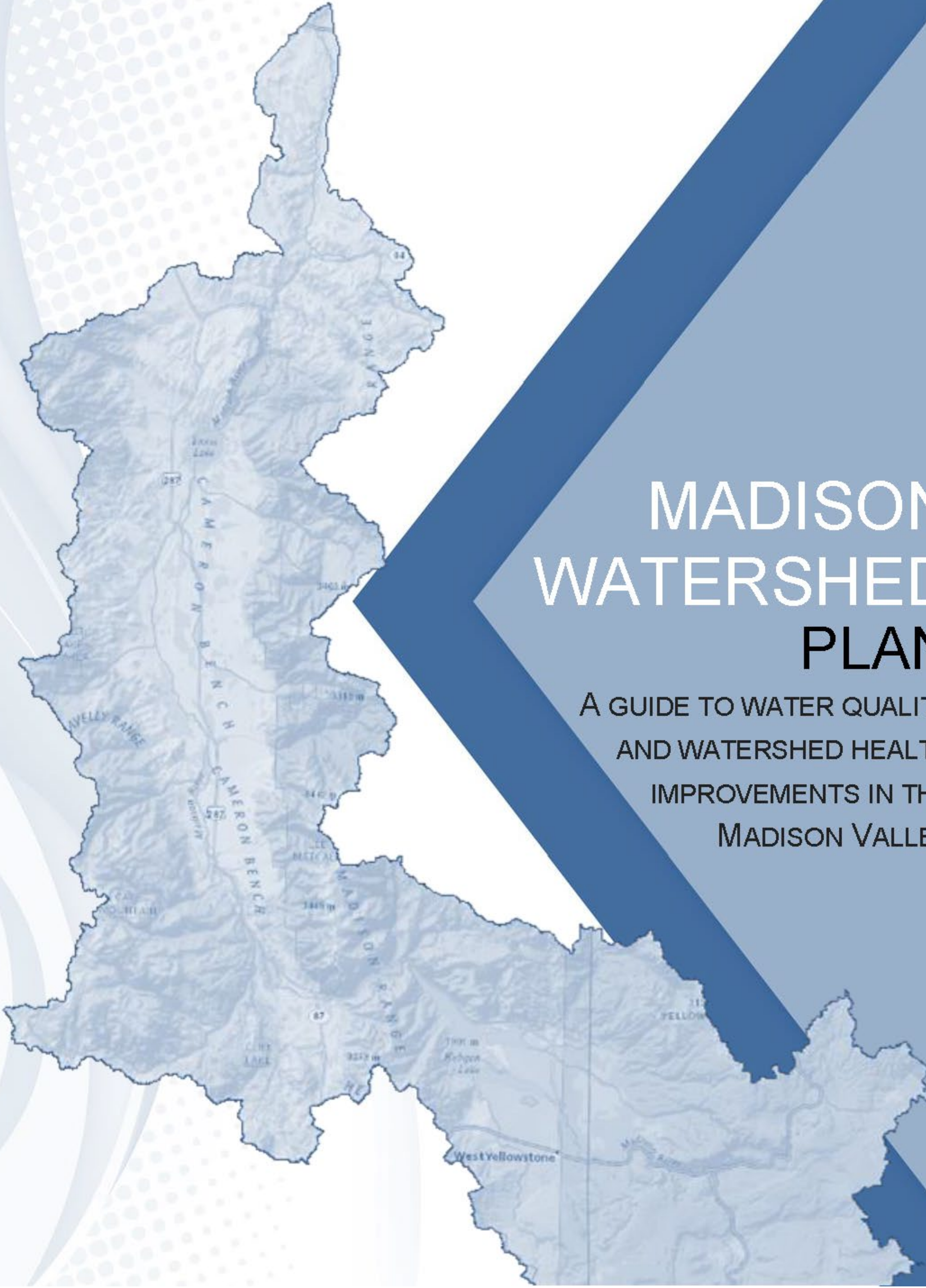
MADISON WATERSHED PLAN

A GUIDE TO WATER QUALITY AND WATERSHED HEALTH IMPROVEMENTS IN THE MADISON VALLEY



Prepared by:

Raeya Gordon, Madison Conservation District

David Laufenberg, Madison Conservation District

Colin Threlkeld, Madison Conservation District

Jeff Dunn, WGM Group

Published: March 2024

CONTENTS

LIST OF ACRONYMS

BLM – US Bureau of Land Management

BMP – Best Management Practice

DEQ – Montana Department of Environmental Quality

DNRC – Montana Department of Natural Resources and Conservation

EPA – Environmental Protection Agency

FSA - Fishing Access Site

FWP – Montana Fish, Wildlife and Parks

GCD – Gallatin Conservation District

MBMG – Montana Bureau of Mines and Geology

MCD – Madison Conservation District

MRF – Madison River Foundation

NRCS – US Natural Resource Conservation Service

SAP – Sampling & Analysis Plan

SOP- Standard Operating Procedures

TMDL – Total Maximum Daily Loads

TU – Trout Unlimited

USFS – US Forest Service

WEPP – Water Erosion Prediction Program

WRP – Watershed Restoration Plan

1.0 INTRODUCTION

1.1 BACKGROUND

It is a time of great change in the Madison Watershed. In the state of Montana, Madison County is second in growth (4.8%; Montana Legislative Fiscal Division 2022) only to Gallatin County (5.2%), and it is the only county to experience a doubling of taxable property values in a five-year period (2016-2020). Temperatures have been increasing as well. They have risen an average of 0.39 degrees Fahrenheit each decade over 65 years and are expected to rise an additional 3-7 degrees by mid-century (Whitlock et.al, 2017). Although the pressures upon our natural resources are increasingly severe, Watershed Restoration Plans (WRP) represent one tool for collective action leading to positive environmental outcomes.

This process began nearly a decade ago as the Department of Environmental Quality (DEQ) teamed up with the Madison Conservation District (MCD) to collect data and work with the community to identify areas of water quality concern. After a few years of field work and laboratory analysis, the DEQ went to work on reporting findings and the MCD began hosting a series of community meetings to discuss the WRP process in 2017 and 2018 with the intent to engage key stakeholders to help enrich and inform the outcome. In 2019 and 2020, the DEQ finalized the Total Maximum Daily Load (TMDL) reports for the Madison Watershed. As part of the analysis, these technical reports utilize both community collected data and agency collected data, and are an integral piece of the finalized WRP. Additionally, DEQ also produced a collection of "Stream Summaries" (*Appendix A)* that provide a useful synthesis of the TMDL reports for people interested in the stream health of the Madison Watershed.

Notably, significant time had elapsed since the earlier stakeholder meetings, so an article in the local paper was published (Spring 2021) and another community meeting was held (July 2022) so that the public could provide additional comments to supplement earlier information. In the meantime, the MCD hired a consultant to help provide expertise and experience and worked with state agencies to help finish the WRP and collect meaningful contributions. Regardless of agency and professional efforts, it is incumbent upon the Madison Valley community and its various key stakeholders to work towards long-term goals and implement conservation activities and projects to ensure a healthy watershed for future generations.

1.2 WHAT IS A WATERSHED RESTORATION PLAN (WRP)?

Watershed restoration plans (WRPs) are designed to help protect and restore our country's water resources. Creating a plan is one of the requirements for groups receiving grants under Section 319 of the federal Clean Water Act, which is administered by the US Environmental Protection Agency (EPA). In Montana, the Montana Department of Environmental Quality (DEQ) manages the EPA grants.

Watershed restoration plans provide a framework for managing efforts to both restore water quality in degraded areas and to protect overall watershed health. A WRP is a comprehensive assessment that identifies nonpoint source pollution, its sources and effects, as well as outlines a set of strategies to measure and mitigate each.

Because nonpoint source pollution arises from many diffuse sources, and mitigating it often requires voluntary action by individual landowners, successfully achieving water quality goals typically involves years of support through a coalition of stakeholders and a variety of programs and funding sources. WRPs help stakeholders holistically address water quality issues by fully assessing the contributing causes and sources of pollution and setting priorities for restoration and protection that are ultimately tied to specific projects and programs.

1.3 EPA'S NINE KEY ELEMENTS OF A WRP

Although many different components may be included in a WRP, EPA lists nine key elements critical for achieving water quality improvements and that must be included in all WRPs supported with Section 319 funding. The elements are summarized below and are included in this WRP in the noted sections.

1. Identify causes and sources of pollution. (Section 3)

2. Estimate pollutant loading into the watershed and expected load reductions. (Section 3)

3. Describe management measures to achieve load reductions in targeted critical areas. (Section 4)

4. Estimate the required technical and financial assistance and the relevant authorities needed to implement the plan. (Sections 4 & 5)

5. Develop an information/education component. (Sections 6 & 7)

6. Develop a project schedule. (Section 6)

7. Describe interim measurable milestones. (Section 6)

8. Identify indicators to measure progress. (Section 6)

9. Develop a monitoring component. (Section 6)

1.4 HOW CAN I PARTICIPATE?

MCD welcomes input and participation from landowners, agriculture groups, business owners, outfitters and guides, conservation groups, local, state, and federal government entities, and individuals. We seek viable restoration projects and ideas for improving watershed health. We encourage citizens to attend community meetings and share their ideas for improving the health and quality of the Madison Watershed. As always, all of our meetings are open to the public.

There are many examples of opportunities for landowner engagement and restoration activity. By using Best Management Practices (BMPs), landowners can reduce the pollutants entering streams and improve stream health. Some BMPs include appropriate culvert sizing, maintaining vegetated stream banks, and pumping septic systems. There are also more active forms of restoration, ranging from beaver mimicry and riparian fencing, to more intensive restoration practices. Please see Section 4.0 in this document for more information about restoration activities and best management practices.

For more information about the MCD, our projects, plans, and meeting minutes, visit us online at madisoncd.org or email us at info@madisoncd.org.

2.0 DESCRIPTION OF THE MADISON WATERSHED

The headwaters of the Madison River lie within the boundaries of the Nation's first National Park. This river system, and the landscape surrounding it, make up one of the most iconic regions in Montana. Mountain snowpack feeds thousands of miles of streams that support productive agricultural lands, distinctive fish and wildlife populations, and vibrant communities that continue to grow throughout the Madison Valley.

Nearly 3,000 miles of tributary streams feed into the Madison River before forming the Missouri River at the confluence near Three Forks, MT. From there, water that originated in the Madison Valley flows through 12 more states before reaching the Gulf of Mexico.

2.1 POLITICAL BOUNDARIES

The Madison Watershed encompasses 1,635,790 acres within Montana and Wyoming. Excluding the 400,000 acres within the headwaters region of Yellowstone National Park, there are just over 1.2 million acres that lie within Montana's borders. Of this, the majority of the drainage is within Madison County, with some smaller portions also occupied by Gallatin and Beaverhead Counties (Figure 1). Likewise, most of the watershed is also within the boundaries of the Madison Conservation District (Figure 2). However, there are some fragmented sections that also fall within the jurisdiction of the Gallatin Conservation District, Beaverhead Conservation District, and Ruby Valley Conservation District.

There are several public agencies that own or manage land in the watershed, including the Beaverhead-Deerlodge National Forest, Custer-Gallatin National Forest, Bureau of Land Management, Montana Department of Natural Resources and Conservation, Montana Fish, Wildlife and Parks, US Fish and Wildlife Service, National Park Service, etc.

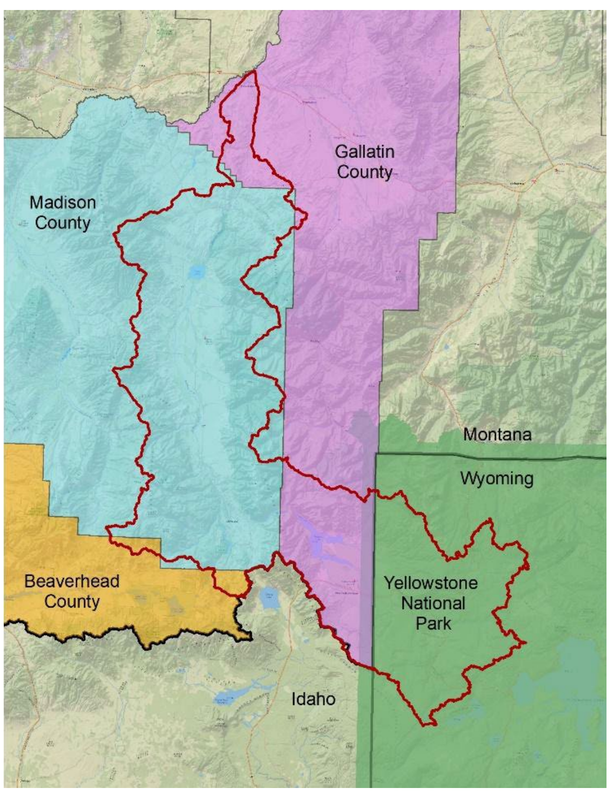


Figure 1. Jurisdictional boundaries of the Madison Watershed

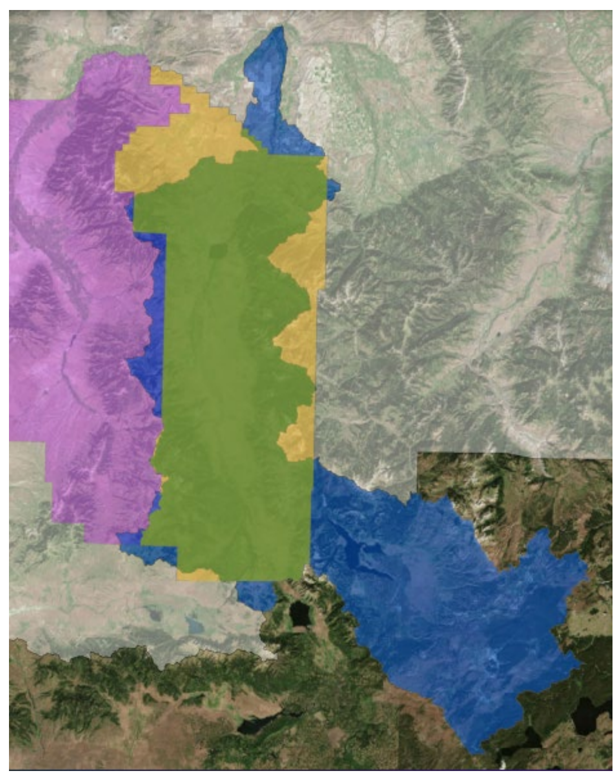


Figure 2. Madison Watershed (blue) and the Madison Conservation District Boundary (yellow)

2.2 PRIMARY LAND USES

Land uses throughout the Madison Valley have evolved over the last century, but generally consist of residential development, agricultural production, recreation, mining, and other activities common on public lands (Figure 3). Of the 1.2 million acres of land in the Madison Valley within Montana's borders, nearly 60% is in public ownership. Meanwhile, of the remaining acreage in private hands, nearly 88% are in agricultural production, leaving the rest to residential development. As of 2017, the Madison Valley also had a high proportion of private land in conservation easements, totaling over 224,000 acres (46.5% of private lands). This land is restricted from future development, and provides future habitat, open spaces, and agricultural production opportunities in perpetuity.

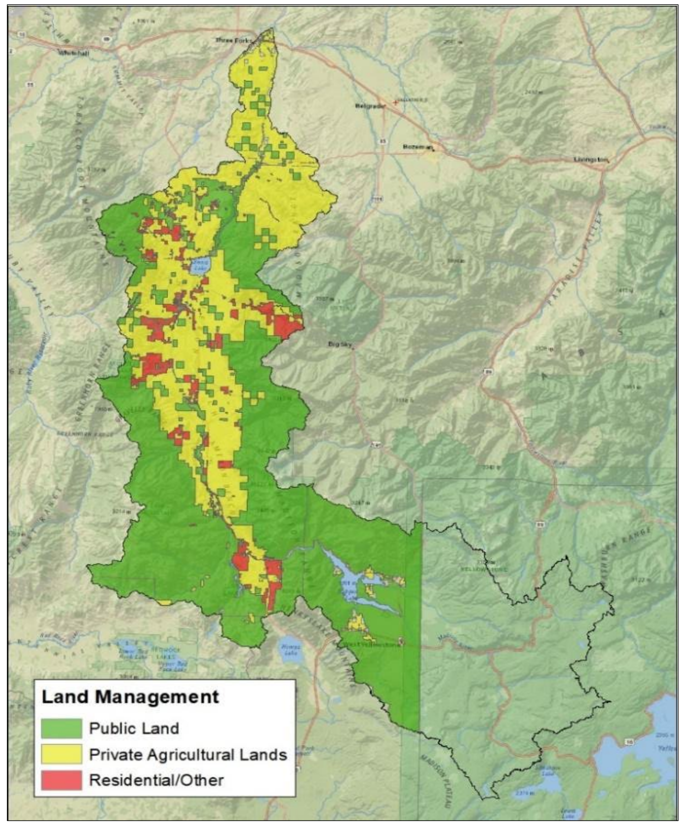


Figure 3. Land Management in the Madison Watershed within Montana

2.3 CLIMATE CONDITIONS

Water in the Madison Watershed is driven by winter snowpack. This snowpack is variable across the valley from the north to south, as well as across the Madison, Tobacco Root, and Gravelly Mountain Ranges. Temperature variations throughout the seasons can be extreme. Expected low temperatures in the winter across all portions of the watershed reach sub-0°F, while summer highs will reach consecutive days of +90°F. Weather data collected over the past century shows slight, but noticeable, changes in the general climate of the Madison Valley over recent decades (Figure 4).

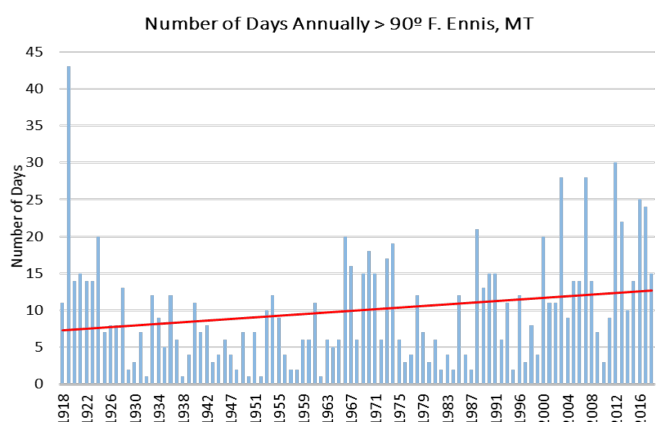


Figure 4. Number of days above 90℉ annually for Ennis, MT from 1918 - 2018. Source: NOAA

TEMPERATURE

Temperatures in the Madison Valley consist of long periods below freezing, with a short growing season. According to the 1965 Water Resources Survey, the growing season for Ennis, MT is 101 days long. Since that time, however, the number of frost-free days has increased, while the number of days above 90°F has also increased (Figure 4). The increasing temperatures have strong implications for water availability as well as agricultural production. Fewer sub-zero days throughout the year are changing the accumulation of snowpack, which can affect the availability of water for irrigation and instream flows. The increased number of frost-free days have the potential to increase agricultural productivity. However, there is also an increase in evapotranspiration from an increased number of days in summer that reach temperatures above 90°F. Figure 4 shows the number of days each year in Ennis with highs above 90°F, while Figure 5 shows the number of days each year where temperatures dropped below 0°F and 32°F respectively.

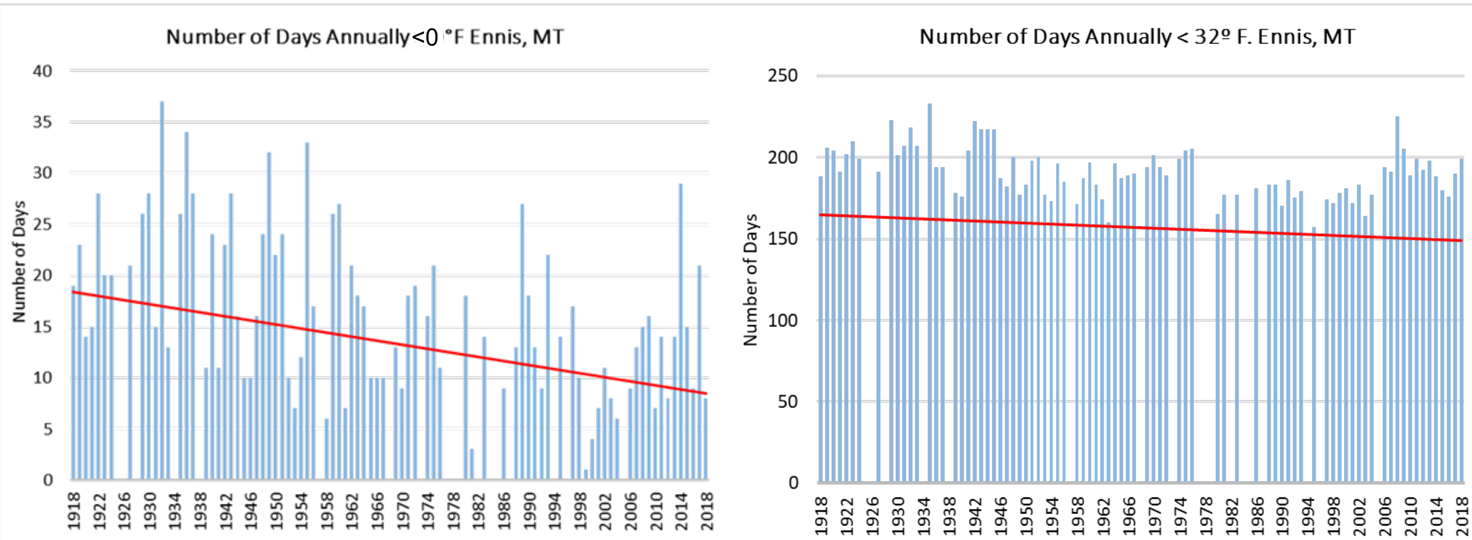


Figure 5. Number of days below 0°F and 32°F annually for Ennis, MT from 1918-2018. Source: NOAA

PRECIPITATION

Precipitation across the Madison Watershed varies considerably. Winter snowpack contributes large amounts of moisture in the Madison, Tobacco Root, and Gravelly Mountain Ranges, while the valley bottoms typically receive much less precipitation overall. The 1965 Water Resources Survey documented the average annual precipitation for Ennis as 11.14 in/year. However, the most recent 30-year (1988-2018) mean precipitation for Ennis is now up to 12.56 in/year. The overall trend for the past 100 years shows a slight increase in precipitation throughout parts of

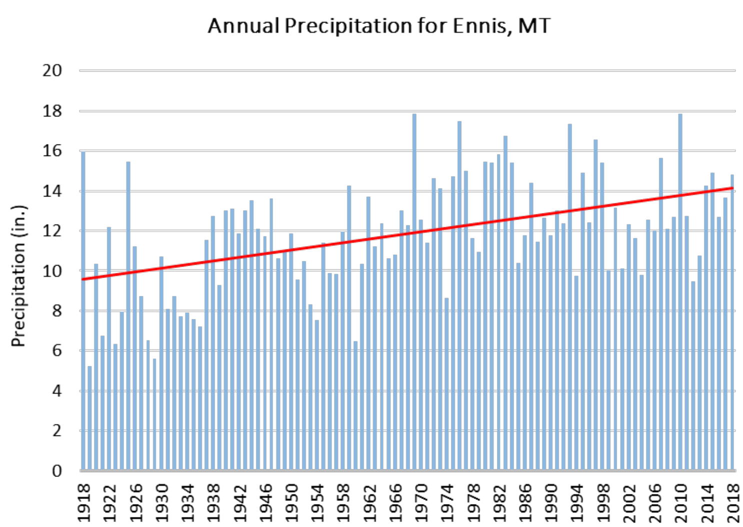


Figure 6. Annual Precipitation in Ennis, MT from 1918-2018. Source: NOAA

the Madison Valley (Figure 6). The important distinction in this data, however, is that the form of this increased precipitation is often rain instead of snow. Furthermore, snowpack is melting off earlier than in previous decades. One indicator of this earlier snowmelt is the April 1st snow water equivalent, which has an overall decline across the entire Madison Watershed (Figure 7).

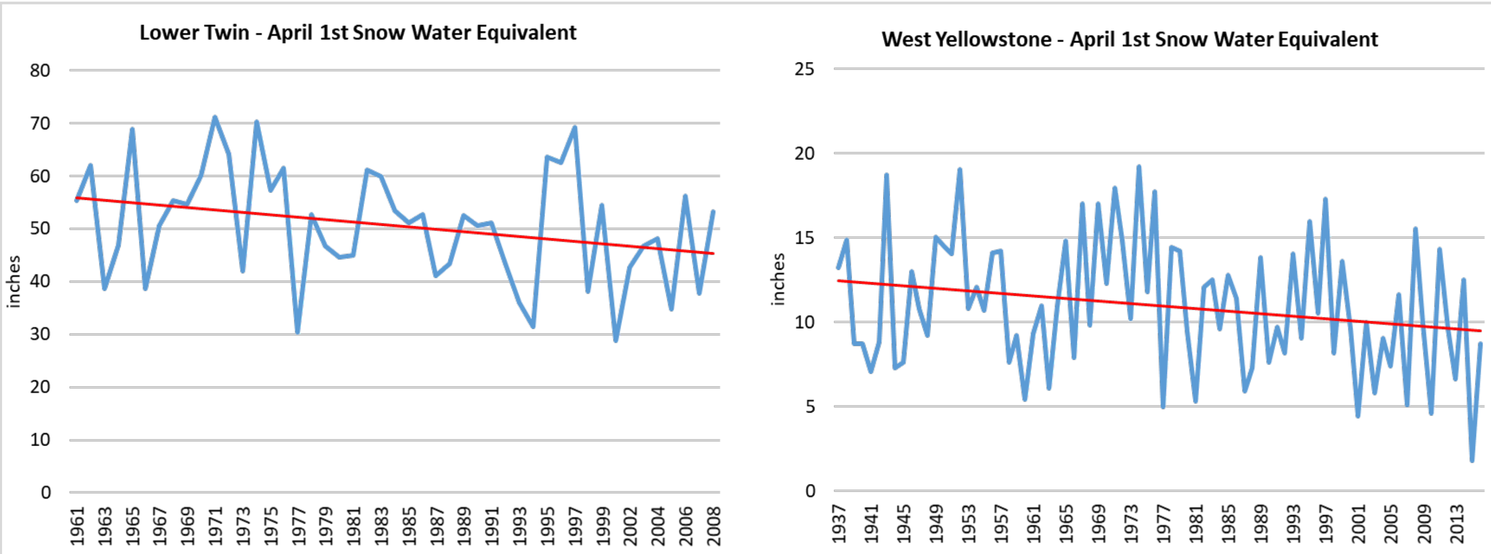


Figure 7. April 1st snow water equivalent at Lower Twin and West Yellowstone SNOTEL sites. Source: NOAA

FUTURE PROJECTIONS

Water is the most limiting resource for growth, agriculture, recreation, and economic development, in the Madison Watershed. The following sections provide a summary of the ways in which surface water and groundwater are utilized throughout the Madison Valley.

The Madison Watershed produces approximately 1.3 million acre-feet of water annually (DNRC, 2014). This water is used for multiple uses, such as agriculture, stock water, domestic and public water supply, hydropower generation, native flora, and fish and wildlife. The use of this water is managed by the Department of Natural Resources & Conservation who administers water rights in Montana, and these water rights are managed through a system of prior appropriations.

2.4 WATER USES AND RELATED INDUSTRIES

AGRICULTURAL IRRIGATION

For over a century, surface water has been diverted and moved across the landscape in the Madison Valley to assist in agricultural production. Agricultural production is a vital component of the social, cultural, and economical makeup of the Madison Valley, and this industry is highly dependent on water availability. Throughout the industry, water is used for hay and crop irrigation, as well as water for livestock.

Compared to surrounding valleys, the Madison Watershed has a relatively small amount of agricultural irrigation due to the high alluvial terraces above the Madison River. However, there is a significant amount of irrigation withdrawal from smaller tributaries feeding into the mainstem that can lend to severely low flows (see Indian Creek and Cherry Creek in DEQ's *Stream Summaries* document). Approximately 39,000 acres of agricultural land are irrigated in the Madison Valley (SEO, 1965) diverting roughly 183,000 acre-feet of water (DNRC, 2014). Most of this diverted water comes from the dozens of perennial tributary streams in the Madison, Tobacco Root, and Gravelly Mountain Ranges.

STOCKWATER

Livestock production is the most widespread use of land in the Madison Watershed. Access to water can sometimes be a limiting factor for livestock. Stockwater sources include both surface water (streams and ditches) and groundwater (stockwater tanks). Stockwater makes up a significantly smaller amount of overall water use compared to irrigation. In the Madison Watershed, stockwater is estimated to use 0.61 Mgal/Day (million gallons per day), compared to irrigation at 250.21 Mgal/Day during the growing season (USGS, 2000).

RECREATION (FISHING, FLOATING, HUNTING, & CAMPING)

Tourism is now the largest industry in Montana. Tourism in the Madison Valley is directly tied to the land, water, and wildlife resources throughout the watershed. Recreation amenities, such as fishing, floating, camping, hiking, hunting, and wildlife viewing, are among the top reasons for tourists to visit the Madison. These amenities are all dependent on clean and abundant water. Currently, the Madison River is the most heavily fished river in Montana, and this increase in popularity creates social and biological challenges that are being discussed within the community. From an economic standpoint, protecting the land and water resources in the Madison Watershed is a necessity to support the recreation and tourism-based economy that has continued to grow in recent years.

HYDROPOWER & RESERVOIR OPERATION

There are two large reservoirs on the Madison River: Hebgen Lake and Ennis Lake. These reservoirs are operated by NorthWestern Energy, and are used to generate electricity from the Madison Dam northeast of McAllister. Hebgen Dam, built in 1914, was built to regulate flows to Ennis Lake. Hebgen has a capacity of roughly 386,000 acre-feet, while Ennis Lake (built in 1901) is significantly smaller and suffers from a century of sedimentation lending to a shallow reservoir that drives elevated temperatures on the Lower Madison. Outgoing flows from each reservoir regulate streamflow on the Madison River for volume and water temperature. During the summer, NorthWestern Energy often releases pulse flows when water temperatures reach critical levels for fish populations. These two lakes are carefully regulated to meet several demands, including: FERC licensing, environmental and recreation needs, and hydroelectric production needs.

DOMESTIC & MUNICIPAL

Residential development in the Madison Watershed has risen sharply in the past two decades (Figure 8). Madison County is the second fastest growing county in Montana (4.8% in 2020; second only to Gallatin County at 5.2%; Montana Legislative Fiscal Division). Development trends in the Madison Watershed are consistent with the general growth patterns observed throughout the High Divide region of Montana and Idaho. With close proximity to recreation opportunities, airports, and other amenities, the Madison Valley is attracting new residents at a faster rate than most other rural areas in Montana. In Madison County, most of this growth is taking place outside municipal areas.

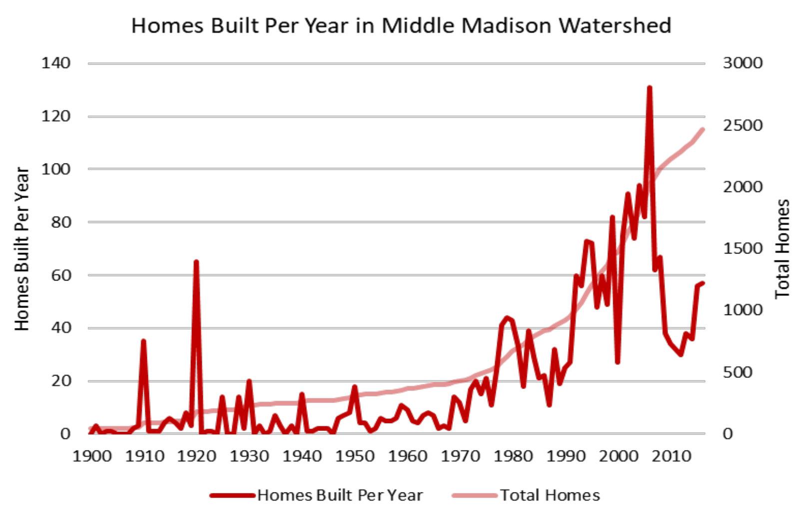


Figure 8. Homes Built Per Year in the Middle Madison Watershed 1900 to 2016

A study from Headwaters Economics shows that 91% of the ~1,680 homes built in Madison County between 2000-2013 were developed outside of the municipal areas. This development and growth in rural areas can present challenges to natural resources. Impacts from increased rural development often include, but are not limited to: increased groundwater consumption, invasive species introduction, increased forest fire risk, and fragmented wildlife habitat. One example of focused rural development in the Madison Watershed is the increased rate of residential development in the headwaters of Jack Creek. Due to environmental pressures and potential impacts in the categories listed above, it will be important to monitor how the water quality of Jack Creek responds to these landscape changes that are occurring in the stream's headwaters.

Figure 8 shows the rate of growth for housing development in the Madison Watershed from 1900-2016. Development and population growth are expected to continue increasing during the foreseeable future, and this growth has potential to adversely affect the health of the landscape and natural resources in coming decades. Figure 9 below shows a series of images depicting the number of homes built throughout the middle portion of the Madison Watershed from 1920-2016.

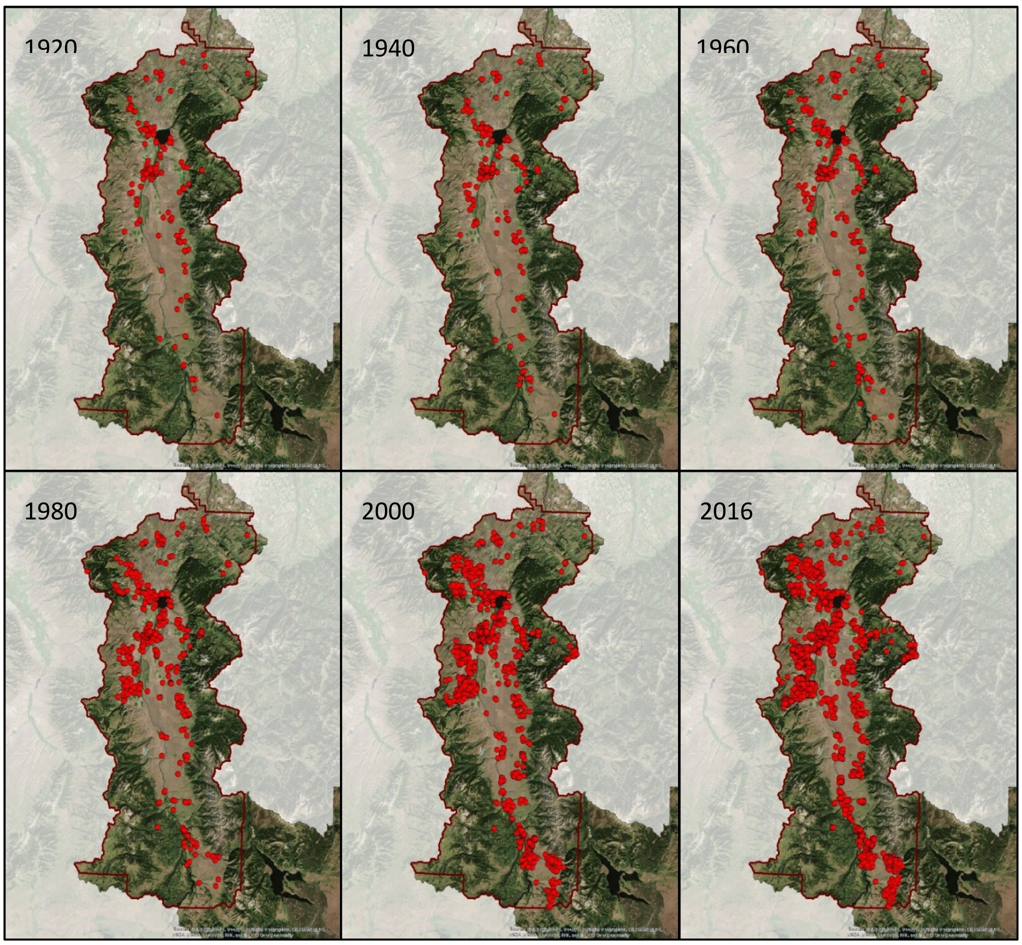


Figure 9. Housing development in the middle portion of the Madison Watershed. Source: Headwaters Economics

2.5 SURFACE WATER MONITORING AND CONDITIONS

WATER QUALITY

Water quality data has been collected on several tributaries to the Madison River since 2010. These data collection efforts have been led by the Montana DEQ and Madison Stream Team. The Madison Stream Team is a citizen science monitoring program managed by the Madison Conservation District that collects streamflow and water quality information on select waterways in the Madison Valley. On a weekly basis, Jack Creek, Moore Creek, and South Meadow Creek are monitored for quality and quantity of water. On an annual basis, MCD conducts a *Tributary Blitz* that monitors 15 tributaries to examine long-term water quality trends. A *Tributary Blitz* is a form of synoptic sampling whereby we manage teams of citizen scientists to collect data across the watershed on a single morning of sampling.

SNOWPACK

Information about mountain snowpack has been collected at various locations in the basin since the 1930s. The NRCS (formerly the Soil Conservation Service) has maintained this network, and added newer technologies over time that collect data on snow depth and moisture content in mountainous areas. Below is a list of SNOW course and SNOTEL sites that have been utilized since the program began. These stations provide critical information during the winter months that help water users and resource managers plan for spring and summer conditions. Additionally, the data can help show historical trends and changes in snowpack over the course of decades.

Station Type	Station Name	Status
SNOTEL	Beaver Creek	Active
SNOTEL	Black Bear	Active
SNOTEL	Clover Meadow	Active
SNOTEL	Lower Twin	Active
SNOTEL	Madison Plateau	Active
SNOTEL	Tepee Creek	Active
SNOTEL	West Yellowstone	Active
SNOTEL	Whiskey Creek	Active
SNOW	Four Mile	Active
SNOW	Hebgen Dam	Active
SNOW	Lake Creek	Active
SNOW	Norris Basin	Active
SNOW	Old Faithful	Active
SNOW	Potomageton Park	Active
SNOW	Twenty-One Mile	Active
SNOW	West Yellowstone	Active
SNOW	Big Sky	Inactive
SNOW	Call Road	Inactive
SNOW	Lower Twin	Inactive
SNOW	Madison Plateau	Inactive
SNOW	Norris Basin (Old)	Inactive
SNOW	North Meadow	Inactive
SNOW	Sentinel Creek	Inactive
SNOW	Tepee Creek	Inactive
SNOW	Whiskey Creek	Inactive

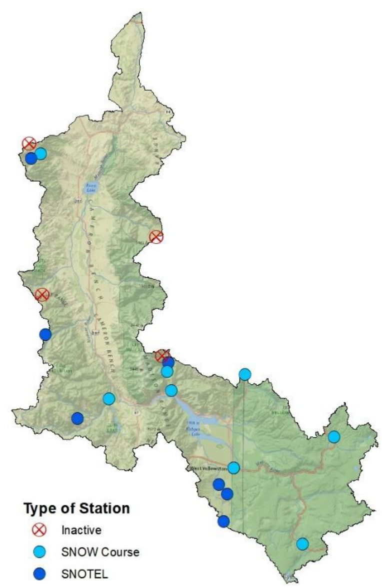


Figure 10. SNOW Course and SNOTEL sites that have been utilized since the program began. Source: USDA

STREAMFLOW

Streamflow in the Madison Watershed is monitored by several agencies, including: USGS, FWP, NorthWestern Energy, and the Madison Conservation District. The USGS, FWP, and NorthWestern Energy manage streamflow gages on the Madison River and its reservoirs, while the Madison Conservation District is responsible for seven gaging stations on tributaries to the Madison River (Jack Creek, South Meadow Creek, and Moore Creek).

To simplify the search for this stream gage data, all of this information is housed on the Madison River Conditions webpage (https://uppermissouriheadwaters.org/river-conditions/).

The streamflows on the Madison River are trending toward earlier peaks in recent years. Figure 11 shows that the flow pattern on the river in 2007-2016 is very similar to 1917-1926, but the time of the peak has shifted slightly earlier. Even if the amount of water is consistent, a change in when the Madison River is receiving water can have implications for the effectiveness of the snowpack as water storage, drought resiliency, and water use.

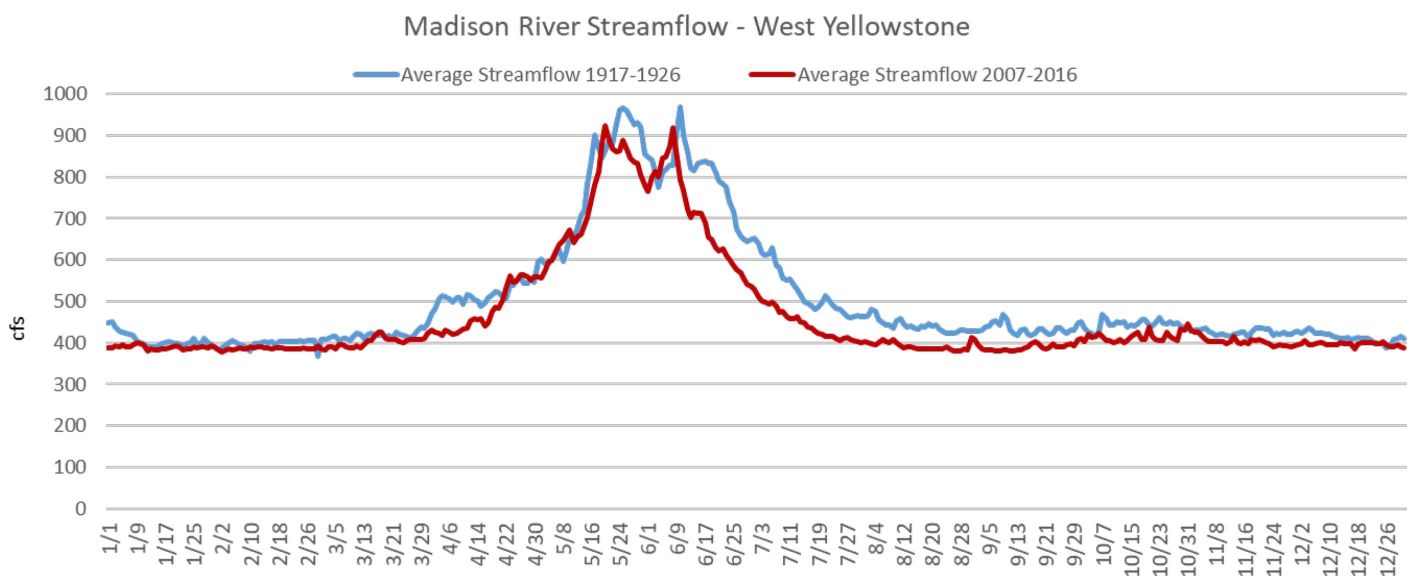


Figure 11. Average streamflow on Madison River (West Yellowstone USGS Gage) during two ten-year periods (1917-1926) and (2007-2016). Source: USGS

WATER STORAGE AND PONDS

The Madison Watershed has approximately 199 private ponds that generate an additional 274 acres of surface water (Holocene and Montana Fish, Wildlife and Parks, 2020). These ponds likely have a biological and hydrologic impact upon the watershed, but not much is known at this time beyond this initial analysis of satellite imagery.

2.6 GROUNDWATER MONITORING AND CONDITIONS

Groundwater throughout the Madison Watershed is monitored primarily by the Montana Bureau of Mines and Geology (MBMG) (Figure 12). As of 2018, MBMG had 22 wells in their long-term monitoring network in Madison County. The wells in this network are regularly measured to detect changes in water elevation, and also undergo periodic water quality testing. This information is easily found on their website by visiting their Groundwater Information Center. Here, users can obtain hydrograph data for each of their long-term monitoring wells that shows seasonal fluctuation, as well as long-term trends. Figure 13 shows an example of seasonal variation and longer-term trends from a monitoring well southwest of Ennis.

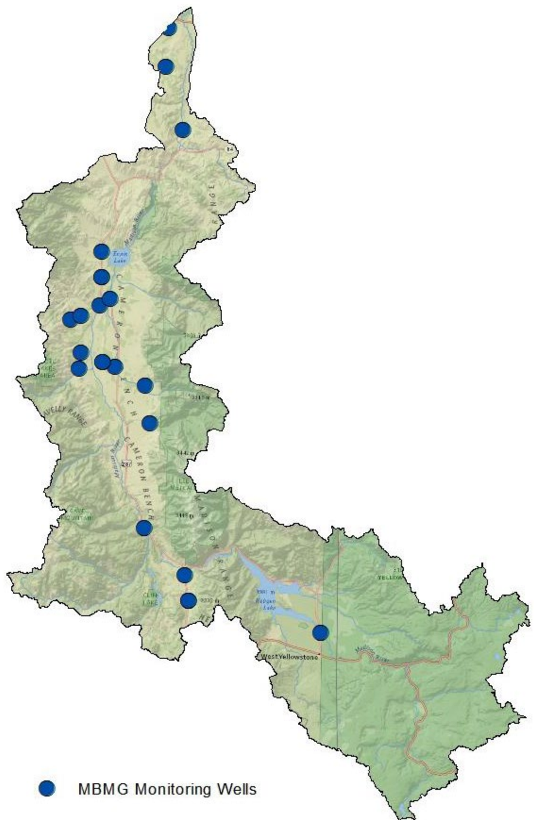


Figure 12. Montana Bureau of Mines and Geology groundwater monitoring locations, 2018

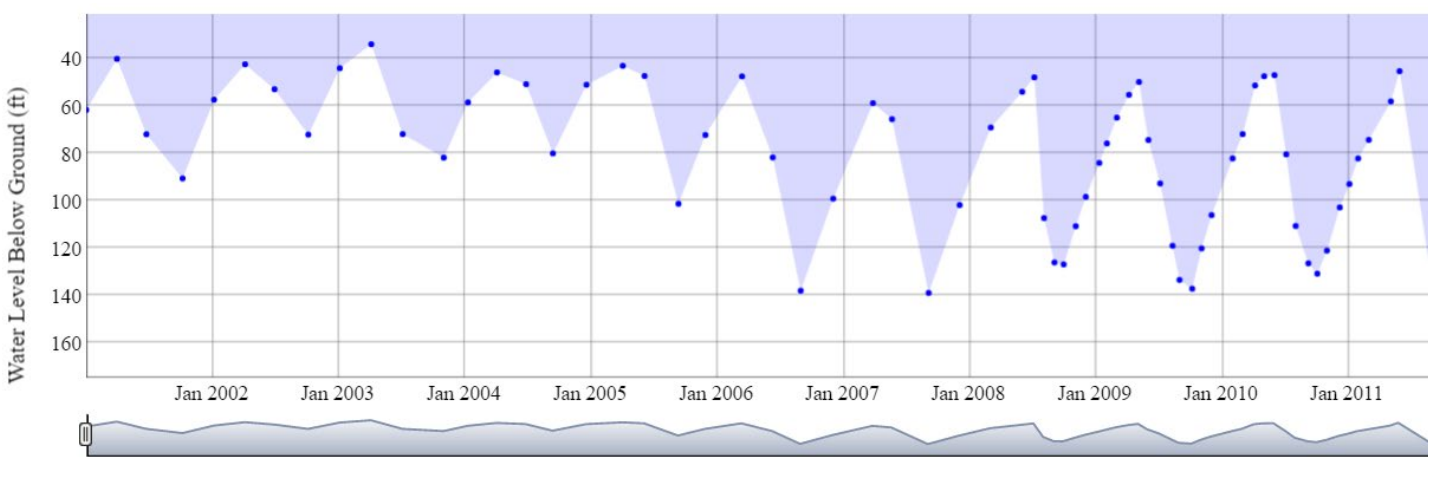


Figure 13. Example of groundwater measurement from Montana Bureau of Mines and Geology

Groundwater is being recognized for having a growing importance throughout Montana, and it is the primary source of most water used for domestic purposes. Additionally, it is an essential resource in agriculture for irrigation and stock use. Although there is an increasing demand on groundwater, there is far less data available to understand long-term trends and changes over time.

PRIMARY USES

A majority of groundwater certificates in Madison County are for domestic water use (Figure 14). Actual consumption of domestic withdrawals, however, tend to be relatively low. In comparison, pumping rates for agricultural irrigation can be significantly higher, but this use is seasonal. Comparatively, household water consumption often increases in the summer with residential lawn irrigation. The number of domestic groundwater claims has increased sharply in recent years with increased development in the County.

