1995). Sediment deposition alters habitat for aquatic plants and animals by filling interstitial spaces in substrates important to benthic macroinvertebrates and some fish species. Physical habitat degradation also occurs when high and frequent flows result in loss of riffle-pool complexes.

Impervious Cover Estimate, Erosion Hazard, & Vulnerability
In 1998, the Center for Watershed Protection (CWP) published the Rapid Watershed Planning Handbook. This document introduced rapid assessment methodologies for watershed planning. The CWP released the Watershed Vulnerability Analysis as a refinement of the techniques used in the Rapid Watershed Planning Handbook (Zielinski 2002). The vulnerability analysis focuses on existing and predicted impervious cover as the driving forces impacting potential stream quality within a watershed. It incorporates the Impervious Cover Model described at the beginning of this subsection to classify Subwatershed Management Units (SMUs). SMUs are defined and examined in more detail in Section 3.3.

AES used a modified Vulnerability Analysis to compare each SMU's vulnerability to land use or development changes across the Lower Dead River watershed. Three steps were used to generate a vulnerability ranking of each SMU. The results were used to make and rank recommendations in the Action Plan related to curbing the negative effects of predicted land use changes on the watershed. The three steps are listed below and described in detail on the following pages:

Step 1: Existing impervious cover classification of SMUs based on 2015 land use/land cover

Step 2: Soil Erosion Hazard score of SMUs based on NRCS soils data

Step 3: Vulnerability Ranking of SMUs based on current impervious cover and soil erosion hazard vulnerability factor

Step 1: Existing Impervious Cover Classification

Step 1 in the Vulnerability Analysis is an existing classification of each SMU based on 2015 land use/land cover and measured impervious cover. 2015 impervious cover was calculated by assigning an impervious cover percentage for each land use/land cover category based upon the United States Department of Agriculture's (USDA) Technical Release 55 (TR55) (USDA 1986). Highly developed land such as the general business district for example is estimated to have over 70% impervious cover while a typical medium density residential development exhibits around 25% impervious cover. Open space areas generally have less than 5% impervious cover. GIS analysis was used to estimate the percent impervious cover for each SMU in the watershed using 2015 land use/land cover data. Each SMU then received a classification (Sensitive, Impacted, or Non-Supporting) based on percent of existing impervious cover (Table 12; Figure 21).

To summarize, thirteen SMUs (SMUs 1-5, 7, 11 – 15, 17, and 20) were classified as Sensitive, five as Impacted (SMUs 6, 9, 10, 16, and 25), and seven as Non-Supporting (SMUs 8, 18, 19, and 21 through 24) based on 2015 impervious cover estimates. Sensitive SMUs were generally located in the northwestern portions of the watershed where relatively little development has taken place. The Impacted SMUs lie towards the southwest and surrounding the outskirts of the most developed portions of the watershed in and around Marquette, while the Non-Supporting SMUs fall within the most urbanized portions of Marquette, along the eastern portions of the watershed.

Table 12- 2015 impervious cover, soils erosion hazard, and vulnerability by Subwatershed Management Unit.

SMU #	Subwatershed/ Creek Names	Step 1: Existing Impervious %	Existing (2015) Impervious Classification	Step 2: Soil Erodibility Score	Soil Erodibility Hazard Classification	Vulnerability Factor	Step 3: Vulnerability Ranking
SMU1	Reany Creek	0.0%	Sensitive	2.4	Moderate	0.00	Low
SMU2	Unnamed Creek	0.6%	Sensitive	2.2	Moderate	0.01	Low
SMU3	Unnamed Creek	2.0%	Sensitive	2.6	Severe	0.05	Low
SMU4	Unnamed Creek	4.3%	Sensitive	2.4	Moderate	0.10	Low
SMU5	Unnamed Creek	7.0%	Sensitive	2.5	Severe	0.17	Low
SMU6	Midway Creek	17.9%	Impacted	2.2	Moderate	0.39	Moderate

SMU7	Unnamed Creek	7.4%	Sensitive	1.6	Moderate	0.12	Low
SMU8	Unnamed Creek	48.9%	Non-Supporting	2.1	Moderate	1.02	High
SMU9	Brickyard Creek	23.9%	Impacted	2.4	Moderate	0.57	Moderate
SMU10	Unnamed Creek	16.5%	Impacted	2.2	Moderate	0.36	Moderate
SMU11	Holyoke Creek	0.1%	Sensitive	2.0	Moderate	0.00	Low
SMU12	Unnamed Creek	0.0%	Sensitive	2.6	Severe	0.00	Low
SMU13	Unnamed Creek	0.2%	Sensitive	2.6	Severe	0.00	Low
SMU14	Unnamed Creek	4.0%	Sensitive	2.6	Severe	0.10	Low
SMU15	Unnamed Creek	4.4%	Sensitive	2.2	Moderate	0.10	Low
SMU16	Brickyard Creek	24.6%	Impacted	1.8	Moderate	0.44	Moderate
SMU17	Unnamed Creek	5.2%	Sensitive	1.7	Moderate	0.09	Low
SMU18	Wolner Creek	52.3%	Non-Supporting	1.7	Moderate	0.86	High
SMU19	Badger Creek	48.6%	Non-Supporting	1.8	Moderate	0.86	High
SMU20	Unnamed Creek	7.5%	Sensitive	1.7	Moderate	0.13	Low
SMU21	Unnamed Creek	27.9%	Non-Supporting	1.5	Moderate	0.40	Moderate
SMU22	Backyard Creek	42.6%	Non-Supporting	2.0	Moderate	0.84	High
SMU23	Raney Creek	43.7%	Non-Supporting	1.2	Slight	0.53	Moderate
SMU24	Unnamed Creek	25.4%	Non-Supporting	0.6	Slight	0.16	Low
SMU25	Unnamed Creek	19.2%	Impacted	2.0	Moderate	0.38	Moderate

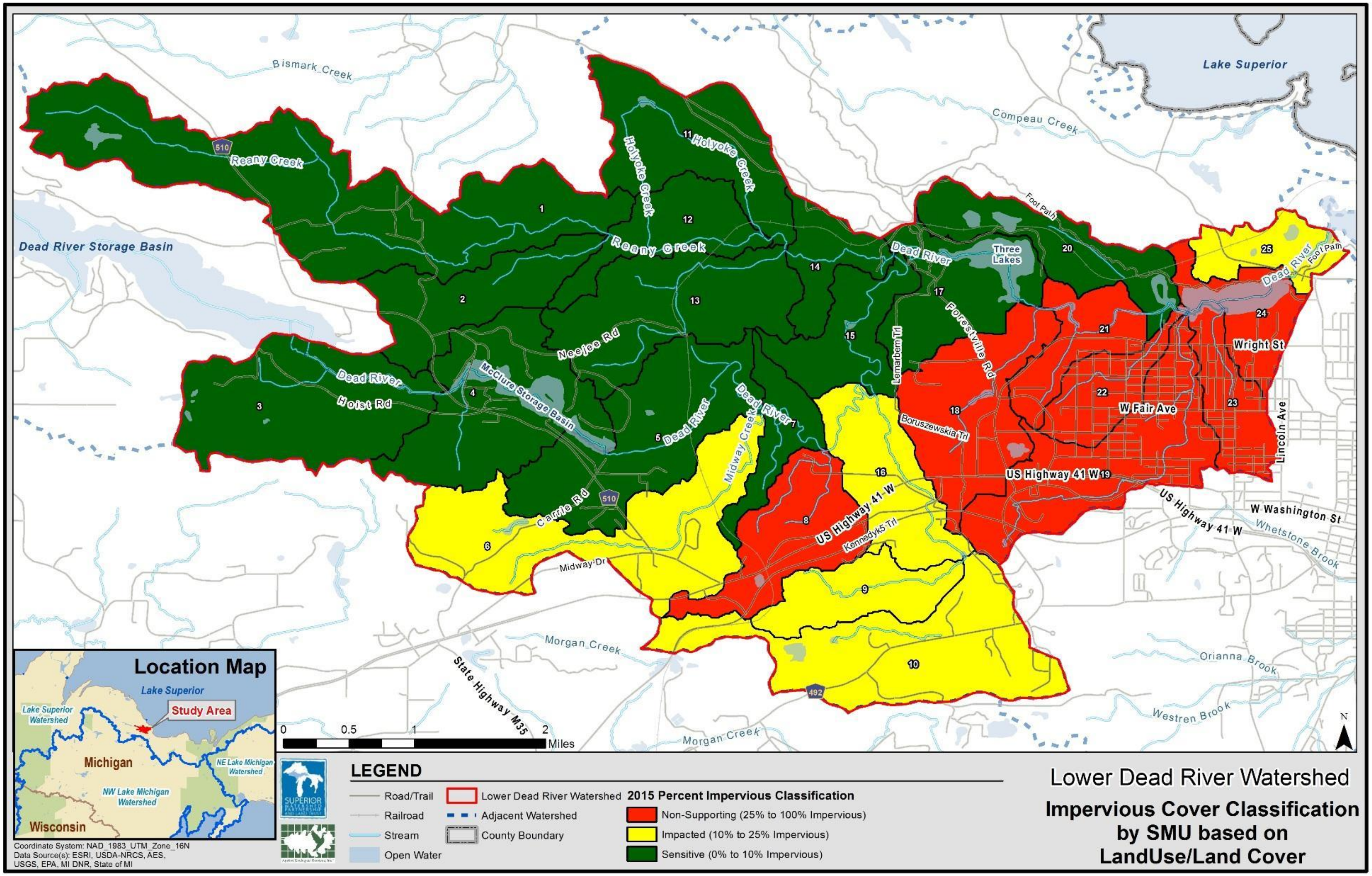

Lower Dead River Watershed
Impervious Cover Classification by SMU based on LandUse/Land Cover
LEGEND
Road/Trail
Railroad
Stream
Open Water
Lower Dead River Watershed
Adjacent Watershed
County Boundary
2015 Percent Impervious Classification
Non-Supporting (25% to 100% Impervious)
Impacted (10% to 25% Impervious)
Sensitive (0% to 10% Impervious)
Location Map
Lake Superior
Study Area
Lake Superior Watershed
Michigan
NW Lake Michigan Watershed
NE Lake Michigan Watershed
Wisconsin
Coordinate System: NAD_1983_UTM_Zone_16N
Data Source(s): ESRI, USDA-NRCS, AES, USGS, EPA, MI DNR, State of MI
0 0.5 1 2 Miles
Dead River Storage Basin
Bismark Creek
Reany Creek
Holyoke Creek
Compeau Creek
Lake Superior
Dead River
Three Lakes
Foot Path
McClure Storage Basin
Hoist Rd
Neejee Rd
Carrie Rd
Midway Creek
Midway Dr
Forestville Rd
Lemarbem Trl
Boruszewskia Trl
Kennedyk5 Trl
US Highway 41 W
W Fair Ave
Wright St
Lincoln Ave
W Washington St
Whetstone Brook
Morgan Creek
Orianna Brook
Westren Brook
State Highway M35
510
492
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Figure 19- Impervious Cover Classification by SMU based on Land Use/Land Cover

Step 2: Erosion Hazard Score by SMU

The soil erosion hazard of each SMU was calculated based on the NRCS soils data available for the watershed and were classified as either Slight, Moderate, or Severe. Table 12 and Figure 22 summarize and depict soil erosion hazard classifications for each SMU. This step identifies SMUs that are most vulnerable to soil erosion if projects or development occurs in these areas in the future. SMUs 23 and 24 have only a slight erosion hazard. Most of the SMUs in the watershed have a moderate erosion hazard, including SMUs 1, 2, 4, 6-11, 15-22, and 25. Finally, SMUs 3, 5, and 12-14 were categorized as being a severe erosion hazard.

Step 3: Vulnerability Ranking

The vulnerability of each SMU to erosion where land use changes might occur was determined by multiplying the percent impervious cover by the soil erosion hazard score for each SMU to determine the vulnerability factor of each SMU. The resulting vulnerability factors ranged from 0 to 1.02.

The vulnerability factors were then ranked for each SMU and categorized as Low, Medium, or High:

Low = a vulnerability factor of 0 to 0.2
Moderate = a vulnerability factor > 0.2 to 0.6
High = a vulnerability factor of > 0.6 to 1.02

The vulnerability analysis resulted in 4 High, 7 Moderate, and 14 Low ranked SMUs (Table 12; Figure 23). SMUs 8, 18, 19, and 22 are ranked as highly vulnerable to land use changes or projects because these are areas that would be not only highly susceptible to erosion, but where the impervious cover classification is also high. Future projects or development in these areas need to take precautions to protect against increasing impervious cover or development and ensure that soils are protected from erosion during construction and development.

SMUs 6, 9, 10, 16, 21, 23, and 25 are ranked as moderately vulnerable to land use changes. The remaining SMUs have a low vulnerability to land use changes and development.

The results of this analysis clearly point to the potential negative impacts of traditional development. It will be important to consider developing the areas that are highly susceptible to development using Conservation/Low Impact Development standards that incorporate the most effective and reliable Stormwater Treatment Train practices whereby stormwater is routed through various water quality and infiltration Management Measures prior to being released from the development site. The use of Conservation/Low Impact Development is discussed in the Programmatic Action Plan section of this report.

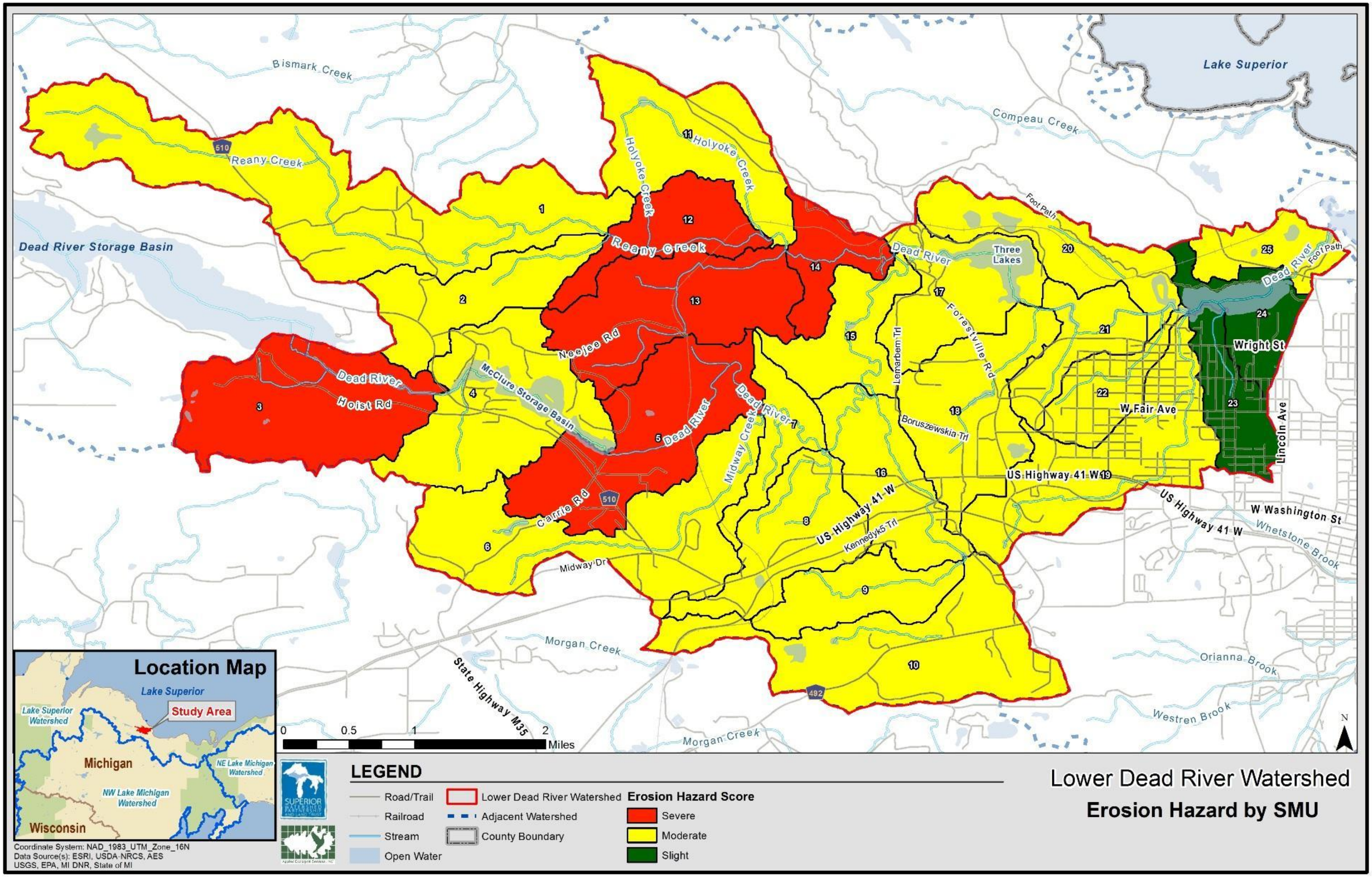


Figure 20- Erosion Hazard by SMU

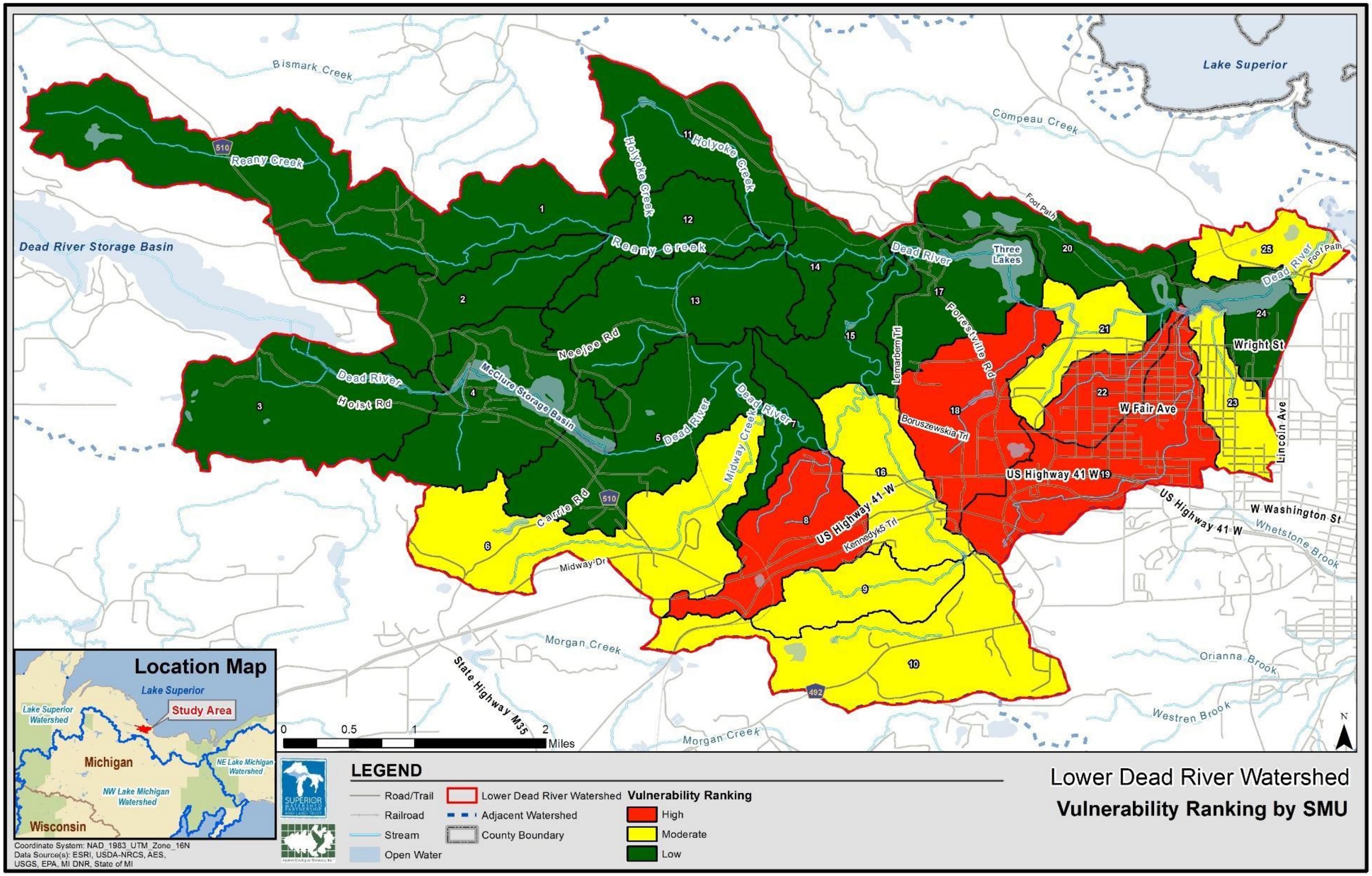

Lake Superior
Bismark Creek
Compeau Creek
Reany Creek
Holyoke Creek
Dead River Storage Basin
Dead River
Three Lakes
Foot Path
Foresteville Rd
Lemarbem Trl
Neejee Rd
Hoist Rd
McClure Storage Basin
Midway Creek
Boruszewskia Trl
W Fair Ave
Wright St
Lincoln Ave
US Highway 41 W
W Washington St
Whetstone Brook
Kennedyk5 Trl
Carrie Rd
Midway Dr
Morgan Creek
State Highway M35
Orianna Brook
Westren Brook
Location Map
Lake Superior
Lake Superior Watershed
Study Area
Michigan
NE Lake Michigan Watershed
NW Lake Michigan Watershed
Wisconsin
Coordinate System: NAD_1983_UTM_Zone_16N
Data Source(s): ESRI, USDA-NRCS, AES, USGS, EPA, MI DNR, State of MI
0 0.5 1 2 Miles
LEGEND
Road/Trail
Railroad
Stream
Open Water
Lower Dead River Watershed
Adjacent Watershed
County Boundary
Vulnerability Ranking
High
Moderate
Low
Lower Dead River Watershed
Vulnerability Ranking by SMU

Figure 21- Vulnerability Ranking by SMU

3.11 Open Space Inventory, Prioritization, & Green Infrastructure Network

A Green Infrastructure Network is a connected system of *Hubs* and linking *Corridors*. Hubs generally consist of the largest and least fragmented areas. Corridors are generally formed by smaller private/unprotected parcels along swales and streams. Corridors are extremely important because they provide biological conduits between hubs. However, not all parcels forming corridors are ideal green infrastructure until residents, businesses, and industries embrace the idea of naturalizing stream corridors. Unique to the Lower Dead River watershed are very undeveloped riparian corridors. The main branches of these rivers are still currently wooded, diverse and have limited development impacts and encroachments.

Figure 22- General depiction of a green infrastructure network. Source: greeninfrastructure.net

A major component of watershed planning includes an examination of open space to determine how it best fits into a "Green Infrastructure Network." Green infrastructure is best defined as an interconnected network of natural areas and other open space that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife (Benedict 2006). Natural features such as stream corridors, wetlands, floodplain, woodlands, and grassland are the primary components of green infrastructure. Working lands such as farms parks/ball fields, school grounds, detention basins, and large residential parcels can also be considered green infrastructure components.

A three-step process was used to create a parcel-based Green Infrastructure Network for the Lower Dead River watershed:

Step 1: All parcels of land in the watershed were categorized as open space, partially open space, or developed.
Step 2: All open and partially open parcels were prioritized based on a set of criteria important to green infrastructure.
Step 3: Prioritized open and partially open parcels and some developed but linking parcels were combined to form a Green Infrastructure Network.

For this watershed plan, an "open space" parcel is generally defined as any parcel that is not developed such as a protected natural area or forested lands. "Partially open" parcels have been developed to some extent, but the parcels still offer potential green infrastructure opportunities. Examples of partially open parcels include some school grounds and residential lots generally greater than two acres with minimal development. Parcels that are mostly built out such as medium and high-density residential development, transportation, and commercial/retail areas are considered "developed". Public versus private and protected versus unprotected status of open and partially open space parcels are other important green infrastructure attributes that are discussed in more detail below.

Open, Partially Open, & Developed Parcels

Step 1 in creating a Green Infrastructure Network was completed by categorizing all parcels in the watershed as "open," "partially open," or "developed" as described above. Figures 25 and 26 summarize and depict Step 1 results. Open space parcels comprise approximately 10,605 acres or 67% of the watershed. Partially open parcels make up another 3,007 acres or 19% of the watershed. Developed parcels account for the remaining 2,267 acres or 14% of the watershed. Most open and partially open parcels are located on forested land, private conservation areas, and large residential lots.

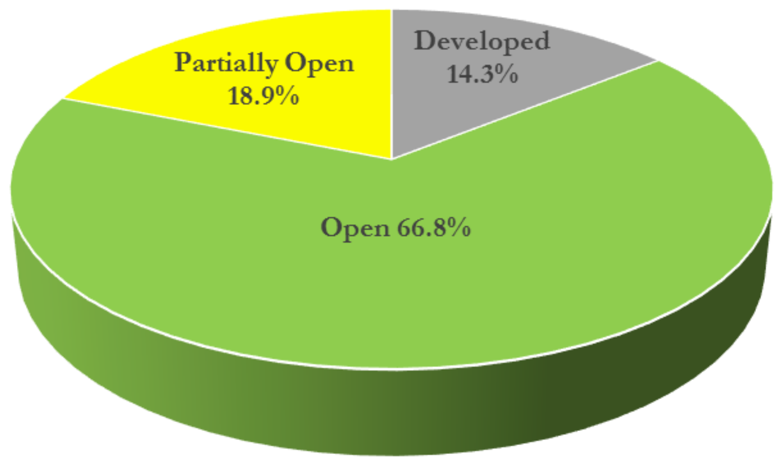


Figure 23- Distribution of open, partially open, and developed parcels.

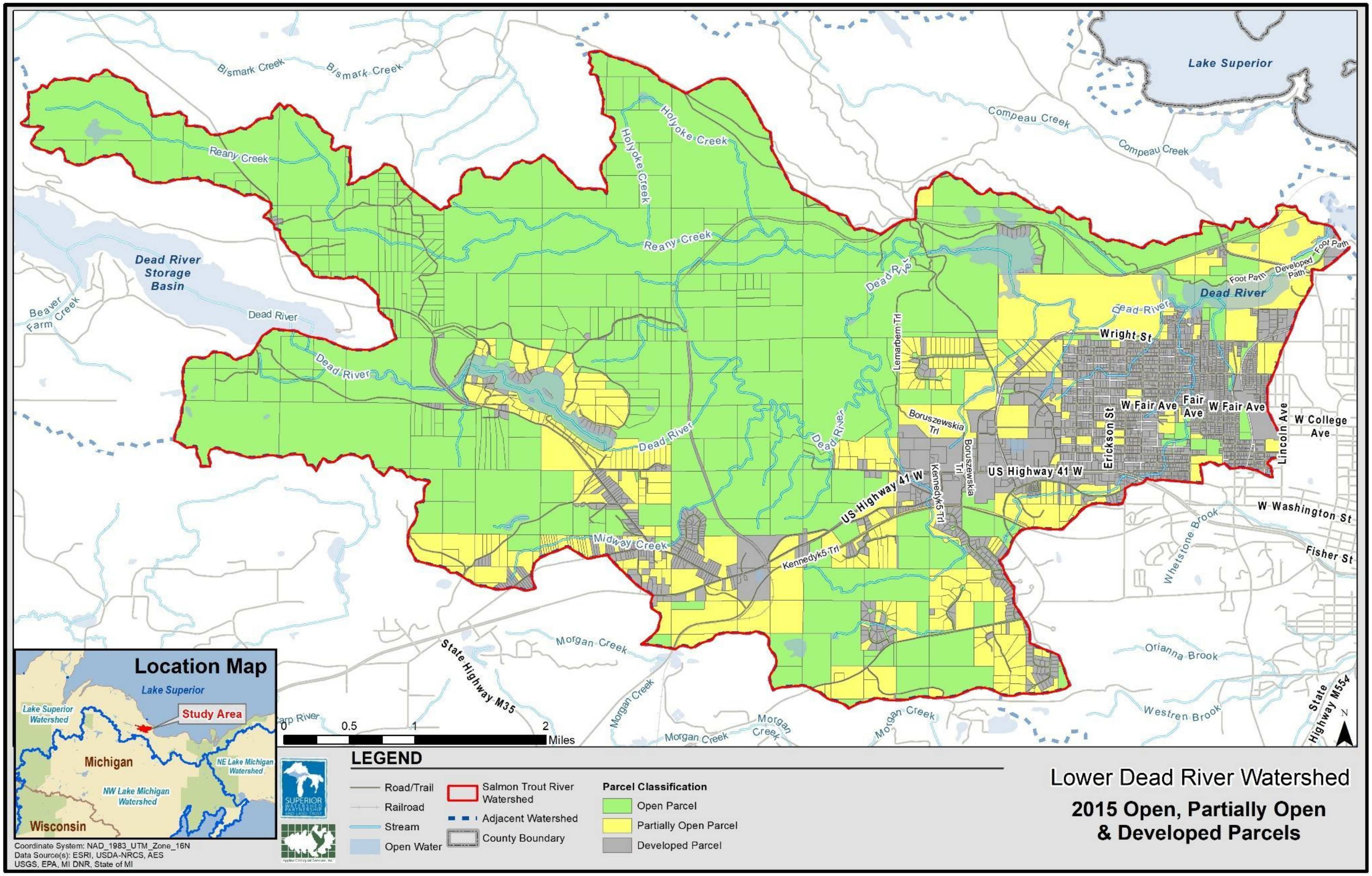

Lake Superior
Dead River Storage Basin
Dead River
Reany Creek
Holyoke Creek
Bismark Creek
Compeau Creek
Midway Creek
Morgan Creek
Wright St
W Fair Ave
US Highway 41 W
Lincoln Ave
W College Ave
W Washington St
Fisher St
State Highway M35
State Highway M554
Location Map
Study Area
Michigan
Wisconsin
LEGEND
Road/Trail
Railroad
Stream
Open Water
Salmon Trout River Watershed
Adjacent Watershed
County Boundary
Parcel Classification
Open Parcel
Partially Open Parcel
Developed Parcel
Lower Dead River Watershed
2015 Open, Partially Open & Developed Parcels
Coordinate System: NAD_1983_UTM_Zone_16N
Data Source(s): ESRI, USDA-NRCS, AES USGS, EPA, MI DNR, State of MI
0 0.5 1 2 Miles

Figure 24- 2015 Open, Partially Open, and Developed Parcel

Public/Private Ownership of Open and Partially Open Parcels

The public or private ownership of each open and partially open parcel was determined from available parcel data. Developed parcels are not included in this summary. Publicly owned parcels generally include those owned by state, county, municipal government, school districts, and park districts. Public open and partially open parcels account for 1% and 4% of the open and partially open acreage, respectively (Figures 27 & 29). Private ownership types include privately owned conservation areas, large lot residential areas, etc. Private open parcels comprise 66% of the open and partially open acreage whereas private partially open parcels comprise 15% (Figures 27 & 29). Public open and partially open parcels are mostly owned by MDNR and the County.

