PLANNING AND STAKEHOLDER ENGAGEMENT FOR WATER QUANTITY IN THE LOWER BIG HOLE WATERSHED

BOR WaterSmart Phase I Grant Application

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1a. Executive Summary

Proposal Date
November 13, 2019

Organization
Big Hole Watershed Committee, 501 c(3) non-profit
Divide, Beaverhead County, Montana

Executive Summary
The Planning and Stakeholder Engagement for Water Quantity in the Lower Big Hole Project will support the Big Hole Watershed Committee's (BHWC) capacity to pro-actively address water scarcity issues in the lower section of our watershed. This project will address water scarcity through Restoration Planning and Watershed Management Project Design activities. These efforts center on our organization's 25-year history of consensus-based decision-making. We will accomplish our goals by taking previous planning efforts to project design stages and by implementing a concerted stakeholder engagement strategy with irrigators and recreationists that will lay the groundwork for an update to our Watershed Restoration Plan. These parallel efforts will demonstrate our organization's capacity to deliver tangible improvements in water availability, building trust and local buy-in and will set the stage for active restoration projects on upland slopes where water availability has been dramatically decreased by conifer encroachment and in the river bottom by Pennington bridge, where channel avulsions are posing substantial risks to irrigation and other infrastructure. This project will provide important resources to our group so that we can expand our stakeholder base and build more community-level support to stretch scarce water supplies and avoid conflicts over water in this notoriously dry part of the watershed.

This project will take place from the Spring of 2020 through the Spring of 2022.

Federal Lands/Facilities
As this project is specifically for planning and project design work, it will all take place in the office spaces and lands of our stakeholders. Some of the future conifer encroachment projects we foresee will occur on federal land, but that work falls outside the scope of this grant.

1b. Background Data

Description of Watershed and Water Use
The Big Hole River watershed is located in Southwest Montana. The Big Hole River is a headwater tributary to the Missouri River, with the bulk of its water supplied by snowpack. It runs 159 miles from its source near Jackson, Montana to its mouth near Twin Bridges, Montana.

The Lower Big Hole River watershed is defined by the River's mostly unconfined reaches below its canyon section. The landscape is rural, with two small towns of Melrose and Glen. Population is sparse. The valley bottom is primarily private lands used for cattle ranching and hay production sustained by a mix of flood and pivot irrigation. The uplands are primarily public lands managed by the United States Forest Service, the Bureau of Land Management, and the State of Montana. Public lands are often leased by ranches for cattle grazing.

Current water use is primarily agricultural, as the majority of land use is cattle ranching with pasture grazing and hay/alfalfa production. Ranches are large and intact; most are descendants of the 1880s homesteads with families owning large expanses of land. A portion of water use is municipal as approximately 300 million gallons are pumped out of the watershed annually to supply the City of Butte, which receives 40% of its domestic water supply from the Big Hole River from a diversion just upstream of the lower section of the river as defined by this project. Domestic use within the watershed is limited as there are only approximately 2,000 year-round residents in the entire watershed. The nearest cities are Butte, Dillon, and Anaconda, which are each about 20 miles outside of the watershed boundary.

Water quantity issues, namely the river going dry nearly 20 years ago, catalyzed the creation of the Big Hole Watershed Committee. BHWC introduced the Big Hole River Drought Management Plan in 1997, the first of its kind in the state, to address low flows and high temperatures in the Big Hole River. The plan designates voluntary flow restrictions for irrigators and mandatory fishing restrictions for anglers (enforced by Montana Fish, Wildlife and Parks) during periods of low flow or high temperatures. BHWC takes voluntary contributions from stakeholders to partially fund 4 stream gages as part of our planning and collaborate at the state level on stream gages and funding with a diversity of state, federal and NGO partners.

BHWC has also commissioned studies to better understand water balances, irrigation infrastructure and opportunities for improving water supply throughout the watershed over its 25 years history. More recently, BHWC has invested significant time and resources into improving natural water storage opportunities in the watershed through the restoration of wetlands, reconnection of streams to their floodplains, use of beaver mimicry, and sediment reduction projects. We are seeing interest in reducing conifer encroachment on the landscape as a water quantity issue and have hired a program manager with a forestry background to develop a program for landowners and public partners to address this issue.

Threatened and Endangered Species Considerations

The Big Hole River and its tributaries are home to native Arctic grayling and Westslope cutthroat trout. The Westslope cutthroat trout is considered a Species of Concern by the State of Montana. Threat of listing of the grayling under the Endangered Species Act prompted a C.C.A.A program by the US Fish and Wildlife Service, which has catalyzed important work in the upper watershed and has been one of the reasons for BHWC's work in the middle section of the river, including Phase II WaterSMART funding from the BoR, currently being finalized.

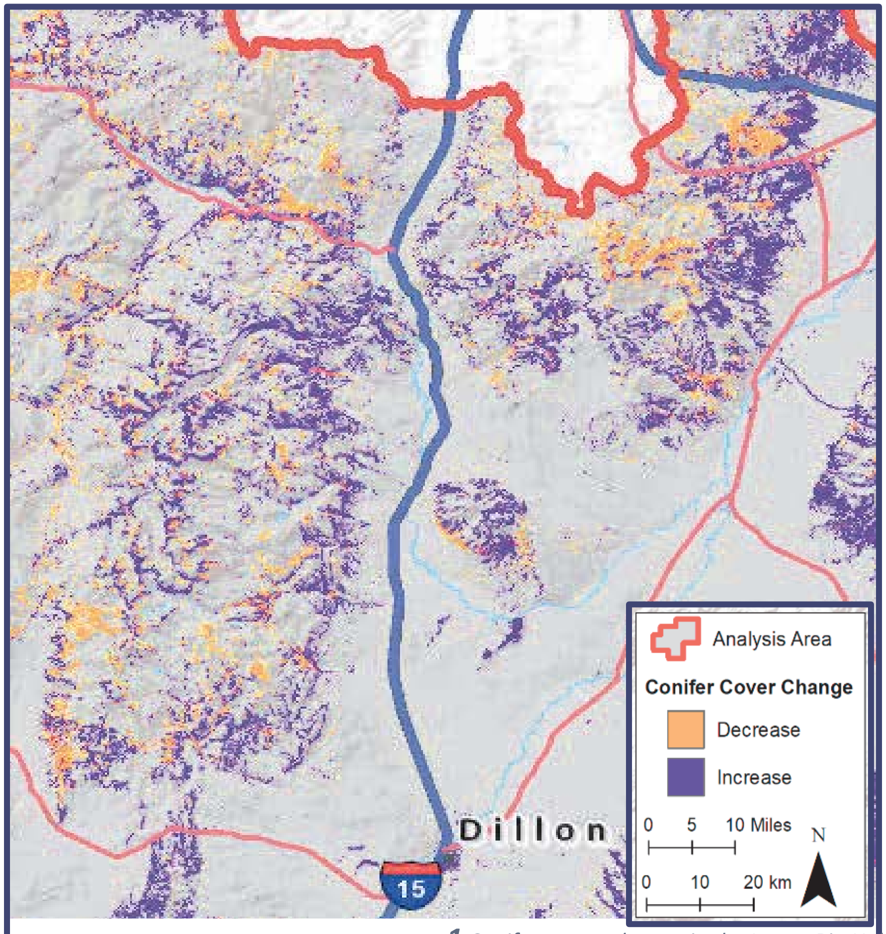
Lower Watershed Character

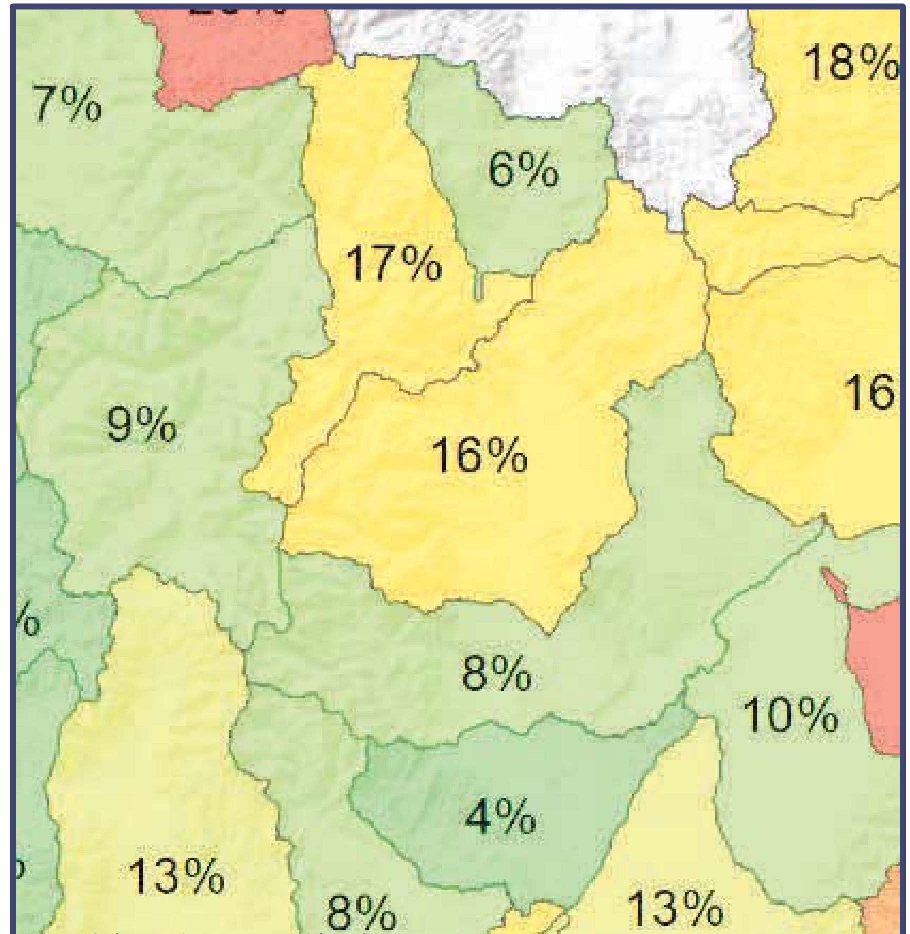
The lower section of the Big Hole, is distinct from the middle and upper sections of the river, particularly its lower elevations, higher temperatures, and reduced snowpack in the low and mid-elevation valleys and foothills. Heightened attention to native fish (grayling and westslope cutthroat) has allowed BHWC and partners to harness significant stakeholder buy-in for restoration projects and grant dollars in the upper and middle sections of the river. These portions of the river see the most snow, and thus are considered important from a hydrologic resilience standpoint and as native fish strongholds. Irrigators in the Upper river all use flood irrigation, which benefit downstream landowners and irrigators due to increased retention time of water slowly leaving the saturated soils the large upper valley.

The Lower portion of the river is dramatically different and BHWC has historically not seen the same levels of stakeholder engagement and buy-in to drought response, drought management or restoration. This project seeks to change that scenario. Two key avenues we will pursue to achieve that change is by mobilizing our stakeholders in the lower section of the river and by developing critical projects that will deliver water savings and ecologic resilience to the lower section of the Big Hole River.

Conifer Encroachment

In 2019, The Nature Conservancy released a high resolution analysis of conifer expansion throughout the High Divide. Expansion rates in the Lower Big Hole ranged from 6% to 17% across the subwatersheds of Divide Creek, Moose/Camp and the unconfined floodplain bottom below the notch to its mouth. Expansion rates were based on 4% increases in canopy cover between 1952 aerial imagery and LANDFIRE Biophysical Settings geospatial dataset derived from NatureServe's Ecological Systems Classifications (Comer et al. 2003). These rates are even higher at sub-watershed scales looking only at uplands.

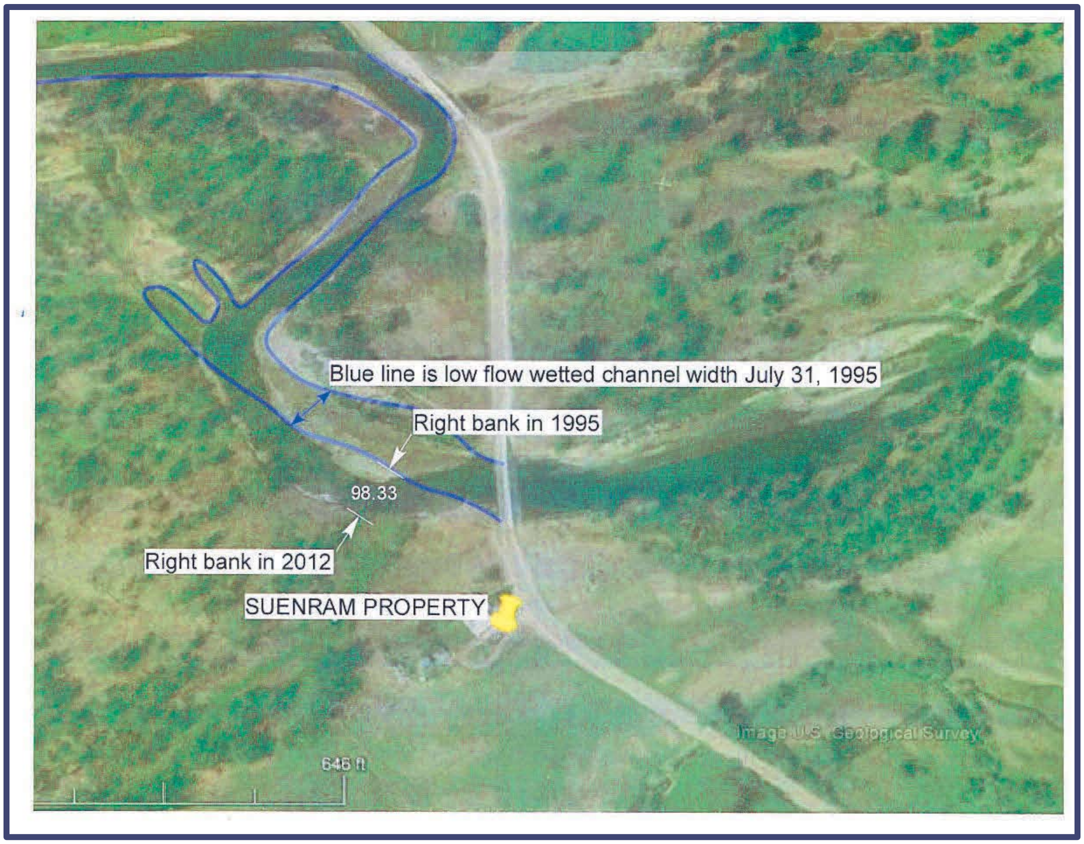




1 Conifer encroachment in the Lower Big Hole Rive. Over 4% change in cover considered increase.

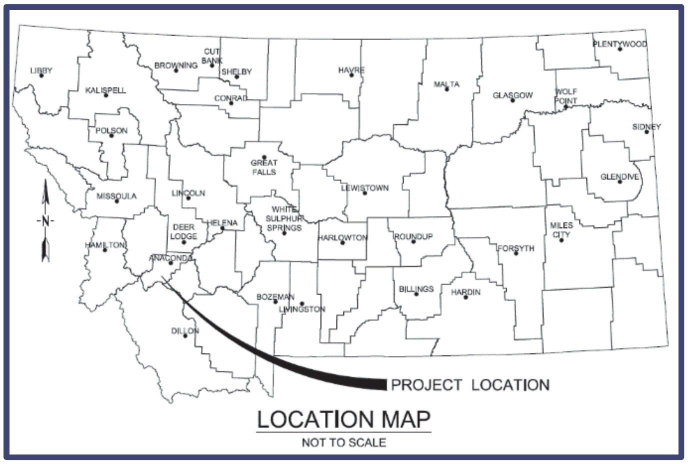
Pennington Bridge

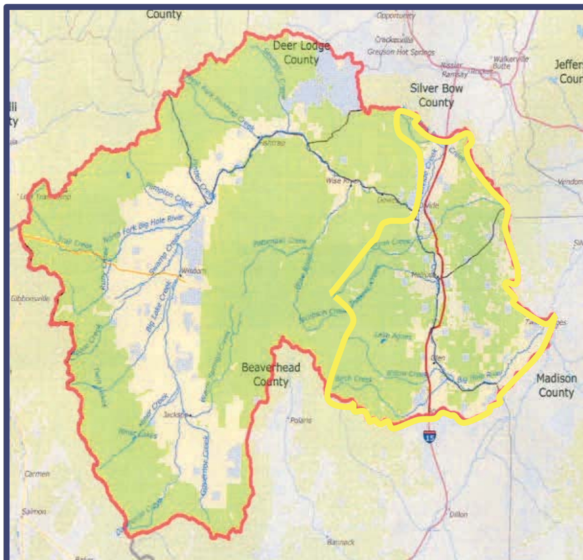
Downstream of a natural constriction in the river bottom called “the Notch”, the Big Hole spills out onto a wide floodplain and becomes multi-threaded, with numerous mid-channel islands and shallow groundwater. Two bridge crossings at Pennington force an “S”-turn in the river. Four hundred feet of Rip-rap was required on a private property upstream of the bridge. This approach is proving to be a temporary patch. This project will develop a stream restoration design for this section of the lower river to improve water reliability, safety to infrastructure and private property, and improve ecological function and natural water storage.



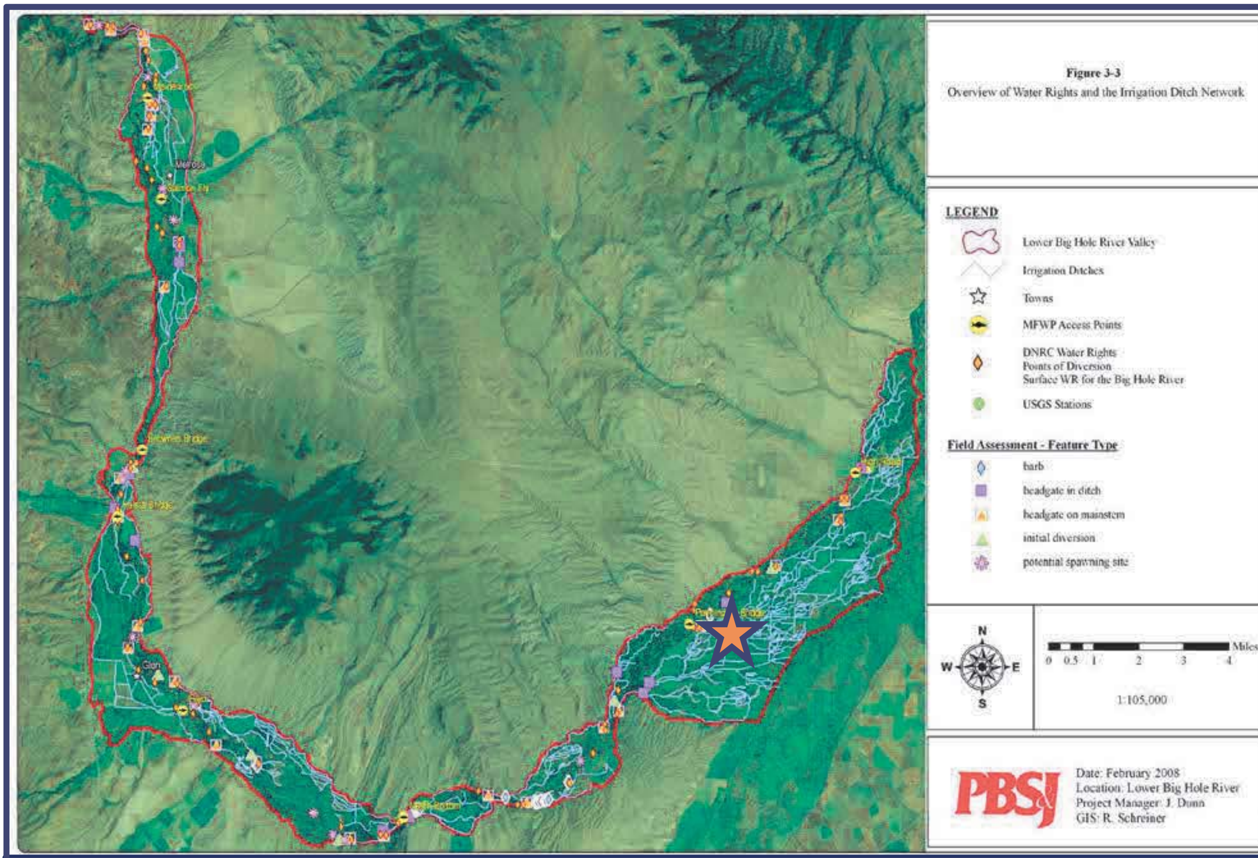
1c. Project Location

The project location includes the lower section of the Big Hole River and the surrounding watersheds, defined as the unconfined reaches of the river below the Maiden Rock stream gage, to its mouth near Twin Bridges, Montana. This project area touches on three counties: Silver Bow County, Beaverhead County, and Madison County. Most project activities will occur in Madison County.





2. Big Hole River Watershed with Lower River project location (yellow)



3. Close-up of Lower River from Irrigation Infrastructure Report. Pennington Bridge location starred.

Past Working Relationships with the Bureau of Reclamation

- 2019: BoR WaterSMART Phase II: Funding agreement currently being finalized for implementation of stream channel restoration project on French Creek in the middle section of our watershed ($86,000).
- 2017-2018: Sub-award from the Montana DNRC as part of BOR Drought Contingency Planning Grant ($20,000) – used to support and operate the Big Hole River Drought Management Plan, build capacity of our drought coordinator, and participate in Upper Missouri Headwaters Basin drought planning.
- 2008 BOR Emergency Drought Relief Act

1d. Technical Project Description

Applicant Category: We are seeking funding as an Existing Watershed Group. Established in 1995, BHWC is a local watershed group and central hub of diverse viewpoints on resource and community concerns. We are a consensus-based nonprofit organization dedicated to conservation of the Big Hole River and surrounding watershed. Our work is comprehensive, spanning floodplains, communities, wildlife, water, and fisheries. We provide education, facilitate conversations and planning for issues in our area, and put meaningful restoration work on the ground. Our organization has always made decisions by consensus.

BHWC is currently composed of a 22-member Governing Board that represents diverse interests including: ranching, utilities, local government, sportsmen, conservationists, tourism, and outfitters. Representatives from local, state, and federal agencies participate as technical advisers. We are a multi-stakeholder entity that works closely with other conservation organizations as well as local, state, and federal agencies on watershed restoration and management plans.

We are committed to:

- Involving all interests that are willing to seek practical solutions that benefit all interests;
- Promoting a common understanding among individuals and groups with diverse viewpoints;
- Fostering the ability of local individuals and groups to create effective solutions to local problems; and
- Seeking long-term solutions based on sound information.

In the past 5 years, BHWC has increased its staffing capacity and expertise and is now a trusted partner in co-designing and overseeing large scale restoration projects on the landscape. From 2018-2019, BHWC secured and deployed $1.3 million in restoration grant funds in the watershed. Over 90% of these investments have been dedicated to the middle and Upper sections of the river. In 2018 we hired a program manager with a forestry background to address what we have seen as a growing need to address conifer encroachment in the lower section of the river, for wildlife, range health and increasingly in order to improve water availability.

Water supply, particularly the ability of the landscape to naturally store water, is increasingly the driving focal point of our restoration work. We have found that this focus resonates with our private landowner base and with the growing recreation users of the river. BHWC has commissioned studies in the past on this issue, but moving forward, we are seeking to re-orient our restoration programs to achieve natural water storage in all the work we do, with the ultimate goal of improving the watershed's ability to provide adequate water supplies to its users and co-benefits for wildlife, fish and water quality improvements.

Eligibility of Applicant: The Big Hole Watershed Committee is a grassroots, non-regulatory entity that has had water availability and water quality at the core of its work since its inception when the Big Hole River went dry. We work with a diverse board of stakeholders by consensus. (See Appendix for eligibility documentation).

Goals: The goals of this project are to:

- **Grow our stakeholder base** and participation in water management and planning in the lower section of our river, particularly from irrigators and the recreation community.
- **Update our watershed restoration plan** for the Lower section of the river to reflect a determined focus on increasing natural water storage on the landscape and thus water reliability, in cooperation with private landowners and our state and federal partners.
- **Pennington Bridge Design.** Develop a solution to bank instability that improves reliability of supply for downstream water users, protects infrastructure and improves hydrologic and ecologic function of the river.
- **Develop conifer encroachment projects** to increase water availability and improve rangeland production and health in a notoriously dry part of our watershed.

Approach

Our project approach is guided by our larger objective of delivering two distinct projects to the lower river area and in the process improving cooperation with lower river landowners and stakeholders on water use and management to ensure reliability with water supply and improved water quality.

Grow Stakeholder Base: To grow our stakeholder base in this part of the river we will:

- Interview agency personnel about project priorities, locations of resource concerns.
- Interview fishing guides and outfitters about resource and management concerns
- Hold multi-stakeholder coordination meetings in offices and in the field
- Hold one of our monthly Watershed Committee meetings in Twin Bridges every year.
- Engage irrigators in BHWC's Drought subcommittee.
- Online coordination
- Update status of projects from Irrigation Improvement Prioritization Document and engage high priority project stakeholders

Update our Watershed Restoration Plan: This effort is highly informed by the previous goal. Information collected from interviews and meetings will inform our update to our Lower River Watershed Restoration Plan. This update will involve:

- Develop GIS project for multi-stakeholder mapping of project priorities for water storage

- Compile information into updated Watershed Restoration Plan. Plan will prioritize projects with direct impacts on water availability and reliability.

Pennington Bridge Design: We will develop a design for a solution to the risk associated with the Pennington Bridge site. Our approach will be to:

- Contract a geomorphologist to assess project conceptual design
- Hire an engineer to develop a project design document
- Coordinate all parties and consult stakeholders throughout design process
- Manage contracts
- Write and submit project permits

Develop Conifer Encroachment Projects: We will work with private landowners and grazing associations to develop conifer encroachment projects.

- Using information from first goal, develop priority project locations
- Meet with agencies and landowners on site to develop projects
- Develop outreach materials about conifer encroachment, water supply

1e. Evaluation Criteria

Evaluation Criteria

A. Watershed Group Diversity and Geographic Scope

1. *Watershed Group Diversity: BHWC is represented by a 22-member board of directors. Since its inception the composition of our board has been committed to a broad-based representation of all relevant stakeholders in the Big Hole watershed. We have active working relationships with all relevant county planners, state and federal agencies, grazing associations and guide/outfitter and recreation groups in the watershed. Funding for our first two goals will involve direct engagement with all of these stakeholders to develop the most inclusive restoration and water supply planning document possible, including prioritization of irrigation improvement projects, upland water storage opportunities and channel restoration projects.*
2. *Geographic Scope: BHWC operates throughout the entire Big Hole Watershed and have a long history of project support from the lower to the upper river. This BoR project will focus on the lower section of the river, where we have historically had less engagement with stakeholders. We have board members representing that part of the river and are actively seeking out willing partners among private businesses in that section of the river. By hosting monthly meetings in Twin Bridges and increasing our visibility in this part of the watershed we will bring key stakeholders to the table who have not been as active historically.*

   We have existing relationships with all state and federal agency partners as well as Madison County. These partners will help our outreach efforts. Delivery of successful on-the-ground project based on the designs developed with this project will build recognition and trust for our group with lower river stakeholders.