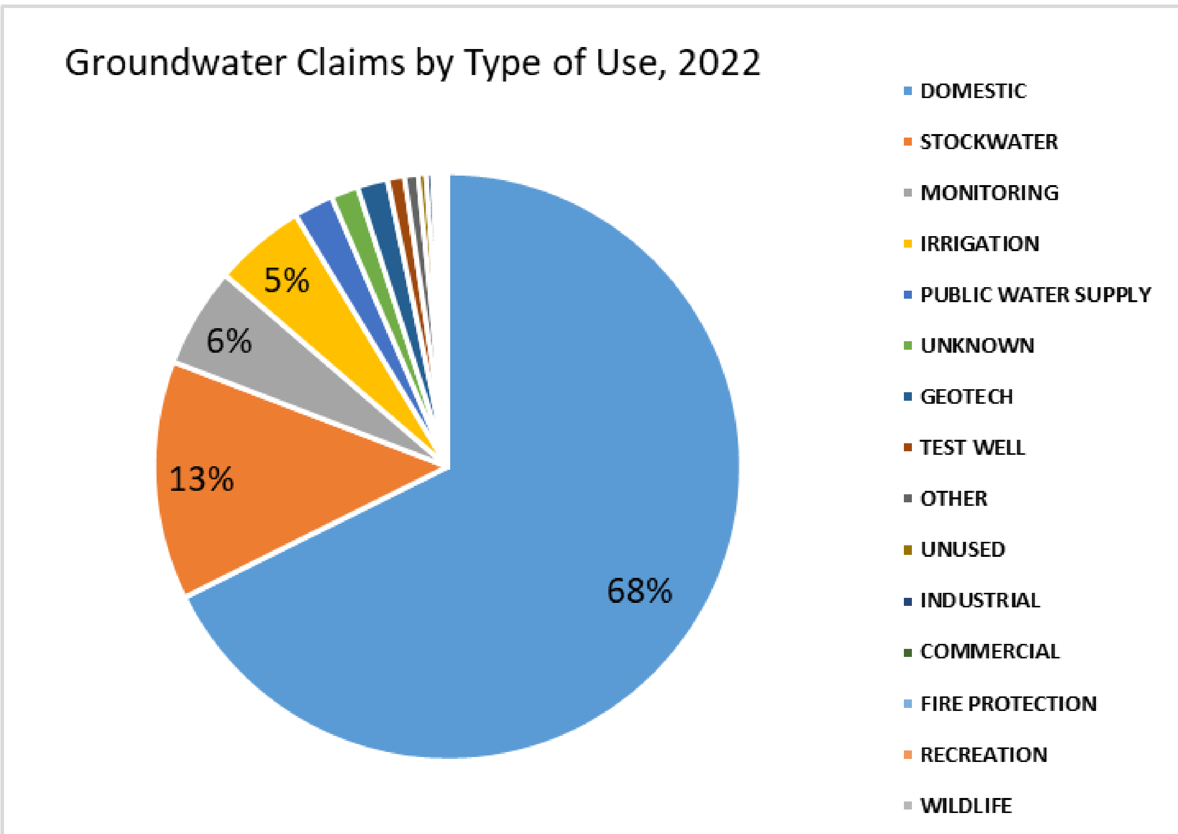


Figure 14. Number of groundwater rights by use type. Source: MBMG Groundwater Information Center, 2022

GROUNDWATER DEMAND

The installation of groundwater wells in the Madison Watershed began increasing sharply in the mid-1990s (Figure 15). These are generally domestic wells, and there is a very strong correlation between this increase and the increase in housing development in the 1990s. Although the Madison Watershed is closed to all new water rights appropriations, new groundwater wells are continually developed through the allowance of exempt wells. With rising demands for groundwater in the Madison Watershed, it's important to remember that all the water within a system is intimately connected. Future watershed planning must take into account rising demand and the strain that will put on groundwater resources.

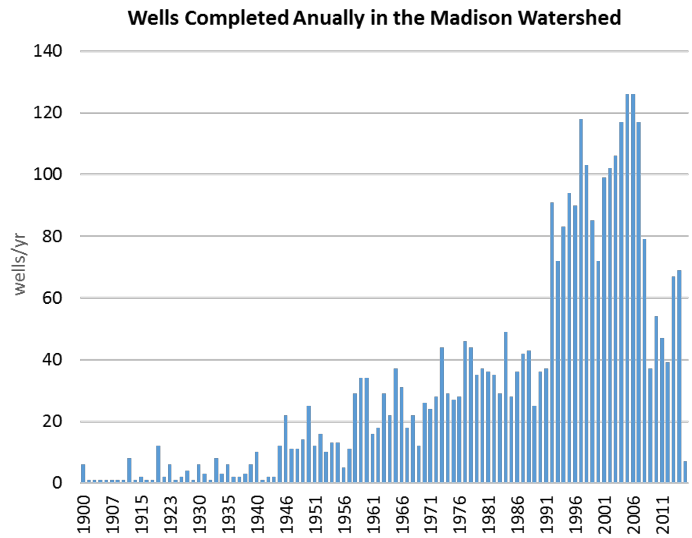


Figure 15. The growing population in the Madison Watershed has resulted in an increased number of wells over the years. Source: MBMG

3.0 IDENTIFYING IMPAIRMENTS AND SOURCES OF POLLUTANTS

3.1 WATER QUALITY IMPAIRMENTS AND TOTAL MAXIMUM DAILY LOADS

Each waterbody in Montana has a set of designated uses. Montana has established water quality standards to protect these uses, and a waterbody that does not meet one or more standards associated with a designated use is called an impaired water. The Montana Department of Environmental Quality (DEQ) produced Total Maximum Daily Load (TMDL) documents identifying the tributaries in the Madison Watershed with impairments. The TMDLs produced for the Madison Watershed cover sediment, temperature, nutrients, metals, *E. coli*, flow modification, and alteration to streamside vegetation. The MT DEQ *Madison Sediment and Temperature TMDLs and Water Quality Improvement Plan was* published in September 2020. The MT DEQ *Madison Nutrient, E. coli, and Metal TMDLs and Water Quality Improvement Plan* was published in February 2019. All the tributaries identified as impaired in the TMDL documents are represented in Table 1 and Figure 16. *Attachment A* includes the *Madison Watershed Stream Summaries* (MT DEQ, 2020), providing more details about each individual tributary and a summary of the two Madison TMDL documents.

Table 1. Impairment causes and anthropogenic sources for impaired streams in the Madison Watershed, as identified in the MT DEQ TMDL documents. MT DEQ, Madison Watershed Stream Summaries, 2020 (*Attachment A*).

Waterbody Name	Nutrient	Metals	E. coli	Sediment	Temperature	Flow Modification	Alteration to Streamside Vegetation
Antelope Creek				**EB**		**RG**	**RG**
Bear Creek				**UR, EB**			
Blaine Spring Creek	**PS, AG, RD, WWS**			**UR, EB**		**RG**	
Buford Creek							
Cherry Creek				**UR, EB**	**AG**		
Elk Creek	**AG, RD, WWS, MA**	**MA**		**UR, CP, EB**	**AG**		**RG, CP**
Ennis Lake		**MA**				**IR**	
Hot Springs Creek	**AG, RD, WWS, SI, MA**	**MA**		**UR, EB**		**AG, RC**	
Indian Creek						**ID**	**RG**
Jack Creek						**RG, EB, CM, RD, UR, RC**	**RG, RD, PR**
Moore Creek	**AG, RD, WWS, SI, MA**	**MA**	**WWS, DP, RU RD, AG**	**UR, EB**	**AG, RD**		**RG, RD**
North Meadow Creek				**UR, EB**		**CM**	
O'Dell Spring Creek	**AG, RD, WWS**						**RG**
Red Canyon Creek				**UR, EB**		**AG, RC**	**RG, RU**
Ruby Creek				**UR, EB**		**AG**	
South Meadow Creek	**AG, RD, WWS, SI, MA**	**MA**		**UR, EB**			
Watkins Creek				**UR, EB**		**AG**	**RG**
West Fork					**AG, RU**		
Wigwam Creek				**UR, EB**			

EB: Eroding Banks
UR: Unpaved Roads
AG: Agriculture
RD: Residential Development
RU: Recreational Use
RG: Riparian Grazing
IR: Instream Reservoir
RC: Road Crossings
ID: Irrigation Diversions/Dewatering

CM: Channel Manipulation
CP: Crop Production
PR: Parallel Roads
WWS: Wastewater systems
DP: Domestic Pets
MA: Mining Activity
PS: Point Source Discharges
SI: Silviculture

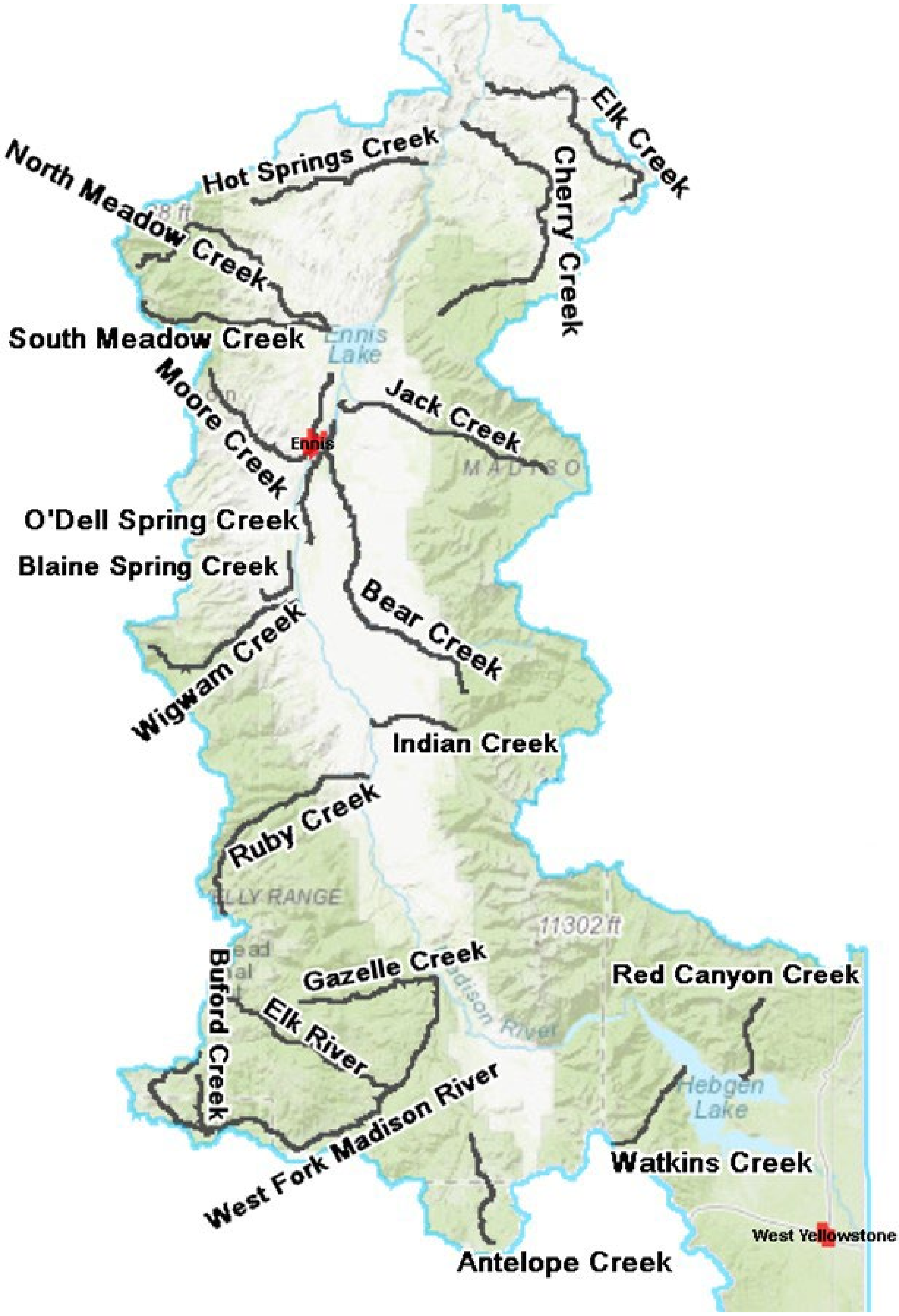


Figure 16. Map of Impaired streams in the Madison Watershed. Source: MT DEQ. 2020. Madison Watershed Stream Summaries. Helena, MT: Montana Dept. of Environmental Quality.

3.2 POLLUTANT SOURCES AND ESTIMATED REDUCTIONS IN POLLUTANT LOADING

The TMDL documents produced by Montana DEQ for the Madison Watershed outline the reduction in loading needed to meet water quality standards and no longer be considered impaired. The document also indicates the estimated reduction in loading that could accrue by adopting BMPs on various streams. The focus of this section is to consider the reductions needed to meet TMDL targets, in combination with the BMPs necessary to achieve that goal.

SEDIMENT LOADING

The sediment TMDL document estimates the allowable sediment load for each stream by estimating the attainable load reduction once all reasonable land, soil, and water conservation practices have been implemented. The three significant sources of sediment that were focused on when determining possible reductions are:

- Streambank erosion
- Upland erosion and riparian health
- Unpaved roads

STREAMBANK EROSION

Human impact and land management can lead to accelerated rates of streambank erosion and cause excessive fine sediment loading in streams and rivers. Causes of streambank erosion include: natural processes, transportation, cropping, mining, silviculture, irrigation related shifts in stream energy, and historical or legacy sources.

Implementing BMPs is estimated to reduce the sediment load due to streambank erosion by up to 32%, depending on the subwatershed. Some examples of BMPs that could reduce sediment load due to streambank erosion include healthy vegetation of streambanks, riparian fencing, floodplain reconnection, and restoration projects that lead to a healthy and balanced stream structure to reduce excessive erosion. Table 2 lists the estimated reduction in sediment load from human-caused streambank erosion for each waterbody in both tons/year and by percent reduction from current estimated loads.

Table 2. Estimated sediment load reductions (tons/yr) due to streambank erosion expected after implementing BMPs. MT DEQ, Madison Sediment and Temperature TMDLs and Water Quality Improvement Plan, 2020 (Table 5-30 and Page 5-45).

Subbasin	Existing Load (Tons/Yr)	Estimated Load w/ BMPs Implemented (Tons/Yr)	% Reduction
Antelope Creek	2115.4	1612.9	24%
Bear Creek	6990.27	5059.4	28%
Blaine Spring Creek	2507.6	1545.2	39%
Cherry Creek	7481.4	5835.0	22%
Elk Creek	4839.5	3346.0	31%
Hot Springs Creek	3884.3	2801.1	28%
Moore Creek	35225.5	2199.4	38%
North Meadow Creek	3277.4	2508.3	24%
Red Canyon Creek	1014.7	701.2	31%

Subbasin	Existing Load (Tons/Yr)	Estimated Load w/ BMPs Implemented (Tons/Yr)	% Reduction
Ruby Creek	2072.7	1914.2	8%
South Meadow Creek	2032.2	1378.1	32%
Watkins Creek	652.2	459.2	30%
Wigwam Creek	1269.3	1044.2	18%
Total	**41659.5**	**30404.3**	**27%**

UPLAND EROSION AND RIPARIAN HEALTH

MT DEQ does not consider upland erosion and riparian health to be a major contributing source of sediment to streams in the Madison TMDL Planning Area (TPA). Upland erosion and riparian health is not addressed as a priority area for restoration projects in this version of the Madison WRP as a result. Elk Creek was, however, assessed for this source category of sediment impairment in the *Madison Sediment and Temperature TMDLs and Water Quality Improvement Plan* (MT DEQ, 2020). Elk Creek is estimated to contribute 13.50 tons/year of sediment to the Madison Watershed as a result of cultivated crop fields with ≤100 ft riparian buffers adjacent to Elk Creek. Furthermore, MT DEQ estimates a sediment load reduction by 64% from existing sediment loads in Elk Creek if upland and riparian buffer BMPs are implemented.

UNPAVED ROADS

In addition to streambank erosion, unpaved roads are a large source of excess sediment inputs to streams. Unpaved roads that cross a stream or run parallel to a stream for a distance lead to dust and fine sediments settling into the streams, as well as contributing significant amounts of sediment during rain events. By paving these sections of road (crossings and parallel road segments), installing water bars to catch sediment during runoff events, and using proper BMPs, the sediment load due to unpaved roads can be greatly reduced. In addition to improving existing roads, it is important to consider the impacts of future road construction. As development continues in the Madison Watershed, roads should be set back from streams and constructed to allow a healthy riparian buffer to reduce sediment loading. Culverts that ensure aquatic organism passage should be installed where stream crossings are necessary. When it is practical, it is also best practice to utilize the construction of appropriately-sized bridges where road crossings are necessary, instead of installing culverts. Table 3 estimates the possible sediment reduction in percent and tons per year when BMPs are implemented on these important sections of roads.

Table 3. Estimated existing loads (no BMPs implemented), estimated sediment loads after BMP implementation, and estimated % load reductions achieved by BMP implementation from unpaved road crossings and unpaved parallel road segments. MT DEQ, Madison Sediment and Temperature TMDLs and Water Quality Improvement Plan, 2020 (Table 5-31 and Page 5-45).

Subwatershed	Existing Loads from Unpaved Road Crossings (Tons/Yr)	Estimated Loads from Road Crossings w/ BMPs (Tons/Yr)	% Load Reductions from Road Crossings w/ BMPs	Existing Loads from Unpaved Parallel Road Segments (Tons/Yr)	% Load Reductions from Parallel Rd Segments w/ BMPs (Tons/yr)	% Load Reductions from Parallel Rd Segments w/ BMPs
Antelope	1.63	0.38	77%	0.07	0.04	46%

Subwatershed	Existing Loads from Unpaved Road Crossings (Tons/Yr)	Estimated Loads from Road Crossings w/ BMPs (Tons/Yr)	% Load Reductions from Road Crossings w/ BMPs	Existing Loads from Unpaved Parallel Road Segments (Tons/Yr)	% Load Reductions from Parallel Rd Segments w/ BMPs (Tons/yr)	% Load Reductions from Parallel Rd Segments w/ BMPs
Bear	10.06	6.76	33%	24.93	12.72	49%
Blaine	4.25	2.89	32%	7.81	3.87	50%
Cherry	9.10	5.71	37%	11.93	5.85	51%
Elk	2.39	1.61	33%	6.14	3.26	47%
Hot Springs	9.25	5.80	37%	38.27	21.62	44%
Moore	4.13	2.04	51%	14.02	7.60	46%
North Meadow	14.25	7.23	49%	19.39	10.06	48%
Red Canyon	4.30	0.90	79%	2.56	1.39	46%
Ruby	0.34	0.15	55%	13.70	8.08	41%
South Meadow	7.46	2.85	62%	10.02	5.36	47%
Watkins	0.15	0.02	88%	0.22	0.12	46%
Wigwam	7.43	4.09	34%	8.60	4.59	47%
Total	**74.7**	**40.43**	**46%**	**157.7**	**84.6**	**46%**

TEMPERATURE LOADING

The temperature TMDL document outlines which tributaries have a temperature impairment, meaning the water temperature is too warm at long and regular enough intervals to cause stress to trout populations. One of the most effective ways to reduce stream temperature is by increasing streamside shade. Many of the sediment BMPs associated with streambank erosion and riparian buffering, including grazing management plans and practices (e.g., riparian fencing, offsite watering, or water gaps), will also benefit water temperature by improving riparian habitat and creating shade.

Table 4 lists the target effective shade necessary to reduce temperature. The streams with a temperature impairment are segmented into sections, comparing the target effective shade to the existing effective shade within each section. The table highlights which sections of stream need increased shade cover to reduce temperatures and improve stream health. Restoration activities such as riparian planting, riparian fencing to reduce grazing pressure, and low-tech process-based restoration (LTPBR) to encourage healthy floodplain connectivity can increase shade cover and help reduce water temperatures.

Table 4. Summary of the Madison TPA shade surrogate temperature TMDLs, and percent effective shade increase needed to meet each TMDL. MT DEQ, Madison Sediment and Temperature TMDL and Water Quality Improvement Plan, 2020 (Table 6-16 and Page 6-57).

Waterbody Name	Stream Segment	Average Target Effective Shade (%) (TMDL)	Average Existing Effective Shade (%)	Effective Shade Increase Needed to Meet TMDL (%)[1]
Cherry Creek	RM 0 to RM 7	70%	76%	Reach Meets or Exceeds Target
	RM 7 to RM 11.5	35%	47%	Reach Meets or Exceeds Shade Target
	RM 11.5 to RM 13.2	44%	41%	**3%**
	RM 13.2 to RM 14.8	33%	37%	Reach Meets or Exceeds Shade Target
	RM 14.8 to RM 17.7	30%	65%	Reach Meets or Exceeds Shade Target
	RM 17.7 to RM 26.5	22%	16%	**6%**
Elk Creek	RM 0 to RM 2.5	88%	82%	**6%**
	RM 2.5 to RM 8.3	63%	28%	**35%**
	RM 8.3 to RM 11	50%	43%	**7%**
	RM 11 to RM 22.4	42%	17%	**25%**
Moore Creek	RM 0 to RM 4.2	83%	82%	**1%**
	RM 4.2 to RM 10.4	65%	71%	Reach Meets or Exceeds Shade Target
	RM 10.4 to RM 11.8	67%	59%	**8%**
	RM 11.8 to RM 18.1	49%	17%	**32%**

[1] Bolded values indicate temperature reductions (shade increases) needed to meet the TMDL

NUTRIENT LOADING

The nutrient TMDL document outlines tributaries of the Madison Watershed that have a nutrient loading impairment. A nutrient loading impairment indicates that the existing load of total nitrogen (TN) or total phosphorus (TP) present in a waterbody exceeds the sum of allowable allocations from all sources. These sources include TN and TP loading from point and nonpoint sources of pollution. Point source pollution means that the pollutant is entering the system from a direct and discernible source such as a municipal wastewater treatment or industrial facility with pipes or ditches that are discharging pollutants to a waterbody. Nonpoint sources of pollution are diffuse in character and include natural background loading of pollutants as well as human-caused loading, including stormwater runoff, streambank erosion, and groundwater seepage resulting from anthropogenic activities such as agriculture, urban development, and forestry. Nutrient TMDLs are the sum of all allowable nutrient allocations from all sources.

There are currently three sources of point source pollution in the Madison Watershed. These include the Ennis National Fish Hatchery, the Ennis Wastewater Treatment Plant and West Yellowstone Wastewater Treatment Plant. Both of these wastewater treatment facilities are facing pressures from increased development, tourism, and population growth. The Ennis Wastewater Treatment Plant is at approximately half of the lagoon system's inflow and outflow operational capacity with the ability to treat wastewater from an approximate 500 additional residential sewer connections. The West Yellowstone Wastewater Treatment Facility is currently at capacity during the tourist season and there is a moratorium in place on new sewer connections in the municipality. West Yellowstone plans to upgrade the plant to a mechanical treatment and reuse system. However, construction of the new facility is being delayed by lease negotiations on the property where the proposed construction is to take place. The Ennis Wastewater Treatment Plant is a 3-cell, partially mixed, aerated lagoon system that provides treatment of domestic sewage generated by the municipality. In a memorandum produced by Great West Engineering in 2021, it is stated that the current wastewater treatment facility has the capacity to treat the waste generated by 2,300 people with an average outflow of 0.24 million gallons per day (MGD). The town of Ennis is currently discharging a daily average of 0.11 MGD. The system currently has the capacity to handle an additional 520 new residential sewer connections. With significant growth expected for the municipality in the coming years, it will be important to monitor the plant's capacity.

Table 5 lists the TMDLs for TN and TP, the actual existing nutrient load, and the percent reduction of each nutrient load necessary to achieve the TMDLs for each stream that is listed as impaired for nutrient loading in the Madison Watershed. These TMDLs are calculated using established numeric water quality standards as a function of mass per unit time (lbs/day). Implementing BMPs for point and nonpoint sources of pollution are used to achieve reductions in nutrient loading. Nutrient pollutant sources and BMPs for each impaired stream are described in the DEQ Madison nutrient TMDL Section 5.6.1-5.6.7

Table 5. Summary of the Madison TMDL Planning Area Nutrient TMDLs expressed at a median growing season flow rate, and percent reductions from existing loading needed to meet each TMDL. MT DEQ, Madison Nutrient, *E. coli*, and Metal TMDL, 2019 (Table 5-46 and Page 5-83).

Waterbody Name	Median Growing Season Flow Rate (cfs)	Pollutant	TMDL (lbs/day)[1]	Existing Load (lbs/day)[1]	Percent Reduction Needed to Meet the TMDL
Elk Creek	0.14	TN	0.23	0.54	57%
		TP	0.023	0.073	68%
Hot Springs Creek	2.4	TN	3.9	6.5	40%
		TP	0.39	1.4	72%
Moore Creek	2.0	TN	3.2	6.2	48%
		TP	0.32	0.60	47%

Waterbody Name	Median Growing Season Flow Rate (cfs)	Pollutant	TMDL (lbs/day)[1]	Existing Load (lbs/day)[1]	Percent Reduction Needed to Meet the TMDL
O'Dell Spring Creek	67	TN	109	134	19%
South Meadow Creek	4.7	TN	7.6	11.7	35%
		TP	0.76	0.89	15%

[1] Based on a median growing season flow rate

Escherichia coli (E. coli) LOADING

While most strains of *E. coli* are nonpathogenic and not explicit indicators of the presence of pathogens, there is a strong correlation between the abundance of *E. coli* and the probability of pathogenic bacteria, protozoans, and viruses being present in a waterbody. Thus, *E. coli* abundance is the preferred indicator of other pathogenic organisms per EPA recommendations. Elevated pathogenic organisms in a waterbody pose a significant risk to human health and to a waterbody's beneficial recreational uses making *E. coli* an important parameter when assessing limnological health and water quality.

In 2016, Moore Creek was listed as an EPA 303(d) impaired stream for *E. coli* from its crossing with HWY 287, just south of Ennis, to its confluence with the Madison River at Fletcher Channel. There were no point sources identified for *E. coli* pollution in the Moore Creek Watershed. Nonpoint sources of *E. coli* pollution, identified by the DEQ *E. coli* TMDL, in the Moore Creek Watershed include (1) agriculture, (2) residential development and subsurface wastewater disposal and treatment [i.e., individual and community septic systems], (3) recreation and domestic animals, and (4) natural background sources. BMPs in these four categories can be implemented to achieve necessary percent reductions for TMDLs of *E. coli* in the Moore Creek Watershed. BMPs and descriptions of these sources of nonpoint *E. coli* pollution in Moore Creek can be found in the DEQ Madison *E. coli* TMDL Section 6.6.2-6.6.2.3. Table 6 shows the *E. coli* TMDL allowable allocations during the summer period at a median flow rate, the actual existing *E. coli* loading present, and the *E. coli* percent reductions necessary to achieve the allowable allocations of the target TMDL during the summer period for *E. coli* in Moore Creek.

Table 6. Moore Creek summer period *E. coli* TMDL at a median flow rate, load allocations, current loading, and reductions needed to meet TMDL targets. MT DEQ, Madison Nutrient, *E. coli*, and Metal TMDLs and Water Quality Improvement Plan, 2019 (Table 6-8 and Page 6-21).

Source Category	Allocation and TMDL (Mcfu/day)[1,2]	Existing Load (Mcfu/day)[1,2]	Percent Reduction Needed to Meet the TMDL
Natural Background	2,342	2,342	0%
Human-caused (Nonpoint Sources)	3,806	29,036	87%
	TMDL = 6,148	**Total = 31,378**	**Total = 80%**

[1] Based on a median summer flow rate of 2.0 cfs
[2] Loads are presented in million colony forming units (Mcfu) per day

METALS LOADING

Eleven waterbodies in the Madison TMDL Planning Area (TPA) are listed as impaired for metals loading in the 2016 Montana 303(d) List. Three of these waterbodies were assessed for TMDLs in the *Madison Nutrient, E. coli, and Metal TMDLs and Water Quality Improvement Plan* (MT DEQ, 2019) document. The three waterbodies assessed for TMDLs and percent reductions needed to achieve the calculated TMDLs for metals impairment in 2019 include Elk Creek, Hot Springs Creek, and South Meadow Creek. Elevated concentrations of metals can be toxic, carcinogenic, and bioaccumulating in plants and animals and thus plants, humans, wildlife, and livestock that consume water or fish from waterbodies with metals impairment can suffer acute and chronic effects from doing so.

Table 8 lists the three streams assessed for TMDLs in the 2019 DEQ document, the calculated TMDL for each metals impaired waterbody, the current loading of metals present in each waterbody, loading allocations attributed to natural background nonpoint sources, loading allocations from abandoned mining point sources and other human-caused sources, and the percent reduction of these allocations necessary to achieve the calculated TMDL for each waterbody. The Madison TPA was subject to extensive mining in the past and wasteload from these abandoned mines was identified as the primary source of metals impairment in waterbodies of the Madison Watershed. Using BMPs to remediate and revegetate abandoned mining sites can be used to obtain necessary percent reductions to achieve metal loading TMDLs in the three waterbodies listed in Table 8. Specific wasteload allocation sources, locations, and assessments can be found in Sections 7.6.1-7.6.3. Table 7 lists the acceptable water quality standards for metals impairments listed in Table 8 for monitoring purposes.

Six of the tributaries, along with Ennis Lake and multiple sections of the Madison River were also identified as having a metals impairment for Arsenic. The cause of these impairments in arsenic are due to naturally occurring background loading as a result of local geologic sources and geothermal water of the Yellowstone Park Caldera (Nimick et.al, 2013).

Table 7. MT DEQ, Circular DEQ-7: Montana Numeric Water Quality Standards, 2019 (Pages 3-6, 23, 46, 47, 64, 74-80).

Pollutant	**Category**[1, 2]	**Aquatic Life Standards (µg/L except where indicated)**[3, 4, 5,6]		**Human Health Standards (µg/L)**[7,8]	
		Acute[3]	**Chronic**[4]	**Surface Water**	**Ground Water**
Copper	Toxic[1]	3.79 @ 25mg/L hardness, PP[5]	2.85 @ 25mg/L hardness, PP[5]	1,300	1,300
Iron	Harmful[2]		1,000, NPP[6]		
Lead	Toxic[1]	13.98 @ 25mg/L hardness, PP[5]	0.545 @ 25 mg/L, PP[5]	15, MCL[8]	15, MCL[8]
Selenium	Toxic[1]	20, PP[5]	5, PP[5]	50, MCL[8]	50, MCL[8]

[1]A toxin is any chemical which has an immediate, deleterious effect on the metabolism of a living organism.

[2]Pollutants typically classified as harmful include substances or measures which are controlled by numeric standards. Examples of harmful numeric standards are iron and *E. coli*.

[3]The one-hour average concentration of these parameters in surface waters may not exceed these values more than once in any three year period, on average, with the exception of silver, which, at present, is interpreted as a “not to exceed” value.

[4]The 96-hour average concentration of these parameters in surface waters may not exceed these values more than once in any three year period, on average.

[5]Priority pollutant criteria.

[6]Non-priority pollutant criteria.

[7]Surface or groundwater concentrations may not exceed these values.

[8]Maximum contaminant level from the drinking water regulations.

Table 8. Elk Creek, Hot Springs Creek, and South Meadow Creek metals TMDLs and allocations for example flow conditions. MT DEQ, Madison Nutrient, *E. coli*, and Metal TMDLs and Water Quality Improvement Plan, 2019 (Tables 7-13, 7-14, 7-15 and Pages 7-28, 7-30, 7-31).

Waterbody Name	Pollutant	Flow[1A, 1B, 1C]	Existing Load (lbs/day)	TMDL (lbs/day)	LA_{NB}[2] (lbs/day)	Comp WLA_{AB+HS}[3] (lbs/day)	Percent Reduction Needed to Meet the TMDL
Elk Creek[1A]	Iron	High	33.04	16.04	7.38	8.66	51%
		Low	0.11	0.054	0.025	0.029	51%
	Selenium	Low	0.00043	0.00027	0.000027	0.00024	38%
Hot Springs Creek[1B]	Iron	High	100	50	23	27	50%
		Low	2.9	1.5	0.7	0.8	50%
	Lead	High	0.31	0.24	0.013	0.23	20%
South Meadow Creek[1C]	Copper	High	1.6	0.56	0.2	0.36	64%
		Low	0.00043	0.00031	0.00005	0.00026	28%

[1A] Elk Creek high flow value is equal to 2.97 cfs, low flow value is equal to 0.01 cfs for all calculations

[1B] Hot Springs Creek high flow value is equal to 9.28 cfs, low flow value is equal to 0.27 cfs for all calculations

[1C] South Meadow Creek high flow value is equal to 36.4 cfs, low flow value is equal to 0.01cfs for all calculations

[2] Load allocation to natural background sources

[3] Wasteload allocation to abandoned mining point sources and all other human sources

INSTREAM AND STREAMSIDE HABITAT ALTERATIONS, FLOW MODIFICATIONS, AND TEMPERATURE LOADING

Several streams in Table 1 are listed as impaired for non-pollutant categories such as instream and streamside habitat alterations, as well as flow modifications. These impairments occur when practices have altered or removed vegetation and in instances in which the stream channel has been physically altered or manipulated. These impairments are placed in the EPA water quality category 4C because biological data and information indicates that the impairment is not caused by a pollutant. However, these impairments can be indirect contributing factors to pollutant loads within a stream. For example, flow modifications can contribute to temperature and sediment loading. Instream and streamside habitat alterations can contribute to sediment and temperature loading, as well as nutrient, *E. coli*, and metals loading. This is due to the ecosystem's decreased ability to: (1) provide shade to the stream increasing instream temperatures, (2) prevent erosion increasing instream sediment loading, and (3) filter pollutants increasing instream loading of pollutants such as nutrients, *E. coli*, and metals.

Some sources of temperature increases in streams can include the removal of native streamside vegetation, irrigation withdrawals, warm irrigation return flows, as well as widening and shallowing of streams due to agricultural and land use practices. We can reduce temperature in streams by improving the health of streamside vegetation to provide shade that decreases water temperature and provide channel stability that can help prevent streams from becoming too wide and shallow.

Flow modifications can be caused by urban development, timber harvest, undersized culverts, irrigation withdrawal management, and the straightening of stream channels. Ways to address water quality impairments due to flow modifications include installing properly-sized culverts at stream crossings, implementing irrigation efficiency projects, maintaining healthy buffers between streams and timber harvest areas, and avoiding the straightening of stream channels. One example of a mechanically straightened stream in the Madison Watershed is a section of Moore Creek north of the town of Ennis. The Madison Conservation District intends to utilize the Madison WRP to restore this mechanically straightened and channelized section of Moore Creek by restoring sinuosity to the stream, reconnecting the stream with its historic floodplain and water table, planting healthy riparian vegetation, as well as routing the stream through 12 acres of emergent and scrub-shrub wetlands, which the straightened section was historically connected with, to filter pollutants and reduce temperature. This project was also prioritized as a result of the timely opportunity presented by NRCS's East Tobacco Roots Riparian Health Targeted Implementation Plan (TIP). This program lent itself to the project as a funding opportunity for the installation of 9,350 ft of riparian fencing to improve riparian health, create a buffer between livestock grazing and the stream, and ensure long-term success of MCD's restoration project. Applications for the East Tobacco Root TIP are currently closed, however, similar project opportunities could be prioritized around the ongoing implementation of projects that were funded by this TIP.

Causes of instream and streamside habitat alterations can include the removal of streamside vegetation, overgrazing in stream corridors, channel straightening to accommodate roads, agricultural fields, or mining operations, and channel alterations as a result of new infrastructure such as roads, bridges, and dam impoundments. Strategies to prevent instream and streamside habitat alterations are maintaining healthy streamside buffers, implementing grazing management practices that maintain healthy streamside vegetation, avoiding the straightening of streams, as well as maintaining natural stream shape and pattern and allowing streams to migrate.

OTHER IMPAIRMENTS TO BE ADDRESSED IN FUTURE PROJECTS

Table 9 provides more information about other impairments found in the Madison Watershed, but were not evaluated in the 2020 Madison TMDLs. The table is from the temperature and sediment TMDL published in 2020, listing the impairments to be addressed in future projects. It does not include all of the impairments listed in the *Madison Watershed Stream Summaries*, also published in 2020.

Table 9. Water quality impairment causes for the Madison to be addressed in a future project. MT DEQ, Madison Sediment and Temperature TMDLs and Water Quality Improvement Plan, 2020 (Table 1-2 and Page 1-6).

Waterbody (Assessment Unit)	Impairment Cause	Pollutant Category
Blaine Spring Creek, Headwaters to mouth (Madison River)	Arsenic	Metals
	Total Nitrogen	Nutrients
Buford Creek, Headwaters to confluence with West Fork Madison River	Arsenic	Metals
Elk Creek, Headwaters to mouth (Madison River)	Arsenic	Metals
Ennis Lake	Arsenic	Metals
	Low flow alterations	Not Applicable; Non-Pollutant

Waterbody (Assessment Unit)	Impairment Cause	Pollutant Category
Ennis Lake	Other anthropogenic substrate alterations	Not Applicable; Non-Pollutant
	Physical substrate alteration	Not Applicable; Non-Pollutant
Moore Creek, Springs to mouth (Fletcher Channel)	Arsenic	Metals
O'Dell Spring Creek, Headwaters to mouth (Madison River)	Arsenic	Metals
West Fork Madison River, Headwaters to mouth (Madison River)	Temperature, water	Temperature

4.0 RESTORATION ACTIVITIES AND BEST MANAGEMENT PRACTICES

Nonpoint source management measures, Best Management Practices (BMPs), and restoration projects will be implemented to reduce pollutant loads to the impaired stream segments and their tributary streams in the Madison Watershed. Potential projects include streambank stabilization and revegetation, riparian buffer enhancement, unpaved road improvements, residential and urban BMPs, agricultural BMPs, forestry BMPs, stormwater BMPs, on-site subsurface wastewater treatment system upgrades, and soil health and drought resilience BMPs, along with actions that promote natural water storage and floodplain connectivity.

4.1 STREAMBANK STABILIZATION AND REVEGETATION

Streambank bioengineering techniques reduce sediment inputs from eroding streambanks and restore natural channel migration rates through streambank revegetation. Bioengineered streambanks are designed to eliminate the sediment load from streambank erosion in the short-term. Over the long-term, bioengineered streambanks are designed to erode naturally, allowing for natural rates of lateral channel migration and restoration of natural sediment transport processes. Streambank bioengineering techniques include the use of woody material, biodegradable coir fabric, gravel, cobbles, soil and willows, which are layered into a brush matrix to produce a stable streambank that will quickly develop riparian vegetation. Streambank bioengineering is typically accompanied by the creation of a vegetated riparian buffer on the floodplain, which is intended to provide long-term stability as the channel continues to migrate, while also providing natural water storage on the floodplain and energy dissipation during flooding events.

Technical Assistance: Low to High. Technical assistance will vary depending on the scale of the project. MCD can organize volunteers for vegetative materials collection efforts, coordinate with landowners, and support annual maintenance activities such as weed control and browse protection. MCD will need technical assistance for survey data collection, wetland delineation, engineering design, permitting, and construction.

4.2 RIPARIAN BUFFER ENHANCEMENT

Riparian buffer enhancement involves the creation and widening of the riparian buffer, which helps naturally stabilize streambanks, provides a filter for the runoff of sediment and nutrients from upland areas, and improves the utilization of nutrients which would otherwise leach below the root zone and contaminate groundwater. Riparian buffer enhancement can be achieved by actively replanting the floodplain or enacting grazing management strategies that limit the amount of time that livestock have access to the riparian zone. Riparian plantings include willow stakes, willow transplants and containerized riparian vegetation. Restoration of channel migration and flood inundation processes that provide fine grained substrate encourages natural recruitment and establishment of riparian vegetation. Grazing management strategies can include fencing, off-stream water development, water gaps, and management of the timing of grazing. In urban and suburban settings, riparian buffer enhancement can reduce the input of lawn fertilizer and stormwater runoff. The enhancement of riparian buffers can greatly reduce the input of sediment and nutrients into impaired stream segments.

Technical Assistance: Medium. MCD can help identify projects, organize volunteers for vegetative materials collection efforts, work with landowners to complete native riparian vegetation plantings, and support development of grazing management plans. Technical assistance may be needed for permitting if a project will impact streambanks or result in filling in wetlands. MCD can also support off stream water development, creation of water gaps, and installation of fencing.

4.3 UNPAVED ROAD IMPROVEMENTS

Sediment loads from unpaved roads can be reduced by creating rolling dips or water bars, adding gravel, enhancing vegetative filter strips, installing ditch relief culverts, adding gutters or railings to bridges, and replacing culverts. Three-sided arch culverts, where the natural stream bottom is retained enable aquatic organism passage and more complex aquatic habitat. The hydrology of the contributing area should also be considered when determining the necessary culvert size. Following these principles will help improve the stream system, increase fish habitat connectivity, and reduce potential sediment loads from failed culverts. Proper management of unpaved roads by eliminating preferential flow pathways can greatly reduce sediment loading from this source.

Technical Assistance: High. MCD can identify problems and support efforts to replace insufficient culverts. MCD will need technical assistance for survey data collection, wetland delineation, engineering design, permitting, and construction and can rely on Montana Fish, Wildlife and Parks to help identify culverts that are critical for fish passage. Coordinating with the Madison County road maintenance crew will be critical to successfully implementing these types of projects.

4.4 RESIDENTIAL AND URBAN BEST MANAGEMENT PRACTICES

Residential and urban BMPs can help reduce the input of sediment, nutrients, and *E. coli* to impaired stream segments and include the following projects:

- Capturing stormwater runoff from impervious surfaces
- Employing proper pet and livestock waste management in yards and open spaces
- Employing proper lawn fertilizer application and mowing practices
- Creating enhanced riparian buffers
- Regularly maintaining individual septic systems
- Minimizing impervious surfaces in new development
- Monitoring/restricting drainage of ponds into adjacent water bodies
- Designing infrastructure and pollutant storage (manure piles, chemicals, road salt) in anticipation of increased flooding frequency and intensity
- Designing flood control infrastructure that also benefits water quality

- Fixing significant sources of inflow and infiltration to sewer systems that could lead to sanitary sewer overflows during storms
- Investing in proper maintenance of central sewer systems

Technical Assistance: Low to High. MCD can organize educational outreach events and increase community awareness. Some of these BMPs require more technical assistance in engineering, hydrology, permitting, and construction. Support at the city and county levels to promote proper installation and maintenance will be critical for promoting residential and urban BMPs, along with support from the development community and engineering firms.

4.5 AGRICULTURAL BEST MANAGEMENT PRACTICES

Agricultural BMPs can help reduce instream temperatures and the input of sediment, nutrients, and *E. coli* to impaired stream segments and include the following projects:

- Improving grazing management with fencing
- Developing off-stream water sources
- Developing water gaps and hardened stream crossings
- Upgrading Irrigation infrastructure
- Improving irrigation water management
- Installing treatment wetlands on irrigation return flows
- Creating enhanced riparian buffers
- Practicing rotational grazing
- Employing proper manure management

Technical Assistance: Medium. MCD can work with landowners, host workshops, and connect people to resources. Technical assistance will be needed to develop off-stream water sources, water gaps, and hardened stream crossings. The Natural Resources Conservation Service is a critical partner that can help support the development and implementation of agricultural BMPs.

4.6 FORESTRY BEST MANAGEMENT PRACTICES

Forestry BMPs can help reduce the input of sediment and nutrients to impaired stream segments and include the following projects:

- Maintaining erosion control practices on unpaved roads in a timely manner
- Creating enhanced riparian buffers
- Properly sizing culverts and replacing undersized culverts
- Adhering to Montana’s Streamside Management Zone (SMZ) rule

Technical Assistance: Low to Medium. MCD can do outreach and provide information and resources about BMPs to private landowners performing small-scale forest thinning projects. The US Forest Service is a critical partner that can lead implementation of forestry BMPs on federal lands.

4.7 STORMWATER BEST MANAGEMENT PRACTICES

Stormwater BMPs can help reduce the input of sediment, nutrients, and *E. coli* to impaired stream segments and include the following projects:

- Developing bioretention treatment areas and media filters
- Creating enhanced riparian buffers
- Creating wetland areas throughout the urban and suburban environment
- Minimizing impervious surfaces in new development
- Minimizing road salt and sand use
- Investing in proper maintenance of unpaved roads. Consider sediment contributions when prioritizing road paving or decommissioning
- Creating long-term management mechanisms for stormwater BMPs

Technical Assistance: Medium to High. MCD can work with Madison County and the Town of Ennis to advocate for these BMPs but has no jurisdiction over stormwater management. Engineering design, wetland delineation, permitting, and construction support will be needed for some of these BMPs. Municipalities, Montana Department of Transportation, and private developers will be critical partners for installing and maintaining stormwater BMPs.

4.8 ON-SITE SUBSURFACE WASTEWATER TREATMENT PRACTICES

On-site subsurface wastewater treatment upgrades and management improvements can help reduce the input of nutrients and *E. coli* to impaired stream segments and include the following projects:

- Regularly maintaining individual septic systems
- Connecting individual septic systems to a centralized wastewater treatment system
- Installing type II (advanced wastewater treatment) septic systems in new developments
- Educating the public on proper use of on-site wastewater systems
- Actively encouraging or incentivizing owners to properly abandon failing systems
- Encouraging the use of phosphate-free detergents

Technical Assistance: Medium to High. MCD can work with Madison County and the Town of Ennis to advocate for these BMPs but has no jurisdiction over wastewater management. MCD can do education and outreach to community members to encourage the adoption of BMPs. Regulatory mechanisms at the city and county levels to promote proper installation and maintenance will be critical for maintaining functional subsurface wastewater systems, along with support from the development community and engineering firms that design these systems.

4.9 SOIL HEALTH FOR DROUGHT RESILIENCE BMPS

The health of streams and rivers are closely tied to soil health. Soils act as a sponge to hold water, reduce irrigation needs, recharge groundwater and aquifers, and help maintain stream flows throughout the year. BMPs to maintain healthy soils include rotational and regenerative grazing practices, limiting soil disturbance, and maintaining adequate ground cover. These practices promote deeper root structures, increase soil aggregates for infiltration, and support healthier microbial ecosystems.

Some specific examples include:

- Using no-till seed drills
- Using stripper headers
- Rotational grazing
- Replace fallow with grazeable cover crops
- Restoration of native grasslands
- Reducing invasive annual weeds and grasses

- Limiting soil disturbance
- Increasing soil organic matter and residue
- Planting windbreaks around irrigated fields

These practices can be implemented on agricultural lands as well as residential housing developments. One of the BMPs that can be most easily implemented on small acreages and housing developments is installing subsurface drip tape irrigation and growing native perennial plant species instead of planting monocultures of non-native annual grasses. Native plants and grasses have more diverse root structures, promote healthier soils, and improve soil water storage capacity.

Technical Assistance: Medium. MCD can provide management recommendations, rental equipment, and seek funding for project opportunities. Implementing these practices could require assistance from range specialists and experts in soil health, as well as agency representatives, including the Natural Resources Conservation Service.

4.10 NATURAL WATER STORAGE AND FLOODPLAIN CONNECTIVITY

Natural water storage can be improved through reconnecting streams to their natural floodplains, restoring wetlands, and diversifying stream structure to slow water flow and allow time for infiltration. One of the simplest ways to make these improvements is through beaver mimicry and other forms of low-tech process-based restoration (LTPBR). Beaver mimicry and LTPBR can be completed with hand tools and natural materials and have been shown to have substantial positive impacts.

Wetland construction and restoration can be used to improve water infiltration and storage in soils, maintain base flows year-round, filter nutrients and pollutants to improve water quality, control erosion, and reduce impacts of flooding by absorbing excess water. LTPBR techniques can be used in the construction and restoration of wetlands. Wetland restoration projects can include livestock fencing around degraded or overgrazed wetlands and installation of engineered nutrient treatment and abatement wetlands to reduce nutrient loading to streams.

Technical Assistance: Low-High. Beaver mimicry and LTPBR construction requires minimal technical assistance. MCD can identify projects, organize volunteers, and help complete projects. Technical assistance will be needed from engineers, hydrologists, and contractors to build wetlands and reconstruct streams to reconnect the floodplain. In some cases, implementing these structures can result in recolonization of beavers. For this reason, it is good practice to consult with a beaver conflict specialist when planning implementation of beaver mimicry and LTPBR structures. FWP and TU, as well as Montana Freshwater Partners in Livingston, MT can provide conflict resolution assistance when recolonization of beavers is a concern.

5.0 IDENTIFYING AND IMPLEMENTING RESTORATION PROJECTS

5.1 WATERSHED HEALTH PRIORITIES

Through several one-on-one interviews and a series of public meetings, the following priorities were developed to help better understand the land and water resource priorities in the Madison Watershed community (Table 10).

Table 10. Priorities for restoration and associated projects and target areas.