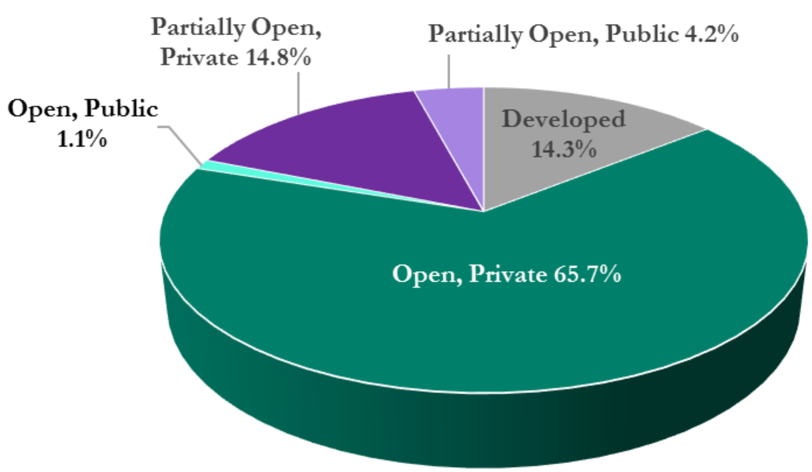


Figure 25- Distribution of private and public open and partially open parcels.

Protected Status of Open and Partially Open Parcels

Preservation of open space is critical to maintaining and expanding green infrastructure and is an important component of sustaining water quality, hydrological processes, ecological function, and the general quality of life for both wildlife and people. Without preservation, open space can be converted to other less desirable land uses in the future. Protected open and partially open parcels account for less than 1% of the open space acreage in the watershed, partially open and partially protected is roughly 4%, while unprotected open and partially open parcels account for the remaining 81% of the watershed (Figures 28 & 30). Much of the unprotected open space in the watershed is forested land owned by timber companies.

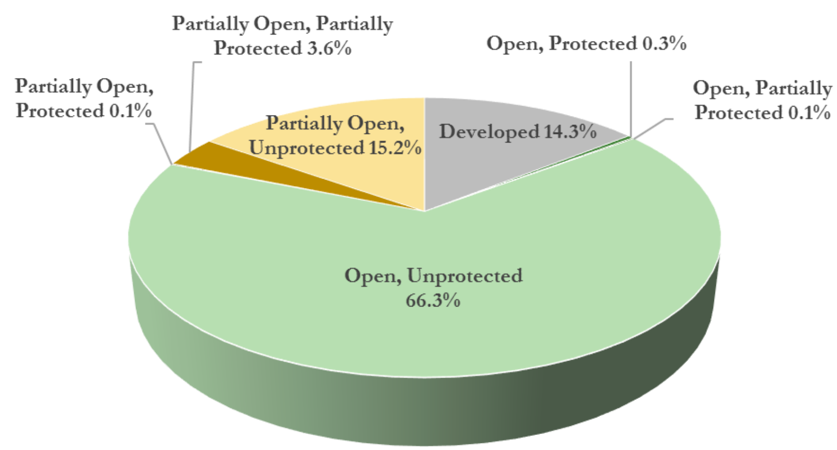


Figure 26- Distribution of protected and unprotected open and partially open parcels.

Figure 27- 2015 Public versus Private Ownership of Open and Partially Open Parcels

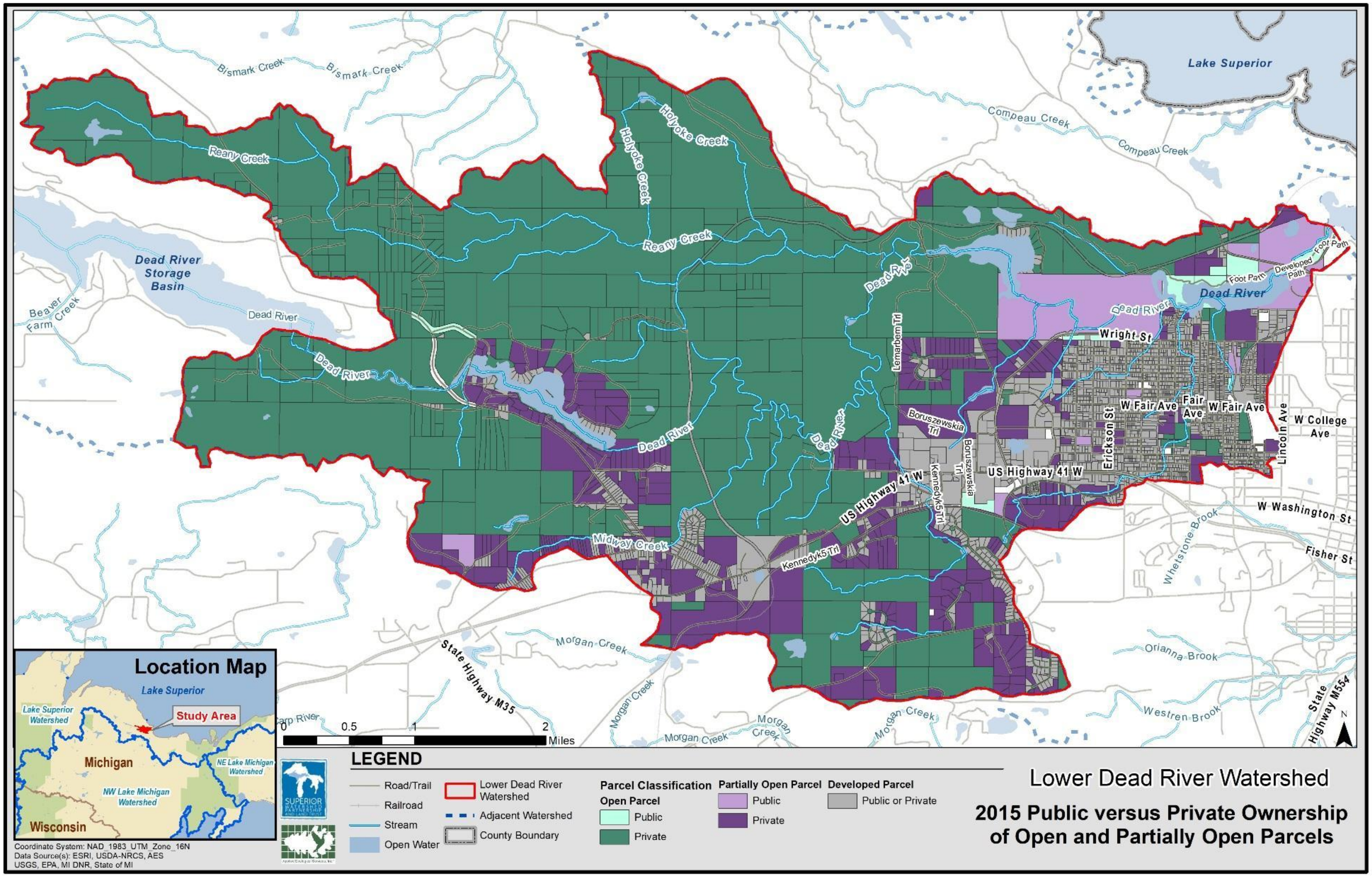


Figure 28- 2015 Public versus Private Ownership of Open and Partially Open Parcels

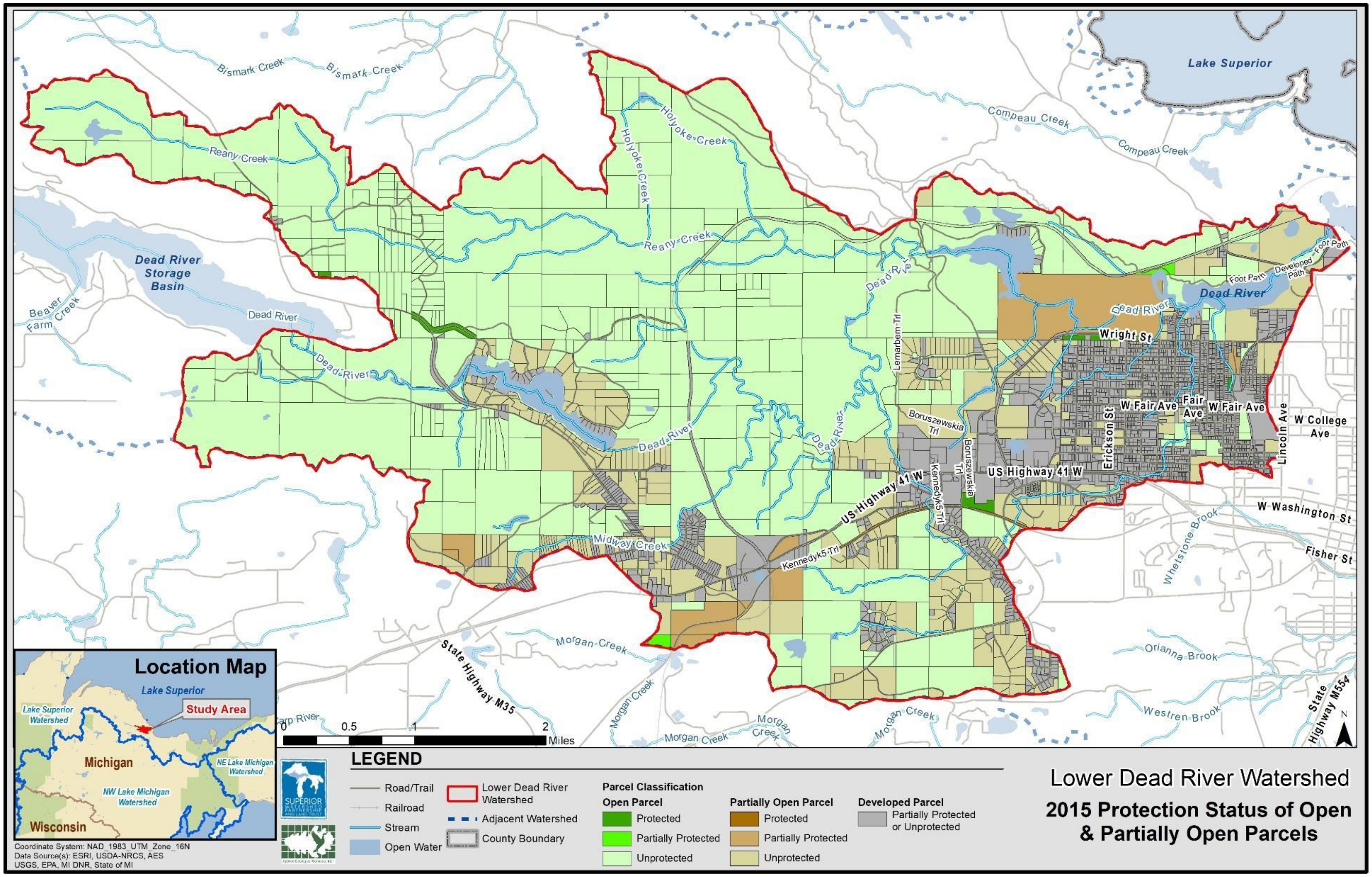


Figure 29- 2015 Protection Status of Open and Partially Open Parcels

Open Space Parcel Prioritization
Step 2 in creating a Green Infrastructure Network for the Lower Dead River watershed was completed by prioritizing open and partially open parcels. For this step, 9 prioritization criteria important to green infrastructure were examined via a GIS analysis (Table 13). If an open or partially open parcel met a criterion it received one point. If the parcel did not meet that criterion, it did not receive a point. This process was repeated for each open and partially open parcel and for all criteria. The prioritization process was not completed for developed parcels. The total points received for each parcel were summed to determine parcel importance for developing the Green Infrastructure Network; parcels with the highest number of points are more important to green infrastructure than parcels that met fewer criteria.

The combined possible total of points any one parcel can accumulate is 9 (9 of 9 total criteria met). The highest total value received by a parcel in the weighting process was 6 (having met 6 of 9 criteria). After completion of the prioritization, parcels were categorized as “High Priority,” “Medium Priority,” or “Low Priority” for green infrastructure based on point totals. Parcels meeting 5-6 of the criteria are designated High Priority for inclusion into the Green Infrastructure Network while parcels meeting 3-4 criteria are designated Medium Priority. Parcels with a combined value of 0-2 are categorized as Low Priority but are not necessarily excluded from the Green Infrastructure Network based on their location or position as linking parcels.

Figure 31 depicts the results of the parcel prioritization. First, many of the High Priority green infrastructure parcels form the *hubs* of the Green Infrastructure Network for Lower Dead River watershed. Many of the Medium Priority parcels are currently privately-owned lands along the stream corridors and necessary for protecting the Trout Streams in the watershed. Low Priority parcels are generally smaller isolated, private residential parcels.

Table 13- Criteria used to prioritize parcels for a Green Infrastructure Network.

Green Infrastructure Criteria
1. Open/partially open parcels that include the FEMA 100-year floodplain
2. Open/partially open parcels within 0.25 miles of a headwater stream
3. Open/partially open parcels that include a wetland
4. Open/partially open parcels that include a Trout Stream of Trout Restoration Area
5. Open/partially open parcels that are within 100 feet of a stream or open water
6. Open/partially open parcels in a “Highly Vulnerable” Land Use/Land Cover SMU
7. Open/partially open parcels adjacent to or including private or public protected open space
8. Open/partially open parcels that include an existing or planned trail
9. Open/partially open parcels that include groundwater recharge areas with greater than 12”/yr potential

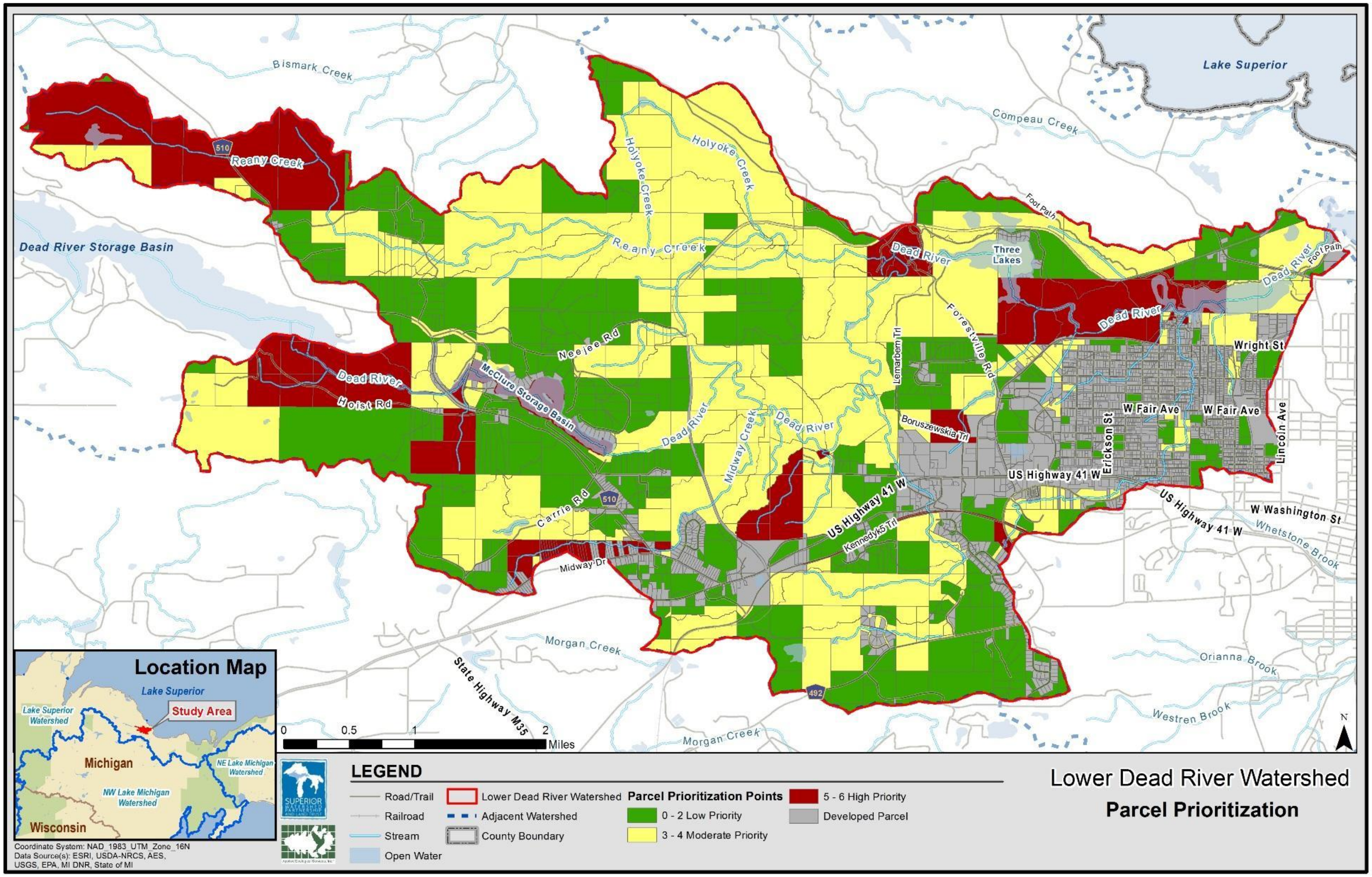


Figure 30- Parcel Prioritization

3.12 Green Infrastructure Network

The final step (Step 3) in creating a Green Infrastructure Network for the Lower Dead River watershed involved laying out the network by using prioritized open space results from Step 2 as the base layer that includes all High Priority, all Medium Priority parcels, and Low Priority or developed parcels along streams corridors and the McClure Storage Basin if they provided *links*, expanded existing green infrastructure, or were simply isolated sites.

County and region-wide green infrastructure plans, where available, generally focus on natural features such as stream corridors, wetlands, floodplain, buffers, and other natural components. The Green Infrastructure Network created for the Lower Dead River watershed captures all the natural components and other green infrastructure such as private or recreational parks and large residential lots at the parcel level. Parcel level green infrastructure planning is important because land purchases, acquisitions, and land use changes almost always occur at the parcel level. A Green Infrastructure Network for the Lower Dead River watershed is illustrated on Figure 32. The total Green Infrastructure Network for the Lower Dead River watershed covers 9,255 acres. The majority of the network (8,596 acres; 93%) is unprotected, while less than 1% (43 acres) is protected and the remaining 7% (617 acres) is partially protected.

Perhaps the most important aspect of green infrastructure planning is that it helps communities identify and prioritize conservation opportunities and plan development in ways that optimize the use of land to meet the needs of people and nature (Benedict 2006). Green infrastructure planning provides a framework for future growth that identifies areas not suitable for development, areas suitable for development but that should incorporate conservation or low impact design standards, and areas that do not affect green infrastructure. The Action Plan section of this report includes various programmatic and site-specific green infrastructure recommendations.

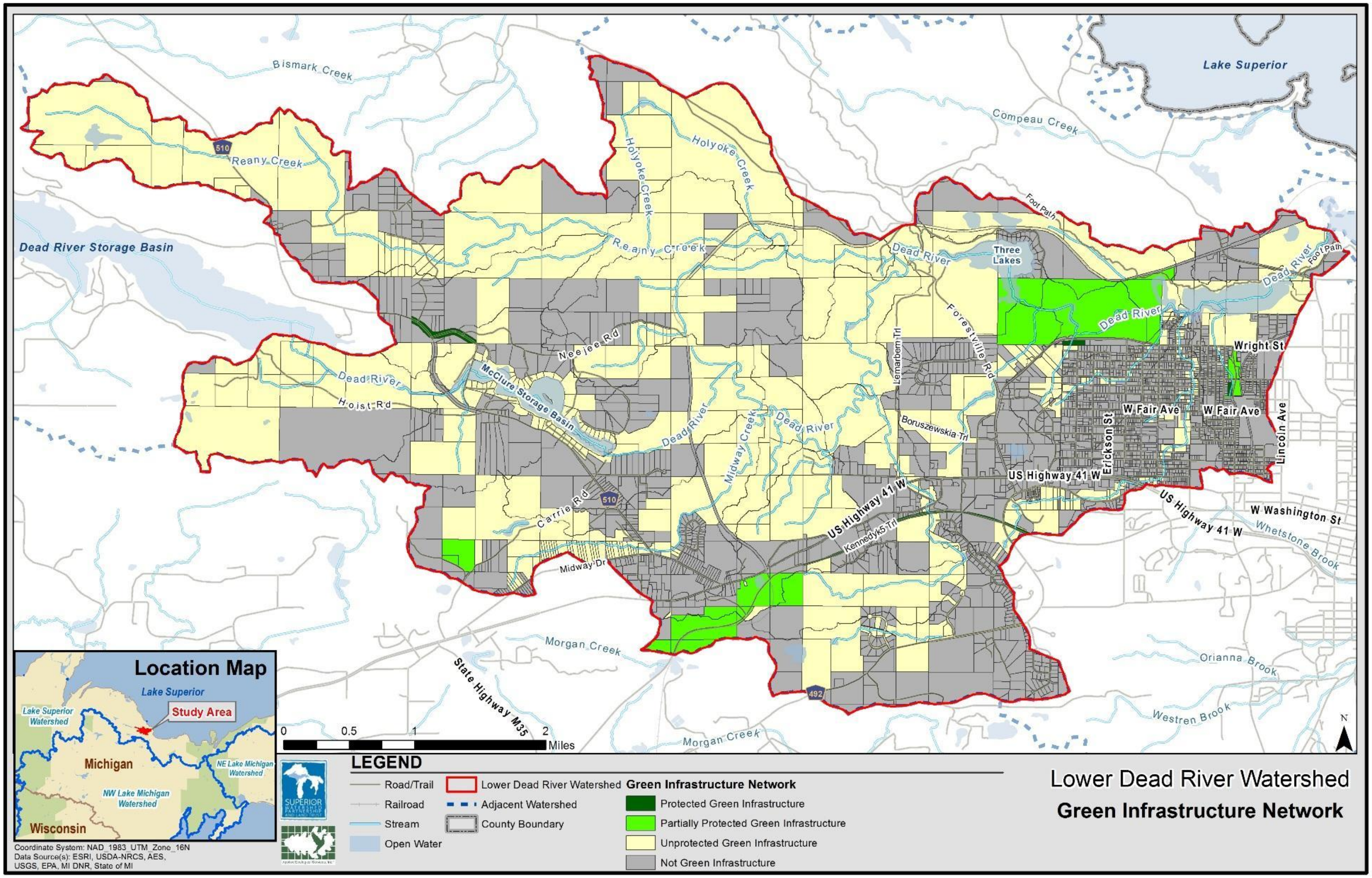


Figure 31- Green Infrastructure Network

3.13 Important Natural Areas

The Michigan Department of Natural Resources defines natural areas as: "Areas that have retained the best example of Michigan's native landscapes, ecosystems, natural communities or scenic qualities". Features used to identify natural areas include: size, uniqueness, pristine nature, aesthetic or scenic qualities, and outstanding opportunities for solitude or a primitive and unconfined type of recreation. To be legally dedicated, natural areas must also contain ecological, geological or other features of scientific, scenic or natural history value. Many areas also have populations of endangered and threatened species." (MDNR)

Natural areas as defined above do not occur in the Lower Dead River watershed.

735 acres of property have at least some level of protection from development. These include the Iron Ore Heritage Trail (4.1 acres), private easements (18.4 acres), Gwinn State Forest Area (3.0 acres), and conservation and recreation land owned by the Marquette Board of Light and Power (710 acres).

In general, forested areas in the northwest portion of the watershed likely have the highest potential for high quality habitat. This same area is the least-developed area of the watershed and contains the headwaters of most of the streams including: Reany, Holyoke and Midway Creeks.

Table 14- Protected Properties

Protected Properties	Size (acres)	Description
Iron Ore Heritage Trail	4.1	Multiuse interpretive trail
Private Easement	18.4	Conservation
Gwinn State Forest Area	3.0	Conservation and Recreation
Marquette Board of Light and Power	710.0	Conservation and Recreation

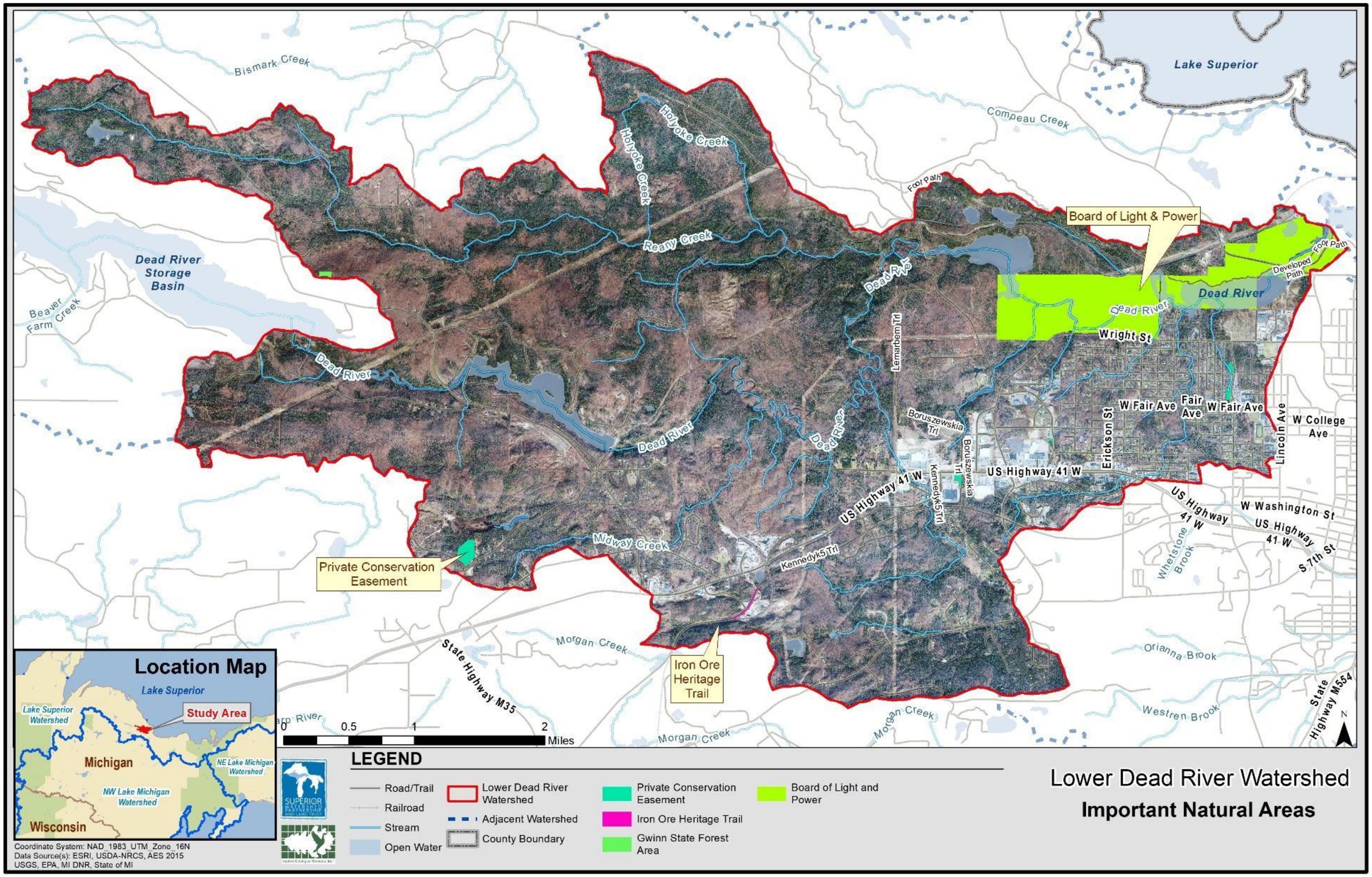


Figure 32- Important Natural Areas

3.13.1 Natural Resource Management

Forestry and Timber Harvesting

Logging has been a prevalent land use in the Lower Dead River watershed due to the plentiful forests and proximity to railways and ports to transport goods. Logging has been identified as one component that has contributed to the sedimentation of the Lower Dead River and its tributaries in the watershed. With the implementation of best management practices, timber harvesting has become more sustainable in recent years. However, the steep topography of the watershed and its highly erodible soils make implementation of practices difficult, and stream crossings tend to result in sediment contributions to the watershed. Other potential issues brought on by timber harvesting include reduction in forest shading contributing to rises in water temperature, changes in hydrology and flow patterns, and changes in water infiltration and evapotranspiration.