B. Addressing Critical Watershed Needs

1. *Critical Watershed needs or Issues: This project has already identified two critical issues for which project designs will be developed. Conifer encroachment is increasingly seen as a key source of water depletion on the landscape. The encroachment has increased dramatically in this section of the watershed and agency and non-profit partners are interested in funding conifer removals to increase hydrologic resiliency as well as improve rangeland and wildlife habitat.*

   The Pennington Bridge area has been identified by Madison County, nearby landowners and County engineers as a concern. BHWC previously attempted to fund a restoration approach but was unsuccessful. The new conceptual plan we propose for this project will address the impending damage to infrastructure and also improve hydrologic connection of the floodplain with potential improvements for water storage.

   Late season water availability is the most consistent watershed need brought up by stakeholders and always a focus of our work. Capacity funding for our first two goals will help us identify other critical watershed needs not currently on our radar. This will include re-visiting an irrigation infrastructure prioritization report previously commissioned. And it will involve updating our WRP, which will T-up water storage projects and also address critical TMDL issues in this part of the watershed.

2. *Developing Strategies to Address Critical Watershed Needs or Issues*
   Task B: Watershed Restoration Planning: We will revisit our existing WRP for this portion of the river with all our relevant agency partners to update prioritizations previously identified. During these interactions we will emphasize a new focus on water availability and work with partners to identify our best opportunities to address multiple resource concerns with single projects. We will rely heavily on studies and the latest science that indicates the effects of conifer encroachment on water availability and landscape resilience.

   One critical issue in the watershed that requires attention is the active participation of the guiding and fishing community into our watershed planning. This project will provide the capacity funding needed for a concerted outreach effort to those stakeholders.
   Part of these planning efforts will involve revisiting existing prioritization plans and ensure they are up-to-date. The WRP document will reflect all changes to those earlier plans.

   Task C: Watershed Management Project Design: We will develop a comprehensive solution to the Pennington Bridge area by discussing a conceptual design that involves re-activating abandoned side-channels of the river and increasing overbank saturation of the floodplain in order to decrease stream velocities against vulnerable *streambanks. We will hire qualified geomorphologists to provide an initial assessment of this conceptual approach and then hire the county engineer to survey the site and develop a site-specific restoration design, ready for construction.*

For conifer encroachment projects, we will base prioritization of projects on the areas with most congruence between landowners and benefits to the resource. Timelines and milestones for these projects will be developed once project designs are completed and funding sources and deadlines identified.

We will consult with BoR cultural resource staff as project designs become available, but do not anticipate doing compliance work under this project.

C. Implementation and Results

1. *Understanding and Ability to Meet Program Requirements*
   Our organization has had substantial success operating large grant programs over the past 5 years. An estimated project schedule is provided below.

Project Goals	Spring 2020	Summer 2020	Fall 2020	Winter 2021	Spring 2021	Summer 2021	Fall 2021	Spring 2022	Summer-Fall 2022
Stakeholder outreach									
Irrigation report update									
Watershed Restoration Plan Update									
Pennington Bridge									
Stakeholder Consultation									
Geomorph Assessment									
Engineer Design									
Final Design									
Conifer Encroachment									
Project Planning									
Implementation under other funding opportunities									

2. *Building on Relevant Federal, State or Regional Planning Efforts*
   Capacity funding under this project will support BHWC to match its water management planning to the State Water Plan, to DEQ water quality priorities and provide for an update to our Watershed Restoration Plan. Our outreach and

stakeholder engagement will also allow us to better align our work with agency priorities for conifer encroachment work, such as the BLM and NRCS. We have found over the years that these alignments often yield multiple resource benefits and costs savings in implementing projects and we will develop this project with that in mind.

D. Department of Interior Priorities

1. *Creating a conservation stewardship legacy second only to Teddy Roosevelt:*
   a. *Utilize science to identify best practices to manage land and water resources and adapt to changes in the environment;*
      - We rely on the best science developed by our agency partners when identifying needs and priorities, including fish population studies, rangeland and forest health, and hydrologic parameters. Our group is the key entity that turns those resource needs into discreet projects. Our use of state-of-the-art UAS technology in past projects have allowed us to track project results with high resolution topography, and vegetation change and we will continue to deploy that technology as needed.

   b. *Examine land use planning processes and land use designations that govern public use and access;*
      - We will continue to implement our Drought management program and in the course of our outreach will identify land use designation issues that come up.

   c. *Revise and streamline the environmental and regulatory review process while maintaining environmental standards.*
      - N/A

   d. *Review DOI water storage, transportation, and distribution systems to identify opportunities to resolve conflicts and expand capacity;*
      - We will stay actively engaged with the USGS and the Water Policy Interim Committee on its review and plans for stream gage funding for the State.

   e. *Foster relationships with conservation organizations advocating for balanced stewardship and use of public lands;*
      - Our partnerships with The Nature Conservancy and The Wildlife Conservation Society will be deepened through this project and pave the way for future partnerships. Our experiences with this project will help inform those organizations, as well as MFWP as to the benefits of restoring the natural resources of our public lands.

   f. *Identify and implement initiatives to expand access to DOI lands for hunting and fishing;*
      - Through the course of our work, locations for improving access may be identified and will be included in our updated Watershed Restoration Plan.

   - *Shift the balance towards providing greater public access to public lands over restrictions to access.*
      - o The improvement of habitat conditions from this project and prioritization will improve wildlife viewing and angling opportunities in this watershed.

2. *Utilizing our natural resources:*
   a. *Ensure American Energy is available to meet our security and economic needs;*

- N/A

b. *Ensure access to mineral resources, especially the critical and rare earth minerals needed for scientific, technological, or military applications;*
    - N/A

c. *Refocus timber programs to embrace the entire 'healthy forests' lifecycle;*
    - N/A

d. *Manage competition for grazing resources.*
    - N/A

3. Restoring trust with local communities:

a. *Be a better neighbor with those closest to our resources by improving dialogue and relationships with persons and entities bordering our lands;*
    - The success of this project will catalyze conversations between BHWC and stakeholders and encourage improved dialogue on important issues in the watershed.

b. *Expand the lines of communication with Governors, state natural resource offices, Fish and Wildlife offices, water authorities, county commissioners, Tribes, and local communities.*
    - Our outreach efforts will certainly increase our engagement with state resource authorities and county partners.

4. Striking a regulatory balance

a. *Reduce the administrative and regulatory burden imposed on U.S. industry and the public;*
    - N/A

b. *Ensure that Endangered Species Act decisions are based on strong science and thorough analysis.*
    - N/A

5. Modernizing our infrastructure

a. *Support the White House Public/Private Partnership Initiative to modernize U.S. infrastructure;*
    - N/A

b. *Remove impediments to infrastructure development and facilitate private sector efforts to construct infrastructure projects serving American needs;*
    - N/A

c. *Prioritize DOI infrastructure needs to highlight:*
    1. *Construction of infrastructure;*
        - N/A
    2. *Cyclical maintenance;*
        - N/A
    3. *Deferred maintenance.*
        - N/A

2. Project Budget

Total Project Cost Table

SOURCE	AMOUNT
Costs to be reimbursed with the requested Federal funding	$99,999.32
Costs to be paid by the applicant	$15,000.00
Value of third party in-kind contributions	$ 0.00
TOTAL PROJECT COST	**$ 114,999.32**

Proposed Project Budget

WORK ITEMS (ITEMIZE BY CATEGORY)	ESTIMATED QUANTITY	UNIT DESCRIPTION	COST/UNIT	TOTAL COST
Goal: Grow Stakeholder Base				
Salaries and Wages: BHWC Personnel				
Hours: Project Administration	120	$/Hour	$30.00	$3,600.00
Hours: Project Coordination	80	$/Hour	$23.00	$1,840.00
Hours: Associate Director	100	$/Hour	$26.00	$2,600.00
			Goal Subtotal	*$8,040.00*
Goal: Update Watershed Restoration Plan				
Salaries and Wages: BHWC Personnel				
Hours: Project Administration	200	$/Hour	$30.00	$6,000.00
Hours: Project Coordination	140	$/Hour	$23.00	$3,220.00
Hours: Associate Director	200	$/Hour	$26.00	$5,200.00
			Personnel Subtotal	*$14,420.00*
Contractual/Construction: Contractor C				
GIS specialist- Project prioritization visuals and analysis for report	100		$80.00	$8,000.00
			Goal Subtotal	*$22,420.00*
Goal: Pennington Bridge Design				
Salaries and Wages: BHWC Personnel				
Hours: Project Administration	80	$/Hour	$30.00	$2,400.00
Hours: Project Coordination	80	$/Hour	$23.00	$1,840.00
Hours: Associate Director		$/Hour	$26.00	$0.00
			Personnel Subtotal	$4,240.00
Contractual/Construction: Contractor A				
Engineering Design and Survey- Pennington Bridge	1		$25,000.00	$25,000.00
Contractual/Construction: Contractor B				
Geomorphic and Hydrologic Assessment- Pennington Bridge	1		$12,000.00	$12,000.00
			Goal Subtotal	*$41,240.00*
Goal: Develop Conifer Encroachment Projects				
Salaries and Wages: BHWC Personnel				
Hours: Project Administration	60	$/Hour	$30.00	$1,800.00
Hours: Project Coordination	100	$/Hour	$23.00	$2,300.00

Hours: Associate Director	20	$/Hour	$26.00	$520.00
			Goal Subtotal	*$4,620.00*
BHWC Staff Fringe Benefits all goals		Fringe Rate-%	16%	$5,011.20
All Goals Sub-Total				**$81,331.20**
Indirect Costs: 10%				**$8,133.12**
Supplies				
Mailings, stamps, misc. office supplies	1	LS	500	$475.00
Meeting support- Refreshments, food	1	LS	2000	$2,000.00
			Supplies Sub-Total	**$2,475.00**
Travel Costs	-	-	-	-
Travel-Milage	7000	$0.58/Mile	$0.58	$4,060.00
Travel-Nightly Lodging Costs	50	$80/Night	$80.00	$4,000.00
			Supplies Sub-Total	**$8,060.00**
TOTAL				**$99,999.32**

Budget Narrative

Salaries and Wages

Project Manager Pedro Marques will be the team lead for implementation of this project, relying heavily on support from Project Coordinator Ben LaPorte, and Associate Director, Tana Nulph, staff members of the BHWC. We provide estimated hours for our team to dedicate to each of the project goals. Their staff hours will be allocated to all aspects of the project not covered by the services contracted for the execution of this project- namely the engineering design, geomorphological assessment, and` specialized GIS analysis. BHWC will hold all contracts with our funders and contract all outside services according to State and Federal procurement policies. Staff time for each goal will be directed towards:

- **Grow our stakeholder base**
  - Meet with agency personnel, private landowners, recreationists
  - Produce information materials relating to water supply, drought management concerns, particularly in the lower stretch of the river
  - Update our electronic newsletters and social media

- **Update our watershed restoration plan**
  - Summarize findings of opportunities identified from previous goal in an update of our water restoration plan
  - Review previous studies and revisit stakeholders identified and status of priority projects from earlier efforts
  - Coordinate with Montana DEQ and other specialists throughout the update process to ensure compliance with EPA 9-points requirements
  - Develop maps and imagery for plan not contracted to GIS specialist
  - Promote new WRP document to our stakeholders and general public through social media, our e-newsletters and during public meetings

- Tie WRP document closely to State Water Plan connection between water quality and quantity

- **Pennington Bridge Design**
    - Contract Engineer and Geomorphic specialists to conduct necessary assessments for Pennington Bridge solution
    - Identify and coordinate with potential funders of project construction activities
    - Write Joint Application permits
    - Coordinate with BoR on Cultural compliance as needed (being an active floodplain, we anticipate minimal cultural resource concerns if any).

- **Develop conifer encroachment projects**
    - Meet with landowners and agency personnel on-site to develop conifer projects
    - Identify potential conifer encroachment funding sources and apply for implementation funding
    - Identify best practices for monitoring water yield impacts from conifer encroachment removals

Fringe Benefits

Our organization's standard fringe rate is 16% for all staff costs.

Travel

Our staff will be required to drive from Missoula and Divide to our project sites numerous times to meet with project partners, conduct potential project walk-throughs. Staff will be required to stay overnight on numerous occasions. Local hotel costs have been estimated for these stays. Updated state mileage rates have been included in project costs and an estimated number of miles to drive to and from project sites.

Equipment

We do not anticipate purchasing any equipment for this project.

Materials and Supplies

We estimate that office supplies related to sending out mailings and permits will be required through the duration of the project. We also anticipate that providing refreshments and lunch will help us attract participation by stakeholders to meetings we hold. We have estimated a budget to cover at least 4 engagements in which food/refreshments will be offered.

Contractual

Under our goal to update our Watershed Restoration Plan, we will require the services of a professional GIS expert in order to summarize resource, ownership, and water supply information we collect during our stakeholder outreach task. We have used average costs in our area for an independent contractor to perform these services and provide us with high quality maps for our restoration planning document. These deliverables will include water supply and water use summaries important for our understanding of critical water supply and distribution in the lower river.

Under our Pennington Bridge goal, we will require a geomorphological assessment of the feasibility of our conceptual design. This work will help us fine-tune our proposed solution to re-activate a river side channel to decrease stream velocity against the vulnerable bank.

Upon consultation with geomorphologist, we will contract an engineer to survey and draft a construction document for the proposed solution.

We will follow State of Montana and Federal procurement guidelines to solicit contractors for all contracted expenses related to this project.

Environmental and Regulatory Compliance Costs
None anticipated for the project.

Indirect Costs
BHWC will use the *de minimus* indirect rate of 10% for our administrative/management role in this project. These costs will cover operation and maintenance costs, our legal and accounting fees that cover payroll.

Funding Plan and Letters of Commitment

The BHWC s 20-year track record of collaborative work for the benefit of our resources has attracted the support of our agency partners and has the support of our board of directors.
BoR funding for the first two goals of this work will provide documented prioritization of water storage projects in the lower river, which will help us leverage project implementation dollars from other relevant sources, in particular for the Pennington Bridge and conifer encroachment projects.

Funding under this project is critical to BHWC establishing the rationale and justification for our proposed project work. We are actively coordinating with entities like the NRCS, Montana DEQ, US Forest Service, BLM, the Montana Department of Natural Resources and Conservation as well as Madison County to identify appropriate project implementation funding sources.

In-kind Contributions
BHWC will provide in-kind contributions of our time from some of our standard outreach activities, such as monthly public meetings and the use of our electronic newsletter and social media to raise awareness to the issues we are pursuing. These in-kind contributions are estimated in the project table above. While we anticipate substantial time being invested by our stakeholders in meeting with us to accomplish our project goals, those third-party in-kind contributions are not estimated at this time.

3. Environmental and Cultural Resources Compliance

A majority of the activities foreseen under this project will occur prior to completed design documents for projects that may impact cultural resources. Without those specific project locations and documents, we cannot accurately anticipate costs for cultural compliance at this time. The Pennington Bridge and Conifer Encroachment projects will require cultural assessments, which will be contracted once we have a clearer picture of the locations and anticipated scope of work. In the case of conifer encroachment, cultural compliance will be mostly be achieved through US Forest Service NEPA processes. As the Pennington project is in an active floodplain, we don't anticipate much conflict with cultural resources as our past experience shows these areas rarely are stable enough to still retain cultural resources.

4. Required Permits and approvals

BHWC will develop a Joint Application for project permitting of the Pennington Bridge project after a project design document is completed. Required approvals for conifer work will be identified depending on land ownership and BHWC will support those efforts.

5. Letters of Project Support

Provided are letters from Montana DNRC, Montana DEQ, and Madison County.

6. Official Resolution

The provided Official Resolution indicates support from our diverse 22-member board of directors for pursuing these watershed planning and project design efforts.

Watershed Group Resolution

The Big Hole Watershed Committee Steering Committee provides leadership for the Big Hole Watershed Committee. The Steering Committee approves of the content and the commitments described in the Big Hole Watershed Committee's Bureau of Reclamation WaterSMART (Phase I) application for funding.

Our Executive Director, Pedro Marques, has the legal authority to enter into an agreement with the WaterSMART program on behalf of the Big Hole Watershed Committee.

The Big Hole Watershed Committee has the experience, infrastructure, and capability to manage funds awarded from the WaterSMART program, provide the required matching funds, and implement the project as described in the application.

The Steering Committee agrees that the Big Hole Watershed Committee will work with the Bureau of Reclamation to meet established deadlines for entering into a financial assistance agreement.

November 12, 2019

Randy Smith, Chairman

Jim Hagenbarth, Vice Chairman

Roy Morris, Secretary

Steve Luebeck, Treasurer

Representative:

Pedro Marques, Executive Director

BHWC Governing Board

Steering Committee

Name	Representing	Location
Randy Smith, Co-Chair	Middle Big Hole Rancher	Glen
Jim Hagenbarth, Co-Chair	Middle Big Hole Rancher	Dillon
Roy Morris, Secretary	George Grant Trout Unlimited	Butte
Steve Luebeck, Treasurer	Sportsman, Fairmont Hot Springs Resort	Butte

Governing Board

Name	Representing	Location
Cindy Ashcraft	Lower Big Hole Rancher, Fishing Lodge Owner	Twin Bridges
Jim Berkey	Conservation Group (The Nature Conservancy)	Missoula/ Dillon
Peter Frick	Resident	Wisdom
Jim Dennehy	Municipal Water (Butte-Silver Bow County)	Butte
Eric Thorsen	Fishing Guide/Outfitter	Melrose
John Jackson	Local Government (Beaverhead County Commissioner)	Dillon
Hans Humbert	Upper Big Hole Rancher	Wisdom
Liz Jones	Middle Big Hole Rancher	Wise River
Mark Kambich	Middle Big Hole Rancher	Divide
Vacant	Conservation Group (Big Hole River Foundation)	Butte
Erik Kalsta	Middle Big Hole Rancher	Melrose
Vacant	Conservation District (Beaverhead Conservation District); Rancher	
Dean Peterson	Upper Big Hole Rancher	Jackson
Phil Ralston	Middle Big Hole Rancher	Wise River
John Reinhardt	Middle Big Hole Rancher	Wise River
Bill Kemph	Fishing Guide/Outfitter	Dillon
Paul Cleary	Resident	Glen
Andy Suenram	Resident	Glen
Mark Raffetty	Lower Big Hole Rancher	Glen
Ray Weaver	Upper Big Hole Rancher	Wisdom

Self-Certification of Watershed Group Status

The Big Hole Watershed Committee (BHWC) is a grassroots, non-regulatory entity that addresses water availability and quality issues within the Big Hole River watershed, represents a diverse group of stakeholders, and is capable of promoting the sustainable use of water resources in the watershed.

BHWC is composed of a Governing Board that represents diverse interests including: ranching, utilities, local government, sportsmen, conservationists, tourism, and outfitters. Representatives from local, state, and federal agencies participate as technical advisers.

Committee Members

- Staff
    - Pedro Marques, Executive Director
    - Tana Nulph, Associate Director
    - Ben LaPorte, Program Manager
- Board Members
    - Randy Smith – Ranching, Middle Big Hole River (Chairman)
    - Jim Hagenbarth – Ranching, Middle Big Hole River (Vice-Chairman)
    - Steve Luebeck – Sportsmen (Treasurer)
    - Roy Morris – George Grant Trout Unlimited (Secretary)
    - Dean Peterson – Ranching, Upper Big Hole River
    - Ray Weaver – Ranching, Upper Big Hole River
    - Peter Frick – Resident
    - Hans Humbert – Ranching, Upper Big Hole River
    - Jim Berkey – The Nature Conservancy
    - Liz Jones – Ranching, Middle Big Hole River
    - John Reinhardt – Ranching, Middle Big Hole River
    - Phil Ralston – Ranching, Middle Big Hole River
    - Jim Dennehy – Butte-Silver Bow County Water Utility Division
    - Mark Kambich – Ranching, Middle Big Hole River
    - Erik Kalsta – Ranching, Middle Big Hole River
    - Eric Thorson – Guiding & Outfitting (Angling)
    - Cindy Ashcraft – Ranching, Lower Big Hole River
    - Paul Cleary – Resident
    - Bill Kemph – Guiding & Outfitting (Angling)
    - Mark Raffety – Ranching, Lower Big Hole River
    - John Jackson – Beaverhead County Commission
    - Andy Suenram – Resident

Restated Articles of Incorporation
of
Big Hole Watershed Committee
A Non-Profit Corporation

Pursuant to Montana Code Annotated Section 35-2-226, the Big Hole Watershed Committee adopts these Restated Articles of Incorporation.

Article 1

The name of this corporation is the BIG HOLE WATERSHED COMMITTEE.

Article 2

The organization is a public benefit corporation.

Article 3

The name and address of the registered agent and registered office of this corporation is Randy Smith, #1 Hartwig Lane, Glen, MT 59732 with a mailing address at P.O. Box 21, Divide, MT 59727.

Article 4

Said organization is organized exclusively for charitable, educational, and scientific purposes, including for such purposes the making of distributions to organizations that qualify as exempt organizations under section 501 (c) (3) of the Internal Revenue Code, or corresponding section of any future federal tax code.
No part of the net earnings of the organization shall inure to the benefit of, or be distributable to its members, trustees, officers, or other private persons, except that the organization shall be authorized and empowered to pay reasonable compensation for services rendered and to make payments and distributions in furtherance of the purposes set forth in the purpose clause hereof. No substantial part of the activities of the organization shall be the carrying on of propaganda, or otherwise attempting to influence legislation, and the organization shall not participate in, or intervene in (including the publishing or distribution of statements) any political campaign on behalf of any candidate for public office. Notwithstanding any other provision of this document, the organization shall not carry on any other activities not permitted to be carried on (a) by any organization exempt from federal income tax under section 501 (c) (3) of the Internal Revenue Code, corresponding section of any future federal tax code, or (b) by any organization, contributions to which are deductible under section 170 (c) (2) of the Internal Tax Code, or corresponding section of any future federal tax code.

Upon the dissolution of the organization, assets shall be distributed for one or more exempt purposes within the meaning of section 501 (c) (3) of the Internal Revenue Code, or corresponding section of any future federal tax code, or shall be distributed to the federal government, or to a state or local government, for the public purpose. Any such assets not disposed of shall be disposed of by the Court of Common Pleas of the county in which the principal office of the organization is then located, exclusively for the purposes or to such organization or organizations, as said court shall determine, which are organized and operated exclusively for such purposes.

Article 5

The period of duration of this corporation is perpetual.

Article 6

The corporation shall have no members.

Article 7

The directors of the corporation shall not be liable to the corporation or its members for monetary damages for breach of a directors' duties to the corporation or its members, except for (a) breaches of the directors' duty of loyalty to the corporation or its members, (b) acts or omissions not in good faith or that involve intentional conduct or a knowing violation of the law, (c) transactions from which a director derived an improper economic benefit, or (d) conflict of interest transactions, loans to or guaranteed for directors and officers or unlawful distributions.

Article 8

The corporation may amend these articles in a manner authorized by law at the time of the amendment.

Article 9

These Restated Articles of Incorporation supersede the original Articles of Incorporation and all amendments thereto.

DATED: ____________________________

BY: ____________________________________

Board Officer Signature, Title

____

Printed Name

Mission Statement

The mission of the Big Hole Watershed Committee is to seek understanding and agreement among groups and individuals with diverse viewpoints on water use and management in the Big Hole River watershed of Southwest Montana.

Self-Certification of Regular Meetings

The Big Hole Watershed Committee holds 8-9 public board meetings per year as well as one annual business meeting that is attended by staff and board members only. We meet on the third Wednesday of each month, excluding July and December. Meetings are occasionally, though infrequently, cancelled due to weather or conflicting schedules.

DEQ
Montana Department
of Environmental Quality

November 8, 2019

Bureau of Reclamation
Financial Assistance Support Section
Attn: Ms. Alisha James
P.O. Box 25007
Denver, CO 80225

RE: Big Hole Watershed Committee

Dear Ms. James,

The Montana Department of Environmental Quality Watershed Protection Section (WPS) is submitting this letter to express support for the WaterSMART Cooperative Watershed Management Program proposal being submitted by the Big Hole Watershed Committee (BHWC). We have a long standing relationship with the BHWC and have committed over $850,000 to them over the past five years for projects that improve water quality by restoring natural stream processes.

The BHWC has a long history of support from ranchers and other local interests that provide salience and legitimacy to their actions. This support enables BHWC to develop projects that provide sustainable solutions for multiple resource benefits including water quality improvements, natural water storage, and fish and wildlife habit enhancements. Continued work to engage new stakeholders will further their ability to find and develop additional projects within the watershed.

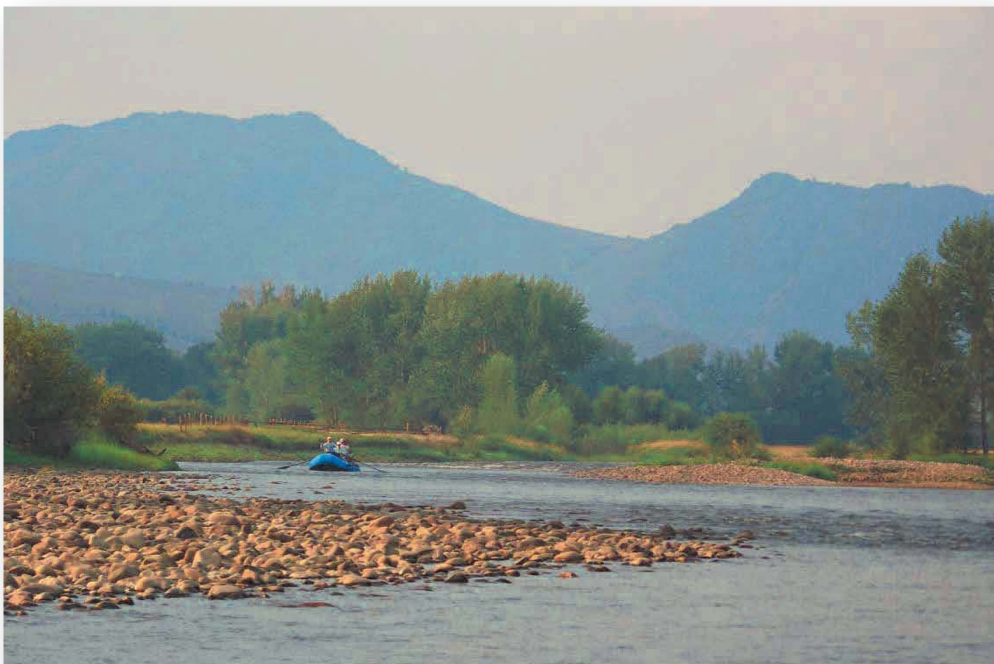
The BHWC has demonstrated on-the-ground accomplishments as well timely and thorough reporting. Funding through this WaterSMART opportunity will ensure new and successful projects in the future.