Priority	Specific Projects/Metrics	Target Areas
River and Stream Protection	Reduce tributary sediment loads	Moore Creek, South Meadow Creek, Wigwam Creek, Elk Creek
	Minimize streamside development	Streams originating in Gravelly and Tobacco Root Mountain Ranges and Valley-bottom streams nearing confluence with Madison River
Restore Floodplain Connectivity and Improve Riparian and Wetland health and function	Natural water storage and floodplain reconnection	Jack Creek, Moore Creek, Wigwam Creek, Elk Creek, North Meadow Creek, South Fork Madison River
	Reduce hardened streambanks in favor of bioengineered and/or deformable banks	Jack Creek, Moore Creek, South Meadow Creek, North Meadow Creek, Bear Creek (lower), Hot Springs Creek, Blaine Spring Creek, Elk Creek, Wigwam Creek, Cherry Creek, West Fork Madison River
	Restore steep eroding streambanks and incised stream channels	
	Restore sinuosity to streams	
	Riparian buffer enhancement	
Reduce Temperature and Evaporative Losses	Increase riparian shading/riparian plantings along streams	Moore Creek, Elk Creek, Cherry Creek
	Increase ground cover (limit bare soil) to reduce evaporative losses from soils	Landowners/agricultural producers
	Manage private recreational ponds	Landowners/managers
Fisheries and Habitat	Healthy habitat for fish	Streams with designated fisheries beneficial use
	Adequate temperature for fish	Moore Creek, Elk Creek, Cherry Creek
	Instream flows for fish	Indian Creek, Bear Creek
	Replace perched culverts to ensure aquatic organism passage	Madison County
	Install fish passage barrier to protect and restore native westslope cutthroat trout	Elk River, Wall Creek, Horse Creek
Development / Urban	Reduce road sediment inputs	Jack Creek, Moore Creek, West Fork Madison River, Elk Creek, North Meadow Creek, South Meadow Creek, Hot Springs Creek

Priority	Specific Projects/Metrics	Target Areas
Development / Urban	Sustainable water supply for future growth (city and subdivisions)	Town of Ennis, subdivided properties
	Upgrade culverts	South Meadow Creek, North Meadow Creek, Hot Spring Creek, Blaine Spring Creek, Ruby Creek, South Fork Madison River
	Opportunities for centralized treatment versus septic	Subdivided properties
	Need septic maintenance program for homeowners	Subdivided properties
	River access site improvements	Madison River, South Fork Madison River
Stormwater Management (Reduce flashiness of stormwater and slow overland flow)	Improving culverts and enhancing water retention during runoff events	Town of Ennis, subdivided properties and HOAs
	Improving streamside road conditions in high traffic locations	Jack Creek Road (~3 miles through canyon)
Water/Irrigation Management	Adapting to changes in timing of runoff	Bear Creek, Cedar Creek, Jack Creek, Indian Creek, South Meadow Creek, North Meadow Creek, Wigwam Creek, Madison River
	Irrigation equipment and scheduling efficiency	
	Upgrade irrigation infrastructure	
	Improve efficiency of diversion systems	
	Protect springs	Hot Springs Creek
	Install treatment wetlands at irrigation outfalls	Rey Creek
Land Management and Health	Healthy vegetation on uplands	Elk Creek, Hot Springs Creek
	Maintain and improve wetland health	Landowners /managers, Moore Creek
	Riparian fencing and pasture generation	Streams with TMDLS for temperature and/or sediment, East Tobacco Root TIP projects
Drought Resilience and Water Storage	Maintain healthy soils	Landowners/agricultural producers
	Restore and improve native perennial vegetation for increased infiltration rates and water storage	Landowners/agricultural producers
	Promote regenerative grazing practices	Landowners/agricultural producers

Priority	Specific Projects/Metrics	Target Areas
Drought Resilience and Water Storage	Use appropriate irrigation to support groundwater recharge and reduce water losses	Landowners/agricultural producers
	Replace fallow with cover crops	Landowners/agricultural producers
	Plant windbreaks around irrigated fields	Landowners/agricultural producers
	Subsurface drip tape irrigation	Small acreage landowners, subdivided property
Education and Outreach	Adult and youth stream/water educational programming	Town of Ennis, Ennis School, GROWW program, Ennis Continuing Education
	Land stewardship workshops	Small acreage landowners, Subdivisions
	Invasive plants and grasses educational programming	Ennis School, GROWW program, Ennis Continuing Education

5.2 NEAR-TERM RESTORATION PLANS AND EFFORTS

There has been a flurry of stream restoration planning in the Madison Watershed over the past decade, and a couple of significant deliverables that were finished in the past few years that will help facilitate and focus near-term restoration efforts. First, the Montana Department of Environmental Quality produced a novel document that supplements their TMDL effort, the *Madison Watershed Stream Summaries 2020* document (*Attachment A*). This document affords an overview of 15 major tributary streams and highlights the ecological issues and potential restoration solutions specific to each stream. Although this is the first watershed to inherit a non-technical summary of DEQ's TMDLs, it has already proven a useful education and conservation opportunities tool for the community.

Also in 2020, through the Madison Technical Advisory Committee (NorthWestern Energy, Montana Fish, Wildlife and Parks, and federal agency partners), funds were allocated for a comprehensive review of private and public land stream restoration opportunities. The private lands effort was led by Trout Unlimited, while the public lands effort was led by the US Forest Service. Maps associated with those identified low-hanging fruit (perched culverts, etc.), with potential stream enhancement and water quality improvement projects on private lands presented in Figure 17 and detailed reports from TU and the USFS included in *Attachment C* and *Attachment D*.

Notably, although there are only a handful of streams highlighted in the main body of this document, both of these should be considered and executed when funding and landowner engagement arise throughout the watershed. For example, the National Fish and Wildlife Foundation's (NFWF) America the Beautiful Initiative indicates a strong preference for "a pursuit of collaborative approaches and a commitment to supporting the voluntary conservation efforts of farmers, ranchers, and fishers." There is an additional emphasis on projects that span public and private lands and waters. The other significant funding opportunity in the Madison Watershed stems from two dams and associated hydropower operations on the Madison River. Annually, the Federal Energy Regulatory Commission requires NorthWestern Energy to monitor and mitigate for the impacts from the operations on fisheries and wildlife. NorthWestern Energy manages a mitigation program and works closely with state (Montana Fish, Wildlife and Parks and Montana DEQ) and federal agencies (US

Forest Service and the Bureau of Land Management) to fund projects that mitigate impacts from hydropower on fish and wildlife. These annual funding opportunities are managed with partners through the Madison Fisheries Technical Advisory Committee (MadTAC) and the Wildlife Technical Advisory Committee (WildTAC).

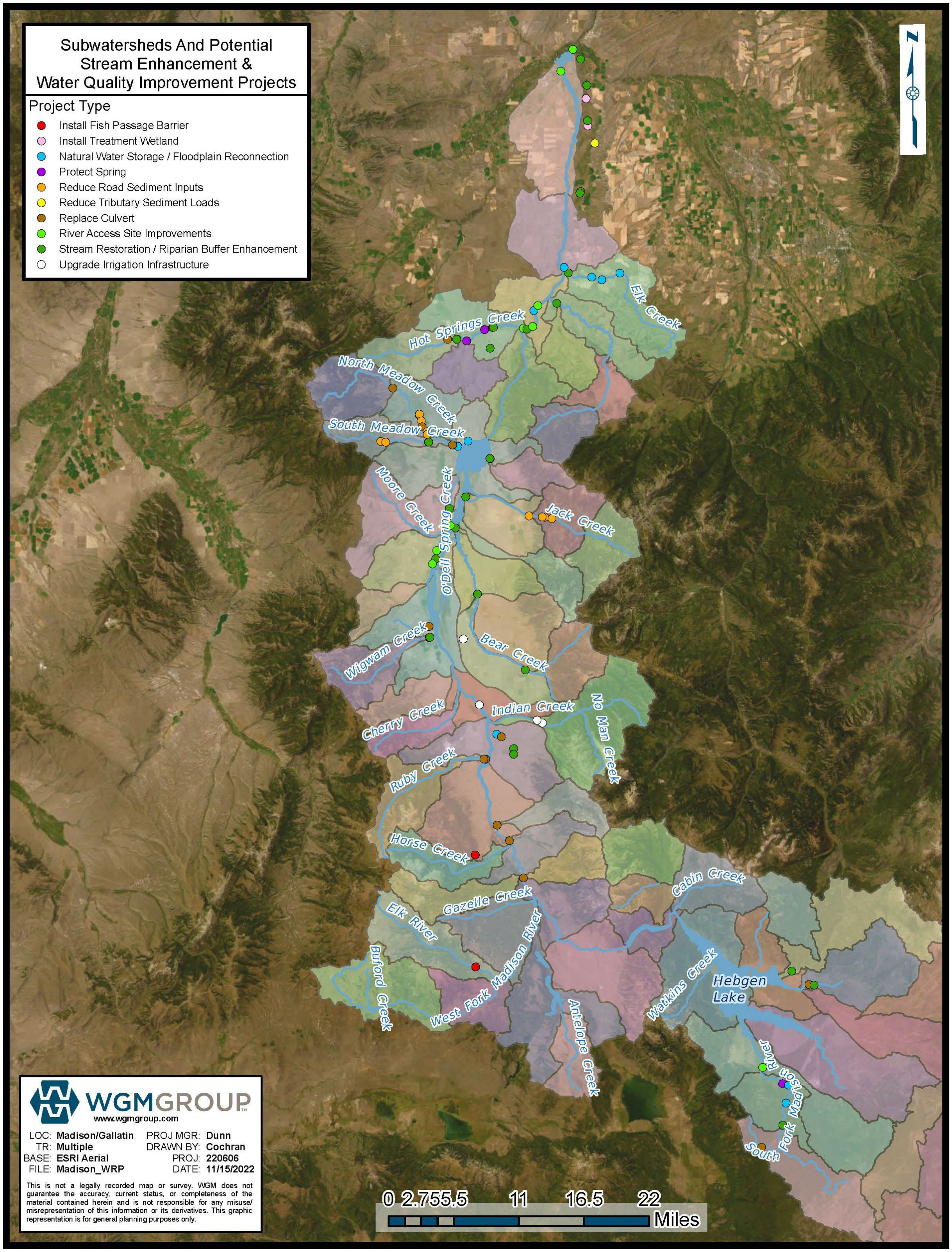


Figure 17. Potential Stream Enhancement and Water Quality Improvement Projects

5.3 COST ESTIMATES FOR PROJECT DEVELOPMENT AND IMPLEMENTATION

Cost estimate ranges for the suite of projects identified in Figure 16 were developed to facilitate project development and fundraising. Cost estimate categories from low to very high correspond with cost estimate ranges as follows:

- Low: $5,000 to $50,000
    - Projects in this category typically include:
        - *Relatively simple projects*, such as culvert replacement and installing fencing to protect springs and other sensitive riparian and wetland areas

- Moderate: $50,000-$100,000
    - Projects in this category typically include:
        - *Small scale* stream restoration and riparian buffer enhancement projects, road sediment reduction projects, and irrigation infrastructure improvement projects
        - Natural water storage and floodplain reconnection projects utilizing low-tech process-based restoration techniques

- High: $100,000-$250,000
    - Projects in this category typically include:
        - *Large scale* stream restoration projects and riparian buffer enhancement projects
        - *Large scale* road sediment reduction projects
        - *Mid-scale* irrigation infrastructure improvement projects
        - *Small scale* fish passage barrier projects

- Very High: $250,000-$500,000+
    - Projects in this category typically include:
        - *Multi-phase* stream restoration and floodplain reconnection projects
        - *Large scale* irrigation infrastructure improvement projects
        - *Large scale* fish passage barrier projects

Table 11. Cost estimates for restoration projects identified in Figure 16.

Project Type	Stream	Cost Estimate Category	Cost Estimate Range	Timeframe
Install Fish Passage Barrier	Elk River	very high	$250,000-$500,000+	2023-2028
	Horse Creek	high	$100,000-$250,000	2023-2028
Install Treatment Wetland	Rey Creek	very high	$250,000-$500,000+	2023-2033
Natural Water Storage / Floodplain Reconnection	Elk Creek	moderate	$50,000-$100,000	2023-2033
	North Meadow Creek	moderate	$50,000-$100,000	2023-2033
	South Fork Madison River	very high	$250,000-$500,000+	2023-2033
Protect Spring	Hot Springs Creek	low	$5,000-$50,000	2023-2028
	South Fork Madison River	low	$5,000-$50,000	2023-2028
Reduce Road Sediment Inputs	Jack Creek	high	$100,000-$250,000	2023-2028
	North Meadow Creek	moderate	$50,000-$100,000	2023-2028
	South Meadow Creek	moderate	$50,000-$100,000	2023-2028
Replace Culvert	Hot Springs Creek	low	$5,000-$50,000	2023-2028
	Blaine Spring Creek	low	$5,000-$50,000	2023-2028
	North Meadow Creek	low	$5,000-$50,000	2023-2028
	South Meadow Creek	low	$5,000-$50,000	2023-2028
	Ruby Creek	low	$5,000-$50,000	2023-2028
	South Fork Madison River	low	$5,000-$50,000	2023-2028
	Wigwam Creek	low	$5,000-$50,000	2023-2028
River Access Site Improvements	South Fork Madison River	high	$100,000-$250,000	2023-2038
	Madison River (Quake to Ennis)	high	$100,000-$250,000	2023-2038
	Madison River (Ennis to mouth)	high	$100,000-$250,000	2023-2038
Stream Restoration / Riparian Buffer Enhancement	Elk Creek	high	$100,000-$250,000	2023-2038
	Cherry Creek	very high	$250,000-$500,000+	2023-2038
	Hot Springs Creek	high	$100,000-$250,000	2023-2038
	Madison River (Ennis to mouth)	very high	$250,000-$500,000+	2023-2038
	Bear Creek	high	$100,000-$250,000	2023-2038
	Madison River (W Yellowstone)	high	$100,000-$250,000	2023-2038
	Jack Creek	moderate	$50,000-$100,000	2023-2038
	South Meadow Creek	moderate	$50,000-$100,000	2023-2038
	Moore Creek	high	$100,000-$250,000	2023-2038
	South Fork Madison River	high	$100,000-$250,000	2023-2038
	Wigwam Creek	high	$100,000-$250,000	2023-2038
	Red Canyon Creek	moderate	$50,000-$100,000	2023-2038
Upgrade Irrigation Infrastructure	Bear Creek	moderate	$50,000-$100,000	2023-2033
	Indian Creek	very high	$250,000-$500,000+	2023-2033
	Wigwam Creek	high	$100,000-$250,000	2023-2033

5.4 OTHER PRIORITY AREAS AND PROJECTS

ELK CREEK

Impairments: Nutrient, Metals, Sediment, Temperature, Alteration to Streamside Vegetation

Elk Creek originates in the northern Madison Range and flows between Gallatin County and Madison County. It joins the Madison River in Gallatin County just beyond the Madison County boundary. Due to crossing jurisdictional boundaries, work done on Elk Creek could require collaboration between MCD and the Gallatin Conservation District (GCD), as well as

Madison and Gallatin Counties. Elk Creek primarily flows through upland grasslands and has poor riparian habitat and streambank erosion, leading to excess fine sediment entering the stream. As well as sediment issues, Elk Creek has elevated temperatures due to lack of riparian vegetation and irrigation dewatering. Elk Creek could benefit from processed-based restoration techniques, including Beaver Dam Analogs (BDAs), along with riparian plantings to increase shade cover and decrease temperatures. This would also improve streambank stability and decrease erosion.

HOT SPRINGS CREEK

Impairments: Nutrient, Metals, Sediment, Flow Modification

Hot Springs Creek represents the northernmost tributary hailing from the Tobacco Root Mountain Range into the Madison Watershed. It suffers from major, historic mining activities in its headwaters (second only to Alder Gulch in local gold production). Although there is little mining activity today, the legacy of those activities continues to shape the character of the stream and lends to issues with sediment and metals. Once it enters the lower, flatter valley near the town of Norris, the landscape is defined by ranchlands and Montana State University's Red Bluff Experimental Station. This state-owned land is utilized as a place for teaching and experimenting on rangeland and livestock management. Present-day management recognizes the value in exemplifying working-lands conservation efforts that benefit stream ecology and long-term ranching resilience, so there may be opportunities for riparian and wetland restoration that helps address some of this creek's current impairments, along with opportunities to protect springs. Downstream of Red Bluff, the creek runs alongside Highway 84 and supports multiple beavers for another 0.7 miles prior to its confluence with the mainstem Madison River at the Warm Spring Fishing Access Site (FAS).

Hot Springs Creek, upstream of Highway 287. August 24, 2022

JACK CREEK

Impairments: Flow Modification, Alteration to Streamside Vegetation

Jack Creek drains a large high-country basin on the western slope of the Madison Range. Although it is largely on private lands, the basin is surrounded by National Forest and represents the northwest corner of the ecologically intact Greater Yellowstone Ecosystem. Its headwaters include the Moonlight Basin Development and the north face of Big Sky Resort Ski Area. After the first few miles, the stream collects a significant additional amount of water from its South Fork and then enters a stretch of canyon. An unpaved, public road runs alongside the creek for a few miles prior to spilling out into the valley.

In the mid-20th century, much of the basin was severely logged. These earlier logging practices lent to issues with landslides and sedimentation given the steep nature of the geography. Present-day, potential sources of nonpoint source pollution include growth and development in the headwaters, sedimentation associated with the canyon stretch of unpaved road, and land management practices in the valley associated with irrigation and livestock.

Over the past couple of years, there has been greater stakeholder concern for this creek given an uptick in low flows, rising temperatures, and changes in landownership and management. Madison Conservation District recently led a stream restoration project on Jack Creek just upstream of the confluence with the Madison River and additional restoration opportunities remain in the lower reaches of Jack Creek.

Jack Creek upstream of Jeffers Road. July 28, 2022

MOORE CREEK

Impairments: Nutrient, Metals, E. coli, Sediment, Temperature, Alteration to streamside vegetation

Originating in the southeastern flanks of the Tobacco Roots Mountain Range, Moore Creek collects a number of smaller tributaries in its descent towards the Town of Ennis, flows through the middle of the town, and then flows another 10 miles through Madison Valley bottomlands largely managed as seasonal pasture for livestock. The creek is colloquially known as “Poop Creek” given its 150-year history of Europeans settling and establishing the Town of Ennis along its banks. Unfortunately, the name is also fitting today as the creek is listed for *E.Coli* from both cattle and human sources. It is also the stream within the Madison Watershed that has more recognized impairments than any other.

Importantly, with a partnership between Montana Fish, Wildlife and Parks, the Madison Conservation District, Natural Resources Conservation Service, multiple NGOs, and multiple landowners, there have been conservation successes and significant steps undertaken for future restoration work on the creek, including channel restoration and the installation of nutrient abatement wetlands.

Moore Creek, downstream of the culvert under Main Street. MST Monitoring Site MC-HOME. August 4, 2022

Lower Moore Creek restoration site, pre-restoration photo monitoring. May 11, 2022

O'DELL SPRING CREEK

Impairments: Nutrient, Alteration to streamside vegetation

Nearly two decades and 18 phases of active restoration have occurred on O'Dell Spring Creek since 2004. This unique, spring fed creek runs parallel to the mainstem of the Madison River for over 20 miles. Historically, it was part of a large wetland complex that tied together the entirety of the valley bottom floor immediately upstream of Ennis. In the first half of the 20th century, the wetlands were mostly tiled and drained, and the creek was severely altered and damaged to facilitate grazing objectives. More recently, the current generation has recognized the stream's ecological and long-term working lands value, and has spent considerable time and money to accomplish major restoration activities along this stretch. At least four active restoration phases remain, and will be completed in the coming years. Additionally, the lower section (below HWY287) provides an opportunity for riparian pasture regeneration and there is some local momentum towards accomplishing that goal within the coming years.

Of additional note is the confluence wetland complex with Bear Creek near the town of Ennis. This area has been historically degraded, but recent changes in land ownership may provide opportunities for future stream and wetland restoration in the area.

O'Dell Creek at Valley Garden Fishing Access Site. August 24, 2022

SOUTH AND NORTH MEADOW CREEKS

South Meadow Creek Impairments: Nutrient, Metals, Sediment

North Meadow Creek Impairments: Sediment, Flow Modification

These two creeks originate in the eastern Tobacco Roots Mountain Range. Both were historically mined, but North Meadow Creek continues to showcase many present-day tailings near its mid and upper reaches. Both streams collect water from larger basins and then enter the mid and low country where they provide significant irrigating waters for agricultural producers and historically represented major contributions towards the larger Madison Watershed fishery. There have been a number of restoration projects associated with working lands on South Meadow Creek over the past decade, and there are more potential projects in development with landowners and the county with the potential to enhance the riparian buffer and improve floodplain connectivity. There are also several culvert upgrades that could be completed, along with road improvements to reduce sediment inputs.

Notably, over the past decade, there has been significant land division, landowner turnover, and increased numbers of owners on both creeks that lends to issues regarding water rights and water management.

South Meadow Creek upstream of Highway 287. August 24, 2022

WEST FORK MADISON RIVER

Impairments: Temperature

The West Fork Madison River runs mostly through USFS National Forest lands and contributes large amounts of water to the mainstem of the Madison River. Tributaries of the West Fork include: Lobo Creek, Portal Creek, Cascade Creek, Fossil Creek, Buford Creek, Miner Creek, Anderson Creek, Fox Creek, Meridian Creek, Tepee Creek, Gazelle Creek, Soap Creek, and Freezeout Creek. There are numerous opportunities to enhance riparian areas and instream habitat in the West Fork with low-tech process-based restoration (LTPBR) treatments, including Beaver Dam Analogs (BDAs) and Post-Assisted Log Structures (PALS).

The description of the West fork below was provided by the USFS *Upper Madison River Tributary Streams Restoration Opportunities Report* (*Attachment C*):

> The upper West Fork Madison River from its headwaters to the confluence with Lobo Creek flows for roughly 15 miles across the southern end of the Gravelly Range. Livestock grazing occurs throughout the upper West Fork over several different pastures with most of the activity centered around the productive grasses closest to the West Fork Madison River and lower sections of the tributaries.
>
> Most of the middle West Fork runs through a valley bottom with little forest cover while Meridian and Tepee Creeks meander through a more forested landscape before reaching the West Fork. The majority of the middle West Fork Madison is void of canopy cover from trees. There is some evidence of historic livestock trailing and bank disturbance in the riparian corridor. With recreational access to the area being difficult, the impacts from associated trails and roads are limited. However, there are several areas on the middle reaches of the West Fork where the adjacent trail does cross the stream or associated perennial and intermittent spring creeks which have become over widened and are likely sources of excess sediment contribution to the West Fork Madison. Many of these crossings are within the private inholdings making the process to undertake necessary improvements more challenging.
>
> The lower sections of the West Fork Madison flows through mostly forested terrain. There is current and historic beaver activity evident in the river’s lowest reaches and the river also regularly accesses its floodplain during

normal water years. The entirety of the West Fork Madison River from the headwaters to mouth has been identified as having impairments for temperature (MT DEQ, Madison Watershed Stream Summaries, 2020). The lower West Fork can be characterized as a high-use recreational area with numerous dispersed camping sites within and along the riparian corridor which has significantly impacted bank stability and streamside vegetation at certain locations but is generally concentrated to these recreational sites. The area also sees a high-level of off-highway vehicle (OHV) use due to the accessibility of the associated network of USFS roads but impacts to aquatic systems are limited.

West Fork Madison River at the US Forest Service Campground. August 27, 2021

WIGWAM CREEK

Impairments: Sediment

Wigwam creek is a spring fed creek originating high in the Gravelly Mountain Range. It runs through a patchwork of USFS and private working lands. It is listed for sediment impairment due to the designated use as important aquatic habitat. Wigwam Creek does not meet the target width to depth ratio to move fine sediment. This combined with excessive fine sediment due to riparian grazing creates sedimentation/siltation issues despite generally healthy channel form and habitat quality. In 2005-2008 there was a large collaborative effort to restore a portion of upper Wigwam creek. Partners included the Madison River Foundation, MCD, USFS, and the Bar 7 Ranch. A low-tech process-based restoration (LTPBR) approach was taken, using wooden stakes, rocks, and mud to create point bars and encourage increased meander in the stream and slow water velocity. Over time, these point bars trapped sediment and diversified the stream structure. The stream was also fenced off to create a riparian pasture and protect vegetation regeneration. Looking forward, there are opportunities for restoration on Wigwam creek using similar LTPBR methods to trap sediment, encourage meandering, and improve water quality over time, along with active channel restoration in severely over widened and degraded areas. The prior restoration on the upper section of Wigwam Creek provides a good model of the potential improvements that could be made on lower sections facing similar challenges.

Upper Wigwam Creek restoration site, pre-restoration. Approximately 2005

Upper Wigwam Creek restoration sites, post-restoration. September 23, 2021

6.0 EVALUATING PROGRESS AND SUCCESS

The success of restoration efforts in the Madison Watershed will be re-evaluated (every 5 years) to ensure the effectiveness of the current Madison WRP. To complete these routine evaluations and decide on the important milestones, MCD relies on many partners for leadership and input on project development, implementation, and monitoring. Some of the main partners include:

- Landowners and the General Public
- Montana Fish, Wildlife and Parks (FWP)
- Montana Department of Environmental Quality (DEQ)
- Montana State University - Extension (MSU Extension)
- US Natural Resources Conservation Service (NRCS)
- US Bureau of Land Management (BLM)
- US Forest Service (USFS)
- Montana Department of Natural Resources and Conservation (DNRC)
- Madison River Foundation (MRF)
- Trout Unlimited (TU)
- NorthWestern Energy
- Jack Creek Preserve Foundation (JCPF)
- Madison Valley Ranchlands Group (MVRG)

6.1 SHORT-TERM MILESTONES

Short-term milestones are considered those that can be accomplished within the coming five years. Short-term milestones to assess progress and success in the Madison Watershed will focus on education and outreach, continued targeted monitoring efforts, low-tech process-based restoration (LTPBR), riparian plantings, and planning for longer-term restoration projects. Specific short-term milestones are listed in Table 12.

Table 12. Short-term milestones, partners, and indicators of progress.

Focus Area	2023-2028	Partners	Indicators
Education/Outreach	Conduct annual Pull Your Share program in Ennis school and educate one grade level every year.	Ennis School	Number of kids educated, lbs of noxious weeds pulled
	Hold annual Land Stewardship Workshop	MSU Extension, NRCS, Ruby Valley Conservation Distrist	Number of participants
	Conduct one tour of a restoration site	USFS, MRF, TU, FWP, DEQ	Number of participants
Infrastructure	Replace failing/undersized culverts	USFS, Madison County	Length of continuous fish passage restored
	Road BMPs at stream crossings and segments paralleling streams	Madison County	Miles of road paved, lbs of sediment reduced per year

Focus Area	2023-2028	Partners	Indicators
Stream improvement	Implement BDA or other LTPBR projects	FWP, TU, landowners	Ft of stream improved, lbs of sediment reduced per year
	Conduct riparian plantings	MRF, volunteers, landowners	Number of landowners reached, ft of stream with increased shade, lbs of sediment reduced per year
	Riparian fencing and off stream wells	NRCS	Lbs of sediment load reduced per year, ft of riparian buffers created
Watershed Group Development	Bring interested parties and individuals together to discuss crucial watershed concerns, plan for collaborative projects, and create a watershed group	Local organizations and community members	Number of individuals involved, restoration projects accomplished

6.2 LONG-TERM MILESTONES

Long-term milestones are considered those that will only be accomplished in the coming decades. In the Madison Watershed, there are many potential projects that would provide great benefits for water quality and water quantity. These projects are outlined in Section 5, but most of them do not have a timeline attached yet. Table 13 identifies specific projects that do have a defined timeline, and uses broad categories for those that do not to provide flexibility depending on how opportunities for restoration are found in the coming years. Our long-term milestones include the planning, implementation, and evaluation components of long-term projects. The long-term milestones take into account the years it will take to develop project ideas and implement a project plan.

Table 13. Long-term milestones, partners, schedule for implementation, and indicators of progress.

Focus Area	2023-2025	2025- 2030	2030 - 2035	Partners	Indicators
Education and Outreach	Created education programming plan for workshops and Ennis School	Implement education program and assess community need	Continue program and adapt to changing community need	JCPF, MRF, MVRG, Ennis School	Number of participants, post-event survey results
Watershed Group Development	Gather interest, set goals and objectives for the group	Conduct regular meetings and keep updated watershed goals	Collectively complete restoration projects to meet WRP goals	Local organizations, agencies, and individuals	Organizations engaged, number of projects completed
Moore Creek restoration	Planning, design and beginning phases of restoration	Completion of restoration and post-restoration monitoring/assess ment	Host restoration tours and use as a case study for future planning	Landowners, FWP, DEQ, MRF, NRCS, NorthWestern Energy, Contractors	Miles of stream restored, lbs of sediment reduced per year, ac of wetland restored

Focus Area	2023-2025	2025- 2030	2030 - 2035	Partners	Indicators
LTPBR	Complete 1 BDA/PALs project	Assess previous projects and utilize for tours and education	Continue implementing LTPBR with educational tours	FWP, TU, MRF, landowners	miles of stream restored, lbs of sediment reduced per year, and temperature reduction
Riparian Enhancement	Complete 1 riparian fencing cost share project	Complete 1 streambank restoration project	Assess previous projects and plan for future projects accordingly	MRF, NRCS, FWP MVRG, DEQ, TU, USFS, landowners	Miles of stream improved, lbs of sediment reduced per year

Long-term plans include collaboration with various agencies, organizations, and private landowners to complete restoration projects with the goal of improving water quality on impaired streams. In Madison County, which encompasses the majority of the Madison Watershed, 48% of land is privately owned. In the coming decades, continued outreach and engagement will be essential in fostering good partnerships and a collaborative environment between landowners in the Madison Watershed and organizations working toward improved water quality and stream health. Many prominent watersheds in Montana have active working groups or organizations that exist to bring together agency representatives, local government, non-profits, and community members to plan for the future and collaborate on projects. The Madison Watershed has many active organizations, but currently no watershed group that fills this role. Creation of a watershed group could improve collaboration and increase capacity for individual organizations, resulting in notable improvements to water quality. Long-term milestones can be measured by recording how many people have attended meetings and the successful projects completed.

Prioritizing education and outreach in MCD's long-term plans will increase awareness and improve collaboration. The creation and implementation of additional education will be an ongoing effort in the coming years. These efforts will extend from lessons and programs for students in the Ennis school, to workshops for adults within the community. MCD will measure the success of these efforts by recording participation, behaviors changed, and collecting surveys evaluating the effectiveness of workshops.

6.3 MONITORING EFFORTS

The Madison Stream Team (MST) is a citizen science monitoring effort focused on the Madison Watershed. Monitoring abilities include background metrics such as temperature, pH, dissolved oxygen, conductivity, turbidity, as well as discharge estimates and hourly logging of temperature and stream stage using TruTrack data loggers. In addition to having the equipment and trained staff to complete this monitoring, the Madison Stream Team has committed volunteers to help assist in these efforts.

This program is equipped to do basic water monitoring, and annual monitoring plans can be adapted to target streams of interest with ongoing projects. In addition to targeted monitoring of streams with ongoing projects, the MST will complete weekly monitoring of high priority streams. The annual *Tributary Blitz*, a synoptic sampling event of fifteen Madison Watershed tributaries, will provide a snapshot of the watershed through nutrient sampling, photo monitoring, and some additional metrics of interest. These monitoring efforts can be utilized to analyze trends over time and evaluate project successes. The annual Jack Creek Winter Sampling provides a snapshot into baseline low flow nutrient levels and field parameters along Jack Creek. This sampling event takes place along 3 established monitoring points on Jack Creek that are also a part of the Madison Stream Team's weekly monitoring efforts and the annual *Tributary Blitz* in late summer.

Madison Stream Team monitoring efforts are supported financially through the MT DEQ's Volunteer Monitoring Lab Analysis Support Program (VMLASP). Technical assistance and data collection field equipment for the Madison Stream Team is provided by a long-term partnership with Montana State University Extension Water Quality (MSUEWQ). Precise protocols, quality assurance and quality controls (QAQC), sampling methods, and schedules are described in the *Madison Stream Team Water Quality and Nutrient Monitoring Sampling and Analysis Plan* (SAP, *Attachment B*) and the *Madison Stream Team Standard Operating Procedures* (SOP).

7.0 EDUCATION AND OUTREACH

The Madison Conservation District began the WRP process in 2016 and held three public meetings on the topic (2017-2019). A survey assessing local concerns, priorities, and potential for watershed improvement was filled out by 14 people and summarized into a comprehensive document to inform further WRP efforts. In 2022, an additional public meeting was held to gather more community input and further the planning process. Over the course of the last five years 46 community members attended Madison Watershed planning meetings.

7.1 BROADER COMMUNITY ENGAGEMENT

The MCD regularly engages the Madison Watershed community through educational speaker series, resource concern meetings, and a suite of community outreach programs to provide services to residents. It is a diverse stakeholder community with many backgrounds, so MCD hosts a broad range of programs and events to engage community members. As a branch of local government, all MCD meetings are open to the public.

Some elements of community outreach include:

- Monthly Board of Supervisors Meetings
- Annual Strategic Planning Meetings
- Biannual Madison Watershed Partner Meetings
- Madison Watershed Speaker Series, a summer educational series designed to highlight various Madison Watershed conservation efforts
- Rancher Roundtable, a winter series of speakers on topics relevant to the ranching community in Madison County
- The Pollinator Initiative, providing native wildflower seed to increase food and habitat for pollinators
- Annual Producer Field Tour, a fall community field tour to educate community members on working lands management in Madison County
- Land Stewardship Workshop for Small Acreages, an annual workshop on conservation and land stewardship topics relevant to landowners who own $\leq$ 50 acres
- Pull Your Share, a spring youth education program where students learn about negative impacts of invasive weeds to watershed health and conduct an annual weed pull at an adopted site on the Bear Creek Wildlife Management Area
- Ennis Continuing Education, a community adult education class where MCD showcases ecological restoration in the area
- Madison Stream Team, a citizen science effort led by the MCD to collect data on Madison River tributaries

7.2 TARGETED EDUCATION STRATEGY

Through the outreach during the WRP process, several opportunities for education were highlighted. Community support is essential for a successful WRP, because the implementation of projects relies on stakeholders taking action on private land. Providing education about watershed health, opportunities to tour previous restoration sites, and access to technical expertise are all essential in our education efforts.

Within the Madison Watershed there are several projects that have been used for education in the past, and will continue to be utilized. These projects range from riparian fencing on South Meadow Creek, to more hands-on restoration on Jack Creek, that included pulling back downcutting banks to reconnect the stream to the floodplain, and revegetation efforts.

One stream of particular interest during outreach efforts was Moore Creek. It runs through downtown Ennis, has several impairments, and is underutilized for education and generally underappreciated. Using this stream as a community project would allow for volunteer opportunities, and in time could become a very accessible study site for youth education as well. The stream flows through several properties under several different ownerships, with multiple landowners who have expressed interest in restoration projects. Additionally, there are ongoing plans for restoration downstream of town, as well as past restoration projects upstream of town that have been greatly successful.

Through using the above opportunities for education and outreach, the MCD hopes to reach a broader base in the Madison Watershed, and connect with landowners who can benefit from the WRP. The MCD will also work with local organizations, businesses, and individuals to share opportunities and reach a broader base.

8.0 REFERENCES

Brubaker, Ashley; Byorth, Patrick (TU, 2023). *Assessment of Riparian Enhancement, Stream Restoration, and Fisheries Improvement Opportunities for Madison River Tributaries.* Trout Unlimited, Montana.

Luckenbill, Patrick (USFS, 2021). *Upper Madison River Tributary Streams Restoration Opportunities Report*. Beaverhead-Deerlodge National Forest, Madison Ranger District.

Montana Department of Environmental Quality (DEQ, 2019). *Madison Nutrient, E. Coli, and Metals TMDLs and Water Quality Improvement Plan*. Water Protection Bureau, Montana Department of Environmental Quality.

Montana Department of Environmental Quality (DEQ, 2020). *Madison Sediment and Temperature TMDLs and Water Quality Improvement Plan*. Water Quality Planning Bureau, Montana Department of Environmental Quality.

Montana Department of Environmental Quality (DEQ, 2020). *Madison Watershed Stream Summaries 2020*. Water Quality Planning Bureau, Water Protection Section, Montana Department of Environmental Quality.

Montana Department of Environmental Quality (DEQ, 2019). *Circular DEQ-7: Montana Numeric Water Quality Standards*. Water Quality Planning Bureau, Water Quality Standards and Modeling Section, Montana Department of Environmental Quality.

Montana Department of Natural Resources and Conservation (DNRC, 2014). *Upper Missouri Basin Water Plan 2014.*

Montana State Engineer's Office (SEO, 1965). *Water Resources Survey: Madison County, Montana.* State Engineer's Office: Helena, MT. 1965.

Nimick, D; Caldwell, Rodney; Skaar, D; Selch, Trevor (Nimick et.al, 2013). Fate of Geothermal Mercury from Yellowstone National Park in the Madison and Missouri Rivers, USA, Science of the Total Environment, Volume 443, Pages 40-54.

Sigler, Adam; Madison Conservation District (Sigler and MCD, 2023). *Madison Stream Team Water Quality and Nutrient Monitoring Sampling and Analysis Plan.* MCD: Ennis, MT. 2023

United States Geological Survey (USGS, 2000). *Estimated Water Use in Montana 2000.* Scientific Investigations Report:2004-5223. USGS: Reston, VA. 2004

Whitlock, C; Cross, W; Maxwell, B; Silverman, N; Wade, AA (Whitlock et.al, 2017). *2017 Montana Climate Assessment.* Bozeman and Missoula MT: Montana State University and University of Montana, Montana Institute on Ecosystems.

ATTACHMENT A

Montana Department of Environmental Quality's Madison Watershed Stream Summaries 2020

ATTACHMENT B

Madison Stream Team Water Quality and Nutrient Monitoring Sampling and Analysis Plan 2023

ATTACHMENT C

US Forest Service Upper Madison River Tributary Streams Restoration Opportunities Report 2021

ATTACHMENT D

Trout Unlimited Assessment of Riparian Enhancement, Stream Restoration, and Fisheries Improvement Opportunities for Madison River Tributaries 2023

ATTACHMENT **C**

US Forest Service Upper Madison River Tributary Streams Restoration Opportunities Report 2021

Upper Madison River Tributary Streams Restoration Opportunities Report

Prepared by:

Patrick Luckenbill

Beaverhead-Deerlodge National Forest

Madison Ranger District

Ennis, MT

Submitted to:

Madison River Technical Advisory Committee

Northwestern Energy

September 2021, Revised April 2022

Acknowledgments

Darin Watschke-USFS

Dale Olson-USFS

Jon Hanson-NorthWestern Energy

Jennifer Mickelson-USFS

Daphne Kampinga-USFS

Travis Lohrenz-MT Fish, Wildlife and Parks

Nick Larson-MT Fish, Wildlife and Parks

Allison Stringer-USFS

Jake Chaffin-USFS

Matt Jaeger-MT Fish, Wildlife and Parks

Mike Duncan-MT Fish, Wildlife and Parks

Chris Hericks-USFS

Jake Stewart-USFS

Sam Tripp-USFS

Ashley Dettman-USFS

Jim King-USFS

Clint Sestritch-USFS

Acronyms

AG	Arctic Grayling
BDA	Beaver Dam Analog
BDNF	Beaverhead-Deerlodge National Forest
BLM	Bureau of Land Management
BMP	Best Management Practices
CGNF	Custer-Gallatin National Forest
EBT	Eastern Brook Trout
FERC	Federal Energy Regulatory Commission
MTFWP & FWP	Montana Fish, Wildlife and Parks
HUC	Hydrologic Unit Code
LL	Brown Trout
LWD	Large Woody Debris
MADTAC	Madison River Technical Advisory Committee
MRD	Madison Ranger District
MTDEQ	Montana Department of Environmental Quality
NEPA	National Environmental Policy Act
NWE	NorthWestern Energy
OHV	Off-Highway Vehicle
PM&E	Protect, Mitigate, and Enhance
RBT	Rainbow Trout
SMZ	Streamside Mitigation Zone
USFS & FS	US Forest Service
WCT	Westslope Cutthroat Trout
YCT	Yellowstone Cutthroat Trout

TABLE OF CONTENTS

All photos contained within this report are property of USFS unless noted otherwise.

INTRODUCTION

This report is a compilation of aquatic and riparian habitat restoration opportunities identified within the tributary streams of the Upper Madison River Watershed that exist on US Forest Service managed land. The information compiled within this report was completed by the Beaverhead-Deerlodge National Forest (BDNF) in accordance with the funding agreement of the Madison River Technical Advisory Committee (MADTAC) which participated in the funding of this report.

The PM&E funding of project costs agreed to by the MADTAC in the tributary streams of the Upper Madison Watershed administered by the USFS fall under FERC 2188 License Articles 408, 409, and 412. Specifically, article 408: (*2) evaluate the potential to enhance tributary spawning to increase the contribution of natural reproduction to the Hebgen Reservoir fishery; (4) identify, restore, and protect important riparian areas; (7) evaluate the potential to enhance tributary spawning to increase natural reproduction to the upper Madison River fishery; (8) monitor fish species of special concern (i.e. Arctic grayling and cutthroat trout)*, article 409: *(3) fish habitat enhancements both in main stem and tributary streams, including enhancements for all life stages of fish; (6) inclusion or exclusion of fish barriers; (9) riparian habitat restoration,* and article 412: *(5) protect and aid the recovery of threatened and endangered fish species of special concern, including the Arctic Grayling, in Ennis Lake and the lower Madison River.*

The focus of this report is only the tributary streams to the *upper* Madison River watershed (from Ennis Lake to the tributary streams of Hebgen Lake) located within USFS (BDNF and CGNF) administered lands to identify and describe restoration actions that would improve impairments of current aquatic and riparian habitat conditions to the benefit of all aquatic life. The framework for these stream evaluations and corresponding recommended restoration actions is based on observations and analysis of current conditions of stream and habitat function along with reviews of historic activities and data, as well as any past mitigation activities.

During the summer and fall of 2020, various tributary streams throughout the Madison River watershed were visited, evaluated, and later analyzed using GIS. Emphasis was given to streams supporting conservation populations of WCT, streams that have the potential to contribute to mainstem Madison River fish populations, streams with previously identified habitat impairments, streams identified by MTDEQ on the 303(d) list and summarized in the Madison Watershed Stream Summaries 2020, and streams with other anthropogenic activities known to influence stream condition. Streams were evaluated for "significance" within 6th code HUCs based on the amount of stream miles that exist on USFS administered land (≥2 miles), capacity to support fish and aquatic life year-round, delineation as Fish & Restoration Key Watersheds or Watershed Conservation Networks as identified within the BDNF and CGNF Forest Plan, and potential for restoration actions to improve existing aquatic and riparian conditions.

Wilderness fisheries were not included in this assessment per the NWE Five Year Plan 2019-2023 to Protect, Mitigate and Enhance Madison River Fisheries from Hebgen Reservoir to Three Forks (Article 409) and agreed upon by cooperating agencies and NWE. However, Wilderness fisheries adjoining USFS administered lands were considered in this analysis.

Project Area

6th LEVEL HUC SUB-WATERSHED DESCRIPTIONS and RESTORATION RECOMMENDATIONS

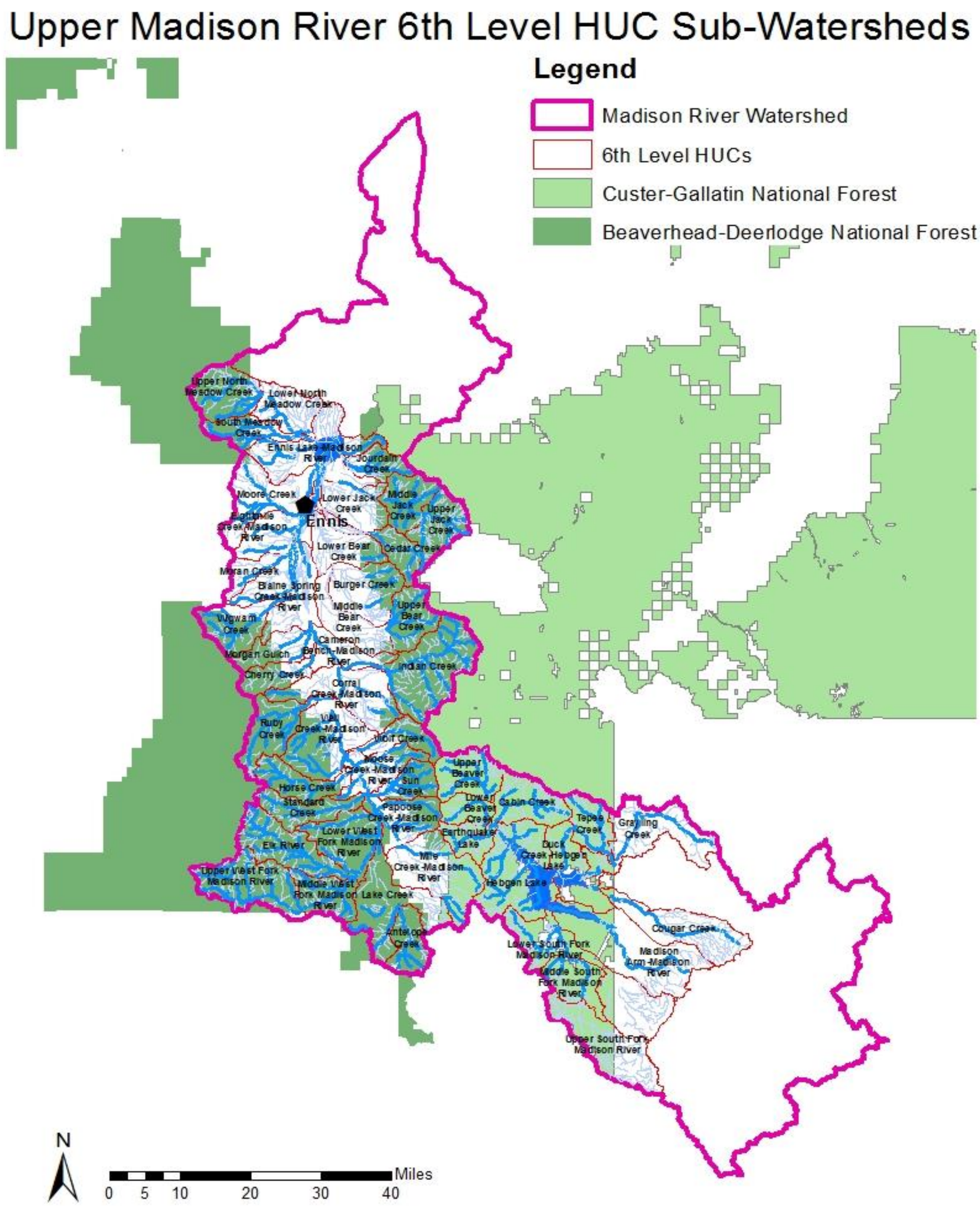


Figure 1 – Map of the Upper Madison Watershed indicating 6th level HUC sub-watersheds and USFS administrative boundaries.

Beaverhead-Deerlodge National Forest

UPPER NORTH MEADOW CREEK (HUC# 100200071101)

Identified streams of significance that are located on FS land in this 6th level sub-watershed are: North Meadow Creek and its tributaries Washington Creek and Sawlog Creek.

Discussion

The Upper North Meadow Creek sub-watershed on FS land can be characterized as a high-use recreational area for motorized travel due to a vast network of FS roads and motorized trails. North Meadow Creek, Sawlog Creek, and Washington Creek are all located in active FS grazing allotments, with the lower third of North Meadow Creek passing through a section of private in-holding surrounded by USFS land where livestock actively graze. This sub-watershed has seen significant historic mining, most of which occurred off-channel within the upper reaches, but small-scale mining operations are still active today around the headwater alpine lakes where North Meadow Creek originates.

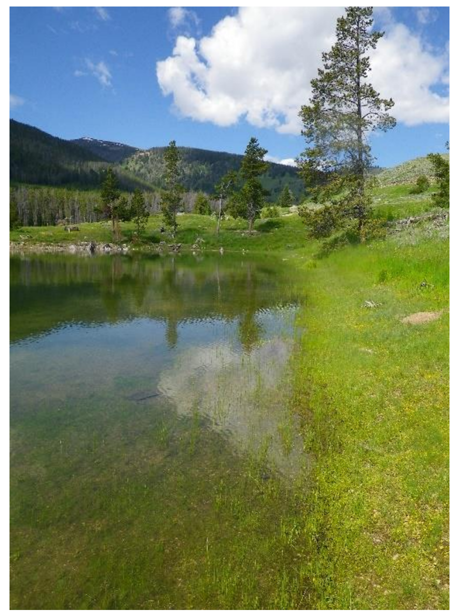


Figure 2: Upper Sureshot Lake

Although Washington and Sawlog Creeks do originate on FS land and fulfills the criteria of having roughly 2 miles of habitat, a large historic and abandoned placer mine site exists downstream of FS property at the confluence of the two streams. Historic sampling indicates a population of EBT within the drainage as well (FWP Fishing Guide Mapper, 2020). MTDEQ has identified North Meadow Creek as having impairments from sedimentation-siltation and flow modifications, although the major contributors to these impairments originate downstream of USFS land. Montana DEQ found the cumulative effects of these impairments can be mitigated through restorative actions on USFS administered property and actions taken on private land further downstream (MT DEQ, Madison Watershed Stream Summaries, 2020).