Through the Commercial Forest Lands program, private land owners can enroll their land into long-term timber production in exchange for property tax incentives. These lands must have a forestry management plan written by a registered forester or natural resources professional describing how the land will be managed.

Management practices on forest lands, by all owners, will help forests and watersheds to stay healthy and stable. The Michigan Department of Natural Resources defines a broad range of best management practices in: "Michigan Forestry Best Management Practices for Soil and Water Quality." These best management practices include:

- Pre-Harvest Planning: Allows for implementation of best management practices in appropriate site locations
- Riparian Management Zones: Provide shading, prevent sedimentation, habitat, and bank stabilization
- Stream Crossings: Provides guidance on staying within regulations and implementation of actions like portable bridges, and culvert sizing and placement
- Harvesting Operations: Prevention and mitigation of rutting, site location and water management of landings, and skid placement
- Site preparation, Reforestation, and Forest Protection: Guidance in prescribed burning, site reforestation, mechanical and chemical vegetation control, and establishment of crop trees
- Forest Road Planning: Proper control of grading, drainage management, knowledge of existing soil conditions, stream crossings, and closure practices prevent soil erosion
- Water Diversion Devices: Diverts water from roads and trails to prevent erosion

Mineral Rights and Exploration

In addition to commercial forestry, private landowners as well as the State are able to lease the mineral harvesting and exploration rights to their land. In the context defined by EGLE, "mineral" and therefore "mineral rights" pertains to: fossil fuels (oil, natural gas, and coal), metals and metal-bearing ores, nonmetallic minerals and mineable rock products (limestone, gypsum, building stone, and salt), and may also include sand and gravel, peat, and marl. Mineral rights, similar to property rights, may be sold, transferred, or leased. They are distinct from "surface rights" and one can transfer "mineral rights" while maintaining "surface rights"

The owner of a parcels "mineral rights" may develop that parcel's mineral deposits or, alternatively, may lease the rights to a mineral development company. In this process, the land owner is generally paid a "bonus" when signing the lease along with royalties from any minerals extracted from the parcel.

This is applied to State-held public lands through the leasing nomination and bidding process. Interested parties have the opportunity to nominate state-owned parcels for leasing mineral rights, and the leases are then auctioned. Interested parties may also apply for a direct lease. The State receives the revenue for these leases and has generated over $255 million in the last seven years which goes into the Michigan State Parks Endowment Fund and the Game and Fish Protection Trust Fund.

Whether the leased land is State or private owned, it is subject to regulation by the EGLE, as leasing itself is not authorization to harvest minerals. The information on what land is leased and how as well as upcoming lease nominations is publicly available on the Michigan DNR "Managing Your Resources-Minerals" page.

At the time of writing, there are currently no lands nominated for mineral leasing in the Lower Dead River watershed area.

3.14 Watershed Drainage System

Waterways such as streams and rivers are a barometer of the health of their watersheds. The story of waterways, as with so many natural resources, has been one of exploitation and lack of understanding. Few waterways throughout the world have escaped pollution, channel modifications, and increased flooding as a result of mismanagement of development in the watershed (Apfelbaum & Haney 2010). Fortunately, many waterways can be restored if stressors in the watershed can be mitigated.

3.14.1 Lower Dead River

Lower Dead River

The Lower Dead River is a 74,875.1 linear ft. (14.18 mi.) section of the Dead River that begins at the Dead River Storage Basin and winds east and north through predominately forested wetlands before emptying into Lake Superior.

In 2003 a dike failure at Silver lake on the Dead River resulted in the release of nine billion gallons of water and mobilized one million cubic yards of sediment and debris into the Upper and Lower Dead River. The flooding destabilized stream banks, blocked tributaries, rerouted four miles of the stream channel and destroyed habitat features such as pools and riffles necessary for trout reproduction. Restoration of the Dead River took place between 2003 and 2006 to reestablish fisheries, stabilize streambanks, and accelerate recovery of the riparian corridor. There is no data prior to or after the flood to compare the health of the Lower Dead River post flood. In 2006, two restored sites located in the Upper Dead River, 4.5 miles downstream of the damn failure reported marginal to good ratings for macroinvertebrates and habitats in comparison to the nearby Conner Creek (Rathbun).

3.14.2 Lower Dead River Tributary Streams

Tributary Streams

Thirty (30) streams totaling 192,773.6 linear feet or 36.51 miles are located within the Lower Dead River Watershed; all are tributaries to the Lower Dead River with the exception of Unnamed Streams 7, 15, and 24 which are likely intermittent streams not connected to any other surface waters (Table 15; Figure 34). For this watershed plan, local tributary names are noted wherever possible. Of the 28 streams, Reany Creek is the longest at approximately 43,468.7 linear feet or about 8.23 miles. Unnamed Stream 13 and Unnamed Stream 9, the second and third longest streams in the watershed, are 17,070.8 linear feet (3.23 miles) and 17,026.8 linear feet (3.22 miles) respectively. The remaining 25 streams account for 115,207.4 linear feet or 21.82 miles.

Table 15- Stream Names and Lengths

Primary Stream Names	Stream Length Assessed (ft)	Stream Length Assessed (mi)
Dead River	74,875.1	14.18
Holyoke Creek	12,918.8	2.45
Midway Creek	16,039.4	3.04
Reany Creek	43,468.7	8.23
Unnamed Stream 1	1,580.1	0.30
Unnamed Stream 2	2,779.5	0.53
Unnamed Stream 3	5,601.1	1.06
Unnamed Stream 4	2,222.3	0.42
Unnamed Stream 5	1,926.3	0.36
Unnamed Stream 6	12,568.6	2.38
Wolner Creek – aka Unnamed Stream 8	8,045.2	1.52
Brickyard Creek – aka Unnamed Stream 9	17,026.8	3.22
Unnamed Stream 10	3,290.7	0.62
Backyard Creek – aka Unnamed Stream 11	6,834.7	1.29
Unnamed Stream 12– a tributary to Badger Creek	2,481.4	0.47
Badger Creek – aka Unnamed Stream 13	17,026.8	3.23
Raney Creek – aka Unnamed Stream 14	4,295.4	0.81
Unnamed Stream 15	4,888.7	0.93
Unnamed Stream 16	3,965.7	0.75
Unnamed Stream 17	4,013.5	0.76
Unnamed Stream 18	3,106.1	0.59
Unnamed Stream 20	5,049.0	0.96
Unnamed Stream 21	4,440.6	0.84
Unnamed Stream 22	1,299.4	0.36
Unnamed Stream 23	1923.7	0.36
Unnamed Stream 24	1,606.6	0.30
Unnamed Stream 25	595.8	0.11

Tributary Stream Inventory

Tributary stream observations were based on previous inventories and data sources including the original Lower Dead River Watershed Management Plan (2003), the analysis of coastal tributaries conducted July 2001 (Godby 2002), and the Lower dead River and Salmon Trout Watershed analysis (AES 2019).

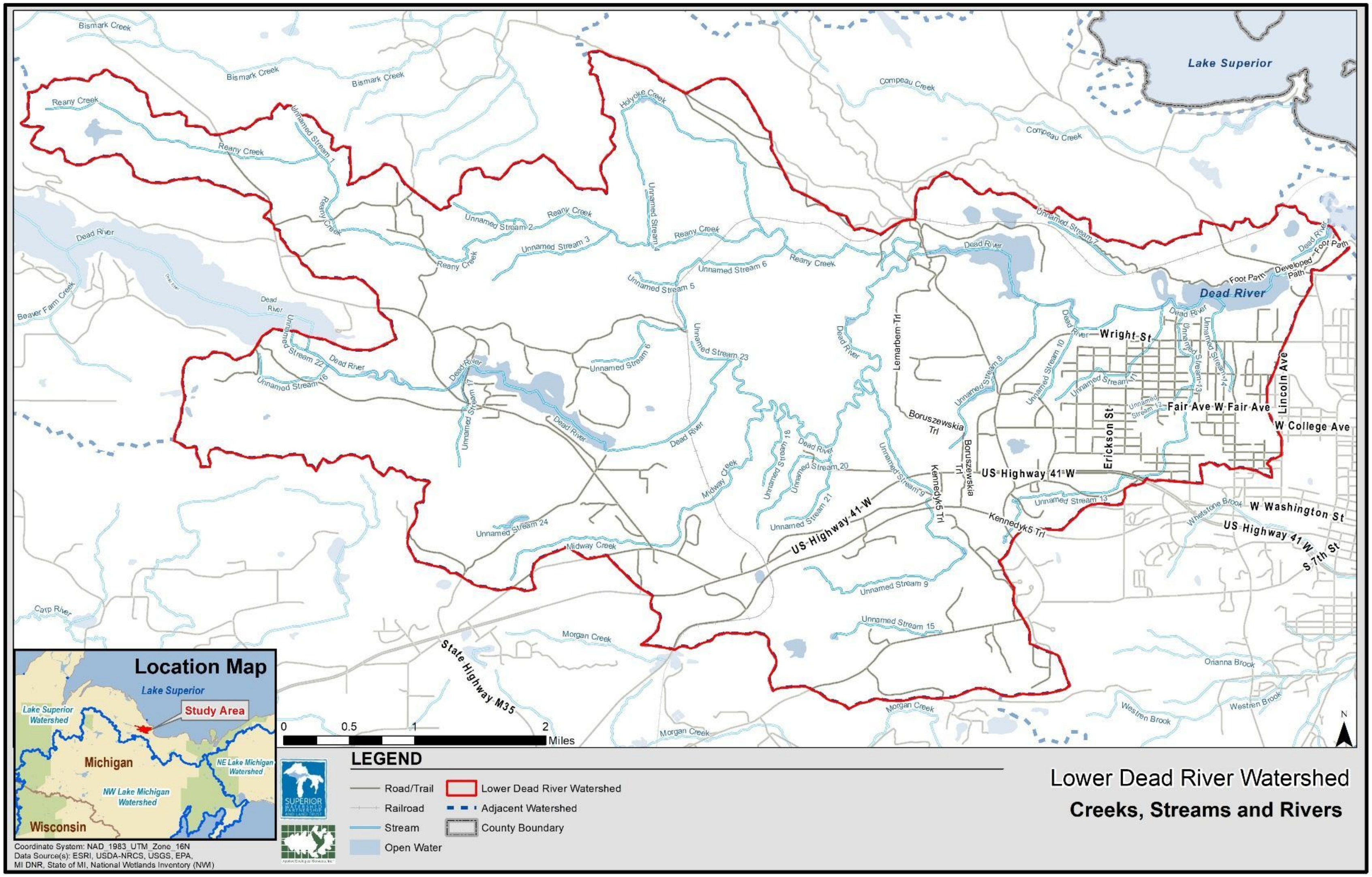


Figure 33- Creeks, Streams, and Rivers

<u>Holyoke Creek</u>
Holyoke Creek is a 12,918.8 linear ft. (2.45 mi.) stream north-centrally located in the watershed in Marquette Count. Holyoke Creek flows north before it bends at the northern boundary of the watershed and flows southeast into Reany Creek.

<u>Midway Creek</u>
Midway Creek is located in the south-central region of the Lower Dead River Watershed and flows northeast for 16,039.4 linear ft. (3.04 mi) before connecting with the Dead River

<u>Reany Creek</u>
Reany Creek begins in the northeast region of the watershed and flows for 43,468.7 linear ft. (8.23 mi.) before meeting the Dead River northwest of Marquette.

<u>Unnamed Stream 1</u>
Unnamed Stream 1 is located in the northwest portion of the watershed where it flows southeast for 1,580.1 linear ft. (0.30 miles) before meeting the Reany Creek.

<u>Unnamed Stream 2</u>
Unnamed Stream 3 is located in the northwest portion of the Lower Dead River Watershed where it flows southeast for 2,779.5 linear ft (0.53 miles) before flowing into Reany Creek.

<u>Unnamed Stream 3</u>
Unnamed Stream 3 is located in the northwest portion of the Lower Dead River Watershed where it flows northeast for 5,601.1 linear ft. (1.06 mi.) before meeting Reany Creek.

<u>Unnamed Stream 4</u>
Unnamed Stream 4 is located in the north-central portion of the Lower Dead River Watershed where it flows north for 2,222.3 linear ft. (0.42 mi.) before meeting Reany Creek.

<u>Unnamed Stream 5</u>
Unnamed Stream 5 is centrally located in the Lower Dead River Watershed where it flows west for 1,926.3 linear ft. (0.36 mi.) before meeting Unnamed Stream 6.

<u>Unnamed Stream 6</u>
Unnamed Stream 6 is centrally located in the watershed where it flows northeast for 12,468 linear ft. (2.38 mi.) before flowing into Reany Creek.

<u>Unnamed Stream 7</u>
Unnamed Stream 7 is a 3.734.6 linear ft (0.71 mi.) intermittent stream located in the northeast portion of the Lower Dead River Watershed.

<u>Wolner Creek – aka Unnamed Stream 8</u>
Unnamed Stream 8 is centrally located within the watershed where it flows northeast for 8,045.2 linear ft. (1.52 mi.) before emptying into Dead River.

<u>Brickyard Creek – Unnamed Stream 9</u>
Unnamed Stream 9 is centrally located within the watershed where it flows east and northwest for 17,070.8 linear ft. (3.22 mi.) before emptying into Dead River.

Unnamed Stream 10

Unnamed Stream 10 is located in the east-central portion of the watershed where it flows northeast for 3,290.7 linear ft. (0.62 mi.) before flowing into Dead River.

Backyard Creek – Unnamed Stream 11

Unnamed Stream 11 flows through Marquette in the eastern portion of the watershed. It flows northeast for 6,834.7 linear ft. (1.29 mi.) before combining with the Dead River

Unnamed Stream 12 – a tributary to Badger Creek

Unnamed Stream 12 flows through Marquette in the eastern portion of the watershed. It flows northeast for 2,481.4 linear ft. (0.47 mi.) before combining with Badger Creek.

Badger Creek – Unnamed Stream 13

Unnamed Stream 13 flows through Marquette in the eastern portion of the watershed. It flows northeast for 17,026.8 linear ft. (3.23 mi.) before combining with the Dead River

Raney Creek – Unnamed Stream 14

Unnamed Stream 14 flows through Marquette in the eastern portion of the watershed. It flows north for 4,295.4 linear ft. (0.81 mi.) before combining with the Dead River

Unnamed Stream 15

Unnamed Stream 15 is located in the in the southeastern portion of the watershed. It is likely an intermittent stream that is 4,888.7 linear ft. (0.93 mi.) long.

Unnamed Stream 16

Unnamed Stream 16 is located in the west-central portion of the Upper Dead River Watershed where it flows east for 3,965.7 linear ft. (0.75 mi.) before flowing into Dead River

Unnamed Stream 17

Unnamed Stream 17 is located in the west-central portion of the watershed where it flows north for 4,013.5 linear ft. (0.76 mi.) before flowing into Dead River.

Unnamed Stream 18

Unnamed Stream 18 is centrally located in the watershed where it flows north for 3,106.1 linear ft. (0.59 mi.) before flowing into Dead River.

Unnamed Stream 20

Unnamed Stream 20 is centrally located in the watershed where it flows north and east for 5,049 linear ft. (0.96 mi.) before flowing into Unnamed Stream 21.

Unnamed Stream 21

Unnamed Stream 21 is centrally located in the watershed where it flows north for 4,440.6 linear ft. (0.84 mi.) before flowing into Dead River.

Unnamed Stream 22

Unnamed Stream 22 is located in the west-central region of the watershed where it splits from Dead River in the Dead River Storage Basin and reconnects 1,299.4 linear ft. (0.36 mi.) upstream.

Unnamed Stream 23

Unnamed Stream 23 is centrally located in the watershed where it flows southwest for 1923.7 linear ft. (0.36 mi.) before flowing into Dead River.

Unnamed Stream 24

Unnamed Stream 24 is a 1,606.6 linear ft. (0.30 mi.) likely intermittent stream located in the south-central region of the watershed.

Unnamed Stream 25

Unnamed Stream 21 is centrally located in the watershed where it flows north for 595.8 linear ft. (0.11 mi.) before flowing into Dead River

3.14.3 Streambank Erosion

Unnatural streambank erosion generally results following an instability in flow rate or volume in the stream channel, human alteration such as channelization, or change in streambank vegetation. Resulting sediment transportation downstream can cause significant water quality problems. There is currently no data on streambank condition for the Lower Dead River Watershed.

3.14.4 Riparian Area Condition

Riparian areas that are in good ecological condition buffer streams by filtering pollutants, providing beneficial wildlife habitat, and connecting green infrastructure. There is currently no data on riparian area conditions for the Lower Dead River Watershed

3.14.5 Designated Trout Streams

A Designated Trout Stream is a stream designated by the state to contain a significant population of trout or salmon. (DNR 2018). The Michigan Department of Natural Resources classifies Designated Trout Streams as Type 1 through 4, Gear Restricted, and Research Areas. There are approximately 1,400 Type 1 Designated Trout Streams in Michigan including most of the Dead River and its tributaries within Lower Dead River Watershed (Figure 35). These streams are high quality waters that support natural reproduction of wild trout and salmon species at or near carrying capacity (WiDNR, 2017). The exceptions are the intermittent streams that are not directly connected to the Dead River.

The Lower Dead River Watershed is currently not ranked as one of the 42 priority habitat subwatersheds for brook trout, according to the Partnering for Watershed Restoration Group and the United States Fish and Wildlife Service (Figure 36) (PWR, 2019). Prioritization was based on population status models, predicted future water temperatures, and field verification. Due to the lack of assessment data within the Lower Dead River watershed, it is unclear why the watershed was not ranked a priority for brook trout species.

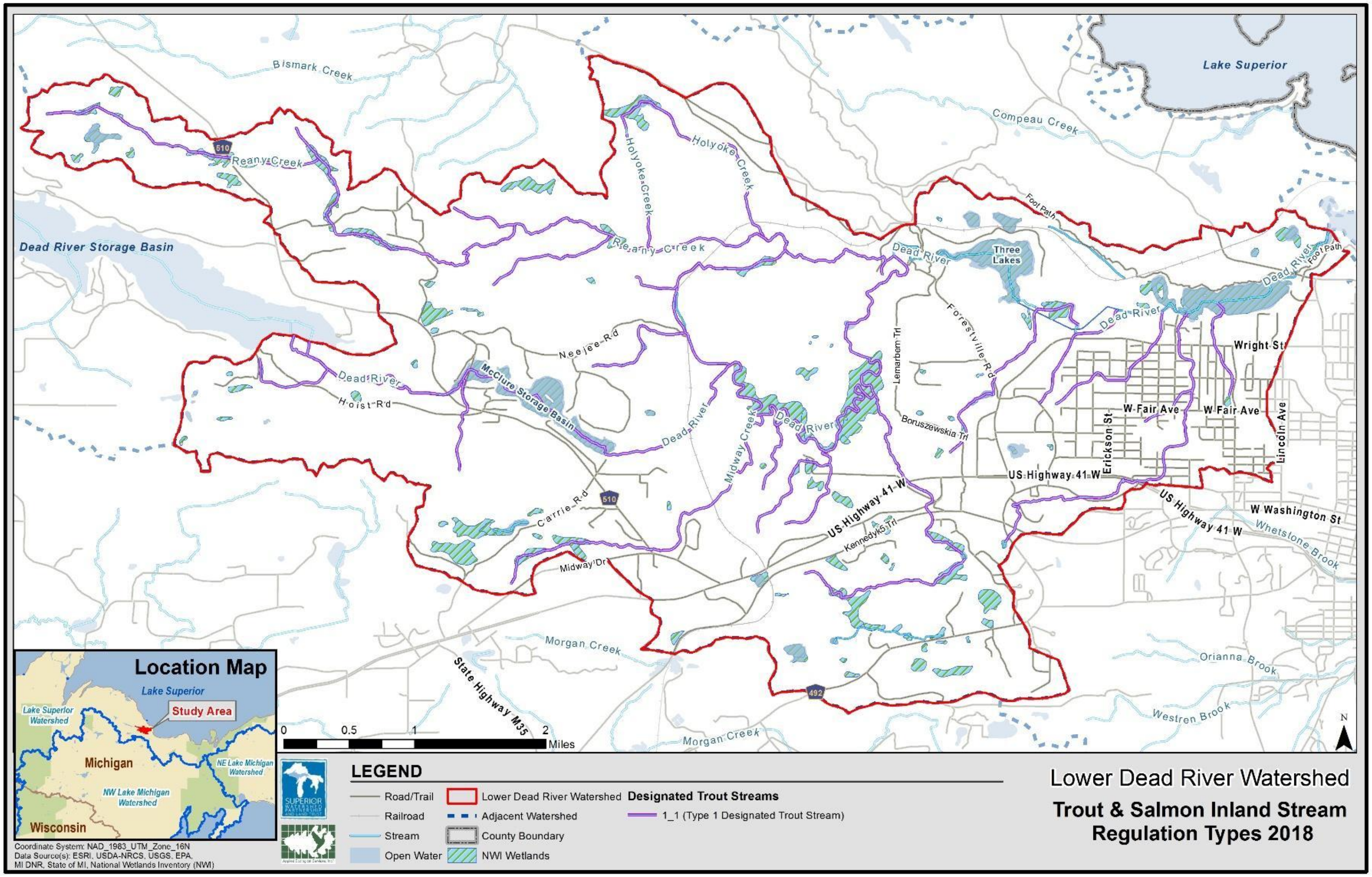


Figure 34- Trout and Salmon Inland Stream Regulation Types 2018

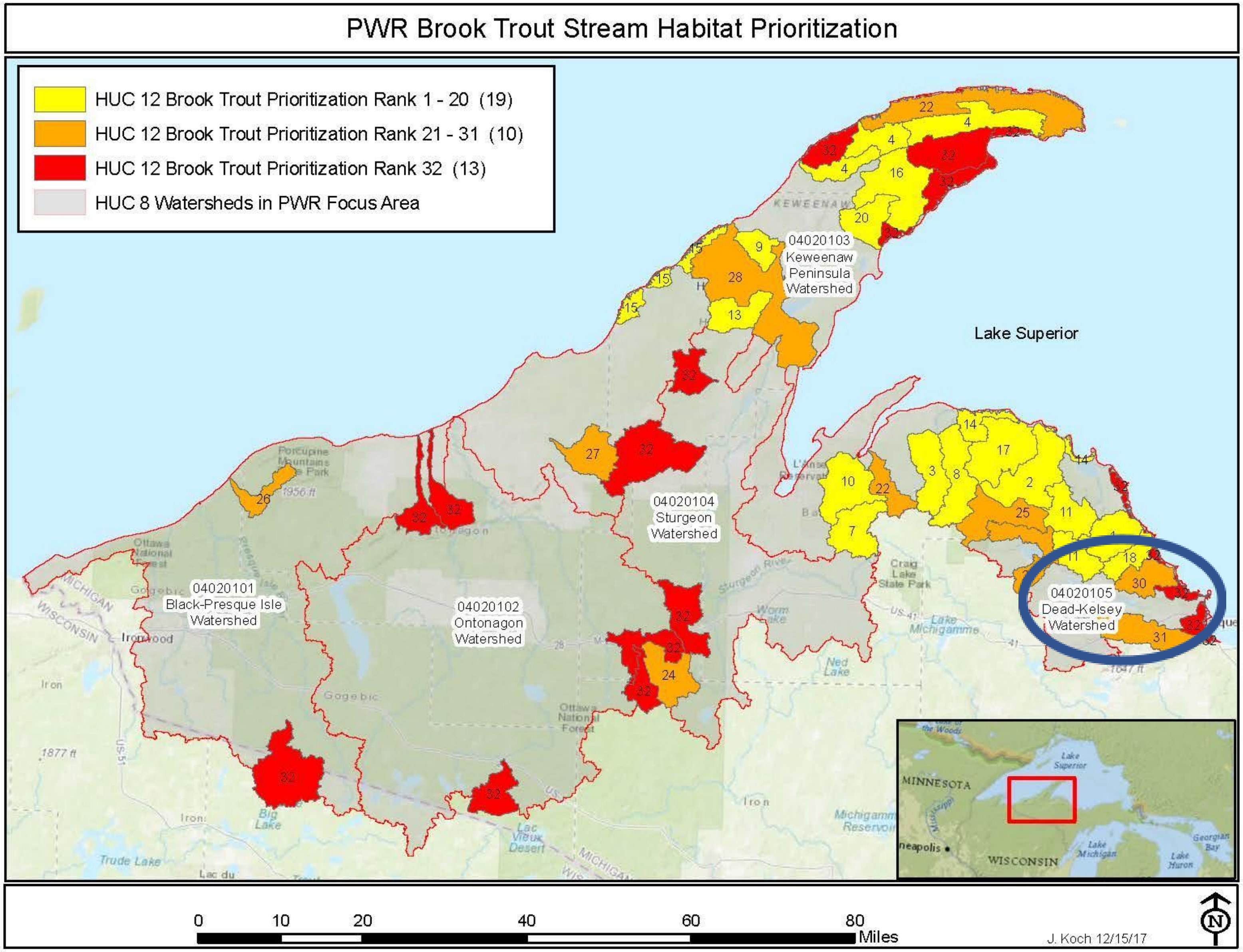

PWR Brook Trout Stream Habitat Prioritization
HUC 12 Brook Trout Prioritization Rank 1 - 20 (19)
HUC 12 Brook Trout Prioritization Rank 21 - 31 (10)
HUC 12 Brook Trout Prioritization Rank 32 (13)
HUC 8 Watersheds in PWR Focus Area
04020103 Keweenaw Peninsula Watershed
Lake Superior
04020104 Sturgeon Watershed
04020101 Black-Presque Isle Watershed
04020102 Ontonagon Watershed
04020105 Dead-Kelsey Watershed
MINNESOTA
WISCONSIN
0 10 20 40 60 80 Miles
J. Koch 12/15/17

Figure 35- PWR Priority Watersheds

3.14.6 Wetlands & Potential Wetland Restoration Sites
Wetlands are a critical part of the earth's hydrologic system, receiving water from snowmelt and rain, slowly releasing it from the land to recharge streams and lakes (Apfelbaum & Haney 2010). Functional wetlands do more for water quality improvement and flood reduction than any other natural resource. In addition, wetlands typically provide habitat for a wide variety of plant and animal species. They also provide some groundwater recharge capabilities and filter sediments and nutrients.

Pre-European Settlement Wetlands
Identification of historical wetland acreage is difficult, as the methods employed by surveyors in the 1800s were not consistent between surveyors nor were the definitions of what constituted a wetland. By cross referencing historical surveys of vegetative cover and locations of hydric soils within the region, there were approximately 567 acres of wetlands in the Lower Dead River watershed prior to European settlement, based on the most up to date hydric soils mapping provided by the USDA Natural Resources Conservation Service (NRCS).

Most existing wetlands in the Lower Dead River watershed are concentrated around stream reaches and are relatively small and fragmented. This is primarily due to the geology of the region, with few small wetlands in upper reaches that are, by-in-large, disconnected from the river channel. The river carves through granite bedrock and cascades through a series of waterfalls, and the character of the river system doesn't really include connections to the channel, except for smaller creeks (such as Reany Creek) further up in the watershed. Almost the entirety of wetlands in the Lower Dead River are forested wetlands. While there are pockets of black ash (*Fraxinus nigra*) and northern white-cedar (*Thuja occidentalis*) swamps, most of the wetlands are just flat and lower spots along the creeks consisting of hemlock (*Tsuga canadensis*) and some aspen (*Populus tremuloides*) interspersed throughout the watershed. As an indicator of wetlands, hydric soils and partially hydric soils total 756 and 543 acres respectively and less than 10% of the total area of the watershed (refer to Section 3.4 for additional details).

Wetlands in the Lower Dead River watershed are limited due to the geology and soils with low organic material in the area.

Table 16- Categorized Wetland Acreage

Wetland Category	Acres	Wetland Attributes
Pre-Euro Settlement Wetlands	567	Based on vegetation types and early records of topography
NWI Wetlands	1,080	Generally, all deep water features within primary corridors and natural areas that are to be protected
PWR Sites	504	Potential Wetland Restoration sites >10AC (2 Categories, Hydric Soils and Pre-Settlement Wetland Overlay, see map and key)

National Wetlands Inventory

The US Fish and Wildlife Service (USFWS) is the principal Federal agency tasked with providing information to the public on the status and trends of our nation's wetlands. The National Wetlands Inventory (NWI) relies on trained image analysts to identify and classify wetlands and deep-water habitats from aerial imagery. The National Wetlands Inventory dataset is a publicly available resource that provides detailed information on the abundance, characteristics, and distribution of US wetlands. The Lower Dead River watershed has 1080 acres of NWI (619 acres after surface water was backed out; Table 16).