Sincerely,

Kristy Fortman, Section Supervisor
Montana Department of Environmental Quality
Watershed Protection Section
1520 E 6th Ave
Helena, MT 59601
Email: Kristy.Fortman@mt.gov
(406) 444-7425

Big Hole River, Montana Watershed Restoration Plan

Part II: Middle & Lower Big Hole Watershed



Produced by:
Big Hole Watershed Committee

Final
August 29, 2013

Big Hole Watershed Committee

PO Box 21

Divide, Montana 59727

e-mail: info@bhwc.org

website: bhwc.org

Produced with Funds and Support from:

Montana Department of Environmental Quality 319 Program

Helena, Montana

Table of Contents

Tables

Figures

Acronyms

BDNF	Beaverhead-Deerlodge National Forest
BHWC	Big Hole Watershed Committee
BHRF	Big Hole River Foundation
BLM	Bureau of Land Management
CCAA	Candidate Conservation Agreement with Assurances
DEQ	Montana Department of Environmental Quality
EPA	Environmental Protection Agency
ESA	Endangered Species Act
MFWP	Montana Fish, Wildlife and Parks
NRDP	Natural Resources Damages Program
TMDL	Total Maximum Daily Load
USFS	United States Forest Service
USFWS	US Fish & Wildlife Service

A Note on Spelling:

It is common for creeks or locations to have several spellings for the same location. A single spelling is used in this document when applicable:

Case 1: Pintlar versus Pintler: Pintlar Creek is the spelling used in the TMDL document from which this plan is based, and therefore used in this document. Pintler Creek is the spelling used on maps and other resources. Since the Anaconda-Pintler Wilderness is a title, “Pintler” is retained. Where “Pintler” is used in text from the USFS plan, Pintler is retained since this is a direct quote from the Forest Plan.

Case 2: Pattengail versus Pettengill: Pattengail Creek is the spelling used in the TMDL; therefore, “Pattengail” is used widely in this document. MFWP and USFS used Pettengill; therefore , “Pettengill” is retained where their information is a direct quote.

Project Area

The Big Hole River watershed is located in southwest Montana (**Figure 1**). The colored areas within the watershed represent public lands and the white areas represent private lands. The Big Hole River headwaters begin in the south-west corner of the watershed and flow north, then east, to its confluence with the Beaverhead River near Twin Bridges. There are two watershed restoration plans at work in the Big Hole River watershed. The black line shows the division between two watershed restoration plans:

Part I: Upper & North Fork Big Hole River Watershed Restoration Plan (separate document)

Part II: Middle & Lower Big Hole River Watershed Restoration Plan (this document)

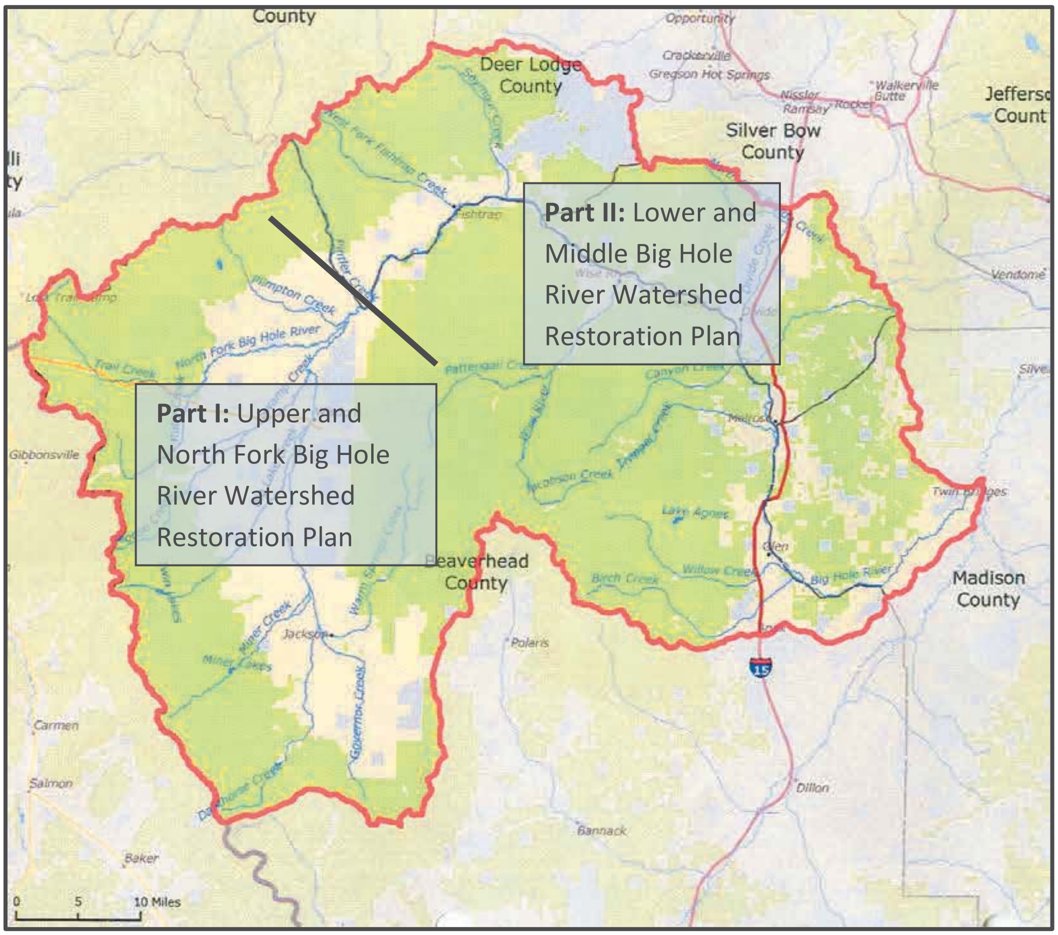


Figure 1: Big Hole River Watershed, Montana

Executive Summary

The Watershed Restoration Plan is a coordinated document that outlines restoration in terms of impacts, goals, objectives, and measures of improvement. The plan serves to coordinate restoration efforts among stakeholders.

There are four active watershed restoration plans in place in the Middle-Lower Big Hole watershed beyond this watershed restoration plan. The four plans are the US Forest Service (USFS) Beaverhead Deerlodge Forest Plan, Bureau of Land Management's (BLM) Watershed Assessments and Land Health Evaluations, Upper Big Hole Candidate Conservation Agreement with Assurances (CCAA) program, and the Montana Fish, Wildlife and Parks Statewide Fisheries Management Plan (see **Figure 2**).

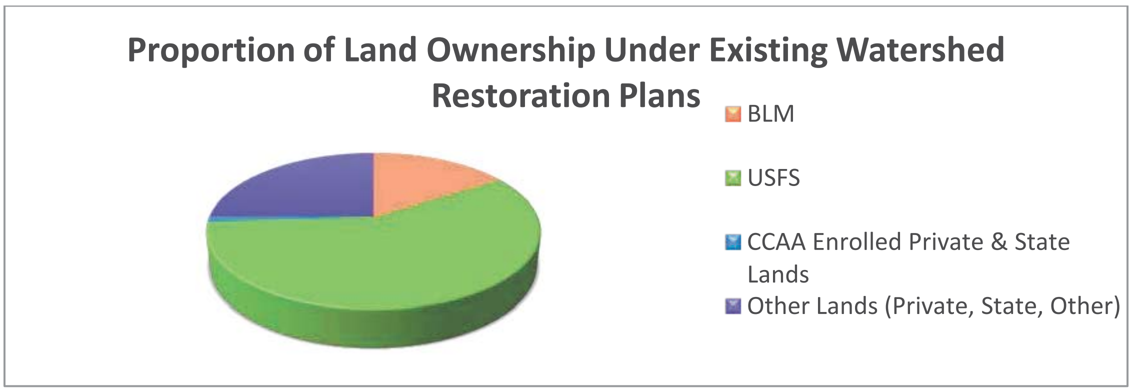
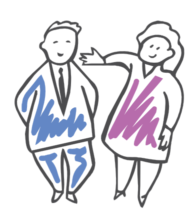


Figure 2: Proportion of land ownership in the Middle-Lower Big Hole watershed managed under existing watershed restoration plans.

The primary water quality issues of concern in the Middle-Lower Big Hole watershed are high water temperature, often attributed to low flows due to drought and irrigation withdrawals and the lack of riparian vegetation, and high sediment loads resulting from channel and bank erosion changes that occur as a result of riparian vegetation loss. Improvement in water temperature and sediment issues are often difficult to track given that changes occur over years or decades and varies with natural changes in precipitation and air temperature. In some cases high nutrients and high metals may also be a water quality issue, but typically on a local scale.

The Middle & Lower Big Hole Planning Area TMDL was completed in 2009 (Montana DEQ, September 2009). Significant effort towards watershed restoration has occurred since the information for the TMDL was collected in 2005.



It is important to focus on land managers interested in making water quality improvements and to continue to implement projects that will decrease water temperature and increase stream flows. This occurs through riparian vegetation, grazing management, irrigation infrastructure upgrades, and wetlands restoration.

Purpose

This Watershed Restoration Plan was compiled by the Big Hole Watershed Committee (BHWC). The BHWC serves as a coordination hub and communication group between interests in the Big Hole Valley, including private land owners, residents, agencies, conservation groups, sportsman, and guides/outfitters.

The goal of this plan is to provide a coordinated approach to restoration in the Big Hole. The Middle-Lower Big Hole Valley is unique in that there are several active restoration plans already in place. These existing plans have varied goals, such as to improve the fishery, forest health, or range production. However, many of the activities used to achieve these goals also have a positive effect on water quality. Identifying plan goals and activities that include water quality benefits can be a cost effective way to improve water quality in the Middle-Lower Big Hole. The BHWC determined the best approach to accomplish watershed restoration in the Middle-Lower Big Hole was to

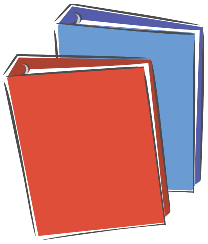
1. Compile the existing efforts into one concise resource (this plan)

2. Coordinate efforts among interests and encourage communication.

3. Support planned activity, either with in-kind, implementation, financial, or other support

4. Advocate including water quality benefits in planned projects.

Watershed Restoration Planning



A Watershed Restoration Plan is a guiding document that outlines watershed restoration goals and needs to address non-point source pollution. The plan describes actions to occur over a 3-5 year period. It is designed to be a working document that is reviewed and updated as needed. The goals and needs outlined will help watershed groups and stakeholders clearly meet objectives and coordinate efforts between stakeholders.

The Big Hole River watershed is divided into two sections - the Upper & North Fork Big Hole River and Middle & Lower Big Hole River. There is a watershed restoration plan for each section. The plans were developed with support from Montana Department of Environmental Quality 319 program.

The Environmental Protection Agency (EPA) developed a protocol for Watershed Restoration Plan development. Each Watershed Restoration Plan should contain the following 9 minimum elements:

1. Identification of causes of impairment (Section I)
2. An estimate of the load reductions expected from management measures (Section III)
3. A description of the nonpoint source management measures that will need to be implemented to achieve load reductions (Section III)
4. Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan (Section IV)
5. An information and education component to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented (Section IV)
6. Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious (Section IV)
7. A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented (Section V)
8. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards (Section V)
9. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established (Section VI)

The Big Hole Watershed Committee

The Big Hole Watershed Committee (BHWC), established 1995, seeks common ground among diverse viewpoints for watershed restoration and preservation in the Big Hole River watershed.

Mission: *"To seek understanding of the Big Hole River and agreement among individuals and groups with diverse viewpoints on water use and management in the Big Hole watershed."*

The BHWC operates within four focus areas, each with a priority initiative:

1. Land Use Planning: Climate resiliency, specifically riparian protection standards and incentives for landowners to preserve riparian systems.

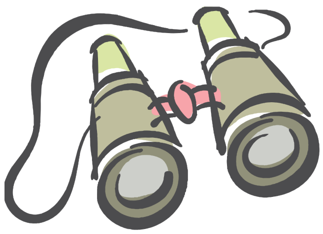
2. Wildlife: Reduce predator-human conflict with non-lethal deterrence

3. Water Quality & Quantity: Gain climate resiliency, specifically in water scarcity & high water temperature. Actions are through management plans, monitoring, research, and restoration activities. This includes the use of wetlands as a tool to improve or maintain water quality.

4. Invasive Species: Reduce and prevent invasive species infestation, particularly noxious weeds.

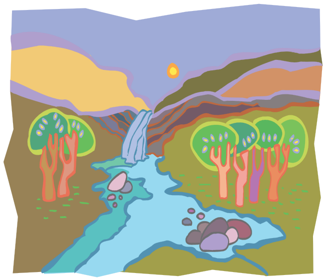
More information is available on our website: **bhwc.org**

Vision



The Big Hole watershed hosts fully functioning aquatic ecosystems and supports and sustains a viable ranching economy. Biological populations and water quality are monitored closely. The watershed is resilient to drought and other climate pattern changes. Plans are in place to adjust human activities during drought to sustain aquatic systems. Its residents are invested in watershed health. Provisions are in place to protect sensitive areas of the watershed in perpetuity. Efforts to improve or protect the watershed are coordinated among interest groups.

Watershed Characterization

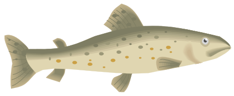


The Middle-Lower Big Hole River watershed is a high elevation valley. The landscape is rural. The valley bottom is primarily private lands used for cattle ranching and hay production sustained by flood irrigation. The uplands are primarily public lands managed by USFS, BLM, or State of Montana. Public lands are often leased by ranches for cattle grazing. The Anaconda-Pintler Wilderness is located at the most upstream portion of the Middle-Lower Big Hole watershed. Population is sparse. Several small towns dot the river bottom, including Wise River, Dewey, Divide, Melrose, and Glen. The confluence of the Big Hole River with the Jefferson River is near the town of Twin Bridges. The Big Hole River is a headwater tributary to the Missouri River. It begins near the town of Jackson at the Continental Divide. The Middle-Lower Watershed begins at the confluence of Pintlar Creek with the Big Hole River and ends at the rivers confluence with the Jefferson River. See **Table 1** for watershed details. Attention has been directed towards this watershed as it is home to the Arctic grayling, a fish that faced significant decline in the 1970-1980's and a candidate for endangered species listing. Significant focus has been placed on actions and plans to recover the species over the last two decades.

Table 1: Watershed Characterization ***(note: The spellings of "Pintler Creek" and "Pintlar Creek" are synonymous and refer to the same creek.)***

Description	Pintlar Creek to Confluence with Beaverhead River
Miles of river in Middle-Lower Big Hole River • Middle Big Hole River (Pintlar Creek to Divide Creek) • Lower Big Hole River (Divide Creek to Beaverhead River)	95.2 miles • 43.8 miles • 51.4 miles
Watershed Area	1,021,021 acres; 1596 square miles
Counties	Beaverhead, Anaconda-Deer Lodge, Madison, Butte-Silver Bow
Land Ownership	USFS: 58% Private: 20% BLM: 16% State: 6%
Fish Species of Special Concern	Westslope Cutthroat Trout Yellowstone Cutthroat Trout Arctic Grayling
High Priority Abandoned Hard Rock Mine Sites (14 mines) (See Table Page 33 of TMDL (Montana DEQ, September 2009))	4 located in Silver Bow County, located in Moose Creek, Camp Creek, Soap Gulch and Maiden Rock. 3 located in Madison County, located in Rochester Creek and Nez Perce Creek. 7 located in Beaverhead County, located in Trapper Creek, Lost Creek, Birch Creek and Wise River.

Sensitive Species



There are 32 Montana Fish, Wildlife and Parks Animal Species of Concern in the Middle-Lower Big Hole watershed. The most prominent aquatic species sensitive to water quality are described below. A full Animal Species of Concern list is provided in **Table 2**.

The Fluvial Arctic Grayling and the CCAA Program

Montana FWP: Species of Special Concern
USFWS: Candidate for Endangered Species Listing
USFS: Sensitive Species
BLM: Sensitive Species

The Fluvial Arctic grayling (*Thymallus arcticus*) is a member of the trout family. The Big Hole River is the last remaining native population in the lower 48 states. They spawn in the spring and their diet is largely made up of aquatic insects. While the grayling can be found throughout the Big Hole River drainage, the majority of the population resides in the Upper Big Hole and the upper portion of the Middle Big Hole. Therefore, much of the restoration effort and future needs are driven by the habitat needs of the Arctic grayling. The grayling require cold and clear waters. They are typically a small fish with an identifiable large, iridescent dorsal fin. (Montana Field Guide)

<u>Candidate Conservation Agreement with Assurances (CCAA) Program</u>: In the Upper and Middle-Lower Big Hole, the BHWC is a partner in an ambitious conservation and restoration initiative known as the Candidate Conservation Agreement with Assurances or CCAA. The Big Hole CCAA is the largest of its kind in the United States. Bringing together local, state, and federal agencies, private landowners, non-profit organizations and many other parties, the CCAA develops restoration projects targeted to the last remaining population of fluvial Arctic grayling in the lower 48 states. Montana Fish, Wildlife & Parks (MFWP) and US Fish & Wildlife Service (USFWS) determined that the most immediate human-influenced threats to fluvial Arctic grayling in the Big Hole River are habitat loss, degradation, and fragmentation. *The CCAA proposes to remediate those threats by addressing the following four issues: reduced streamflows; degraded and non-functioning riparian habitats; barriers to fish migration; and entrainment in ditches.* The agencies "have developed a phased implementation schedule to provide immediate and long-term benefits to grayling, facilitate maximum landowner participation, and enable development of meaningful site-specific plans that are tailored to (each) property," including a monitoring plan. (Montana Fish, Wildlife and Parks and the U.S. Fish and Wildlife Service, 2006)

<u>Legal Status of Fluvial Arctic Grayling:</u> On April 24, 2007 the USFWS determined that the grayling population in the upper Missouri River basin was no longer warranted for listing under the ESA. This determination removed grayling from the Candidate Species List. Grayling remain a "Species of Special Concern" in Montana. On November 15, 2007 a lawsuit was filed by the Center for Biological Diversity, the Grayling Restoration Alliance, the Federation of Flyfishers and the Western Watersheds Project to overturn the USFWS decision not to list the grayling population in the upper Missouri River basin as

either Threatened or Endangered. In the settlement agreement, the Service agreed to publish a new status review finding on or before August 30, 2010. As part of the settlement, the Service agreed to consider the appropriateness of a Distinct Population Segment (DPS) designation for Arctic grayling populations in the upper Missouri River basin. Since the 2007 finding, additional research has been conducted and new information on the genetics of Arctic grayling has become available. As a result, on September 8, 2010, the Service determined that listing the upper Missouri River basin as a DPS of Arctic grayling, as threatened or endangered under the Endangered Species Act is warranted, but that listing the fish is precluded at this time by the need to complete other listing actions of a higher priority. In 2011, the Center for Biological Diversity reached an agreement with the USFWS to move forward on listing decisions on 757 species, including the Arctic grayling. Under the settlement, a final listing proposal is due in 2014. (Montana Fish, Wildlife and Parks, 2012)

Westslope Cutthroat Trout

Montana Fish, Wildlife and Parks: Species of Special Concern
USFWS: NA
USFS: Sensitive
BLM: Sensitive

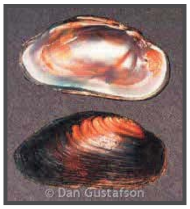
The Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi)* is one of two cutthroat trout species in Montana. The cutthroat is the Montana state fish. The fish is identified by red throat slashes and black spots on the body. The cutthroat population is significantly reduced, now occupying less than 3% of its original range. The decline is attributed to hybridization and competition from non-native trout and from habitat degradation. The cutthroat trout requires cool waters with little sediment. They spawn in the spring leaving their eggs in redds made in the gravels. Westslope cutthroat trout restoration is active in the Big Hole watershed. (Montana Field Guide)

Western Toad

Montana Fish, Wildlife and Parks: Species of Concern
USFWS: N/A
USFS: Sensitive
BLM: Sensitive

The Western Toad (*Bufo boreas*) is, with one rare exception, the only toad species in western Montana. The Western Toad may occupy a wide range of habitat types including wetlands, dry conifer forest and aspen stands, streams, and wet meadows. The toad reproduces in the spring. Their eggs and larvae require shallow, still water for survival through the summer. The toad eats live insects. Specialists recommend the following actions to benefit toads in their known breeding sites: Reduce grazing and avoid pesticide use in and near, avoid stocking predatory game fish if not already present, and remove toads prior to use lethal stream treatments on the fishery. (Montana Field Guide)

Western Pearlshell Mussel



Montana Fish, Wildlife and Parks: Species of Concern
USFWS: N/A
USFS: Sensitive
BLM: N/A

The Western Pearlshell (*Margaritifera falcata*) is the only mussel to live in Montana's coldwater streams in habitats that typically also house westslope cutthroat trout. Their typical size range is between 50-80mm long. Threats to this species include impoundments, siltation and eutrophication (resulting from high nutrients). (Montana Field Guide)

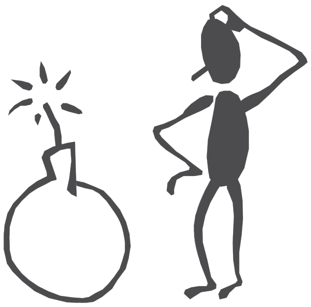
Table 2: Montana animal Species of Concern located in the Middle –Middle Lower Big Hole watershed (Montana Natural Heritage)

Species *Latin Name* Common Name	**Habitat**
Mammals	Sagebrush
Gulo gulo Wolverine	Boreal Forest and Alpine Habitats
Martes pennanti Fisher	Mixed conifer forests
Lasiurus cinereus Hoary Bat	Riparian and forest
Myotis thysanodes Fringed Myotis (Bat)	Riparian and dry mixed conifer forests
Brachylagus idahoensis Pygmy Rabbit	Sagebrush
Corynorhinus townsendii Townsend's Big-eared Bat	Caves in forested habitats
Birds	
Ardea herodias Great Blue Heron	Riparian forest
Strix nebulosa Great Gray Owl	Conifer forest
Accipiter gentilis Northern Goshawk	Mixed conifer forests
Catharus fuscescens Veery	Riparian forest
Haemorhous cassinii Cassin's Finch	Drier conifer forest
Leucosticte atrata Black Rosy-Finch	Alpine
Nucifraga columbiana Clark's Nutcracker	Conifer forest
Numenius americanus	Grasslands

Long-billed Curlew	
Spizella breweri Brewer's Sparrow	Sagebrush
Falco peregrinus Peregrine Falcon	Cliffs / canyons
Certhia americana Brown Creeper	Moist conifer forests
Otus flammeolus Flammulated Owl	Dry conifer forest
Dryocopus pileatus Pileated Woodpecker	Moist conifer forests
Centrocercus urophasianus Greater Sage-Grouse	Sagebrush
Buteo regalis Ferruginous Hawk	Sagebrush grassland
Artemisiospiza belli Sage Sparrow	Sagebrush
Oreoscoptes montanus Sage Thrasher	Sagebrush
Athene cunicularia Burrowing Owl	Grasslands
Rhynchophanes mccownii McCown's Longspur	Grasslands
Dolichonyx oryzivorus Bobolink	Moist grasslands
Fish	
Oncorhynchus clarkii lewisi Westslope Cutthroat Trout	Mountain streams, rivers, lakes
Thymallus arcticus Arctic Grayling	Mountain rivers, lakes
Oncorhynchus clarkii bouvieri Yellowstone Cutthroat Trout	Mountain streams, rivers, lakes
Amphibians	
Anaxyrus boreas Western Toad	Wetlands, floodplain pools
Invertebrates	
Euphydryas gillettii Gillette's Checkerspot (Butterfly)	Wet meadows
Margaritifera falcata Western Pearlshell (Mussel)	Mountain streams, rivers
Leucorrhinia borealis Boreal Whiteface (Dragonfly)	Forested Wetlands

- *For More Information:* **Montana Natural Heritage - Animals of Concern**

Section I: What is the Problem? Causes of Impairment in the Middle-Lower Big Hole Watershed



Non-point source impairments to water quality in the Middle-Lower Big Hole watershed include high water temperature, sediment, nutrients and metals (**Table 3**). Factors that contribute to water quality impairments are largely human caused due to agriculture (grazing and hay production), historic mining, development, and forest land practices (roads and timber harvest); however weather patterns and natural causes also are contributing factors. Impairments in the Middle-Lower Big Hole River can largely be attributed to a loss of riparian vegetation resulting in channel changes. Other water quality issues include dewatering, nutrient influx, abandoned mines and unpaved roads. As a result, streams may be listed on Montana DEQ's list of impaired waters. Listed streams in the Middle-Lower Big Hole are presented in **Table 4** and **Figure 3**.

Table 3: Water quality impairments, causes, and remedies in the Big Hole River watershed. See for detailed impairments by sub watershed and stream. Source: (Montana DEQ, September 2009)

Water Quality Impairment	Cause of Impairment	Remedy
Temperature	Lack of riparian vegetation for shade Low summer time stream flows Widened channels	Restore Riparian Vegetation to: 1 Provide shade 2. Reduce width-to-depth ratios 3. Absorb nutrients 4. Reduce bank erosion 5. Prevent additional sediment inputs 6. To catch sediment before reaching the stream Improve Irrigation Efficiency Prevent sediment from washing into streams from roads. Use wetlands as a means to attain water quality
Nutrients	Natural sources Upland grazing runoff Streambank erosion Fertilizer use Animal feeding operations	
Sediment	Streambank erosion Upland erosion Erosion off unpaved roads Historic mining	
Metals	Abandoned mines Natural sources	
Other Watershed Issues	**Cause of Issue**	**Remedy**
Arctic grayling	High water temperature Low stream flows Entrainment in ditches	Riparian vegetation restoration to decrease water temperature Improve irrigation efficiency Provide fish passage or exclusion

Table 4: Sub-watersheds, 2012 listed streams, and their impairment sources (4 pages). See Table 16 and Table 17 for details. See Figure 3 for map. See page 84 for sub-watershed summaries.