As a recreational fishery, North Meadow Creek and its tributaries are home to abundant non-native EBT, as well as stocked WCT in the headwater lakes (FWP Fishing Guide Mapper, 2020). On the main tributary to North Meadow Creek, Upper and Lower Sureshot Lakes are two highly accessible and visited recreational fisheries that support both EBT and stocked WCT populations, as well as critical breeding habitat for Western Toad and Columbia Spotted Frog. A diversion of a North Meadow Creek tributary and ditch that feeds both lakes is the result of historic mining activities. After several years of reports of low water in the lakes, an effort was led by USFS Fisheries staff in 2015 to repair the failing headgate, restore function to the historic ditch, and provide more stable water levels in the lake throughout the year to support the recreational fishery. Annual monitoring and maintenance of this ditch by the USFS is on-going.

Recommendations

Until further investigation into the effects from the historic placer mine in the lower Washington and Sawlog Creek drainages, no restoration actions are recommended at this time for these creeks.

Current impairments to North Meadow Creek include bank and shoreline degradation at Upper and Lower Sureshot Lakes leading to direct impacts on Western Toad spawning habitat and increased sedimentation into the lakes. Lack of overwintering habitat structure and fluctuating water levels within the lakes could also be limiting fish populations. Impacts from grazing are nominal due to active management methods used by the permittee and monitored by USFS Range staff (Tripp, Comm. 2020). Active management methods used by permitees and range managers described further in this report include; ongoing monitoring of use levels, moving livestock based on use levels, using salt blocks to draw livestock out of sensitive riparian areas, as well as the use of infrastructure such as temporary fencing and involvement in creating water developments to mitigate impacts to streams. Improvements to bank and shoreline habitat, as well as a comprehensive recreation management plan (designated camp sites, riparian/shoreline fencing, sunken log structures) can improve aquatic habitat conditions for fish and amphibian populations within the lakes and surrounding littoral habitat.

Excess contributions of sediment and silt to streams by adjacent roads are of ongoing concern throughout USFS administered land. In North Meadow Creek, identification of road systems, including user created trails and crossings, that are contributing to these excess contributions will need to be coordinated with appropriate road management authorities. Following prescribed BMPs and regular monitoring will help mitigate the cumulative effects of excess sediment and silt entering the system.

One-long term opportunity that exists in this sub-watershed would be to establish a population of native fish within the drainage. This would be possible by securing the inflow of Upper Sureshot Lake with a screened headgate and construction of a spillway at the outflow of both lakes which will provide for stable lake levels throughout the year and isolate the populations from non-native species downstream. By modifying the existing 0.25 mile long channel between the two lakes into a spawning channel, an opportunity exists for this population to be self-sustaining. This long-term opportunity would provide recreational anglers the opportunity to catch native WCT or AG, which having angling opportunities for both are rare in the upper Madison watershed.

Scheduled to begin in summer 2022, the popular OHV trail on Forest Road 965 leading to McKelvey, Kid, Cliff, Mine, and Twin Lakes is slated to have five failing bridges that span upper North Meadow Creek replaced. The replacement of the old bridges with longer and more structurally substantial structures will increase safety and reduce direct sedimentation into upper North Meadow Creek by moving abutments and sills off of the streambank as well as improving the approaches to direct road sediment away from the stream.

SOUTH MEADOW CREEK (HUC# 100200071102)

Identified streams of significance that are located on FS land in this 6th level sub-watershed are: South Meadow Creek and its tributaries Leonard Creek and Daisy Creek.

Discussion

The South Meadow Creek sub-watershed is a moderately used recreational area with all the streams located within an active grazing allotment. Impacts to stream function, riparian condition, and fish populations from livestock grazing is nominal due to dense forest and steep topography within the drainage which pushes livestock into meadow pastures. Past logging and fuels reduction activities have occurred in the drainage, but most of this activity was located off-channel with no persisting effects to riparian and aquatic habitat. Stream surveys indicate South Meadow Creek is home to both EBT and RBT, with a wild population of RBT existing in South Meadow Lake (FWP Mountain Lake Fisheries Status, 2018).

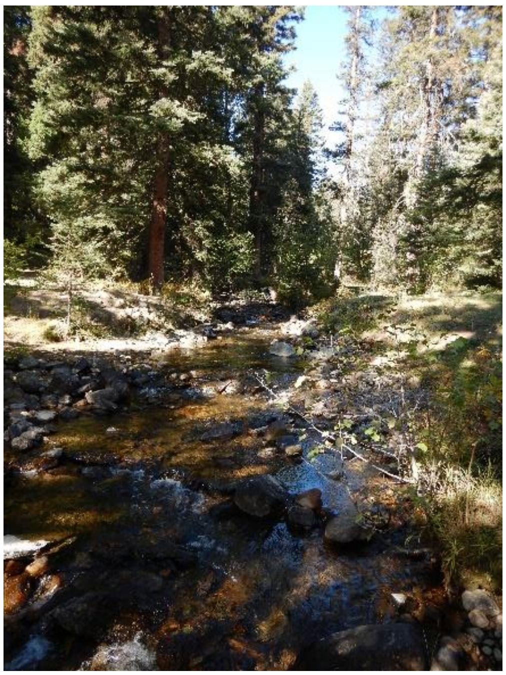


Figure 3: Lower South Meadow Creek

At the head of the drainage is South Meadow Lake which is impounded by an earthen dam and operated by downstream irrigators. Downstream of the USFS boundary, South Meadow Creek runs through several livestock and agricultural properties where stream condition and function become degraded before reaching Ennis Lake. However, FWP, along with agency partners, have worked on a project area of lower South Meadow Creek where channel modification, riparian degradation, and lack of fish habitat have been restored (MADTAC Annual Report, 2019). Neighboring landowners have taken notice of this type of work and expressed interest in future stream restoration activities.

Several miles of road and motorized trail adjacent to South Meadow Creek and up to South Meadow Lake have several spring and tributary crossings that are lacking culverts or have culverts that are non-functioning. During spring runoff or significant rain events, water will run across or even flow down these roads and trails and eventually into upper South Meadow Creek creating sources of excess sediment and siltation which has been identified as an impairment in this watershed by MTDEQ (MT DEQ, Madison Watershed Stream Summaries, 2020).

Dispersed recreational and motorized use on USFS property in the lower reaches of South Meadow Creek have led to destabilized and eroding streambanks as well as disturbance and removal of riparian vegetation which has increased sedimentation of the creek impacting water quality and aquatic habitat.

Recommendations

All the tributaries to South Meadow Creek, including Leonard and Daisy Creeks, fulfill the criteria of roughly 2 miles of habitat of FS land, but with the existence of small numbers of EBT in the reaches on FS land, restoration is not recommended due to the inability of these tributary habitats to support substantial fish populations and would likely have negligible impacts to South Meadow Creek and Madison River fish populations overall.

Recommendations to mitigate recreational and motorized use impacts in the lower reaches of South Meadow Creek include improvements to and reinforcement of stream banks in high use areas, reestablishment of riparian grasses and willows on exposed banks to limit sedimentation and siltation, riparian fencing to exclude livestock and to limit recreational impacts where applicable, as well as moving the dispersed camping sites away from the stream corridor (recommend ≥30ft). Current impacts from livestock grazing are nominal due to active management techniques being implemented by the permittee and continually monitored by USFS Range staff (Tripp, Comm. 2020). Ongoing implementation of active management techniques should continue to be coordinated between the permitee and USFS to ensure riparian and aquatic habitat integrity throughout the allotment.

Other methods to limit sediment and silt from entering the creek should include installation or replacement of culverts at tributary and spring crossings, as well as adhering to road and trail BMP's when performing maintenance. Closure of illegal motorized trails that parallel and cross the stream will also contribute to improving stream health while also conforming to road and trail designations outlined in the Tobacco Root Mountains Motor Vehicle Use Map.

Ennis Lake (HUC# 100200071208)

Identified streams of significance that are located on FS land in this 6th level sub-watershed are: Saint Joe Creek.

Discussion

Saint Joe Creek is a tributary to the Madison River that runs for roughly 4 miles, with 2 miles of the headwaters originating on FS land. The lower reaches and confluence with Ennis Lake run through only one private landowner with an active livestock operation. No historic survey data exists for Saint Joe Creek and it was not visited in 2020.

Recommendations

Further investigation into species present, distributions, and abundance is needed and access through private land will need to be obtained. Saint Joe Creek is one of a few number of creeks that run into Ennis Lake and appears to have potential as spawning and rearing habitat for Madison River fish populations as observed through GIS analysis.

Jourdain Creek (HUC# 100200071207)

Identified streams of significance that are located on FS land in this 6th level sub-watershed are: Jourdain Creek and its tributaries, Crooked Creek and Watkins Creek.

Discussion

The lower 4 miles of Jourdain Creek to Ennis Lake, as well as the confluences with Watkins and Crooked Creek, all exist on private land. The upper 3 miles is on FS property. No historic survey data exists for any of these streams and they were not visited in 2020.

Recommendations

Further investigation into species present, distributions, and abundance is needed and access through private land will need to be obtained. Initial GIS analysis indicate Jourdain Creek potentially lacks surface flow or runs completely dry before reaching the confluences with Watkins and Crooked Creeks during base flows. BDA's may be appropriate within certain sections to hold water for later in the year, but these observations will need to be verified to better understand future restoration opportunities in the Jourdain Creek sub-watershed (USFWS, *Beaver Restoration Guidebook*, 2017).

Madison River-Papoose Creek (HUC# 100200070703)

Streams of significance that are located on FS land in this 6th level sub-watershed are: Papoose Creek.

Discussion

The majority of Papoose Creek lies within a steep watershed that originates at the Cradle Lakes and Papoose Lake of the Lee Metcalf Wilderness Area. Roughly 1.5 miles of the lower watershed runs through USFS and BLM land, before crossing private property and meeting the Madison River. Although the USFS administered section is an active grazing allotment, the steep topography, abundant upland forage, and limited numbers of livestock has resulted in negligible stream and riparian impacts due to grazing (Tripp, Comm. 2020).

Figure 4: Lower Papoose Creek

No information is available for when Papoose Lake was last surveyed, but stocking data from 1993 suggests the lake may have been planted with YCT and is likely fishless today without supplemental stocking (FWP Mountain Lake Fisheries Status, 2018). Cradle Lake was last surveyed in 1999 and was found to have 8yr old fish from the last stocking efforts in 1991, although today it is likely fishless (FWP Mountain Lake Fisheries Status, 2018).

Only the lower 4 miles of Papoose Creek holds fish, of which 2016 survey and genetic data shows a conservation population of 98% WCT persisting (FWP Fishing Guide Mapper, 2020). A diversion structure in the lower mile of stream on USFS land is believed to be acting as a fish passage barrier as sampling data indicates only WCT are found above this structure while RBT, LL, and WCTxRBT hybrids are present lower in the drainage (FWP Fishing Guide Mapper, 2020). There is some concern that this unscreened diversion structure is a contributor to fish entrainment into the associated irrigation ditch and that population abundance and distribution of WCT upstream is limited (Lohrenz, Comm. 2020).

Most of Papoose Creek flows through forested sections where impacts from livestock are minimal, stream and riparian conditions are functioning, and LWD is abundantly available for future recruitment.

Recommendations

Although the topography and overall stream condition of Papoose Creek make it an appealing conservation project area in the upper Madison River, further consideration should be given to securing more stream miles due to limited abundances and distribution of WCT above the diversion structure currently acting as a barrier. Should downstream landowners or partners initiate restoration, improvement actions on the water diversion, or construction of a barrier lower in the drainage, a further evaluation of this watershed may be warranted as more stream miles could be secured and conserved to ensure the long-term persistence of a secure population of fish.

Actions to continue to monitor the effectiveness of the diversion structure as a barrier through sampling of the upstream population is recommended. Genetic sampling should also continue to ensure integrity of this conservation population as well as identification of a practical potential barrier location. Cooperation with associated private landowners and water rights users will be integral in securing this population into the future.

Wigwam Creek (HUC# 100200071201)

Streams of significance that are located on FS land in this 6th level sub-watershed are: Wigwam Creek and its tributaries, Arasta Creek and Buffalo Creek.

Discussion

The Wigwam Creek watershed is comprised of roughly 17 miles of perennial stream, including the North Fork of Wigwam, Arasta Creek, and Buffalo Creek, on mostly USFS administered land as well as a small section of BLM property. An unsecured conservation population of 95% pure WCT exist within Arasta, Buffalo and Wigwam Creeks (FWP Fishing Guide Mapper, 2020) down to the confluence with Haypress Creek. Although all of these creeks lie within an active FS grazing allotment, the steep slopes and rocky headwaters, combined with numerous off-channel water developments and stock tanks, active livestock management by the permittee and monitoring by USFS range staff as well as seasonal rotation make the impacts to riparian condition and habitat negligible (Tripp, Comm. 2020). However, evidence of historic grazing within the riparian areas before current management practices were implemented and impacts to stream function is still an area of concern within this watershed.

Figure 5: Restoration site on Wigwam Creek.

This drainage presents unique challenges in the upper Madison watershed with the fact that it holds an unsecured conservation population of WCT, while at the same time being within the same drainage of several lakes stocked with non-native RBT and LL on Haypress Creek which is located on private land. Escapement of RBT and LL from these lakes and their expansion farther upstream into the habitat currently occupied by WCT seems inevitable without a barrier being constructed. The exploration of partnerships with the private landowners in the past have not been successful.

A section of Wigwam Creek located immediately upstream of the FS Road 290 bridge crossing was severely degraded because of historic livestock overuse and was restored between 2005 and 2010 by USFS Fisheries staff and volunteer partners using bioengineering techniques along with native materials. Using harvested rock and onsite wood, several pools and baffle structures were installed to improve stream function and riparian habitat conditions. As a part of this project, fencing was installed around the roughly 10-acre restoration site to prevent future degradation of the stream and riparian areas. A hardened crossing was also installed to limit bank trampling while moving livestock between nearby pastures. This fencing component, as well as evidence of this type of restoration are still visible today and have served as an example of a successful small-scale restoration project.


Figure 6: Burn area proximity to Wigwam Creek.

The upper reaches of the North Fork of Wigwam Creek and a roughly 1 mile stretch of Wigwam Creek below the FS Road bridge were within the fire area of the 2018 Wigwam Fire which burned across roughly 6,000 acres of USFS land. Although the riparian corridors along Wigwam, Buffalo, and Arasta Creeks escaped any severe fire effects, forested sections in the upper reaches of the North Fork of Wigwam Creek were burned over leaving standing burned timber adjacent to the riparian area. Although not aesthetically pleasing in the years immediately following the fire, benefits to the forest and the associated stream ecosystem from this fire include a future recruitment source of LWD for pool habitat creation, as well as improvements in adjacent riparian aspen spread and growth due to removal of competition with conifers.

Finally, just below the USFS boundary is a water diversion which services downstream irrigators and livestock operations. Although a major portion of the flow in Wigwam Creek is diverted into the ditch system, a small amount of surface flow remains in the channel and reaches the Madison River during base flows. Several reaches of lower Wigwam Creek below this diversion have degraded habitat conditions such as channel modifications, bank erosion, and lack of vegetation leading to increased sedimentation (MT DEQ, Madison Watershed Stream

Summaries, 2020) which when combined could be creating a passage barrier to non-native fish lower in the drainage, or impeding fish from moving farther upstream.

Recommendations

The Wigwam Creek drainage presents an opportunity to secure one of the few remaining abundant WCT conservation populations within the Madison drainage. Although this is more easily stated than in practice, access to a suitable building site for a barrier, construction costs, and most importantly coordination with owners of an adjoining private lake all take time to come to fruition which has been the peril of other conservation populations in the past.

Immediate activities that can improve current habitat conditions and benefit the fish and stream health of Wigwam, Buffalo, and Arasta Creeks would be to continue the habitat improvements with low-tech bioengineering techniques of riparian and channel restoration that has proven to be successful in other impaired sections of Wigwam Creek. Upper sections of Arasta Creek and sections of lower Wigwam Creek where livestock historically and currently congregate have been identified as areas with unstable banks, over-widened channel sections, and a lack of pool habitat. Improvements such as willow planting, channel restoration, and bank stabilization is recommended. Coordination with USFS Range staff as well as exclusion fencing of any future stream and riparian improvements should also be considered due to active livestock grazing within this sub-watershed.

Cherry Creek (HUC# 100200070806)

Streams of significance that are located on FS land in this 6th level sub-watershed are: Cherry Gulch.

Discussion

Cherry Gulch is an intermittent system with several small springs that is lacking any sustained surface flow. This drainage is within an active grazing allotment, but the lack of any fish habitat, fish population, or baseflow reaching the mainstem Madison River makes this system exempt from any recommended restoration actions.

Ruby Creek-HUC 100200070803

Streams of significance that are located on FS land in this 6th level sub-watershed are: Ruby Creek and its tributaries, Dry Fork, Grindstone Gulch, Skunk Creek, South Fork Ruby Creek, and Beartrap Canyon.

Discussion

From 2012 to 2013, FWP along with other cooperating partners removed non-native RBT, LL, EBT, and hybrid WCTxRBT from the entire Ruby Creek drainage and its tributaries down to a natural waterfall barrier on the Wall Creek Game Management Area. In the years following the treatment, aboriginal WCT from neighboring Madison River drainages have been transferred into Ruby Creek in hopes of seeing a protected population of native fish return to the Madison drainage.

Figure 7: Rock and mud slides within the burn area of the upper Ruby Creek drainage.

During the summer of 2018 most of the Ruby Creek drainage, along with most of its upper tributaries except for Skunk Creek and the South Fork of Ruby Creek, were completely burned over in the lightning caused Monument Fire. The USFS and FWP received reports of heavy sediment flows following significant localized rain events reaching the Madison River at Ruby Creek Fishing Access Site the following summer. USFS fisheries staff surveyed the drainage in 2019 and found substantial hillside erosion of rock and mudslides into the floodplain within the burned areas of the upper drainage. In these upper reaches, Ruby Creek lacks sufficient surface flow to support aquatic life until its confluence with Grindstone Gulch which is outside of the fire area. Any significant amounts of sediment reaching the Madison River was transported through the drainage from these upper reaches. Sediment transport from the fire area following rain events will be an ongoing concern as downstream effects to WCT occupied habitat could accumulate.

The lower 5-6 miles of Ruby Creek habitat is occupied by the introduced aboriginal WCT from neighboring Madison River tributary populations. The ownership of these lower watershed sections is made up almost entirely of USFS, MTFWP game management administered land, and State School Trust land. These sections are mostly forested with abundant woody vegetation throughout the riparian habitat. Stream restoration and bank stabilization work was completed by FWP in 2014 to stabilize a heavily eroding streambank, restore a stream channel, and to preserve the foundation of a historic homestead. An access trail leading to the USFS boundary also runs along Ruby Creek which is used primarily by OHV and foot traffic during hunting season. This trail has steep banks and is heavily eroding directly into Ruby Creek in certain sections. The portions of trail on USFS land are designated as non-motorized.

Figure 8: Downstream reach of Ruby Creek occupied by WCT.

Recommendations

Although the upper reaches of Ruby Creek on USFS administered land saw a significant fire event in 2018, the downstream sections occupied by reintroduced WCT are an example of a naturally functioning stream system. The drainage assessment conducted in 2019 showed no evidence of excess sediment accumulation within the sections of WCT habitat. However, ongoing monitoring and evaluation of the ability of the stream to transport the upstream sediment load should be continued. Future LWD recruitment will remain abundant as the standing burned timber within the fire area falls into the floodplain and is sorted downstream. Should excess fine sediment from the fire area become a concern to the downstream WCT population and habitat, further study and evaluation would be needed to mitigate and engineer a solution from these effects.

Impairments to the Ruby Creek drainage identified by MTDEQ include excess fine sediment inputs and flow modifications as the result of current and historic livestock grazing practices causing bank trampling and channel over-widening at access points along the stream (MT DEQ, Madison Watershed Stream Summaries, 2020). Although Ruby Creek is within an active USFS grazing allotment, most of the current grazing activity occurs on the Johnny Gulch side of the allotment where abundant grasses and forbs are more easily accessible for livestock (Tripp, Comm. 2020).

Another contributor to fine sediment that was identified by MTDEQ and USFS fisheries staff is the access road/trail through the Wall Creek Game Management Area that is adjacent to the stream and leads to the USFS boundary. This trail allows for OHV use on portions through the Game Management Area, but OHV use is restricted once on USFS land. Although the degraded section of trail is on MTFWP managed land, it does provide user access to USFS land and would not be supported for decommissioning. However, improvements to the road/trail that include bank stabilization, revegetation, and associated channel improvements to impacted areas would be fully supported by the USFS.

Madison River-Wall Creek (HUC# 100200070802)

Streams of significance that are located on FS land in this 6th level sub-watershed are: Hyde Creek, English George Creek, Bobcat Creek, and Wall Creek.

Discussion

The land ownership of this 6th level sub-watershed falls almost entirely within USFS and FWP managed property with several WCT population restoration projects either already completed or scheduled to be completed in 2021. All the identified stream sections of significance within USFS administered land are within an active grazing allotment. Some of the streamside riparian habitat has been identified as having impacts from historic and current grazing practices, measures to mitigate these impacts such as installing seasonal electrical fencing have been taken within the upper reaches of English George Creek. As other impacted habitats are identified, coordination between USFS Range and Fisheries staff will be needed to implement further mitigation measures such as fencing and active management practices.

Farthest north in this sub-watershed, Hyde Creek originates on USFS land and runs through the Wall Creek Game Management Area before meeting with the Madison River. Sampling conducted in 2015 show the CT within the system having 88% WCT genetics, leaving them just below the 90% threshold to be considered a conservation population (FWP Fishing Guide Mapper, 2020). Although the WCT population in Hyde Creek has been hybridized out of conservation status, the overall quality and availability of habitat, as well as the size of the existing population demonstrate the ability of this stream system to support viable numbers of fish which may be a contributor to mainstem Madison River fish populations (Lohrenz, Comm. 2021). Further study would be needed to validate the contributions of this population to the Madison River.

Figure 9: English George Creek wood barrier.

Just south of Hyde Creek, English George Creek also originates on USFS land and runs through the Wall Creek game management area before reaching the Madison River. Roughly 5 miles of English George Creek is protected by a barrier that was installed in 2017 near the Lower Wall Creek Game Range Road crossing which has secured a 93% genetically pure population of WCT (FWP Fishing Guide Mapper, 2021). English George Creek has served as a model for future construction in the Madison River watershed of the more affordable wooden barrier structures.

Further south of English George Creek is Bobcat Creek. Little to no sampling information is available for this system and no viable fish populations are believed to exist in this stream due to lack of connectivity, limited available habitat, and lack of sufficient surface flow to support aquatic life (Lohrenz, Comm. 2021). This stream was not visited for review in 2020.

At the southern boundary of this sub-watershed is Wall Creek which has been identified as a “fish key-watershed” in the BDNF Forest Plan which prioritizes analysis and restoration work. Originating in the Gravelly Mountains at Wall Creek Lake, Wall Creek flows for roughly 8 miles on USFS administered land before reaching the confluence with Curley Bill Creek at the USFS boundary. Wall Creek Lake is fishless and disconnected from Wall Creek (FWP Mountain Lake Fisheries Status, 2018). Much of the flow in upper Wall Creek is diverted to Curley Bill Creek for downstream private agricultural use, with flows from both creeks reaching the Madison River only during high water events.

Construction of a concrete fish passage barrier at the confluence of Curley Bill Creek and Wall Creek is scheduled to begin in 2021 which will secure roughly 8 miles of habitat for a conservation population of WCT. The barrier will prevent upstream migration of any non-native fish from the Madison River during sustained high-flow events occurring on Curley Bill and Wall Creeks. This project is a partnership between the USFS, FWP, and NWE.

Recommendations

With the installation of a barrier on English George Creek and another to be installed on Wall Creek during the summer of 2021, the primary focus for this sub-watershed up to this point in time has been to protect conservation populations of WCT. In conjunction with these efforts should be the preservation and enhancement of the aquatic and riparian habitat that these barriers are protecting. This includes active and ongoing monitoring of riparian and stream condition to eliminate current and future impacts from livestock grazing. Ongoing coordination between USFS Range and Fisheries staff will be required to maintain communication and monitoring efforts with grazing permitees.

Further evaluation would be needed for Hyde Creek to be a candidate site for a future WCT conservation project. Updated population estimates will indicate if Hyde Creek is able to support a viable population size following a conservation project. Having not visited Hyde Creek in 2020, the upper reaches on USFS property will also need to be evaluated for any current and historic impairments that would limit habitat potential. Identification of barrier sites will also need to be conducted; however, Hyde Creek does cross the Upper and Lower Wall Creek Game Management Roads which have been used in other projects as barrier sites.

Overall, the Wall Creek sub-watershed will continue to be a source of monitoring and habitat improvements to sustain the viability of protected populations into the future.

<u>Horse Creek (HUC# 100200070705)</u>

Streams of significance that are located on FS land in this 6th level sub-watershed are: Horse Creek and its tributaries Camp Creek, Deer Creek, Alpine Creek, and Tepee Creek.

Figure 10: Horse Creek baffle installation in 2006.

Discussion

The entirety of this sub-watershed, including all the tributary streams, are contained within USFS administered land except for the lowest 2 miles of Horse Creek which flow through private property before reaching the Madison River. The Horse Creek drainage is relatively remote and within a mix of closed and open USFS grazing allotments. The allotment within the upper reaches of Horse Creek has been closed to grazing for over 30 years and the allotment within the lower reaches has been closed for the last 20 years with no future grazing allowed without administrative NEPA being performed. An abundant conservation population of WCT exist within the roughly 15 miles of available habitat. The Horse Creek sub-watershed has been identified as a “fish key-watershed” by the BDNF Forest Plan prioritizing any analysis and future restoration work for the protection and restoration of Threatened, Endangered, and Sensitive aquatic species. Currently, a waterfall feature in the middle of the drainage is preventing upstream migration of nonnative species, but a potential barrier site has also been located farther downstream which would secure the existing population over more stream miles.

Significant restoration work to manage fine sediment deposition and restore channel morphology has been done by the USFS Fisheries staff within Tepee Creek beginning in 2004 and concluding in 2008. Past restoration work included the installation of willow weirs to influence fine sediment deposition, as well as riparian plantings such as sedges which are used to trap sediments, restore bank stability, and induce channel meandering. Although the project area is fishless due to a natural cascade barrier located downstream, the intent was to provide water quality benefits to the conservation population of WCT in Horse Creek and other aquatic life that occur downstream (FWP Fishing Guide Mapper, 2021). This project received funding support from PPL Montana-Article 409 FERC licensing requirements (MADTAC), as well as the Madison-Beaverhead County RAC (Resource Advisory Committee).

In 2015, USFS Fisheries staff performed a drainage assessment of Horse Creek, monitoring the condition and distribution of the resident population of WCT while also evaluating habitat conditions and past improvements on Tepee Creek. Although relatively untouched from the impacts of fire, beetle kill of the surrounding timber stand was evident throughout the drainage increasing the risk of future fire potential. However, even with a significant amount of beetle killed trees adjacent to riparian areas, they do provide a good source of future LWD recruitment (King, Comm. 2021).

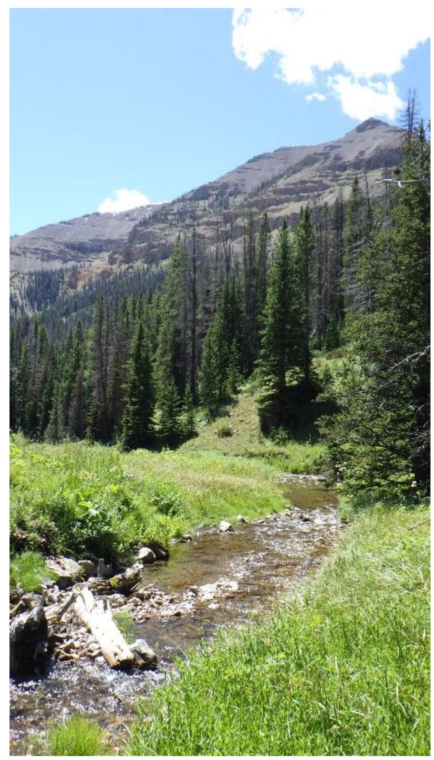


Figure 21: Upper Horse Creek

Recommendations

Due to its remote location, limited access, and lack of any recent grazing impacts, recommended restoration actions in Horse Creek and its associated tributaries are limited. Areas that had been impacted by historic livestock use have been given time to repair naturally and should be allowed to continue. Monitoring of past restoration projects should continue to be evaluated for the intended effectiveness and potential implementation into future projects.

The most significant action that could take place in this sub-watershed would be to secure the existing conservation population of WCT in Horse Creek with construction of a fish passage barrier. The most accessible and reasonable location for future barrier construction would be in the lower 2 miles of Horse Creek which runs through private land. Participation with willing private landowners would be critical to the process of securing roughly 15 miles of habitat for the resident population of WCT.

Standard Creek (HUC# 100200070704)

Streams of significance that are located on FS land in this 6th level sub-watershed are: Standard Creek and Wolverine Creek.

Discussion

The approximately 12-mile-long Standard Creek sub-watershed, along with its tributary Wolverine Creek, run entirely through USFS administered land except for the lowest ½ mile at the confluence with the Madison River. Being one of the longer connected sub-watersheds on USFS land, Standard Creek and Wolverine Creek run through two separate grazing allotments. Although used historically but not grazed in 2020, the lower allotment is currently open and available to the permit holder should they choose to begin operating livestock in the drainage once again (Stewart, Comm. 2021). The upper allotment that encompasses the headwater reaches of Standard Creek and all of Wolverine Creek is also open, but this allotment is dedicated to sheep grazing exclusively. Ongoing monitoring of stream and riparian habitats within sheep allotments has noted less impact to sensitive riparian and aquatic habitats in comparison to use by other livestock species. Current impacts in the lower drainage from livestock have been minimal due to infrequent use, steep topography of the drainage, abundant upland grasses, and a 150-acre private land holding in the middle of the watershed that is fenced to exclude livestock from access to the stream corridor (Stewart, Comm. 2021).

Figure 22: Wolverine Creek culvert on USFS Road 237.

USFS Road 237, which runs along Standard Creek from the West Fork Madison Road and up to the Gravelly Range Road, provides one of the few public access points to reach the South Gravelly Range. Although the road only crosses Standard Creek at one location in the headwater reaches and is not of concern to impairments in water quality or aquatic organism passage, the culvert crossing of Wolverine Creek near its confluence with Standard Creek is partially perched but likely not impeding aquatic organism passage at this time.

Both Standard Creek and Wolverine Creek have populations of WCT, but past genetic testing indicates YCT present in Wolverine Creek likely from historic stocking efforts (FWP Fishing Guide Mapper, 2021). More recent genetic sampling and abundance estimates would better indicate the expanse of this population. However, with this system being connected to the Madison River without a fish passage barrier, it is likely this population has already been hybridized. Existing LWD and future recruitment of LWD, as well as pool/riffle habitat is abundant throughout as these creeks flow through mostly forested sections before reaching the Madison River.

Recommendations

With the potential reintroduction of livestock into the lower allotment of Standard and Wolverine Creeks, ongoing monitoring of riparian and aquatic habitats will need to be conducted to evaluate changes compared to current conditions during periods of non-use. Ongoing monitoring efforts will also help in identifying sensitive and high-use areas by livestock that will need future mitigation actions.

Should improvements be scheduled in the future to USFS Road 237, upgrades to the existing culvert structures should be considered as well as adhering to BMP's to reduce sediment point sources into Standard and Wolverine Creeks. Until that time, these structures should also be monitored to ensure they do not fall into disrepair and prohibit the passage of aquatic organisms or contribute excess sediment to the stream.

In conjunction with the collection of more recent fish population abundance, distribution, and genetic data, identification of potential fish barrier locations should also be conducted. Decisions regarding future conservation efforts, enhancement, and necessity of restoration activities concerning this population will more easily be made with updated population and genetic data.

Lower West Fork Madison River (HUC# 100200070604)

Streams of significance that are located on FS land in this 6th level sub-watershed are: West Fork Madison River and its tributaries: Gazelle Creek, Soap Creek, and Freezeout Creek.

Discussion

This large sub-watershed encompasses roughly 23,000 acres contained entirely within USFS administered land which includes three tributaries to the West Fork Madison River, along with the lower reaches of the West Fork Madison and its confluence with the Madison River. The lower sections of the West Fork Madison flows through mostly forested terrain with future and current LWD abundant. There is current and historic beaver activity evident in the river's lowest reaches and the river also regularly accesses its floodplain during normal water years.

The entirety of the West Fork Madison River from the headwaters to mouth has been identified as having impairments for temperature (MT DEQ, Madison Watershed Stream Summaries, 2020), however this sub-watershed analysis covers the lower reaches of the West Fork Madison from Freezeout Creek to the confluence with the Madison River. Further analysis covering the middle and upper stretches of the West Fork Madison watershed is contained in later sections of this report.

The lower West Fork Madison River sub-watershed can be characterized as a high-use recreational area with numerous dispersed camping sites within and along the riparian corridor which has significantly impacted bank stability and streamside vegetation at certain locations but is generally concentrated to these recreational sites. The area also sees a high-level of OHV use due to the accessibility of the associated network of USFS roads but impacts to aquatic systems is limited.

This sub-watershed is within one of the largest active grazing allotments on the BDNF. The impacts from livestock on the riparian and stream systems is varied as there are three separate pastures with active grazing, each with its own sensitive stream and riparian areas. Like Standard Creek, this allotment received limited or no grazing in 2020, although the permit holder reserves the right to continue at any time and should be expected to operate at full capacity in the future (Stewart, Comm. 2021). Due to the size of the area, impairments and impacts to specific creeks will be discussed further within the description of each tributary stream system. In 2014, a fencing project led by USFS Fisheries staff and other partners on the Lower West Fork Madison River sought to exclude livestock and mitigate OHV use within a section of degraded streamside riparian habitat with jack-leg fencing. Further improvements have been ongoing such as restoring vegetation to degraded streamside springs as well as seasonal monitoring of the fencing for any failures or needed improvements.

Figure 23: 2014 Fencing project area on Lower West Fork Madison River.

Farthest north in the sub-watershed, Gazelle Creek runs for roughly 8 miles through heavily forested terrain before reaching its confluence with the West Fork Madison River. The upper reaches have been within past fuels reduction and timber sale project areas, but this activity occurred off-channel and there are no known current impacts to aquatic and riparian habitat. Limited data is available regarding population abundances, distributions, and genetic status of any WCT within the stream, but consensus among stakeholders is that any unprotected system that provides aquatic organism passage to the Madison River has already been occupied by nonnative fish. Gazelle Creek also has two significant road crossings, one at Standard Creek Road and the other on the West Fork Madison Road. Both culvert crossing sites have been evaluated as potential future barrier locations.

South of Gazelle Creek is Soap Creek. Soap Creek runs for roughly 5 miles through forested terrain and adjacent to a network of USFS roads before its confluence with the West Fork Madison River. At the confluence, Soap Creek runs through a small private in-holding where it flows into a roughly 2-acre pond created by an earthen dam with an outflow pipe immediately upstream of the West Fork Madison Road crossing. Little is known about the efficacy of the outflow pipe as a fish passage barrier, but genetic sampling as recent as 2005 throughout the drainage has shown a conservation population of 95% pure WCT still existing (FWP Fishing

Guide Mapper, 2021). A cascade just upstream from the pond is thought to be the mechanism currently acting as a fish passage barrier by FWP and USFS Fisheries staff.

Farther south, a collection of multiple small tributaries, headwater ponds, and wetlands join to form Freezeout Creek. Although the headwaters originate in forested terrain, it quickly flows into a valley of sagebrush/grass interface preferred by livestock for its abundant grasses. Based on historic sampling, fish only reside in the lower 2 miles of stream connected to the West Fork Madison River where sufficient flows exist to support aquatic species. Historic sampling data indicates no native species present within the system, although the headwater wetlands and ponds are documented breeding and rearing habitat for native Western Toad and Columbia Spotted Frog (FWP Fishing Guide Mapper, 2021). Freezeout Creek has been identified by BDNF as a “restoration key-watershed” for having the highest risk of degraded conditions and analysis and future restoration work would be prioritized in this stream over non-key watersheds.

Figure 24: Upper Soap Creek.

Recommendations

To better target the recommendations for restoration in this sub-watershed, each stream will be separated as to specific enhancements that will improve existing condition beginning with the lower 7 miles of the West Fork Madison River.

Several anthropogenic factors are contributing to current stream conditions on the lower West Fork Madison River including livestock grazing practices and high levels of recreational use. As previously stated, although livestock grazing was limited or non-existent in 2020, past use has impacted certain sections of stream. Some of the impairments identified are bank trampling, livestock trailing within the riparian zone, and grazing within the stream corridor. Identifying, protecting, and maintaining important streamside buffers as well as monitoring and improvement of current grazing management practices in coordination with USFS Range staff and permit holders will help maintain bank integrity and allow vegetation to reestablish at impacted sites.

Similar to grazing impacts, the concentrated recreational use in the lower West Fork Madison River is causing changes to streamside riparian habitat as well as streambank erosion at several sites. Recommendations to mitigate recreational and motorized use impacts include improvements and reinforcement to stream banks in high use areas, reestablishment of riparian grasses and willows to exposed banks to limit excess sedimentation and siltation, riparian fencing to exclude livestock and to limit recreational impacts where applicable, as well as moving dispersed camping sites away from the stream corridor (recommend ≥30ft). Monitoring and management of frequently used recreational sites, including seasonal closures of sites or those that are already severely degraded will be critical to improving future conditions. Coordination with USFS Range, Recreation, and Fisheries staff will be an important component to implementing future improvements on the lower West Fork Madison River.

Figure 25: Wheel ruts adjacent to the West Fork Madison River at a Recreational Site.

Recommended restoration activity in Gazelle Creek is limited to gathering updated abundance, distributions, and genetic information for fish within this drainage, as well as monitoring road crossings as excess sediment input point sources to the stream.

Future restoration activity recommended in Soap Creek include updating the abundance, distribution, and genetics of the resident WCT to ensure their conservation status is being maintained.

Finally, although fish only occur in the lowest 2 miles of Freezeout Creek, updated abundance and distribution data will give insight into the availability of fish habitat within this drainage. Monitoring should also continue for Western Toad and Columbia Spotted Frog to ensure population persistence in the Madison drainage.

<u>Lake Creek (HUC# 100200070502)</u>

Streams of significance that are located on FS land in this 6th level sub-watershed are: Lake Creek.

Discussion

The headwaters of the Lake Creek sub-watershed originate from a hillside spring source at the divide separating Wade Lake from the West Fork Madison River watershed, running for roughly 2 miles before its confluence with the West Fork Madison. Just before reaching the confluence, Lake Creek forms the 5 acre Smith Lake which was historically created with an earthen dam by irrigators and agricultural users as a site for a water wheel pump which was used to transport water to stock tanks located on an elevated bench to the east (Lohrenz, Comm. 2021). Remnants of the water wheel and the earthen dam are still present at the site today, although the earthen dam is not an identified fish passage barrier. A fish ladder was installed in 2015 by FWP and USFS Fisheries staff to aide in the upstream migration of fish into the lake and the productive upstream spawning reaches of Lake Creek.

Figure 26: Smith Lake dam and water wheel.

Even though this sub-watershed does not account for many stream miles, its abundance of primarily LL fish is well documented (FWP Fishing Guide Mapper, 2021). Impacts from livestock grazing have been limited due to surrounding topography and its location east of the West Fork Madison River which livestock rarely cross. Recreational access is also limited in this area due to the closure of a trail ford crossing of the West Fork Madison which had historically allowed OHV access to the upstream area.

Figure 27: Smith Lake fish ladder.

Stream condition is highly functional above and below Smith Lake evidenced by the abundant population of spawning and resident LL that have been sampled throughout (FWP Fishing Guide Mapper, 2021). With no identified active sources of silt and sediment to the stream, gravels have remained clean. LWD is also abundant and available for future recruitment below Smith Lake as the stream runs through mostly forested terrain, while above the lake the channel meanders through a valley bottom of sedges, willows, and other riparian grasses.

Recommendations

With overall stream conditions being near pristine, recommendations to improve current conditions are limited. Maintaining a functioning fish ladder at Smith Lake will be critical in continuing to allow the passage of fish into the upper spawning and rearing habitat of Lake Creek. Ongoing monitoring of the LL population and overall stream condition should also continue to ensure persistence of this population into the future.

Elk River (HUC# 100200070603)

Streams of significance that are located on FS land in this 6th level sub-watershed are: Elk River and its tributaries: Moss Creek, Dirty Creek, Little Elk Creek, Indian Springs Creek, Hellroaring Creek, Nelson Creek, Barnett Creek, and Rossiter Creek.

Discussion

The Elk River sub-watershed and its tributaries cover an area of over 25,000 acres, with the headwaters originating in the upper basins of the Gravelly Range before its confluence with the West Fork Madison River flowing over an estimated 35 miles collectively. Recreational access is limited to the lower sections of Elk River with most users being during hunting season. Near the mouth, two separate motorized trail ford crossings are used to access private property and USFS land further upstream on the West Fork Madison River. Both of these crossing have become over-widened with severely eroded banks. Although these trail crossings are concentrated to two sites, replacement of these crossings with a bridge or other means is further complicated due to the public trail through the private land being an unperfected easement between the USFS and the current landowner (Stewart, Comm. 2021).

Livestock grazing is spread over three separate allotments in this sub-watershed. The downstream reaches from Dirty Creek to the mouth is within an active grazing allotment. The tributaries on the south side of Elk River from Dirty Creek to Hellroaring are in a closed allotment, while the north side tributaries and those upstream of Hellroaring Creek are within a dedicated sheep allotment. Like Standard Creek, differences in impacts to stream and riparian habitat is noticed between the sheep and livestock allotments. Although limited numbers of livestock were grazed in the lower reaches in 2020, historic concentrated use in the more accessible grass valley bottoms closer to the West Fork Madison River has impacted streambank condition, riparian vegetation, and sediment point sources. Even though Elk River is not a listed stream for sediment impairments, theses cumulative additions are a suspected contributor to the West Fork Madison and mainstem Madison being listed (MT DEQ, Madison Watershed Stream Summaries, 2020).

From Barnett Creek in the headwaters to roughly one mile from the mouth, Elk River runs through a forested canyon with abundant LWD available for future recruitment. The lightning caused Lobo Mesa Fire in late summer and early fall of 2020 burned roughly 500 acres at low intensity on the immediate slopes of Hellroaring Creek. The fire consumed a large amount of the dead and down fuels on the ground but did not reach the riparian areas of Hellroaring Creek. Similar to the fire event that occurred in Wigwam Creek, burned standing timber has opened the stream corridor for riparian expansion, as well as creating a source of future LWD recruitment into the stream.

Although currently occupied by an abundant population of mostly hybrid WCTxRBT, Elk River and its tributaries have been identified by FWP, the USFS, and MADTAC partners as being a future major project area for Westslope Cutthroat trout restoration in the Madison River watershed. A barrier site in the lower reaches within a steep canyon has already been identified, as well as the required design and engineering of the barrier structure completed. Despite being in the early organizational and fundraising stages, the Elk River sub-watershed would restore native WCT back into roughly 35 miles of habitat they once occupied.

Figure 28: Elk River identified barrier site.

Recommendations

Activities recommended for the lower reaches of Elk River within the active livestock grazing allotment include ongoing monitoring of grazing impacts to stream and riparian habitat to better assist USFS Range staff in identifying impacted areas and developing mitigation actions in cooperation with the permit holder. Such actions could include development of off-channel water tanks and implementation of an active management plan to keep livestock impacts to sensitive stream and riparian areas at a minimum. Other actions in the lower reaches include evaluation of the lower ford crossings and to advance recommendations for improvement with USFS Recreation and Range staff to develop appropriate plans for a trail bridge or improved hardened crossings.

In the headwaters, the Gravelly Range Road parallels Rossiter Creek before crossing both Rossiter Creek and upper Elk River. The crossing of Rossiter Creek is a culvert that currently allows for aquatic organism passage but is potentially undersized for its location during high water events or significant snowmelt. Also due to its location on the landscape where the road slopes down towards the crossing, transport of runoff with sediment from the road surface and into the stream is more likely. Raising the height of the crossing and replacement with a larger culvert will help alleviate both issues, but further evaluation would be needed to determine appropriate sizing and effectiveness at this location given limited fish distributions and abundances in these uppermost reaches due to low water during base flows.

Another stream crossing that has been identified as in need of replacement or repair is located several hundred feet south of the Rossiter Creek crossing where the Gravelly Range Road crosses the uppermost reaches of Elk River. In 2020 this bridge crossing was identified as needing upgrade, repair, or replacement by USFS Engineering staff. Although fish passage at this site is not as issue, there is a risk of sediment entering the stream at the crossing due to road geometry and current bridge design. When replaced, adhering to road and bridge BMPs will help to alleviate any future point source sediment contribution to the stream at this site.

Finally, in advance of the construction of a fish passage barrier on USFS land in lower Elk River the NEPA process will need to be conducted and approved. Evaluation of the impacts from construction activity and other potential implications will need to be accounted for by USFS specialists before any project can begin. Coordination internally led by USFS Fisheries staff with other USFS specialists will be critical in accomplishing this step to restoring a native population of WCT back into the Madison River watershed.

Middle West Fork Madison River (HUC# 100200070602)

Streams of significance that are located on FS land in this 6th level sub-watershed are: West Fork Madison River and its tributaries, Meridian Creek and Tepee Creek.

Discussion

The middle West Fork Madison River sub-watershed that includes Meridian and Tepee Creeks begins just below the mouth of Lobo Creek and runs for roughly 8 miles downstream until just above the confluence with Elk River. Most of the middle West Fork runs through a valley bottom with little forest cover while Meridian and Tepee Creeks meander through a more forested landscape before reaching the West Fork. There are three separate, roughly 100-acre private inholdings located directly on the middle West Fork Madison. Two of them are located downstream of the confluence with Tepee Creek and between the confluence with Elk River, while the third is just upstream of the confluence with Meridian Creek.

Meridian, Tepee, and the lower reaches of the West Fork Madison are all within an active pasture of one larger grazing allotment, while the middle and upper sections of the West Fork are contained in another pasture that also has active grazing. Similar to the lower West Fork, the numbers of active livestock in 2020 were limited, but the area historically sees significant annual grazing activity and is expected to be at full capacity in 2021 and beyond (Stewart, Comm. 2021). The majority of the middle West Fork Madison is void of canopy cover from trees; this has resulted in limited numbers of livestock congregating in the riparian areas and has pushed them to higher elevations offering more cover during the warmer summer months. Although livestock numbers have been limited most recently, there is some evidence of historic livestock trailing and bank disturbance in the riparian corridor.

With recreational access to the area being difficult, the impacts from associated trails and roads is limited. However, there are several areas on the middle West Fork Madison where the adjacent trail does cross the stream or associated perennial and intermittent spring creeks which have become over widened and are likely sources of excess sediment contribution to the West Fork Madison. Many of these crossings are within the private inholdings making the process to undertake necessary improvements difficult.

Historic sampling indicates no fish of conservation status have been found in this sub-watershed within portions of both Tepee and Meridian Creeks that are directly connected to the West Fork Madison (FWP Fishing Guide Mapper, 2021). Although not visited for evaluation in 2020, GIS analysis and review of historic sampling indicates both Meridian and Tepee Creeks lack sufficient connected habitat and flows to support significant populations of fish above the lower reaches of stream. Sampling data on the West Fork Madison is also limited for this section, but upstream and downstream sampling data is available but outdated.

Although willow is expansive throughout the floodplain in this section, the entire West Fork Madison River has a 303 (d) listed impairment for temperature (MT DEQ, Madison Watershed Stream Summaries, 2020). While the expanse of willow indicates the stream does have the ability to regularly access its floodplain, this impairment listing is possibly due to the width and shallow depth of the river, as well as a lack of trees within the valley bottom compared to the upland forested tributaries.

Recommendations

Recommended activities to improve stream condition and function in the Middle West Fork Madison sub-watershed include allowing stream banks to heal by trailing cattle out of the stream corridor. This could be achieved through better coordination with USFS Range staff to identify sensitive and degraded reaches, implement monitoring of these sites to limit further degradation, as well as enacting an active management strategy with the permit holder to keep livestock out of the stream and riparian corridor. Other activities include working with the private landowners to improve the trail crossings on their property that accesses FS land to limit excess sediment contribution and enhance bank stability at these sites.

Another recommendation to better understand the fish populations and habitat condition within this section would be to update abundance and distribution estimates while documenting the current condition of the riparian and stream habitat on Tepee and Meridian Creeks. The data that is currently available is limited in scope and having an updated assessment would provide managers with a better idea of the status of resident fish and current conditions of these creeks.

<u>Upper West Fork Madison River (HUC# 100200070601)</u>

Streams of significance that are located on FS land in this 6^{th} level sub-watershed are: West Fork Madison River and its tributaries Lobo Creek, Portal Creek, Cascade Creek, Fossil Creek, Buford Creek, Miner Creek, Anderson Creek, and Fox Creek.