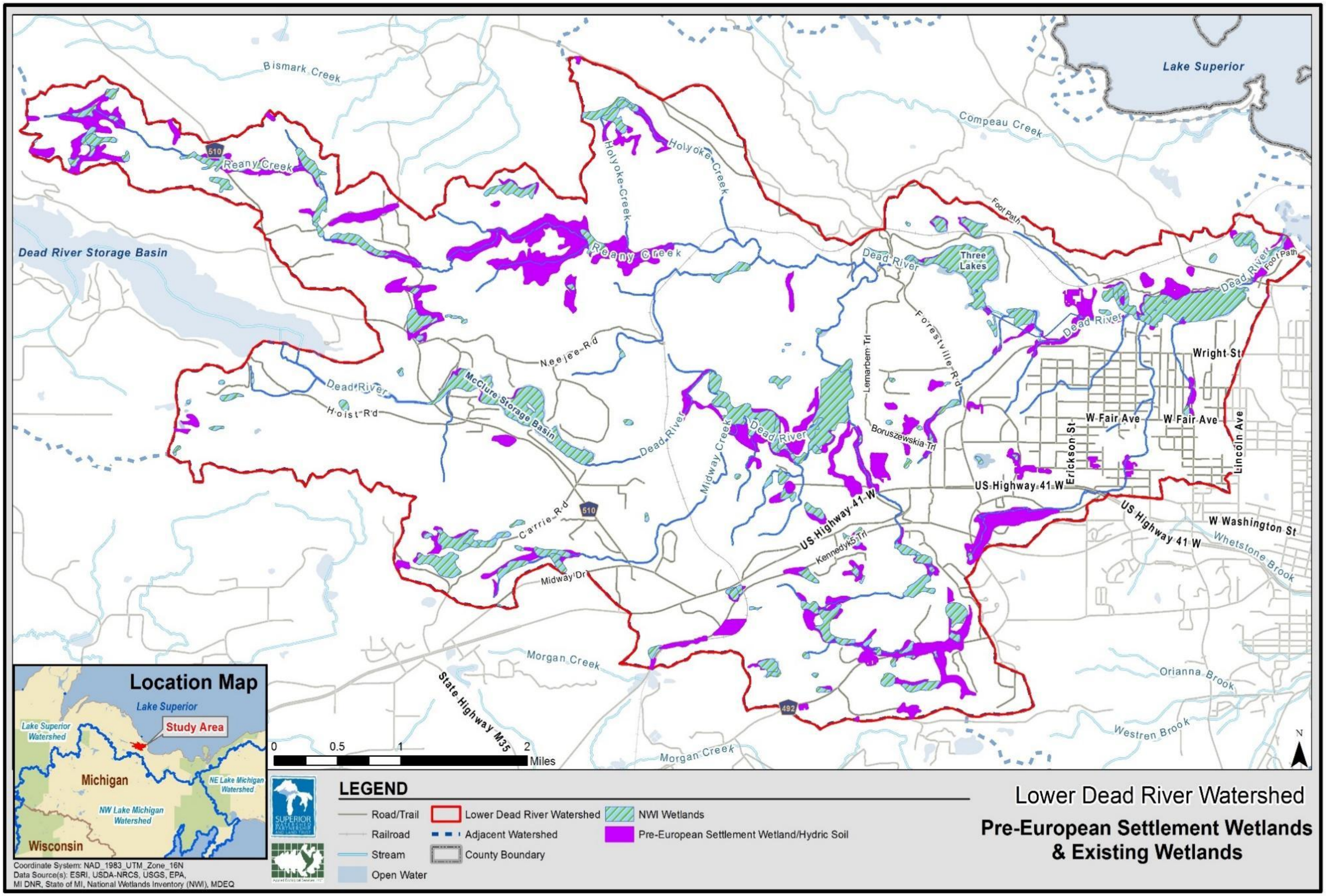

Lower Dead River Watershed
Pre-European Settlement Wetlands & Existing Wetlands
LEGEND
Road/Trail
Railroad
Stream
Open Water
Lower Dead River Watershed
Adjacent Watershed
County Boundary
NWI Wetlands
Pre-European Settlement Wetland/Hydric Soil
Location Map
Lake Superior
Study Area
Lake Superior Watershed
Michigan
NE Lake Michigan Watershed
NW Lake Michigan Watershed
Wisconsin
Coordinate System: NAD_1983_UTM_Zone_16N
Data Source(s): ESRI, USDA-NRCS, USGS, EPA, MI DNR, State of MI, National Wetlands Inventory (NWI), MDEQ
0 0.5 1 2 Miles
Lake Superior
Dead River Storage Basin
Bismark Creek
Reany Creek
Holyoke Creek
Compeau Creek
Dead River
McClure Storage Basin
Neejee Rd
Hoist Rd
Carrie Rd
Midway Dr
Midway Creek
US Highway 41 W
Kennedy Tri
Forestville Rd
Lemarbem Trl
Boruszewskia Trl
Three Lakes
Foot Path
Wright St
W Fair Ave
Erickson St
Lincoln Ave
W Washington St
Whetstone Brook
Morgan Creek
Orianna Brook
Westren Brook
State Highway M35
510
492

Figure 36- Pre-European Settlement Wetlands and Existing Wetlands

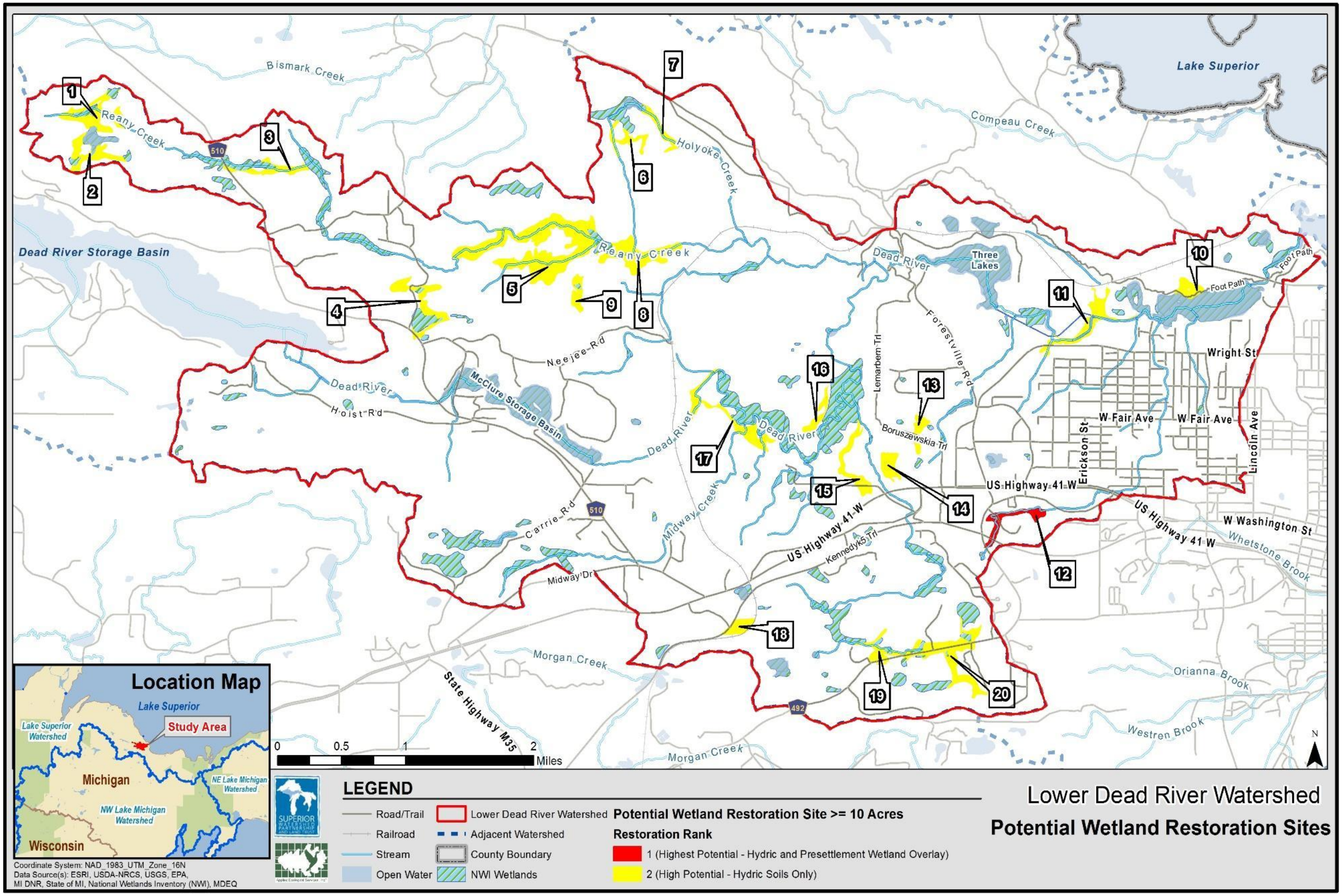
Potential Wetland Restoration Sites

Wetland restoration projects are among the most beneficial in the context of improving watershed health. Wetlands are vitally important because they improve basic environmental functions such as storing floodwaters, increasing biodiversity, creating green infrastructure, and improving water quality. The wetland restoration process involves returning hydrology (water) and vegetation to soils that once supported wetlands but no longer do because of human impacts such as tile and ditch draining and/or filling. Potential wetland restoration sites were identified using a Geographic Information Systems (GIS) exercise whereby sites were selected that include at least 10 acres of drained hydric soils located on an open or partially open parcel where no wetlands currently exist.

The GIS exercise resulted in 20 sites meeting the above criteria in the Lower Dead River watershed. Of the 20 sites, 19 are "High Potential," meaning they have hydric soils, and only 1 met the criteria for "Highest Potential" (hydric soils and pre-settlement overlay; Table 17). Almost all of the wetland restoration sites are located along the edge of the river or feeder creeks. It is important to note that a feasibility study beyond the scope of this project will need to be completed prior to the planning and implementation of any potential wetland restoration.

Table 17- Size, feasibility, and existing condition of potential wetland restoration sites on the Lower Dead River. Note: A feasibility study will need to be completed prior to the planning and restoration of any potential wetland restoration

Map ID #	Restoration Rank	Acres
1	2	31
2	2	21
3	2	13
4	2	25
5	2	128
6	2	11
7	2	11
8	2	42
9	2	10
10	2	13
11	2	25
12	1	17
13	2	10
14	2	14
15	2	20
16	2	10
17	2	29
18	2	12
19	2	11
20	2	49
Total		**504**


Lower Dead River Watershed
Potential Wetland Restoration Sites
Location Map
Lake Superior
Study Area
Lake Superior Watershed
Michigan
NE Lake Michigan Watershed
NW Lake Michigan Watershed
Wisconsin
Coordinate System: NAD_1983_UTM_Zone_16N
Data Source(s): ESRI, USDA-NRCS, USGS, EPA, MI DNR, State of MI, National Wetlands Inventory (NWI), MDEQ
LEGEND
Road/Trail
Railroad
Stream
Open Water
Lower Dead River Watershed
Adjacent Watershed
County Boundary
NWI Wetlands
Potential Wetland Restoration Site >= 10 Acres
Restoration Rank
1 (Highest Potential - Hydric and Presettlement Wetland Overlay)
2 (High Potential - Hydric Soils Only)
0 0.5 1 2 Miles
Dead River Storage Basin
McClure Storage Basin
Three Lakes
Reany Creek
Bismark Creek
Holyoke Creek
Compeau Creek
Dead River
Midway Creek
Morgan Creek
Orianna Brook
Westren Brook
Whetstone Brook
Neejee Rd
Hoist Rd
Carrie Rd
Midway Dr
Kennedy's Trl
Lemarbem Trl
Forestville Rd
Boruszewskia Trl
US Highway 41 W
State Highway M35
Erickson St
W Fair Ave
Wright St
Lincoln Ave
W Washington St
Foot Path
510
492
1
2
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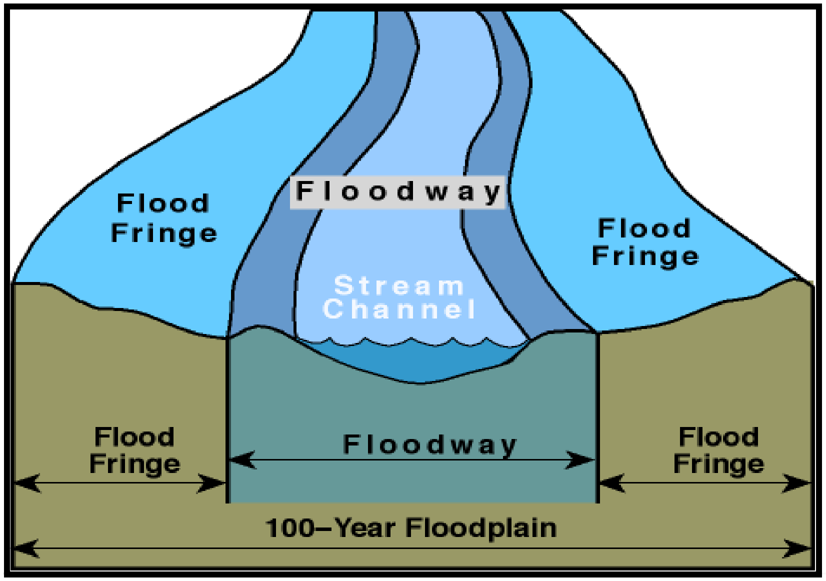
18
19
20

Figure 37- Potential Wetland Restoration Sites

3.14.7 Floodplain

FEMA 100-Year Floodplain

Functional floodplains along stream, river, and lake corridors perform a variety of green infrastructure benefits such as flood storage, water quality improvement, passive recreation, and wildlife habitat. The most important function however is the capacity of the floodplain to hold water following significant rain events to minimize flooding downstream. The 100-year floodplain is defined by the Federal Emergency Management Agency (FEMA) as the area that would be inundated during a flood event that has a one percent chance of occurring in any given year (100-year flood). 100-year floods can and do occur more frequently, however the 100-year flood has become the accepted national standard for floodplain regulatory and flood insurance purposes and was developed in part to guide floodplain development to lessen the damaging effects of floods.



The 100-year floodplain along streams also includes the floodway. The floodway is the portion of the stream or river channel that comprises the adjacent land areas that must be reserved to discharge the 100-year flood without increasing the water surface. Figure 39 depicts the 100-year floodplain and floodway in relation to a hypothetical stream channel.

Figure 40 depicts the 100-year floodplain which occupies 343 acres or about 2% of the watershed. The most extensive floodplain areas are located in the eastern, downstream portion in the watershed. The floodplains are around the Forestville Reservoir (aka Three Lakes Area) and the impounded portion of the Dead River.

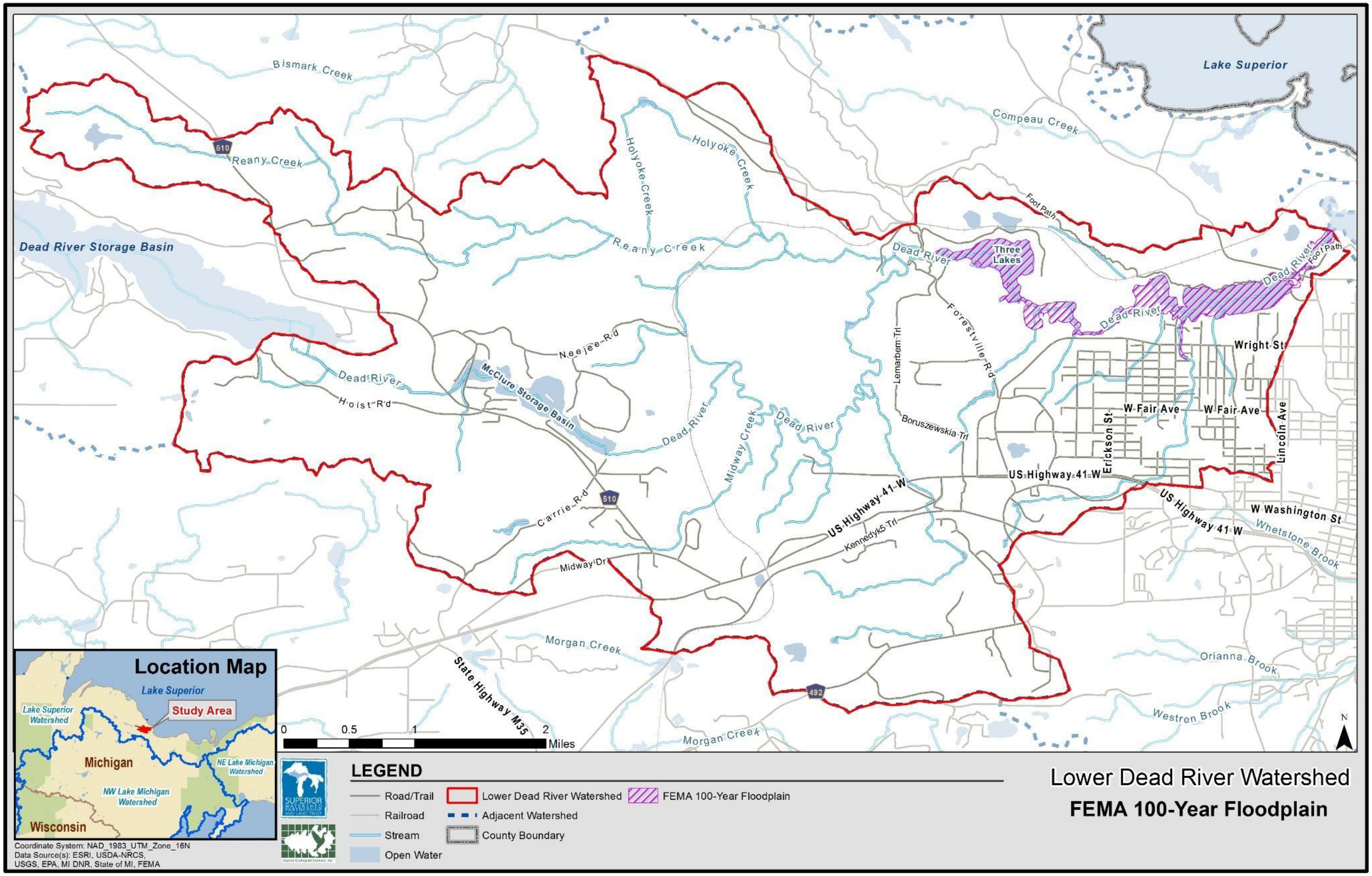

Lower Dead River Watershed
FEMA 100-Year Floodplain
Location Map
Lake Superior
Study Area
Lake Superior Watershed
Michigan
NW Lake Michigan Watershed
NE Lake Michigan Watershed
Wisconsin
LEGEND
Road/Trail
Railroad
Stream
Open Water
Lower Dead River Watershed
Adjacent Watershed
County Boundary
FEMA 100-Year Floodplain
0 0.5 1 2 Miles
Coordinate System: NAD_1983_UTM_Zone_16N
Data Source(s): ESRI, USDA-NRCS, USGS, EPA, MI DNR, State of MI, FEMA
Lake Superior
Bismark Creek
Reany Creek
Dead River Storage Basin
Holyoke Creek
Compeau Creek
Three Lakes
Dead River
Foot Path
Neejee Rd
McClure Storage Basin
Hoist Rd
Carrie Rd
Midway Dr
Midway Creek
Lemarbem Trl
Forestville Rd
Boruszewskia Trl
Kennedyk5 Trl
US Highway 41 W
Wright St
W Fair Ave
Erickson St
Lincoln Ave
W Washington St
Whetstone Brook
Orianna Brook
Westren Brook
Morgan Creek
State Highway M35

Figure 39- FEMA 100-Year Floodplain

3.15 Groundwater Aquifers & Recharge, Contamination Potential, & Water Supply

Groundwater Aquifers and Recharge

Groundwater is water that saturates small spaces between sand, gravel, silt, clay particles, or crevices in underground rocks. Groundwater is found in aquifers or underground formations that provide readily available quantities of water to wells, springs, or streams. Groundwater is important to the Great Lakes ecosystem because it provides a reservoir for storing water and slowly replenishing the lakes in the form of base flow in the tributaries.

Groundwater resources of Marquette County are divided between bedrock aquifers and those in glacial deposits. Depending on location within the county, wells range from less than 100 feet to reach bedrock aquifers in the northern and far southern parts, and up to 200 feet to draw water from glacial deposits in the central part of the county (USGS, 1992 and 1982).

Geology in the Lower Dead River watershed consists of bedrock of Precambrian age, specifically, metamorphic formations in the eastern portion of the watershed and metasedimentary formations in the western portion. As mentioned in the geology section, the Upper Peninsula was glaciated multiple times, resulting in deposition ranging from nothing to over 400 feet. In the watershed, the quaternary geology includes glacial outwash-sand/gravel-postglacial alluvium, coarse-textured glacial till, and thin to discontinuous glacial till over bedrock.

Typically, these bedrock and quaternary geology formations have relatively low yields of groundwater due to their relative lack of storage capacity. The storage capacity and yield of the outwash and till quaternary geology is largely dependent on its thickness. The Precambrian bedrock aquifers have similar characteristics, and hold water in fractures and joints, with bedrock covered in glacial deposits having the most capacity. Groundwater in the area is typically high in iron and hardness.

In the region, the yield from aquifers is generally enough for private wells, which typically draw from small-diameter, shallow wells in glacial outwash. (USGS, 1982)

As the largest municipality in the region, Marquette is unable to meet its water needs through groundwater withdrawals and therefore it draws drinking water from Lake Superior.

Negaunee Township draws from two 12-inch wells at depths of 195’ and 152’ in the glacial outwash sand and gravel.

With the dense, Precambrian bedrock layer acting predominantly as an aquitard, groundwater travels horizontally relatively easily through the glacially deposited quaternary layers. Similar to surface water, groundwater flows through the landscape eventually discharging to the lowest point; typically, a lake or river. Wells can affect this flow by lowering the local water level and creating a gradient where the well is the lowest point, rather than the typical body the groundwater would discharge to. This is called a cone of depression. A combination of water table drawdown due to groundwater withdrawal and hydrological droughts can result in decreasing recharge to streams, lakes, and wetlands.

Soil-water recharge estimates from the MI EGLE show recharge occurs mostly along the western portion of Lower Dead River watershed (Figure 41). These numbers are reported similar to precipitation, in inches per year (Table 18). The lower soil-water balance recharge values across the watershed generally relate to areas of increased urban development such as in eastern portions of the watershed, while higher recharge areas tend to occur where the land is more vegetated.

Table 18- Annual Groundwater Recharge Acreage

Inches/Year	Acres	% of Watershed
10	1,017	6.4
11	5,419	34.1
12	4,691	29.5
13	637	4.0
14	4,114	25.9
Totals	**15,879**	**100**

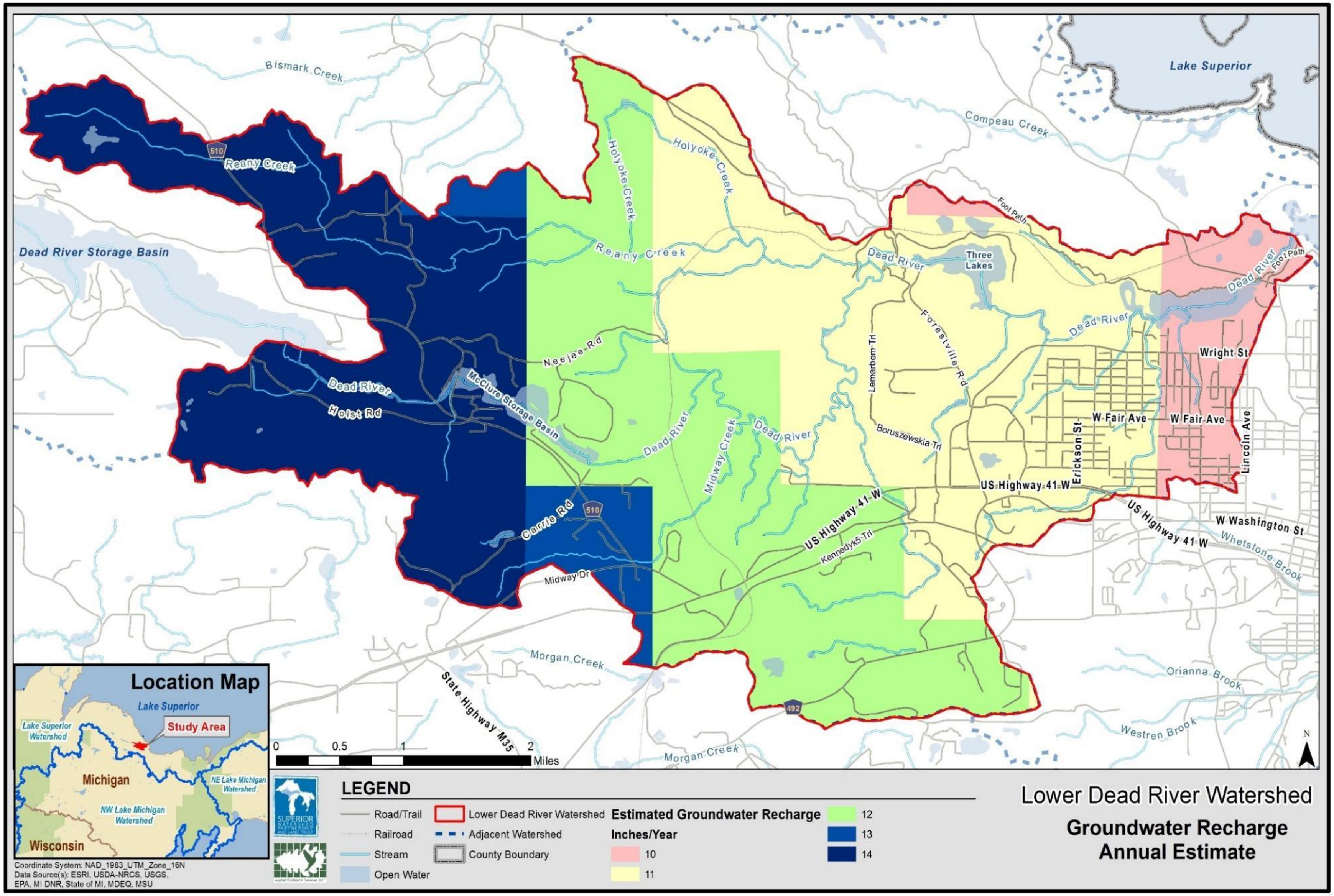

Lake Superior
Bismark Creek
Compeau Creek
Reany Creek
Holyoke Creek
Dead River Storage Basin
Dead River
Three Lakes
Foot Path
Neejee Rd
McClure Storage Basin
Hoist Rd
Midway Creek
Lemarbem Trl
Forestville Rd
Boruszewskia Trl
Wright St
W Fair Ave
Erickson St
Lincoln Ave
US Highway 41 W
W Washington St
Whetstone Brook
Carrio Rd
Kennedy Trl
Midway Dr
Morgan Creek
State Highway M35
Orianna Brook
Westren Brook
Location Map
Study Area
Lake Superior Watershed
Michigan
NE Lake Michigan Watershed
NW Lake Michigan Watershed
Wisconsin
0 0.5 1 2 Miles
Coordinate System: NAD_1983_UTM_Zone_16N
Data Source(s): ESRI, USDA-NRCS, USGS, EPA, MI DNR, State of MI, MDEQ, MSU
LEGEND
Road/Trail
Railroad
Stream
Open Water
Lower Dead River Watershed
Adjacent Watershed
County Boundary
Estimated Groundwater Recharge Inches/Year
10
11
12
13
14
Lower Dead River Watershed
Groundwater Recharge Annual Estimate

Figure 40- Groundwater Recharge Annual Estimate

Groundwater Contamination Potential

According to the US Geological Survey (USGS), unconsolidated and semi-consolidated sand and gravel aquifers, such as those found in the Lower Dead River watershed, are particularly susceptible to contamination. Given that Marquette is the only local municipality that sources drinking water from surface water, while other residents draw from wells, it is important that the groundwater is protected.

EGLE identifies areas which should be targeted for groundwater protection measures. These areas are referred to as Wellhead Protection Areas. Michigan's voluntary Wellhead Protection Program helps communities protect their drinking water by identifying the groundwater contributing area, identifying potential sources of contamination, and developing procedures to manage the area in order to minimize threats. The program includes steps to determine roles within the protection plan, wellhead protection area, potential sources of contamination, determining management plans to prevent contamination, contingency planning, assessing aquifer capacity for new development, and developing a public education program.

Though wellhead protection programs are excellent means of protecting community drinking water, there are still many private wells at risk of contamination. Housing located away from municipalities is typically not accessed by a water or wastewater distribution network, and therefore must incorporate private drinking water wells as well as septic systems. However, in a system where the aquifer is unconfined and composed of unconsolidated material, contaminants can easily travel into drinking water systems, and out of septic treatment systems.

Therefore, it is important for communities to be aware of the potential contaminant sources for their drinking water. Some of those sources are: leaking storage tanks, superfund sites, oil and gas spills, hazardous water generators, groundwater discharges, agricultural operations, septic systems, landfills, industrial and manufacturing facilities, abandoned wells, and others.

Potential problem areas are places where naturally vulnerable areas overlap areas where potential contaminant sources are located. While practices like zoning regulations are effective at preventing the two from overlapping, it is very important that extra diligence is paid to this given the high hydraulic conductivity of the soils and the dependence local residents have on groundwater.

Community Water Supply

Groundwater is an essential resource to the Upper Peninsula as underlying aquifers provide the drinking water supply for many people. According to an EGLE well inventory within Marquette County, since 2000 there have been over 2,500 private water wells drilled. There are two active public water supply wells located within the Lower Dead River watershed, with the City of Marquette drawing from Lake Superior. (Table 19).