	Water body & Stream Description	Probable Cause of Impairment
Big Hole River Mainstem	**Big Hole River –Middle Segment** Pintlar Creek to Divide Creek	**Copper** **Lead** **Temperature** Alteration in stream-side or littoral vegetative cover Low flow alterations Physical substrate habitat alterations **Sedimentation/ Siltation**
	Big Hole River –Lower Segment Divide Creek to the mouth at Jefferson River	Cadmium Copper Lead Zinc **Temperature** Low flow alterations Physical substrate habitat alterations
Big Hole River - Fishtrap Creek	**Fishtrap Creek** Confluence of West & Middle Forks to mouth (Big Hole River)	Alteration in stream-side or littoral vegetative cover Low flow alterations Phosphorus (Total) **Sedimentation/ Siltation**
	Sawlog Creek Tributary to Big Hole River	Alteration in stream-side or littoral vegetative cover Arsenic Phosphorus (Total) **Sedimentation/ Siltation**

	Water body & Stream Description	Probable Cause of Impairment
Deep Creek	**Corral Creek** Headwaters to mouth (Deep Creek)	Alteration in stream-side or littoral vegetative cover Physical substrate habitat alterations **Sedimentation/ Siltation**
	Deep Creek Headwaters to mouth (Big Hole River)	Alteration in stream-side or littoral vegetative cover Low flow alterations **Sedimentation/ Siltation**
	California Creek Headwaters to mouth (French Cr-Deep Creek)	**Arsenic** Iron **Copper** Dewatering Bank erosion **Sedimentation/ Siltation** Riparian degradation **Turbidity** Fish habitat degradation
	French Creek Headwaters to mouth (Deep Creek)	**Arsenic** **Copper** **Sedimentation/ Siltation**
	Oregon Creek Headwaters to mouth (California Creek - French Creek - Deep Creek)	Alteration in stream-side or littoral vegetative cover **Arsenic** **Copper** Lead Other anthropogenic substrate alterations Physical substrate habitat alterations **Sedimentation/ Siltation**
	Twelvemile Creek Headwaters to mouth (Deep Creek)	Sedimentation/ Siltation
	Sevenmile Creek Headwaters to mouth (Deep Creek)	Alteration in stream-side or littoral vegetative cover **Sedimentation/ Siltation**
	Sixmile Creek Headwaters to mouth (California Creek)	Physical substrate habitat alterations **Sedimentation/ Siltation**
Wise River	**Elkhorn Creek** Headwaters to mouth (Jacobson Creek-Wise River)	**Arsenic** **Cadmium** **Copper** **Lead** **Zinc** **Sedimentation/ Siltation**
	Gold Creek Headwaters to mouth (Wise River)	Alteration in stream-side or littoral vegetative cover Phosphorus (Total) **Sedimentation/ Siltation**
	Grose Creek Headwaters to mouth (Big Hole River)	Alteration in stream-side or littoral vegetative cover Other flow regime alterations **Phosphorus (Total)** **Sedimentation/ Siltation**
	Pattengail Creek Headwaters to mouth (Wise River)	Alteration in stream-side or littoral vegetative cover Physical substrate habitat alterations **Sedimentation/ Siltation**
	Wise River Headwaters to mouth (Big Hole River)	Alteration in stream-side or littoral vegetative cover Low flow alterations Physical substrate habitat alterations **Sedimentation/ Siltation** **Copper, Lead, Cadmium**

	Water body & Stream Description	Probable Cause of Impairment
Big Hole River - Divide	**Charcoal Creek** Tributary of the Big Hole River	Nitrogen (Total) Phosphorus (Total) Sedimentation/ Siltation
	Jerry Creek Headwaters to mouth (Big Hole River)	Alteration in stream-side or littoral vegetative cover **Copper** Excess algal growth Lead Low flow alterations Physical substrate habitat alterations **Sedimentation/ Siltation**
	Delano Creek Headwaters to mouth	Alteration in stream-side or littoral vegetative cover **Sedimentation/ Siltation**
Divide Creek	**Divide Creek** Headwaters to mouth (Big Hole River)	Alteration in stream-side or littoral vegetative cover Low flow alterations **Phosphorus (Total)** **Sedimentation/ Siltation** **Temperature** **Total Kjeldahl Nitrogen (TKN)**
Big Hole River - Melrose	**Moose Creek** headwaters to mouth (Big Hole River)	Low flow alterations **Sedimentation/ Siltation**
	Camp Creek headwaters to mouth (Big Hole River)	Alteration in stream-side or littoral vegetative cover Arsenic Low flow alterations **Phosphorus (Total)** **Sedimentation/ Siltation** **Solids (suspended/bedload)**
	Trapper Creek Headwaters to mouth (Big Hole River)	Alteration in stream-side or littoral vegetative cover **Copper** **Lead** **Zinc** **Arsenic** **Cadmium** Low flow alterations Physical substrate habitat alterations **Sedimentation/ Siltation**
	Lost Creek	Alteration in stream-side or littoral vegetative cover **Arsenic** **Nitrogen (Total)** **Phosphorus (Total)** **Sedimentation/ Siltation**
	Wickiup Creek Tributary to Camp Creek (Big Hole River)	Alteration in stream-side or littoral vegetative cover Bottom deposits **Copper** Lead Mercury Phosphorus (Total)
	Canyon Creek Headwaters to mouth (Big Hole River)	Low flow alterations **Sedimentation/ Siltation**
	Soap Creek Headwaters to mouth (Big Hole River)	Alteration in stream-side or littoral vegetative cover **Nitrogen (Total)** **Phosphorus (Total)** **Sedimentation/ Siltation**
	Sassman Gulch Headwaters to mouth (Big Hole River)	Arsenic

	Water body & Stream Description	Probable Cause of Impairment
Lower Big Hole River	**Birch Creek** Headwaters to the USFS Boundary	**Sedimentation/ Siltation** Alteration in stream-side or littoral vegetative cover Low flow alterations Physical substrate habitat alterations
	Birch Creek USFS Boundary to mouth (Big Hole River)	Physical substrate habitat alterations Low flow alterations Other anthropogenic substrate alterations Alteration in stream-side or littoral vegetative cover **Sedimentation/ Siltation**
	Rochester Creek Headwaters to mouth (Big Hole River)	**Arsenic** **Copper** **Lead** **Mercury** Physical substrate habitat alterations **Sedimentation/ Siltation**
	Willow Creek Headwaters to mouth (Big Hole River)	Low flow alterations Sedimentation/ Siltation

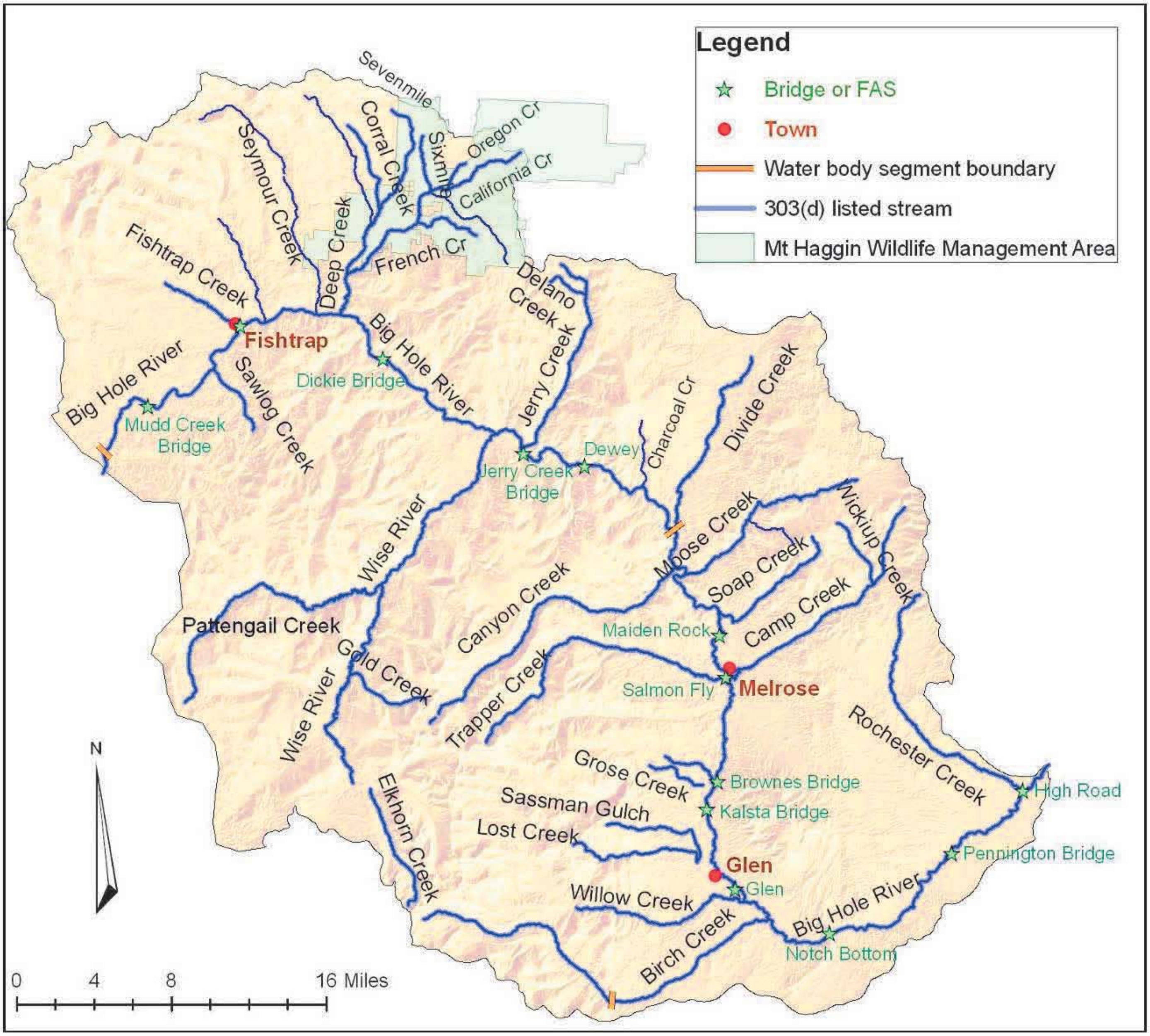


Figure 3: Middle-Lower Big Hole watershed impaired water bodies. From Middle-Lower Big Hole Planning Area TMDLs and Water Quality Improvement Plan Appendix A-2 (Montana DEQ, September 2009).

Section II. Who Addresses Water Quality Issues?

This section identifies key players in the Big Hole River watershed that work under plans that ultimately improve water quality:

- Montana Department of Environmental Quality (DEQ)
- US Forest Service: Beaverhead Deerlodge National Forest (USFS)
- Bureau of Land Management (BLM)
- CCAA/US Fish and Wildlife Service (CCAA)
- Montana Fish, Wildlife and Parks (MFWP)
- Big Hole Watershed Committee (BHWC)

Each plan has unique goals, work areas, and action plans. This section provides a summary of each plan and reference to each plan. This watershed restoration plan incorporated the goals and actions identified in the other plans in order to create a coordinated approach to watershed restoration.

Water Quality: Montana Department of Environmental Quality

The TMDL & Impaired Waters List:

The Middle & Lower Big Hole River Planning Area TMDLs (Total Maximum Daily Loads) and Framework was finalized in 2009 (Montana DEQ, September 2009). The TMDL summarized non-point source water quality impairments, targets for restoration, and guidelines for restoration for the mainstem Big Hole River and several tributaries. A non-point source pollutant cannot be tied to a single source as the source is widespread. In contrast, a point source pollutant can be tied to single location or source. A summary of the impairments listed in the TMDL are provided in **Table 4**.

Every two years, DEQ publishes a Water Quality Integrated Report that includes a list of impaired waters (Appendix A) (Montana DEQ, March 2012). Streams found on this list are not meeting one or more beneficial uses for water quality. There are four beneficial uses: 1. Drinking Water, 2. Aquatic Life, 3. Agriculture, 4. Recreation. The intention of this list is to provide a list of impaired waters in which TMDLs have been developed or need to be developed (303(d) list). A list of impaired waters and 303(d) listed streams in the Middle-Lower Big Hole watershed is provided in **Table 4**, **Table 16** and **Table 17.** Links to these resources are also provided:

- **Montana 2012 Water Quality Integrated Report**
- **Montana Impaired Waters List Summary (Appendix A of Integrated Report)**
- **303d lists on CWAIC**
- **Middle-Lower Big Hole River Planning area TMDL and Framework**

The TMDL produced for the Middle-Lower Big Hole developed targets that can be used to assess progress towards meeting water quality goals. The targets are described in detail in the TMDL document in Tables 5-2, 6-2, 7-4 and 8-1 (Montana DEQ, September 2009). Four impairments and the measures used in the targets are described in **Table 5.**

Table 5: TMDL Target Summary

Impairment	Target Measures
Temperature	Maximum Allowable Temperature Over Naturally Occurring Temperatures, or Riparian Shade Channel Width-Depth Ratio Irrigation Water Management Inflows to Stream
Sediment	Percent Fine Sediment Channel Width-Depth Ratio Pool Frequency Fish Population BEHI (Bank Erosion Hazard Index)Rating Eroding Banks Riparian Shrub Cover Along Green Line Macroinvertebrate Assessment Periphyton Human Caused Sources
Nutrients	Total Nitrogen NO_3+NO_2 as N Total Phosphorous Chlorophyll a Human Caused Sources Riparian Shrub Cover Along Green Line Percent Bare Ground Along Green Line
Metals: Cadmium, Copper, Mercury, Zinc and Lead	Montana's Numeric Water Quality Standards Supplemental Indicators Periphyton Sediment Metal Concentrations Human Caused Sources

USFS Beaverhead - Deerlodge Forest Plan

The US Forest Service Beaverhead-Deerlodge National Forest (BDNF) adopted a Forest Plan in 2009 (US Forest Service, 2009). The plan covers the entire forest of 3.38 million acres, of which the Middle-Lower Big Hole watershed is a part. The BDNF manages for four forest services and commodities: recreation, timber, grazing, and leasable minerals. Within the plan, BDNF addresses several natural resource and forest condition goals, objectives and standards (listed in Table 6). A link to the plan is provided:

- Beaverhead Deerlodge National Forest Plan

Table 6: USFS Beaverhead Deerlodge National Forest Plan - Resource Categories. Each category lists goals, objectives and standards. (US Forest Service, 2009)

Resource Categories - Chapter 3 of Forest Plan
Forest Wide
Air Quality
American Indian Rights & Interests
Aquatic Resources
Economic & Social Values
Fire Management
Heritage Resources
Infrastructure
Lands
Livestock Grazing
Minerals, Oil, Gas
Recreation & Travel Management
Scenic Resources
Soils
Special Designations
Timber Management
Vegetation
Wildlife Habitat

The plan outlines a move by the USFS to manage lands with an aquatics focus. New additions include the installation of a 300 foot buffer on each side of the stream to protect riparian zones, project work must not have a negative impact on aquatic resource without mitigation in key watersheds, and the creation of key watersheds for either 1) Fish, representing the highest quality watersheds, and 2) Restoration, representing the most impacted watersheds that are in need of restoration. As part of the plan, grazing plans are being reviewed to update grazing management and travel management is under review to address roads and road maintenance (US Forest Service, 2009). Appendix H of the Forest Plan outlines the key watersheds. The Middle-Lower Big Hole key watersheds are provided in Table 7 and Figure 4.

Table 7: USFS Beaverhead Deerlodge National Forest Key watersheds in the Middle-Lower Big Hole watershed. (US Forest Service, 2009)

Key Watershed	Resource Emphasis
Seymour Creek	Restoration
Sullivan Creek	Restoration
Deep Creek	Fish
Upper Jerry Creek	Fish
Cherry Creek	Fish
Lost Creek	Restoration
Willow Creek (Upper and Lower)	Restoration
Birch Creek	Restoration

USFS Watershed Assessments in Middle-Lower Big Hole Watershed

See Also:

- Fleecer Mountains Watershed Assessment
- Birch Willow Lost Watershed Assessment

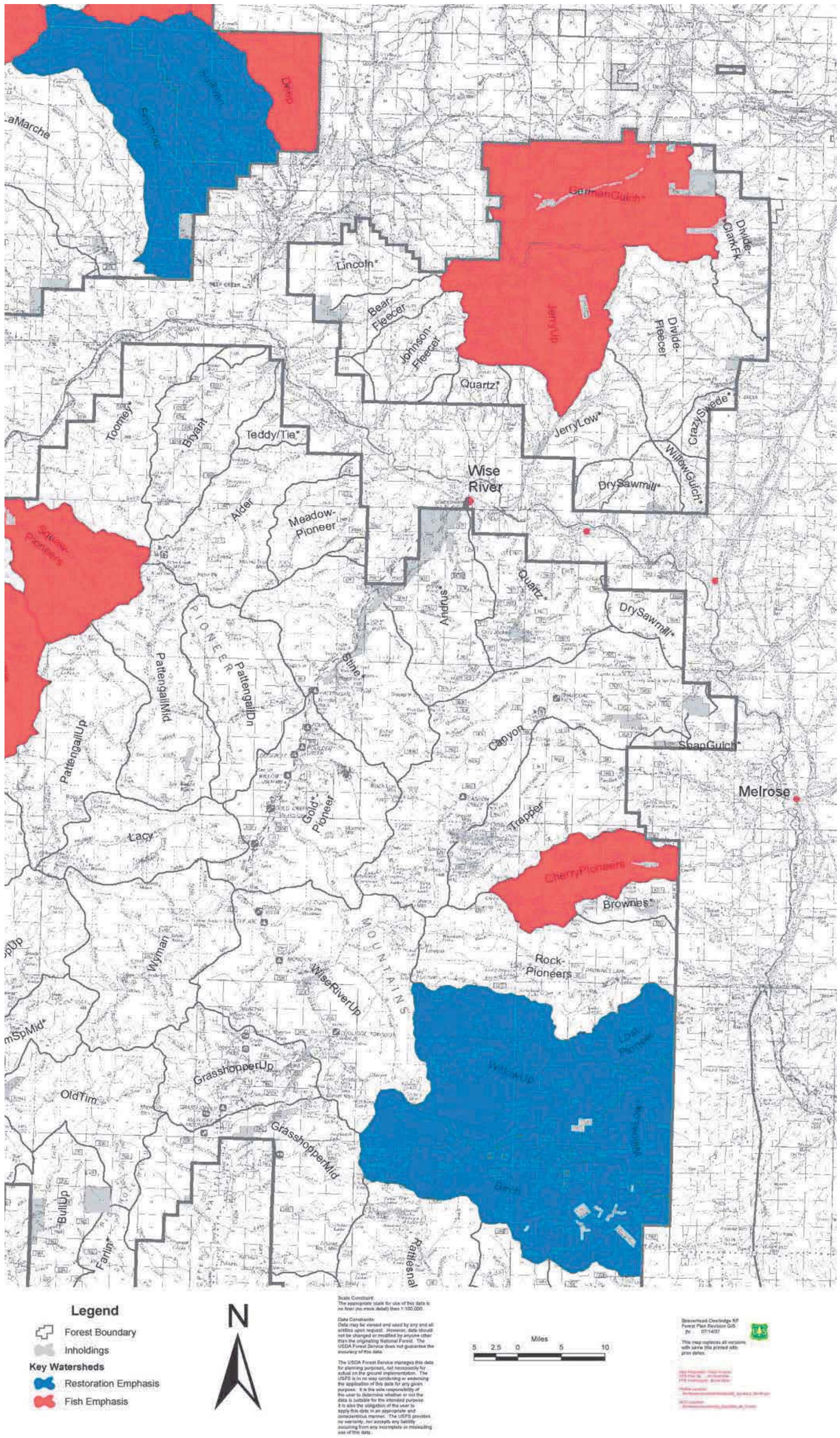


Figure 4: USFS Beaverhead Deerlodge National Forest Plan - Key watersheds. Note: This map is cropped from its original size to show only the Middle-Lower Big Hole watershed. (US Forest Service, 2009)

The Forest Plan defines the area for the Middle-Lower Big Hole watershed in the "Management Area Direction: Big Hole Landscape."

The USFS Forest Plan specifically addresses water quality and the TMDL as "Total Maximum Daily Loads (TMDLs): Management actions are consistent with TMDLs. Where waters are listed as impaired and TMDLs and Water Quality Restoration Plans are not yet established, management actions do not further degrade waters. Water quality restoration supports beneficial uses." (US Forest Service, 2009).

The USFS also manages the Anaconda-Pintler Wilderness. The wilderness area is 158,516 acres and contains the headwaters of streams originating in the upper portion of the Middle-Lower Big Hole watershed, including Mudd Creek, Fishtrap Creek, LaMarche Creek, and Seymour Creek. Motorized travel is not allowed in the wilderness.

USFS Strategy

The USFS Beaverhead Deerlodge National Forest Plan outlines specific goals, objectives and standards for forest management in each category, one of which is Aquatic Resources, as "Chapter 3: Forestwide Direction." This chapter, and specifically the Aquatic Resources portion, details specific plans for how the USFS intends to meet water quality and other aquatic resources needs. Additional criteria are applied to the key watersheds described in section 1 of this document, a minimum of which is no negative ecological response in fish key watersheds. The objectives of the Aquatic Resources section is provided here, beginning on page 13 of the Forest Plan

- **Chapter 3: Forestwide Direction**

The following is a direct excerpt from the Forest Plan. Use the link above to see the entire document.

Objectives

Vegetation Management: Manage vegetation to reduce the risk of adverse wildfire impacts to isolated native fish populations and water resources at the sub-watershed scale (6th Code HUC).

TMDLs: Cooperate with the state, tribal, and other agencies and organizations to develop and implement Total Maximum Daily Loads (TMDLs) and their implementation plans for 303(d) impaired water bodies influenced by National Forest System lands.

Watershed Analysis: Prepare and maintain a schedule for completing watershed analysis, with emphasis on key watersheds shown on page 58, or listed in Appendix H (IN).

Management Indicator Species: Maintain habitat conditions for native species as reflected by changes in abundance of *Drunella doddsi* (Mayfly) as a Management Indicator Species (MIS).

Restoration Key Watersheds: Complete watershed assessments for restoration key watersheds and associated restoration activities.

Spawning Areas: Reduce impacts from grazing practices in known or suspected threatened, endangered or sensitive fish spawning areas to avoid or reduce trampling of redds that may result in adverse impacts to threatened or endangered species, loss of viability, or a trend toward federal listing of sensitive species **(**GM 4**).**

Riparian Management Objectives: Establish stream specific Riparian Management Objectives (RMOs) using watershed or other analyses incorporating data from streams at or near desired function. RMOs are a means to define properly functioning streams and measure habitat attributes against desired condition. The following RMOs apply by stream reach until new RMOs are developed through watershed or other site specific analysis,

(West of the Continental Divide) *(not included in this document)*

(East of the Continental Divide)

- Entrenchment Ratio (all systems) Rosgen Channel: A - <1.4, B – 1.6 – 1.8, C - >10.3, E ->7.5.
- Width/Depth Ratio (all systems) Rosgen Channel: A - <11.3, B – <15.8, C - <28.7, E -<6.9.
- Sediment Particle size, % < 6.25mm (all systems) Stream Type: B3 - <12, B4 - <28, C3 - <14, C4 - <22, E3 - <26, E4 - <28.
- Large Woody Debris: (forested systems) >20 pieces per mile, > 6 inch diameter, >12 foot length.
- Bank Stability: (nonforested systems) >80% stable.

Wildland Fire Management: Suppression activities are designed and implemented so as not to prevent attainment of desired stream function, and to minimize disturbance of riparian ground cover and vegetation. Strategies recognize the role of fire in ecosystem function and identify those instances where fire suppression actions could perpetuate or damage long-term ecosystem function or native fish and sensitive aquatic species (FM 1).

Temporary Fire Facilities: Incident bases, camps, helibases, staging areas, helispots and other centers for incident activities are located outside of RCAs. An interdisciplinary team, including a fishery biologist, is used to predetermine incident base and helibase location during pre-suppression planning (FM 2).

Fire Suppression: Chemical retardant, foam, or additives are not delivered to surface waters. Guidelines (fire management plan) are developed to identify exceptions in situations where overriding safety or social imperatives exist (FM 3).

Mineral Inspection: Mineral activities are inspected and monitored. The results of inspections and monitoring are evaluated and applied to modify mineral plans, leases, or permits as needed to eliminate impacts that prevent attainment of desired stream function and avoid adverse effects on threatened and endangered aquatic species and adverse impacts to sensitive aquatic species (MM 6).

Road Drainage: Reconstruct road and drainage features that do not meet design criteria or operation and maintenance standards, or are proven less effective than designed for controlling sediment delivery, or retard attainment of desired stream function, or increase sedimentation in Fish or Restoration Key Watersheds (RF 3a).

Roads: Close and stabilize or obliterate and stabilize roads not needed for future management activities (RF 3c).

Recreation Sites: Existing, new, dispersed, or developed recreation sites and trails in RCAs are adjusted if they retard or prevent attainment of desired stream function, or adversely affect threatened or endangered species or adversely impact sensitive species. Adjustments may include education, use limitations, traffic control devices, increased maintenance, and relocation of facilities (RM 1).

Bull Trout Restoration: Prioritize bull trout restoration activities with consideration given to bull trout core areas population status and health. Coordination will occur with USFWS, other federal, state, and local agencies.

End excerpt from USFS Forest Plan, Chapter 3

Bureau of Land Management

The Bureau of Land Management (BLM) holds land in several locations in the Middle-Lower Big Hole watershed. The lands are managed by two field office: Butte Field Office and Dillon Field Office. Most BLM lands in the watershed are used primarily as leased grazing allotments. In the middle segment, the BLM also holds lands that are used often by recreationists.

The Dillon field office has completed several watershed assessments throughout the Big Hole. The Butte field office uses more site specific assessments called Land Health Evaluation Reports. Each evaluation reviews land health and water quality and provides recommendations based on reports. **Table 8** summarizes the evaluation results pertaining to water quality.

Dillon Office: East Pioneer Watershed Assessments

- East Pioneer Watershed Assessment
- Beaverhead West Watershed Assessment (Small , most north-east portion)

Butte Office: Land Health Evaluation Reports (to link to report, Ctrl + Click on allotment name)

- **Copp-Jackson Allotment**
- **Deep Creek Allotment**
- **Indian Creek Allotment**
- **Jerry Creek Allotment**
- **Moose Creek AMP Allotment**
- **Moose Creek Non-AMP Allotment**
- **Alder Creek Allotment**
- **Charcoal Mountain Allotment**
- **Dickie Allotment**
- **Foothills Allotment**
- **Harriet Lou Allotment**
- **Leffler Allotment**
- **Quartz Hill Allotment**

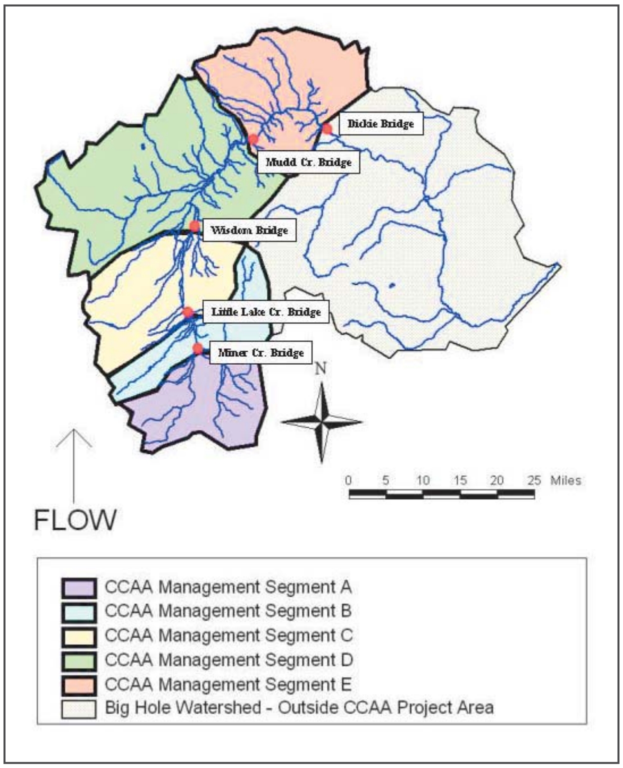
Table 8: BLM Allotments and Watershed Assessments pertaining to water quality (Source: See links to allotments and watershed assessments above)

Allotment	Sub-Watershed	Impaired Stream?	Meeting Riparian Standard? Cause?
Copp-Jackson	Big Hole River-Divide	No	Yes
Deep Creek	Deep Creek	Yes	Yes
Indian Creek	Big Hole River - Divide	No	No - Sedimentation
Jerry Creek	Big Hole River - Divide	Yes	No – Vegetation Loss
Moose Creek AMP	Big Hole River - Melrose	Yes	No – Channel degradation
Moose Creek Non-AMP	Big Hole River Melrose	Yes	Not Applicable
Alder Creek	Big Hole River - Fishtrap	No	Yes
Charcoal Mountain	Big Hole River - Divide	Yes	Yes
Dickie	Big Hole River - Fishtrap	No	Not Applicable
Foothills	Wise River	No	Yes
Harriet Lou	Wise River	No	Yes
Leffler	Big Hole River - Divide	No	Yes
Quartz Hill	Big Hole River - Divide	No	Yes
East Pioneer	Big Hole River Melrose Lower Big Hole River	Yes: Birch Creek Willow Creek Lost Creek	Varied

CCAA Program

The Candidate Conservation Agreement with Assurances (CCAA) program assesses and identifies impairments for restoration on lands enrolled in the CCAA program (**Figure 5**). Each land is assessed individually and the results of the assessment are largely confidential. Each land is required to follow guidelines for restoration and for meeting milestones in order to be part of the program. Program staff reviews lands for riparian condition, irrigation infrastructure condition, noxious weed infestation, and so on. More information is available in the CCAA plan and can be accessed using the following link:

- **Candidate Conservation Agreement with Assurances for Fluvial Arctic Grayling in the Upper Big Hole River**



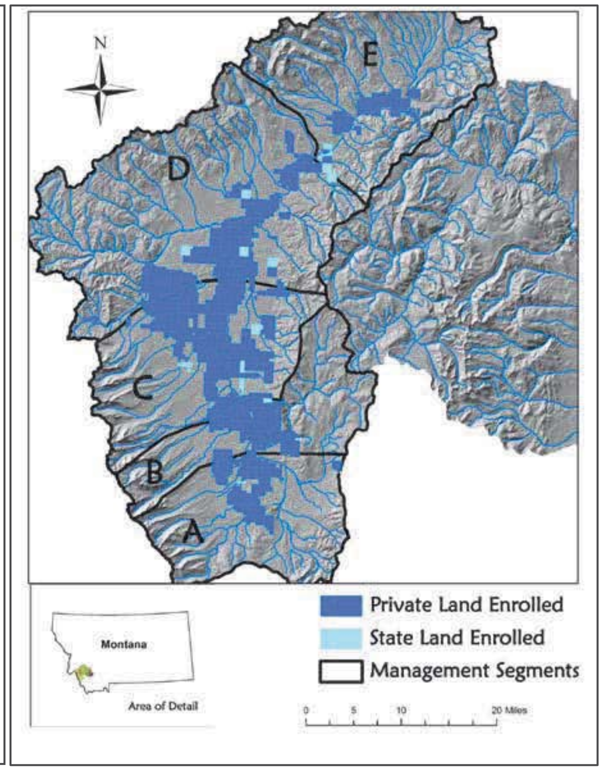


Figure 5: Left: CCAA Management Sections. Right: Area of state and private land enrolled into the Big Hole Grayling CCAA Program since August 1, 2006.