Discussion

The upper West Fork Madison River from its headwaters to the confluence with Lobo Creek flows for roughly 15 miles across the southern end of the Gravelly Range. With eight significant tributary creeks included, this sub-watershed has over 30 miles of perennial streams and river, as well as several intermittent streams and springs that are also connected. Access to certain sections of this sub-watershed is difficult with no established road or trail access throughout except for certain trails used by permit holders to access their range improvements.

Livestock grazing occurs throughout this sub-watershed over several different pastures with most of the activity centered around the productive grasses closest to the West Fork Madison River and lower sections of the tributaries. Starting at the lower end of the upper West Fork Madison sub-watershed and moving upstream, the lower reaches of Lobo Creek down to its confluence with the West Fork are lacking in the same abundance of riparian cover compared to other neighboring creeks. Although not visited in 2020, GIS analysis shows a significant lack of surface flow in the lower reaches may be a contributing factor in contrast to upper reaches of the creek indicating that water may run sub-surface somewhere higher in the drainage. The steeper topography and a closed pasture in the upper sections of Lobo Creek have limited any significant impacts from livestock on stream and riparian habitat. Although the reaches of the West Fork Madison immediately upstream of Lobo Creek are easily accessible to livestock, a small section of exclusion fencing prevents trailing and congregating within the stream and riparian corridor. Livestock crossings are concentrated to one small area upstream of the exclusion fencing before the surrounding adjacent topography steepens forcing livestock into the uplands and out of the stream corridor.

Moving upstream to the confluence with Portal Creek, riparian and stream habitat of the West Fork Madison becomes greatly impaired with limited channel complexity, a lack of riparian habitat, and several sections of eroded and impacted streambank. Portal Creek itself lacks perennial flow to support aquatic life, but degraded conditions in the lower sections could be contributing excess sediment during periods of high flows. The roughly one-mile section of the West Fork Madison upstream of Portal Creek sits in an open valley bottom that is highly accessible to livestock. Evidence of trailing in the stream and riparian corridor is evident, as well as a lack of any riparian cover which is likely contributing to the 303 (d) listing of the West Fork as having an impairment for temperature (MT DEQ, Madison Watershed Stream Summaries, 2020).

Stream and riparian conditions around Cascade Creek and further upstream improve as the stream corridor narrows and the land adjacent become steeper with more forested tree cover. A limited amount of data exists to accurately describe the abundance, distribution, and genetic status of any populations of fish that reside in Cascade Creek (FWP Fishing Guide Mapper, 2021). Disturbance from livestock grazing on the creek is limited due to its steep topography, abundant forested cover, and there being a closed allotment covering the upper half of the drainage. Further evaluation would be needed to determine the streams perennial flow and if any isolated populations or barriers exist in these undisturbed upper reaches.

Moving further upstream to the areas around the confluences of Fossil and Buford Creeks, the valley again widens, and tree cover becomes sparse. The area is more conducive to livestock settling in the riparian and stream corridors which there is evidence of. Riparian condition on the mainstem West Fork is relatively healthy compared to degraded sections downstream near Portal Creek, although there is evidence of bank trampling and trail crossings used by permit holders and livestock that are over widened and potential contributors of excess sediment to the river located within this section. The lower reaches of Fossil Creek are within the same active pasture as the West Fork, but the upper sections are within a closed pasture, while Buford Creek runs through two active pastures. The lower sections of both tributaries closest to the West Fork exhibit similar impacts from current and historic livestock grazing practices. This includes bank instability and shearing in areas where livestock cross or congregate, inhibited riparian expansion, as well as over widening of the channel at crossings. Stream and riparian conditions do improve higher in the watershed as the terrain becomes steeper and more forested. Although no recent population data exists for fish in these creeks, both are believed to host hybrid RBTxWCT due to the proximity and free passage to the West Fork

Madison where these fish are known to currently reside (Lohrenz, Comm. 2021). Further evaluation of these populations will be needed to estimate abundances and distributions.

Roughly 2 miles upstream from Buford Creek on the West Fork Madison begins a large section of fencing on both sides of the stream corridor, which includes the area at the confluences of Miner and Anderson Creeks but not the entirety of the tributaries. This riparian fencing ends roughly 1 mile below the confluence with Fox Creek. Riparian and stream conditions on the West Fork Madison throughout the fenced section are as expected. Abundant willow and sedge growth with a properly functioning stream channel hosting a healthy population of hybrid RBTxWCT (FWP Fishing Guide Mapper, 2021). However, there is evidence to suspect that the West Fork Madison either seasonally runs dry or flows sub-surface within the fenced-out section, acting as a fish passage barrier. Both Miner and Anderson Creeks are short tributaries to the West Fork Madison that originate in the surrounding foothills. Miner Creek has a sparse riparian area and small channel that carries a limited amount of water that may host a small population of fish, but further investigation would be needed to confirm this. Further upstream on the West Fork Madison, Anderson Creek is slightly larger than Miner Creek but has seen significant impacts from livestock. Although still small, the channel has been over widened in several areas due to multiple livestock crossings, banks have been trampled and are severely eroded, and the stream is lacking any significant amount of woody vegetation to protect the stream from solar radiation. Historic sampling data indicates hybrid RBTxWCT fish exist in Anderson Creek, although this population may be very small (FWP Fishing Guide Mapper, 2021). More recent data would also need to be collected on Anderson Creek to confirm this assumption.

Upstream of the fenced section on the West Fork Madison is the confluence with Fox Creek, after which the West Fork continues to its headwaters which originate near the USFS West Fork Cabin in Eureka Basin. The area around Fox Creek and the headwaters of the West Fork Madison were within the 8,000-acre Eureka Basin Fire of 2013. Island stands of burned timber adjacent to the upper West Fork Madison are still evident today although the fire never reached the riparian corridor along the stream. In 2019 an effort led by USFS Fisheries staff and funded by MADTAC was undertaken to create overwintering pool habitat by strategically placing burned trees into the channel for a population of conservation WCT in a reach of the upper West Fork immediately downstream of the USFS cabin. Several pool structures were created as well as stabilization of eroding streambanks and modifications to over widened sections of stream

Figure 29: Installation of pool habitat in Upper West Fork Madison.

channel. Funding has been secured to continue this type of work in 2021/2022 in other downstream sections of the upper West Fork where appropriate.

With no permanent mechanisms of separation for the upper West Fork Madison, Fox Creek, and other neighboring tributaries, the threat of further introgression of RBT genetics and other nonnatives into this population of conservation WCT seems to be eminent (FWP Fishing Guide Mapper, 2021). GIS, historic research, and anecdotal evidence suggest certain sections of the upper West Fork Madison near Miner and Anderson Creeks may lack surface flow or that the water runs sub-surface providing a seasonal barrier to upstream migration by nonnative fish. Although this has provided separation for WCT in the upper drainage, their status as a conservation population is already evidence that nonnative fish are able to reach these higher locations most likely during spring run-off or other high flow events when the channel is connected. Ongoing cooperation and coordination between USFS Fisheries staff, FWP, and other stakeholders will be critical to protecting and securing remaining populations of WCT within the Upper Madison River watershed.

Recommendations

Due to the large area this sub-watershed covers, recommended restoration actions will start lower in the drainage and progress upstream to the headwaters beginning with Lobo Creek and sections of the West Fork Madison up to the confluence with Portal Creek. With livestock access to the West Fork Madison limited by steep topography and sections of fencing within this pasture, the areas that have the most impact from current and historic grazing activities are lower reaches of Lobo Creek and a short section upstream of the confluence with the West Fork. As previously stated, although this area was not visited in 2020, further evaluation is needed to determine the water quantity contributions of Lobo Creek to the West Fork Madison as well as availability of suitable habitat. As for conditions of the West Fork Madison upstream of the confluence, disturbance is limited with some evidence of livestock accessing the riparian corridor. However, this disturbance to streambanks and impacts to the riparian area can be better assessed through more thorough on the ground evaluations.

Figure 30: Example of a fenced-out spring development and trough system.

Further upstream on the West Fork Madison at the confluence with Portal Creek, a roughly one-mile section of the West Fork that is highly accessible to livestock has been degraded through historic and current grazing practices. Riparian vegetation is lacking throughout and there is evidence of livestock congregating and accessing the river at various locations leading to sections of bank disturbance and stream channel widening. Although this location on the landscape may be conducive to livestock access, it does provide an opportunity to install exclusion fencing around the degraded section of river due to the lack of any surrounding forest cover that may damage fences and increase maintenance costs and time. Off-channel water developments such as stock tanks and troughs to draw livestock away from the river corridor should also be explored as several nearby springs are located close to this degraded reach. Coordination and cooperation with USFS Range staff will be necessary to implement these recommendations. As for conditions on Portal Creek, contributions of water quantity to the West Fork and availability of aquatic habitat will need to be further evaluated to better understand the need for future restoration actions as current GIS analysis indicates the stream may be intermittent.

At the confluence with Cascade Creek and further upstream on the West Fork Madison up to Fossil Creek, the surrounding steep topography limits access by livestock to the stream and riparian corridor making stream conditions functional with the riparian area intact and relatively undisturbed. Little to no sampling data exists for any fish populations that may reside in these tributary systems and GIS analysis indicates perennial flow reaching the West Fork Madison, although the quantity is unknown and further investigation and data collection is recommended.

Recommended actions at the confluence with Buford Creek, moving upstream on the West Fork Madison to Miner Creek include an evaluation of several OHV trail crossings over lower Buford Creek and another on the West Fork Madison. Although limited to two specific areas, GIS analysis shows these crossings at particularly over widened sections of stream that may need to be reinforced. Several nearby off-channel water and stock tank developments appear to have alleviated any significant congregation or degradation by current livestock use to the stream and riparian corridor within this area. 2016 genetic sampling data indicates fish in Buford Creek and near the mouth on the West Fork Madison are WCTxRBT hybrids (FWP Fishing Guide Mapper, 2021). Although the current status of the population in Buford Creek does not justify an effort to isolate this population, riparian conditions in the lower reaches of the tributary may warrant an effort to explore the use of BDAs in the single-thread channel within the narrow floodplain. The use of BDAs at this location can be used to trap excess sediment otherwise directly flowing into the West Fork Madison, create overwintering pool habitat for resident fish, recharge ground water, as well as improve riparian establishment and expansion along the stream corridor (USFWS, *Beaver Restoration Guidebook*, 2017). Consultation with USFS Hydrology staff is recommended before implementing.

Further upstream, the existing nearly 4-mile riparian exclosure would not be possible without the development of several off-channel water developments and stock tanks that have drawn livestock away from the stream and riparian corridors. Recommended restoration actions for Miner and Anderson Creek include validation of habitat availability and evaluation of current condition on Miner Creek, as well as confirmation of the amount of habitat available and water quantity that is contributed by Miner Creek to the West Fork Madison as there is some doubt to its perennial flow. For Anderson Creek, collecting updated data regarding population abundance, distribution, and genetics should be conducted to validate the existence of any fish in this creek. In addition, extension of the riparian fencing to include the lower and most degraded sections of Anderson Creek should also be considered along with in-stream channel restoration to repair over widened crossings, reestablishment of stream bank integrity, and plantings of native riparian vegetation along the stream corridor. The use of low-cost bioengineering techniques may be most practical at this location due to its remote nature. Consultation with USFS Range and Hydrology staff would be needed to implement any such improvements. Evaluation is also needed to verify if the West Fork Madison channel within this section does in fact lack seasonal surface flow providing a temporary barrier to upstream fish migration.


Figure 31: Degraded and over widened section of Anderson Creek.

Finally, with stream bank and pool habitat work continuing in the headwater reaches of the West Fork Madison by USFS Fisheries staff, restoration focus for Fox Creek and the remainder of the upper portions of the West Fork Madison should focus on preservation and isolation of this conservation population of WCT. Discussions between agencies is ongoing regarding the use of cost-saving wooden barriers, similar to those used on English George Creek, at select locations to isolate populations such as these that have limiting factors such as limited stream miles (<2.5 miles), limited population size (<2,500 fish), and limited population demographics (fish <75mm). These low-cost options can be used in place of other multi-year, drainage wide applications of barriers offering a reasonable alternative to the conservation of WCT in the Madison River drainage. Until a fish restoration plan is implemented, evaluation of potential barrier sites along with ongoing monitoring should continue to document the advance of nonnatives into this remaining population of WCT.

Custer-Gallatin National Forest

Mile Creek-Madison River (HUC# 100200070701)

Stream of significance that are located on FS land in this 6th level sub-watershed are: Sheep Creek, Mile Creek and its tributary Little Mile Creek.

Discussion

Beginning with Sheep Creek, this 6-mile drainage is directly connected to the Madison River just below the slide area downstream of Quake Lake and originates below Sheep Mountain at Sheep Lake. The farthest downstream mile of stream flows through several parcels with different private ownership, while the entire upper 5 miles is on USFS administered land. Most of the stream length on USFS land runs through narrow, steep, and forested terrain, except for the lower ½ mile that enters the valley bottom where willow and aspen dominate the streamside riparian habitat. The one road culvert crossing on USFS land is properly functioning and appropriately sized to handle upstream flows. However, several downstream crossings on private land have not been evaluated as aquatic organism passage obstructions. Upon entering the valley, an agricultural diversion sends a portion of the surface flow to a ditch network that connects to the neighboring Mile Creek network of ditches. Sampling and genetic data shows YCTxRBTxWCT hybrids mainly occupying the lower reaches. No fish were captured in the middle and uppermost reaches of stream (FWP Fishing Guide Mapper, 2021). In the headwaters, RBT were found naturally reproducing in the outlet of Sheep Lake in 2010 and are probably still present (FWP Mountain Lake Fisheries Status, 2018). There is no evidence that the narrow stream channel is impaired from any anthropogenic activities or that the floodplain on USFS land is being limited.

Figure 32: Downstream riparian habitat on Sheep Creek.

Mile Creek and Little Mile Creek both originate below the peaks of the continental divide and flow for roughly 3 miles of forested riparian cover on USFS administered land before entering the valley and private property. Mile Creek and Little Mile Creek are relatively small systems, with narrow channels and estimated baseflows of 2-3cfs. Once the stream enters the valley bottom, the entire surface flow is diverted multiple times into a network of irrigation ditches leaving the channel downstream of USFS land dry for roughly 4 miles. There is evidence that the channel was connected at one point to the Madison River just downstream of Raynolds Pass Bridge, but this has likely not happened within the last 100 years. Past sampling and genetic data indicate a very small population of YCTxRBTxWCT fish occupying the lower half of the drainage on USFS land with no sampling data available for downstream (FWP Fishing Guide Mapper, 2021).

Figure 33: Downstream riparian habitat of Mile Creek.

Recommendations

Opportunities to improve conditions on USFS land for Sheep Creek or Mile Creek are limited given the lack of livestock grazing or other anthropogenic impairments. Impacts from livestock grazing are limited on many of the streams in the CGNF due to less suitable grazing land available on USFS land when compared to the BDNF. The potential for fish entrainment from Mile Creek into the associated irrigation ditches may be worth investigating further, despite the relatively small size of the resident fish population.

<u>Earthquake Lake (HUC# 100200070404)</u>

Streams of significance that are located on FS land in this 6th level sub-watershed are: Rock Creek and Eagle Creek.

Discussion

Rock Creek is a roughly 2-mile-long stream that originates at 8,950 feet at Brownie Lake and ends at its confluence with Quake Lake at 6,400 feet. This extremely steep drainage runs between two mountain hillsides with scree slopes on either side creating a narrow riparian and stream corridor lacking suitable fish habitat. Brownie Lake is a small, high-alpine snowmelt lake that is connected to several small ponds and wetlands. Brownie Lake appears to be the only lake with sufficient depth and size to fish but has not been sampled as part of the Mountain Lake Fisheries Status Report. No fish were caught when sampling the lower reaches of the creek (Lohrenz, Comm. 2021). Rock Creek flows into a roughly 2-acre pond created by MT highway 287 that is relieved by a perched culvert into Quake Lake.

Figure 34: Rock Creek pond at MT Highway 287 culvert crossing.

Upon further investigation, Eagle Creek is an ephemeral system that does not support fish.

Recommendations

Recommended actions to improve aquatic conditions for the Earthquake Lake sub-watershed include investigation of the perched culvert on Rock Creek at MT highway 287 as an impediment to aquatic organism passage. Although its use as a potential spawning tributary by fish in Quake Lake is unknown, modification or replacement of the road culvert should be evaluated to open any available spawning and rearing habitat in the lower reaches of Rock Creek.

Although Eagle Creek and neighboring drainages are ephemeral streams, consideration should be given to them as a source of excess sediment into Quake Lake.

Lower Beaver Creek (HUC# 100200070403)

Streams of significance that are located on FS land in this 6th level sub-watershed are: Lower Beaver Creek and its tributary West Fork Beaver Creek.

Discussion

The lower Beaver Creek watershed from the mouth at Quake Lake to just upstream of the confluence of West Fork Beaver Creek flows within USFS administered land, while the entire 5 miles of West Fork Beaver Creek flows within designated Wilderness. The headwaters of the West Fork of Beaver Creek contain several fish bearing and fishless high-alpine lakes including Avalanche Lake, Blue Danube Lake, Upper, Middle, and Lower Triple Lakes, High Hope Lake, Ramona Lake, and Dome Lake. Avalanche Lake has a wild population of YCT which has not been supplemented with stocking since 1997. Ramona Lake has a population of hybrid YCTxWCT which was last stocked with WCT in 2016 (FWP Mountain Lake Fisheries Status, 2018). Dome Lake and the Triple Lakes are fishless, while High Hope Lake has WCT that were recently stocked in 2017 (FWP Mountain Lake Fisheries Status, 2018). Blue Danube Lake, last surveyed in 2010, was stocked with Golden Trout in 1989 and appears to maintain this population alongside a population of YCT that previously occupied the lake (FWP Mountain Lake Fisheries Status, 2018). YCTxGT hybrids are now likely dominant in the lake.

Figure 35: Lower Beaver Creek

Just north of highway 287 in the Lower Beaver Creek floodplain is a large section of inundated and disconnected beaver ponds adjacent to the stream channel. South of highway 287, Beaver Creek passes under a bridge and flows for roughly another ½ mile adjacent to a developed recreation site before reaching the confluence with Quake Lake. At this confluence, Beaver Creek has formed a small delta 700 ft long by 800 ft wide of deposited sediment that stretches out into Quake Lake. This feature of deposited sediment does not appear to hinder fish passage from the lake into Beaver Creek.

USFS road 985, or Beaver Creek Cabin Road, runs adjacent to Beaver Creek for over 2 miles with several sections of the road and associated dispersed camp sites within the floodplain. At certain points, the channel has migrated into exposed sections of roadbed where it is acting as streambank and the road is actively eroding and transporting sediment into the stream.

Sampling data from lower reaches of Beaver Creek indicate the presence of RBT and LL within the system, while sampling near the confluence with West Fork Beaver Creek show RBTxWCT hybrids and RBT (FWP Fishing Guide Mapper, 2021).

Recommendations

Although a large portion of this watershed is within Wilderness, several lower portions of Beaver Creek could benefit from management actions to improve current conditions. Some of these actions include reinforcing sections of streambank where the road is actively eroding into the stream to decrease excess sediment inputs as well as creating a management plan for the current dispersed camping and recreation occuring in the floodplain. Reinforcement of road/streambank sections with riprap, or a larger scale effort to modify the existing stream channel away from the road will lead to less sediment being directly input into the stream and offer longer term protection to USFS infrastructure. To better manage the dispersed camping and recreation along the stream corridor, signage and fencing at access points is recommended to limit impacts of users into the riparian corridor of the stream.

Figure 36: Eroding road segment along Lower Beaver Creek.

With the entirety of the West Fork of Beaver Creek flowing within Wilderness, the current state of the stream and associated riparian areas is in a generally natural state that has had little human impact. However, the stocking of various species of fish in the headwater lakes and current lack of a fish passage barrier has led to the entire drainage likely hosting hybrids. Past investigations into existing cascades or waterfalls acting as barriers have shown them to be unsuccessful at preventing fish passage (Lohrenz, Comm., 2020). Should consideration be given to a large-scale native species restoration project in Beaver Creek, investigation of a potential future barrier site at the highway 287 crossing would be most feasible and would protect the greatest number of stream miles. However, thought should also be given to the contributions of Beaver Creek to the populations of fish in Quake Lake and greater Madison River.

Upper Beaver Creek (HUC# 100200070402)

Streams of significance that are located on FS land in this 6th level sub-watershed are: Upper Beaver Creek and its tributaries Rose Creek, Hilgard Creek, Sentinel Creek, and Timber Creek.

Discussion

The Upper Beaver Creek 6th level sub-watershed has been identified by the CGNF as a Conservation Watershed Network within the Forest Plan which highlights key aquatic habitats that will support the long-term persistence of populations of native fish and other aquatic species in the face of climate change (Custer-Gallatin Forest Plan, Appendix C, 2020). Likely contributing to Upper Beaver Creek's designated status, the large tributaries of Sentinel and Hilgard Creeks both flow over a combined 10 miles through designated Wilderness, while the mainstem of Beaver Creek, along with Rose and Timber Creeks are within USFS managed land. There is no grazing within this sub-watershed.

The headwaters of Hilgard Creek are split into two forks that both originate in the Taylor Hilgard basin at a collection of over 15 named high-alpine lakes. Within these lakes is a collection of RBT, YCT, WCT, and hybrids, with some populations able to reproduce naturally, others supplemented with planting, and some of them fishless (FWP Mountain Lake Fisheries Status, 2018). It is assumed that these lakes are connected to the main channel and that these fish and their genetics have already migrated throughout the drainage. Other than the Mountain Lakes Fisheries Status data, little sampling exists to estimate distributions and abundances.

Just north of Hilgard Creek, the headwaters of Sentinel Creek starts at a collection of high-alpine snow melt ponds before moving down a steep drainage and joining with lower Hilgard Creek. Like Hilgard Creek, little sampling data exists for Sentinel Creek.

A tributary to Upper Beaver Creek, Timber Creek originates at the fishless Minnie Lake and flows for only 2 miles before its confluence with Beaver Creek. Although no sampling data exists, this small stream is likely fishless for the majority of the year, with fish potentially moving into the very lowest reaches at the confluence with Beaver Creek only occasionally. There is a seasonal travel route used by OHVs adjacent to Timber Creek with only one crossing in the upper reaches, but there are no known current impacts to the aquatic and riparian habitats from this activity. There is also a burn scar from the Cabin Creek Fire of 2001 in the uppermost reaches of Timber Creek which burned over 5500 acres (Shanafelt, Comm., 2021). Future recruitment of LWD is abundant in this area due to standing and down timber within the stream corridor.

One mile past the end of Beaver Creek Road (USFS Road 985) and further upstream is Rose Creek. Rose Creek originates at Rose and Meadow Lakes in the steep hillside to the west of Beaver Creek and only flows for roughly one mile before its confluence. These shallow ponds are fishless and historic sampling and genetic data shows a potential population of WCT existing but there is no documented isolating mechanism known on this stream (FWP Fishing Guide Mapper, 2021). Like Timber Creek, the upper reaches of Rose Creek are within the 2001 Cabin Creek Fire area and contain abundant future LWD.

The remaining 3 miles of Upper Beaver Creek upstream from Rose Creek originates at snow melt ponds at the divide to the Taylor Fork of the Gallatin River. The stream corridor is locked in a narrow valley between two steep hillsides and is relatively untouched with the western border against the Lee Metcalf Wilderness and the only associated human impacts being a hiking trail running up the drainage. Just downstream of the confluence with Rose Creek, a multi-year effort was led by CGNF Fisheries staff to manipulate a steep slide by moving existing rock with blasting to remove a resting pool at the bottom of the slide (Stringer, Comm., 2021). Investigation into the effectiveness of this slide to act as an effective barrier is currently ongoing (Lohrenz, Comm. 2021). The riparian cover throughout the drainage is predominantly forest cover with only a few sections of upland meadow.

Figure 37: Rockslide formation in Upper Beaver Creek.

Recommendations

Due to the highly functional conditions of the stream and riparian systems, and the Wilderness designation that covers the Sentinel and Hilgard Creek drainages, no restoration actions are recommended for these streams. Recommended actions to improve aquatic and riparian conditions within the rest of the watershed include monitoring of any excess sediment inputs from the fire scar in the upper reaches of Rose and Timber Creeks while also updating genetic status, distributions, and abundance estimates of fish in these creeks, as well as within the remainder of the Upper Beaver Creek drainage. In addition, evaluation of the blasting effort and its effectiveness as a barrier to protect the upstream conservation population is also recommended.

To better understand the contributions of the Upper and Lower Beaver Creek sub-watersheds to Madison River fish populations, further study may be warranted to recognize the importance of this system as critical spawning and rearing habitat. In addition, identifying any impediments or bottlenecks to migration into or out of the drainage will help managers in determining the importance of the watershed to Madison River fish populations.

Cabin Creek (HUC# 100200070401)

Streams of significance that are located on FS land in this 6th level sub-watershed are: Cabin Creek and its tributaries: Cub Creek, Forest Creek, and Gully Creek.

Discussion

The Cabin Creek sub-watershed has been identified by the CGNF Forest Plan as a Conservation Watershed Network that emphasizes habitat conservation and restoration to support the protection of native fish into the future (Custer-Gallatin Forest Plan, Appendix C, 2020). This critical watershed located just downstream of Hebgen Dam is home to one of the few WCT strongholds on the Madison River. With the construction of a fish passage barrier in 2015, roughly 18 miles of habitat have been secured for an existing population of 97% pure WCT (FWP Fishing Guide Mapper, 2021). Before the barrier was constructed, a waterfall feature located roughly .75 miles upstream from the mouth had begun to allow non-native RBT to ascend into the upper watershed due to erosion, jeopardizing the genetic status of the upstream WCT. Led by CGNF Fisheries staff and MTFWP biologists, the barrier was constructed .25 miles downstream from the existing waterfall and efforts to remove non-native species between the two barriers with electrofishing have been successful.

Figure 38: Cabin Creek Barrier.

The tributaries that flow from the north into Cabin Creek (Cub Creek, Gully Creek, and an unnamed tributary connected to the fishless Juncus Lake) are all within the 2001 fire area of the Cabin Creek Fire. Although more than 20 years has past, there is still some concern of the ability of these streams to transport the excess sediment loads that has resulted from the loss of forest cover. Riparian cover for stream reaches within the fire area is mostly upland grasses, but adjacent LWD is abundantly available for future recruitment into the channel.

The remainder of the Cabin Creek system outside of the fire area, which includes Forest Creek, the South Fork, Middle Fork, and mainstem of Cabin Creek, is in a fully functional state with a predominantly forested riparian cover and some sections of upland meadow near the headwaters. There is no livestock grazing within this sub-watershed. Most of the recreational activity is confined to the lowest reaches near highway 287 where a USFS campground and private lodge adjacent to the confluence offer access to the Madison River.

Recommendations

Due to the protected status of this population, functioning habitat conditions, and stable size of the population, recommended restoration actions in Cabin Creek and its tributaries are limited. Maintaining a regular schedule of monitoring population abundance, distribution, and genetics will help ensure the conservation status of these fish into the future.

Hebgen Lake (HUC# 100200070307)

Streams of significance that are located on FS land in this 6th level sub-watershed are: Kirkwood Creek, Dave Johnson Creek, Moonlight Creek, McClure Creek, Watkins Creek, Rumbaugh Creek, Cherry Creek, and Coffin Creek, Trapper Creek and its tributary West Fork Trapper Creek.

Discussion

Due to the number of streams contained within this sub-watershed, descriptions of the current conditions and significant impacts within each system will be separated in the following paragraphs. The Hebgen Lake sub-watershed and the streams within has been identified by the CGNF as a Conservation Watershed Network (Custer-Gallatin Forest Plan, Appendix C, 2020).

Kirkwood Creek and North Fork Kirkwood Creek have a small stream channel that primarily catch snowmelt from the surrounding hillsides, but do have some perennial flow, before crossing under highway 287 and depositing into Hebgen Lake. Although there is significant development in the lower 0.5 miles of stream which has degraded the riparian area, the stream is considered fishless. RBT have been observed at the mouth during spawning season but it is unlikely they are able to access anywhere upstream beyond the lowest reaches at the lake (Lohrenz, Comm., 2021).

Moving east, Dave Johnson Creek shares many of the same qualities as Kirkwood Creek, but is an ephemeral stream with no fish or habitat.

Figure 39: Stream and riparian habitat downstream of culvert on Trapper Creek.

Beginning at the northwest corner of Hebgen Lake and moving south, Trapper Creek and its tributary West Fork Trapper Creek are the first main streams encountered. The headwaters of the West Fork originate at a disconnected and fishless lake that flows through a forested steep canyon for roughly 2.5 miles before meeting up with mainstem Trapper Creek. Mainstem Trapper Creek also originates in the surrounding hillsides and flows for roughly 4 miles through predominantly forested riparian cover before its confluence with West Fork Trapper Creek, crossing USFS road 167 and then meeting Hebgen Lake just downstream. Half a mile upstream from the confluence with West Fork Trapper Creek, mainstem Trapper Creek flows through an old logging area adjacent to a now closed USFS access route. Within this area there is evidence that logging occurred within the streamside management zones and into the riparian areas, but healthy regrowth has occurred in the past 30+ years since the logging operation and there is no evidence of resulting impairments to the in-stream habitat. Past sampling efforts indicate RBT and WCTxRBT hybrids are resident to this sub-watershed, but distribution is limited to the lower 2 miles of stream where there is ample water quantity (FWP Fishing Guide Mapper, 2021). Fish passage in this drainage is aided by a newly installed bottomless arch culvert on USFS road 167.

Just south of Trapper Creek is Moonlight Creek. This short 1-mile forested system has a limited amount of fish habitat available due to a low baseflow of 1-2 cfs. Fish from Hebgen Lake may try to spawn at the mouth, but further passage upstream is highly unlikely. An undersized culvert further upstream on an old roadbed and downcutting of the stream channel affecting a ¼ mile length of stream are concerns of sediment delivery into Hebgen Lake.

Further south along the western shoreline of Hebgen Lake is McClure Creek. This short 4-mile system hosts a population of genetically pure WCT that have been a critical genetics source for other WCT restoration projects on the Upper Madison. These fish are protected by a barrier located just upstream from the USFS 167 road crossing. The 3 miles upstream of the barrier is predominantly forested stream habitat in functioning condition that supports the long-term persistence of this population. Other past work on this stream includes improvement of an over widened crossing of a gated and closed USFS access road that runs adjacent to the lower sections of stream. This stream also lies within an active livestock allotment but almost all the grazing activity occurs in the neighboring Watkins Creek drainage or downstream of the barrier site. The number of livestock that are permitted to use this allotment is also smaller than other allotments of similar size. Downstream of USFS road 167 on private land, a ditch connected to nearby Watkins Creek seasonally diverts water into lower McClure Creek, nearly doubling its flow before reaching Hebgen Lake.

Figure 40: Livestock impacted crossing on lower Watkins Creek.

In the neighboring drainage to the south, Watkins Creek and its tributaries West Fork Watkins Creek and Coffin Creek originate at over 8,500ft in the high alpine against the Continental Divide. Coffin Creek originates at the Coffin Lakes below Coffin Mountain for which survey data of the lake shows a wild population of RBTxWCT and RBTxYCT hybrids of various age classes (FWP Mountain Lake Fisheries Status, 2018). Coffin Creek flows for roughly 2 miles through a steep and narrow forested drainage between two hillsides before joining with Watkins Creek. West Fork Watkins originates on the north side of Coffin Mountain and also flows for roughly 2 miles through a steep and narrow forested drainage before joining with Watkins Creek near the confluence with Coffin Creek. The amount of water in Watkins Creek significantly increases with the contribution of these two tributaries. Before the stream reaches Denny Creek Rd., a portion of the stream is diverted into a ditch that joins with nearby lower McClure Creek. Even with water being diverted into this ditch, an ample amount of water remains in the stream to reach Hebgen Lake. During spawning season, observations have been made of RBT from Hebgen moving through the portion of stream north of Denny Creek Rd. and onto USFS land in search of suitable spawning habitat.

The entire Watkins Creek drainage is within an active grazing allotment with the most noticeable impacts concentrated in the lower reaches on USFS land. Livestock are more dispersed in the upper and middle reaches of the drainage but tend to congregate in the riparian areas to access water which has impacted willow spread along the stream. Sections of channel are over widened with associated bank trampling due to livestock is also evident in these lower reaches.

Figure 41: Two culvert system on Rumbaugh Creek.

Several miles south of Watkins Creek along Denny Creek Rd. is Rumbaugh Creek. This short, roughly 2-mile system flows through steep forested terrain, through a potentially undersized side-by-side culvert under Denny Creek Rd and out to Hebgen Lake. Historic sampling data shows resident LL and RBTxCT hybrids occupying the stream, but abundances are limited. Baseflow in the lower reaches is estimated to be roughly 3-4cfs, but the stream does have connectivity with Hebgen Lake allowing fish to migrate into the system during spawning season to access the lower 1.5 miles of suitable habitat.

Finally, the stream system farthest south in this sub-watershed is Cherry Creek. This stream originates in the hillsides above Hebgen Lake and flows for roughly 1.5 miles adjacent to a recent timber project area, into a culvert crossing under Denny Creek Rd. and through a USFS campground before the channel becomes braided into a large pond and wetland area connected to Hebgen Lake. Streamside mitigation zone setbacks and practices appear to have been followed in sections of stream adjacent to the timber/fuels project area. The downstream end of the culvert under Denny Creek Rd. appears to be slightly perched during baseflows, but the culvert is appropriately sized for its location and ability to handle higher flows. No historic or current fish sampling data exists on this stream, but field investigations and GIS analysis indicate that connectivity to Hebgen Lake may be limited due to the complexity of the pond and wetland complex in the lowest reaches.

Figure 42: Downstream culvert on Cherry Creek.

Recommendations

Following the format for the discussion section of each stream system, recommendations for stream enhancement will be broken out by individual stream.

Due to lack of habitat and existence of any fish populations in Kirkwood or Dave Johnson Creeks, no restoration actions are recommended. However, consideration should be given to coordinating with landowners in the lower reaches of Kirkwood Creek to restore riparian habitat and channel integrity to aid in allowing RBT from Hebgen Lake access to quality spawning and rearing habitat.

Recommended activities for the Trapper Creek drainage include monitoring of the stream and riparian habitat adjacent to the logging areas in the upper drainage to ensure excess sediment is not entering the channel and riparian regrowth is meeting targeted growth rates. Updated water quantity measurements and sampling efforts would also better inform managers with more current population distributions and abundances for this system as there is anecdotal evidence that low water temperatures may be influencing fish growth and recruitment.

Restoration actions for Moonlight Creek include investigating the removal and necessity of the upstream undersized culvert and also the use of BDAs to build channel integrity within the ¼ mile length of stream affected by the downcutting.

With a valuable population of WCT persisting above the barrier on McClure Creek, efforts to maintain this healthy population will be critical to other restoration projects within the Madison River watershed. Although not currently impacting stream and riparian conditions on McClure Creek, active livestock grazing in the neighboring Watkins Creek drainage has the potential to threaten the quality stream and riparian habitat of McClure Creek. With current grazing management practices sufficient to keeping livestock out of the drainage, installation and maintenance of fencing would be a proactive approach to protecting this critical population of WCT. Cooperation between USFS Range, Fisheries staff, and the associated grazing permit holder will be needed to coordinate an effort of this scale.

With most of the impacts from grazing being concentrated to the lower reaches on Watkins Creek, efforts to mitigate impacts from livestock should be focused to this area. Impacts to riparian woody vegetation, streambank stability, and channel width could be remedied with a hardened crossing and associated riparian fencing to funnel livestock to crossing the stream at a designated site. This remedy will allow for the expansion of woody vegetation and limit inputs of sediment into the stream at various locations while also allowing streambanks to heal at sites that are currently impacted by livestock activity.

While historic sampling does indicate fish occupying Rumbaugh Creek, updates to species presence, population abundance and distributions are recommended to provide managers with better direction as to the significance of this stream to fish in Hebgen Lake. One recommended action that was identified during a field visit was the improvement of the undersized two culvert system currently in place. Although the roadbed is not well built up over the existing culverts, consideration of a wider box culvert would still allow for significant flows while not inhibiting fish passage into habitat further upstream.

Finally, without current or historic sampling data for Cherry Creek and its direct connection to Hebgen Lake as a potential spawning tributary not well established, no improvements are recommended at this time. Future sampling efforts should be conducted to confirm that no species of concern inhabit this small stream system.

Duck Creek (HUC# 100200070304)

Streams and waters of significance that are located on FS land in this 6th level sub-watershed are: Red Canyon Creek and the Rainbow Point area of Hebgen Lake.

Discussion

This sub-watershed covers over 22,000 acres and although named after Duck Creek, it contains only a small portion of lower Duck Creek proper within its boundaries. The two main areas of focus for this review will be Red Canyon Creek along the north shore of Hebgen Lake and areas of Rainbow Point adjoining Hebgen Lake.

Beginning with the Red Canyon Creek drainage, this stream originates in the hillsides below Graycroft Ridge which separates Red Canyon Creek from the Cabin Creek drainage to the north. The stream runs for roughly 4 miles through USFS land before flowing through 1.5 miles of private property, crossing under highway 287 and culminating at Hebgen Lake. Almost 3 miles of this stream runs adjacent to the seasonally closed USFS road 681 which ends at a trail head that accesses Upper Tepee basin and Upper Cabin Creek basin. The stream crosses USFS road 681 at two separate culverts, but these culverts appear to be appropriately sized for the location and do not raise any concerns for aquatic organism passage. When this location was visited in July of 2020, streambanks appeared stable after seasonal high flows while gravels looked clean without noticeable accumulations of excess sediment.

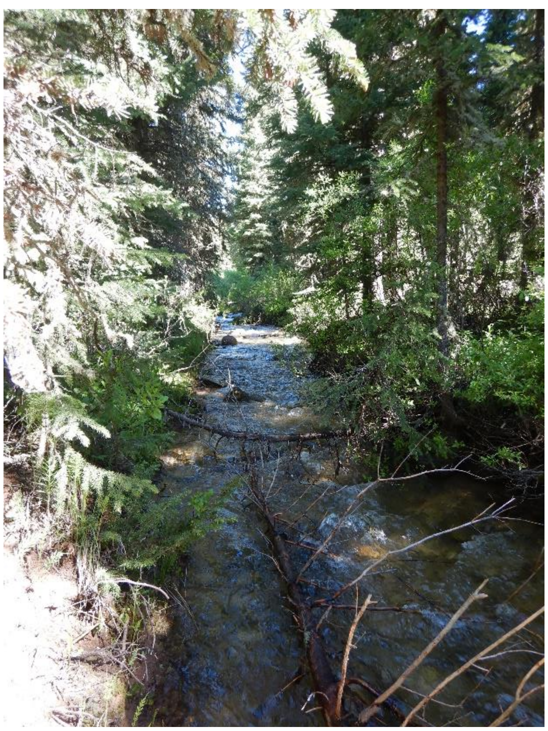


Figure 43: Upper Red Canyon Creek.

On USFS land, Red Canyon Creek runs through a riparian corridor of mostly conifer cover with an abundance of future LWD for recruitment while lower sections of stream on private land have reaches that are completely lacking any streamside woody vegetation and cover. The most noticeable reaches are within a private land pasture just north of Highway 287. Historic sampling and genetic testing show an abundant population of hybrid RBTxWCT fish throughout the system and with no identified barriers to migration, it is likely a spawning stream for Hebgen Lake fish (FWP Fishing Guide Mapper, 2021).

Moving south and east across the Grayling Arm of Hebgen Lake is the Rainbow Point area. This highly accessible and popular area of Hebgen Lake has a large USFS fee-based campground, boat ramp, and miles of OHV trail. Surprisingly, even with the high volume of concentrated recreational use along this area of Hebgen Lake impacts to shoreline habitat and from OHV trail users is limited. At the confluence of Duck Creek with Hebgen Lake, the meandering channel cuts through the wide floodplain of willow where along the north side of the stream the channel has cut into the adjacent sagebrush flats creating a section of steep exposed banks. Trails down these exposed banks used by fisherman to access lower Duck Creek are likely contributing sediment into the channel and eventually into the lake, although the overall impacts of this erosion into the stream is difficult to quantify since this section is located very close to the mouth.

Recommendations

With an adjacent USFS road along 3 miles of upper Red Canyon Creek, recommended activities for watershed improvement include using WEPP (Water Erosion Prediction Project model) to quantify the potential delivery of road surface sediment into the nearby stream as well as evaluating any BMP mitigations to prevent future sediment delivery. Also, cooperation and coordination between interested agencies and entities with downstream landowners to improve riparian condition in degraded sections of stream would help improve overall watershed health.

With most of the recreational use concentrated to the developed areas and trails of the Rainbow Point area, recommendations to improve watershed function and health are limited to one section of lower Duck Creek where bank erosion and user created trail use has caused sediment to easily be transported into the stream. Closing and obliterating the user created trail, fencing the area, and reinforcing the eroding bank using heavy equipment or bio-engineering techniques will help alleviate this point source of sediment.

One final observation of concern is the unmonitored boat ramp at the Rainbow Point campground. With the transport and proliferation of AIS (Aquatic Invasive Species) becoming more prevalent throughout the state, this unregulated boat ramp provides an easy entry point into Hebgen Lake and entire upper Madison River. Although staffing such a ramp may not be financially feasible, the placement of educational signage and warnings may at least give the public pause before contaminating an important resource like Hebgen Lake.

<u>Tepee Creek (HUC# 100200070306)</u>

Streams of significance that are located on FS land in this 6th level sub-watershed are: Tepee Creek and its tributaries: East Fork Tepee Creek and Little Tepee Creek.

Discussion

The entire Tepee Creek sub-watershed and its tributaries have been identified by the CGNF as a Conservation Watershed Network which emphasizes habitat conservation and restoration to support native fish and other aquatic species (Custer-Gallatin Forest Plan, Appendix C, 2020). This system flows south out of Tepee Basin for roughly 9 miles before exiting USFS land, crossing Highway 191 and immediately joining with Grayling Creek just inside the Yellowstone National Park boundary. This highly functional system is predominantly conifer throughout its riparian area with sporadic open meadows of willow in the upper sections.

Little Tepee Creek is the only fork that has an adjacent road with one upper crossing, but the crossing and road do not appear to be negatively impacting aquatic conditions. There also appears to several sections of historic logging in the upper reaches of Little Tepee Creek, but these areas are in upland sections out of the SMZ and have experienced substantial regrowth. In 2010, a fishless reach above FS Road 986 was discovered upstream of several high gradient cascades. In the following years eggs from Last Chance Creek and Wally McClure Creek, as well as adults from Wally McClure were introduced into this reach of Little Tepee Creek and are assumed to be proliferating today.

Sampling and genetic data shows a population of conservation WCT inhabiting the main stem of Tepee Creek above a waterfall cascade in the middle of the drainage (FWP Fishing Guide Mapper, 2021). In 2019, this waterfall cascade was the site of a USFS blasting project to improve its effectiveness as a fish passage barrier (Duncan, Comm., 2021). Although still questionable, work is ongoing to prove the integrity of this barrier before further treatments are implemented upstream. Other fish in the lower sections of Little Tepee Creek and Tepee Creek down to the confluence with Grayling Creek include RBT and RBTxWCTxYCT hybrids (FWP Fishing Guide Mapper, 2021).

Recommendations

Due to the highly functioning condition of this system, recommendations to improve riparian and aquatic conditions is limited. Continuing the work to validate the effectiveness of the waterfall cascade as a fish passage barrier should proceed before any treatments are implemented upstream.

The identification of another barrier site on Grayling Creek, downstream of the confluence with Tepee Creek, could effectively secure another 10+ miles of habitat for WCT and AG. Although subsequent treatments would need to be planned and implemented to remove nonnatives, securing another large drainage in the Upper Madison system aligns with the conservation goals of the Tepee Creek sub-watershed by the CGNF. The status of the Grayling Creek sub-watershed will be discussed further in subsequent sections.

Grayling Creek (HUC# 100200070305)

Streams of significance that are located on FS land in this 6th level sub-watershed are: Grayling Creek.

Discussion

The short 6-mile section of Grayling Creek that flows out of Yellowstone National Park to Hebgen Lake through USFS land has been identified as a Conservation Watershed Network by the CGNF emphasizing habitat restoration and conservation activities to support native fish and other aquatic species (Custer-Gallatin Forest Plan, Appendix C, 2020). While flowing through a mix of USFS and private property, this downstream section of Grayling Creek develops the

Figure 44: Downstream channel and floodplain below Highway 287 bridge of Grayling Creek.

qualities of a larger river system with a wider floodplain and more braided channel as it nears its confluence with the Grayling Arm of Hebgen Lake. Immediately upon exiting the Park, Grayling Creek flows for more than 2 miles on USFS land, under Highway 191 and into a forested canyon section of streamside willow and conifer with LWD throughout the channel. Once the stream exits USFS into a reach of private residential and adjacent livestock operation, willow and cottonwoods become more abundant while the channel becomes wider and more braided downstream. Although there is some buffer along the stream in most of this section of private property, a cluster of homes and a livestock corral with a developed ford crossing are within the riparian corridor.

The lower 2 miles of stream from the mouth to just downstream of the private property again turns to USFS administered land. This wide and braided channel has abundant willow throughout the floodplain and several point bars within the channel. At the Highway 287 bridge crossing the stream is actively eroding the road grade and makes an unnatural turn for roughly 300 feet to pass underneath the bridge. Downstream of the bridge the stream flows along the edge of the wide willow complex before joining with the Grayling Arm of Hebgen Lake. There is evidence that the channel has migrated possibly due to historic beaver activity in this wide complex in the past with the old channel creating abundant pond and wetland habitat. No barriers exist in this sub-watershed to stop the upstream migration of fish from Hebgen Lake into tributaries and streams further upstream.

Fish species that have been sampled from this section of stream include LL, RBT, RBTxWCT hybrids, Whitefish, and Sculpin (FWP Fishing Guide Mapper, 2021). Beginning in 2012, a large restoration project undertaken by the National Park Service, MTFWP, and various other public and private organizations reinforced a waterfall feature along Highway 191 upstream of the confluence of Tepee Creek and has restored WCT and AG to 59 miles of connected habitat within Yellowstone National Park. As these native fish begin occupying and moving out of the restoration area, there is hope native WCT and AG will be seen in these lower reaches of Grayling Creek once again.

Recommendations

Although this portion of the Grayling Creek sub-watershed that is on USFS land is small compared to upstream sections within Yellowstone Park and other neighboring drainages, its importance to the Hebgen lake fishery and other connected tributaries is significant. One opportunity that exists to build on the upstream restoration efforts already in place would be the identification of a suitable location and construction of a downstream barrier that would include securing the associated Tepee Creek drainage. Although potentially cost prohibitive to build a stand-alone barrier, two significant highway bridge crossings pose an opportunity to work with transportation managers at these locations to potentially modify these structures into barriers when they are due for improvement or replacement.

Along with barrier placement at bridge crossings, should the Highway 287 bridge need to be replaced in the future, the relocation or reengineering of the bridge to better accommodate the existing channel should be explored. With the channel currently actively eroding the road grade and unnaturally moving to pass under the bridge, a wider structure may allow the stream to meander and function more naturally at this location and in the wide floodplain just downstream.

Finally, several opportunities exist to improve riparian encroachment and a ford crossing on a private land. Improvements such as these appear to be a great opportunity for MTFWP managers or other non-profit partners to begin a dialogue with the landowners and how they can be a part of improving the important fishery of Grayling Creek and Upper Madison River.

Lower Madison River (HUC# 100200070202)

Waters of significance that are located on FS land in this 6th level sub-watershed are: Madison Arm of Hebgen Lake.

Discussion

The Madison Arm sub-watershed of Hebgen encompasses roughly 48,000 acres and for this review includes the north and south shoreline areas from the confluence of the South Fork Madison River in the west to Highway 191 in the east. Areas of the Madison River further east of Highway 191 are under the jurisdiction of Yellowstone National Park.

The Madison Arm area is a popular recreational destination for visitor to Yellowstone, with most of the land managed by the USFS, except for a private campground and several small pockets of clustered private homes along the southern shoreline. The area has a well-established network of roads and trails along the shoreline leading to numerous beaches and coves popular with campers. Although there are numerous trails leading to the shoreline, all the sites are in relatively good condition with no indication of concentrated use at one site versus another.

A 2007 human-caused fire burned 3,500 acres of the sub-watershed down to the riparian corridor along the south shoreline and at the confluence of the Madison River and Hebgen Lake. Although burned and dead trees on the immediate slopes of the lake and river have now fallen, there is hope these trees will provide cover and complexity to near shore and stream habitat. Sampling data shows relatively large abundances of RBT and LL have been caught at the mouth of the Madison River (FWP Fishing Guide Mapper, 2021). Several Western Pearlshell Mussels have also been found in the stretch of river between Highway 191 and confluence with Hebgen Lake (FWP Fishing Guide Mapper, 2021).