Table 19-Community Water Supply

WSSN	Name	Population	Source
04120	Marquette	21,000	SW
04140	Marquette Township	2,700	GW
04655	Negaunee Township	982	GW

4.0 Water Quality Assessment and Pollutant Loading Analysis

4.1 Point and Nonpoint Source Water Quality Pollutants

Water quality can be adversely affected by both point and nonpoint source pollutants. Point sources are identified as any discharge that comes from a pipe or permitted outfall, such as municipal and industrial discharges. Municipal and industrial discharges within the Lower Dead River watershed are regulated by Michigan's National Pollution Discharge Elimination System (NPDES) program and Industrial Pretreatment Program (IPP).

Michigan NPDES Permit Program

The Federal Water Pollution Control Act of 1948 established the first legislation aimed at addressing water pollution. Section 402 of the federal Clean Water Act established the National Pollutant Discharge Elimination System in 1972. This program regulates point source discharges of pollutants into United States waters and sets specific limits on discharges from point sources, establishes monitoring and reporting requirements, and establishes exceptions. The permitting program is designed to prevent storm water runoff from washing harmful pollutants into local surface waters such as streams, rivers, lakes or coastal waters. It also allows for the USEPA to authorize states to assume many of the permitting, administrative, and enforcement responsibilities of the program (USEPA, 2012).

In Michigan, the authority to administer the Federal Water Pollution Control Act was delegated to the Michigan Department of EGLE. While the permitting process has evolved over time the Act has four main tenants:

1. *The discharge of pollutants to navigable waters is not a right.*
2. *A discharge permit is required to use public resources for waste disposal and limits the amount of pollutants that may be discharged.*
3. *Wastewater must be treated with the best treatment technology economically achievable - regardless of the condition of the receiving water.*
4. *Effluent limits must be based on treatment technology performance, but more stringent limits may be imposed if the technology-based limits do not prevent violations of water quality standards in the receiving water.*

EGLE, 2019

A National Pollutant Discharge Elimination System (NPDES) permit is required of anyone discharging waste or wastewater into surface waters in Michigan. Indirect discharges (those who discharge to a municipal treatment facility via a sanitary sewer) do not need an NPDES permit but may require a permit from the municipality under the Industrial Pretreatment Program (IPP). Goals of the Industrial Pretreatment Program include maintaining and restoring watershed quality, encouraging pollution prevention, prevention of poisonous gases forming in sanitary sewer systems, increased beneficial uses of sewage sludge, and helped communities to meet wastewater discharge standards (EGLE, 2019).

NPDES Permit Sites

There are four permitted NPDES sites within the Lower Dead River watershed (Table 20). All four are construction site permits, two of which are held by the Michigan Department of Transportation (MDOT).

Permit Number	Site Name	City
MIR116244	GLFC Marquette	Marquette
MIR114936	MDOT-US-41/M-28 & Brickyard Rd/CR 492	Marquette
MIR115205	MDOT-US-41 & M-28-Marquette Co	Marquette
MIR116002	Wisconsin Electric-Marquette	Marquette

Table 20- NPDES Permitted Sites in Lower Dead River Watershed

Nonpoint Source Pollutants

Nonpoint source pollutants are pollutants that enter a waterway from a source other than a pipe or permitted outfall. Historically these pollutants are the most difficult to control because tracking them back to their source is difficult. Nonpoint source pollutants can include, but are not limited to, illicit discharges into waterways, excess nutrients (such as nitrogen and phosphorus), oils and chemicals washed off of roadways (such as chlorides from deicing agents), and/or excess sediment (from construction sites or streambank destabilization). Most nonpoint source pollutants are monitored via physical-chemical water quality testing.

4.2 Water Quality Report, Designated Use, & Impairments

The Federal Clean Water Act requires Michigan and all other states to submit to the United States Environmental Protection Agency (USEPA) a biannual report of the quality of the state's surface and groundwater resources and an updated Section 303 (d) list. The *Water Quality and Pollution Control in Michigan 2020 Sections 303(d), 305(b), and 314 Integrated Report* was compiled by the EGLE is the most recent of these reports to be finalized.

This report must also describe how Michigan assessed water quality and whether assessed waters meet or do not meet water quality standards specific to each "Designated Use" of a stream or lake as defined in the State of Michigan's Part 4 Rules of the Water Resources Protection Act (Act 451, Part 31). When a waterbody is determined through biological and/or physical-chemical sampling to be impaired, EGLE must list potential causes and sources for impairment in the 303 (d) impaired waters list (EGLE 2020).

Michigan's Water Quality Standards require that all designated uses of surface waters be protected, and those designated uses include: agriculture, navigation, industrial water supply, public water supply at the point of water intake, warmwater or coldwater fish, other indigenous aquatic life and wildlife, fish consumption, partial body contact recreation, and total body contact recreation from May 1 to October 31 (EGLE 2020). Each designated use is associated with particular water quality criteria and sets the standards that a waterbody must meet in order to protect the intended use.

According to EGLE's *Water Quality and Pollution Control in Michigan 2020 Sections 303(d), 305(b), and 314 Integrated Report* (EGLE, 2020), all of the streams and rivers in the Lower Dead River watershed are fully supporting for the agriculture, navigation, and industrial water supply use designations. Holyoke Creek, Reany Creak, Brickyard Creek, Badger Creek, Midway Creek, Dead River and the McClure Storage Reservoir (an impoundment of the Dead River west of Marquette upstream of Carrie Rd) are fully supporting of the other indigenous aquatic and wildlife use designation. The Dead River is not supporting for fish consumption due to mercury found in fish tissue in three locations: 1.) Tourist Park Dam upstream to the powerhouse at west end of Forestville Reservoir (HUC04020105020501), 2.) Dead River (HUC04020105020506), and 3.) McClure Storage Reservoir. A Total Maximum Daily Load Assessment completion date has not been established in the report. The Dead River was assessed as a warm water fishery, but insufficient information was found to make a determination; all other uses for all streams were not assessed. Additionally, the lakes within the Lower Dead River watershed were assessed only for the navigation, agriculture, and industrial water supply uses and all are fully supporting for these uses. Use designations for all waterbodies in the Lower Dead River watershed are summarized in Table 21 (EGLE 2020).

Table 21 Use designations

AUID/Waterbody	Agriculture	Navigation	
040201050205-01/From Tourist Park Dam u/s to the powerhouse at west end of Forestville Reservoir	Full	Full	
040201050205-02/ Holyoke Creek & Reany Creek	Full	Full	
040201050205-03/ Brickyard Creek	Full	Full	
040201050205-04/ Badger Creek	Full	Full	
040201050205-05/ Midway Creek	Full	Full	Full
040201050205-06/ Dead River	Full	Full	Full
040201050205-07/ McClure Storage Reservoir - Impoundment of the Dead River west of Marquette u/s of Carrie Rd	Full	Full	Full
040201050205-NA/ Other Unassessed Rivers/Streams	Full	Full	Full
040201050205-NAL/Lakes	Full	Full	Full

Notes: Abbreviations: Full - Fully Supporting, Not - Not Supporting, NA - Not Assessed, Info - Insufficient Information

(Previous page) Cells highlighted in green fully meet the use designation, cells highlighted in red do not meet the use designation, and the one in yellow shows where there was not enough information to make a determination. All remaining uses were not assessed.

Table 22 Threatened designated uses in the Lower Dead River Watershed

Designated Uses	Source of Threat	Pollutants	Sources
Public water supply	Increased stormwater inputs	Oils, grease, and metals	Urban stormwater runoff
Navigation	Dam impoundments Stream channelization	Sediment	Streambanks
Fish Consumption	Mercury in fish tissue	Atmosphe ric deposition	Nearby coal fired power plants
Cold Water Fishery	Sedimentation Nutrient loading Stream crossings Hydrologic flow Dam impoundments Impervious pavement	Sediment Nutrients Altered hydrologic flow	Stream crossings Streambanks Failing septic systems Residential fertilizer Urban stormwater runoff
Other Indigenous Aquatic Life and Wildlife	Eroding stream crossings Nutrient loading River flooding Transportation/Utility corridors Increased development Loss of riparian vegetation Impervious pavement	Sediment Nutrients Altered hydrologic flow	Stream crossings Streambanks Failing septic systems Residential fertilizer Urban stormwater runoff

Sensitive, Impacted, and Non-Supporting Subwatershed Management Units

The modified watershed vulnerability analysis conducted by Applied Ecological Services compared each SMU's vulnerability to land use or development changes across the Lower Dead River watershed (Section 3.10). Three steps were used to generate a vulnerability ranking of each SMU, which included 1.) 2015 impervious cover classification, 2.) Soil erosion hazard rankings based on NRCS soils data, and 3.) Vulnerability rankings based on current impervious cover and soil erosion hazard rankings (AES 2019). Overall, the Lower Dead River watershed is partially impacted by impervious pavement types. To summarize, thirteen SMUs (SMUs 1-5, 7, 11 – 15, 17, and 20) were classified as Sensitive (including Reany and Holyoke Creek), five as Impacted (SMUs 6, 9, 10, 16, and 25) (including Midway and Brickyard Creek), and seven as Non-Supporting (SMUs 8, 18, 19, and 21 through 24) (including Wolner, Backyard, Badger, and Raney Creek).

Desired Uses

In addition to water quality concerns, desired uses for the Lower Dead River watershed were also identified. A desired use is based on factors important to the watershed community, how residents want to use the watershed, or how they want it to look. The following list identifies the original 2003 desired uses for the watershed:

- Restoration of the designated uses to the Lower Dead River watershed that includes physical improvements and quantifiable protection goals
- Protection of the Dead River system through enforcement of zoning ordinances, buffer strip and setback guidelines, and permanent conservation easements
- Creation of better stormwater management techniques through education/demonstration sites and stormwater ordinances implemented by local municipalities
- Continuation of watershed outreach through bi-annual newsletters, community watershed events, youth education, and volunteer clean ups and monitoring
- Identification of open space planning and low impact development practices that will protect the ecological resources of the watershed.

The most important water quality related activities were identified as a comparison between the Lower Dead River watershed and the Salmon Trout River watershed in the Urban and Rural Watershed Restoration Project 2018 report. These desired uses were identified by compiling social survey data.

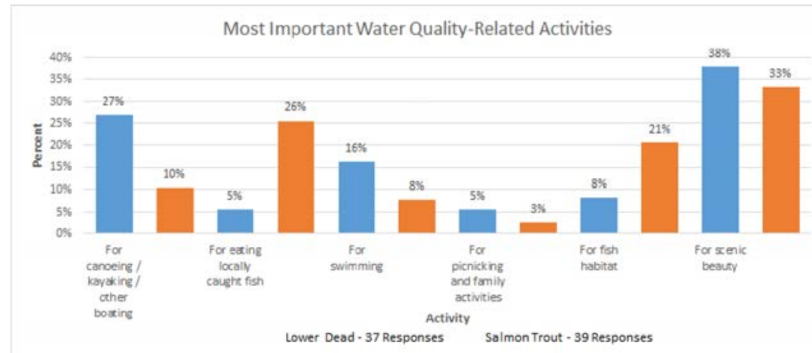


Figure 41 Most Important Water Quality Related Activities

Ecosystem Service Valuations

Ecosystem service values can be used as one way to assess the desired uses of a watershed by quantifying the uses important to watershed stakeholders in monetary terms. The results of the ecosystem services valuation (ESV) assessment involving an April 2017 webinar/workshop and analysis by Key-Log Economics identified the highest ecosystem service values, in terms of their monetary value to humans, in the watershed (Phillips, 2018).

Table 23 Highest ESV by value in the Lower Dead River watershed

1. Food/Nutrition
2. Recreation
3. Protection from Extreme Events
4. Aesthetics

4.3 Physical, Chemical, and Biological Water Quality Monitoring

In Michigan, EGLE manages a number of programs that collect and report physical, chemical, and biological, and habitat monitoring throughout the state in order to assess the health of streams and waterbodies and to determine water quality condition and/or impairment.

Typically, when summarizing water quality data, all sample results taken within the last ten years are analyzed. For the Lower Dead River watershed, there were no water quality data found within that time frame. Looking further back in time, there has only been one stream/river monitoring result and that occurred in 2001. Sampling also occurred at two lake locations. Table 24 lists all known surface water quality data collected in the watershed through 2018 while Figure 43 displays the location of each sample site where the data was collected. In general, the most recent data were analyzed and averaged so that recommendations and management strategies are based on the most current depiction of the water quality and biological conditions.

Only one stream sampling location could be found within the Lower Dead River and only water temperature, dissolved oxygen, pH, and mercury were sampled for. Additionally, there were two lake/reservoir sample sites, which included additional sample parameters, as outlined in Table 24.

Table 24- List of water quality sample locations, dates, and parameters through 2018

Site ID	Organization	WQX Monitoring ID	Monitoring Location/Name	Monitoring Type	Date or Date Range	Water Quality and other Parameters
S01	EGLE	21MICH-520291	DEAD RIVER - GLEC MERCURY PROJECT	Stream	9/12/2001	pH, mercury, dissolved oxygen, water temp
L01	USGS Michigan Water Science Center	USGS-463308087311201, USGS-463308087311202, USGS-463308087311203, USGS-463308087311205, USGS-463308087311206, 21MICH-520217	MCCLURE STOR RES NR MARQUETTE, MI	Lake	5/3/2001, 8/15/2001	Alkalinity, ammonia and ammonium calcium, chloride, chlorophyll a, secchi depth, hardness, hydrogen ion, inorganic nitrogen, kjeldahl nitrogen, magnesium, total nitrogen, organic nitrogen, oxygen, pH, phosphorus, potassium, sodium, specific conductance, sulfate, water temp
L02	EPA National Aquatic Resources Survey (NARS)	NARS_WQX-NLA06608-1654	Forestville Basin	Lake	7/9/2007	Chlorophyll a, conductivity, secchi depth, dissolved oxygen, pH, water temp,

.

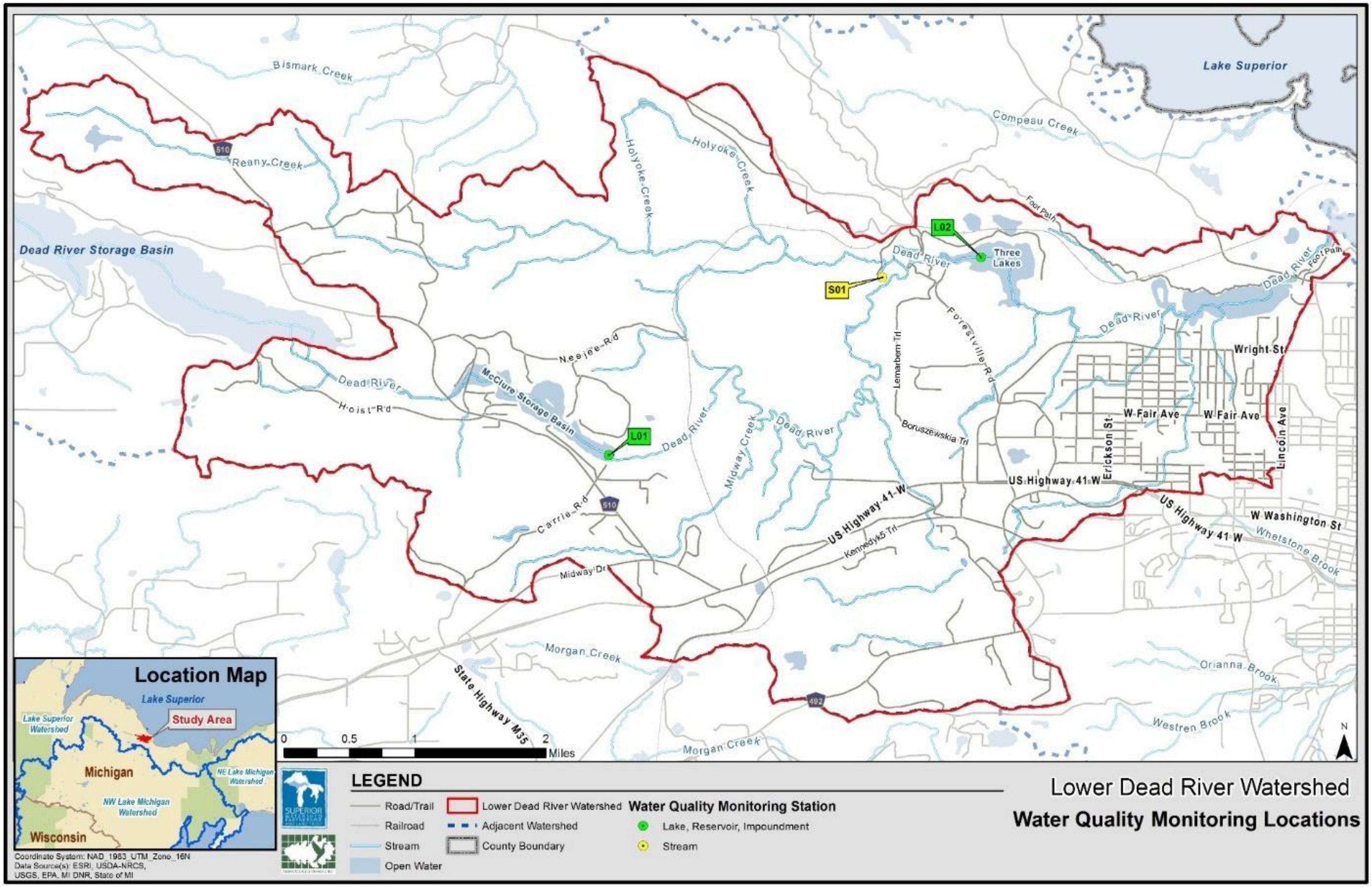


Figure 42- Water Quality Monitoring Locations

Water Chemistry Monitoring

All streams within the Lower Dead River watershed fully support their designated uses with one exception. The Dead River from Tourist Park Dam upstream to the powerhouse at the west end of Forestville Reservoir is not supporting for fish consumption due to mercury found in fish tissue. A Total Maximum Daily Load Assessment and Report has been established.

Tables 25 and 26 summarize the water quality sample results for the Lower Dead River watershed through 2018 and also provide statistical and numerical guidelines for the various criteria. It is important to note that water quality guidelines of streams differ from those of lakes, and these are reflected in the tables. Michigan provides numeric guidelines within its administrative code for many physical and chemical characteristics within Act 451, Part 31 Water Quality Standards (Part 4 Rules). For this report water temperature, dissolved oxygen, pH, and mercury were summarized for streams and water temperature, dissolved oxygen, pH, chlorides, total nitrogen, and total phosphorus were summarized for lakes and reservoirs, based on available data. These parameters were held against Michigan's water quality standards. Michigan has not yet derived its own guidelines for nutrient criteria so USEPA's Ambient Water Quality Criteria Recommendations for Lakes and Reservoirs in Nutrient Ecoregion VIII guidelines (USEPA, 2000) were utilized as a reference standard.

Table 25- Stream sampling parameters, guidelines, and results for Lower Dead River watershed

Parameter	Statistical, Numerical, or General Use Guidelines	Site S01
Temp (F)		MAX

Overall, very little water quality monitoring data exists for the Lower Dead River watershed and what does exist was completed more than ten years ago. All water quality parameters that were sampled for at stream site S01 were summarized in Table 25. While additional physical and chemical criteria were sampled for at the lake/reservoir sites, this report summarizes results only for water temperature, dissolved oxygen, pH, chlorides, total nitrogen, and total phosphorus (Table 26). All other sample results for other sampled parameters at lake/reservoir sites fell within normal values.

Noteworthy- Numeric Water Quality Standards

USEPA has tasked states to establish *numeric* water quality standards for nutrients (phosphorus and nitrogen) in lakes and streams. To date, Michigan has not developed *numeric* standards for phosphorus and nitrogen in streams. *Numeric* criteria have been proposed by USEPA for nutrients based on a reference stream method for the Nutrient-Poor, Largely Glaciated Upper Midwest and Northeast Ecoregion (VIII) which includes the Lower Dead River watershed.

	<74° F*	66
Dissolved Oxygen (DO)	>7.0 mg/l*	AVG 8.2
pH	>6.5 or <9.0*	AVG 7.7
Mercury	0 ug/L*	AVG 0.7

- Cells highlighted in red exceed recommended statistical, numerical, or General Use guidelines, cells in orange are for reference.
- Temperature listed as the maximum value available for each site.

* State of Michigan's Part 4 Rules, Water Quality Standards (of Part 31, Water Resources Protection, of Act 451 of 1994)

Table 26- Lake sampling parameters, guidelines, and results for Lower Dead River watershed.

Parameter	Statistical, Numerical, or General Use Guidelines	Site L01	Site L02
Temp (F)	<85° F*	MAX 71.6	75.7
Dissolved Oxygen (DO)	>5.0 mg/l*	AVG 5.86	5.97

pH	>6.5 or <9.0*	AVG 6.57	7.61
Chlorides	<50 mg/L*	AVG 1	N/A
Total Nitrogen	<0.40 mg/L**	AVG 0.51	N/A
Total Phosphorus (TP)	<0.00969 mg/L**	AVG 0.0131	N/A

- Cells highlighted in red exceed recommended statistical, numerical, or General Use guidelines, cells in orange are for reference.
- Temperature listed as the maximum value available for each site.
* State of Michigan's Part 4 Rules, Water Quality Standards (of Part 31, Water Resources Protection, of Act 451 of 1994)
** Ambient Water Quality Criteria Recommendations Lakes and Reservoirs in Nutrient Ecoregion VIII, USEPA 2000

Generally speaking, there is insufficient sampling data, particularly recently, to draw conclusions about the current water quality conditions in the watershed. Mercury was detected in one sample conducted in 2001 at Site S01, resulting in not supporting the designated use of fish consumption and ultimately in the scheduling of a TMDL for the Lower Dead River in 2022. Total nitrogen and total phosphorus at Site L01 exceed the guidelines set forth in USEPA's Ambient Water Quality Criteria Recommendations Lakes and Reservoirs in Nutrient Ecoregion VIII in two samples taken in 2001. Neither nitrogen or phosphorus were tested for as part of the stream sampling that occurred for the Lower Dead River.

Mercury can be a source of environmental contamination when present in seed dressing fungicides, anti-slime fungicides in pulp and paper industries, by-products of burning coal, mine tailings, wastes from chlorine-alkali industries, and from atmospheric deposition. In 1994, the EPA settled a case with Copper Range Company in White Pine, Michigan due to airborne emissions of excessive amounts of mercury, some of which contaminated "water and surrounding landscape of the Lake Superior Basin" (Brooks, 1993). Whatever the source, mercury finds its way into water sources and can impair a stream or lake's biological community and, in extreme cases, its recreational potential. Most metals are acutely and chronically toxic to all forms of life and have the capacity to bioaccumulate in the food web. There is likely no point source of mercury in the watershed. Rather, atmospheric deposition (from global coal combustion) is a likely source and is not addressed in this planning effort. Again, a TMDL Assessment and Report is scheduled for 2022 to address mercury.

Nutrients such as phosphorus and nitrogen are a necessary component of plant growth and are therefore included in many fertilizers. Unfortunately, both have adverse effects on water quality, with phosphorus being particularly detrimental to aquatic systems in excess quantities. These nutrients are typically applied as fertilizer, either in an agricultural setting or by applicators or residents and the excess nutrients not absorbed by plants are then washed into waterways. Excess nutrients can cause algal blooms, accelerated plant growth, decreasing oxygen levels, and can lead to fish kills. Currently there is no Michigan state standard for nitrogen or phosphorus; however, the USEPA's ambient water quality criteria recommend a concentration of less than 0.44 mg/L for nitrogen and less than 0.012 mg/L for phosphorus.

Biological Monitoring

Biological data can also be used in conjunction with physical-chemical data to determine the health of a waterbody. Michigan utilizes the Great Lakes and Environmental Assessment Section (GLEAS) Procedure 51 protocols for sampling biological communities. This protocol uses a scaled scoring metric as follows (EGLE, 1996):

> +1 = *Community performing better than the average condition found at the excellent sites;*
> 0 = *Community performing between the average condition and (minus) 2 standard deviations from the average condition found at the excellent site;*
> -1 = *Community performing outside of (minus) 2 standarddeviations from the average condition found at the excellent sites.*

EGLE biological monitoring exists for the upper portions of the Dead River, and one 2002 assessment is on record with EGLE for the Lower Dead River watershed which was part of a biological survey of Lake Superior coastal tributaries in Northern Marquette County. In its entirety, the survey included an assessment of macroinvertebrate communities at 27 locations on coastal tributaries in different watersheds. This 2002 EGLE assessment found that five of the main tributaries within the Lower Dead River watershed are relatively high quality and meeting Michigan Water Quality Standards (Godby 2002) (Table 27).

Table 27 Habitat Rating

Stream Branch	Habitat Rating	Macroinvertebrate Rating
Dead River (Bypassed Channel)	Good	Acceptable
Reany Creek	Good	Excellent
Midway Creek	Fair	Excellent
Brickyard Creek	Fair	Acceptable
Badger Creek	Fair	Acceptable

Additional biological monitoring was conducted through Michigan Clean Water Corps' (MiCorps') Volunteer Stream Monitoring Program (VSMP). MiCorps is a network of volunteer water quality monitoring programs in Michigan. It was created through Michigan Executive Order #2003-15 to assist EGLE in collecting and sharing water quality data for use in water resources management and protection programs. MiCorps supports and trains volunteer monitoring organizations interested in monitoring the benthic macroinvertebrate communities in their streams and rivers.

MiCorps conducted one macroinvertebrate survey on the Lower Dead River watershed in November of 2007. The total survey score for this site was 28, with a rank of Fair.

4.4 Pollutant Loading Analysis

In 2016 and 2017, the Superior Watershed Partnership conducted an erosion inventory and riparian restoration summary comparison of the Lower Dead River and Salmon Trout River Watersheds. Nineteen of the Lower Dead River Watershed sites were restored by implementing best management practices for erosion control on streambanks, however, 131 remaining eroding sites remain.

Table 28 Pollutant Load Reduction Estimates for Restored Sites

	N Load (no BMP)	**N Load (with BMP)**	**N Reduction**	**%N Reduction**	**P Load (no BMP)**	**P Load (with BMP)**	**P Reduction**	**%P Reduction**
	lb/year	lb/year	lb/year	%	lb/year	lb/year	lb/year	%
Dead River 2016	11,390.80	11,262.70	128.1	1.1	2,362.30	2,313.00	49.3	2.1
Dead River 2017	11,408.1	11,284.9	123.2	1.1	2,369.0	2,321.5	47.4	2.0
Dead River Total	22,798.9	22,547.6	251.3	2.2	4,731.3	4,634.5	96.7	4.1
	BOD (no BMP)	**BOD (with BMP)**	**BOD Reduction**	**%BOD Reduction**	**Sediment Load (no BMP)**	**Sediment Load (with BMP)**	**Sediment Reduction**	**%Sediment Reduction**
lb/year	lb/year	lb/year	lb/year	%	t/year	t/year	t/year	%
Dead River 2016	41,075.90	40,819.80	256.1	0.6	411.6	317.4	94.2	22.9
Dead River 2017	41,110.6	40,846.1	246.5	0.6	424.3	333.7	90.6	21.4

Dead River Total	82,186.50	81,665.90	502.60	1.20	835.90	651.10	184.80	44.30

5.0 CAUSES/SOURCES OF IMPAIRMENT & REDUCTION TARGETS

5.1 Causes & Sources of Impairment

There are a number of pollutants in the Lower Dead River watershed that adversely affect or threaten designated and desired uses. Pollutant sources and causes were identified by investigating scientific research reports, water quality monitoring data, road/stream crossing inventory data, field observations, land use analysis, and social surveys with watershed residents. Sediment is the greatest pollutant of concern in the Lower Dead River watershed. Sand and sediment harm fish and other aquatic life by covering the natural stream substrate they rely upon. Excessive inputs of sediment also fill in stream channels, making them shallower and wider and more susceptible to changes in hydrologic flow, increases in water temperature, and occasionally problematic for navigation. Sediment is deposited in the low gradient reaches of the Lower Dead River and is released through the river outlet which inhibits spawning habitats, riverine ecosystems, and nearshore indigenous aquatic life. While other sources such as forest management practices in rural areas currently contribute some additional sediment to surface waters, these sources are either minor or not quantified due to unknown history of events. Recreational activities near waterways do have erosion impacts and should continue to be monitored for on-going sediment contributions. New developments have the potential to increase sediment loads as does any kind of excavation, earth moving, drainage, crossing, tunneling, or other activity in which soil is disturbed and transported to nearby streams. In addition, the use of impervious pavement in vulnerable areas that are susceptible to erosion may lead to increased hydrologic flow and flooding problems, as well as increased erosion and urban stormwater runoff.

Heavy metals, nutrients, and toxins (herbicides, pesticides, oils, gas, grease, salts/chloride, etc.) often enter water bodies unnoticed via stormwater runoff, making them difficult to locate and quantify. The potential exists for these pollutants to contaminate both surface water and groundwater sources in the Lower Dead River watershed due to current and anticipated future land uses. These pollutants have the potential to impact Lake Superior terrestrial and aquatic ecosystems as well as public health if concentrations are high enough. Heavy metals, nutrients and toxins often attach to soil particles, thus linking them to sediment pollution. Mercury levels exceeding water quality standards for fish consumption were detected in the Lower Dead River from Tourist Park Dam upstream to the powerhouse at the west end of Forestville Reservoir, the Lower Dead River (HUC04020105020506), and the McClure Storage Reservoir. This section of the watershed is not supporting for fish consumption due to mercury found in fish tissue. Mercury contamination is a widespread problem in waterbodies across the Upper Peninsula of Michigan and should be monitored during future stream evaluations. Methods to determine the presence and extent of mercury and the other potential pollutants listed above were not employed during this project.