The CCAA program implements strategies and reviews progress to improve the Arctic grayling fishery through six mechanisms:

I. Fisheries Population Monitoring

II. Entrainment Surveys

III. Instream Flow Monitoring

IV. Instream Temperature Monitoring

V. Channel Morphology Measurements

VI. Riparian Health Monitoring

The strategies are in place to achieve three goals:

1. Improve riparian and channel function - Includes channel restoration, riparian fencing, willow planting, stockwater systems, grazing management plans, weed control.

2. Improve instream flows - Include communication, education, hydrological monitoring network, flow/drought management plans, improved infrastructure, programmatic effort.

3. Provide connectivity to important life-history habitats - includes improving stream flows, improve channel function, remove barriers - i.e. fish ladders, culvert replacements, minimize/eliminate entrainment.

The overarching goals of the program are two positive indicators:

1. Numbers of Arctic grayling show a positive population trend.

2. Arctic grayling occupy historic habitat.

CCAA Strategy

The CCAA program works towards five positive indicators. Progress towards these goals are measured and reviewed annually and every 5 years (Montana Fish, Wildlife and Parks and the U.S. Fish and Wildlife Service, 2006):

- Improve riparian and channel function - Measure: Sustainable Riparian Areas in 15 Years
- Improve instream flows - Measure: Meet established flow targets
- Provide connectivity to important life-history habitats - Measure: Increased fish distribution/use
- There will be and continue to be a positive trend in Arctic grayling numbers
- Arctic grayling will occupy historic habitats within 10 years of CCAA start (2006)

Middle-Lower Big Hole watershed CCAA Segments

The CCAA is divided into five management sections labeled sections A-E. A portion of section D and all of section E are located within the Middle-Lower Big Hole watershed.

Montana Fish, Wildlife and Parks

Montana Fish, Wildlife and Parks (MFWP) prioritize fisheries management work statewide under a Statewide Fisheries Management Plan, approved in 2012 and in action 2013-2018. Follow the link below to view the entire plan:

Montana Fish, Wildlife and Parks Statewide Fisheries Management Plan (Big Hole River, page 219)

The plan contains priorities by species and location for the entire Big Hole watershed. While MFWP works to improve fisheries is species driven, the environment for which these species rely is dependent on good water quality. Therefore, the BHWC can work with MFWP on restoring fish populations by addressing the water quality portion of their habitat needs. Portions of the plan that apply to the Middle-Lower Big Hole portions of the watershed are provided in **Table 9**.

Table 9: MFWP Statewide Fisheries Management Plan priorities for the Big Hole Watershed. This table includes priorities that apply to the Middle-Lower Big Hole River Watershed. The contents of this table for a direct copy from the statewide plan (Montana Fish, Wildlife and Parks, 2012)**. * denotes priority that applies to entire Big Hole River watershed.**

Water	Miles/Acres	Species	Origin	Management Type	Management Direction
Big Hole River and Tributaries - Headwaters to Dickey Bridge	93 miles	Arctic grayling, Lake trout, Mountain whitefish, Burbot, Westslope cutthroat trout Brook trout, Rainbow trout, Brown trout, Hybridized cutthroat trout	Wild Wild	Conservation General/ Special Regulations	Continue native species conservation to maintain a viable, self-sustaining population Continue to manage to minimize potential impact on viability of Arctic grayling and secondarily for recreational angling
Habitat needs and activities: Continue to improve stream flows, improve riparian habitats, improve stream channel form and function, continue to prevent fish entrainment into irrigation ditches.					
Big Hole River and Tributaries - Dickey Bridge to Mouth	72 miles	Brook trout, Rainbow trout, Brown trout, Hybridized cutthroat trout, Mountain whitefish(N)	Wild	General	Maintain present numbers and sizes. Consider increasing angler harvest to reduce numbers if necessary to maintain fish growth and, in some instances, to ensure they are not limiting the viability of westslope cutthroat trout or Arctic grayling populations.
		Westslope cutthroat trout (N)	Wild	Conservation	Continue native species conservation to maintain a viable, self-sustaining population
Habitat needs and activities: Implement and refine drought management plans to minimize impacts on fish populations. Continue to look for opportunities to increase river flows and develop spawning habitat in the Big Hole River downstream from Notch Bottom FAS. Pursue Fishing Access acquisition near High Road Bridge at Twin Bridges and between East Bank FAS and Jerry Creek FAS.					

Wise River and Tributaries	25 miles	Brook trout, Rainbow trout, Brown trout, Hybridized cutthroat trout, Mountain whitefish (N) Westslope cutthroat trout (N)	Wild Wild	General Conservation	Maintain present numbers and sizes. Consider increasing angler harvest to reduce numbers if necessary to maintain fish growth and, in some instances, to ensure they are not limiting the viability of westslope cutthroat trout. Continue native species conservation to maintain a viable, self-sustaining population
Habitat needs and activities: Develop drought management plan for Wise River. Pursue opportunities for habitat improvements in river section from Pettengill Creek to confluence with Big Hole which was affected by the Pettingill Dam breach in 1920's. Determine if Wise River could serve as possible Arctic graying reintroduction area.					
*Mountain Lakes		Westslope cutthroat trout, Hybridized cutthroat trout, Yellowstone cutthroat trout, Rainbow trout, Brook trout, Golden trout	Wild	Put- Take/ General	Monitor mountain lakes. Continue to manage stocking and harvest to maintain present numbers and sizes. Consider increasing angler harvest to reduce numbers if necessary to maintain fish growth. Where appropriate pursue opportunities to expand golden trout into mountain lakes where such management would not conflict with cutthroat conservation.
*Cutthroat Conservation Streams	350 miles	Westslope cutthroat trout and other native fish species	Wild/ Transport	Conservation	Secure populations in tributary streams by removing non-native fish upstream of fish barriers and restoring westslope cutthroat trout.
Habitat needs and activities: Work with Forest Service, BLM and DRNC and private landowners on grazing regimes to minimize livestock impacts to streams. Work on water conservation projects to improve stream flows. Construct or utilize natural fish barriers to preclude non-native fish movement upstream. Remove non-native fish and restore WCT upstream.					

Water	Miles/Acres	Species	Origin	Management Type	Management Direction
Big Hole River and Tributaries - Headwaters to Dickey Bridge	93 miles	Arctic grayling, Lake trout, Mountain whitefish, Burbot, Westslope cutthroat trout Brook trout, Rainbow trout, Brown trout, Hybridized cutthroat trout	Wild Wild	Conservation General/ Special Regulations	Continue native species conservation to maintain a viable, self-sustaining population Continue to manage to minimize potential impact on viability of Arctic grayling and secondarily for recreational angling
Habitat needs and activities: Continue to improve stream flows, improve riparian habitats, improve stream channel form and function, continue to prevent fish entrainment into irrigation ditches.					

Big Hole River and Tributaries - Dickey Bridge to Mouth	72 miles	Brook trout, Rainbow trout, Brown trout, Hybridized cutthroat trout, Mountain whitefish(N) Westslope cutthroat trout (N)	Wild Wild	General Conservation	Maintain present numbers and sizes. Consider increasing angler harvest to reduce numbers if necessary to maintain fish growth and, in some instances, to ensure they are not limiting the viability of westslope cutthroat trout or Arctic grayling populations. Continue native species conservation to maintain a viable, self-sustaining population
Habitat needs and activities: Implement and refine drought management plans to minimize impacts on fish populations. Continue to look for opportunities to increase river flows and develop spawning habitat in the Big Hole River downstream from Notch Bottom FAS. Pursue Fishing Access acquisition near High Road Bridge at Twin Bridges and between East Bank FAS and Jerry Creek FAS.					
Wise River and Tributaries	25 miles	Brook trout, Rainbow trout, Brown trout, Hybridized cutthroat trout, Mountain whitefish (N) Westslope cutthroat trout (N)	Wild Wild	General Conservation	Maintain present numbers and sizes. Consider increasing angler harvest to reduce numbers if necessary to maintain fish growth and, in some instances, to ensure they are not limiting the viability of westslope cutthroat trout. Continue native species conservation to maintain a viable, self-sustaining population
Habitat needs and activities: Develop drought management plan for Wise River. Pursue opportunities for habitat improvements in river section from Pettengill Creek to confluence with Big Hole which was affected by the Pettingill Dam breach in 1920's. Determine if Wise River could serve as possible Arctic graying reintroduction area.					
*Mountain Lakes		Westslope cutthroat trout, Hybridized cutthroat trout, Yellowstone cutthroat trout, Rainbow trout, Brook trout, Golden trout	Wild	Put- Take/ General	Monitor mountain lakes. Continue to manage stocking and harvest to maintain present numbers and sizes. Consider increasing angler harvest to reduce numbers if necessary to maintain fish growth. Where appropriate pursue opportunities to expand golden trout into mountain lakes where such management would not conflict with cutthroat conservation.
*Cutthroat Conservation Streams	350 miles	Westslope cutthroat trout and other native fish species	Wild/ Transport	Conservation	Secure populations in tributary streams by removing non-native fish upstream of fish barriers and restoring westslope cutthroat trout.
Habitat needs and activities: Work with Forest Service, BLM and DRNC and private landowners on grazing regimes to minimize livestock impacts to streams. Work on water conservation projects to improve stream flows. Construct or utilize natural fish barriers to preclude non-native fish movement upstream. Remove non-native fish and restore WCT upstream.					

Big Hole Watershed Committee

The BHWC met with its board members, residents, landowners, agencies, counties and conservation groups to determine the top priorities and methods for watershed restoration planning. The results are consolidated and provided in **Figure 6**.

Figure 6: BHWC Watershed Restoration Planning Goals and Methods

The BHWC implements the goals and methods through four categories:

- Land use planning
- Wildlife
- Weeds/invasive Species
- Water quality/quantity

BHWC Strategy

The BHWC is a strong supporter of the restoration in the entire Big Hole watershed. The BHWC will measure success by:

1. Support and participation or partnership with Middle-Lower Big Hole restoration efforts. This includes continued close contact with agency employees, private landowners, and other stakeholders and continued fiscal support of restoration efforts.

2. Work with private landowners outside of the CCAA program on restoration goals when applicable.

3. Restore natural function ecosystems. Primarily, this means restoring adequate riparian vegetation and appropriate channel shape to meet water quality and fish and wildlife needs. Advocate the use the wetlands in wetland restoration as an important watershed restoration tool to improve water quality.

3. Support installation of functioning headgates, water measurement, and fish passage of every irrigation withdrawal point in the Big Hole watershed. In addition, BHWC supports the use of stockwater tanks to reduce late season irrigation withdrawals and supports the reconfiguration of irrigation systems for overall water savings to maintain instream flows. The BHWC recognizes that increased stream flows are critical to the health of the entire watershed.

4. Engagement and Education: The BHWC role in the restoration is to provide opportunities and encourage participation from stakeholders in activities, learning, listening and education on restoration activities. The BHWC will work to continue and increase support and engagement the restoration. Methods include monthly meetings with presentations, invitations to agencies to present progress and needs, information and announcements posted on website, social media, e-mail and newsletters, host public events called "tours" to view completed work, and more. This is measured by:

- Attendance at BHWC monthly meetings
- Number of social media members
- Number of members and/or annual donations
- Attendance at BHWC "tours" or other public events.
- Participation in BHWC Drought Management Plan

Wetlands for Water Quality

Montana Department of Environmental Quality and Montana Wetlands Legacy Partnership embarked on a project from 2011-2012 to incorporate wetlands into local watershed restoration plans as a means to meet water quality targets set forth by the TMDL. Historically, there has not been a large focus on using wetlands to help meet water quality goals in streams and rivers in the state. Two watershed groups were chosen to serve as a demonstration - the Big Hole and the Gallatin. These two groups were chosen because they were each beginning their watershed restoration plan, neither group had previously done wetland projects, and they represented a diverse area - the Big Hole as a rural and agricultural watershed and the Gallatin as an urban and developed watershed. For two field seasons, watershed representatives worked with Steve Carpenedo of Montana DEQ and Tom Hinz of Montana Wetlands Legacy Partnership to review the existing wetlands capacity, the water quality needs, and identified how wetlands could benefit water quality. Using reports generated by Montana DEQ, potential wetlands projects were sought based on TMDL targets and the potential for wetlands to aid in meeting TMDL targets. The scope and area were narrowed based on TMDL planning areas and the potential for sites to be impacted (See **Figure 7** and **Figure 8**). Sites were reviewed on the ground and a short list of potential projects was generated in Section IV under "Restore". An end goal of the project was to incorporate wetlands into this watershed restoration plan.

Resources

Montana DEQ's Exploring Your Aquatic Resources Mapping Program

Middle-Lower Big Hole River TMDL

Purpose

The BHWC is one of two demonstration watersheds hosted by the Montana Department of Environmental Quality Wetland Program and Montana Wetlands Legacy Partnership. The goal of the program was to incorporate wetlands into watershed restoration planning for watershed groups. Specifically, wetland priorities were established to meet water quality goals within the watershed restoration plan.

Partners

Currently several groups address wetland and water quality related issues. Our partners for this project include:

- Big Hole Watershed Committee
- Montana Department of Environmental Quality Wetland Program
- US Forest Service/Beaverhead-Deerlodge National Forest
- Montana Wetlands Legacy Partnership
- Montana Fish, Wildlife and Parks
- Montana Natural Heritage
- Private Landowners

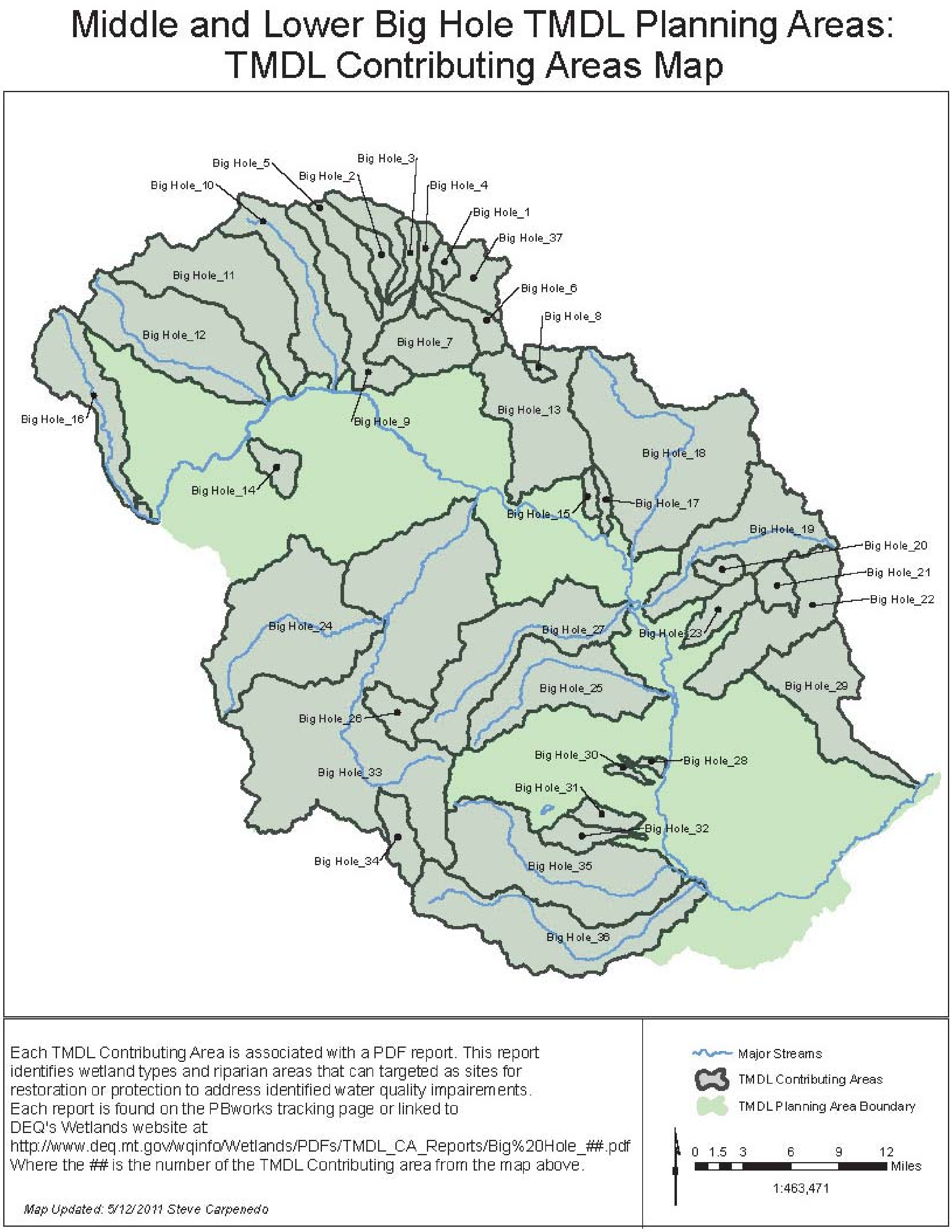


Figure 7: Middle-Lower Big Hole Planning Area TMDL Contributing Areas map. Watershed labels refer to a contributing area report (use the link provided above to see these reports). From Steve Carpenedo, Montana Department of Environmental Quality Wetlands.

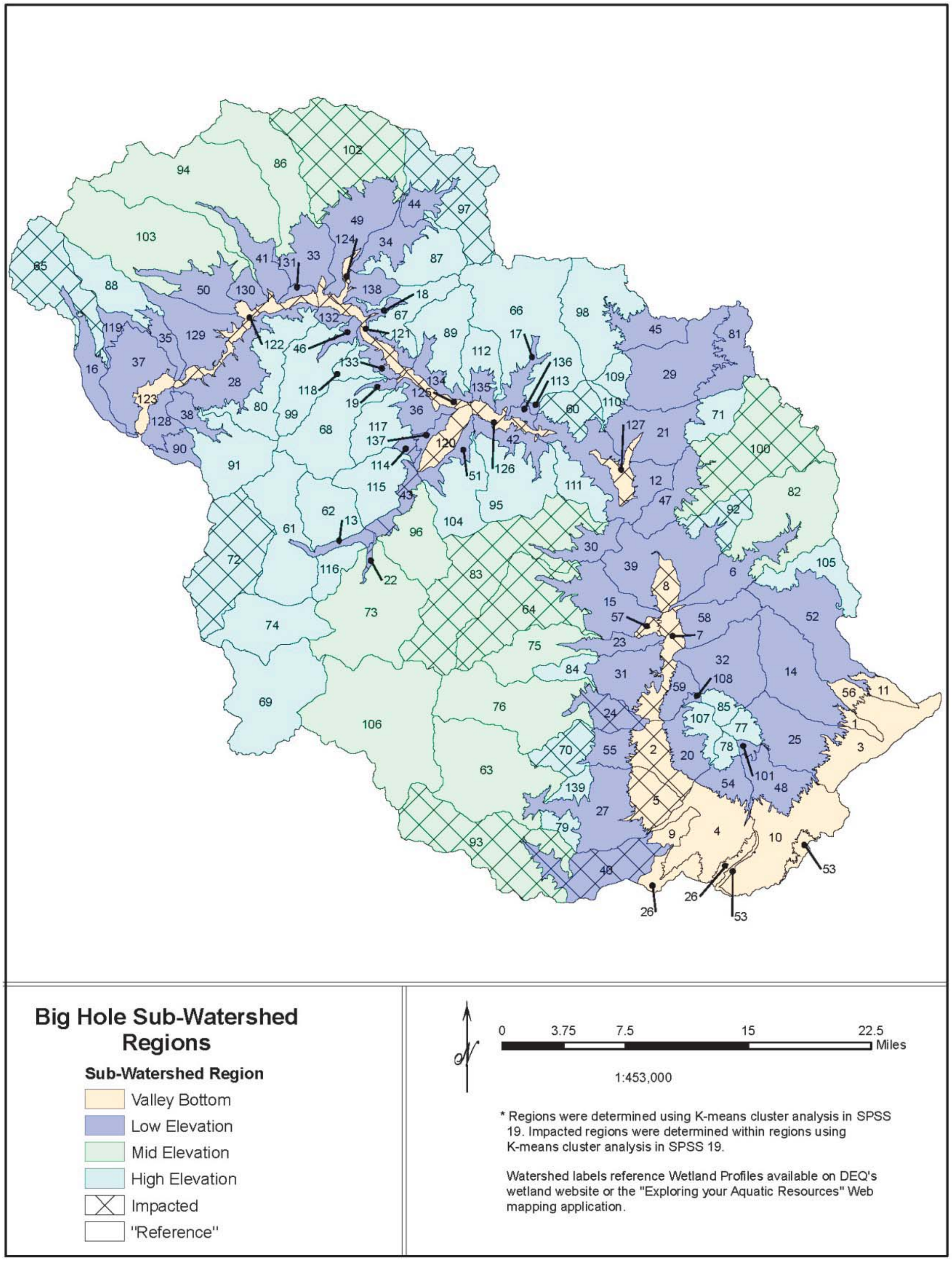


Figure 8: Middle-Lower Big Hole TMDL Planning Area Sub-Watersheds. Cross-hatched watersheds are considered more likely to be impacted based on many factors including roads, mining, irrigation, timber, water quality data, etc. Map created by Steve Carpenedo, Montana Department of Environmental Quality Wetlands. Sub-watershed labels refer to a short report.

Wetlands Goals and Priorities

Primary Goal

Conduct projects that improve or protect existing wetlands or create new wetlands that provide a specific benefit to water quality (nutrients and sediment) and water quantity

Secondary Goal

Conduct projects that improve or protect existing wetlands or create new wetlands that provide a specific benefit to fisheries, especially Arctic grayling and westslope cutthroat trout, and wildlife through water quality and habitat improvements.

Plan & Research

Incorporate wetland goals into watershed planning effort and other plans and policies. Support with research.

Educate

Incporate wetland education into BHWC education strategies, including interpretation, materials, youth, and landowner education.

Restore

Restore non-functional wetland sites. Utilize natural methods where possible.

Preserve/Protect

Seek protections of high quality wetland zones through policy, easement, grazing plans, and other means.

Priority Wetland Reaches:

Priority reaches were selected based on impacted water quality and the availability of wetland resources. See *Figure 3* *for map.*

- **Top Priority: Big Hole River Mainstem - Pintlar Creek to Mouth**
  Mitigate for water temperature by seeking wetlands that will have a direct effect on water temperature, and wetlands that will have an indirect effect on water temperature by improving resiliency through stream flow maintenance, vegetation, and channel shape alteration.
- **Secondary Priority: Impaired Waters**
  Listed tributaries with listings other than metals
  Address tributaries on a case by case basis based on recommendations made by the TMDL, existing and available wetland zones, and sources for water quality improvement. Several tributaries are listed for metals. While metals are a significant negative impact, wetlands were not targeted towards metals reduction for this project. Tributaries with the greatest available wetland potential and identified as impacted watersheds are:
  Top Priority Tributaries:

Fishtrap Creek	*Deep Creek*
Wise River	*Jerry Creek*
Divide Creek	*Trapper Creek*
Willow Creek	*Birch Creek*

Wetlands for Water Quality Objectives

Plan and Research

- Incorporate wetlands prioritization into the Middle-Lower Watershed Restoration Plan.
- Support the wetland prioritization with research and studies.

Education

- Provide wetland interpretation where appropriate, such as within fishing access sites.
- Include wetland function in landowner education efforts.

Restore

- Identify and implement high quality wetland restoration projects that will have direct impact on goals.

Preserve & Protect

- Work with four counties to include wetland protection in county Growth Policies.
- Work with three Conservation Districts on wetland permitting, protection and education.
- Include language for wetland role and protection in the Big Hole Watershed Committees Land Use Planning effort - a committee working towards protection of channel migration zones from development.
- Seek support for landowners to protect lands through easement or other protections. Solicit landowners with identified high quality wetlands to participate in easement.

Section III: What Should the Watershed Look Like?
Water Quality Goals & Priorities

Blended Watershed Restoration Goals

There are several working watershed restoration plans in the Middle-Lower Big Hole watershed. Each varies by location, lead agency or group, and goals. However, many of the actions described in these plans ultimately benefit water quality. These plans work in unison in the Middle-Lower Big Hole watershed and are summarized in Section II of this document.

In order to fully reach watershed restoration and water quality goals in a timely and cost effective manner and to leverage expertise and resources most effectively, it is important to blend goals from the several current watershed restoration plans (see Section II) into one meaningful summary that focuses on watershed restoration. Table 10 combines the goals of each of these plans into seven watershed restoration categories.

Table 10: Blended watershed restoration goals from state, federal, and local groups.