Recommendations

Due to relatively static conditions of the shoreline habitat of Madison Arm and functioning condition of the short stretch of Madison River, no actions are recommended at this time to improve sub-watershed health and function. However, with several recreational sites providing easy access to launch a boat from and the high numbers of visitors to the area, the concern over the unintended transfer of AIS into Hebgen Lake is elevated. Appropriate educational and warning signage may be appropriate at day use sites used to launch watercraft.

Lower South Fork Madison River (HUC# 100200070205)

Streams of significance that are located on FS land in this 6th level sub-watershed are: *Lower* South Fork Madison River, Buttermilk Creek, East Fork Denny Creek, and West Fork Denny Creek.

Discussion

This large 42,000-acre sub-watershed contains a large portion of private land in the lower sections of Denny Creek, Buttermilk Creek, and portions of the South Fork Madison River. The upstream sections and portions on USFS land will be the focus for review in this section.

Figure 45: Lower South Fork Madison floodplain.

Beginning with the South Fork Madison River from Highway 20 north to its confluence with Hebgen Lake, this 4-mile section of river is wide, meandering, and adjacent to numerous types of development along its western edge. The streamside vegetation throughout the floodplain is predominantly willow except for the very lowest reaches near the confluence with Hebgen Lake where sagebrush and juniper are more prevalent. The Madison Arm Road provides access to numerous recreational sites along this stretch of river, many with trails leading to the waters edge. Motorized access into the riparian corridor is restricted at many of these sites and has generally not been a problem along this stretch of river. However, one site has an old ford crossing that is still accessible to vehicles and two other sites allow vehicles to drive dangerously close to the edge of an eroding and unstable bank leading to excess sediment entering the stream. The downstream reaches of the South Fork Madison on the western bank at the confluence with Hebgen Lake to the confluence with Denny Creek is an active 150-acre livestock grazing allotment. Although impacts to riparian and bank stability immediately along the South Fork Madison are negligeable, there are noticeable impacts to stream and riparian habitat at the confluence with Denny Creek which is private land.

This stretch of river has characteristics of being a primarily a depositional zone of the higher gradient system further upstream. Being one of the larger tributary systems of Hebgen Lake, there are no known barriers to fish migration through this section that would inhibit passage upstream to preferred spawning habitats.

Buttermilk Creek originates in the hillsides south of Highway 20 and flows for roughly 2 miles adjacent to areas that have been logged by the USFS in the last 30 years before reaching private land. Downstream of USFS land, Buttermilk Creek is diverted into several ponds and irrigation ditches before crossing Highway 20 and joining the South Fork Madison River. Recent sampling on USFS land indicates a sizeable population of RBT, EBT, and Mottled Sculpin present in the system (FWP Fishing Guide Mapper, 2021). There are no indications timber harvest occurred within the streamside management zone and there is only one road crossing in the upper reaches of Buttermilk Creek, although that crossing was not evaluated for AOP effectiveness or potential sediment delivery into the stream. Downstream of Highway 20 on private land, riparian cover on Buttermilk Creek is mostly absent and there is evidence of bank instability and several over widened crossings.

In the drainage immediately west of Buttermilk Creek is East Fork Denny Creek. East Fork Denny Creek also flows out of the hillsides south of Highway 20 for roughly 2 miles before joining with Denny Creek on private land. The stream has one road crossing in the lower drainage and one road crossing in the upper drainage with the road running adjacent to the stream for most of its entirety on USFS land. The area is heavily used by OHV recreationalists to access the network of trails in the Upper South Fork Madison drainage. Although this stream system was not visited during the 2020 field season, GIS analysis shows the riparian cover for the extent of stream on USFS land to be primarily conifer. Impacts from the road and trail crossings would need to be further evaluated to verify any impacts related to stream health and integrity. No current or historic sampling data is available for this stream; however, a 2007 genetic sample indicates RBTxYCTxWCT hybrids are present within the system (FWP Fishing Guide Mapper, 2021). With the entire system being directly connected to Denny Creek and the South Fork Madison River, it is expected that nonnative species would be present. The primary concern for this system would be the sections of stream on private property downstream from USFS administered land where riparian condition, stream function, and bank stability are severely impaired.

The larger of the two forks of Denny Creek is the West Fork of Denny Creek. Multiple tributaries of this drainage originate below the peaks of the Continental Divide to the west and converge before flowing for roughly 5 miles on USFS administered land. The adjacent hillsides of West Fork Denny Creek and an unnamed tributary have seen extensive historic logging in the last 50 years, but regrowth indicates most of the cutting occurred outside of the SMZ and along the established road system above West Fork Denny Creek. However, cutting along the unnamed tributary did occur close to the stream and into the riparian corridor from a now closed logging road that runs adjacent to the stream for 1 mile. Although impacts to riparian and stream function of the unnamed tributary may have been evident immediate years following the logging operation, closure of the road along with substantial regrowth have allowed for recovery of this system into functioning habitat. Sampling of the unnamed tributary near the confluence with West Fork Denny Creek shows EBT present within the system (FWP Fishing Guide Mapper, 2021). Sampling throughout the West Fork of Denny Creek also shows EBT present, even in the upper reaches.

Figure 46: Signage along West Fork Denny Creek.

From the confluence of the unnamed tributary and West Fork Denny Creek, the lower 1-mile of stream channel on USFS land flows through a culvert crossing of W Denny Creek Road and past several popular dispersed camping sites before entering a wide corridor of willow and onto private land. Gallatin NF Recreation staff have installed signage at these dispersed sites to discourage camping and recreating within the riparian corridor. These appear to have been somewhat effective in preventing further degradation of the streamside habitat. Immediately downstream of USFS land, West Fork Denny Creek is impounded into several ponds and flows next to a private campground development before entering multiple private livestock pastures where riparian and stream condition are severely degraded.

Recommendations

Beginning with the Lower South Fork Madison, identified recreational sites with access to the riparian corridor, river crossing, and unstable and actively eroding banks is the greatest concern. Just north of Highway 20 off Madison Arm Road, closing the trail that fords the river would prevent unnecessary damage to the streambanks and associated riparian area at the crossing. At two other sites just downstream from the crossing, also just off of Madison Arm Road, vehicles are able to drive close to a steep and eroding streambank at a bend in the river creating not just a safety concern, but also increasing sediment delivery into the river. Prohibiting vehicles from driving close to the eroding edge by placing large boulders and regrading the existing parking area to divert sediment from entering the river would protect the public from potential injury and the river from further degradation.

No restoration actions are recommended for Buttermilk Creek, although a site visit of the upstream crossing that was not visited in 2020 should occur to evaluate the effectiveness of the culvert allowing for aquatic organism passage, as well as ensuring the road is not delivering excess sediment at any point sources into the stream. Similar to Buttermilk Creek, a site visit to East Fork Denny Creek should occur to ensure none of the adjacent trails and crossings are impacting stream health or integrity.

Finally, in the West Fork Denny Creek system, there are no habitat improvement projects recommended at this time. The management of the dispersed recreational sites in the lower reaches of the stream currently being implemented should continue to keep users from degrading the streambanks and riparian areas further. Monitoring of the closed logging road along the unnamed tributary and associated riparian recovery should continue to ensure riparian habitat expansion and growth is trending toward desired condition. Overall, West Fork Denny Creek should continue to be preserved in its current condition as a functioning refuge for aquatic life compared to downstream habitat conditions. Lower Denny Creek provides a great opportunity for an outside resource partner or other agency to work with a private landowner to vastly improve aquatic and riparian conditions in a stream system that could likely influence Lower South Fork Madison River and Hebgen Lake fish populations.

Middle South Fork Madison River (HUC# 100200070204)

Streams of significance that are located on FS land in this 6th level sub-watershed are: *Middle* South Fork Madison River and its tributaries West Fork Cream Creek, East Fork Cream Creek, and Mosquito Gulch.

Discussion

The entire 15,940-acre Middle South Fork Madison River sub-watershed and the streams within have been identified by the CGNF as a Conservation Watershed Network which emphasizes habitat conservation and restoration to support native fish and other aquatic species (Custer-Gallatin Forest Plan, Appendix C, 2020).

West Fork of Cream Creek is an intermittent system with no aquatic habitat or known populations of fish that exist on USFS land. The stream does accumulate water in the very lowest reaches below USFS property at a wetland/willow complex before joining with the East Fork of Cream Creek. Although a large portion of this drainage has seen historic logging activity with some cutting units within streamside buffers, due to the intermittent status of this stream, impacts to any aquatic life and habitat are of no concern.

Like the West Fork of Cream Creek, the East Fork of Cream Creek has also seen extensive logging throughout most of the drainage with past logging also occurring within the streamside corridor. However, East Fork Cream Creek is a perennial system with a conifer and willow dominant riparian corridor throughout with LWD abundant for future recruitment. Past sampling efforts show RBT, LL, and RBTxWCT hybrids are present throughout (FWP Fishing Guide Mapper, 2021). Used primarily by OHV recreationalists as an access route to the connected trail network, USFS Road 987 has one culvert crossing and does parallel the stream for most of its entirety on USFS land. There is some concern of excess sediment delivery into the stream from this road due to its proximity to the stream. Even with the amount of past logging that has occurred in this drainage, the stream does have the characteristics of a functioning system in desired condition given the amount of time the system has been given to recover. The lowest reaches of the East Fork of Cream Creek at the confluence with the West Fork of Cream Creek and the short stretch of Cream Creek proper before joining with the South Fork Madison River are all within sections of private land.

Figure 47: East Fork Cream Creek streamside habitat.

The portions of the Middle South Fork Madison River sub-watershed that are within USFS administered land runs from just downstream of the confluence with Black Sand Springs to just upstream of the confluence with Mosquito Gulch. The river flows through a wide willow dominated floodplain in its lower reaches that becomes narrower with more abundant conifer in the upper reaches. The South Fork Road runs adjacent to the river for most of its length in this sub-watershed with one bridge crossing with a section of road bisecting the floodplain in the lower reaches just upstream from the Black Sand Springs confluence. As a part of the Great American Outdoors Act to provide better recreational access to the forest, a project has been identified to improve the bridge crossing and install several culverts along the roadway that will allow the river to better access the constricted floodplain (Stringer, Comm., 2021). Another relic of transportation infrastructure that still impacts this drainage is an old railroad bed that runs through the floodplain up to Mosquito Gulch, limiting meandering and constricting the channel at old bridge crossing locations. Beavers are active in the lower sections of river with active dam building occurring at several of these old bridge crossings. A large scale veg/fuels/timber harvest project is currently being planned in this drainage for implementation in 2022 and beyond. As a part of the project, the entire South Fork Road up to Mosquito Gulch adjacent to the river will be closed to motorized traffic and reclaimed as a hiking and biking trail to hopefully eliminate the current and future sources of sediment input into the stream. Fish found in past sampling efforts of the Middle South Fork Madison River include RBT, LL, EBT and WCT hybrids (FWP Fishing Guide Mapper, 2021).

Finally, at the very upstream reaches of this sub-watershed is Mosquito Gulch. No known fish or aquatic habitat exists in this intermittent stream and extensive logging has occurred throughout this connected system. There are no known impairments or contributors to degraded down-system habitat in the South Fork Madison.

Recommendations

Beginning with the West Fork of Cream Creek, recommended actions include evaluation of past logging areas for sufficient regrowth occurring within the streamside corridors. Although the West Fork of Cream Creek is an intermittent system, it should not be a source of any cumulative effects further downstream when the channel does transport water during snowmelt or storm events.

Even with the historic logging that has occurred in the East Fork Cream Creek drainage, enough time seems to have passed where any degradation to the riparian and aquatic habitat has seemed to recover on its own (Stringer, Comm., 2021). One specific area adjacent to the stream at the intersection of USFS Road 987 & 1723 seems to have been harvested more recently than the surrounding upland areas. Although no logging activity appears to have occurred in the riparian corridor at this site, no buffer was left between the area that was cut and the streamside woody vegetation, leaving exposed soils able to transport downslope into the stream corridor. Monitoring and evaluation at this site will ensure no further mitigation is needed to prevent excess sediment from entering the channel. Furthermore, proper road maintenance and adhering to established BMPs will prevent sections of the adjacent road from transporting excess sediment into the stream as well.

Project opportunities identified within the Middle South Fork Madison River sub-watershed include improvements to water quality, maintaining habitat complexity, and restoring function and integrity to this critical drainage. With the historic railroad bed running through a majority of the floodplain of the South Fork Madison, further breaches and removal of the raised bed at critical locations along the stream channel should be explored to allow for natural channel meander and full access to the floodplain during high water. In addition, with the closing and rerouting of motorized use on the South Fork Road, reclamation and rehabilitation work such as installation of drainage features should be highly considered at previously identified sediment point sources. With the reclassification of the South Fork Road into a trail there is an increased risk of the existing roadbed falling into disrepair since it will no longer be receiving regular inspection and maintenance like an open travel route would. Lastly, with the veg/fuels/timber harvest forthcoming, pre and post monitoring of the prescriptive actions by appropriate resource specialists will help ensure recommended actions, such as stream and riparian setbacks are being followed and maintained in this critical watershed.

Upper South Fork Madison River-HUC 100200070203

Streams of significance that are located on FS land in this 6th level sub-watershed are: Upper South Fork Madison River and its tributaries Dry Canyon and Black Bear Canyon.

Discussion

The final sub-watershed reviewed will be the Upper South Fork Madison River which has been identified by the CGNF as a Conservation Watershed Network which emphasizes habitat conservation and restoration to support native fish and other aquatic species (Custer-Gallatin Forest Plan, Appendix C, 2020).

Beginning with the two named tributaries of the Upper South Fork Madison River, Dry Canyon and Black Bear Canyon are both ephemeral streams that only flow during snowmelt and precipitation events. There are wetlands and ponds in the upland headwater reaches of both drainages, but no known fish or fish habitat exists throughout either. From Mosquito Gulch upstream to the South Fork Road Crossing, several other small tributaries also drain into the South Fork Madison River, but these tributaries are also intermittent or ephemeral and do not hold fish or fish habitat.


Figure 48: Weir-like metal fish passage barrier grate installed into tunnel in 2007.

The Upper South Fork Madison River upstream of Mosquito Gulch to the crossing of USFS Road 1704 is dry for a majority of the year, except for spring runoff or other precipitation events. Given the seismic history of the area, water from the upper reaches is believed to flow sub-surface in this section before surfacing again at the substantial rail bed crossing just upstream from Mosquito Gulch. This roughly 3.5 mile stretch of stream channel still has a willow dominated floodplain with some conifer that is expectedly not as expansive due to the channel being dry for a portion of the year compared to the perennial sections downstream of this sub-watershed. Downstream of the upper South Fork Road crossing to the Mosquito Gulch confluence, the channel runs through the same type of wide canyon as further downstream sections, but for a mile upstream of the South Fork Road crossing the dry channel meanders through a wide meadow of expansive willow buffered by forest. Upstream of the USFS Road 1704 crossing to the headwater seeps below the Continental Divide, the floodplain narrows but is still primarily dominated by willow except for the uppermost forested reaches.

With the channel dry for 3.5 miles below the USFS Road 1704 crossing, a 95% pure population of WCT has managed to persist in the uppermost reaches above this crossing where there is sufficient perennial flow (FWP Fishing Guide Mapper, 2021). So far, two projects have been undertaken by USFS Fisheries Staff and FWP to protect this population from invasion by downstream nonnatives and further genetic introgression. In 2007, a weir-like metal grate was installed at the inlet to the tunnel running under the railroad crossing just upstream from Mosquito Gulch to prevent fish passage during high flows. During the following years runoff, the grate became clogged with debris creating a large upstream pool that began to jeopardize the integrity of the century old railroad grade. In 2008, explosives, an excavator, a cement mixer, and hand work were used to improve a waterfall feature just downstream from where the sub-surface flow surfaces again, just downstream from the railroad grade crossing. Although an improvement from the weir-like metal grate system, there is still doubt as to the effectiveness of this improved structure during higher flows and due to the presence of redds discovered in the reach above the barrier (Sestrich, Comm., 2021).

Figure 49: Improved barrier structure on the Upper South Fork Madison

This entire sub-watershed, along with the Middle South Fork Madison and portions of the Lower South Fork Madison sub-watershed, are included in the project area of the South Plateau Area Landscape Treatment Project. This proposed project would focus on forest health, hazardous fuels reduction, and road network concerns providing some benefits to stream and aquatic ecosystem. The timeline for implementation of this project is uncertain and USFS Fisheries and Aquatics staff will be crucial in ensuring proper protocols and adherence to SMZ rules and laws are followed to realize the full benefits to stream and aquatic ecosystems.

Recommendations

With a 95% pure population of WCT inhabiting the upper 2-3 miles of habitat in the upper South Fork Madison River, enhancement recommendations are geared towards the long term persistence and proliferation of this population and habitat since other associated tributaries in this sub-watershed do not support aquatic life.

Although effort has been made to improve the existing waterfall feature into a functioning fish passage barrier, doubt still exists as to its effectiveness. Further study should be conducted as to the ability of downstream fish to ascend the improved structure. Regular annual monitoring of the site will also ensure bedload and sediment do not raise the downstream water level of the pool making it easier for fish to leap over the structure. Maintenance at the site may include removal of debris, bedload, and sediment using heavy equipment.

To fully ensure protection of this population of conservation WCT the construction of a more substantial and proven fish passage structure may be warranted. Exploration of other potential barrier sites may need to be explored given the location of the current feature being directly downstream of the old railroad grade which is at risk of failing. Should the railroad grade become structurally unsound, it has the potential to compromise the current barrier structure allowing downstream fish to move into the habitat currently occupied by WCT. Given many of the tributaries are intermittent and do not hold fish or fish habitat in the upper and middle portions of this sub-watershed , if a more suitable downstream barrier location was identified along with a subsequent nonnative removal treatment, the amount of habitat available for WCT that are currently occupying the upper 2-3 miles of the drainage could be increased dramatically.

There is some concern that given the geology of the area and that stream flows already go sub-surface in these upper reaches that any efforts to augment flows will not be realized. Test structures may be warranted to evaluate their effectiveness before fully implementing.

Finally, continued population and genetic monitoring of the resident WCT population will help ensure abundances, distributions, and genetic integrity are maintained while future improvements to habitat and stream function are implemented.

Summary Narrative

Contained within this summary of restoration opportunities of the Upper Madison River watershed is a variety of recommendations to improve aquatic and riparian conditions for the benefit of all aquatic species. While select sub-watersheds on USFS administered land were reviewed in this report, several themes have emerged that will be critical in guiding the implementation of these projects moving forward.

First, cooperation between management agencies and partners, between key players at these agencies and advocacy groups, and between resource specialists will make the process of implementing these projects smoother, directed, and more impactful.

Partnerships between agencies, advocacy groups, and private landowners will be critical in connecting many of these restoration and stream improvement opportunities to include downstream landowners will help in bridging the gap between small-scale restoration and drainage wide improvements. Having these partnerships in place and building off these relationships will help in not just improving conditions on tributary streams, but to the mainstem Madison River as well.

Next, stewardship will be a critical component to realizing the full impact that many of these smaller-scale improvements can have on the landscape. Without maintenance or regular oversight, a restoration tool such as fencing will only be impactful if it is properly functioning.

Lastly, the goal of many of these smaller scale restoration and improvement projects is to not just improve conditions at specific sites, but to realize the larger cumulative impacts that can be achieved in the Upper Madison River watershed and ecosystem as a whole. Continued efforts to support and fund improvements in the tributary systems of the Upper Madison watershed will help multiple management agencies and advocacy groups achieve our collective goals and objectives for conservation. It is with hope that this document will help disseminate useful information about these areas and will be used as guide for conservation and restoration efforts into the future.

Appendix A

Summary Table of Streams, Identified Impairments, and Recommendations

6th Level HUC w/ Stream Names	Identified Impairments	Recommendations
Upper North Meadow Creek-HUC 100200071101 • North Meadow Creek • Washington Creek • Sawlog Creek	• Livestock grazing • Road sedimentation-siltation • Recreation/motorized impacts	• Livestock use monitoring, fencing • Use of BMPs and drainage improvements on roads • Recreation management plan
South Meadow Creek-HUC 100200071102 • South Meadow Creek • Leonard Creek • Daisy Creek	• Recreation/motorized impacts • Road sedimentation-siltation	• Streambank repair/reestablish riparian vegetation/riparian fencing • Culvert Installation/replacement, use of drainage BMPs
Ennis Lake-HUC 100200071208 • Saint Joe Creek	• Unknown	• Obtain access to survey stream
Jourdain Creek-HUC 100200071207 • Jourdain Creek • Crooked Creek • Watkins Creek	• Unknown	• Obtain access to survey stream • BDAs for water storage
Madison River-Papoose Creek-HUC 100200070703 • Papoose Creek	• Unprotected conservation population of WCT • Questionable effectiveness of diversion structure to act as barrier • Fish entrainment	• Barrier construction/WCT Restoration • Reinforcement of diversion structure • Screen diversion structure
Wigwam Creek-HUC 100200071201 • Wigwam Creek • Arasta Creek • Buffalo Creek	• Unprotected conservation population of WCT • Livestock grazing • Bank instability, over-widened channel, lack of pool habitat	• Barrier construction • Fencing • Bank stabilization, channel restoration, willow planting
Cherry Creek-HUC 100200070806 • Cherry Gulch	• None (Intermittent)	• None
Ruby Creek-HUC 100200070803 • Ruby Creek • Dry Fork • Grindstone Gulch • Skunk Creek • South Fork Ruby Creek • Beartrap Canyon	• Sedimentation-siltation from fire scar • Bank erosion along motorized trail	• Ongoing monitoring for excess sediment delivery • Bank stabilization, revegetation, and channel repair to mitigate trail repair.
Madison River-Wall Creek-HUC 100200070802 • Hyde Creek • English George Creek • Bobcat Creek • Wall Creek	• Livestock grazing	• Livestock use monitoring, fencing
Horse Creek-HUC 100200070705 • Horse Creek • Camp Creek • Deer Creek • Alpine Creek • Tepee Creek	• Unprotected conservation population of WCT	• Barrier Construction
Standard Creek-HUC 100200070704 • Standard Creek • Wolverine Creek	• Livestock grazing • Road sediment-siltation	• Livestock use monitoring, fencing • Road BMPs
Lower West Fork Madison River-HUC 100200070604 • West Fork Madison River • Gazelle Creek • Soap Creek • Freezeout Creek	• 303 (d) Temperature impairment • Livestock grazing • Recreational/motorized impacts • Bank erosion, lack of riparian vegetation • Road delivery of sediment-siltation	• Livestock use monitoring, fencing • Streambank stabilization and riparian revegetation • Recreation management plan • Mitigate sediment point-source delivery from roads

Lake Creek-HUC 100200070502 • Lake Creek	• None	• Maintain functioning fish ladder
Elk River-HUC 100200070603 • Elk River • Moss Creek • Dirty Creek • Little Elk Creek • Indian Springs Creek • Hellroaring Creek • Nelson Creek • Barnett Creek • Rossiter Creek	• Livestock grazing • Identified WCT restoration project • Bridge and road crossing	• Water developments, livestock use monitoring • Barrier construction • Repair/replacement of existing structures
Middle West Fork Madison River-HUC 100200070602 • West Fork Madison River • Meridian Creek • Tepee Creek	• 303 (d) Temperature impairment • Livestock grazing/trailing • Limited population demographics	• Active livestock management, livestock use monitoring • Updated population abundance and distribution
Upper West Fork Madison River-HUC 100200070601 • West Fork Madison River • Lobo Creek • Portal Creek • Cascade Creek • Fossil Creek • Buford Creek • Miner Creek • Anderson Creek • Fox Creek	• 303 (d) Temperature impairment • Livestock grazing • Sedimentation-siltation • Bank trampling, over-widened channel, lack of riparian vegetation (Anderson Creek) • Unprotected conservation population of WCT	• Livestock use monitoring, active livestock management, off-channel water developments, fencing • Use of BDAs • Bank stabilization, channel restoration • Barrier site identification and construction
Mile Creek-Madison River-HUC 100200070701 • Sheep Creek • Mile Creek • Little Mile Creek	• Downstream dewatering • Fish entrainment	• Water rights • Ditch screens
Earthquake Lake-HUC 100200070404 • Rock Creek • Eagle Creek	• Connectivity to Quake Lake, perched culvert • Sediment transport	• Culvert replacement, aquatic organism passage
Lower Beaver Creek-HUC 100200070403 • Beaver Creek • West Fork Beaver Creek	• Point-source sediment from roads • Recreation impacts	• Bank armoring or stream channel modification • Signage, fencing
Upper Beaver Creek-HUC 100200070402 • Beaver Creek • Rose Creek • Hilgard Creek • Sentinel Creek • Timber Creek	• Barrier effectiveness • Future WCT conservation project area	• Monitoring and genetic sampling • Identify potential barrier locations
Cabin Creek-HUC 100200070401 • Cabin Creek • Cub Creek • Forest Creek • Gully Creek	• None	• None
Hebgen Lake-HUC 100200070307 • Kirkwood Creek • Dave Johnson Creek • Moonlight Creek • McClure Creek • Watkins Creek • Rumbaugh Creek • Cherry Creek • Coffin Creek • Trapper Creek • West Fork Trapper Creek	• Livestock grazing • Undersized culverts • Unsurveyed stream systems	• Fencing • Evaluate culvert function and replacement • Survey unsampled streams
Duck Creek-HUC 100200070304 • Red Canyon Creek • Rainbow Point	• Sediment delivery into stream from adjacent road • User created trail causing bank erosion	• Implement road BMPs to mitigate sediment delivery into stream • Close and obliterate user trail

	• Unmonitored boat ramp into Hebgen Lake	• Educational signage about AIS at boat ramp
Tepee Creek-HUC 100200070306 • Tepee Creek • East Fork Tepee Creek • Little Tepee Creek	• Unproven waterfall barrier • Barrier site identification	• Evaluate effectiveness of improved waterfall cascade as an effective AOP barrier • Identify suitable barrier site on Grayling Creek that would secure additional miles of protected habitat
Grayling Creek-HUC 100200070305 • Grayling Creek	• Barrier site identification • Unnatural channel migration at Highway 287 bridge	• Identify suitable barrier site downstream of confluence with Tepee Creek • Explore opportunity to replace existing bridge to better accommodate channel meander
Lower Madison River-HUC 100200070202 • Madison Arm	• Unmonitored boat ramp into Hebgen Lake	• Educational signage about AIS at boat ramp and lake accessible recreational sites
Lower South Fork Madison River-HUC 100200070205 • South Fork Madison River • Buttermilk Creek • East Fork Denny Creek • West Fork Denny Creek	• Ford crossing and eroding/unstable banks at recreation sites • Dispersed camping within riparian corridor • Downstream habitat and stream condition severely degraded	• Close ford crossing and recreation sites where banks are eroding • Fencing or recreation monitoring to ensure dispersed camping is outside the riparian area • Advocate for stream improvement on downstream private land
Middle South Fork Madison River-HUC 100200070204 • South Fork Madison River • West Fork Cream Creek • East Fork Cream Creek • Mosquito Gulch	• Excess sediment delivery into stream from adjacent road • Old railroad bed within floodplain	• Stream monitoring for excess sediment delivery into stream from roads and crossings • Adhering to road BMPs • Further breaches or removal of old railroad bed to allow for more natural channel meander • Reclamation and rehabilitation of South Fork Road sediment point sources before closing to motorized use
Upper South Fork Madison River-HUC 100200070203 • South Fork Madison River • Dry Canyon • Black Bear Canyon	• Unevaluated barrier structure • Lack of available habitat for conservation population of WCT	• Evaluate barrier structure during high flows and monitor effectiveness as an AOP • Explore the use of BDAs to increase perennial flows and expand available habitat

References

Montana Department of Environmental Quality (MTDEQ). 2020. *Madison Watershed Stream Summaries*. Helena, MT.

Montana Fish Wildlife and Parks (MTFWP). Weiss and Moser. 2019. *Madison/Gallatin Drainages Mountain Lakes Fisheries Information.* Bozeman, MT

USDA Forest Service. 2021. *Ruby-Madison Watersheds Riparian Vegetation Monitoring Report.* Salix, Manning, and Weinner. Beaverhead-Deerlodge National Forest. Dillon, MT.

Montana Fish Wildlife and Parks (MTFWP). Lohrenz, Larson, and Duncan. 2019. *Madison River Drainage 2188 Project Monitoring Report to NorthWestern Energy Environmental Division.* Ennis, MT.

United States Fish and Wildlife Service. Pollock, Lewallen, Woodruff, Jordan, and Castro (Editors). 2017. *The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains.* Version 2.0. Portland, Oregon.

USDA Forest Service. 2020. *Appendices for the 2020 Land Management Plan*. Custer-Gallatin National Forest. Bozeman, MT.

USDA Forest Service. 2009. *Land and Resource Management Plan-Forest Plan.* Beaverhead-Deerlodge National Forest. Dillon, MT.

USDA Forest Service, National Stream & Aquatic Ecology Center. Yochum. 2018. *Guidance for Stream Restoration.* Technical Note TN-102.4. Fort Collins, CO.

Montana Fish Wildlife and Parks (MTFWP). *FWP Fishing Guide Mapper.* 2021. https://fwp.mt.gov/gis/maps/fishingGuide/

ATTACHMENT D

Trout Unlimited Assessment of Riparian Enhancement, Stream Restoration, and Fisheries Improvement Opportunities for Madison River Tributaries 2023

Assessment of Riparian Enhancement, Stream Restoration, and Fisheries Improvement Opportunities for Madison River Tributaries

Prepared by:
Ashley Brubaker and Patrick Byorth
Trout Unlimited
Bozeman, MT

Submitted to:
Madison River Technical Advisory Committee
Northwestern Energy
August 15, 2023

Contents

Figures

Introduction

Northwestern Energy (NWE) operates two impoundments on the Madison River under a license for Project #2188 issued by the Federal Energy Regulatory Commission (FERC). One requirement of the license is to offset impacts to river resources, fish and wildlife populations, and habitats from continued operations governed by conditions outlined in a License Article for Protection, Mitigation and Enhancement projects (PM&E). The Madison Technical Advisory Committees (MadTAC) assists NWE in selecting projects that meet PM&E priorities for fish and wildlife restoration. Priority 2 projects include habitat restoration in tributaries and adjacent lands that would benefit the Madison River. NWE, MadTAC, and Trout Unlimited, Inc. agreed to provide an assessment of riparian enhancement, stream restoration and fisheries improvement for tributaries of the Madison River to help guide and support watershed planning and restoration activities with a focus on streams with sediment, nutrient, pathogen and temperature impairments.

The focus of this report is assessing tributaries of the Madison River between the Missouri headwaters at Three Forks to the boundary of Yellowstone National Park (Figure 1). Streams were evaluated on public and private land, but individual private landowners were not necessarily contacted about the identified projects. Streams were prioritized for restoration based on their physical condition and function at the proposed restoration site, and the ability of the restoration to improve downstream and/or overall watershed health, fish habitats, and water quality. Evaluations included site visits where possible, aerial imagery review, partner meetings, and document reviews including the USFS Upper Madison River Tributary Streams Restoration Opportunities Report and Montana Department of Environmental Quality (MTDEQ) Total Maximum Daily Load (TMDL) requirements.

Assessments are presented below, identifying a set of potential projects within each sub-watershed. For the purpose of this report potential projects are identified and classified but should be considered conceptual and will require more extensive analysis and development prior to implementation.

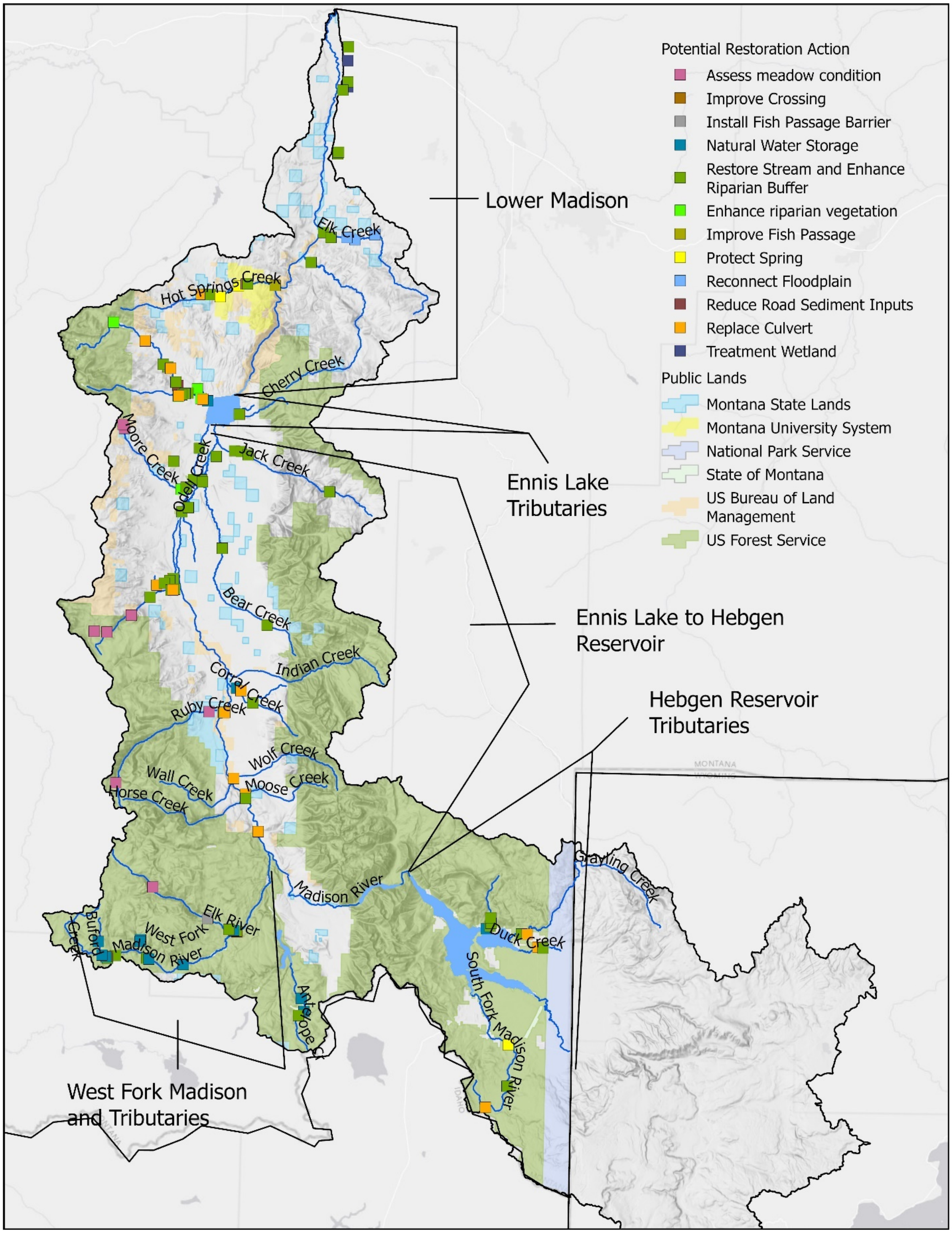


Figure 1: Map of the Madison Watershed with overview of key tributaries and recommended restoration actions.

Impairments

The Madison River watershed streams have a long history of agricultural use, and these streams show varying degrees of degradation from harmful grazing practices and irrigation. Increasingly, streams on public land also show degradation from recreational uses such as dispersed camping and eroding stream crossings. Between 2013 and 2015 MTDEQ monitored the Madison and its tributaries for sediment, temperature, and related pollution impairments and developed TMDL limits for each impaired stream. Across the watershed, MTDEQ established sediment TMDLs on 13 streams, temperature TMDLs on three streams, and TMDL's for one or more different pollutants (nutrients, metals, and pathogens) on five streams (MTDEQ, 2019; MTDEQ, 2020a). MTDEQ identified additional impairment categories including sediment, temperature, flow modifications, alterations to streamside vegetation, turbidity, physical substrate habitat alterations, and other alterations (MTDEQ, 2020b).

Impairments due to grazing are prevalent in the Madison basin. In some cases, the impairment is mild, and improving grazing practices such as adding riparian fencing and providing an off-channel water source may be enough to allow the stream to recover on its own. In other cases, the stream is degraded beyond the point of self-recovery and will require further restoration actions in addition to improved grazing practices. Decades of use by livestock often causes streams to become incised, cutting a deep channel that confines floodwaters and disconnects the stream from the floodplain. This results in a sub-optimal riparian zone, loss of channel complexity, and increased erosion.

Road and trail crossings are common causes of stream impairment in the Madison basin, and frequent sediment sources. Stormwater runoff from roads and trails can contribute sediment to the stream, and unimproved or informal crossings often degrade the stream bank, causing bank erosion and over-widening of the channel. Culverts also commonly cause stream degradation and loss of floodplain function in a variety of ways. An improperly sized culvert can cause increased downstream erosion and can inhibit aquatic organism passage. Some culverts that have created a barrier to fish passage have the unintended effect of protecting an unhybridized population of native Westslope Cutthroat Trout above the barrier. It is important to evaluate fish populations above a culvert before conducting a culvert improvement project.

Heavy recreational use can cause stream impairments in several ways. Much like over-grazing, pressure from recreation such as camping, fishing, hiking, and ATV use along stream banks can denude the riparian vegetation and lead to bank instability and excessive erosion. Impairments from recreational use are typically limited to streams on public land and river access sites.

Another source of impairment to tributaries of the Madison River is stream dewatering due to irrigation diversions, leaving reaches of stream below diversions dry or severely depleted during summer months. Dewatering disrupts the entire ecological web during the heat of the summer, from primary production and macroinvertebrates to increased fish mortality, driving water temperatures to high levels unsuitable for coldwater fish, and stressing or killing riparian vegetation. Not all stream dewatering is anthropogenic; post-glacial geology throughout the Madison basin also plays a role in stream dewatering. Deep alluvial gravels, moraines, and even bedrock faults can naturally interrupt surface flows entering the valleys, disconnecting streams from the mainstem river during dry years. The frequency, duration, and intensity of the natural dewatering is exacerbated by irrigation abstractions.

Currently, streamflow restoration projects have reconnected six historically dewatered tributaries to the Madison system, and potential exists to expand this effort.

Recommendations

The Madison River changes character between the Yellowstone National Park boundary and its confluence with the Jefferson and Gallatin Rivers at the Missouri Headwaters. Each reach of the river or reservoir system possesses unique characteristics and impairments that warrant different applications to correct limiting factors. Recommended project concepts below are summarized for given tributaries by reach. Each narrative generally describes potential projects and refers to a map of identified project locations.

Lower Madison

The lower Madison, from the confluence to the mouth of Bear Trap Canyon, experiences very warm summer water temperatures and has few tributaries that support spawning or have potential to provide coldwater refuge for mainstem fishes. Only three tributaries are significant to fish for spawning and cold-water refuge - Elk Creek, Cherry Creek, and Hot Springs Creek. Rey Creek, a spring creek, arises and flows parallel to the Madison River, entering the Gallatin River less than a mile above its confluence with the Madison and Jefferson.

Rey Creek

Rey Creek is a spring creek that originates in the Madison valley before flowing north to its confluence with the Gallatin River. It supports wild populations of rainbow and brown trout however their numbers are limited due to degraded habitat from historic and current land use practices. Recent data indicate that Rey Creek likely provides seasonal thermal refuge, spawning habitat, and recruitment to the lower Madison fishery. Heavy grazing from livestock has resulted in the loss of woody riparian vegetation and over-widened the stream channel. Additionally, Warm Springs Ditch conveys irrigation water from the Madison and wastewater returns to Rey Creek with a high load of fine sediment and temperatures elevated nearly 10 degrees. A project has been identified and is in development on State Trust land to restore over a mile of historically overgrazed and over-widened stream channel and capture irrigation wastewater laden with sediments in wetlands to cool, filter, and improve water quality (Figure 2: 3, 4). Aerial photograph analysis and site visits indicate additional potential restoration sites exist upstream and downstream of the state lands project (Figure 2: 1, 2, 5).

Elk Creek

Impairments: Sediment, Temperature, Turbidity, Alterations to Streamside Vegetation
TMDL: Sediment, Temperature, Nutrients, Metals
Elk Creek is listed as impaired for temperature, and is heavily impacted from grazing, crops, and irrigation. This creek is a candidate for floodplain reconnection, natural water storage projects using post assisted log jams (PALs) or beaver dam analogs (BDAs) (Figure 3: 3, 4, 5), and for revegetation projects on the lower reaches (Figure 3: 1, 2). The most highly degraded reach extends just above the mouth as it travels through a private ranch. The degraded state is likely causing decreased spawning use of this stream and small improvements to the stream condition in this lower reach could make the entire stream more available to use by fish. Restoration in the lower reach of Elk Creek should be high

priority, improved spawning habitat and decreased water temperatures would have a positive impact on the fish population in the lower Madison. Two potential project sites were identified in the lower reach, and three additional locations were identified upstream.

Cherry Creek

Impairments: Sediment, Temperature
TMDL: Sediment, Temperature

Cherry Creek is listed as impaired for temperature and sediment largely due to historic impacts from livestock causing eroding banks and pool filling. Riparian vegetation and floodplain connectivity could be improved along much of the lower reach of the stream (Figure 4: 1). This stream is currently the primary spawning tributary available to trout in the lower Madison River below Beartrap Canyon and may also serve as cold water refugium from summer high temperatures. The primary landowner in the subbasin has a strong aquatic conservation program and has taken steps to conserve and restore Cherry Creek. Westslope Cutthroat Trout restoration in Cherry Creek between a waterfall barrier and the headwaters has recreated a small spawning population in the Madison River. Habitat and flow improvements in the reach below Cherry Creek Falls (approximately 5 air miles) would likely build resiliency into the lower Madison system.

Hot Springs Creek

Impairments: Sediment, Flow Modification
TMDL: Sediment, Nutrients, Metals

Hot Springs Creek is an important spawning tributary for lower Madison fish, but an active beaver population is impairing passage of fall spawning fish within 100 yards of the mouth. The creek is listed as impaired for sediment, and while the beaver complex in lower reaches is effective at sediment control, it may be restricting spawning access to the creek. Relocating or managing passage through the beaver dams near the mouth to further upstream could be an effective sediment control measure that also opens more of the channel to spawning fish (Figure 5: 1). Building BDAs upstream in relocation reaches could help beavers establish. Appropriate locations for these structures need to be identified in collaboration with Montana State University ranch managers and other landowners. Temporarily notching the beaver dams in the lower channel during fall spawning could allow passage for spawners and open more of the creek for spawning without removing the beaver dams. Additional sediment control measures such as riparian plantings and restructuring grazing practices would also decrease sediment in the creek (Map x: 2, 6). Potential to improve culverts (Figure 5: 3, 7) and protect springs (Figure 5: 4, 5) should be explored.