Table 29 Known and potential pollutants, sources, and causes in the Lower Dead River watershed

<table>
<tr><th>Threatened Designated Uses</th><th>Pollutants</th><th>Sources</th><th>Causes</th></tr>
<tr><td rowspan="5">Coldwater fishery

Other indigenous aquatic life and wildlife

Navigation</td><td rowspan="5">Sediment (k, p)</td><td>Road stream crossings (k)</td><td>Poor design/construction/maintenance (k)
Lack of erosion controls (k)
Steep approaches (k)
Culverts not aligned to stream bed (k)
Undersized culverts (k)
Lack of crossing structure (k)
Road grading operations (k)</td></tr>
<tr><td>Forest management practices (p)</td><td>Removal of riparian vegetation (lack of riparian buffers) (p)
Clearing by landowners (p)
Equipment problems due to steep topography (p)
Numerous crossings of small streams and drainage routes (p)</td></tr>
<tr><td>Recreational activities (p)</td><td>Recreational trails near wetlands and streams (p)</td></tr>
<tr><td>Development (p)</td><td>Removal of riparian vegetation (lack of riparian buffers) (p)
Construction of industrial sites and roads (p)
Clearing by landowners (p)
Construction of secondary access roads (p)
Removal of vegetation and topsoil to excavate for a quarry (p)</td></tr>
<tr><td>Stormwater runoff (p)</td><td>Impervious surfaces (p)
Lack of stormwater management BMPs (p)
Unsuitable sites/soils (p)</td></tr>
</table>

Fish consumption Coldwater fishery Other indigenous aquatic life and wildlife Public water supply (groundwater)	Heavy metals (mercury and others) (p)	Atmospheric deposition (p)	Nearby coal fired power plants (p) Other industries (p) Forest fires (p) Use of burn barrels (p)
		Stormwater runoff (p)	Runoff from industrial/commercial lots (p) Highway runoff contaminants (p)
Fish consumption Coldwater fishery Other indigenous aquatic life and wildlife Public water supply (groundwater)	Nutrients (p)	Septic systems (p)	Poorly designed/maintained systems (p) Unsuitable sites/soils (p)
		Residential fertilizer use (p)	Improper application (amount, timing, frequency, location, method, chemical content) (p)
		Forest management practices (p)	Improper application (amount, timing, frequency, location, method, chemical content) (p) Hazardous waste spills from heavy equipment (p)
		Pet and yard waste (p)	Animal waste concentrated on public parks and near waterways, trails, and beaches
Coldwater fishery Other indigenous aquatic life and wildlife Public water supply (groundwater)	Toxins (herbicides, pesticides, oils, gas, grease, salts/chloride, etc.) (p)	Atmospheric deposition (p)	Use of burn barrels (p)
		Stormwater runoff (p)	Road salt application (p) Improper application (amount, timing, frequency, location, method, chemical content) (p)

Coldwater fishery Other indigenous aquatic life and wildlife	Altered hydrologic flow (p)	Stormwater runoff (p)	Impervious surfaces (p) Unsuitable sites/soils (p)
		Channelization (p)	Poorly designed stormwater management and use of impervious pavement (p) Unsuitable sites/soils (p)

k=known, p=potential

5.2 Critical Areas, Management Measures & Estimated Impairment Reductions

Critical areas in the Lower Dead watershed are defined as the portions of the watershed that are most sensitive to environmental degradation and those areas having the most impact or potential to impact water quality and designated and desired uses. They include areas that may contribute the greatest amount of pollutants to the watershed, either now or in the future, and where preservation and restoration efforts will have the most profound results. Critical areas were identified through a detailed analysis concerning protection potential, current and future land uses, pollutant loading, and anticipated load reductions from particular Best Management Practices. The goal of this analysis was to target specific strategies to areas most in need of protection or restoration. It should be noted that these critical areas are by no means the only areas in need of protection and restoration efforts; they are simply those with the highest priority. Without implementation of the strategies outlined under the Goals and Objectives section of this management plan, the future negative impacts in critical areas of the Lower Dead River watershed will be significant and the mitigation very costly.

The first goal of the watershed planning process is restoration: to identify and improve areas of sedimentation, erosion, fish passage barriers, and stormwater runoff contributing to the decline of water quality and aquatic habitat in the Lower Dead River watershed. Critical areas with sediment issues to be addressed include sites with a severe lateral recession rate throughout the watershed (Figure 43). These areas are impacted by frequent human use and recreation causing damage to aquatic habitats.

The second goal is monitoring and prevention: to create and/or continue watershed and land conservation programs and develop better stormwater management techniques that will help to protect the water quality and aquatic habitat in the Lower Dead River watershed. Critical areas in need of monitoring and prevention with a higher risk for stormwater pollution were determined by the impervious cover estimate, erosion hazard, and vulnerability assessment. To summarize, thirteen SMUs (SMUs 1-5, 7, 11 – 15, 17, and 20) were classified as Sensitive, five as Impacted (SMUs 6, 9, 10, 16, and 25), and seven as Non-Supporting (SMUs 8, 18, 19, and 21 through 24) based on 2015 impervious cover estimates. Sensitive SMUs were generally located in the northwestern portions of the watershed where relatively little development has taken place. The Impacted SMUs lie towards the southwest and surrounding the outskirts of the most developed portions of the watershed in and around Marquette, while the Non-Supporting SMUs fall within the most urbanized portions of Marquette, along the eastern portions of the watershed.

The third goal is planning: to identify open space planning and low impact development practices in order to protect ecological resources while still supporting economic and social growth within the community. Careful planning is crucial for the preservation of natural areas in the watershed. Critical areas for the protection of ecological resources include existing natural areas as well as wetlands, riparian areas, and coastal habitats. 735 acres of property have at least some level of protection from development. These include the Iron Ore Heritage Trail (4.1 acres), private easements (18.4 acres), Gwinn State Forest Area (3.0 acres), and conservation and recreation land owned by the Marquette Board of Light and Power (710 acres).

In general, forested areas in the northwest portion of the watershed likely have the highest potential for high quality habitat. This same area is the least-developed area of the watershed and contains the headwaters of most of the streams including: Reany, Holyoke and Midway Creeks.

The fourth goal is to align with the regional vision: to create a watershed management plan that assists in the realization of the vision for Lake Superior as defined by the Lake Superior Binational Forum. Critical areas for aligning with the regional vision for the great lake include coastal wetlands, aquatic biological communities, riparian biological communities, coastal terrestrial habitats, and all tributaries.

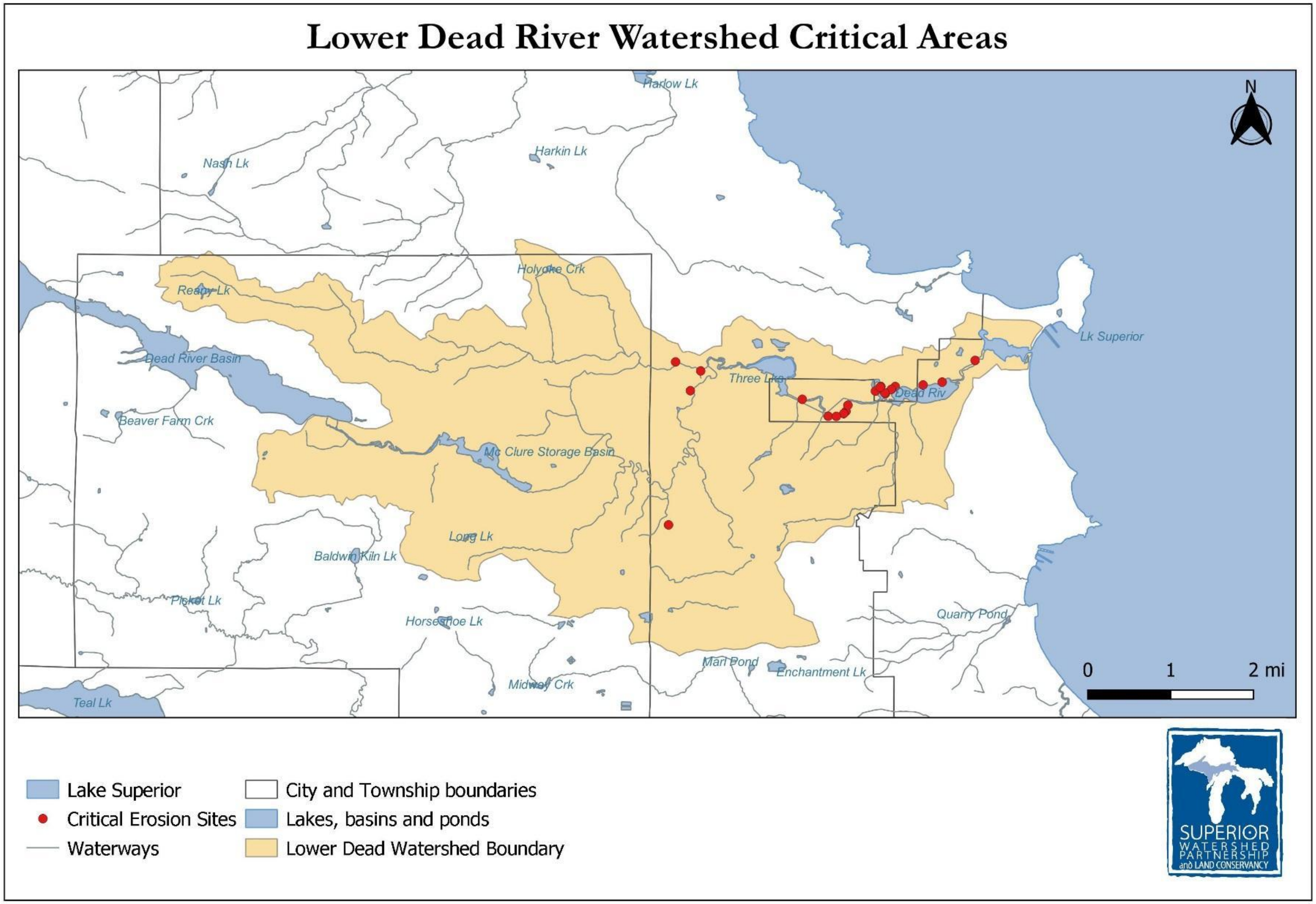


Figure 43 Lower Dead River Critical Areas

5.3 Watershed Impairment Reduction Targets

In a 2017 assessment of streambank erosion, 131 sites were identified with a range of slight, moderate and severe erosion for a total or 2,843.6 feet of identified eroding streambanks (Table 30; Figure 44). This streambank erosion inventory was estimated by measuring and quantifying eroding streambanks in the field, and the annual sediment loads were calculated using the Spreadsheet Tool for Estimating Pollutant Loads (STEPL). This is different from the modified vulnerability analysis used to compare subwatershed management unit (SMU) land use classifications (based on data from the National Land Cover Database (NLCD) which is derived from classifying Landsat satellite imagery with a 30-meter spatial resolution).and NRCS soils data. The former analysis resulted in impervious cover estimates, erosion hazard factors, and vulnerability rankings (Table 12, Figure 21).

Table 30 - 2017 Lower Dead River Erosion Inventory Sites (not restored)

Priority Rank	Waypoint #	Length (ft)	Height (ft)	Lateral Recession Category	Rate Range (ft/yr)	Rate (ft/yr)	BMP Efficiency (0-1)	Soil Textural Class	Soil Dry Weight (ton/ft^3)	Nutrient Correction Factor	Annual Load (ton)	STEPL Estimated Load Reduction (t/y)
1	DRE87	62.3	40	Severe	0.3 - 0.5	0.5	0.95	Fine Sandy loam	0.05	0.85	62.3	59.2
2	DRE06	40.6	22.8	Severe	0.3 - 0.5	0.5	0.95	Sands, Loamy sands	0.055	0.85	25.5	24.2
3	DRE43	43.3	24	Severe	0.3 - 0.5	0.4	0.95	Sands, Loamy sands	0.0575	0.85	23.9	22.7
4	DRE76	43	23	Severe	0.3 - 0.5	0.3	0.95	Sands, Loamy sands	0.06	0.85	17.8	16.9
5	DRE32	42.9	14.1	Severe	0.3 - 0.5	0.5	0.95	Sands, Loamy sands	0.0575	0.85	17.4	16.5
6	DRE27	63.6	16.3	Severe	0.3 - 0.5	0.3	0.95	Sands, Loamy sands	0.055	0.85	17.1	16.2
7	DRE73	58.5	15	Severe	0.3 - 0.5	0.5	0.95	Clay loam	0.0375	1.15	16.5	15.6
8	DRE74	68.3	10.8	Severe	0.3 - 0.5	0.4	0.95	Loams, sandy clay loams	0.045	0.85	13.3	12.6
9	DRE45	21.3	19.7	Severe	0.3 - 0.5	0.5	0.95	Sands, Loamy sands	0.0575	0.85	12.1	11.5
10	DRE41	67.8	9.3	Severe	0.3 - 0.5	0.4	0.95	Loams, sandy clay loams	0.045	0.85	11.3	10.8
11	DRE37	43.1	11.7	Severe	0.3 - 0.5	0.4	0.95	Sands, Loamy sands	0.055	0.85	11.1	10.5
12	DRTE08	36.4	17	Severe	0.3 - 0.5	0.3	0.95	Fine Sandy loam	0.05	0.85	9.3	8.8

13	RCE17	14.6	25	Severe	0.3 - 0.5	0.5	0.95	Fine Sandy loam	0.05	0.85	9.1	8.7
14	DRE75	23.9	20.8	Severe	0.3 - 0.5	0.3	0.95	Fine Sandy loam	0.05	0.85	7.5	7.1
15	DRE29	31.3	13.3	Severe	0.3 - 0.5	0.3	0.95	Sands, Loamy sands	0.055	0.85	6.9	6.5
16	DRE42	29.5	10.2	Severe	0.3 - 0.5	0.5	0.95	Loams, sandy clay loams	0.045	0.85	6.8	6.4
17	DRE71	19.8	13.8	Severe	0.3 - 0.5	0.4	0.95	Sands, Loamy sands	0.06	0.85	6.6	6.2
18	DRE98	21.3	20	Severe	0.3 - 0.5	0.3	0.95	Fine Sandy loam	0.05	0.85	6.4	6.1
19	DRE79	19.7	20	Severe	0.3 - 0.5	0.3	0.95	Fine Sandy loam	0.05	0.85	5.9	5.6
20	DRE44	18.4	17.9	Severe	0.3 - 0.5	0.3	0.95	Sands, Loamy sands	0.0575	0.85	5.7	5.4
21	DRE25	20.5	21.7	Moderate	0.06 - 0.2	0.2	0.95	Sands, Loamy sands	0.055	0.85	4.9	4.6
22	DRE01	45	6	Severe	0.3 - 0.5	0.3	0.95	Sands, Loamy sands	0.055	0.85	4.5	4.2
23	RCE19	50	4.7	Severe	0.3 - 0.5	0.4	0.95	Sandy loam	0.045	0.85	4.2	4.0
24	DRE02	24	7.5	Severe	0.3 - 0.5	0.5	0.95	Sandy loam	0.045	0.85	4.1	3.8
25	DRE78	18.6	14	Severe	0.3 - 0.5	0.3	0.95	Fine Sandy loam	0.05	0.85	3.9	3.7
26	DRE99	18.7	15	Severe	0.3 - 0.5	0.3	0.95	Sandy clay	0.045	0.85	3.8	3.6
27	DRE72	17.75	20.1	Moderate	0.06 - 0.2	0.2	0.95	Fine Sandy loam	0.05	0.85	3.6	3.4
28	RCE01	68	5	Moderate	0.06 - 0.2	0.2	0.95	Fine Sandy loam	0.05	0.85	3.4	3.2
29	DRE96	37	6	Severe	0.3 - 0.5	0.3	0.95	Fine Sandy loam	0.05	0.85	3.3	3.2
30	RCE02	32	5	Severe	0.3 - 0.5	0.5	0.95	Silty clay loam, silty clay	0.04	1	3.2	3.0
31	RCE25	63	4.4	Moderate	0.06 - 0.2	0.2	0.95	Sands, Loamy sands	0.055	0.85	3.0	2.9
32	DRE40	16.7	8	3. Severe	0.3 - 0.5	0.5	0.95	Sandy clay	0.045	0.85	3.0	2.9
33	DRE22	30.3	4.5	3. Severe	0.3 - 0.5	0.4	0.95	Sands, Loamy sands	0.055	0.85	3.0	2.8
34	RCE18	38	7	Moderate	0.06 - 0.2	0.2	0.95	Sands, Loamy sands	0.055	0.85	2.9	2.8
35	DRE68	49.9	11.5	Moderate	0.06 - 0.2	0.1	0.95	Fine Sandy loam	0.05	0.85	2.9	2.7
36	DRE46	17.1	9.5	Severe	0.3 - 0.5	0.3	0.95	Sands, Loamy sands	0.0575	0.85	2.8	2.7
37	DRE49	23	6	Severe	0.3 - 0.5	0.4	0.95	Fine Sandy loam	0.05	0.85	2.8	2.6
38	DRE65	27.5	5	Severe	0.3 - 0.5	0.4	0.95	Fine Sandy loam	0.05	0.85	2.8	2.6
39	DRE47	13.8	13	Severe	0.3 - 0.5	0.3	0.95	Fine Sandy loam	0.05	0.85	2.7	2.6

40	RCE24	28.3	4.2	Severe	0.3 - 0.5	0.4	0.95	Sands, Loamy sands	0.055	0.85	2.6	2.5
41	DRE63	20	5	Severe	0.3 - 0.5	0.5	0.95	Fine Sandy loam	0.05	0.85	2.5	2.4
42	RCE27	18	5	Severe	0.3 - 0.5	0.5	0.95	Sands, Loamy sands	0.055	0.85	2.5	2.4
43	RCE20	18.3	4.5	Severe	0.3 - 0.5	0.5	0.95	Sands, Loamy sands	0.0575	0.85	2.4	2.2
44	DRE17	58.8	2	Severe	0.3 - 0.5	0.5	0.95	Silty clay loam, silty clay	0.04	1	2.4	2.2
45	RCE13	24.3	4.2	Severe	0.3 - 0.5	0.4	0.95	Sands, Loamy sands	0.055	0.85	2.2	2.1
46	RCE23	23.3	5.5	Severe	0.3 - 0.5	0.3	0.95	Sands, Loamy sands	0.0575	0.85	2.2	2.1
47	DRE50	48.6	4	Moderate	0.06 - 0.2	0.2	0.95	Sands, Loamy sands	0.055	0.85	2.1	2.0
48	RCE08	22.6	5.3	Severe	0.3 - 0.5	0.3	0.95	Sands, Loamy sands	0.055	0.85	2.0	1.9
49	DRTE05	10.7	16.5	Moderate	0.06 - 0.2	0.2	0.95	Loams, sandy clay loams	0.055	0.85	1.9	1.8
50	RCE05	15	12	Moderate	0.06 - 0.2	0.2	0.95	Fine Sandy loam	0.05	0.85	1.8	1.7
51	DRE56	23.8	3	Severe	0.3 - 0.5	0.5	0.95	Fine Sandy loam	0.05	0.85	1.8	1.7
52	RCE04	7	12	Severe	0.3 - 0.5	0.4	0.95	Fine Sandy loam	0.05	0.85	1.7	1.6
53	DRE66	53	1.5	Severe	0.3 - 0.5	0.4	0.95	Fine Sandy loam	0.05	0.85	1.6	1.5
54	RCE09	35	2	Severe	0.3 - 0.5	0.5	0.95	Sandy clay	0.045	0.85	1.6	1.5
55	DRE54	15.5	6	Severe	0.3 - 0.5	0.3	0.95	Sands, Loamy sands	0.055	0.85	1.5	1.5
56	DRE88	44.7	17	Slight	0.01 - 0.05	0.05	0.95	Silty clay loam, silty clay	0.04	1	1.5	1.4
57	DRE85	14	18	Moderate	0.06 - 0.2	0.1	0.95	Sands, Loamy sands	0.06	0.85	1.5	1.4
58	RCE16	8.7	6.8	Severe	0.3 - 0.5	0.5	0.95	Loams, sandy clay loams	0.045	0.85	1.3	1.3
59	RCE14	26.6	3	Severe	0.3 - 0.5	0.3	0.95	Sands, Loamy sands	0.055	0.85	1.3	1.3
60	DRE48	8.5	9.7	Severe	0.3 - 0.5	0.3	0.95	Fine Sandy loam	0.05	0.85	1.2	1.2
61	DRTE07	13.2	4.5	Severe	0.3 - 0.5	0.4	0.95	Fine Sandy loam	0.05	0.85	1.2	1.1
62	DRE60	19	2.5	Severe	0.3 - 0.5	0.5	0.95	Fine Sandy loam	0.05	0.85	1.2	1.1
63	DRE05	23.5	22.1	Slight	0.01 - 0.05	0.05	0.95	Loams, sandy clay loams	0.045	0.85	1.2	1.1
64	DRE58	51	1.5	Severe	0.3 - 0.5	0.3	0.95	Fine Sandy loam	0.05	0.85	1.1	1.1

65	RCE15	26	4	Moderate	0.06 - 0.2	0.2	0.95	Fine Sandy loam	0.05	0.85	1.0	1.0
66	DRE39	16.4	6.7	Moderate	0.06 - 0.2	0.2	0.95	Loams, sandy clay loams	0.045	0.85	1.0	0.9
67	RCE22	15	3.7	Severe	0.3 - 0.5	0.3	0.95	Sands, Loamy sands	0.0575	0.85	1.0	0.9
68	DRE94	86.7	4	Slight	0.01 - 0.05	0.05	0.95	Sands, Loamy sands	0.055	0.85	1.0	0.9
69	DRE14	44.5	7.5	Slight	0.01 - 0.05	0.05	0.95	Sands, Loamy sands	0.055	0.85	0.9	0.9
70	DRE70	5.5	14.8	Moderate	0.06 - 0.2	0.2	0.95	Sands, Loamy sands	0.055	0.85	0.9	0.9
71	DRE13	11.2	5.8	Severe	0.3 - 0.5	0.3	0.95	Loams, sandy clay loams	0.045	0.85	0.9	0.8
72	DRE12	8.8	5.4	Severe	0.3 - 0.5	0.4	0.95	Loams, sandy clay loams	0.045	0.85	0.9	0.8
73	DRE20	18.4	13.2	Slight	0.01 - 0.05	0.05	0.95	Sands, Loamy sands	0.0575	0.85	0.7	0.7
74	RCE07	10.5	6	Moderate	0.06 - 0.2	0.2	0.95	Sands, Loamy sands	0.055	0.85	0.7	0.7
75	RCE26	19.5	3.9	Moderate	0.06 - 0.2	0.2	0.95	Fine Sandy loam	0.045	0.85	0.7	0.7
76	DRE77	10.2	6	Moderate	0.06 - 0.2	0.2	0.95	Sands, Loamy sands	0.055	0.85	0.7	0.6
77	DRE82	21.6	11.4	Slight	0.01 - 0.05	0.05	0.95	Fine Sandy loam	0.05	0.85	0.6	0.6
78	DRE97	6	20	Moderate	0.06 - 0.2	0.1	0.95	Fine Sandy loam	0.05	0.85	0.6	0.6
79	DRE23	15.3	6.3	Moderate	0.06 - 0.2	0.1	0.95	Sands, Loamy sands	0.055	0.85	0.5	0.5
80	RCE10	33.4	1.7	Moderate	0.06 - 0.2	0.2	0.95	Loams, sandy clay loams	0.045	0.85	0.5	0.5
81	DRE64	4	6	Severe	0.3 - 0.5	0.4	0.95	Fine Sandy loam	0.05	0.85	0.5	0.5
82	DRE83	15.7	10.5	Slight	0.01 - 0.05	0.05	0.95	Sands, Loamy sands	0.055	0.85	0.5	0.4
83	DRE30	6.7	4	Moderate	0.06 - 0.2	0.4	0.95	Silty clay loam, silty clay	0.04	1	0.4	0.4
84	DRE57	4	4.5	Moderate	0.06 - 0.2	0.4	0.95	Sands, Loamy sands	0.0575	0.85	0.4	0.4
85	DRE69	20.2	4.5	Moderate	0.06 - 0.2	0.1	0.95	Loams, sandy clay loams	0.045	0.85	0.4	0.4
86	RCE11	7.2	2.4	Severe	0.3 - 0.5	0.4	0.95	Sands, Loamy sands	0.055	0.85	0.4	0.4
87	DRE17	35.2	3.9	Slight	0.01 - 0.05	0.05	0.95	Sands, Loamy sands	0.055	0.85	0.4	0.4

88	DRTE06	23	3	Moderate	0.06 - 0.2	0.1	0.95	Fine Sandy loam	0.05	0.85	0.3	0.3
89	DRE21	30.6	2.5	Moderate	0.06 - 0.2	0.1	0.95	Loams, sandy clay loams	0.045	0.85	0.3	0.3
90	RCE06	10.7	3	Moderate	0.06 - 0.2	0.2	0.95	Loams, sandy clay loams	0.045	0.85	0.3	0.3
91	DRE81	7	4	Moderate	0.06 - 0.2	0.2	0.95	Fine Sandy loam	0.05	0.85	0.3	0.3
92	RCE12	35.7	2.4	Slight	0.01 - 0.05	0.05	0.95	Sands, Loamy sands	0.055	0.85	0.2	0.2
93	DRE80	6.4	13.5	Slight	0.01 - 0.05	0.05	0.95	Fine Sandy loam	0.05	0.85	0.2	0.2
94	DRE15	24.1	3.9	Slight	0.01 - 0.05	0.05	0.95	Loams, sandy clay loams	0.045	0.85	0.2	0.2
95	DRTE02	41.3	2	Slight	0.01 - 0.05	0.05	0.95	Fine Sandy loam	0.05	0.85	0.2	0.2
96	DRE09	11.1	8.4	Slight	0.01 - 0.05	0.05	0.95	Silty clay loam, silty clay	0.04	1	0.2	0.2
97	DRE95	7	8	Slight	0.01 - 0.05	0.05	0.95	Sands, Loamy sands	0.06	0.85	0.2	0.2
98	DRE31	4.3	2.4	Severe	0.3 - 0.5	0.4	0.95	Silty clay loam, silty clay	0.04	1	0.2	0.2
99	DRE55	16.4	2	Moderate	0.06 - 0.2	0.1	0.95	Fine Sandy loam	0.05	0.85	0.2	0.2
100	DRE67	10.5	3	Moderate	0.06 - 0.2	0.1	0.95	Fine Sandy loam	0.05	0.85	0.2	0.1
101	DRTE01	29.3	2	Slight	0.01 - 0.05	0.05	0.95	Fine Sandy loam	0.05	0.85	0.1	0.1
102	DRE93	5	11.6	Slight	0.01 - 0.05	0.05	0.95	Fine Sandy loam	0.05	0.85	0.1	0.1
103	DRE89	9.2	7.8	Slight	0.01 - 0.05	0.05	0.95	Silty clay loam, silty clay	0.04	1	0.1	0.1
104	DRE84	10	6	Slight	0.01 - 0.05	0.05	0.95	Loams, sandy clay loams	0.045	0.85	0.1	0.1
105	RCE03	7.4	7	Slight	0.01 - 0.05	0.05	0.95	Fine Sandy loam	0.05	0.85	0.1	0.1
106	DRE62	6	4	Moderate	0.06 - 0.2	0.1	0.95	Fine Sandy loam	0.05	0.85	0.1	0.1
107	DRE53	8.5	2.5	Moderate	0.06 - 0.2	0.1	0.95	Fine Sandy loam	0.05	0.85	0.1	0.1
108	DRE19	7.3	4.6	Moderate	0.01 - 0.05	0.05	0.95	Sands, Loamy sands	0.055	0.85	0.1	0.1
109	DRE11	11.9	3.4	Moderate	0.01 - 0.05	0.05	0.95	Loams, sandy clay loams	0.045	0.85	0.1	0.1
110	DRE59	3	3	Moderate	0.06 - 0.2	0.2	0.95	Fine Sandy loam	0.05	0.85	0.1	0.1
111	DRE16	11.6	3.2	Slight	0.01 - 0.05	0.05	0.95	Loams, sandy clay loams	0.045	0.85	0.1	0.1
112	DRE10	4.8	8.1	Slight	0.01 - 0.05	0.04	0.95	Loams, sandy clay loams	0.045	0.85	0.1	0.1
113	DRE90	5	6.8	Slight	0.01 - 0.05	0.05	0.95	Silty clay loam, silty clay	0.04	1	0.1	0.1

114	DRE92	8.2	4	Slight	0.01 - 0.05	0.05	0.95	Silty clay loam, silty clay	0.04	1	0.1	0.1
115	DRE61	3	2	Moderate	0.06 - 0.2	0.2	0.95	Fine Sandy loam	0.05	0.85	0.1	0.1
116	DRTE03	10.8	2	Slight	0.01 - 0.05	0.05	0.95	Fine Sandy loam	0.05	0.85	0.1	0.1
117	DRE07	3.3	6.5	Slight	0.01 - 0.05	0.05	0.95	Silty clay loam, silty clay	0.04	1	0.04	0.04
118	DRE91	3.6	5.9	Slight	0.01 - 0.05	0.05	0.95	Silty clay loam, silty clay	0.04	1	0.04	0.04
119	DRTE04	5	3	Slight	0.01 - 0.05	0.05	0.95	Fine Sandy loam	0.05	0.85	0.04	0.04
120	DRE52	1.4	4.7	Moderate	0.06 - 0.2	0.1	0.95	Fine Sandy loam	0.05	0.85	0.03	0.03
121	DRE51	2	2	Moderate	0.06 - 0.2	0.1	0.95	Fine Sandy loam	0.05	0.85	0.02	0.02
122	DRE86	2	3	Slight	0.01 - 0.05	0.05	0.95	Sands, Loamy sands	0.0575	0.85	0.02	0.02
123	DRE08	3.3	2.6	Slight	0.01 - 0.05	0.05	0.95	Silty clay loam, silty clay	0.04	1	0.02	0.02
Total		2,843.6										400.5 t/y

Pollution Load Reduction Estimates

In addition to sediment, STEPL also computes watershed surface runoff; nutrient loads, including nitrogen, phosphorus, and 5-day biological oxygen demand (BOD5); and sediment delivery based on various land uses and management practices. Using STEPL and watershed-wide land use data, a watershed wide pollution load was calculated for Nitrogen (N), Phosphorus (P), Biological Oxygen Demand (BOD) and sediment based on current land use data (Table 31).