Watershed Restoration Category	Category Goal
Water Temperature	• Improve water temperature, especially during July - September
Stream Flow	• Improve stream flows, especially during July - September
Sediment	• Reduce sediment inputs
Nutrients	• Reduce nutrient inputs
Fish & Wildlife	• Conduct activities that will improve fish and wildlife population, diversity, and native species. • Prevent the decline of species considered threatened or endangered. • Support coexistence with predator species and reduce human-predator conflict. • Reduce the spread of wildlife-cattle diseases.
Weeds/Invasive Species	• Prevent the spread of noxious weeds and invasive species already present. Prevent the introduction of new noxious weeds and invasive species.
Regulatory Protections	• Support existing regulatory protections. • Advocate and support the development and implementation of new regulatory protections. • Advocate for the insertion of watershed protections wherever possible into revision or development processes.

Restoration Priorities and Locations

The top restoration priorities are:

- Repair damaged riparian zones
- Improve irrigation infrastructure, add water measurement and fish passage devices.
- Take all measures possible to improve stream flows and water temperatures. This includes the use of wetlands, voluntary irrigation reductions and improvements, riparian corridors, etc.
- Protect completed restoration and lands in good condition. Incentivize good watershed stewardship.
- Protect the river corridor with land use planning and regulatory protections.
- Promote collaboration among stakeholders

The top restoration priority regions are:

- Section D & E of the CCAA
- USFS Restoration Watersheds Seymour Creek, Sullivan Creek, Lost Creek, Willow Creek and Birch Creek.
- BLM lands allotments not meeting riparian standards or water quality standards
- Stream Restoration:

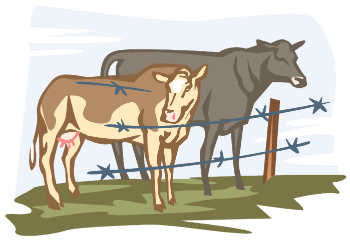
French Creek	*Middle Big Hole River*
Lower Big Hole River	*Big Hole River at Glen*

- Wetlands Top Priority Tributaries:

Big Hole River Mainstem – Pintlar to the mouth

Fishtrap Creek	*Deep Creek*
Wise River	*Jerry Creek*
Divide Creek	*Trapper Creek*
Willow Creek	*Birch Creek*

Best Management Practices



The Big Hole watershed has a reputation for its progressive, grassroots efforts towards watershed restoration. This is largely due to the immense challenges the watershed has faced in the last two decades and the dedication of the people who live and work here. As a result, many of the restoration and management tactics used are bottom-up. That is, they are developed by the people who use them. Therefore, we know the practices are used since they are bought-into, they are reasonable, and they are effective. They are also voluntary, yet there is a high rate of participation and support. Many of the methods rely on conversations, understanding, long-term solutions that work for all (consensus), partnership/coordination, and education. Our Best Management Practices mirror this approach. See Table 11 for Best Management Practices.

Table 11: Best Management Practices

Management Strategy	Watershed Restoration Category	Schedule
Education *Private land ownership and public land manager buy-in to restoration goals is critical to ensure participation and support.*		
Request reporting of progress annually from CCAA program, USFS, BLM and BHWC (Watershed Restoration Plan review, report on progress). Presentations will be made to the BHWC meetings.	All	BHWC meetings occur monthly. Each group will be invited to present 1 time/year.
Provide public opportunity for involvement to promote restoration goals. This occurs through student education, public tours, seminars, web and social media management, printed media, etc.	All	Several times annually/ongoing
Encourage involvement, partnership and collaboration from diverse viewpoints and open communication.	All	
Drought Management Plan *The BHWC Drought Management Plan includes triggers and voluntary actions to increase stream flow, and subsequently decrease water temperature, during times of drought. This plan is reviewed annually and implemented when triggers are met. Enrolled landowners in the CCAA program follow additional drought management triggers.*	Temperature Stream Flow Fish& Wildlife	Reviewed annually, implemented as needed.
Irrigation Infrastructure *Just as it is important to restore the watershed, it is equally important to maintain the ranching operations located in the valley. While irrigation is critical to watering stock and pasture for feed production, infrastructure improvements can improve efficiency and water quality.*		
BMPs for irrigation improvements include:	Stream Flow, Temperature Fish	One per year

<table>
<tr><td>Replace/improve headgates located on rivers and tributaries to allow water control, water measurement, and fish passage/deter fish entrainment.
Install offsite stockwater tanks when doing so would provide an instream water savings.
Conversion of one type of irrigation system to a more efficient system to improve instream flows (without compromising other water quality parameters)</td><td>In some cases, sediment

Stream Flow, Temperature</td><td>until complete - led by CCAA program, supported by BHWC.
As needed</td></tr>
<tr><td>Riparian Vegetation
The restoration of riparian vegetation was identified in the TMDL as the top rated activity to achieve multiple watershed restoration goals and can decrease sediment loading, increase stream flows, and decrease stream temperatures. Several projects to improve riparian restoration in the Big Hole River have been completed, both through active manipulations (i.e. plantings, machine manipulated channels) and passive (i.e. fencing to reduce grazing pressure) restoration. In a review of CCAA restoration, staff reported passive restoration to be the best means of riparian restoration for use of funds and results. Therefore, efforts in riparian restoration will focus on passive restoration. In select cases, active restoration may need to supplement passive restoration.

BMPs to improve riparian vegetation include:
Fencing to reduce grazing pressure
Off-stream watering facilities or water gaps
Livestock protection structures
Hardened stream crossings with fencing to protect riparian vegetation
Grazing management plans to improve upland and riparian vegetation conditions
BLM and USFS: Review grazing leases to promote healthy riparian zones and wetlands and to sustain the fishery.

CCAA: Continue implementation of grazing management plans including the use of riparian fencing to reduce riparian pressure and allowing riparian zones to return to functioning condition.</td><td>Nutrients
Sediment
Stream Flow
Temperature
Fish & Wildlife</td><td>On-going</td></tr>
<tr><td>Wetlands
The restoration of degraded wetlands can provide a positive impact to water quality and quantity. Wetlands can retain water for late season flows, cool waters, absorb nutrients, and trap sediment and other toxic substances.

BMPs for wetland restoration or creation can include:
Education on the value and function of wetlands
Proper identification of potential wetland areas that can improve water quality/quantity</td><td>Stream Flow
Temperature
Nutrients
Fish & Wildlife
Sediment</td><td>Identify opportunities - 2013</td></tr>
</table>

- Restore/repair dikes, ditches, and other irrigation control structures to improve hydrologic connectivity in potential wetland areas - Support efforts that can protect existing wetlands, such as easements, NRCS's conservation and wetland reserve programs, and grazing management plans - Beaver management where appropriate BLM: Notes degraded wetlands. Work with BLM staff on remedy. USFS: Identify degraded wetlands for possible restoration. Work with BLM staff on remedy. CCAA: Support incorporation of wetlands in landowner plans as a grazing management or irrigation management strategy. Support restoration as needed. Other: Support restoration of wetlands outside of the CCAA enrolled lands, USFS and BLM lands.		
Regulatory Environment *Regulations are an important tool for long-term watershed protections. An existing 150 foot development setback is in place and growth policies touch on the importance of resources in the Big Hole watershed. The following are guidelines for a positive regulatory environment:* 1. Land use development standards should be in place to adequately protect the most sensitive watershed resources, particularly those under restoration currently (this includes riparian zones and wetlands) from development. 2. Incentives should be used to encourage landowner driven conservation, such as the use of easements and payment for ecological services. 3. County Growth Policies should reflect the importance the protection of watershed resources in the Big Hole watershed for water quality, tourism, fish and wildlife, and rural landscape.	Regulatory protections	In-process

Restoration Objectives and Load Reductions

Riparian restoration goals can be further broken down into objectives. Each restoration objective can be tied to a reduction in load causing the water quality impairment or the resolution of a water quality or natural resource issue. These improvements are based on estimates and represent a best guess as to potential watershed improvement as a result of an activity. Table 12 lists watershed restoration objectives, potential load reductions and the source of the provided information. See Table 18 through Table 26 for detailed targets by watershed and stream reach.

Table 12: Restoration objectives and associated potential load reductions.

Remedy	Watershed Restoration Category	Restoration Objective	Load Allocation Associated with:	Source
Riparian Condition	Temperature	Riparian Shade: Middle Big Hole: Existing percent shade is between 1.4% and 7.9% Lower Big Hole: Existing percent shade is between 2.1% and 14.2%. Big Hole River between Pintlar Creek and Wise River should be 80% willows, 20% grass cover (3.5% shade) Big Hole River from Butte Diversion to mouth should be 30% cottonwood gallery, 70% grass cover (7.4% shade) Divide Creek should be 80% willows, 20% grass cover (27% shade).	Middle Big Hole: Increase percent shade between 5% and 15% Lower Big Hole: Increase percent shade between 3.5% and 42%	DEQ TMDL (Table 8-10, Table 8-11, Table 8-1)
		On USFS Lands: Large Woody Debris: (forested systems) >20 pieces per mile, > 6 inch diameter, >12 foot length. Bank Stability: (nonforested systems) >80% stable.		USFS Plan
	Sediment	Stream banks should have a stable or improving trend. Non-eroding banks for at least 85% of reach for A, B and C type streams.		DEQ TMDL (Table 5-2)
	Sediment	Percent of streambank with riparian shrubs >48%		DEQ TMDL (Table 5-2)
		Conservation and restoration of riparian habitats by fencing, off-channel livestock watering facilities,		CCAA (Table 5)

		prescribed grazing plans, more active livestock management, etc. • Frequency of livestock presence in riparian areas with decrease significantly during first 5 years leading to rapid improvement. • Steady riparian recovery thereafter with "sustainable" status achieved on 95% of enrolled lands by year 15. Current Riparian Assessment Rankings: • 9.5 miles "Not Sustainable" • 110 miles "At Risk" • 57 miles "Sustainable" • 176.5 total assessed miles	68% or 119.5 miles of enrolled lands need to achieve "Sustainable Rating" Priority Areas: Sections C & D of CCAA (near Wisdom)	
Width-Depth Ratio (w/d ratio)	Temperature, Sediment	On the Middle Big Hole River between Pintlar Creek and Wise River, decrease the median w/d ratio from 92 to <= 60	34% decrease in width-to-depth	DEQ TMDL (Table 8-10)
	Sediment	*On USFS Lands:* Entrenchment Ratio (all systems) Rosgen Channel: A - <1.4, B – 1.6 – 1.8, C - >10.3, E ->7.5. Width/Depth Ratio (all systems) Rosgen Channel: A - <11.3, B – <15.8, C - <28.7, E -<6.9.		USFS Plan
Irrigation	Temperature	Warm water irrigation return flows to the Big Hole River and its tributaries are unknown, but likely a minor source. Address in adaptive management.	If present, reduce warm water irrigation return flows by 50%.	DEQ TMDL (Table 8-10)

		Improve irrigation efficiency	15% improvement in irrigation efficiency during warmest months (mid-June through August)	DEQ TMDL (Table 8-1)
In-Stream Flow	Temperature	Big Hole River and its tributaries, stream flows are often below flows recommended for most sensitive uses.	All reasonable irrigation water management practices with water savings applied to in-stream flow via local, voluntary approach.	DEQ TMDL (Table 8-10)
		Increased flows through: water rights compliance, improved irrigation management, less water intensive crops, instream flow leases, stockwater wells, etc. (Table 5, CCAA Plan)	Water right compliance, installation of headgates/measuring devices within 5 years of enrollment As part of landowner site plans, ensure streamflows meet flow targets 75% of the time by 2015.	CCAA (Table 5)
In-Stream Sediment	Sediment	Percent fine surface sediment <6mm comparable to reference. Percent fine surface sediment <2mm average value not to exceed 15% for E channels and 13% for all other channels. Width/Depth ratio, see above. Entrenchment ratio >1.8 for E Channels, >5.1 for C Channels, >3.7 for E channels. Pool frequency 5.5 to median bankfull width per reach. Sediment load reductions achieved through riparian re-vegetation, riparian and upland grazing management, and road maintenance BMP's.	Sediment load varied by segment (*See **Table 18** through **Table 26***). Sediment loads ranged from 129 tons per year to 191,651 tons per year. Sediment load reductions required to meet water quality targets ranged between 8% - 40%.	DEQ TMDL Table 5-2 Table 9-1
		On USFS Lands: Sediment Particle size, % < 6.25mm (all systems) Stream Type: B3 - <12, B4 - <28, C3 - <14, C4 - <22, E3 - <26, E4 - <28.		USFS

Fish: Wild (not Arctic Grayling)	Temperature	*Improve wild fisheries:* • Secure and restore native Westslope Cutthroat Trout Populations • Alter harvest to maintain growth • Improve stream channels • Reduce fish entrainment in ditches • Improve flows to benefit fish • Improve and expand drought management plans		MFWP
		On USFS Lands: **Spawning Areas:** Reduce impacts from grazing practices in known or suspected threatened, endangered or sensitive fish spawning areas to avoid or reduce trampling of redds that may result in adverse impacts to threatened or endangered species, loss of viability, or a trend toward federal listing of sensitive species **(**GM 4**).** **Management Indicator Species:** Maintain habitat conditions for native species as reflected by changes in abundance of *Drunella doddsi* (Mayfly) as a Management Indicator Species (MIS).		USFS
Fish: Arctic Grayling		Positive trend grayling population within 5 years (2010)	n/a	CCAA
		Grayling reoccupation of historic waters within 10 years (2015)	n/a	CCAA
Nutrients	Nutrients	Immediate reduction in threat at time of site specific plan implementation	varied	CCAA
		Total Nitrogen < 0.320 mg/l NO3 + NO2 as N < 0.100 mg/L Total Phosphorous < 0.048 mg/L Chlorophyll a < 150 mg/m2 for foothill/valley Percent shrubs along greenline, except where	15%-92% reduction in nitrogen 0%-90% reduction in phosphorus	DEQ TMDL (Table 6-2, Section 6-

		coniferous >= 49% Percent bare ground along greenline <= 5% Restoration to improve nutrients most often relates to improving riparian grazing and fertilizer use. Recommendations include improving streamside grazing management, off-stream livestock watering, irrigation and fertilizer improvement, and improving streamside vegetative buffer (TMDL Section 9.4.2 and Table 9-1)		0, Table 9-1)
Roads	Sediment	*On USFS Lands:* **Road Drainage:** Reconstruct road and drainage features that do not meet design criteria or operation and maintenance standards, or are proven less effective than designed for controlling sediment delivery, or retard attainment of desired stream function, or increase sedimentation in Fish or Restoration Key Watersheds (RF 3a**).** **Roads:** Close and stabilize or obliterate and stabilize roads not needed for future management activities (RF 3c**).**		USFS Plan
Wetlands	Temperature, Sediment, Nutrients	Improve and expand wetland resources to benefit water quality.	See DEQ water quality targets - wetlands are used to achieve these targets.	BHWC

Section IV: How Will We Get There?
Road Map to Watershed Restoration

Restoration activities that can support improvements in water quality as defined in the previous section are divided into four watershed restoration goals:

- Plan & Research
- Restoration
- Education
- Preservation

In order to achieve water quality goals and ultimately our vision for the Big Hole watershed, activities will need to occur in each of the four categories for a balanced approach to restoration that is calculated, timely, sustainable, and cost effective.

In addition, significant restoration activity has occurred since 2005 when the TMDL data was collected.

This section includes activities for watershed restoration in each of the four categories. Activities in each category that have occurred between 2005 and the present are listed and are followed by proposed future activities. *Note: Past projects are not a comprehensive list, but do serve to identify many important landmark projects or events.* Each activity's anticipated watershed restoration impact is listed. For future activities, anticipated costs and funding sources are indicated.

The watershed restoration categories are:

Watershed Restoration Goal Category
Water Temperature
Stream Flow
Sediment
Nutrients
Fish & Wildlife
Weeds/Invasive Species
Regulatory Protections

This section is divided into two parts:

1. Projects Completed or On-Going
2. Projects On-Going or Proposed

Projects Completed or On-Going:

Plan & Research Projects Completed Since 2003:

Year	Project	Watershed Restoration Category	Lead	Reference or Contact
2003	Lower Wise River Stream Corridor Assessment	Water Temperature, Sediment, Nutrients	BHWC, NRCS, DNRC	(NRCS, DNRC, 2003)
2003	Southwest Highlands Watershed Assessment Report	Water Temperature, Sediments, Nutrients, Fish & Wildlife, Weeds/Invasive Species	BLM	(U.S. Bureau of Land Management, 2003)
2005	Flood Inundation Potential Mapping and Channel Migration Zone Delineation, Big Hole River, Montana	Water Temperature, Sediment, Nutrients, Regulatory Protections	BHWC	(Thatcher & Boyd, 2005)
2007	Montana Non-Point Source Management Plan	Water Temperature, Sediment, Nutrients	DEQ	(Montana Department of Environmental Quality, 2007)
2008	Using Historic Aerial Photography and Paleoflood Hydrology to Assess Long-term Ecological Response to Two Montana Dam Removals	Water Temperature, Sediment	MSU	(Schmitz, 2008)
2008	Modeling Stream Flow and Water Temperature in the Big Hole River, Montana	Water Temperature, Stream Flow	DEQ	(Flynn, 2008)
2008	Beaverhead West Watershed Assessment Report	Water Temperature, Sediments, Nutrients, Fish & Wildlife, Weeds/Invasive Species	BLM	(U.S. Bureau of Land Management, 2008)
2008	Lower Big Hole Irrigation Infrastructure Survey & Prioritization	Water Temperature, Stream Flow, Fish & Wildlife	BHWC	(PBS&J, March 2008)
2009	East Pioneer Watershed Environmental Assessment	Water Temperature, Sediments, Nutrients, Fish & Wildlife, Weeds/Invasive Species	BLM	(U.S. Bureau of Land Management, July 2, 2009)
2009	Middle-Lower Big Hole River TMDL	Water Temperature, Sediment, Nutrients	DEQ	(Montana DEQ, September 2009)
2010	Freshwater Mussels in Montana . . .	Fish & Wildlife	Montana	(Stagliano, 2010)

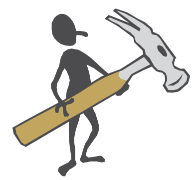
			Natural Heritage	
2010	Big Hole River Thermal Infrared (TIR) Temperature Analysis Interpretive Report	Water Temperature	USGS, BHWC	(Watershed Consulting, LLC, July 2010)
2010	Wise River Irrigation Infrastructure Survey & Prioritization	Water Temperature, Stream Flow, Fish & Wildlife	BHWC	(Oasis Environmental, 2010)
	Fluvial Arctic Grayling Pit-Tag Study	Fish & Wildlife	MSU, BHWC	
2011	Streb-Gallagher Ditches, Alternatives Assessment	Water Temperature, Stream Flow, Sediment	BHWC	(Mainstream Restoration and Allied Engineering, 2011)
2011	Beaver Habitat Suitability Model - Big Hole Watershed	Water Temperature, Sediment, Fish & Wildlife	DEQ	(Carpenedo, March 2011)
2012	Lower Big Hole River Corridor Assessment	Fish & Wildlife, Water Temperature, Stream Flow	BHWC	(Confluence Consulting, Inc., 2012)
2011-2012	Wetlands and Watershed Restoration	Water Temperature, Stream Flow	BHWC & DEQ	Included in this document.
2013	Middle-Lower Big Hole Watershed Restoration Plan	All	BHWC	(This document)
2013	Big Hole River Trend Analysis	Water Temperature, Stream Flow	BHWC, USFS	(Big Hole Watershed Committee and Beaverhead Deerlodge National Forest, 2013)

Educate

Educate - Projects Completed or On-Going since 2005:

Year	Project	Watershed Restoration Category	Lead
Big Hole Watershed Committee			
	Big Hole Watershed Committee Online Resources • Website • Social Media • E-Mails	All	BHWC
1995 -	Monthly Watershed Meetings (10 meetings/year)	All	BHWC
Annual	Weed Whackers Ball Fundraiser	Weeds	BHWC
3-4 times per year	Newsletters	All	BHWC
Annual	Watershed Tours	All	BHWC
Annual	Youth Field Days	All	BHWC
Occasional	Classroom visits to MSU, MSU-Western, University of Montana	All	CCAA
Annual	CCAA Annual/5 Year Report Presentations to local meetings of American Fisheries Society, Trout Unlimited, BHWC, etc.	All	CCAA
Other Education and Outreach			
May	Arctic Grayling Recovery Program (AGRP) Annual Meeting	All	AGRP
2008-	Kids Day on the Big Hole at Meriwether Ranch	All	BHRF
2012	"Landscape Conversations" Seminar with Montana Wildlife Society	All	CCAA
2012-2013	CCAA Landowner Appreciation Dinner & Progress Report	All	CCAA
	Newsletters	All	BHRF
2012 -	Arctic Grayling Genetics Project - Spokane High School	Fish & Wildlife	CCAA
2013 -	Wildlife Workshops “Living with Wildlife Series”	Fish & Wildlife	WCS, et. al.

Restore



Restoration - Projects Completed or On-Going Since 2004:

Year(s)	Project	Watershed Restoration Category	Lead, Partner
Irrigation Infrastructure Improvements			
2004	Company & Truman Ditch Flow Control Structure, Company Ditch Headgate (Wise River)	Fish & Wildlife	BHWC
2007	Hagenbarth Big Hole Ditch	Water Temperature, Stream Flow	BHWC
2007	Carpenter Ditch	Water Temperature, Stream Flow	BHWC
2010	Kalsta Spring Creek Slough	Water Temperature, Stream Flow, Fish & Wildlife, Nutrients, Sediment	BHWC
2010	Kamperschroer Stockwater Tanks	Stream Flow	USFWS - BHWC
2010	Big Hole Cooperative Ditch	Water Temperature, Stream Flow	BHWC, RVCD
2011-12	Corder Ditch	Sediment, Stream Flow	Future West Sonoran Institute
2012	Wise River Irrigation Infrastructure *5 points of diversion consolidated into one with new headgate, flow measurement. In addition, landowner replaced one remaining Wise River headgate.*	Stream Flow, Water Temperature, Sediment, Fish & Wildlife	BHWC - DEQ
Other Restoration			
2012	Carpenter Fence Project	Sediment, Water Temperature	BHRF, BHWC
2011-12	Cherry Creek Barrier and WCT	Fish & Wildlife	FWP, USFS, BLM, BHWC
2011-2012	Divide Diversion Dam and Pump House Replacement	Fish & Wildlife	BSB County
Invasive Species Management			
On-going	Weed Spray Days	Weeds/Invasive Species	BHWC, County, BLM, USFS
On-going	Oxeye Daisy Test Site	Weeds/Invasive Species	BHWC

Preserve & Protect

Preserve & Protect – Projects Completed Since 2000:

Year(s)	Project	Watershed Restoration Category	Lead
2000	Land Use Development Standards: Subdivision Setback: Building site must be >150ft from Big Hole River. Big Hole River Conservation Development: No structure with a roof within 500ft of Big Hole River Floodplains: Building in 100 year floodplain requires mitigation. Septic/Sewage: All buildings required to have water and sewer.	Water Temperature, Sediment, Nutrients, Regulatory Protections	BHWC, Future West, Counties
1997 - ongoing	Big Hole River Drought Management Plan	Stream Flow, Water Temperature, Fish & Wildlife	BHWC, DNRC, FWP (Big Hole Watershed Committee, 1997 - 2013)
2005	Beaverhead County Growth Policy	Regulatory Protections	Beaverhead County (Beaverhead County, 2005)
2008	Butte-Silver Bow Growth Policy	Regulatory Protections	Butte-Silver Bow County (Butte-Silver Bow County, 2008)
2011	Anaconda Deer Lodge County Growth Policy	Regulatory Protections	Anaconda-Deer Lodge County (Anconda-Deer Lodge County, 2010)
2012	Madison County Growth Policy	Regulatory Protections	Madison County (Madison County, 2012)

Projects On-Going or Proposed

Plan & Research:

Future and On-Going:

Year	Project	Watershed Restoration Category	Lead (Partner)	Cost & Potential Funding Source
Lower Wise River Water Resources Investigation				
2011-2013	*Monitoring included groundwater levels, surface water flow and temperature, and fisheries collected 2011-2012. The results will be available summer 2013.* Continuation: Portions of this project will continue including continuous stream flow and water temperature, continuous groundwater level monitoring, habitat changes, and fisheries. This information will provide baseline data for future work and will aid in developing future restoration projects.	Water Temperature, Stream Flow, Fish & Wildlife	BHWC, DNRC, MBMG, FWP	BHWC, DEQ, GWIP
Big Hole River Water Monitoring				
On-going	*There are several continuous USGS real-time gages in the Middle-Lower Big Hole. Maintaining the monitoring network is critical to the BHWC Drought Management Plan and monitoring water quality improvements. Funding for existing gages is required annually. In addition, there are several upgrades identified:* • Maintain existing USGS stream gages. • Upgrade USGS gages to include water temperature, weather. • Install a USGS real time flow & temperature gage near the mouth of Wise River. • Include air temperature with all water temperature gages. • Maintain two weather stations in the Big Hole that track air temperature, precipitation, solar radiation, etc.	Water Temperature Stream Flow Fish & Wildlife	BHWC, DNRC MFWP, USGS	BHWC, DNRC, MFWP
Other Planning Efforts				
	Watershed Assessment - Seymour Creek Deep Creek Watershed Assessment	Sediment, Fish & Wildlife	USFS	USFS
2008 -	Macroinvertebrates	Fish & Wildlife	BHRF	BHRF, BHWC

Educate:

Future or On-Going:

Year or Time Period	Project	Watershed Restoration Category	Lead	Cost - Source
Big Hole Watershed Committee				
Monthly - 3rd Wednesdays	**Monthly Watershed Meetings** *Includes seminars on watershed topics, updates from 4 BHWC subcommittees, updates from BHWC, and new watershed news. Serves as monthly opportunity to address watershed issues. Public welcome.*	All	BHWC	$10,000/year - Private funds, project specific sources
~1/year	**Watershed Tours** *1-2x/year depending on topics. Public opportunity to visit projects and hear watershed restoration progress.*	All	BHWC	$4,000/year - Project specific sources
~1-2/year	**Youth Programs** *Annual events for kids grades K-8 with watershed related activities. Opportunity to build watershed stewardship among students. Field days are science based on during a normal school day. Other school events may include presentations or activities in school.*	All	BHWC, Others	$2000/year - Project specific sources, private funds
Continuous	**BHWC Online Resources** *E-mails* *Website* *Social Media*	All	BHWC	Private Donations
1/year	**Weed Whackers Ball** *Fundraiser put on by the Big Hole Watershed Weed Sub-Committee each September to raise money to fights weeds.*	Weeds	BHWC	Fundraiser
~3/year	**BHWC Newsletters**	All	BHWC	BHWC

Pending	**Interpretation** *Notch Bottom Fishing Access Site* Due to the high traffic volume and the poor habitat condition, this site could be restored and used to provide interpretation on the importance of wetlands to the river landscape.	All	BHWC	DEQ Mini Grant, MFWP
	Conservation Easement Seminar *Provide seminar on methods, resources, and benefits of conservation easements. The goal of the seminar would be to encourage landowners to seek long-term land protections.*	All	BHWC and Partners	Partners
CCAA				
March/year	**AGRP - Arctic Grayling Restoration Annual Meeting**	Fish & Wildlife	CCAA/AGRP	CCAA
2012	**CCAA Tours** *Agencies involved in CCAA program visit CCAA to view progress.*	Fish & Wildlife	CCAA	CCAA
Annual	**CCAA Annual/5 Year Report Presentations** To local meetings of American Fisheries Society, Trout Unlimited, BHWC, etc.	All	CCAA	CCAA
Other Education & Outreach Efforts				
May/year	**Kids Day on the Big Hole at Meriwether Ranch** *Kids invited to spend day fishing and learning topics surrounding fishing. Program is recreation based.*	All	BHRF	Varied, but requires $2000-$5000/year
~3/year	**Newsletters**	All	BHRF	BHRF
Ongoing	**Local Museum and Historical Compilation**	All	Wise River Community Foundation	Wise River Community Foundation
Varied	**Community Exchange Days, Wildlife Series**	All	Wildlife Conservation Society	Wildlife Conservation Society
July Annually	**Big Hole River Day**	Fish & Wildlife	BHRF	BHRF