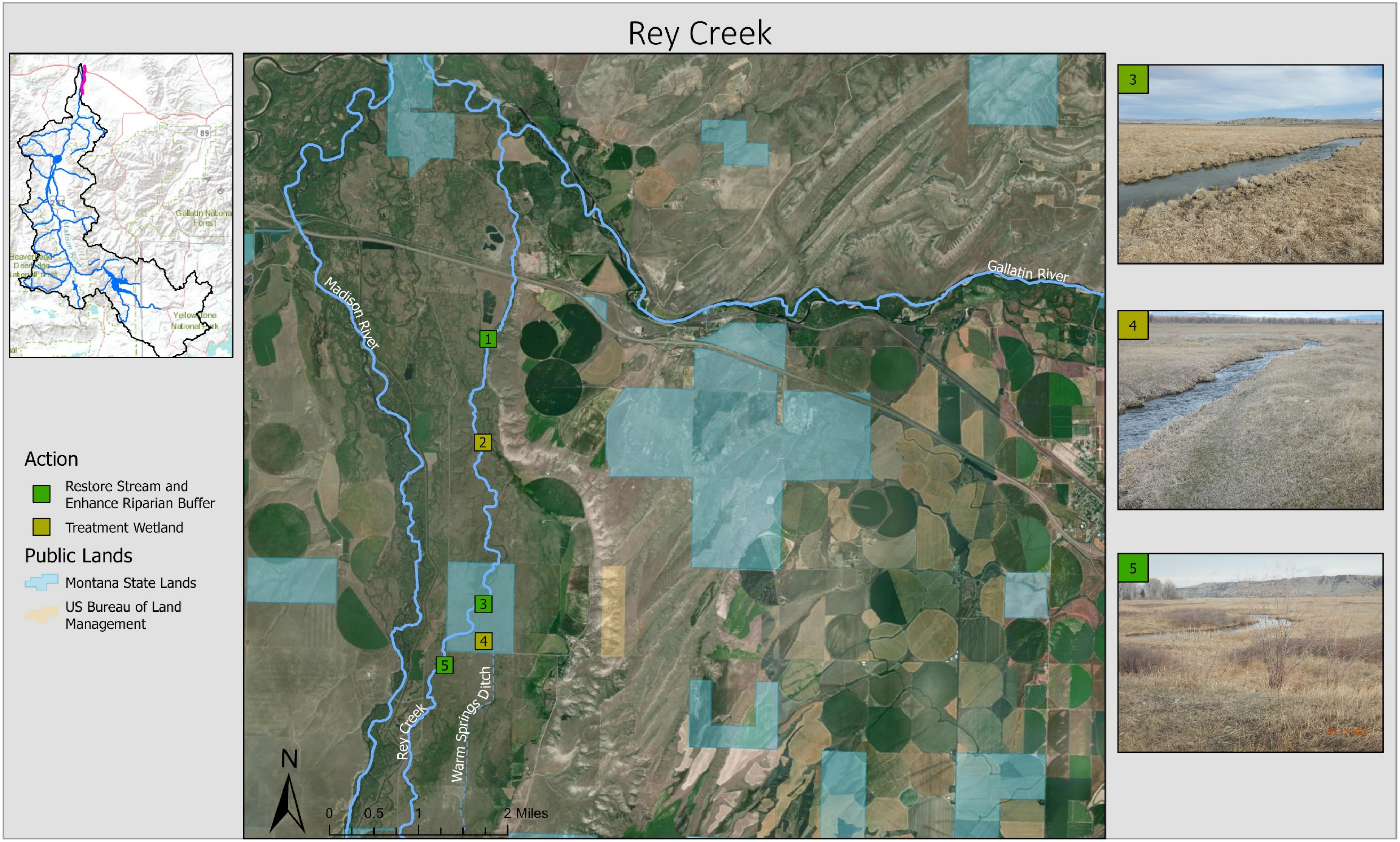


Figure 2: Map of Rey Creek

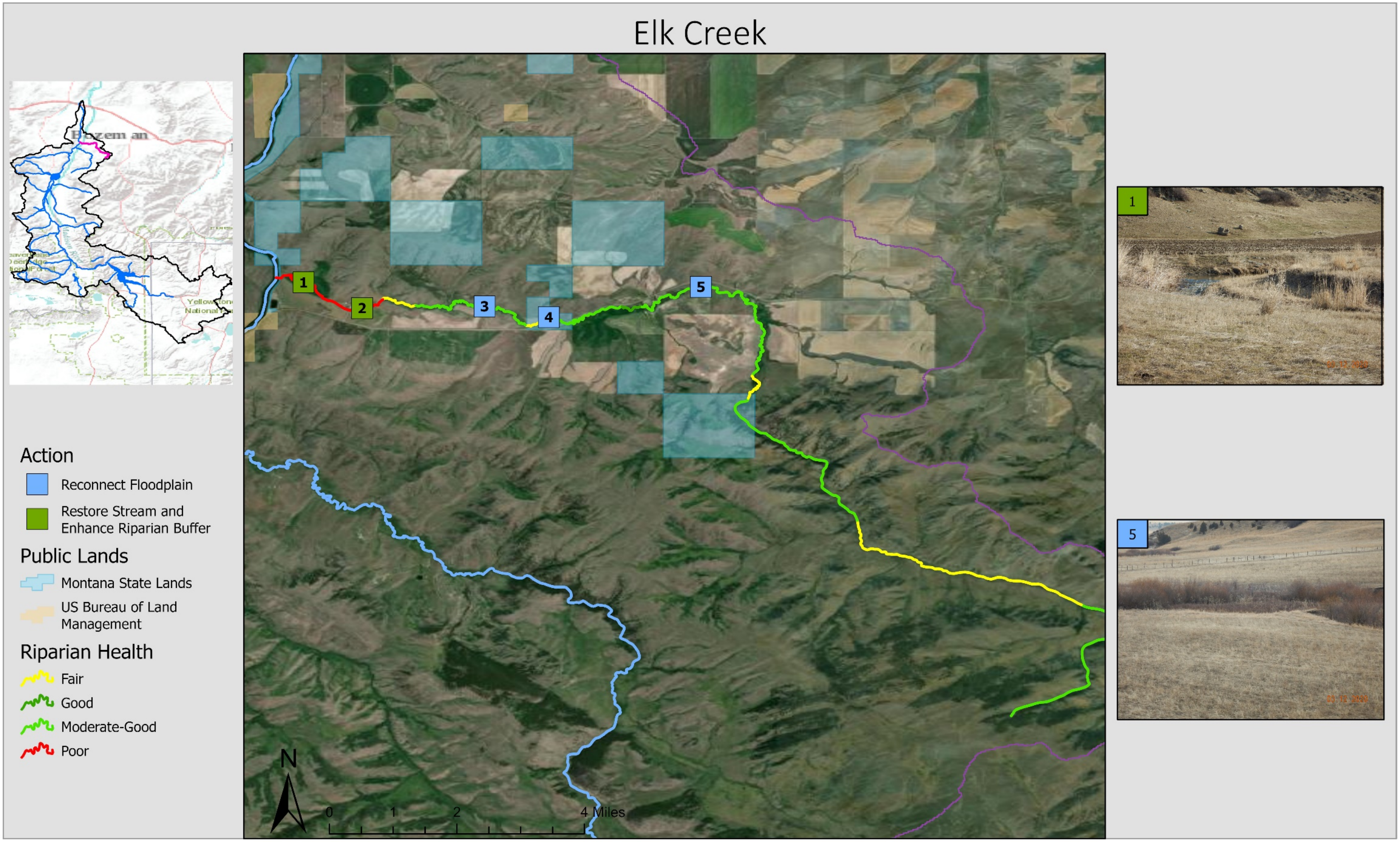


Figure 3:Map of Elk Creek

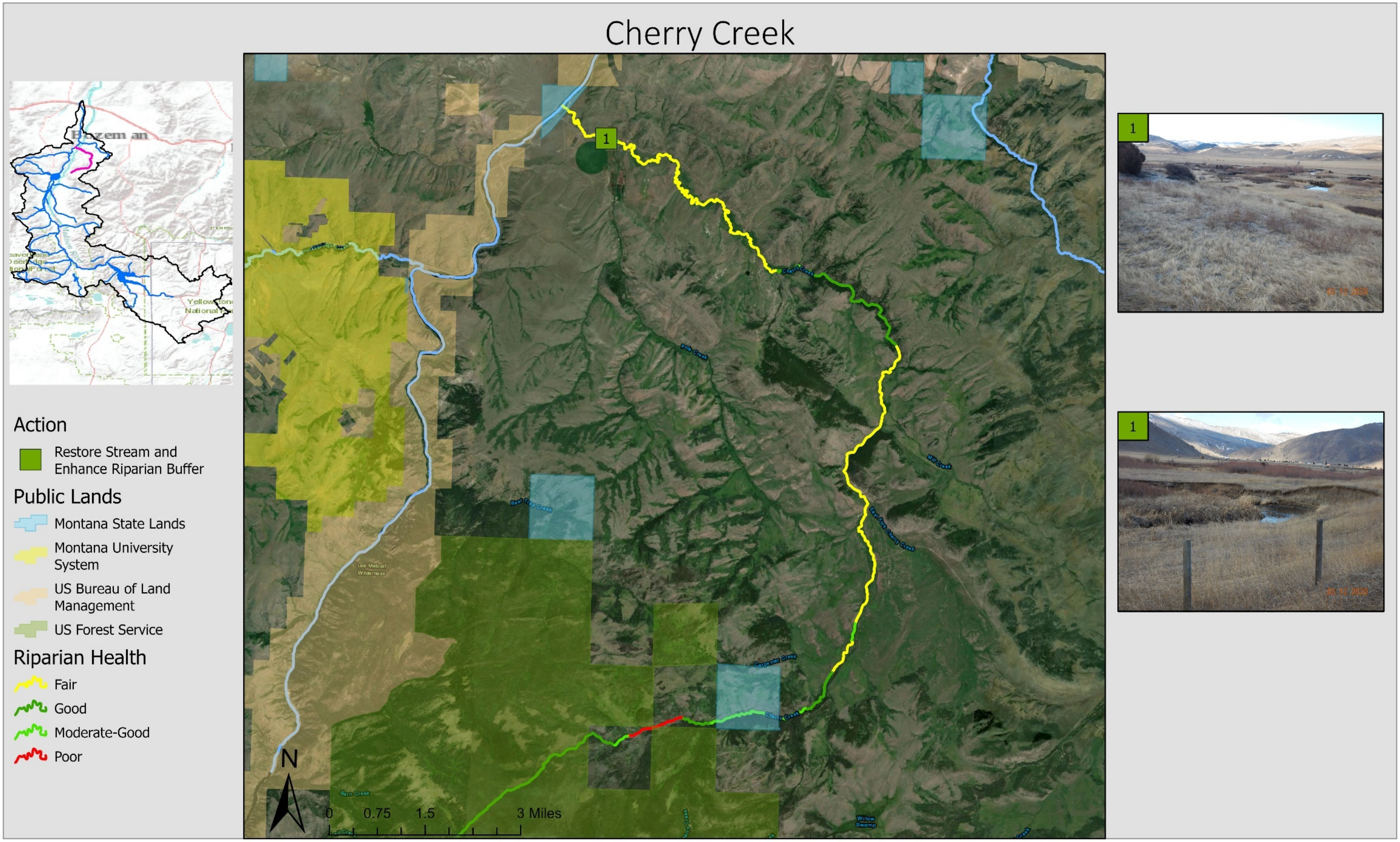


Figure 4: Map of Cherry Creek

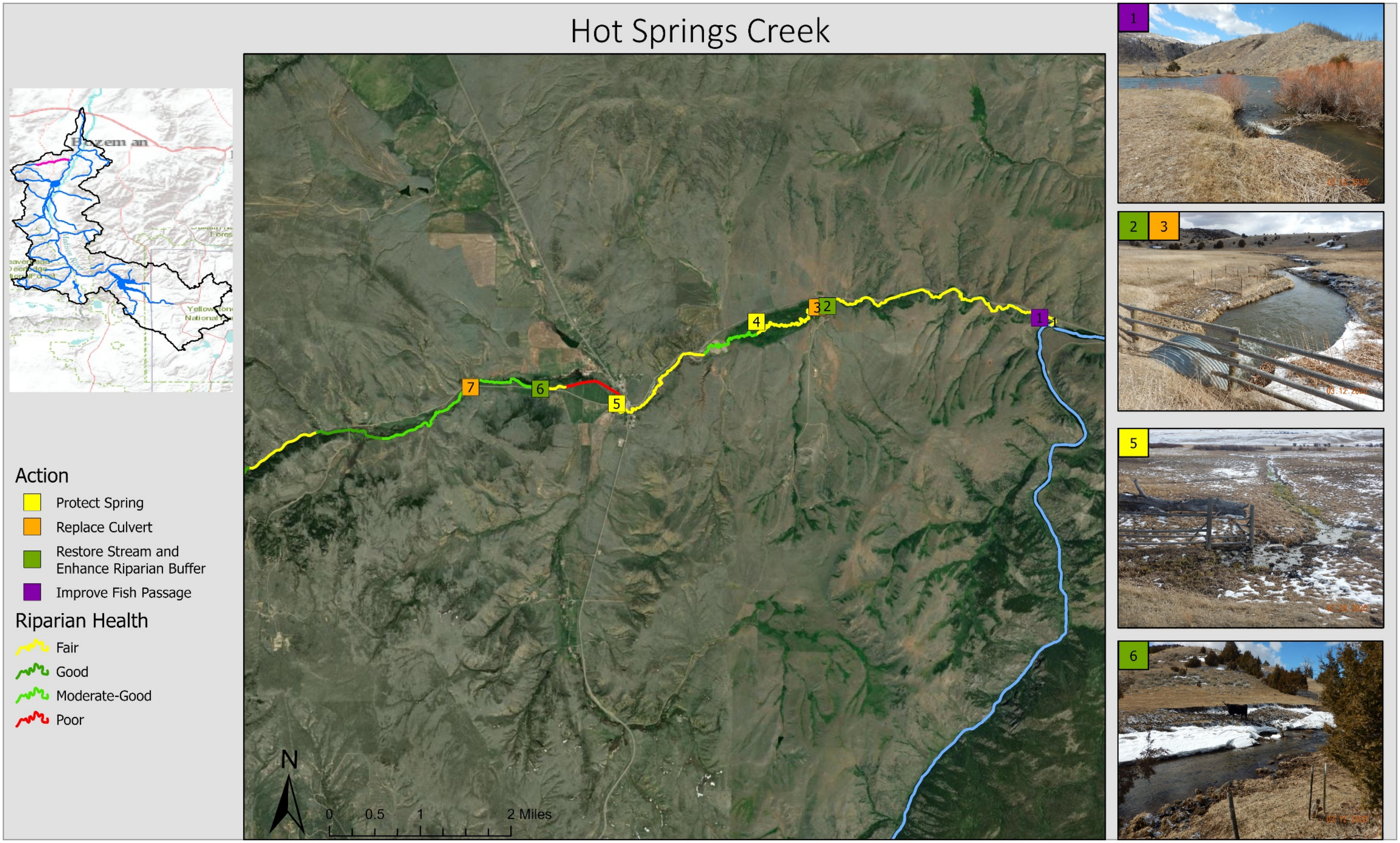


Figure 5: Map of Hot Springs Creek

Ennis Lake Tributaries

North Meadow Creek

Impairments: Sediment, Flow Modifications
TMDL: Sediment

North Meadow Creek runs through private land from its mouth at Ennis Lake upstream for 11 miles. Above this point the stream runs through mostly USFS land, with a small portion on BLM and private inholdings. Grazing is common along the entirety of the creek, and the portion on National Forest sees high recreational use including motorized travel on an extensive road and trail network (USDA Forest Service, 2021). MTDEQ has identified North Meadow Creek as sediment impaired, due primarily to eroding banks and to sediment inputs from roads and trails. Most of the sediment input happens downstream of the national forest boundary, where heavy grazing has denuded riparian vegetation and caused the stream to incise. The lower 10 miles of North Meadow Creek is classified by FWP as chronically dewatered (FWP 2005). The projects identified on the map are intended to capture sediment and to reduce bank erosion and spread water out onto the floodplain, decreasing its erosive power. Increased vegetation and floodplain connection would also aid in decreasing water temperature and improving fish habitat (Figure 6: 1, 2, 3, 5, 6, 8). Cattle exclusion fencing with off-channel water sources and improved recreational practices are essential components of the identified projects. Two culverts have been identified as insufficient and replacing them would improve natural stream function and aquatic organism passage (Figure 6: 4, 7).

South Meadow Creek

Impairments: Sediment
TMDL: Sediment, Nutrients, Metals

South Meadow Creek runs through private land from its mouth at Ennis Lake upstream for 7 miles to the forest service boundary. Upstream of the USFS boundary the stream receives moderate recreational pressure (USDA Forest Service, 2021) and FWP has classified the lower 3.5 miles as chronically dewatered (FWP 2005). South Meadow Creek receives heavy grazing pressure downstream from the forest boundary, and MTDEQ has listed it as impaired for sediment. Bank erosion and road crossings are the primary causes of excess sediment, and identified projects are aimed at capturing sediment, decreasing bank erosion, restoring floodplain connectivity (Figure 7: 2, 3, 4, 5, 6, 8), and improving stream function at road crossings (Figure 7: 1, 7). Much of the channel including and beyond the identified project locations could benefit from cattle exclusion fencing and off-channel water sources or water gaps. Some restoration work has been undertaken downstream of North Meadow Creek Rd., but opportunities exist for additional work.

Moores Creek

Impairments: Sediment, Temperature, Alterations to Streamside Vegetation
TMDL: Sediment, Temperature, Pathogens (E. coli), Nutrients

Moores Creek runs almost entirely through private land, with only the headwaters on national forest and state property. Below the town of Ennis, the riparian area consists primarily of grasses with low channel complexity. The Madison Conservation District (MCD) is actively working with private landowners to restore up to eight miles of lower Moores Creek. Design work is in progress and implementation will begin in 2024 (Figure 8: 1). Upstream of the town of Ennis several stream reaches are also lacking healthy riparian vegetation and appear disconnected from the floodplain. MCD has completed a restoration project in this reach. The headwaters run through federal and state lands, and a meadow health assessment is recommended on these areas (Figure 8: 5, 6). Restoration efforts in the lower 5 miles of Moores Creek are likely to improve streamflows on this chronically dewatered reach (FWP 2005).

Jourdain and St. Joe Creeks

Jourdain and St. Joe Creeks are small streams feeding into Ennis Lake from the east. These streams both lack public access and assessments were conducted from their Ennis Lake Road crossing and through aerial images. Both streams appear to have a mostly intact riparian area with active beavers and some impacts from cattle grazing. Grazing impacts appear heaviest on St. Joe Creek downstream of Ennis Lake Rd. These streams are potentially important sources of cold-water input to Ennis Lake. The possibility to decrease their water temperature and subsequent downstream benefits could be investigated further. Reaches of these streams may have potential for natural water storage projects (Figure 9).

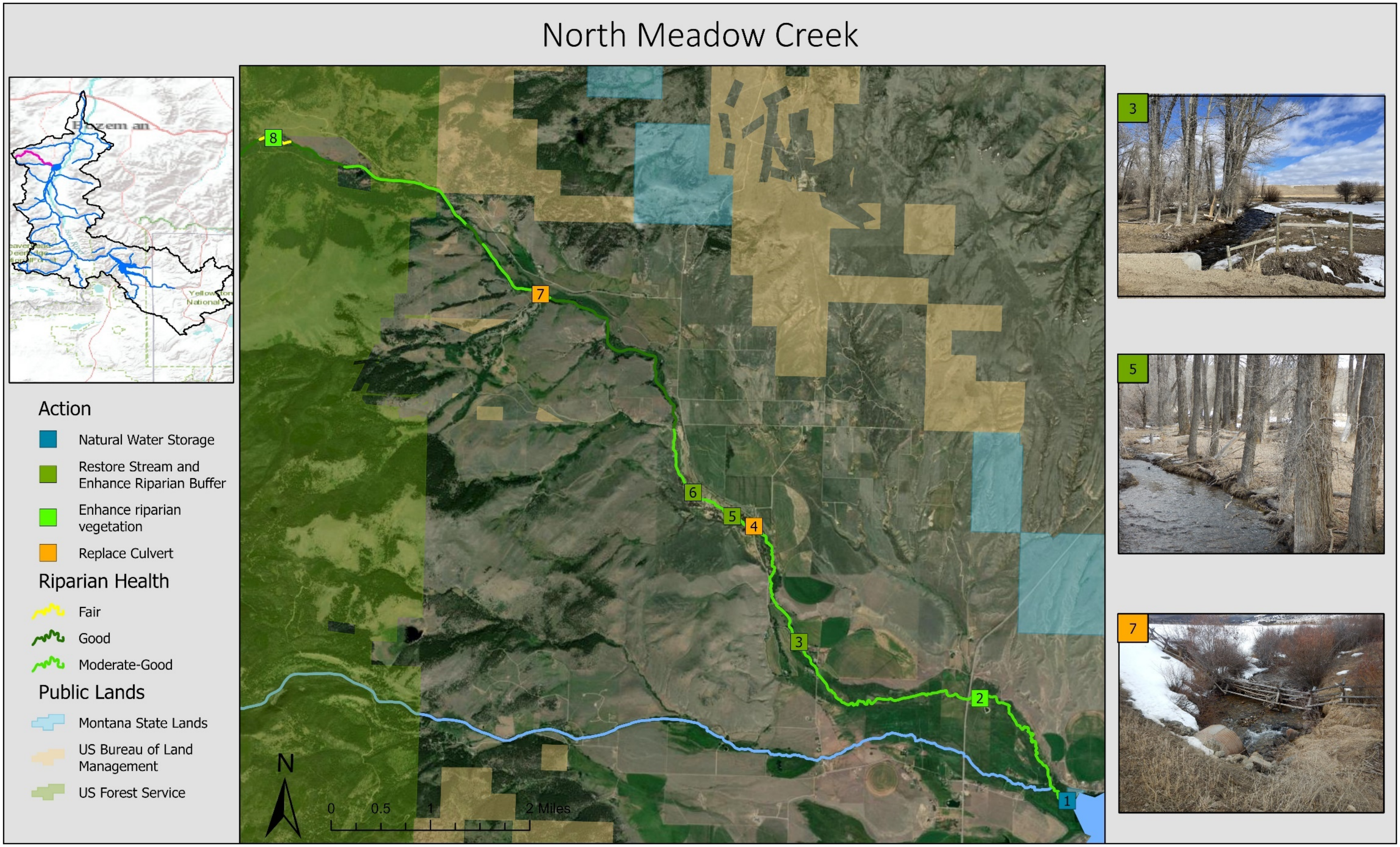


Figure 6: Map of North Meadow Creek

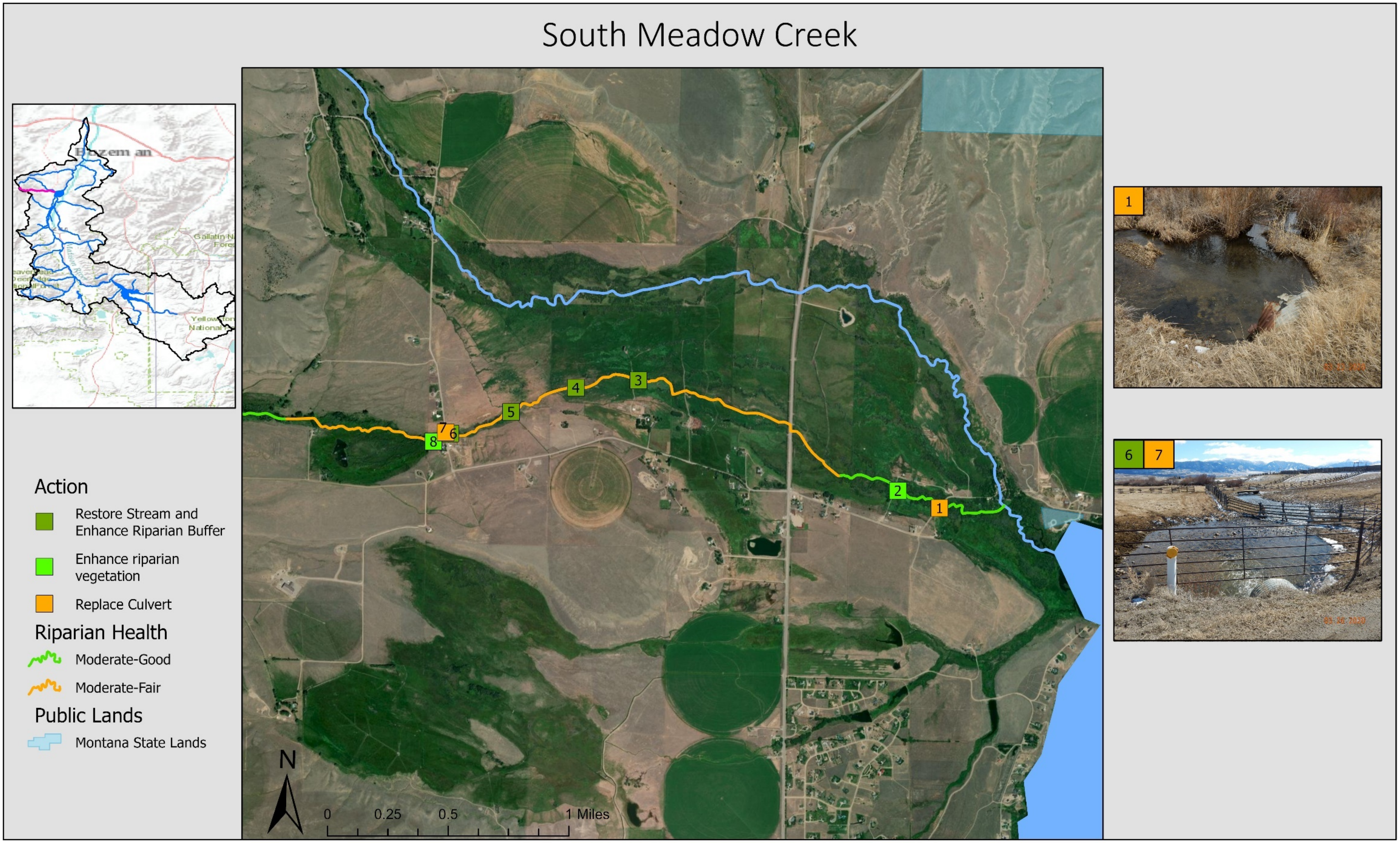


Figure 7: Map of South Meadow Creek

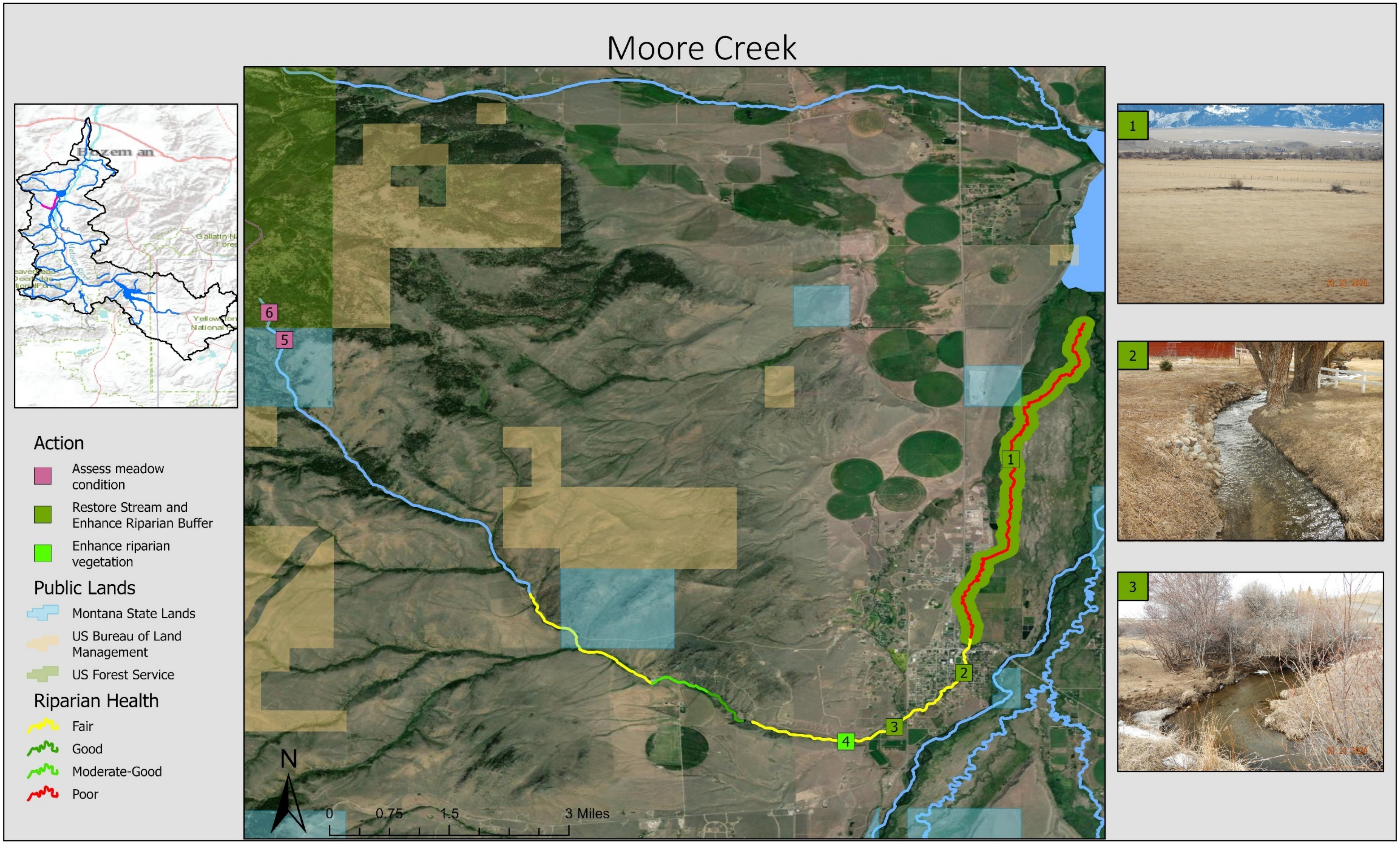


Figure 8: Map of Moore Creek

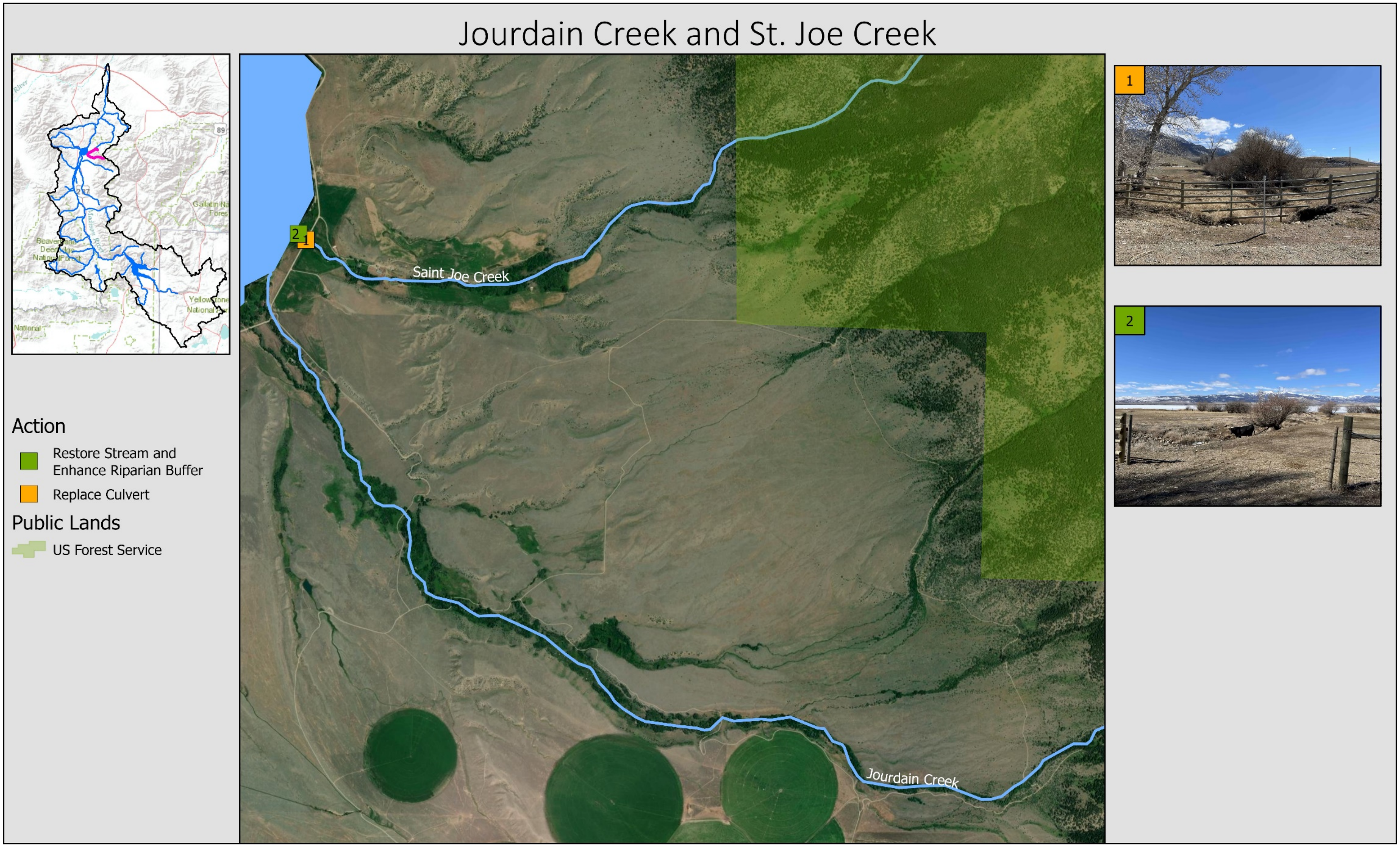


Figure 9: Map of Jourdain and St. Joe Creeks

Ennis Lake to Quake Lake

Jack Creek

Impairments: Alterations to streamside Vegetation, Flow Modification

Jack Creek is a tributary of the Madison River in the channels reach above Ennis Lake draining approximately 38,500 acres. From its headwaters in the Moonlight Basin development, Jack Creek runs almost entirely through private lands. A large portion of the creek runs directly adjacent to Jack Creek Road, leading to channel confinement and sediment inputs. Madison County often receives complaints that the road is being graded into Jack Creek and efforts to improve road maintenance practices should continue. More in-depth study is needed to ascertain the potential to reconstruct either the stream channel or the road through the channelized section (Figure 10: 5). Grazing degradation and eroding banks are common along lower reaches of Jack Creek within the Madison valley. A recent collaborative project with MCD and Trout Unlimited successfully stabilized and revegetated eroding banks along Jack Creek. This model could be extended upstream or downstream. Riparian vegetation enhancement, floodplain reconnection, and increased channel complexity would improve overall stream function (Figure 10: 1, 2, 3, 4), as would re-meandering the channel through straightened reaches and improving crossings to decrease sediment input. In certain areas, improved grazing management would improve stream health and is essential for restoration project success. The Madison River Foundation (MRF) has partnered with the Jack Creek Foundation to complete a restoration project on 0.5 miles of stream. This project will use low-tech restoration methods to improve floodplain connectivity and enhance fish habitat. Implementation is scheduled for 2023, and possibility exists to expand this project in the future. Jack Creek has been classified by Montana Fish, Wildlife, and Parks as chronically dewatered in the 4.6 miles above its confluence with the Madison River (FWP 2005). However, recent efforts by landowners have significantly improved late summer streamflows.

Blaine Spring Creek

Impairments: Sediment, Flow Modification

TMDL: Sediment

Blaine Spring Creek flows entirely through private lands, with the exception of the Ennis National Fish Hatchery at the spring origin. Historic and current grazing practices led to eroding banks and degraded riparian vegetation, and the creek is classified by FWP as periodically dewatered in the lower 2.3 miles of stream (FWP 2005). Landowners have undertaken restoration work on some reaches of the stream. Improved grazing practices and riparian vegetation restoration projects (Figure 11: 1, 3, 4), as well as replacing undersized culverts at several road crossings (Figure 11: 2, 5) would restore natural processes and increase the health of this stream.

Wigwam Creek

Impairments: Sediment

TMDL: Sediment

Wigwam Creek flows through private land from the mouth upstream 4.5 miles, above which is a small stretch of BLM, then National Forest land. MTDEQ has found Wigwam Creek to be impaired for sediment, primarily in the lower third of the creek, and FWP classifies the lower 2.0 miles as chronically dewatered. Projects aimed at restoring riparian vegetation and floodplain connectivity, while reducing bank erosivity are key projects in this stream (Figure 12: 1, 3, 4). Additionally, improving crossings to decrease sediment input and grazing improvements will increase overall stream health (Figure 12: 2). Opportunities for high meadow assessment exist in the upper reaches (Figure 12: 5, 6, 7).

O'Dell Spring Creek

Impairments: Alterations to Streamside Vegetation, Physical Substrate Habitat Alterations, Other Alterations

TMDL: Nutrients

O'Dell Spring Creek has been the focus of an ongoing 19 phase restoration project to de-channelize the creek and restore wetland hydrology to the surrounding areas. This project has been touted as the "largest wetland restoration project in Montana," and has had positive impacts on many species, including wild trout. Northwestern Energy and WildTAC have been primary funding partners for much of this work (Figure 13). O'Dell Spring Creek downstream of the highway 287 crossing still exhibits over-widened areas associated with grazing and lack of woody vegetation. Expanding the restoration downstream would continue to dramatically improve the stream's ecosystem function (Figure 13: 1, 2, 3).

Bear Creek

Impairments: Sediment

TMDL: Sediment

Bear Creek drains over 50,000 acres of the Madison Range, flowing west, then North to its confluence with O'Dell Creek at Highway 287 near Ennis. Bear Creek changes character as it leaves the forested headwaters before it is heavily appropriated for irrigation and is impacted from grazing, stream crossings, and lacks a defined stream channel as it decreases in gradient. Historically Bear Creek was dewatered through the middle reaches and is classified as chronically dewatered across a 6-mile reach (FWP 2005), but recent efforts by landowners have maintained surface flows, reinvigorating historically drought stressed riparian vegetation. Bear Creek re-emerges as a perennial stream about 5 airmiles upstream of its confluence, where groundwater sustains its flow. Reaches of lower Bear Creek have undergone restoration efforts. While discrete projects in key locations could be identified and implemented, subbasin-wide coordinated project planning would be necessary to undertake significant restoration efforts (Figure 14).

Indian Creek

Impairments: Alterations to Streamside Vegetation, Flow Modification

Indian Creek is a large tributary to the Madison River draining approximately 30,000 acres of the Madison Range and is the only major eastside tributary in a 25-mile reach between Ennis and Wolf Creek seasonally connected to the Madison River. Indian Creek is heavily impacted by irrigation withdraws to three ditch systems, the largest of which irrigates up to 3,500 acres as far as 9 miles north, causing lower reaches to typically be dewatered by late June. FWP classifies the lower 5.8 miles of Indian Creek as chronically dewatered (FWP 2005). The primary restoration focus on Indian Creek is restoring year-round streamflow to maintain connectivity with the mainstem Madison throughout the year. Riparian vegetation along Indian Creek has suffered constant drought stress but is likely to respond with improved flows. Trout Unlimited, in partnership with Northwestern Energy and landowners, has conducted a hydrologic study on Indian Creek to inform strategies for maintaining year-round flow. Preliminary findings indicate the potential for irrigation infrastructure improvements and stockwater developments that may conserve enough water to sustain Indian Creek during baseflow periods and to improve sediment transport (Figure 14: 1).

Corral Creek

Corral Creek is a small, spring-fed tributary of the Madison River just north of Indian Creek. Throughout its length grazing and irrigation are the limiting factors. While improvements could be made, its small size, lack of fisheries, and intermittent connection with the Madison renders this stream a low priority (Figure 15).

Ruby Creek

Impairments: Sediment, Flow Modification
TMDL: Sediment
Ruby Creek originates on the Beaverhead-Deer Lodge National Forest and runs through the Wall Creek Wildlife Management Area (WMA) administered by FWP. The lower portion of the creek runs through BLM land and a public campground at the confluence with the Madison. The lower 0.4 miles of Ruby Creek is classified as periodically dewatered (FWP 2005). Ruby Creek was the site of a Westslope Cutthroat restoration program above the falls about a half mile upstream of the confluence (USDA Forest Service, 2021). Some potential exists for floodplain reconnection in the upper basin and riparian restoration and culvert replacement may be warranted in the lower reach (Figure 16: 1, 2, 3). Excess sediment in the stream is due to historic and current grazing practices, and an OHV trail running along the creek through the WMA. Further assessment of this stream above the falls is warranted to target areas for sediment reduction and additional restoration work.

Wolf, Moose and Sun Creeks

These three eastside tributaries drain a large area of the Madison Range from headwaters in the Lee Metcalf Wilderness Area and cross the Sun Ranch, a large privately-owned cattle ranch. Historically, the streams were seasonally disconnected from the Madison River by irrigation withdrawals. Since 2001, Trout Unlimited has leased Sun Ranch water rights in these tributaries to maintain year-round instream flows, the 10-year leases were renewed through 2024. Cattle grazing is still active along Wolf and Sun Creeks. Some intensive horse grazing impacts are localized near the mouth of Sun Creek and at a few key locations in Wolf Creek. Although consistent flows keep these tributaries connected with the Madison River, culverts under Highway 287 may present passage barriers to fish migrating to spawn or find thermal refuge in the cold tributary waters. Our primary recommendation on these streams is assessing the culverts as passage barriers (Figure 17: 1, 2, 4).

Horse Creek

Horse Creek originates in the Gravelly Mountains and flows about 2 miles on private land to its confluence with the Madison River. Historically, the stream was dewatered for irrigation, but the homeowner's association that owned the water rights converted a portion to instream flow. The remainder of the water rights may be available for instream lease from the homeowners' association, but they have taken measures to maintain good, year-round streamflow to the Madison. A culvert approximately 0.25 miles upstream of the confluence is passable, although may need maintenance or replacement in the future to maintain fish passage (Figure 17: 3).

<u>Antelope Creek</u>

Impairment: Sediment, Flow Modification, Alterations to Streamside Vegetation
TMDL: Sediment

Antelope Creek is a tributary to Cliff Lake and has no direct connection to the Madison River. The creek is listed as impaired for sediment, flow modifications, and alterations to streamside vegetation, largely due to grazing impairments. Bank stability and riparian vegetation are improving in the lower part of the creek after livestock access was restricted by a riparian fencing project and hardened stream crossing (Montana DEQ, 2020b). Projects aimed at reducing livestock access in the upper stream reaches could yield similar results. Additional projects targeting natural water storage would benefit aquatic life below the Antelope Basin Road crossing, where the stream seasonally runs dry (Figure 18).