Table 31 Pollutant Load Reduction Estimates for the Erosion Inventory Sites (not restored)

	N Load (no BMP)	**N Load (with BMP)**	**N Reduction**	**%N Reduction**	**P Load (no BMP)**	**P Load (with BMP)**	**P Reduction**	**%P Reduction**
	lb/year	lb/year	lb/year	%	lb/year	lb/year	lb/year	%
Dead River Total	38,497.3	37,944	553.3	1.4%	6,384.7	6,171.7	213.1	3.3%
	BOD (no BMP)	**BOD (with BMP)**	**BOD Reduction**	**%BOD Reduction**	**Sediment Load (no BMP)**	**Sediment Load (with BMP)**	**Sediment Reduction**	**%Sediment Reduction**
	lb/year	lb/year	lb/year	%	t/year	t/year	t/year	%
Dead River Total	143,004.3	141,897.6	1,106.7	0.77%	2,271.8	1,833.5	400.5	17.6%

Priority Pollutant Ranking

The pollutants listed in Table 32 were ranked and prioritized based on how they most affect or have the potential to affect water quality and the watershed's threatened designated uses (Table 29). Overall, sediment is the highest priority pollutant with known sources occurring from most land uses within the watershed. Without implementation of corrective actions at degraded sites, improved zoning ordinances, and improved land use practices, sedimentation problems will likely result in further degradation of water quality and designated and desired uses. Impacts from nutrients (septic, residential fertilizer, etc.) pose a significant threat to designated and desired watershed uses. The potential for impacts from heavy metals and toxins also pose threats to water quality and designated uses in the Lower Dead River watershed. Future water quality monitoring efforts should include periodic sampling for these pollutants. While each pollutant has a different effect on water quality and threatened designated uses, all are important and should be priorities for periodic monitoring.

Table 32 Priority Pollutant Ranking

Pollutant	**Priority Ranking**

Sediment	1
Nutrients	2
Heavy metals, toxins	3

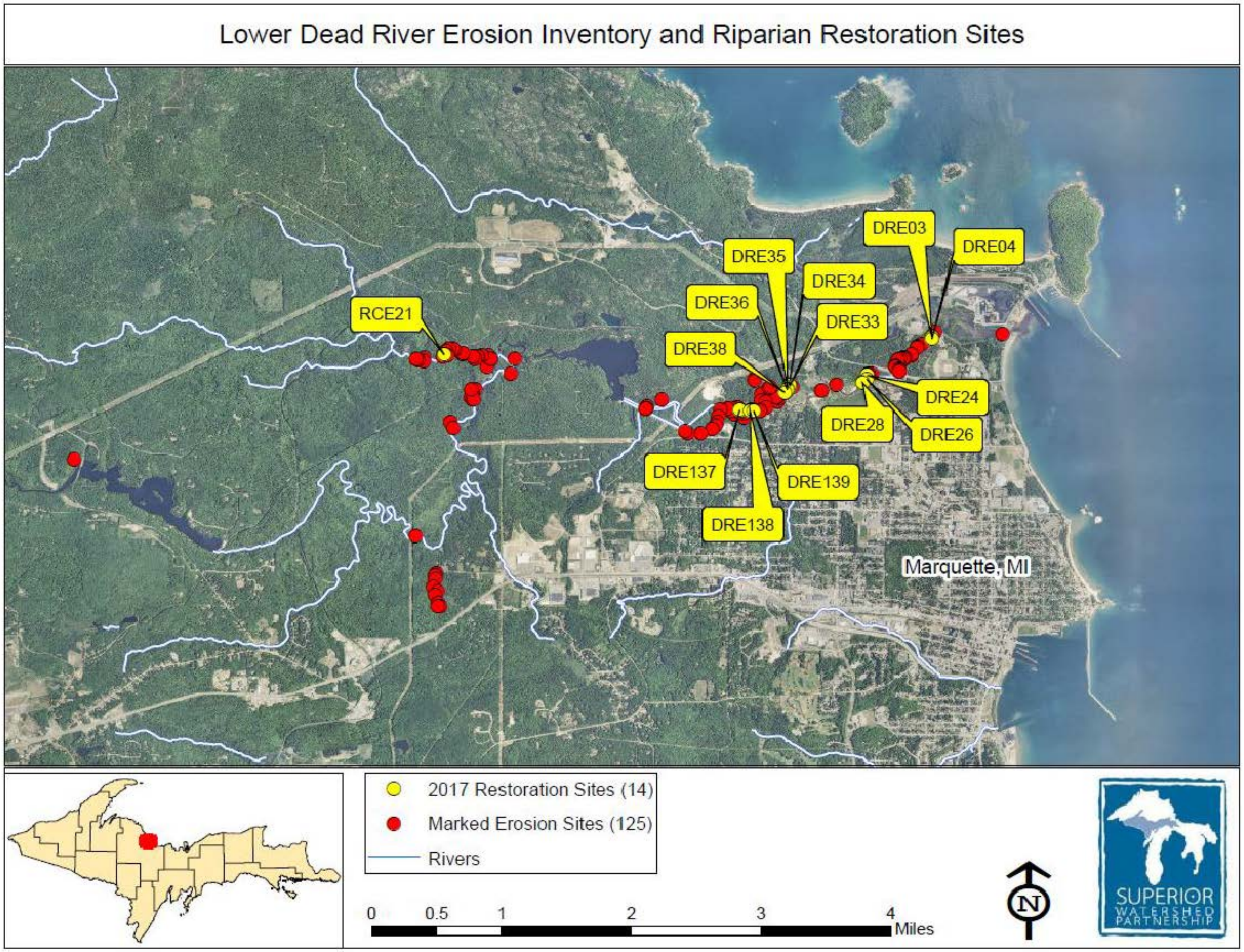

Lower Dead River Erosion Inventory and Riparian Restoration Sites
RCE21
DRE35
DRE34
DRE36
DRE33
DRE38
DRE03
DRE04
DRE24
DRE28
DRE26
DRE137
DRE139
DRE138
Marquette, MI
2017 Restoration Sites (14)
Marked Erosion Sites (125)
Rivers
0
0.5
1
2
3
4
Miles
N
SUPERIOR
WATERSHED
PARTNERSHIP

Figure 44 Lower Dead River Erosion Inventory and Riparian Restoration Sites

6.0 MANAGEMENT MEASURES ACTION PLAN

6.1 Programmatic Management Measures Action Plan

Starting in 2018, Applied Ecological Services conducted a comprehensive analysis comparing the watershed characteristics and management strategies between the Salmon Trout River watershed and the Lower Dead River watershed. The primary goal of the Lower Dead River Watershed and Salmon Trout River Watershed analyses was to improve the approach to watershed planning, and identify unique management measures to benefit watershed health. In the analysis, comparison between an urban (Lower Dead) and rural (Salmon Trout) watershed within the same region provided helpful context. The assessment results include an analysis of setbacks and a percentage of impervious surfaces. Overall, the Lower Dead River watershed is partially impacted by impervious pavement types. To summarize, thirteen SMUs (SMUs 1-5, 7, 11 – 15, 17, and 20) were classified as Sensitive, five as Impacted (SMUs 6, 9, 10, 16, and 25), and seven as Non-Supporting (SMUs 8, 18, 19, and 21 through 24) based on 2015 impervious cover estimates.

AES identified parts of the Lower Dead River watershed that have a higher ecological function score. A high ecological function score indicates that these regions within the watershed would benefit the overall watershed the most by implementing improved best management practices. Most of the areas with high ecological functions are adjacent to waterways, and some areas include water wells. Programmatic BMPs may address regional management concerns by implementing setback increases, creating ordinances, planned greenspace designations, planned conservation/low impact development, and conducting education and outreach. Individual BMPs are ranked based on ease and cost of implementation as follows: A, representing easy to implement at low cost; B, moderate to implement at moderate cost; and C, difficult to implement and costlier (Table 33).

Table 33 Programmatic best management practices

BMP Number	Best Management Practices Descriptor	Residential target audience	Commercial target audience	Local Government target audience	Rank
1	Provide place-based education for educators	x		x	A
2	Green infrastructure strategies such as vegetation, soils, and natural processes to manage water flows rather than engineering water routes	x	x	x	B
3	Governmental planning toolkits and overlay ordinances to protect and preserve watershed characteristics through permeable pavement installation and buffers			x	B/C
4	Encourage voluntary landowner assistance programs for conservation practices	x			A
5	Encourage the use of conservation easements	x	x	x	B

Task 1: Implement outreach and communication action plan

Implement a simplified, and tactical outreach and communication plan to increase awareness and provide education to specific target audiences within the Lower Dead River watershed. Utilizing a variety of mediums, the outreach efforts will communicate watershed information such as hydrological concerns, ecological importance, non-native invasive species, pollutants, sources, causes, management practices and resources. Targeted locations for educational signage in the watershed include the Dead River Falls area, Marquette Tourist Park and NTN North Trails. Proposed steps are adapted from Upleaf Technology Services template (https://upleaf.com/nonprofit-resources/strategy-design/communication-plan-template); The Wallace Foundation "Workbook A: Creating a Communication Plan" (https://www.wallacefoundation.org/knowledge-center/Documents/Workbook-A-Communication.pdf); and a template provided by Convene, LLC, an independent consultant working with the Model Forest Policy Program:

Goals Accomplished:
Goal #3: Planning
Goal #4: Align with Regional Vision

Estimated Cost: $10,000
Timeline: 3 years
Priority: Medium

Milestones:

Step 1: Define target audiences including Lower Dead River landowners and local governmental decision makers, and establish goals of outreach to/communications with target audiences.

- Increase Decision Makers' (and Partners') awareness of the hydrological, ecological and economic importance (ecosystem services valuation) of maintaining the Lower Dead Watershed's water quality not only to the immediate watershed but regionally.
- Increase Decision Makers' (and Partners') awareness of potential sources of water pollutants and conditions that can impact water quality especially those that may be exacerbated by changing climate conditions.
- Educate Decision Makers (and Partners) on policy options to protect the watershed's water quality.

Step 2: Align efforts with goals of outreach to/communications with target audiences – See Section 7.0 on (*Lake Superior: Urban and Rural Watershed Restoration - MFPP 2018 Final Report page* 30) including:

- Increase landowners' awareness of the hydrological, ecological and economic importance (ecosystem services valuation) of maintaining the Lower Dead Watershed's water quality not only to the immediate watershed but regionally.
- Increase landowners' awareness of potential sources of water pollutants and conditions that can impact water quality especially those that may be exacerbated by changing climate conditions.
- Increase landowners' awareness of management practices and potential support (e.g. cost-sharing, equipment-sharing opportunities, management tools, and

labor resources (conservation corps) that could assist in implementing practices.
- Share success stories

Step 3: Use the key messages developed in the MFPP survey process.

- **Water Quality = Economic Value.** Protection of the Lower Dead Watershed is crucial to protecting its fisheries, recreational activities, scenic beauty, and overall (economic) importance to the area.
- Stressors to the watershed include soil erosion from construction, street salt/sand, soil erosion from shorelines and/or streambanks; littering/illegal dumping of trash.
- Climate change will exacerbate stressors.

Step 4: Create a tactical outreach plan. How will you reach your audience? (Email, website, social media, in-person events, phone calls, traditional media: advertising, commercials, etc.)

- Critical to the Lower Dead Strategy is working with the "Information Sources" identified as most trusted by survey respondents. The top four listed for the Lower Dead are:
    - Soil and Water Conservation District;
    - University Extension;
    - Local Watershed Project;
    - Natural Resource Conservation Service

Measurements:

- Number of outreach actions completed
- Number of partners participating
- Number of public notices issued
- Number of new partnerships created

Task 2: Implement low-impact open-space planning

Use green infrastructure network maps developed in this planning process to help local communities identify and prioritize conservation opportunities and plan development in ways that optimize the use of land to meet the needs of people and nature. Specifically focus efforts to increase and restore green infrastructure in areas designated vulnerable due to soil type and impervious cover >10% (impacted) and up to 25% (non-supporting); these areas are in or near urban centers. Through land use/land management planning, increase linkages between existing open/partially open spaces and natural areas such as the Iron Ore Heritage Trail (4.1 acres), private easements (18.4 acres), Gwinn State Forest Area (3.0 acres), and conservation and recreation land owned by the Marquette Board of Light and Power (710 acres).

Goals Accomplished:
Goal #3: Planning
Goal #2: Monitoring and Prevention

Estimated Cost: $10,000
Timeline: 10 years
Priority: High

Milestones:
- Coordinate project partners (Year 1)
- Communicate with regional and local planners to provide detailed maps and data (Years 1-2)
- Help local governments identify and prioritize conservation opportunities and make recommendations (Year 2).
- Implement planning objectives (Year 2-10).
- Provide public information/notification regarding any proposed zoning changes (Year 3)

Measurements:
- Number of conservation easements created (Years 1-10)
- Number of new green spaces restored or protected in vulnerable areas (Years 1-10).
- Number of new linkages connecting existing protected parcels (Years 1-10).

Potential Partners: Private landowners, City of Marquette, Marquette Township, Negaunee Township, Marquette County, Great Lakes Restoration Initiative, National Fish and Wildlife Foundation, Michigan Department of Environment, Great Lakes and Energy, Marquette Board of Light and Power.

6.2 Site Specific Management Measures Action Plan

In the 2018 analysis, Applied Ecological Services identified areas in the Lower Dead River Watershed that may benefit from the implementation of site-specific best management practices (BMPs) to reduce watershed pollutants and address sources and causes. Individual BMPs are ranked based on ease and cost of implementation as follows: A, representing easy to implement at low cost; B, moderate to implement at moderate cost; and C, difficult to implement and costlier (Table 34). While many restoration projects have been implemented, ongoing monitoring, maintenance, and other site-specific adjustments are needed.

Table 34 Best management practices (BMPs) by number

BMP Number	Best Management Practices Descriptor	Residential/ Commercial	Utility Easement s	Quarry Sites	Forestr y Sites	Rank
1	Stormsewer inlet biofilters	x				B
2	Stormsewer inlet stenciling	x				A
3	Lawn/yard waste collection	x				A
4	Lawn fertilizer switch to slow release or organic	x				A
5	Lawn conversion to no-mow/low mow	x				A
6	Lawn conversion to native perennial wildflowers	x				B
7	Disconnect direct discharge from roof, driveway, sidewalk to stormsewer inlet and redirect to rain gardens	x				B
8	Create rain gardens to accept roof top drainage	x				A/B
9	Disconnect direct discharge from all impervious surfaces and redirect to rain gardens	x				A/B

10	Survey stream centerlines and edges of streams so that ordinance can be enforced (needed because of imprecision of mapped locations now available)	x				B
11	River access better definitions and safe water quality sensitive access needed	x				B/C
12	Invasive species management needed	x	x	x	x	A-C
13	Homeowner education needed about invasive species in their yards and how to manage them	x				A/B
14	Stream stabilization using bioengineering needed	x				B
15	Septic survey and subterranean wetland biofilters to ensure clean water prior to release	x				A/B
16	Parking lot infiltration galleries	x				B/C
17	Parking lot sunken biofilters	x				B/C
18	Parking lot retention	x	x			B/C
19	Culvert inlet elevation adjustment to ensure biological mobility in stream/drainageways	x	x		x	B/C
20	Waste/debris management (blown, wash off, and intentionally dumped) from parking lots	x	x			A
21	On parking lot water storage for rare events to reduce stream blow outs	x	x			A
22	Alternative deicing strategy to reduce salt impacts to streams/biota	x			x	A/B
23	Plowed snow stockpile locations with silt fence and water quality management	x		x		A
24	Road designs to minimize direct runoff into streams		x	x	x	C
25	Waterbar installation to divert road runoff regularly (and prevent concentrated high-volume flows) to biofilter and infiltration locations		x	x	x	B/C

26	Plant cover crops to eliminate bare soil in log staging /utility yards, areas/heavily impacted hauling roads, etc.		x	x	x	A
27	Regrade quarry locations and logging staging yards to internalize drainage and direct it to infiltration locations			x	x	B/C
28	Cover crop quarry locations and roadway cuts with annual cover crops and locally derived genetic stock native grasses, wildflowers		x	x	x	A
29	Mulch disturbed ground with clean straw applied at 2,000-3,000 lbs./acre and use crimper to crimp into substrates		x	x	x	A
30	Convert rutted, muddied roadways into water containment/management locations or regrade.		x	x	x	A/B
31	Minimize open working face to some efficient working area			x	x	A/B
32	Log yard and staging areas designed to totally internally drain with water collection, infiltration gallery				x	A/B
33	Focus vegetation clearance management of lines/infrastructure by doing LIDAR and Multispectral imaging mapping every 2-3 years to determine where woody vegetation management to meet clearance requirements may be necessary.		x			B
34	Focus revegetation on the use of diverse native planting of locally derived genetic stocks of species		x			A
35	Minimize forest fragmentation by revegetating cuts with diverse tree species to maintain landscape diversity and continuity		x			B
36	Culvert assessment and replacement to fit site characteristics	x				A

Selected Locations for Implementation of Best Management Practices

Figure 45 shows locations for BMP implementation. Identified locations are throughout the entire watershed and include residential/commercial, utility and road easements, and forestry sites. The residential/commercial sites would generally benefit from BMPs that involve managing invasive species and minimizing the effect of runoff from parking lots. The utility and road corridors extending from the southwest to the northeast was identified as an area for clearing vegetation and watching for invasive species. Forestry sites comprise the largest number of locations where water quality would benefit from properly installed culverts, minimizing direct road/developed surface water runoff into streams, and eliminating bare soil. Furthermore, eroding streambanks were prioritized based on their pollutant load severity and proximity to urban areas resulting in increasingly higher rates of human impact.

Each location identified on Figure 45 corresponds with the point number in Table 35. The site description listed in Table 35 then corresponds to the BMP Number(s) in Table 34. For example, location 5 located along Midway Creek would benefit from BMP number 12 (invasive species management needed) in Table34. Location 10 is a utility corridor that corresponds with BMP 33 in Table34. This indicates that focus on vegetation clearance around infrastructure is needed and could benefit from imaging the area with a multispectral camera every 2-3 years. Not all locations have a single best management practice that would improve the local ecological environment. Location 1 which is a residential/commercial site in the urban center has six potential BMPs (16-18, 20-22) associated with it. While each BMP will affect the site differently, all involve decreasing the amount of direct runoff such as from a parking lot directly into waterways.

Table 35 Selected locations for BMP implementation

Point Number	Description	BMP Type	BMP Number	BMP Example Number	Pollutants Addressed	Priority Rank

16	Implement stormwater management program and replace poorly performing/nonfunctioning culverts in Backyard Creek.	Residential	7, 19, 24, 30, 36	36, 16	Sediment, Altered hydrologic flow	1
3	Retrofit culvert and restore fish passage (wooden stabilization deteriorating at an unnamed tributary.	Forestry Site	19, 22, 24-32	19	Sediment, Altered hydrologic flow	2
2	Parking lot BMPs, vegetation management willow, and reed canary grass (RCG) in the Brickyard Creek subwatershed	Residential / Commercial	1 through 23	16-18, 20-22	Toxins, Altered hydrologic flow, Sediment	3
1	Parking lot BMPs in the Wolner Creek subwatershed.	Residential / Commercial	1 through 23	16-18, 20-22	Toxins, Altered hydrologic flow, Sediment	4
4	Road BMP, redirect drainage attenuation from flowing directly into Midway Creek.	Forestry Site	19, 22, 24-32	24, 25	Toxins, Altered hydrologic flow, Sediment	5
17	Stabilize eroding slopes along the Dead River Falls nature trails (DRE87)	Forestry Site	29, 34	34	Sediment	6
18	Stabilize eroding slopes on the Dead River downstream of the Co Rd 550 bridge (DRE06)	Forestry Site	29, 34	34	Sediment	7
19	Stabilize eroding slopes on the Dead River Basin and along the NTN North Recreational trails (DRE43, DRE 32, DRE27, DRE45, DRE41, and DRE37).	Forestry Site	29, 34	34	Sediment	8
20	Stabilize eroding slopes on the Dead River west of the Marquette Board of Light and Power office building (DRE73, DRE74).	Forestry Site/ Commercial	29, 34	34	Sediment	9

7	White cedar/tag alder, gravel road management, continue preventing direct runoff into stream, road water bar/BMP native veg swale in the Reany Creek subwatershed	Forestry Site	19, 22, 24-32	22, 24, 25	Sediment	10
8	White Bear Rd (at Reany Creek) culvert in disrepair and failing, talked to the Sandy Owner	Forestry Site	19, 22, 24-32	19	Sediment	11
9	Small tributary on Old Rt 510. Culvert lowered for fish passage at an unnamed tributary.	Forestry Site	19, 22, 24-32	19	Sediment, Altered hydrologic flow	12
13	Fisherman parking at the Collinsville area access has an invasion of burdock, Japanese knotweed, tansy, and reed canary grass. There is significant erosion on slopes below burdock (DRE76).	Forestry Site	19, 22, 24-32	12	Sediment	13
11	Logging operation, clear cut even in drainage areas and slopes near McClure Storage Basin	Forestry Site	19, 22, 24-32	26-29, 32	Sediment	14
10	Utility corridor vector for spread of invasive species, point locations of de-vegetation due to recreation use, look for unvegetated areas in proximity to stream (unnamed tributary) near the east side of the Dead River Storage Basin.	Utility Easement	18-21, 24-26, 28-30	33	Sediment	15
6	Co Rd 510 new bridge, slope stabilization on far lake and bluff facing NE (west end of McClure Storage Basin).	Forestry Site	19, 22, 24-32	26, 28, 29	Sediment	16
15	The dam tailwater has an invasion of reed canary grass, and a high use recreation area. Educational signage about water quality and hydrology near the Marquette Tourist Park would support WMP goals.	Residential / Commercial	1 through 23	9 through 12	Sediment	17
5	Bridge at Midway Creek and Co Rd 502-510. Fix bridge stability, remove cistern, and address honeysuckle.	Forestry Site	19, 22, 24-32	12	Sediment	18

12	Clark Street, some non-native, invasive plants present including reed canary grass, privet hedge, and tansy. The hydrology was stable with rocky, woody debris in Badger Creek.	Residential / Commercial	1 through 23	12, 13	Sediment	19
14	Unstable soil with invasion of burdock, backyard leaf dumping in the subwatershed of Backyard Creek.	Residential / Commercial	1 through 23	3, 5, 12, 13	Sediment	20

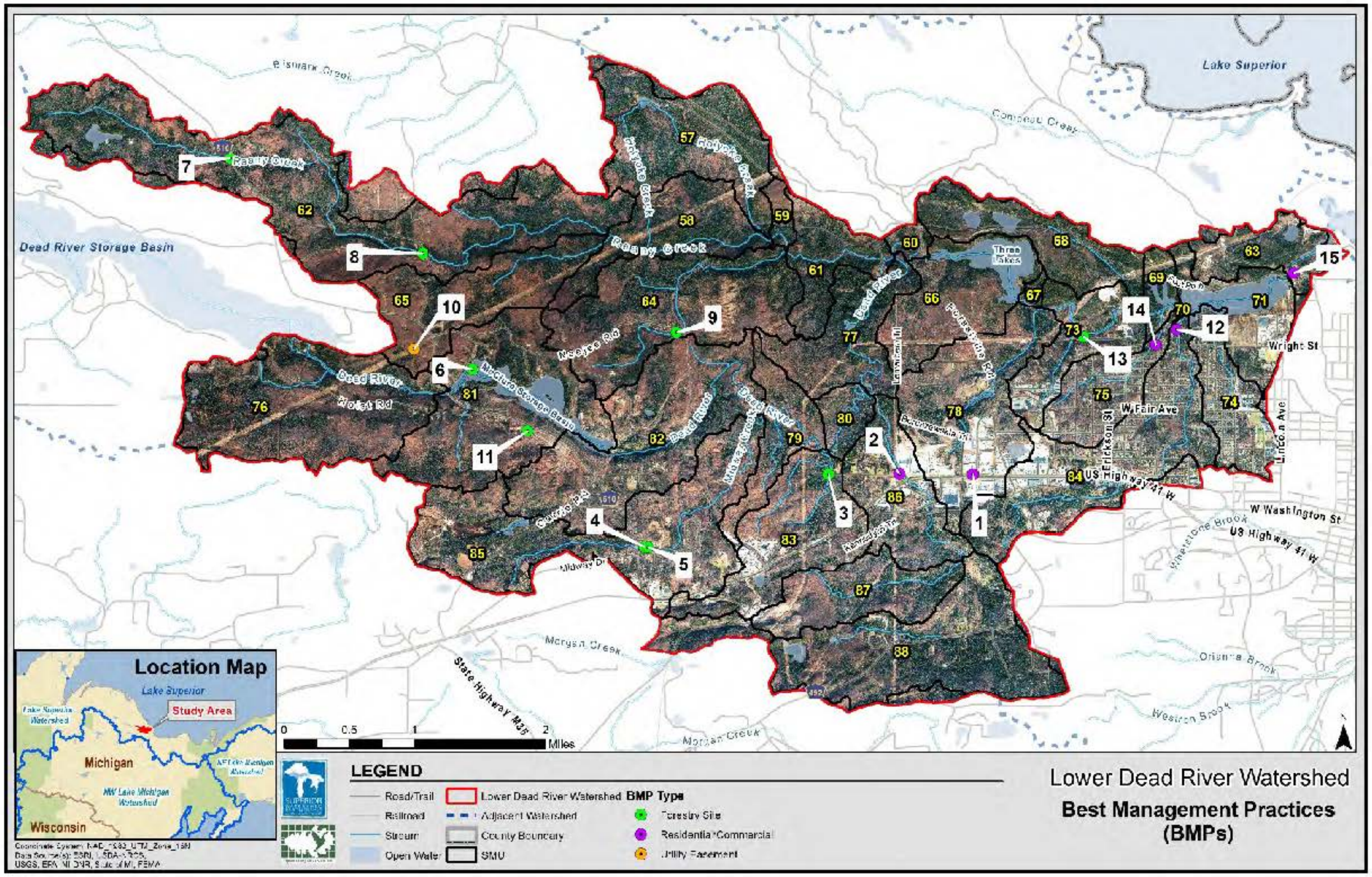


Figure 45 – Best Management Practice Recommendations

Task 3: Reduce sedimentation and remove fish passage barriers at road/ stream crossings, and restore eroding streambanks and recreational access points

Replace or adjust culverts at BMP sites 3, 8, 9, 16, and restore bridge stability at BMP site 5. In addition, implement proper erosion controls at heavily-impacted eroding streambanks on the Dead River at/near recreation areas (BMP sites 6, 13, 17, 18, 19, 20). Address drainage issues at BMP sites 4, and 7. This includes an analysis of land features (soils, land use, slope, etc.) and development of feature specific land use planning tools and management recommendations, including but not limited to, road redesign to minimize runoff, regrading, culvert elevation adjustments, culvert replacements, installing live stakes, brush bundles, mulch blanket installation, and other erosion control BMPs. Assist Marquette Township with developing plans to restore infrastructure.