Restoration:

Future and On-Going:

Projected Year	Project	Watershed Restoration Category	Partners	Potential Funding Source
Riparian Restoration				
High Priorities:				
2013 - 2017	**French Creek Restoration (includes California Creek)** *Repair sediment issues associated with historic placer mining and smelter damage by reducing sediment loads reaching the stream via a gully wash, reconnecting the stream to its floodplain, and restoring upland, riparian and wetland areas.* *→ California Creek headwaters to French Creek/French Creek Headwaters to Deep Creek*	Sediment, Fish & Wildlife	MFWP, NRDP, BHWC	MFWP, Private Foundations, BHWC, NRDP, DEQ Cost: >$100,000
2014 - ongoing	**Middle Big Hole River Riparian Re-Vegetation and Channel Restoration.** *Encourage implementation of riparian and streambank BMPs to restore riparian vegetation growth, reduce bank erosion, and narrow the river channel over time.* *→ Big Hole River Pintlar Creek to Deep Creek*	Water Temperature, Sediment	BHWC, BLM, DNRC, MFWP, NRCS	Dependent on Method Cost: >$100,000
2013 - ongoing	**Lower Big Hole River** *Restoration activities to occur as recommended by the BHWC Lower Big*	All	BHWC, MFWP, Private Landowners	BHWC, Madison County, MFWP, Private, NRCS

	Hole River Sub-Committee, Lower Big Hole River Corridor report, etc. Improvements needed in riparian health and bank erosion, fish habitat, and irrigation infrastructure *→ Glen to the Big Hole River mouth*			Cost: >$100,000
2013 - ongoing	**Big Hole River Channel at Glen** *The Big Hole River in the Glen area has several in-stream alterations that may cause the river to form a new channel in time which could have detrimental effects on property, roads, etc. Potential solutions could include identifying appropriate channel migration areas, small natural structures to encourage the river to maintain the existing channel.* *→ Big Hole River at Glen*	Sediment	BHWC, Beaverhead County, Madison County, NRCS	Beaverhead County, Madison County, NRCS Cost: Dependent on method.
Lower Priorities:				
	Upper Jerry Creek Restoration *Fisheries and riparian restoration and protection to reduce nutrient inputs, sediment and habitat degradation. Restore native fish populations.* *→ Jerry Creek headwaters and headwater tributaries.*	Fish & Wildlife Sediment Nutrients	USFS	USFS
	Birch-Willow-Lost Creeks Restoration *Wide-spread vegetation management /watershed restoration that includes reducing conifer encroachment to*	Sediment, Fish & Wildlife, Weeds/Invasive Species	USFS	USFS

	revitalize aspen-dominated riparian areas to improve water quality. → *Upper Birch, Willow and Lost Creeks (USFS Lands)*			
	Upper Wise River *Work with USFS to alter grazing management to allow riparian re-vegetation and channel restoration.* → *Wise River headwaters to Pattengail Creek*	Stream Flow, Sediment, Fish & Wildlife	BHWC, USFS	USFS
	Lower Wise River Habitat Improvement *Repair historic channel disruption resulting from Pattengail Dam failure by increasing channel complexity.* → *Wise River Pattengail Creek to mouth*	Fish & Wildlife	Private, BHWC, MFWP	DEQ, MFWP, NRCS, DNRC Cost: Dependent on method.
	Lower Moose Creek *Work with landowner to alter livestock management and encourage riparian re-vegetation.* → *Moose Creek private lands*	Sediment, Water Temperature	Private, BHWC	BHWC, DEQ Cost: <$100,000
Wetlands to Improve Water Quality				
High Priorities:				
2013 - 2015	**French Creek (Includes California Creek)** *Restoration work planned with FWP to restore damaged riparian zones and wetlands in upper French Creek. Plans include implementing road and riparian BMPs to reduce sediment loading to the creek.*	Sediment	BHWC, MFWP, DEQ	BHWC, MFWP, DNRC, NRDP, DEQ Cost: >$100,000

	→ *California Creek headwaters to French Creek, French Creek to Deep Creek*			
2014 - ongoing	**Lower Big Hole River Corridor** *Alter existing irrigation system with upgrades to irrigation structures and rewetting of historic wetlands. See "Lower Big Hole River Corridor Phase I Report, 2012" for specific details.* (Confluence Consulting, Inc., 2012) → Big Hole River High Road Bridge and 3 miles upstream	Stream Flow, Water Temperature	BHWC, MFWP	MFWP, DNRC Cost: >$100,000
2014	**Big Hole River Pintlar to Deep Creek** *This reach of the Big Hole River suffers from a widespread lack of streamside vegetation and over widened channel causing high late summer water temperatures. Create long-term plan for targeted small area restoration to stabilize banks and retain flows/temperature.* → *Big Hole River Pintlar Creek to Deep Creek*	Stream Flow, Water Temperature	BHWC, BLM, DNRC, MFWP, NRCS	BHWC, BLM, DNRC, MFWP, NRCS Cost: >$100,000
	Wise River Beaver Recolonization *Wise River is entrenched in several segments near Lacy Creek. Beaver recolonization could repair widespread bank destabilization* → *Wise River headwaters to Pattengail Creek*	Sediment, Stream Flow	BHWC, USFS	BHWC, USFS, DEQ Cost: <$100,000

Lower Priorities:				
	Zuckers Big Hole Pasture Land *Work with landowner to alter pasture management and grazing plan to allow rewetting of historic wetland. Presently a ditch drains this pasture.* *→ Big Hole River near Wise River*	Stream Flow, Water Temperature	BHWC	BHWC, Private Cost: <$100,000
	North Fork Pasture Land & Toomey Lake *Work with landowner to alter pasture management and grazing plan to allow rewetting of historic wetland and improve pond on site.* *→ Big Hole River near North Fork Road*	Stream Flow, Water Temperature	BHWC	BHWC, Private Cost: <$100,000
	Jerry Creek *Work with landowners on grazing management plans to improve bank stabilization. Revegetation of willows.* *→ Jerry Creek near Delano Creek*	Nutrients, Sediment	BHWC	BHWC Cost: <$100,000
	Lower Big Hole River near Twin Bridges *Hydro-modified. Alter pasture management to allow rewetting of historic wetland* *→ Twin Bridges*	Stream Flow, Water Temperature	BHWC	DEQ Cost: <$100,000
	Burma Road Pinch Point *This region is also referred to as the turtle ponds due to many water potholes. However, chronic dewatering in the region causes late season water issues. Reduce dewatering impacts.*	Stream Flow, Water Temperature	BHWC, MFWP	BHWC, MFWP, Private Cost: <$100,000

	Follow with long term land protection. *→ Big Hole River Burma Road near Glen*			
	Bacon Modified Pasture *Need onsite view, but listed as large hydrologically modified wetland. May be good site for rewetted area with alteration in grazing and irrigation practice.* *→ Big Hole River near Seymour Creek*	Stream Flow, Water Temperature	BHWC	BHWC, DEQ, DNRC, NRCS Cost: Dependent on method.
	Mt. Haggin Wildlife Refuge *Alter range management to protect wetlands.* *→ Mt. Haggin Wildlife Refuge*	Sediment	BHWC, MFWP	MFWP Cost: <$100,000
	Moose Creek Headwaters *This high elevation pasture land suffers from extreme hummacing. Alter grazing management to allow willow growth* *→ Moose Creek headwaters*	Stream Flow	BHWC	DEQ Cost: <$100,000
	Pintlar Creek/Christensen Complex *The region of the Big Hole River on the east end of the North Fork Road and its intersection with Highway 43 holds many opportunities to alter current land use to allow for water storage and late season temperature buffers.* *→ Big Hole River near Pintlar Creek*	Water Temperature	BHWC	BHWC, Private Cost: Dependent on method.
	Pattengail Dam Site *Pattengail Dam site as storage wetland.* *→ Pattengail Creek*	Fish & Wildlife, Stream Flow	BHWC , USFS	BHWC, Private, USFS, MFWP Cost: Dependent on method.

Irrigation Infrastructure Improvements				
Big Hole River Irrigation High Priority				
2012-?	**Lower Big Hole River Corridor Restoration** Lott-Harvey & Logan-Smith Ditch Orphan Home Ditch → *Near Twin Bridges*	Water Temperature, Stream Flow, Fish & Wildlife	MFWP, BHWC	BHWC, DNRC Cost: >$100,000
	Streb-Gallagher Ditches → *Near Melrose*	Water Temperature, Stream Flow, Sediment	BHWC	DEQ, DNRC, NRCS Cost: >$100,000
	Garrison-Kilwien Ditch → *Near Glen*	Water Temperature, Stream Flow	BHWC	DEQ, DNRC, NRCS Cost: >$100,000
	Rafferty's Upper South Side → *Near Melrose*	Water Temperature, Stream Flow	BHWC	DEQ, DNRC, NRCS Cost: Dependent on method.
2013	**Lower McCauley** → *Near Melrose*	Water Temperature, Stream Flow	BHWC or Landowner	Private Cost: <$100,000
	Meriwether's & Meriwether's Buyan Slough → *Near Melrose*	Water Temperature, Stream Flow	BHWC or Landowner	DEQ, DNRC, NRCS Cost: Dependent on method.
	Melrose Canal → *Near Melrose*	Water Temperature, Stream Flow	BHWC or Landowner	DEQ, DNRC, NRCS Cost: Dependent on method.
	Hamilton Ranch Ditch → *Twin Bridges*	Water Temperature, Stream Flow	Landowner	Private Cost: Dependent on method.
	Sandy Ditch →	Water Temperature, Stream Flow	BHWC or Landowner	DEQ, DNRC, NRCS Cost: Dependent on method.

Wise River Irrigation High Priority				
	The following ditches need flow measurement devices installed, a need for participation in a proposed Wise River Drought Management section. Additional needs are noted when applicable. *Jolly Ditch – Review status and needs* *Town Ditch –Stabilize* *Truman Ditch – Stabilize* *Company Ditch - Stabilize* *Vineyard Ditch* *Connolly Ditch* *Split Diamond – Review POD change and flow control options* → *Lower Wise River*	Water Temperature, Stream Flow	BHWC, DNRC	BHWC, DNRC Cost: Flow Measurement Devices are usually <$2500. Other upgrades dependent on method, but all expected to be <$100,000 each.

Preserve & Protect

Future and On-Going:

Year(s)	Project	Watershed Restoration Category	Lead	Cost - Potential Source
2012-2014	**Big Hole River Floodplain Maps** *Floodplain Approximate Zone A mapping was complete November 2012. The state of Montana will adopt the map in 2013. Anaconda-Deer Lodge, Beaverhead and Madison counties will seek county adoption of the maps followed by their own regulatory ordinances associated with the maps. This will provide a strong regulatory environment to protect the river corridor.*	Water Temperature, Sediment, Nutrients, Regulatory Protections	BHWC, Future West, Beaverhead, Butte-Silver Bow, Madison and Anaconda-Deer Lodge Counties, DNRC	Ongoing - FutureWest, DEQ, BHWC, Counties, DNRC
2010 -	**Land Use Planning Incentive Program** *Payment for Ecological Services.*	Water Temperature, Sediments, Nutrients, Fish & Wildlife, Stream Flow	BHWC, FutureWest, Counties	Ongoing - FutureWest, DEQ, BHWC, Counties
1997 -	**Big Hole River Drought Management Plan** *Review and update January annually.*	Water Temperature, Stream Flow	BHWC, DNRC, FWP	$3000 annually - DEQ, BHWC
2014	**Wise River Drought Management Plan** *Include Wise River irrigators in the Drought Management Plan.*	Stream Flow	BHWC	BHWC
Varied	**Easements** *Seek land easements for protection*	Water Temperature, Nutrients, Sediment, Fish & Wildlife	BHWC and Partners	Varied - many sources
2013	**Beaverhead County Growth Policy Revision** (Last Update, 2005)	Regulatory Protections	BHWC, Beaverhead County, Future West	Beaverhead County
2014	**Butte-Silver Bow County Growth Policy Revision** (Last Update, 2008)	Regulatory Protections	BHWC, Butte-Silver Bow County, Future West	Butte-Silver Bow County

2017	**Madison County Growth Policy Revisions** (Last Update, 2012)	Regulatory Protections	BHWC, Madison County, Future West	Madison County
2015	**Anaconda-Deer Lodge County Growth Policy Revision** (Last Update, 2010)	Regulatory Protections	BHWC, Anaconda-Deer Lodge County, Future West	Anaconda-Deer Lodge County
Wetlands Specific Protection				
	Easements Encourage landowner to enter land into easement to preserve high quality sections: • Divide Creek • Deep Creek • Big Hole River near Burma Road	Sediment, Stream Flow, Water Temperature, Fish & Wildlife		
	Wetland Protection Language *Work with greater land use planning efforts and agencies to incorporate wetland protection language where appropriate (i.e. Growth Policies, laws, plans, etc.)*	Regulatory Protections		

Partners

Partnership Collaboratives Existing & Ongoing:

Project, Status	Watershed Restoration Category
Big Hole Watershed Committee Sub-Committees *Sub-Committees provide an opportunity for partners to collaborate on a focused topic.*	
BHWC Wildlife Committee *Focus is on reducing predator conflict and the health of native wildlife populations.*	Fish & Wildlife
BHWC Weed Committee *Focus is on eliminating noxious weeds and preventing the introduction and spread of invasive and noxious terrestrial and aquatic plant species.*	Weeds
BHWC Land Use Planning Committee *Focus is to promote responsible land use development particularly in the Big Hole River floodplain. This includes maintaining and improving floodplain development standards and mapping, working with counties to strengthen regulatory protections, and developing an incentive program for appropriate floodplain conservation.*	Regulatory Protections
BHWC Lower Big Hole Committee *Focus is on the Big Hole River between Glen and the mouth and to be initiated in 2013. Partners will review issues at work in the Lower Big Hole including erosion, river migration, lack of fish habitat, low stream flows, high water temperatures, and more.*	Fish & Wildlife, Water Temperature, Stream Flow
Other Partnerships	
Missouri Headwaters Partnership - Annual meeting each fall.	All
Wildlife Conservation Society - Wolf deterrence, watershed restoration	All
Montana Watershed Coordination Council (MWCC) - Coordination between watershed groups	All
Montana Non-Profit Association (MNA) - Annual meeting each fall. BHWC's attendance brings watershed groups to the table with statewide non-profits and non-profit management.	All
Rural Voices for Conservation Coalition (RVCC)	All
High Divide/Crown of the Continent	All
Interagency Coordination Council of Beaverhead County	All

See next page (partners list) for a list of individual groups involved in the Middle-Lower Big Hole River watershed

Partners

The stakeholders of the Big Hole watershed and those who work, live and play here have a strong sense of partnership, from helping a neighbor or serving the community, to leveraging resources to accomplish big goals. There are many partners involved in the watershed and its restoration. Many have individual goals or methods, but in mass they have one common goal - to restore the watershed to fully functioning to sustain ranching, fish and wildlife, water quality, and communities. Each partner listed is also a link:

Conservation Groups & Related Non-Profit Organizations

- American Fisheries Society (AFS) Montana Chapter
- American Rivers
- Arctic Grayling Recovery Program (AGRP)
- Center for Biological Diversity
- Big Hole River Foundation (BHRF)
- Big Hole Watershed Committee (BHWC)
- Blackfoot Challenge
- Ducks Unlimited, Inc.
- Missouri Headwaters Partnership (MHP)
- Montana Association of Land Trusts
- Montana Audubon
- Montana Land Reliance
- Montana Natural Heritage Program
- Montana Non-Profit Association (MNA)
- Montana Trout Unlimited (TU)
- Montana Watershed Coordination Council (MWCC)
- Montana Wetlands Legacy Partnership
- National Fish Habitat Action Plan
- People and Carnivores
- Pheasants Forever - Beaverhead Chapter
- Rocky Mountain Elk Foundation (RMEF) Montana
- The Conservation Fund
- The Nature Conservancy (TNC)
- The Trust for Public Land
- Western Native Trout Initiative
- Wildlife Conservation Society (WCS)
- Wildlife Society - Montana Chapter

Agencies

- Montana Bureau of Mines & Geology (MBMG)
- Montana Department of Environmental Quality - Water Quality Bureau (MDEQ)
- Montana Department of Natural Resources & Conservation (DNRC)
- Montana Department of Transportation
- Montana Fish, Wildlife & Parks
- Natural Resources Conservation Service (NRCS)
- Natural Resources Damages Program (NRDP)
- US Forest Service Beaverhead Deerlodge National Forest - Wisdom Ranger District (USFS)
- US Bureau of Land Management - Dillon Field Office (BLM)
- US Bureau of Land Management - Butte Field Office (BLM)
- US Fish & Wildlife Service - Partners Program
- US Geological Survey (USGS)
    - USGS Climate Change Center

Local Government & Conservation Districts

- Beaverhead County
- Beaverhead Conservation District
- Anaconda-Deer Lodge County
- Butte-Silver Bow County
- Mile High Conservation District
- Madison County
- Ruby Valley Conservation District

Educational Institutions

- **Rural Schools (K-8):** Wise River School, Divide School, Melrose School , Reichle School
- **Elementary Schools:** Twin Bridges
- **High Schools:** Butte High School, Butte Central School, Beaverhead County High School, Twin Bridges High School, Spokane High School
- University of Montana Western Environmental Studies & Biology Programs
- Montana Tech
- University of Montana
    - Avian Science Center
- Montana State University
- Montana State Fisheries Cooperative Unit (MTCFRU)

Section V: How Will We Know When We Arrive?

Each plan discussed in this document describes its own goals, priorities and milestones. Yet, in mass many goals lead to improved water quality. The milestones, criteria and monitoring plans of each are summarized below. Success documented by these groups using their own criteria can show positive change in the watershed. This is followed by broader watershed milestone, criteria and monitoring. The professionals leading the plans for the CCAA, USFS, and BLM are dedicated and with a high skill level. The best use of resources is to refer to their work in assessing success. The monitoring components are provided in **Table 13**. Progress in watershed restoration can be tracked by achieving interim milestones, provided in **Table 14**. Finally, success targets can be viewed in **Table 15**.

Table 13: Monitoring components, responsible party, and occurrence.

Monitoring Component	Primary Responsibility	Source	When
Stream Flows • *USGS Gaging Stations* • *Individual Measurements* • *TruTracks (Flow & Temp)*	DNRC	CCAA	CCAA reports annually and every 5 years.
Water Temperature • *USGS Gaging Stations* • *Individual Measurements* • *TruTracks/Thermographs* • *Temperature Loggers*	DNRC, DEQ, MFWP	CCAA, DEQ (TMDL)	CCAA reports annually and every 5 years TMDL Implementation Evaluation (approx. 2014 or later)
Fish & Wildlife Arctic grayling	MFWP	CCAA,	CCAA reports annually and every 5 years
Other Fish & Wildlife	MFWP	MFWP projects	FWP reports are project specific.
Education and Outreach	BHWC, others	Attendance and involvement tracking	BHWC reports annually.
Weeds	BHWC, Counties, MFWP	CCAA, varied	CCAA reports annually and every 5 years Other weed support provided as needed.
Riparian conditions and/or streambank condition		Aerial Photographs, CCAA, varied	Associated with specific restoration projects, CCAA.

Table 14: Watershed restoration interim milestones.

Milestone	End Point
Irrigation Infrastructure: Minimum one improvement per year (headgate, diversion, flow measurement or stockwater tank)	All irrigation infrastructures are updated to allow for water control, water efficiency, water measurement and adequate diversion that do not cause stream degradation.
Minimum one riparian improvement project per year in a stream reach as identified as having sparse or moderate riparian density.	95% of CCAA enrolled lands have a riparian condition rating of sustainable.
10 public opportunities each year to participate in watershed restoration, i.e. tours, seminars, meetings, etc.	No end point
Meet with each of the following one time annually to identify needs for watershed restoration and to report progress on watershed restoration: • DEQ • USFS • BLM • CCAA • MFWP	No end point

Table 15: Overarching watershed restoration success indicators.

Restoration Success Indicator	Goal
Positive restoration results in the CCAA restoration plan upon 5 year reviews	Results reported to BWHC every 5 years. Positive trends are based on CCAA approved monitoring plans and results.
Positive restoration results in BLM watershed assessments or land health evaluations every five years.	BLM Watershed Assessments reviewed every 5 years. Positive trends are based on BLM approved monitoring plans and results.
Positive restoration results in USFS efforts every three years.	Request updates from USFS every three years. Positive restoration includes expanded westslope cutthroat trout habitat, road improvements or closures that reduce sediment input, riparian restoration, etc.
Declining trend in water temperature over 10 year period.	Negative trend in water temperature is calculated as average water temperature from stream gages over a 10 year period July - September. Declining trend = average water temperature July - September is declining.
Positive trend in stream flow over 10 year period.	Positive trend in stream flow is calculated as average stream flow stream gages over a 10 year period July - September. Positive trend = average stream flow July - September is increasing.
Positive riparian vegetation growth throughout the Big Hole watershed.	Photo monitoring using both on site before and after photos and aerial photos or software.
Improve all river sources of irrigation withdrawals.	All irrigation structures are improved with flow measurement and fish passage.
100% participation in Drought Management	All irrigators and river users participate in the BWHC Drought Management Plan and/or the CCAA Drought Management Plan.
High education & engagement numbers in watershed activities.	A wide range of stakeholders and high number of stakeholders continue to regularly attend and engage in the restoration work of the Big Hole watershed. Measured by BHWC meeting attendance, online activity, and annual donations.
Regulatory environment provides increasing protections of sensitive watershed areas.	The number of easements or other land conservation protection measures are increasing. The development standards in the watershed protect sensitive riparian zones and wetlands from development and continue to strengthen.

Section VI: Discussion, Recommendations & Review

In the 1980's and 1990's the Big Hole watershed faced challenges that at the time seemed insurmountable. Ranchers, agencies, and other stakeholders were at odds. The drought, the dry river bed, the rapidly declining Arctic grayling population, and ranch livelihoods on the line resulted in an ugly finger pointing battle.

Fast-forward 20 years: While drought has reoccurred, the river has not run dry and Arctic grayling numbers are increasing. Landowners have embraced the notion of coexistence -- what's good for the watershed is good for ranching and good for neighbors. Agencies have embraced the notion of coexistence as well, with partnerships with landowners, listening to needs, and adapting restoration to meet those needs.

Coexistence has become the culture in the Big Hole, from predator deterrence to reduced wolf-human conflicts, to enrolled state and private lands in the CCAA program, to continued consensus based efforts of the BHWC, and the shared sacrifice of the Drought Management Plan.

Coexistence, or the collaboration and education of stakeholders, is why restoration is working in the Big Hole. It is trust and relationship building, teamwork, and patience. It is critical that this culture continues into the future for continued success. Without this continued culture, much of the work done to this point will unravel and be lost effort.

Much of this plan points to the coexistence culture as a high priority for restoration. Coexistence is not measured in, for example, miles of river restored or sediment load reduced. Therefore, indicators are developed to take into account a broader scope of restoration success, one that occurs over a long period and over a broad area. In reality, this broad scope for long-term success both fits the vision for the Big Hole watershed and is representative of a cumulative watershed effect.

Review the Watershed Restoration Plan

The Watershed Restoration Plan was compiled by the BHWC. The plan reviewed and takes into account existing plans and known upcoming projects. The next review of this plan should occur in 2018.

The 2018 review should include the revised BLM Watershed Assessment and the results of several monitoring and research studies that are currently in process. The results of those works will prove beneficial in future decision making. The 2018 version should also include updates in the Land Use Planning process and the updated Beaverhead County Growth Policy.

Note that 2015 is the 10th anniversary of the TMDL data collection for the Middle-Lower Big Hole watershed. It may be appropriate at this time to review Montana DEQ's targets and criteria for impairment and revise recommendations based on restoration efforts. This may be accomplished through Montana DEQ's own process of evaluating TMDL implementation activities. The Watershed Restoration Plan should be updated whenever a major landmark in the restoration plans occurs, such as a CCAA 5-year review, updated Forest Plan, updated BLM Watershed Assessment or other milestone.

Sub-Watershed Summaries

The Middle - Lower Big Hole watershed can be subdivided into smaller watershed basins (HUC 5). The sub-basins are ordered in the following pages upstream to downstream. Within each sub-basin, tributaries are ordered from upstream to downstream for easy reference.

Middle-Lower Big Hole Watershed - Whole

Water Quality Issues:

2012 303d Listed Streams: 13 streams listed - see **Table 16** and **Table 17** for streams

HUC 5 Watersheds within the Middle-Lower Big Hole Watershed

- Deep Creek
- Big Hole River - Fishtrap
- Wise River
- Big Hole River - Divide
- Divide Creek
- Big Hole River - Melrose
- Lower Big Hole River

Major Tributaries:

Fishtrap Creek
LaMarche Creek
Deep Creek
Bryant Creek
Johnson Creek
Wise River
Jerry Creek
Divide Creek
Canyon Creek
Moose Creek
Camp Creek
Trapper Creek
Cherry Creek
Rock Creek
Lost Creek
Willow Creek
Birch Creek

Major Issues: Fluvial Arctic Grayling, Wolves, Drought, High Water Temperatures, Lack of Riparian Vegetation and Appropriate Channel Shape.

Plans in place:

- USFS Beaverhead Deerlodge National Forest - Forest Plan
- Montana Fish, Wildlife & Parks - Conservation Strategy
- Big Hole Watershed Committee Drought Management Plan
- Bureau of Land Management Dillon & Butte Field Office Watershed Assessments
- Partners for Fish and Wildlife CCAA

Ownership: USFS Beaverhead Deerlodge National Forest & Anaconda-Pintler Wilderness, DNRC, BLM, Private Lands.

Watershed	Stream Reach	Sediment		Nutrients		Metals			Temperature	
		Total Sediment Load (tons/year)	*Target % Reduction*	*Location*	*Target Percent Reduction*	*Metal*	*Metals Load (pounds/day)*	*Target Percent Reduction*	*Existing Condition*	*Target Reduction*
Middle Big Hole River Mainstem	Middle Big Hole River (Pintlar Creek to Divide Creek)	191,651	28%			Copper Lead	Hi Flow: 61.884 Lo Flow .743 Hi Flow: 12.377 Lo Flow .371	Hi Flow: 5% Lo Flow: 0% Hi Flow: 10% Lo Flow: 0%	Reduce warm irrigation return flows by 50% Maintain instream flows	
	Pintlar Creek to Mudd Creek								%shade = 1.4% to 1.7% Median Channel W/D = 92	%shade = 15% increase W/D <= 60 35% decrease
	Mudd Creek Bridge to Deep Creek								%shade = 4.8% to 5.1% Median Channel W/D = 92	% shade = 5% increase W/D <= 60 35% decrease
	Deep Creek to Wise River								%shade = 3.5% to 3.8%	% shade = 9% increase
	Wise River to Diversion								% shade = 7.9%	n/a

Table 18: Middle Big Hole River mainstem TMDL targets for sediment, nutrients, metals and water temperature. Data from the Middle-Lower Big Hole River TMDL (Montana DEQ, September 2009).