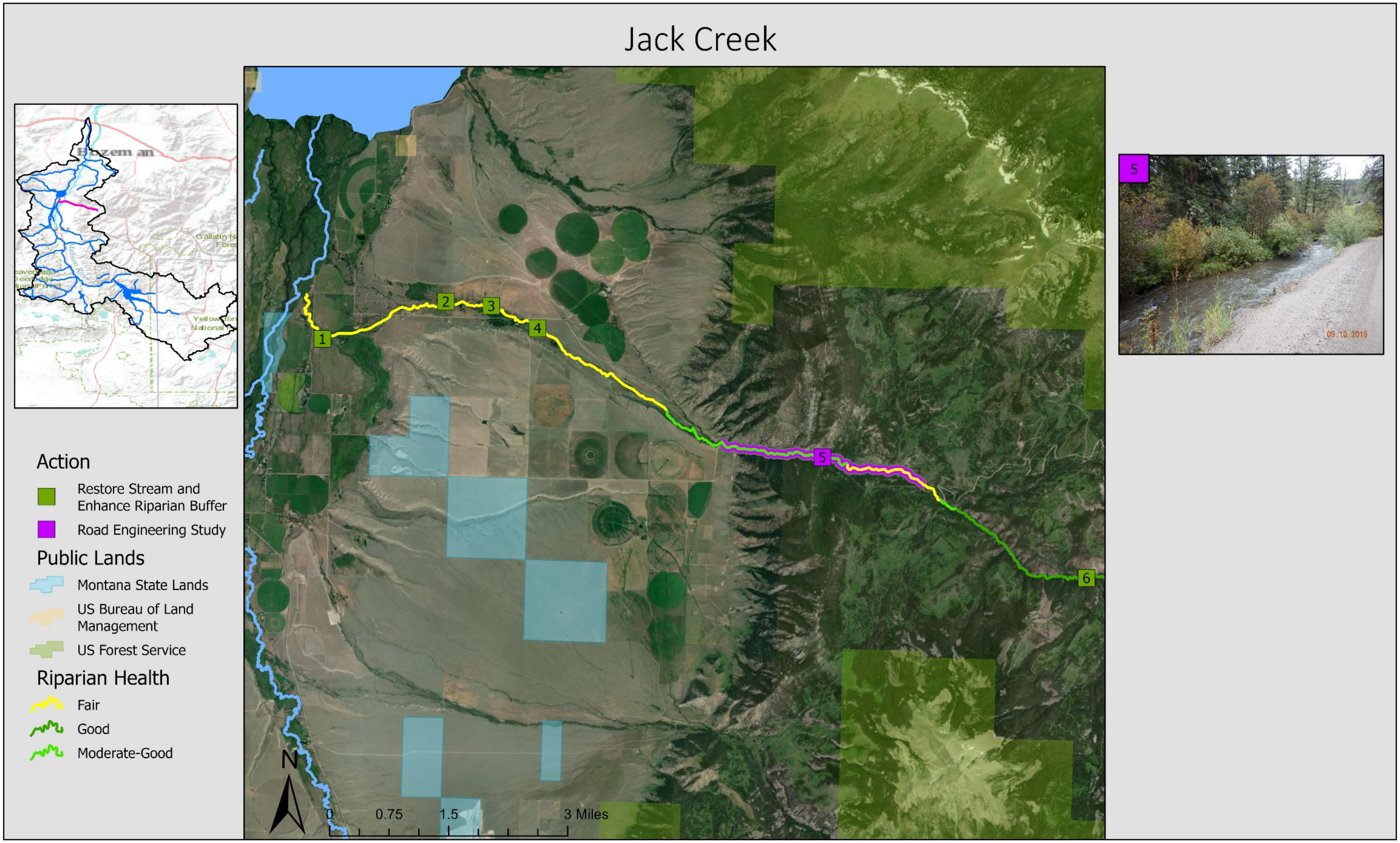


Figure 10: Map of Jack Creek

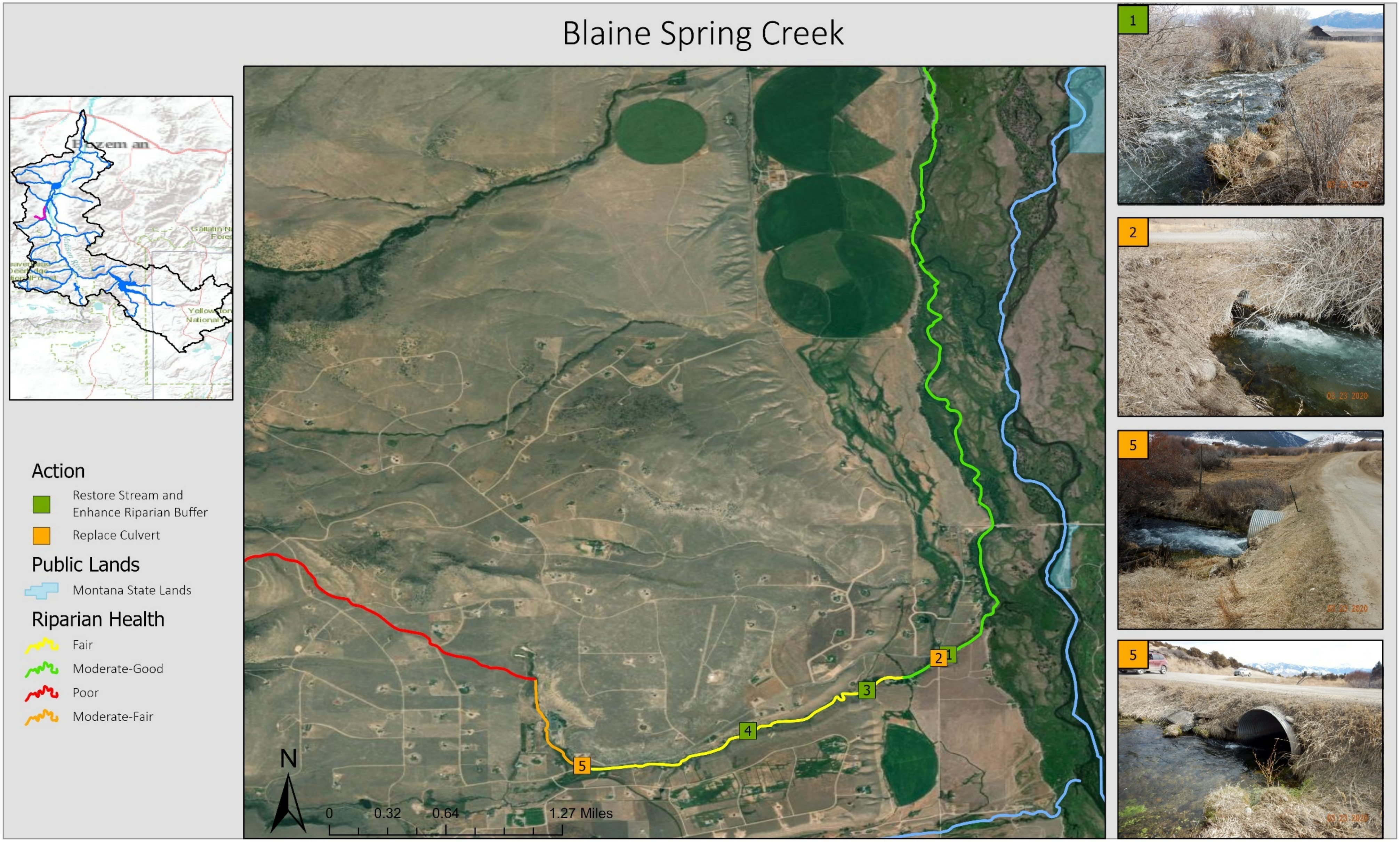


Figure 11: Map of Blaine Spring Creek

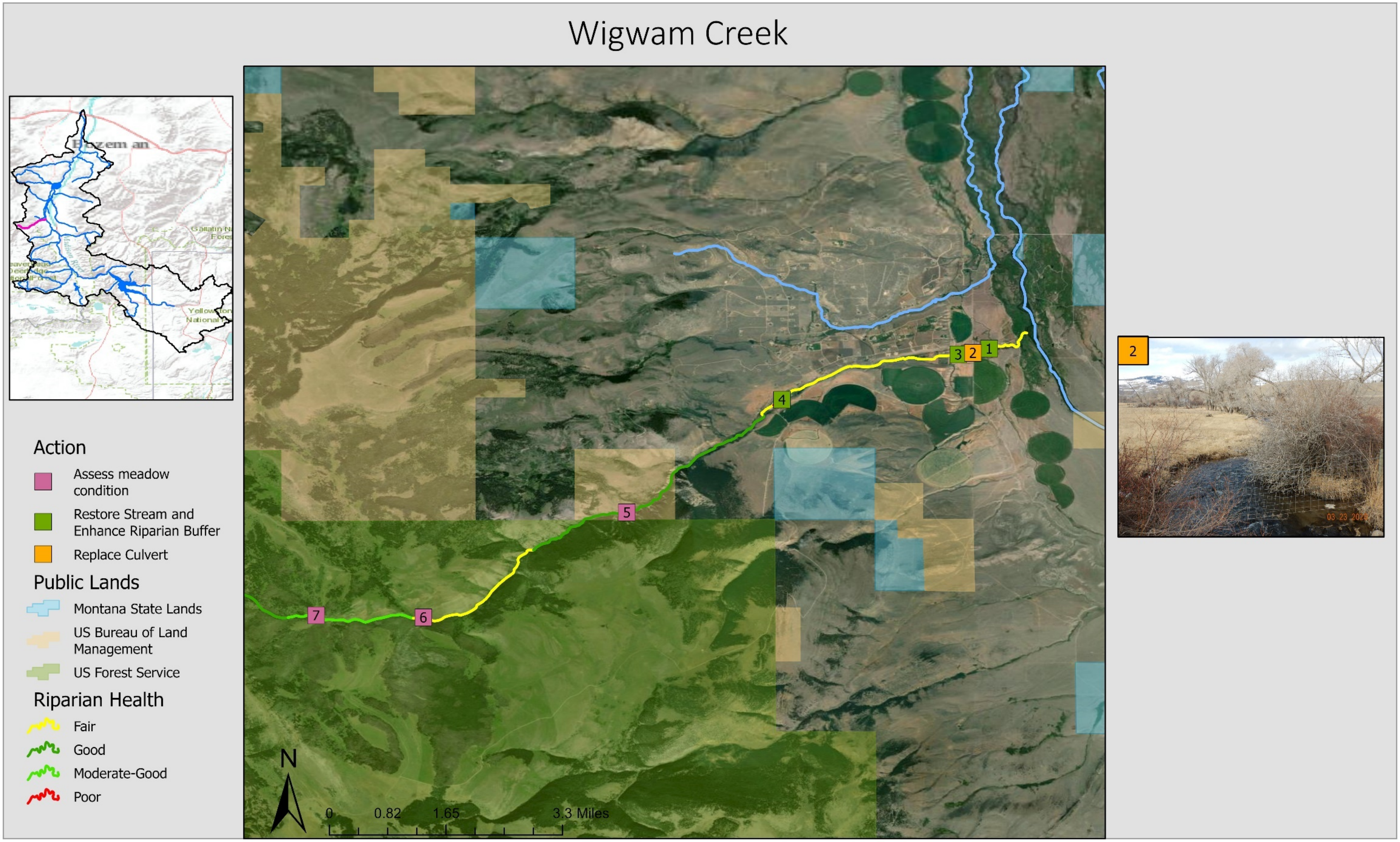


Figure 12: Map of Wigwam Creek

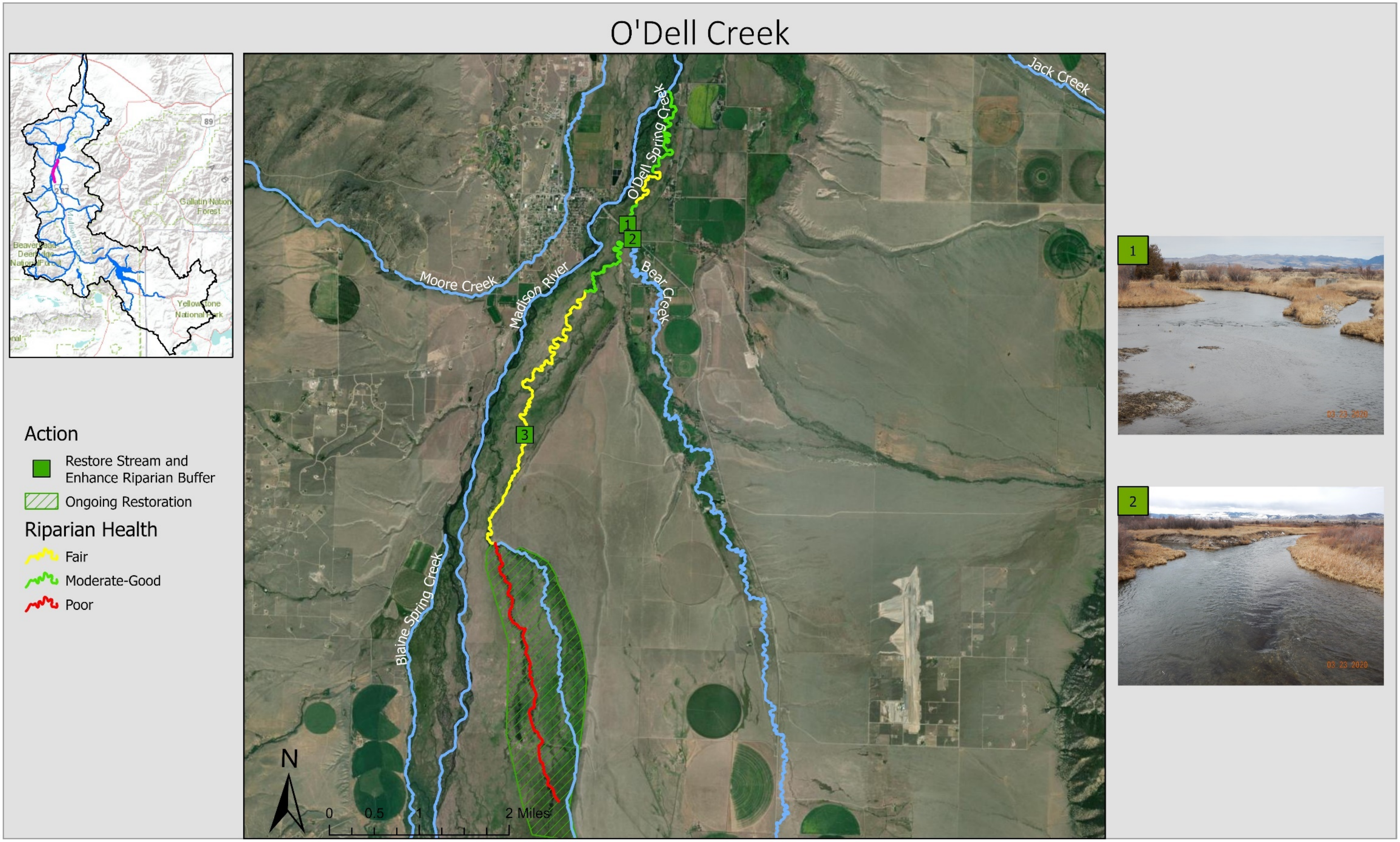


Figure 13: Map of O'Dell Creek

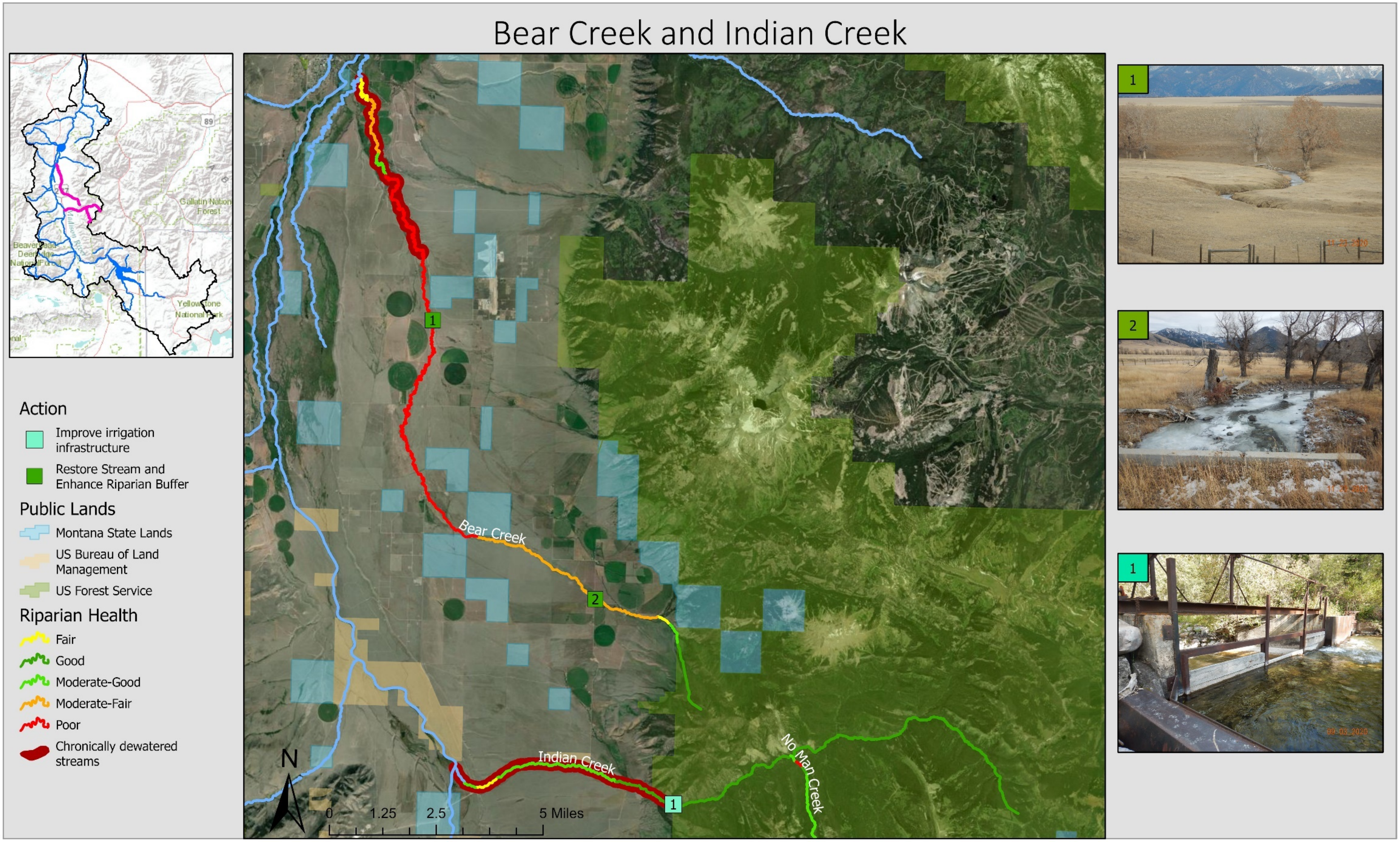


Figure 14: Map of Bear Creek and Indian Creek

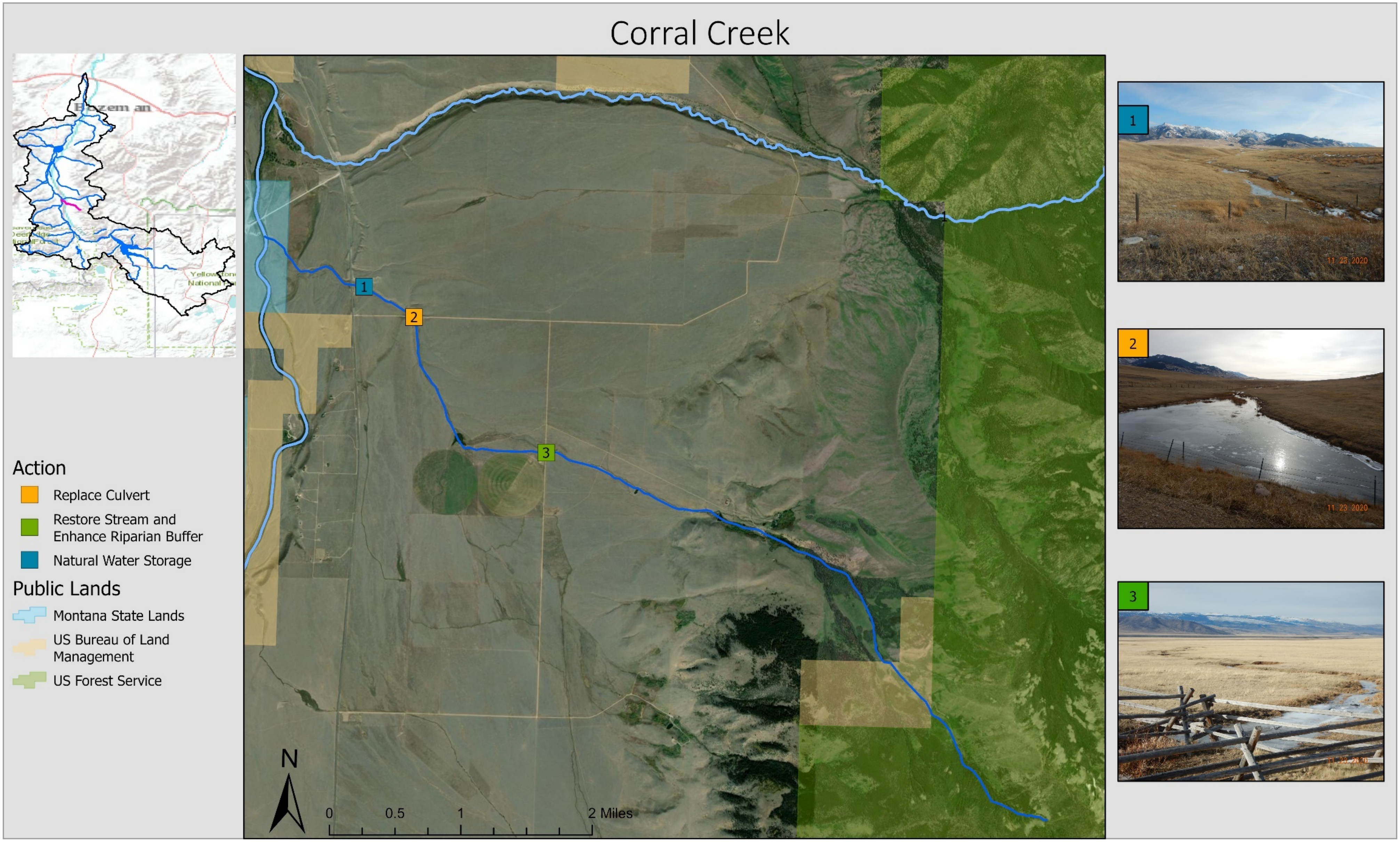


Figure 15: Map of Corral Creek

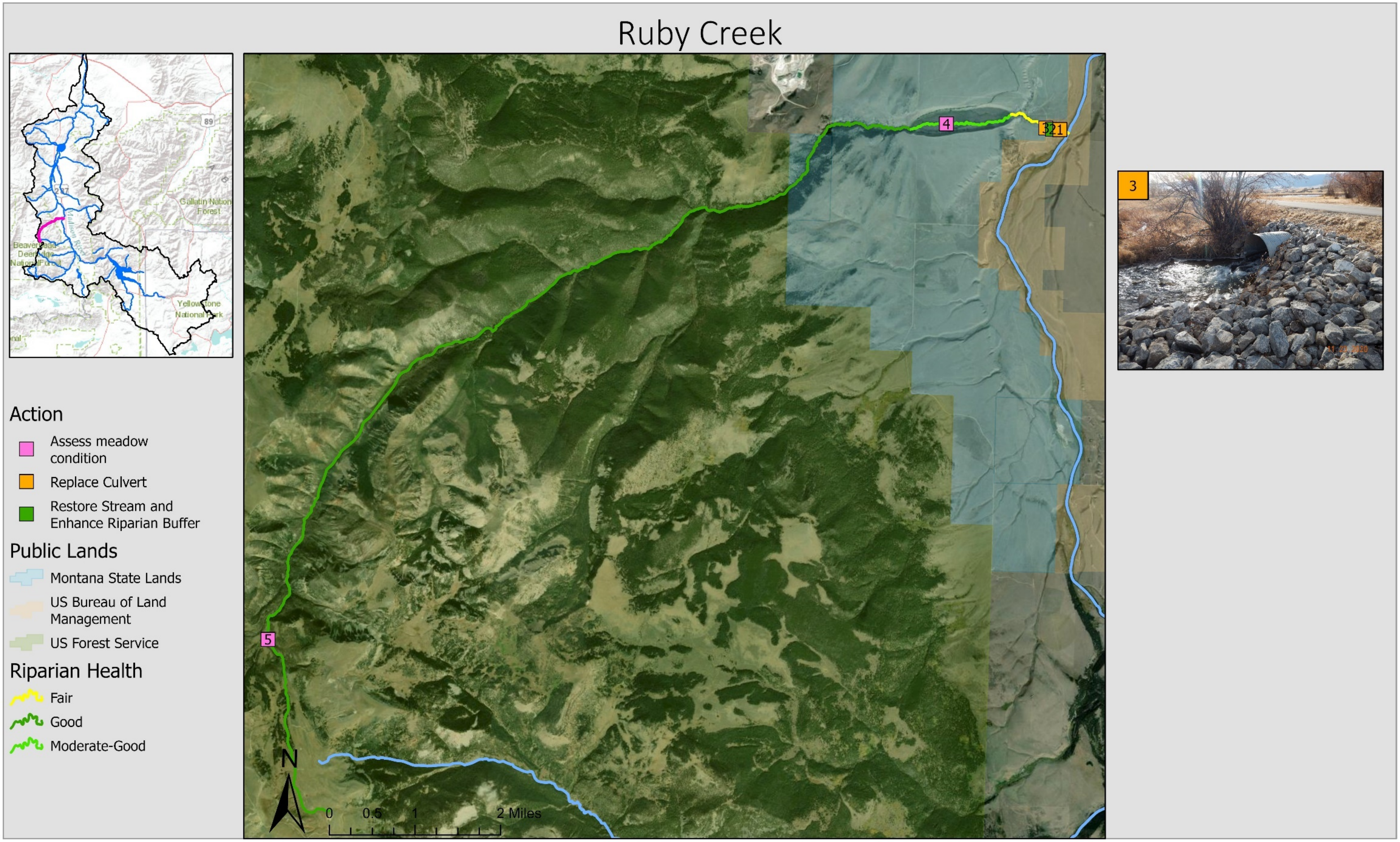


Figure 16: Map of Ruby Creek

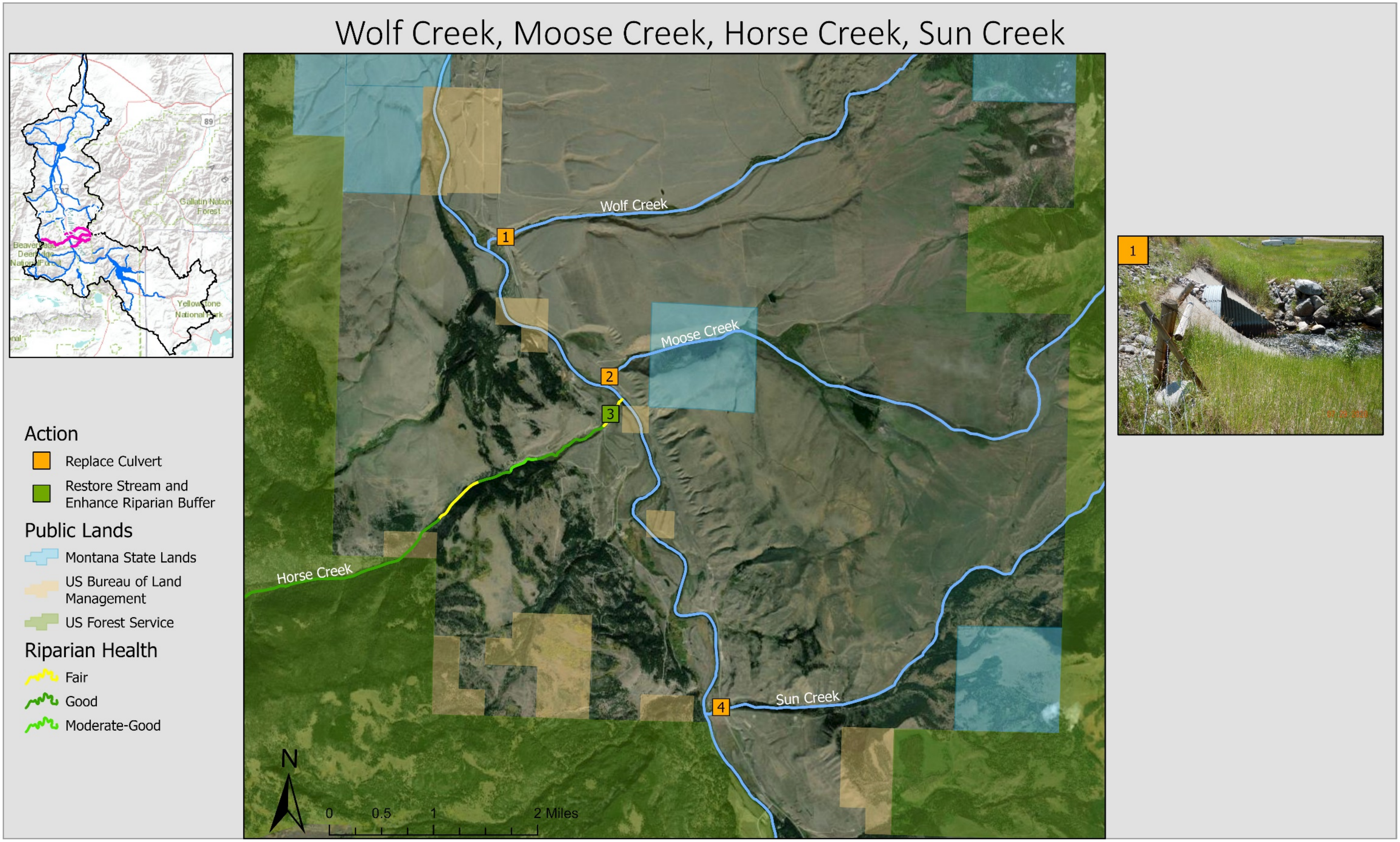


Figure 17: Map of Horse, Wolf, Moose, and Sun Creeks

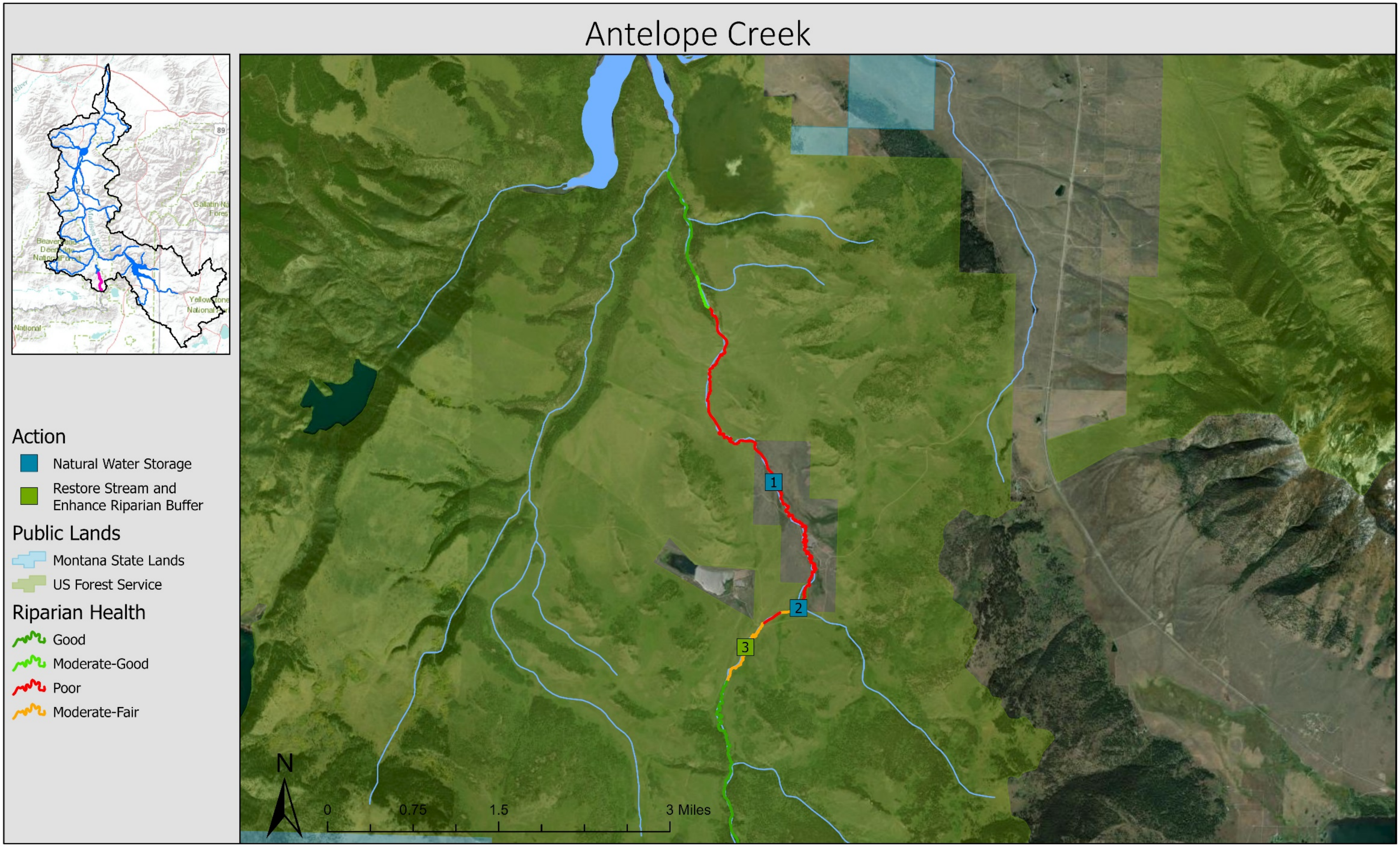


Figure 18: Map of Antelope Creek

West Fork Madison and Tributaries

West Fork Madison

Impairments: Temperature

The West Fork of the Madison and its tributaries, including Gazelle Creek, Cascade Creek, Buford Creek, Elk River, and others, is an 80,000-acre subbasin on primarily Forest Service land. DEQ listed the entire West Fork as temperature impaired but did not develop a TMDL (Montana DEQ, 2020b). Though generally in good condition with vegetated banks and low beaver activity throughout its length, the West Fork has points of heavy degradation due to recreational and grazing use. The series of roads and trails throughout the subbasin also cross the West Fork and tributaries numerous times and are a source of increased sediment input. The lower reaches see especially heavy dispersed camping use and livestock grazing, causing bank instability in certain locations. The middle reach, roughly between Elk River and Cascade Creek, is generally wide and shallow, with several grazing allotments and private inholdings. The upper reaches become narrower with steep forested banks. This generally protects the banks from trampling by livestock, but concentrates grazing pressure in a few open flat areas, which are denuded of vegetation and have eroding banks. The West Fork could benefit from improved grazing practices such as exclusion fencing or off-channel water sources and fencing or boulders to move dispersed campsites away from the river. Revegetation and BDAs in specific locations throughout the watershed could decrease water temperatures and maintain a wide floodplain in the open meadows of the higher reaches (Figure 18: 1-5). Additional BDAs on intermittent tributaries and improving the crossings throughout the watershed will decrease sediment load. The West Fork is the focus of several ongoing restoration projects, including a meadow restoration, improving crossings near and on Elk River, and adding wood to the upper reaches to improve habitat near burn areas. The West Fork is a large and remote subbasin, and more on-the-ground reconnaissance would likely identify more potential projects.

Elk River

Private inholdings at the mouth of Elk River contain several stream crossings that are contributing sediment to the system, and the lower reach of Elk River has grazing impairments. Improving these crossings, providing off-channel water to keep cattle out of the riparian zone, and targeted bank stabilization and revegetation will improve the quality of Elk River and decrease sediment input to the WF Madison. FWP is in early planning phases of a fish barrier on Elk River. This would secure approximately 12 miles of stream for native Westslope cutthroat trout and bring the Madison basin closer to the goal of Westslope cutthroats occupying 20% of tributary miles (Figure 19: 6-11).

Other Tributaries

Many other perennial and intermittent tributaries to the West Fork Madison are contributing sediment during high flows. A further assessment to identify locations for sediment traps in the form of BDAs, and road and trail crossings that may be contributing excess sediment to these small streams would identify potential ways to decrease the fine sediment load into the West Fork (Figure 19: 5, 15). Several possible locations for BDAs on Cascade Creek and Buford Creek have been identified from a desktop analysis, further field investigation is needed (Figure 19: 13, 14, 16-18).

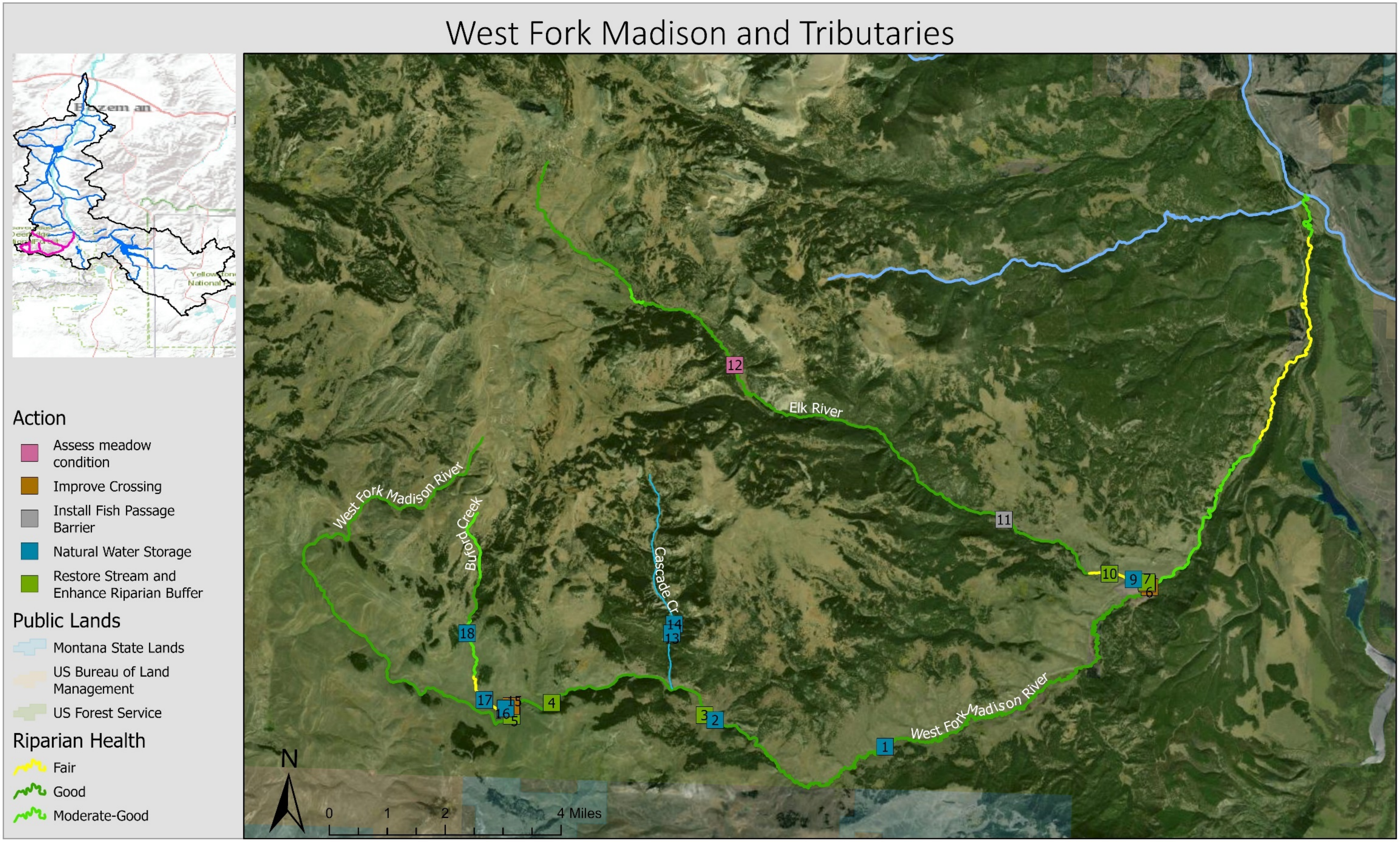


Figure 19: Map of West Fork Madison and Tributaries

Hebgen Reservoir Tributaries

The trout fishery of Hebgen Reservoir is primarily supported through natural reproduction of Rainbow and Brown Trout in tributaries. Watschke (2006) studied tributaries of Hebgen, finding evidence of spawning in 11 tributaries, although Duck Creek and the South Fork support about 80% of spawning and recruitment. Smaller tributaries including Rumbaugh, Watkins, Trapper, and Red Canyon Creeks each provide some recruitment, but their cold stream temperatures and smaller size limits their productivity. We focus on three primary tributaries and Red Canyon Creek, where a TMDL has been drafted.

Duck Creek

Duck Creek originates in Yellowstone National Park, flowing west into the Grayling Arm of Hebgen Reservoir. Duck Creek is known to support a substantial spawning run out of the reservoir, providing extensive rearing and recruitment to the reservoir's wild trout populations. An onstream reservoir was built by private entities just upstream of the Highway 191 crossing. While a fish ladder has functioned adequately for decades, the Duck Lake Pond may elevate water temperatures and be a predator sink for young trout recruits. Removing the dam and restoring a natural channel may be an option, or rerouting the stream around the pond may reduce thermal issues. However, concerns have been voiced that that western pearl-shell mussels population downstream of the highway crossing could be impacted by sediment during pond removal, but may not be a reproducing population (Figure 20).

South Fork Madison

The South Fork of the Madison River is a large watershed draining the continental divide, flowing north to Hebgen Lake. The South Fork is the second largest recruitment source to the Hebgen fishery. Lower reaches of the South Fork downstream of Highway 20, are known to support spawning and rearing for wild trout of Hebgen Reservoir. Black Sands Springs is a short but productive spawning area tributary to the South Fork (Figure 21: 2). With the coarse granitic geology in the upper basin, sedimentation is a limiting factor. Historic timber operations created an extensive road network in the headwaters, resulting in fine sediment deposition throughout the basin. Custer-Gallatin National Forest has led efforts to reduce erosion and sedimentation in the headwaters by retiring roads and removing culverts. A current project at the South Fork Road crossing recently replaced the bridge. Future components of this project aim to add several culverts underneath the roadway in the floodplain to increase longitudinal floodplain connectivity and organism passage, and to decommission the South Fork Road where it turns south and runs parallel to the river (Figure 21: 3, 4). This road is a major source of sediment input and decommissioning it would decrease the South Fork's sediment load.

Grayling Creek

The headwaters of Grayling Creek lie in Yellowstone National Park, where a major effort to remove non-native trout for restoration of Westslope Cutthroat Trout and Arctic Grayling has been completed. On the Custer-Gallatin National Forest, a barrier falls prevents recolonization by Rainbow and Brown trout. The 8-mile reach below the barrier remains accessible for resident and spawning trout. This reach has been disrupted by livestock grazing, highway construction, and instability caused by a fault. Potential for channel restoration exists in lower reaches, where floodplain reconnection upstream of Highway 287 may improve channel stability and overwintering and rearing habitat (Figure 22).

Red Canyon Creek

Impairments: Sediment, Flow Modification, Alterations to Streamside Vegetation.

TMDL: Sediment

Red Canyon Creek flows south out of the Custer-Gallatin National Forest, flowing through federal land and 2 miles of private land prior to its confluence with Hebgen Reservoir. Impairments are mostly related to agricultural practices and roads, which channel fine sediments into the stream at crossings and where the road closely parallels the stream. Restoring riparian vegetation buffers and regrading or restoring stream crossings would decrease sediment loads. Reconnecting the stream and floodplain using BDAs paired with livestock exclusion fencing in lower reaches could increase water storage in the alluvial fan and restore riparian shading (Figure 23). Fisheries values are moderate in this stream and not likely a high priority.

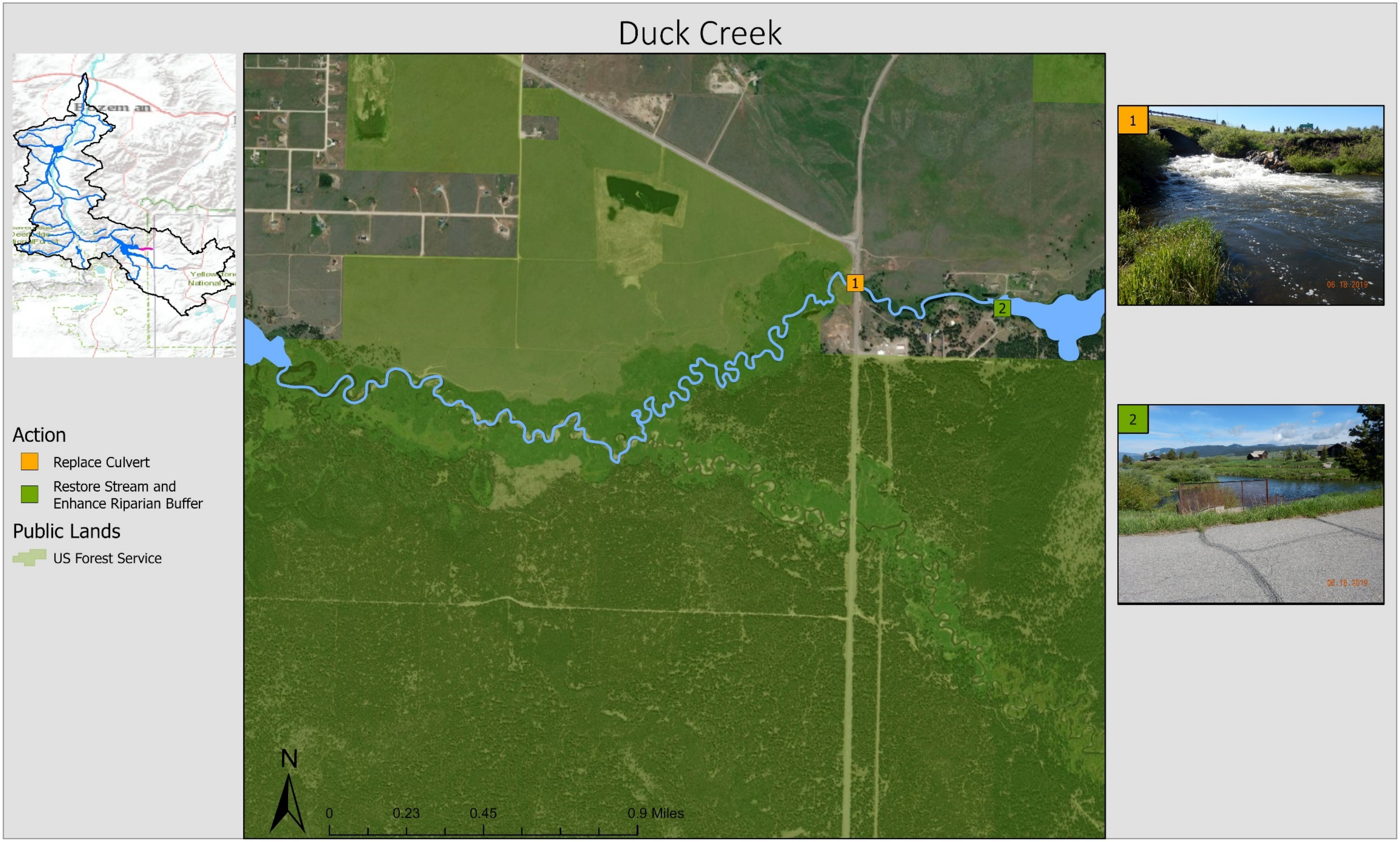


Figure 20: Map of Duck Creek

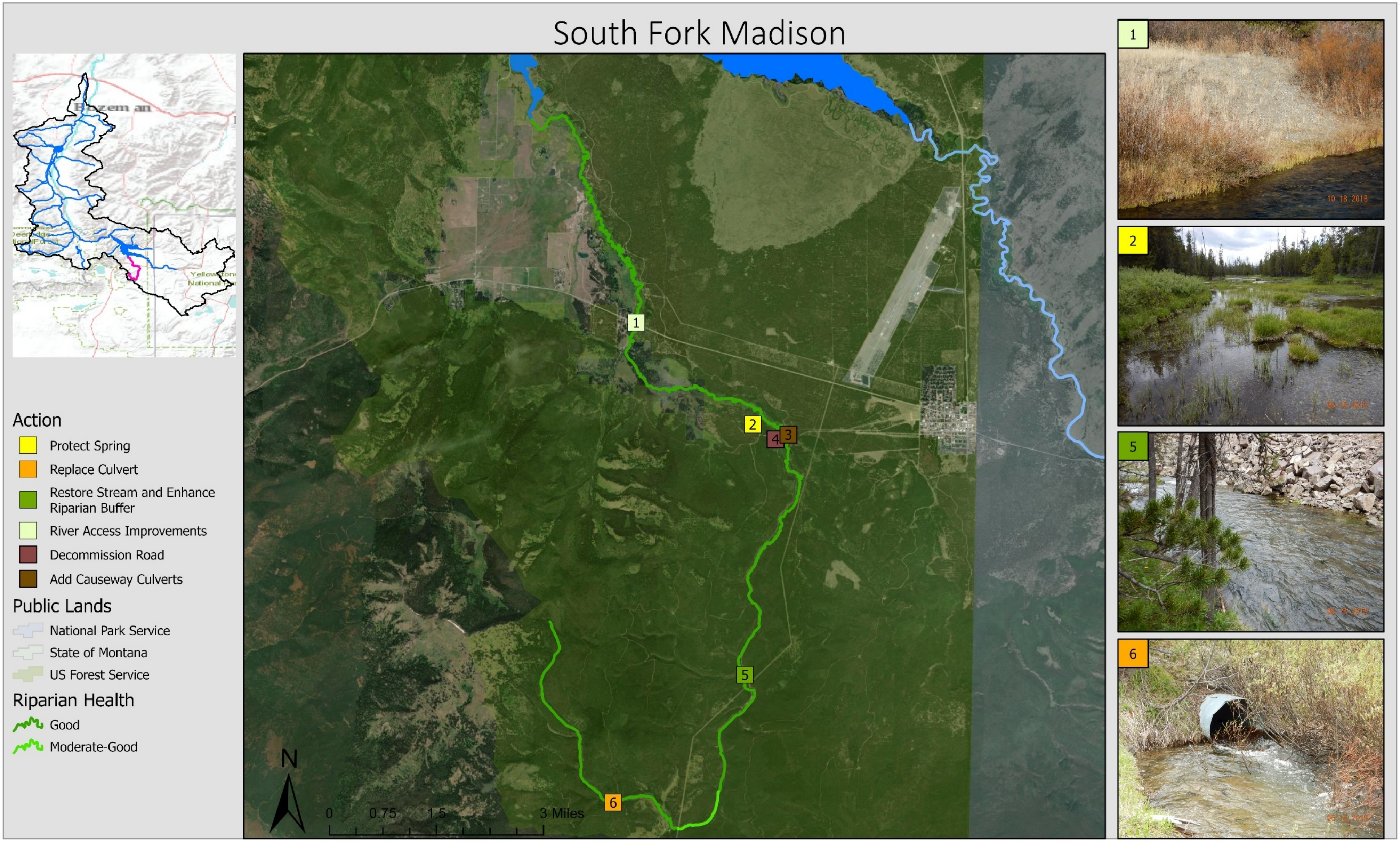


Figure 21: Map of South Fork Madison

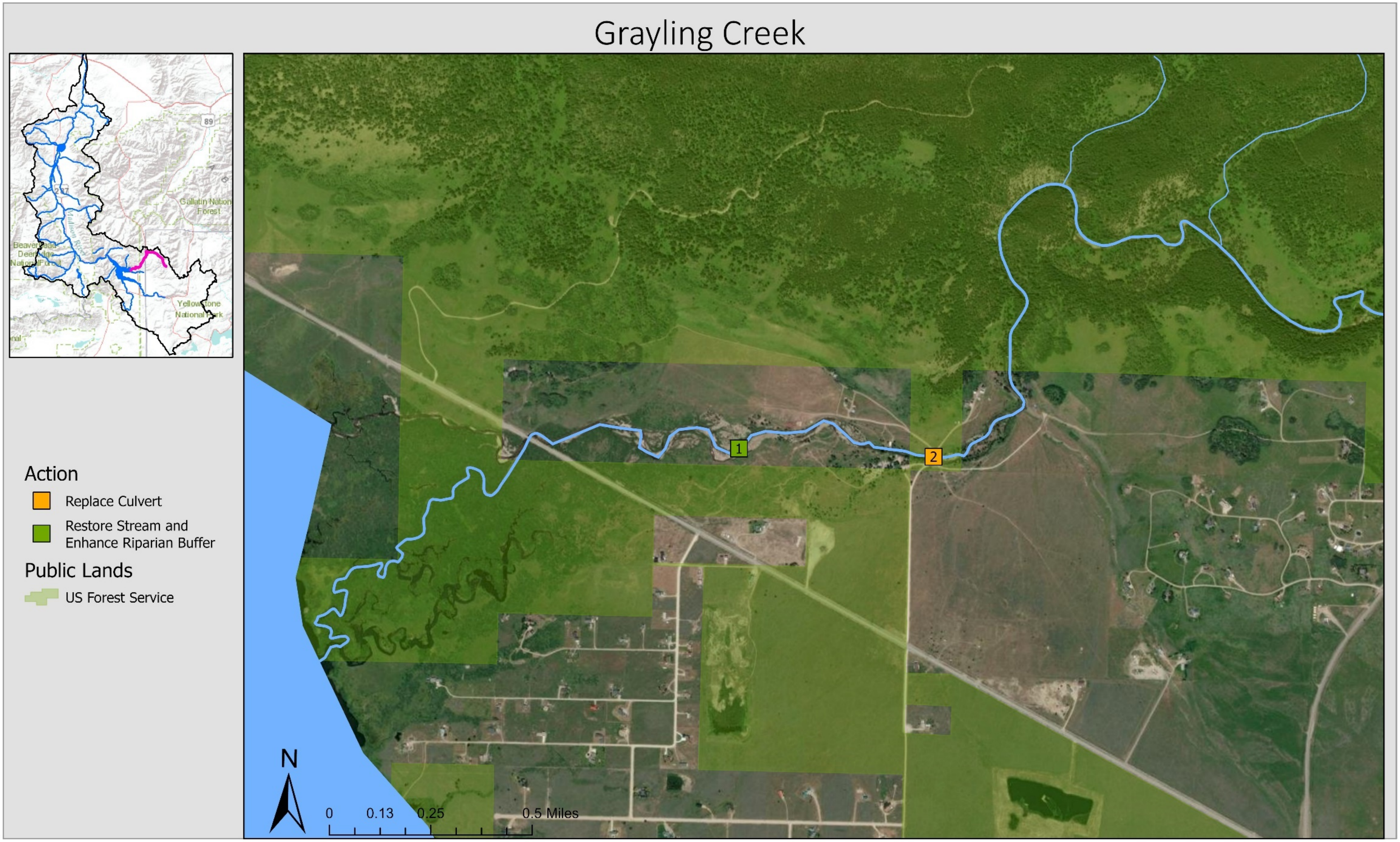


Figure 22: Map of Grayling Creek

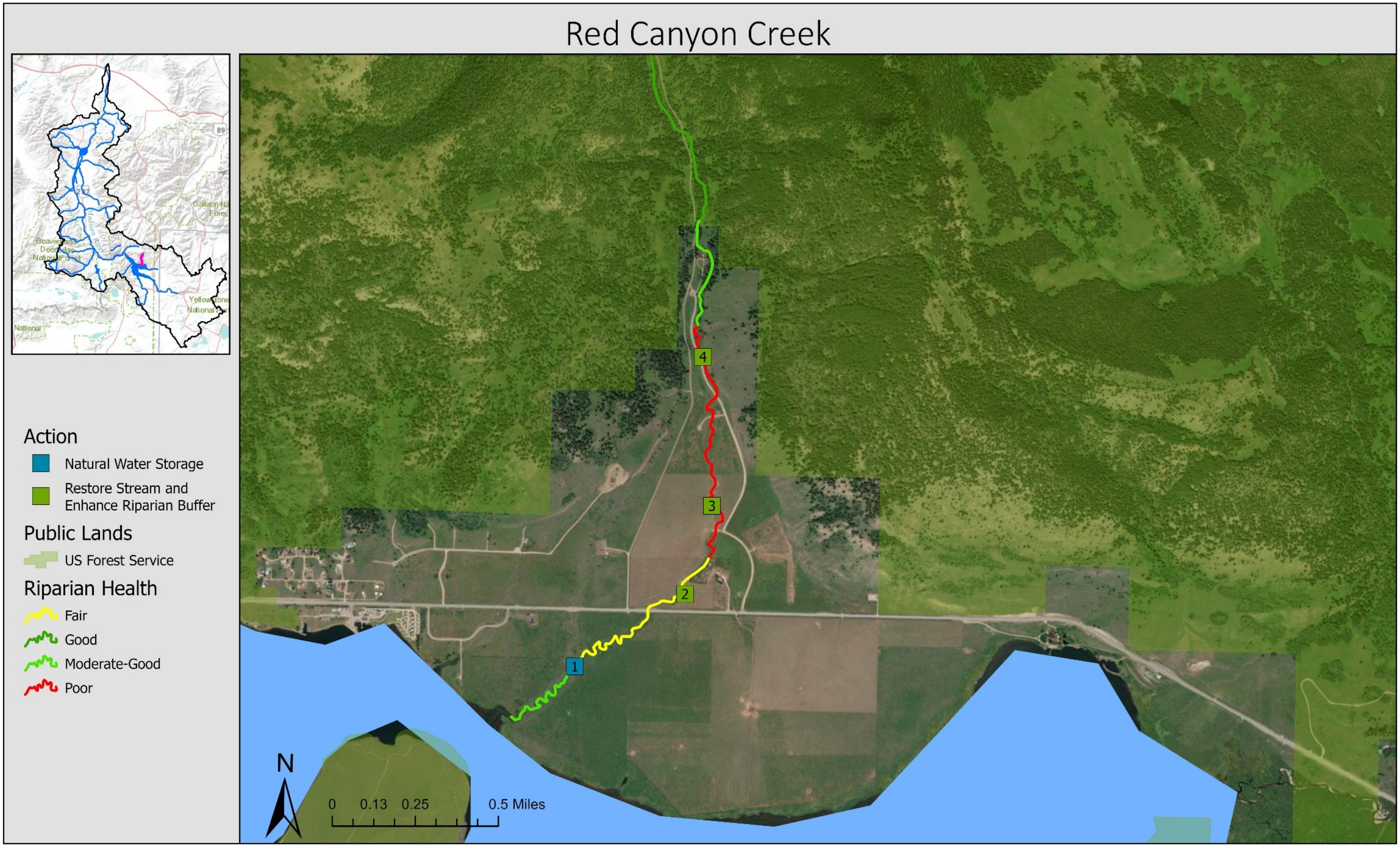


Figure 23: Map of Red Canyon Creek

Additional Opportunities

Further opportunities exist for stream assessment in the Madison Basin. Cabin Creek and its tributaries and West Fork Beaver Creek appear to be in good condition, on the ground surveys may identify locations to increase natural water storage. Beaver Creek and West Fork Beaver Creek may have opportunities to reduce road sediment input and to install signage and fencing at access points to limit impacts from recreational use. Watkins Creek below Denny Creek Rd has a very narrow riparian area, further assessment could better categorize stream condition in this reach and identify restoration opportunities.

Conclusion

This document is an attempt to catalog restoration opportunities throughout the Madison River watershed, but by no means does it capture every potential opportunity. It is intended for use to guide future restoration efforts and has identified stream locations that could benefit from restoration. Other factors, including landowner support, project feasibility, available funding, and project partners should also be considered when selecting projects for implementation. High priority tributaries include those in the lower Madison, including Hot Springs Creek, Cherry Creek, Elk Creek, and Rey Creek. Increasing access to these tributaries for spawning and thermal refugium could help strengthen the fishery in the lower Madison. Additional high priority areas include working with the Beaverhead-Deerlodge National Forest on the West Fork Madison sub-basin and supporting and expanding upon recent and ongoing restoration efforts.

References

Montana FWP. 2005. FWP Dewatering Concern Areas. Helena, MT: Montana Fish, Wildlife, and Parks

Montana DEQ. 2019. Madison Nutrient, E. coli, and Metal TMDLs and Water Quality Improvement Plan. Helena, MT: Montana Dept. of Environmental Quality.

Montana DEQ. 2020a. Madison Sediment and Temperature TMDLs and Water Quality Improvement Plan. Helena, MT: Montana Dept. of Environmental Quality.

Montana DEQ. 2020b. Madison Watershed Stream Summaries. Helena, MT: Montana Dept. of Environmental Quality.

USDA Forest Service. Luckenbill, P. 2021. Upper Madison River Tributary Streams Restoration Opportunities Report. Beaverhead-Deerlodge National Forest, Ennis, MT.