- Replace undersized, poorly aligned, and/or perched crossing structures
- Install bottomless culverts and bridges where possible
- Stabilize road approaches, side slopes and embankments
- Plant native vegetation on disturbed or bare soil areas
- Create diversion outlets and spillways to direct road runoff away from surface waters

Goals Accomplished:
Goal #1: Restoration
Goal #2: Monitoring and Prevention
Goal #3: Planning

Estimated Cost: $340,000
Timeline: 3 years

Priority: High

Table 37 Selected sites for erosion and road-stream crossing BMPs

Main tributary affected	Number of priority manmade erosion sites	Culvert replacement or adjustment needed	Est. cost	Est. sediment load reduction (tons/ year)
Backyard Creek	4	4	$80,000	7.6
Dead River tributary (SMU8)		1	$20,000	TBD
Dead River (SMU25)	1		$20,000	25.5
Dead River (SMU21)	3		$60,000	47.6
Dead River (SMUs 20/24)	6		$120,000	92.9
Reany Creek		1	$20,000	TBD
Dead River tributary (SMU13)		1	$20,000	TBD
Total	**15**	**7**	**$340,000**	**173.6**

*Based on an estimated average cost of $20,000 per site

Milestones:

- Coordinate project partners (Year 1)
- Conduct analysis and field verification of data (Years 1-2)
- Develop BMP recommendations and tools (culvert replacement, erosion stabilization, etc. (Year 2).
- Implement restoration plans (Year 2-3).
- Assist township with adoption of new or improved ordinances (Following development of recommendations (Years 2-3)
- Provide public information/notification regarding any proposed zoning changes (Years 2-10)
- Pre and post BMP field evaluations (Years 1-10)

Measurements:

- Restoration of impacted streams (stream miles improved)
- Number of partners participating
  Improved water quality (ratings of good or better at all monitoring sites by year 10)
- Conduct pre- and post-BMP field evaluations (site condition evaluation and stream monitoring) (Years 1-10)
- Achieve 10% reduction in sediment load (Year 5)
- Achieve 25% reduction in sediment load (Year 10)

Potential Partners: Marquette Township, Marquette Board of Light and Power, Noquemanon Trail Network, Great Lakes Restoration Initiative, National Fish and Wildlife Foundation, Michigan Department of Environment, Great Lakes and Energy

Task 4: Implement stormwater management BMPs and revegetate riparian areas with diverse native species

Implement proper stormwater management BMPs at parking lots near Wolner Creek (BMP site 1) and Brickyard Creek (BMP site 2). BMPs may involve redirecting stormwater flows, stormwater capture, retention, infiltration galleries, and sunken biofilters. Use diverse native plantings of locally derived genetic stocks of species to restore native vegetation at heavily impacted sites, eroded slopes, and exposed bare ground throughout the Lower Dead Watershed. Work with local units of government on planning and adopting new or improved zoning ordinances related to stormwater management improvements. Targeted locations include, but are not limited to sites near the McClure Storage Basin (BMP sites 10 and 11). Replace non-native invasive species with diverse native species at BMP sites 2, 13, 15, 5, 12, and 14. Where appropriate, encourage participation in landowner incentive programs and/or provide landowner education.

Goals Accomplished:
Goal #1: Restoration
Goal #2: Monitoring and Prevention
Goal #3: Planning

Estimated Cost: $100,000

Timeline: 3 years
Priority: High

Milestones:
- Coordinate project partners (Year 1)
- Conduct analysis and field verification of site data (Years 1-2)
- Develop BMP recommendations (Year 2).
- Implement restoration plans (Year 2-3).
- Provide public information/notification regarding any proposed zoning changes (Years 2-10)
- Pre and pose BMP field evaluations (Years 1-10)

Measurements:
- Restoration of impacted streams (stream miles improved)
- Improved water quality (ratings of good or better at all monitoring sites by year 10)
- Conduct pre- and post-BMP field evaluations (site condition evaluation and stream monitoring) (Years 1-10)

Potential Partners: Private landowners, Marquette Township, Great Lakes Restoration Initiative, National Fish and Wildlife Foundation, Michigan Department of Environment, Great Lakes and Energy, Noquemanon Trail Network, Marquette Board of Light and Power.

Non-Native Invasive Species Management Plan

As an urban watershed with high quality aquatic and terrestrial habitats, the Lower Dead River should remain protected from non-native and invasive species of regional priority. The state designates cooperative weed management areas, public-private partnerships, to identify, strategize, and manage species of regional concern to protect and restore native habitats. Partnership with the local cooperative weed management area, Lake 2 Lake CISMA, will be sought to address priority concerns. More information about Lake 2 Lake CISMA can be found here **www.michiganinvasives.org/l2lcisma**.

Goals Accomplished:
Goal #1: Protect the integrity of aquatic and terrestrial ecosystems within the watershed.

Timeline: 3 years

Priority: Medium
Estimated Cost: $5,000

Milestones:
- Coordinate project partners (Year 1)
- Conduct analysis and field verification of site data (Years 1-2)
- Develop specific BMP recommendations and tools for each site (Year 2).
- Implement restoration plans (Year 2-3).
- Pre and post BMP field evaluations (Year 1-10)

Measurements:
- Number of partners participating
- Conduct pre- and post-BMP field evaluations (Years 1-10)

Table 35 Locations where Non-Native Invasive Species (NNIS) management is needed

SWP Site Number	Description	NNIS regional priority species	BMP #	Priority Rank
2	Parking lot BMPs, vegetation management willow, and reed canary grass (RCG) in the Brickyard Creek subwatershed	Yes	12	1
13	Fisherman parking at the Collinsville area access has an invasion of burdock, Japanese knotweed, tansy, and reed canary grass. There is significant erosion on slopes below burdock (DRE76).	Yes	12	2

15	The dam tailwater has an invasion of reed canary grass, and a high use recreation area. Educational signage about water quality and hydrology near the Marquette Tourist Park would support WMP goals.	Yes	12	3
12	Clark Street, some non-native, invasive plants present including reed canary grass, privet hedge, and tansy. The hydrology was stable with rocky, woody debris in Badger Creek.	Yes	12	4
3	Retrofit culvert and restore fish passage (wooden stabilization deteriorating at an unnamed tributary.	No	12	5
1	Parking lot BMPs in the Wolner Creek subwatershed.	No	12	6
4	Road BMP, redirect drainage attenuation from flowing directly into Midway Creek.	No	12	7
7	White cedar/tag alder, gravel road management, continue preventing direct runoff into stream, road water bar/BMP native veg swale in the Reany Creek subwatershed	No	12	8
8	White Bear Rd (at Reany Creek) culvert in disrepair and failing, talked to the Sandy Owner	No	12	9
9	Small tributary on Old Rt 510. Culvert lowered for fish passage at an unnamed tributary.	No	12	10
11	Logging operation, clear cut even in drainage areas and slopes near McClure Storage Basin	No	12	11
10	Utility corridor vector for spread of invasive species, point locations of de-vegetation due to recreation use, look for unvegetated areas in proximity to stream (unnamed tributary) near the east side of the Dead River Storage Basin.	No	12	12
6	Co Rd 510 new bridge, slope stabilization on far lake and bluff facing NE (west end of McClure Storage Basin).	No	12	13
5	Bridge at Midway Creek and Co Rd 502-510. Fix bridge stability, remove cistern, and address honeysuckle.	No	12	14
14	Unstable soil with invasion of burdock, backyard leaf dumping in the subwatershed of Backyard Creek.	No	12	15

7.0 INFORMATION & EDUCATION PLAN

7.1 Social Survey

As a part of the *Lake Superior: Urban and Rural Watershed Restoration Project*, the Model Forest Policy Program (MFPP) assisted SWP with development of a social survey and analyzed the results collected in 2016. The survey data were collected from the Salmon Trout River watershed as well as the Lower Dead River watershed in the City and Township of Marquette, MI for urban and rural comparison. The survey was designed to 1.) Identify the watershed and conservation priorities and concerns of landowners, 2.) Inform policy development, and 3.) Improve land use planning and actions by local units of government and landowners. In addition, the survey results helped to assess the social indicators of the region, which are helpful when developing plans to educate and promote watershed-based awareness.

The survey categories and their relative significance were obtained from the Great Lakes Regional Water Program - Social Indicators Data Management and Analysis (SIDMA). The survey was developed using "The Social Indicator Planning & Evaluation System (SIPES) for Nonpoint Source: A Handbook for Watershed Projects Management" ("Handbook") as a guide. The required guidelines allowed for minimal modification of survey questions. The Salmon Trout and Lower Dead survey forms can be observed at: https://superiorwatersheds.org/social-surveys. The survey was initially sent to 127 deliverable addresses within the Dead River watershed and 132 deliverable addresses within the Salmon Trout River watershed.

Observations from the Watershed Survey

The bullet points below highlight key (high-level) observations that stood out in reviewing the survey results. The full document is called "*Lower Dead (Dead River) and Salmon Trout Survey – Use for Curriculum and Policy Development (2018).*"

- Approximately 1/3 response rate; considered quite high.
- Basic **knowledge of hydrology by respondents is good**; **knowledge about impacts somewhat less** so.
- **Scenic beauty, boating and fish** stood out as important for people on both rivers. [The majority of respondents rated water quality in both rivers as good though the Lower Dead River was seen as less desirable for edible fish or fish habitat.]
- **Respondents value water quality** and its importance to their quality of life - less see connection to their business.

The survey results and analysis provided key insights into watershed curriculum development and education/outreach projects. The characteristics of the surveyed respondents are provided in the following table.

Table 36 Survey Respondents Demographic Information

Demographic Information	**Lower Dead**	**Salmon Trout**
Gender	Male (73.0%); Female (27.0%)	Male (67.4%); Female (32.6%)
Age (Mean)	57.78 years	58.59 years
Highest Grade in School Top Two)	Post Graduate (34.2%); 4-year college degree (28.9%)	Post Graduate (31.0%); Some College (31.0%); and 4-Year College Degree (28.9%)
Total Household Income (Top Two)	$100,000 or more (33.3%); and $25,000 to $49,999 (27.3%)	$75,000 to $99,999 (30.3%); and $25,000 to $49,999 (24.2%) and $100,000 or more (24.2%)
Ethnicity	White/Caucasian (97.1%)	White/Caucasian (88.4%)
Media Source of Information (Top Three Out of Seven)	Newsletters/brochure/factsheet (62.2%); Internet (54.1%); and Workshops/ Demonstrations/Meetings (43.2%)	Newsletters/brochure/factsheet (65.9%); Internet (59.1%); and Conversations with Others (54.5%)
Regularly Read a Local Newspaper	No (64.9%); Yes (35.1%)	No (69.8%); Yes (30.2%)
Primary Residence	Yes (83.3%); No (16.2%)	Yes (34.9%); No (65.1%)
Best describes where you live.	In a town, village, or city (26.3%); In an isolated, rural, non-farm residence (28.9%); Rural subdivision or development (39.5%); On a farm (5.3%)	In a town, village, or city (4.7%); In an isolated, rural, non-farm residence (69.8%); Rural subdivision or development (30.2%); On a farm (9.3%)
In addition to your residence, which of the following do you own or manage?	An agricultural operation (5.4%); Forested land (32.4%); Rural recreational property (32.4%); None of these (51.4%)	An agricultural operation (4.7%); Forested land (69.8%); Rural recreational property (30.2%); None of these (9.3%)

8.0 PLAN IMPLEMENTATION

8.1 Plan Implementation Roles and Coordination/Responsibilities

The strategies for protection, restoration, and public involvement outlined under the goals and objectives of this watershed management plan will be implemented through a suite of recommendations or tasks. These tasks were developed based on the prioritization of watershed pollutants, sources, and causes, and critical areas of the watershed. A ten-year timeline was used as the schedule for implementation. Tasks that should be done in the short term were given a completion timeline of 3 years. Tasks that should be undertaken annually were given a timeline of "ongoing." Estimated costs for implementation tasks do not include staff oversight or administrative costs. A summary of implementation tasks and milestones is provided.

8.2 Implementation Schedule

Table 38 Implementation tasks and milestones

Task	Timeline (years)									
	1	2	3	4	5	6	7	8	9	10
Task 1: Implement outreach and communication action plan	X	X	X	X						
● Define target audiences including Lower Dead River landowners and local governmental decision makers, and establish goals of outreach to/communications with target audiences.	X									
● Align efforts with goals of outreach to/communications with target audiences	X	X								
● Use the key messages developed in the MFPP survey process.		X	X							
● Create a tactical outreach plan. How will you reach your audience? (Email, website, social media, in-person events, phone calls, traditional media: advertising, commercials, etc.)		X	X							
Task 2: Implement low-impact open-space planning	X	X	X	X	X	X	X	X	X	X
● Coordinate project partners (Year 1)	X									
● Communicate with regional and local planners to provide detailed maps and data (Years 1-2)	X	X								

● Help local governments identify and prioritize conservation opportunities and make recommendations (Year 2).		X								
● Implement planning objectives (Year 2-10).		X	X	X	X	X	X	X	X	X
● Provide public information/notification regarding any proposed zoning changes (Year 3)			X							
Task 3: Reduce sedimentation and remove fish passage barriers at road/ stream crossings, and restore eroding streambanks and recreational access points	X	X	X	X	X	X	X	X	X	X
● Coordinate project partners (Year 1)	X									
● Conduct analysis and field verification of data (Years 1-2)	X	X								
● Develop BMP recommendations and tools (culvert replacement, erosion stabilization, etc. (Year 2).		X								
● Implement restoration plans (Year 2-3).		X	X							
● Assist township with adoption of new or improved ordinances (Following development of recommendations (Years 2-3)		X	X							
● Provide public information/notification regarding any proposed zoning changes (Years 2-10)		X	X	X	X	X	X	X	X	X
● Pre and post BMP field evaluations (Years 1-10)	X	X	X	X	X	X	X	X	X	X
Task 4: Implement stormwater management BMPs and revegetate riparian areas with diverse native species										
● Coordinate project partners (Year 1)	X									
● Conduct analysis and field verification of site data (Years 1-2)	X	X								
● Develop BMP recommendations (Year 2).		X								
● Implement restoration plans (Year 2-3).		X	X							
● Provide public information/notification regarding any proposed zoning changes (Years 2-10)		X	X	X	X	X	X	X	X	X
● Pre and post BMP field evaluations (Years 1-10)	X	X	X	X	X	X	X	X	X	X
Task 5: Implement NNIS BMPs	X	X	X	X	X	X	X	X	X	X
● Coordinate project partners (Year 1)	X									
● Conduct analysis and field verification of site data (Years 1-2)	X	X								
● Develop specific BMP recommendations and tools for each site (Year 2).		X								
● Implement restoration plans (Year 2-3).		X	X							

• Pre and post BMP field evaluations (Year 1-10)	X	X	X	X	X	X	X	X	X	X

8.3 Funding Sources

Past projects in the Lower Dead River watershed have been implemented by a variety of sources including the Federal Emergency Management Agency, National Fish and Wildlife Foundation, and the Great Lakes Restoration Initiative. A list of ongoing and recently completed projects in the Lower Dead River watershed with funding source is provided below.

2020 FEMA: Lakeshore Boulevard Coastal Resilient Infrastructure Project. $2,025,000 federal funds: $675,000 local match. Total project: $2,700,000.

2018 National Fish and Wildlife Foundation: Lake Superior Coastal Community Resiliency Project: $2, 500,000 federal funds. $3,050,000 local match. Total project: $5,550,000.

2016 GLRI: Stopping Urban Runoff to Lake Superior; A Coastal Wetland Solution: $288,500 federal funds, $112,500 local match. Total project: $401,000.

2015 GLRI: Lake Superior Urban Stormwater/Coastal Wetland Restoration: $199,451 federal funds, $36,100 local match. Total project: $235,551.

2015 GLRI Northeast State and Private Forestry: $169,955 federal funds, $17,245 local match. Total project $187,200.

2014 GLRI: Lake Superior: Urban and Rural Watershed Restoration: $303,403 federal funds/$23,148 local match. Total project: $326,551.

2012 GLRI: Making Lake Superior Beaches Safer through Green Practices: $179,700 federal funds/$12,508 local match. Total project: $192,208.

Future funding could be sought from organizations on this list and expanded to include additional potential sources such as:

- Landscape Scale Restoration Grant Program
- NOAA Great Lakes Habitat Restoration Regional Partnership Grants
- NOAA Bay Watershed Education and Training (B-WET)
- US Fish and Wildlife Service
- Private foundations

9.0 MEASURING PLAN PROGRESS & SUCCESS

9.1 Water Quality Monitoring Plan & Evaluation Criteria
Continual evaluation provides information regarding the success of ongoing efforts to improve watershed characteristics. It allows for an assessment of the effectiveness and appropriateness of the original goals and objectives of this plan as tasks are implemented and conditions change over time. Evaluation also provides a feedback mechanism for periodically assessing the effectiveness of management practices and allows stakeholders to identify areas where program improvements are possible.

The measurements identified in relation to the goals and objectives of this plan provide helpful tools for local stakeholders to assess the effectiveness of their implementation projects or educational/outreach efforts. These measures however, are by no means exhaustive. Many other evaluation measures exist and local stakeholders must ensure evaluation programs and protocols meet local needs.

Evaluation programs typically include two types of measures: quantitative and qualitative. Quantitative attributes are those which it is possible to measure. Qualitative measures try to shed light on changes in attitudes, perceptions and knowledge levels. Examples of the two approaches as they related to the goals and objectives of the Lower Dead River Watershed Management Plan are provided below.

Quantitative Measures

- Biological monitoring of surface waters (e.g. macroinvertebrate communities)
- Chemical monitoring or surface waters (e.g. temperature, dissolved oxygen)
- Stream flow monitoring (e.g. volume, velocity)
- Sediment monitoring (e.g. deposition, quantity)
- Number of buffer ordinances adopted by townships
- Number of acres protected (conservation easements)
- Educational workshop attendance levels
- Number of storm water Best Management Practices implemented
- Number of restoration projects completed

Qualitative Measures

- Workshop evaluation surveys
- Public opinion surveys (e.g. increased awareness of impacts of nonpoint source pollutants on aquatic habitats, etc.)
- Increased cooperation and networking between stakeholders and other entities
- Level of enthusiasm expressed about revising zoning ordinances and master plans
- Public confidence that groundwater is safe

10.0 LITERATURE CITED

Apfelbaum, Steve & Haney, Alan. 2010. Restoring Ecological Health to Your Land. Washington: Island Press. 240p.

Applied Ecological Services. 2019. Lower Dead River and Salmon Trout River Watershed Analysis. Prepared for Superior Watershed Partnership and Land Conservancy. Brodhead, WI

Aurele A. Durocher. “The Lake Superior and Ishpeming Railroad Company,” The Railway and Locomotive Historical Society Bulletin, No. 98 (APRIL, 1958), pp. 7-31. https://www.jstor.org/stable/43520202

Benedict, Mark A. and Edward T. McMahan. 2006. Green Infrastructure: linking landscapes and communities. Washington: Island Press.

Booth, D. and L. Reinelt. 1993. Consequences of Urbanization on Aquatic Systems-measured effects, degradation thresholds, and corrective strategies, pp. 545-550 *cited in* Schueler, T. 1994. The Importance of Imperviousness. Watershed Protection Techniques. 1(3): 100-111.

Brooks, Dick. 1993. “Poisoned Fish, Polluting Smelters, and Worried Workers.” Living on Earth. Public Radio International’s Environmental News Magazine. Boston, MA.

Center for Watershed Protection. 1998. A Comprehensive Guide for Managing Urbanizing Watersheds. Prepared for USEPA Office of Wetlands, Oceans and Watersheds and Region V.

City of Marquette Zoning. City of Marquette Land Development Code Chapter 54 Code of Ordinances. Revised February 23, 2019. https://www.marquettemi.gov/wp-content/uploads/2019/02/Marquette-Adopted-Land-Development-Code-Effective-2019_02_23-1.pdf

CUPPAD Regional Commission. Negaunee Township Comprehensive Plan. 1998.

CUPPAD. Upward 2025 A Framework for Prosperity. December 2016. http://www.centralupdashboard.org/wp-content/uploads/2016/12/RPI-10-Year-Plan-Update.pdf

Dudka, Stanislaw, and Domy C. Adriano. "Environmental impacts of metal ore mining and processing: a review." Journal of environmental quality 26.3 (1997): 590-602.

Emerick, Jacob. “Waterfalls of the Keweenaw Area-Marquette County,” 2008. https://www.waterfallsofthekeweenaw.com/marquette-county/

Galli, J. 1990. Thermal impacts associated with urbanization and stormwater management best management practices. Metro. Wash. Counc. Gov., Maryland Dep. Environ. Washington, D.C.

188 pp *cited in* Schueler, T. 1994. The Importance of Imperviousness. Watershed Protection Techniques. 1(3): 100-111.

Godby, Neal. 2002. A biological survey of Lake Superior coastal tributaries in Northern Marquette County July 2001. Michigan Department of Environment, Great Lakes and Energy. MI/DEQ/SWQ-02/017. 31 pp.

Godby, Neal and John Suppnick. Channel Morphology, Fish Community, and Temperature
Conditions of the Dead River Bypassed Channel Prior to Flow Augmentation. 2001. Michigan Department of Natural Resources, Surface Water Quality Division Report: MI/DEQ/SWQ-00/104.

Great Lakes Integrated Sciences and Assessments. "Great Lakes Regional Climate Change Maps." Last modified 2014. http://glisa.umich.edu/resources/great-lakes-regional-climate-change-maps

Hall, Margaret & Thaler, T. (Authors). Grant, Geri, Hanson, A. & Thaler, T. (Ed.). December 2018. Final Report: Lake Superior: Urban and Rural Watershed Restoration Project - Salmon Trout and Lower Dead Rivers, Marquette County, Michigan. Model Forest Policy Program (Sagle, ID) and Superior Watershed Partnership (Marquette, MI).

Janowiak, M. 2012. An Introduction to Forest Carbon Management. USDA - FS Climate Change Resource Center. http://www.fsl.orst.edu/fs-pnw/pep/carbon/janowiak/.

Janowiak, M. K., L. R. Iverson, D. J. Mladenoff, E. Peters, K. R. Wythers, W. Xi, L. A. Brandt, P. R. Butler, S. D. Handler, P. D. Shannon, C. Swanston, L. R. Parker, A. J. Amman, B. Bogaczyk, C. Handler, E. Lesch, P. B. Reich, S. Matthews, M. Peters, A. Prasad, S. Khanal, F. Liu, T. Bal, D. Bronson, A. Burton, J. Ferris, J. Fosgitt, S. Hagan, E. Johnston, E. Kane, C. Matula, R. O'Connor, D. Higgins, M. S. Pierre, J. Daley, M. Davenport, M. R. Emery, D. Fehringer, C. L. Hoving, G. Johnson, D. Neitzel, M. Notaro, A. Rissman, C. Rittenhouse, and R. Ziel. 2014. Forest ecosystem vulnerability assessment and synthesis for northern Wisconsin and western Upper Michigan: a report from the Northwoods Climate Change Response Framework project.

Marquette County Planning Commission. "Community Profile Sheets." Accessed February 28, 2019. https://www.mqtcoplan.org/data

Marquette Township. Marquette Charter Township Zoning Ordinance. 1996. https://marquettetownship.org/wp-content/uploads/2015/03/MARQUETTE-TOWNSHIP-ZONING-ORDINANCE.pdf

Michigan Department of Environment, Great Lakes, and Energy (EGLE). "National Pollutant Discharge Elimination System-NPDES," Accessed February 15, 2019. www.mi.gov/deqnpdes

Michigan Department of Environment, Great Lakes, and Energy (EGLE). 1996. Revised 1998. "Update of GLEAS Procedure 51 Metric Scoring and Interpretation." Surface Water Quality Division. Staff Report. MI/DEQ/SWQ-96/068.

Michigan Department of Environment, Great Lakes, and Energy (EGLE). 2020. Water Quality and Pollutions Control in Michigan 2020 Sections 303(d), 305(b), and 314 Integrated Report. Water Resources Division. EGLE/WRD-16/001. Accessed 26 Oct, 2020.

Michigan Department of Environment, Great Lakes, and Energy (EGLE). 2019. "Michigan Water Quality Standards," Water Resource Division, State of Michigan. Accessed February 14, 2019:
https://www.michigan.gov/deq/0,4561,7-135-3313_3681_3686_3728-350340--,00.html

Michigan Department of Environment, Great Lakes, and Energy (EGLE). 2019. "National Pollutant Discharge Elimination System - NPDES," Water Resource Division, State of Michigan. Accessed February 14, 2019:
https://www.michigan.gov/deq/0,4561,7-135-3313_71618_3682_3713---,00.html

Michigan Department of Environment, Great Lakes, and Energy (EGLE). "Wellhead Protection," Accessed March 05, 2019. www.mi.gov/deqwhp

Michigan Department of Environment, Great Lakes, and Energy (EGLE). "Community Water Supply," Accessed March 05, 2019.
https://www.michigan.gov/deq/0,4561,7-135-3313_3675_3691---,00.html

Michigan Department of Natural Resources (MiDNR). Brook Trout. 2019. Michigan.
https://www.michigan.gov/dnr/0,4570,7-350-79135_79218_79614_82522---,00.html

Michigan Department of Natural Resources (MiDNR). 2018 Michigan Fishing Guide. 2018. Michigan.
https://www.michigan.gov/documents/dnr/2018-MI-Fishing-Guide-WEB_615716_7.pdf

Michigan Department of Natural Resources (MiDNR). "Commercial Forest Lands." Accessed March 7, 2019.
https://www.michigan.gov/dnr/0,4570,7-350-79136_79237_80945_83262---,00.html

Michigan Department of Natural Resources (MiDNR). "Minerals." Accessed March 7, 2019.
https://www.michigan.gov/dnr/0,4570,7-350-79136_79239---,00.html

Michigan Department of Natural Resources (MiDNR). "Natural Resources." Accessed March 7, 2019.
https://www.michigan.gov/dnr/0,4570,7-350-79133_79200---,00.html

Michigan Department of Natural Resources (MiDNR). "Michigan Water Strategy." October 2016.
https://www.michigan.gov/ogl/0,9077,7-362-85258---,00.html

Michigan Department of Natural Resources (MiDNR). "DNR Maps and Data." Accessed February 2019. http://gis-midnr.opendata.arcgis.com/

Michigan State University. "Michigan History," Accessed January 16, 2019. http://michiganhistory.leadr.msu.edu/

Negaunee Township. Negaunee Township Zoning Ordinance. Revised February 2013. http://www.negauneetownship.org/planning_and_zoning_department/docs/Zoning_Ordinance_FINAL_Feb2017.pdf

Ozaukee County. "Major Watersheds and Floodplains." Accessed February 2019. https://www.co.ozaukee.wi.us/749/Major-Watersheds-Floodplains

Partnering for Watershed Restoration (PWR). "PWR Brook Trout Priority Watersheds." Revised March 15, 2019. www.pwr-up.org/reference-library.html

Rathbun, Joe, Ralph Reznick. Dead River Steam Restoration. Accessed March 20, 2019. https://www.michigan.gov/documents/deq/wrd-nps-success-dead-river_560114_7.pdf

Sargent, M.S and Carter, K.S., ed. 1999. Managing Michigan Wildlife: A Landowners Guide. Michigan United Conservation Clubs, East Lansing, MI. 297pp

Schaetzl, Dr. Randall J. "Geography of Michigan and the Great Lakes Region." Michigan State University. Accessed February 7, 2019. http://geo.msu.edu/extra/geogmich/

Schueler, T. 1994. The Importance of Imperviousness. Watershed Protection Techniques. 1(3): 100-111.

Seeking Michigan. "Survey Maps of Marquette County," Accessed January 16, 2019. http://seekingmichigan.contentdm.oclc.org/cdm/compoundobject/collection/p15147coll10/id/2303/rec/1695

State of Michigan. "Michigan's Open Data Portal." Accessed February 2019. https://data.michigan.gov/

Sundberg, Carlson and Associates, Inc. Charter Township of Marquette - Comprehensive Development Plan. 1995. Project #93-464.

Superior Watershed Partnership. "Lower Dead River Management Plan." July 2003. https://superiorwatersheds.org/wp-content/uploads/Lower_Dead_River_Watershed_Management_Plan.pdf

Superior Watershed Partnership. "Great Lakes Shoreviewer." 2015. http://www.greatlakesshoreviewer.org/#/great-lakes

United States Census Bureau. "American Community Survey- Data Table and Tools" Accessed February, 2019. https://www.census.gov/acs/www/data/data-tables-and-tools/

United States Environmental Protection Agent (USEPA). Community Solutions for Stormwater Management: A Guide for Voluntary Long-Term Planning. October 2016. https://www.epa.gov/sites/production/files/2016-10/documents/draftlongtermstormwaterguide_508.pdf

United States Environmental Protection Agency (USEPA). 2016. Climate Change Impacts by State. Overviews and Factsheets. https://www.epa.gov/climateimpacts/climate-change-impacts-state.

United States Environmental Protection Agency (USEPA). 2001. *Ambient Water Quality Criteria Recommendations Information Supporting the Development of State and Tribal Nutrient Criteria Rivers and Streams in Nutrient Ecoregions VIII*. Office of Water. EPA 822-B-01-015

United States Fish and Wildlife Service National Wetlands Inventory. "Wetlands Mapper." Revised October 17, 2018. https://www.fws.gov/wetlands/data/Mapper.html

United States Geological Survey (USGS). "Ground water and geology of Marquette, County, Michigan." Open-File Report 82-501. 1982. https://pubs.er.usgs.gov/publication/ofr82501

United States Geological Survey (USGS). "Ground water atlas of the united states Iowa, Michigan, Minnesota, Wisconsin" HA 730-J. 1992. https://pubs.usgs.gov/ha/ha730/ch_j/index.html

Waters, T.F. 1995. Sediment in Streams: Sources, Biological Effects, and Control. American Fisheries Society Monograph 7. Bethesda, Maryland, 251pp.

Weather Channel. "Climate Almanac-Marquette, MI." Accessed January 16, 2019. https://weather.com/weather/monthly/l/USMI0525:1:US

Wisconsin Department of Natural Resources (WiDNR). Trout Stream Classifications. January 23, 2017. https://dnr.wi.gov/topic/fishing/trout/streamclassification.html (Accessed March 19, 2019)

Zielinski, J. 2002. Watershed Vulnerability Analysis. Center for Watershed Protection. Ellicott City, MD, 22pp.