Watershed	Stream Reach	Sediment		Nutrients		Metals			Temperature	
		Total Sediment Load (tons/ year)	*Target % Reduction*	*Location*	*Target Percent Reduction*	*Metal*	*Metals Load (pounds/day)*	*Target Percent Reduction*	*Existing Condition*	*Target Reduction*
Lower Big Hole River mainstem	Lower Big Hole River								Reduce warm irrigation return flows Maintain instream flow	
	Butte Diversion to end of Lower End Maiden Rock Canyon								% shade = 14.2% to 14.7%	% shade = 3.5% increase
	Maiden Rock Canyon to Brownes Bridge FAS								% shade = 7.5% to 9.6%	% shade = 28% increase
	Browns Bridge FAS to Glen FAS								% shade = 6.3% to 7.5%	% shade = 19% increase
	Glen to Notch Bottom FAS								% shade = 2.1% to 3.2%	% shade = 52% increase
	Notch Bottom FAS to Pennington FAS								% shade = 3.1% to 4.1%	% shade = 32% increase
	Pennington FAS to Jefferson River								% shade = 3.8% to 5.4%	% shade = 42% increase

Table 19: Lower Big Hole River mainstem TMDL targets for sediment, nutrients, metals and water temperature. Data from the Middle-Lower Big Hole River TMDL (Montana DEQ, September 2009).

Deep Creek

Water Quality Issues Summary: Metals and Physical Habitat Alterations. Damages due to mining and atmospheric deposition, agriculture, roads, and natural causes.

2012 303d Streams: California Creek - Iron, Oregon Creek - Lead, Twelvemile Creek - Sediment

Area: 106.3 square miles *Hydrologic Unit Code:* 1002000407

HUC 6 Watersheds within the Deep Creek watershed:

- California Creek
- French Creek
- Deep Creek

Major Infrastructure: Mill Creek Road (569), Past Anaconda Smelter Operation, Mount Haggin State Wildlife Management Area

High Priority Abandoned Hardrock Mines: None

Tributaries:

- Big Hole River
  - Deep Creek
    - Tenmile Creek
      - Tenmile Lakes
    - Coral Creek
    - Twelvemile Creek
    - Sullivan Creek
    - Poronto Creek
      - Dry Creek
    - French Creek
      - California Creek
        - Crooked John Creek
        - Little California Creek
        - Oregon Creek
        - American Creek
          - Little American Creek
        - Sixmile Creek
      - First Chance Creek
      - Moose Creek
    - Connor Gulch

Downstream

Watershed	Stream Reach	Sediment		Nutrients		Metals			Temperature	
		Total Sediment Load (tons/ year)	*Target % Reduction*	*Location*	*Target Percent Reduction*	*Metal*	*Metals Load (pounds/day)*	*Target Percent Reduction*	*Existing Condition*	*Target Reduction*
Deep Creek	Deep Creek (headwaters to mouth)	9180	15%							
	California Creek	1328	32%			Arsenic	Hi Flow: 6.347 Lo Flow: .544	Hi Flow: 57% Lo Flow: 52%		
						Copper	Hi Flow: 3.035 Lo Flow: .052	Hi Flow: 62% Lo Flow: 0%		
	Sixmile Creek	528	24%			Arsenic	Hi Flow: 17.297 Lo Flow: .854	Hi Flow: 62% Lo Flow: 29%		
	Oregon Creek	n/a	19%			Arsenic	Hi Flow: .983 Lo Flow: .076	Hi Flow: 50% Lo Flow: 71%		
						Copper	Hi Flow: .541 Lo Flow: .006	Hi Flow: 74% Lo Flow: 0%		
	French Creek	3773	22%			Copper	Hi Flow: n/a Low Flow: .061	Hi Flow: 14% Lo Flow: 0%		
	Corral Creek	446	24%							
	Sevenmile Creek	468	18%							

Table 20: Deep Creek watershed TMDL targets for sediment, nutrients, metals and water temperature. Data from the Middle-Lower Big Hole River TMDL (Montana DEQ, September 2009).

Big Hole River - Fishtrap

Water Quality Issues Summary: Nutrients and physical habitat alteration due to agriculture and roads.

303d Listed Streams: Sawlog Creek - Phosphorous, Fishtrap Creek (Confluence of forks to mouth) - Phosphorous

Area: 291.70 square miles *Hydrologic Unit Code:* 1002000408

HUC 6 Watersheds within the Big Hole-Fishtrap watershed:

- Fishtrap Creek
- LaMarche Creek
- Big Hole River-Fishtrap
- Seymour Creek
- Bryant Creek
- Alder Creek
- Big Hole River - Dickie Bridge
- Big Hole River - Meadow Creek

High Priority Abandoned Hardrock Mines: None

Tributaries:

Downstream

Big Hole River (Pintler (Pintlar) Creek Confluence to Wise River Confluence)
- Salefsky (Squaw) Creek
- Goris Gulch
- Christiansen Creek
  - Papoose Creek
    - Shaw Creek
- Mudd Creek
  - Mudd Lake
  - Toomey Lake
- Toomey Creek
- Sawlog Creek
- Stewart Creek
- Tucker Creek
- Calvert Creek
- Walker Creek
- Fishtrap Creek
  - West Fork Fishtrap Creek
  - Middle Fork Fishtrap Creek
  - Swamp Creek
- Minnie Creek
- LaMarche Creek
  - West Fork LaMarche Creek
    - Warren Lake
  - Middle Fork LaMarche Creek
    - LaMarche Lake
    - Trout Creek
  - East Fork LaMarche Creek
    - Emerald Lake

Pony Creek
Seymour Creek
- Chub Creek
- Lower Seymour Lake
- Upper Seymour Lake

Bear Creek
Bryant Creek
- Calvert Creek
- Dowell Creek

Teddy Creek
Johnson Creek
- Dodgeson Creek
- Cat Creek

Alder Creek
- Johanna Lake
- Osborne Creek
- Ferguson Lake
- Foolhen Creek
    - Foolhen Lake

Meadow Creek
- Harriet Lou Creek

Deep Creek confluence with Big Hole River - See Deep Creek HUC 5 Summary.

Watershed	Stream Reach	Sediment		Nutrients		Metals			Temperature	
		Total Sediment Load (tons/ year)	*Target % Reduction*	*Location*	*Target Percent Reduction*	*Metal*	*Metals Load (pounds/day)*	*Target Percent Reduction*	*Existing Condition*	*Target Reduction*
Big Hole River - Fishtrap	Fishtrap Creek	3234	18%							
	Sawlog Creek	373	18%							

Table 21: Big Hole River Fishtrap watershed TMDL targets for sediment, nutrients, metals and water temperature. Data from the Middle-Lower Big Hole River TMDL (Montana DEQ, September 2009).

Wise River

Water Quality Issues Summary: Metals, Phosphorous, Physical Habitat Alterations due to mine activity, agriculture, roads and past dam construction.

303d Listed Streams: Gold Creek – Phosphorous

Area: 261.90 square miles *Hydrologic Unit Code:* 1002000409

HUC 6 Watersheds within Wise River watershed:

- Headwaters Wise River
- Wyman Creek
- Lacy Creek
- Upper Wise River
- Upper Pattengail Creek
- Middle Pattengail Creek
- Lower Pattengail Creek
- Middle Wise River
- Lower Wise River

Major Infrastructure: Pattengail Dam and subsequent blowout, Pioneer Mountain Scenic By-Way, Elkhorn Mine (abandoned), Several USFS camping areas, Town of Wise River

High Priority Abandoned Hardrock Mines: Old Elkhorn (Elkhorn Creek)

Tributaries:

Downstream

- Wise River
  - Jacobson Creek
    - Schulz Lakes, Tahepia Lake, Teacup Lake
    - Lamb Creek
    - David Creek
      - Glacier Lake, Torrey Lake
    - Elkhorn Creek
      - Hopkins Lake, Hall Lake, Elkhorn Lake
  - Mono Creek
    - Sheldon Creek
  - Happy Creek
  - Gorman Creek
  - Little Joe Creek
  - Wyman Creek
    - Deer Creek
    - Rabbia Creek
    - Giant Powder Creek
    - Armor Creek
    - Halfway Creek
    - Odell Creek
      - Odell Lake, Lake of the Woods
    - Stringher Creek
    - Table Creek
    - Crozier Creek

- Lacy Creek
  - Schwinger Lake
  - Skull Creek
  - Bobcat Creek
    - Bobcat Lakes
- Elk Creek
- Gold Creek
- Boulder Creek
  - Black Lion Creek
- Fourth of July Creek
- Pattengail Creek
  - Baldy Lake, Grassy Lake, Elbow Lake
  - Sand Creek
    - Sand Lake
  - Whiskey Creek
  - Demijohn Creek
  - Copper Creek
  - Stone Creek
    - Stone Lakes
  - Lost Horse Creek
    - Rocky Creek
    - Deboose Creek
    - Effie Creek
  - Cow Creek
  - Kelly Creek
  - Lambrecht Creek
    - Dicks Creek
    - Toland Creek
  - Reservoir Creek
  - Lews Creek
  - Evans Creek
  - Grouse Creek
    - Grouse Lakes
- Ross Gulch
- Sheep Creek
  - Clifford Creek
- Stine Creek
- Butler Creek
- Deno Creek
- Adson Creek
- Swamp Creek

Watershed	Stream Reach	Sediment		Nutrients		Metals			Temperature	
		Total Sediment Load (tons/ year)	*Target % Reduction*	*Location*	*Target Percent Reduction*	*Metal*	*Metals Load (pounds/day)*	*Target Percent Reduction*	*Existing Condition*	*Target Reduction*
Wise River	Elkhorn Creek	491	22%			Copper	Hi Flow: 23.970 Lo Flow: .656	Hi Flow: 95% Lo Flow: 81%		
						Cadmium	Hi Flow: .306 Lo Flow: .013	Hi Flow: 99% Lo Flow: 97%		
						Zinc	Hi Flow: 44.344 Lo Flow: 4.024	Hi Flow: 63% Lo Flow: 60%		
	Pattengail Creek	2626	8%							
	Wise River	12037	34%			Copper	Hi Flow: 16.200 Lo Flow: .408	Hi Flow: 43% Lo Flow: 5%		
						Cadmium	Hi Flow: .389 Lo Flow: .005	Hi Flow: 92% Lo Flow: 0%		
						Lead	Hi Flow: 15.228 Lo Flow: .034	Hi Flow: 89% Lo Flow: 0%		
	Gold Creek	729	19%							

Table 22: Wise River watershed TMDL targets for sediment, nutrients, metals and water temperature. Data from the Middle-Lower Big Hole River TMDL (Montana DEQ, September 2009).

Big Hole River - Divide

Water Quality Issues Summary: Metals, Nutrients, Physical Habitat Alteration due to past mining activity, agriculture, roads, and development.

> *303d Listed Streams:* Jerry Creek - Lead, Charcoal Creek - Phosphorous, Nitrogen, Sedimentation/Siltation

Area: 170.70 square miles *Hydrologic Unit Code:* 1002000411

> *HUC 6 Watersheds within Big Hole River-Divide watershed:*

- Jerry Creek
- Big Hole River - Quartz Hill Gulch
- Canyon Creek
- Big Hole River - Dewey

Major Infrastructure: Highway 43, Divide Diversion Dam and Pumphouse (replaced 2011-2012), Town of Dewey, Town of Divide.

High Priority Abandoned Hardrock Mines: None

Tributaries:

Downstream ↓

- Big Hole River
  - Jimmie New Creek
  - Jerry Creek
    - Flume Creek
    - Delano Creek
    - Libby Creek
    - Long Tom Creek
      - Granulated Creek
      - Hansen Creek
      - Labree Creek
      - Fish Lake
    - Indian Creek
      - Parker Creek
    - Spruce Creek
    - Moores Creek
    - Laducet Creek
  - Leffler Creek
  - Charcoal Creek
  - Sawmill Gulch

Watershed	Stream Reach	Sediment		Nutrients		Metals			Temperature	
		Total Sediment Load (tons/ year)	*Target % Reduction*	*Location*	*Target Percent Reduction*	*Metal*	*Metals Load (pounds/day)*	*Target Percent Reduction*	*Existing Condition*	*Target Reduction*
Big Hole River - Divide	Jerry Creek	2640	19%			Copper	Hi Flow: n/a Lo Flow: 1.236	Hi Flow: 0% Lo Flow: 59%		
	Delano Creek	129	17%							

Table 23: Big Hole River Divide Creek watershed TMDL targets for sediment, nutrients, metals and water temperature. Data from the Middle-Lower Big Hole River TMDL (Montana DEQ, September 2009).

Divide Creek

Water Quality Issues Summary: Nutrients, temperature & water, and physical habitat alterations as a result of agriculture

303d Listed Streams: none

Area: 92.8 square miles *Hydrologic Unit:* 1002000410

HUC 6 watersheds within Divide Creek watershed:

- North Fork Divide Creek
- Upper Divide Creek
- Lower Divide Creek

Major Infrastructure: Butte-Silver Bow Water Department Reservoir, railroad, Frontage Road, Interstate 15

High Priority Abandoned Hardrock Mines: None

Tributaries:

Downstream

- Big Hole River
  - Divide Creek
    - North Fork Divide Creek
      - South Fork of North Fork Divide Creek
    - South Fork Divide Creek
      - South Fork Reservoir
    - East Fork Divide Creek
    - Curly Gulch
      - Fly Creek
      - Climax Gulch
    - Crazy Swede Creek
    - Tucker Creek - North & South Fork
    - Water Gulch
    - Lime Gulch
    - Willow Gulch

Watershed	Stream Reach	Sediment		Nutrients		Metals			Temperature	
		Total Sediment Load (tons/ year)	*Target % Reduction*	*Location*	*Target Percent Reduction*	*Metal*	*Metals Load (pounds/day)*	*Target Percent Reduction*	*Existing Condition*	*Target Reduction*
Divide Creek	Divide Creek	4783	12%	Downstream of North & East Forks	N: 82% to 89% P: 78% to 88%				% shade = 22%	% shade = 23% increase
				Near Mouth	N: 75% to 92% P: 50% to 65%					

Table 24: Divide Creek watershed TMDL targets for sediment, nutrients, metals and water temperature. Data from the Middle-Lower Big Hole River TMDL (Montana DEQ, September 2009).

Big Hole River - Melrose

Water Quality Issues Summary: Metals, nutrients, physical habitat alterations as a result of past mine activity, agriculture, and roads.

303d Listed Streams: Camp Creek - Arsenic, Wikiup Creek - Bottom Deposits, Mercury, Phosphorous, Sassman Gulch - Arsenic

Area: 306.90 square miles *Hydrologic Unit Code:* 1002000412

HUC 6 watersheds within Big Hole River - Melrose watershed:

- Moose Creek
- Big Hole River - Melrose
- Camp Creek
- Trapper Creek
- Cherry Creek
- McCartney Creek
- Big Hole River - Brownes Gulch
- Rock Creek
- Big Hole River - Lost Creek

Major Infrastructure: Railroad, Frontage Road, Interstate 15, County Barns, Town of Melrose, Glen and Twin Bridges.

High Priority Abandoned Hardrock Mines: Middle Fork Millsite (Moose Creek), Clipper (Camp Creek), Maiden Rock (Melrose), True Blue, Lower and Upper Cleve, Trapper, Silver King (Trapper Creek), Tungsten Mill Site (Lost Creek), Old Glory (Soap Gulch)

Tributaries:

Downstream

- Big Hole River
  - Canyon Creek
    - Canyon Lake, Lake Abundance, Grayling Lake, Crescent Lake, Grace Lake
    - Lion Creek
      - Lion Lake, Vera Lake
    - Vipond Creek
      - Buffalo Head Gulch
    - Trusty Gulch
  - Moose Creek
    - Middle Fork & North Fork Moose Creek
    - Maclean Creek
    - Chicken Gulch
  - Camp Creek
    - Wickiup Creek
      - Blacktail Creek
    - Willow Creek
    - L Camp Creek
  - Trapper Creek
    - Trapper Lake
    - Sucker Creek

- Sappington Creek
Cherry Creek
- Cherry Lake, Granite Lake
McCartney Creek
Brownes Creek
Rock Creek
- Storm Park Creek
- Long Creek
  - Long Lake, Long Branch Lake
- Brownes Lake, Lake Agnes, Rainbow Lake, Green Lake, Waukena Lake
Lost Creek

	Stream Reach	Sediment		Nutrients		Metals			Temperature	
		Total Sediment Load (tons/ year)	*Target % Reduction*	*Location*	*Target Percent Reduction*	*Metal*	*Metals Load (pounds/day)*	*Target Percent Reduction*	*Existing Condition*	*Target Reduction*
Big Hole River - Melrose	Grose Creek	294	40%	Upper Site	N: 31% to 45% P: 53% to 77%					
				Lower Site	N: 33% to 53% P: 43% to 78%					
	Camp Creek	3450	29%	Between Reservoir & Irrigation Ditch	N: 27% to 60% P: 0 to 90%					
				Near Mouth	N: 64% to 76% P: 4% to 37%					
	Wikiup Creek					Copper	Hi Flow: .447 Lo Flow: .556	Hi Flow: 90% Lo Flow: 97%		
	Trapper Creek	3326	22%			Copper	Hi Flow: 2.552 Lo Flow: .436	Hi Flow: 66% Lo Flow: 7%		
						Cadmium	Hi Flow: .076 Lo Flow: .019	Hi Flow: 66% Lo Flow: 38%		
						Lead	Hi Flow: 12.906 Lo Flow: 2.485	Hi Flow: 98% Lo Flow: 95%		
						Zinc	Hi Flow: 21.981 Lo Flow: 6.297	Hi Flow: 50% Lo Flow: 17%		
	Lost Creek	742	21%	Upper Site	N: n/a to 23% P: 59% to 64%	Arsenic	Hi Flow: .027 Lo Flow: .302	Hi Flow: 0% Lo Flow: 64%		
				Middle Site	N: n/a P: 63% to 67%					
				Lower Site	N: n/a P: 60%					

Table 25: Big Hole River Melrose watershed TMDL targets for sediment, nutrients, metals and water temperature. Data from the Middle-Lower Big Hole River TMDL (Montana DEQ, September 2009).

Lower Big Hole River

Water Quality Issues Summary: Metals and physical habitat alterations as a result of past mine activity, agriculture and dam construction.

303d Listed Streams: none

Area: 285.0 square miles *Hydrologic Unit Code:* 1002000413

HUC 6 watersheds within Lower Big Hole River watershed:

- Upper Willow Creek
- Lower Willow Creek
- Birch Creek
- Big Hole River - Stevens Slough
- Big Hole River - Biltmore Hot Springs
- Nez Perce Creek
- Rochester Creek
- Big Hole River - Twin Bridges

Major Infrastructure: Railroad, Frontage Road, Interstate 15, Town of Glen and Twin Bridges, Burma Road

High Priority Abandoned Hard Rock Mines: Indian Queen (Birch Creek), Emma (Nez Perce Creek), Thistle Mine/Tailings, Watseca (Rochester Creek)

Tributaries:

Downstream

- Big Hole Creek
  - Willow Creek
    - Tendoy Lake
    - Gorge Creek
      - Gorge Lakes
    - Buckhorn Creek
    - Debois Creek
      - Barb Lake
    - Bond Creek
      - Bond Lake, Deerhead Lake
    - North Creek
  - Birch Creek
    - Lily Lake, Boot Lake, May Lake, Pear Lake, Tub Lake, Chan Lake, Anchor Lake
    - Mule Creek
    - Thief Creek & South Fork Thief Creek
    - Armstrong Gulch
    - Sheep Creek
    - Farlin Gulch
    - Bridge Gulch
    - Canyon Gulch
  - Garrison Ditch
  - Stevens Slough
  - Nez Perce Creek
  - Rochester Creek

Watershed	Stream Reach	Sediment		Nutrients		Metals			Temperature	
		Total Sediment Load (tons/ year)	*Target % Reduction*	*Location*	*Target Percent Reduction*	*Metal*	*Metals Load (pounds/day)*	*Target Percent Reduction*	*Existing Condition*	*Target Reduction*
Lower Big Hole River	Birch Creek (Upper Segment)	2015	13%							
	Birch Creek (Lower Segment)	3827	21%							
	Rochester Creek	2288	32%			Arsenic	Hi Flow: .020 Lo Flow: .020	Hi Flow: 89% Lo Flow: 95%		
						Mercury	Hi Flow: .00001 Lo Flow: .00021	Hi Flow: 0% Lo Flow: 660%		
						Copper	Hi Flow: .004 Lo Flow: .004	Hi Flow: 6% Lo Flow: 75%		
						Lead	Hi Flow: .001 Lo Flow: .0009	Hi Flow: 0% Lo Flow: 55%		

Table 26: Lower Big Hole River watershed TMDL targets for sediment, nutrients, metals and water temperature. Data from the Middle-Lower Big Hole River TMDL (Montana DEQ, September 2009).

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Link Addresses

FWP	
Montana Field Guide Online - Montana FWP	http://fieldguide.mt.gov/statusCodes.aspx
Montana Statewide Fisheries Management Plan	http://fwp.mt.gov/fishAndWildlife/management/fisheries/statewidePlan/managementPlan.html
USFS	
Beaverhead Deerlodge National Forest Plan	http://www.fs.usda.gov/detailfull/bdnf/landmanagement/planning/?cid=stelprdb5052938&width=full
Chapter 3: Forestwide Direction	http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5052768.pdf
BLM	
BLM: Butte Field Office	http://www.blm.gov/mt/st/en/fo/butte_field_office.html
BLM Dillon Field Office	http://www.blm.gov/mt/st/en/fo/dillon_field_office.html
USFWS	
Candidate Conservation Agreement with Assurances for Fluvial Arctic Grayling in the Upper Big Hole River	http://www.fws.gov/mountain-prairie/species/fish/grayling/CCAA_June2006.pdf
DEQ	
303d lists on CWAIC	http://cwaic.mt.gov/query.aspx
Middle-Lower Big Hole River Planning area TMDL and Framework	http://www.deq.mt.gov/wqinfo/TMDL/finalReports.mcpx
Montana DEQ's Exploring Your Aquatic Resources Mapping Program	http://www.deq.mt.gov/wqinfo/wetlands/exploringaquaticresources.mcpx
2012 Water Quality Integrated Report	http://cwaic.mt.gov/wq_reps.aspx?yr=2012qryId=102298
Conservation Groups & Related Non-Profit Organizations	
American Fisheries Society (AFS) Montana Chapter	http://www.fisheriessociety.org/AFSmontana/
American Rivers	http://www.americanrivers.org/
Arctic Grayling Recovery Program (AGRP)	http://www.fishhabitat.org/
Center for Biological Diversity	http://www.biologicaldiversity.org/species/fish/Montana_fluvial_Arctic_grayling/index.html
Big Hole River Foundation (BHRF)	http://www.bhrf.org/
Big Hole Watershed Committee (BHWC)	http://bhwc.org/
Blackfoot Challenge	http://blackfootchallenge.org/
Ducks Unlimited, Inc.	http://www.ducks.org/
Missouri Headwaters Partnership (MHP)	http://mtwatersheds.org/Watersheds/WatershedGroups/MissouriHeadwatersPartnership.html
Montana Association of Land Trusts	http://www.montanalandtrusts.org/
Montana Audubon	http://www.mtaudubon.org/
Montana Land Reliance	http://www.mtlandreliance.org/
Montana Natural Heritage Program	http://mtnhp.org/

Montana Non-Profit Association (MNA)	http://www.mtnonprofit.org/
Montana Trout Unlimited (TU)	http://montanatu.org/
Montana Watershed Coordination Council (MWCC)	http://www.mtwatersheds.org/
Montana Wetlands Legacy Partnership	http://www.wetlandslegacy.org/
National Fish Habitat Action Plan	http://www.fishhabitat.org/
People and Carnivores	http://peopleandcarnivores.org/
Pheasants Forever - Beaverhead Chapter	http://montanapf.org/MTPF/mt-chapters/dillon-beaverhead-862/
Rocky Mountain Elk Foundation (RMEF) Montana	http://www.rmef.org/Conservation/WhereWeWork/Montana/
The Conservation Fund	http://www.conservationfund.org/
The Nature Conservancy (TNC)	http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/montana/placesweprotect/big-hole-valley.xml
The Trust for Public Land	http://www.tpl.org/
Western Native Trout Initiative	http://www.westernnativetrout.org/
Wildlife Conservation Society (WCS)	http://www.wcs.org/
Wildlife Society - Montana Chapter	http://joomla.wildlife.org/Montana/
Agencies	
Montana Bureau of Mines & Geology (MBMG)	http://www.mbmg.mtech.edu/
Montana Department of Environmental Quality - Water Quality Bureau (MDEQ)	http://www.deq.mt.gov/wqinfo/default.mcpx
Montana Department of Natural Resources & Conservation (DNRC)	http://dnrc.mt.gov/
Montana Department of Transportation	http://www.mdt.mt.gov/
Montana Fish, Wildlife & Parks	http://fwp.mt.gov/
Natural Resources Conservation Service (NRCS)	http://www.mt.nrcs.usda.gov/
Natural Resource Damages Program (NRDP)	https://doj.mt.gov/lands/
US Forest Service Beaverhead Deerlodge National Forest - Wise River Ranger District (USFS)	http://www.fs.usda.gov/wps/portal/fsinternet/!ut/p/c5/04_SB8K8xLLM9MSSzPy8xBz9CP0os3gjAwhwtDDw9_AI8zPwhQoY6IeDdGCqCPOBqwDLG-AAjgb6fh75uan6BdnZaY6OiooA1tkqlQ!!/dl3/d3/L2dJQSEvUUt3QS9ZQnZ3LzZfMjAwMDAwMDBBODBPSEhWTjBNMDAwMDAwMDA!/?ss=110102&navtype=forestBean
US Bureau of Land Management - Dillon Field Office (BLM)	http://www.blm.gov/mt/st/en/fo/dillon_field_office.html
US Bureau of Land Management - Butte Field Office (BLM)	http://www.blm.gov/mt/st/en/fo/butte_field_office.html
US Fish & Wildlife Service - Partners Program	http://www.fws.gov/partners/
US Geological Survey (USGS)	http://www.usgs.gov/
USGS Climate Change Center	https://nccwsc.usgs.gov/
Local Government & Conservation Districts	
Beaverhead County	http://www.beaverheadcounty.org/
Anaconda-Deer Lodge County	http://www.anacondadeerlodge.mt.gov/index.aspx

Butte-Silver Bow County	http://co.silverbow.mt.us/
Madison County	http://madison.mt.gov/
Ruby Valley Conservation District	http://www.rvcd.org/
Educational Institutions	
University of Montana Western Environmental Studies & Biology Programs	http://www.umwestern.edu/
Montana Tech	http://www.mtech.edu/
University of Montana	http://www.umt.edu/future.aspx
Avian Science Center	http://avianscience.dbs.umt.edu/default.php
Montana State University	http://www.montana.edu/
Montana State Fisheries Cooperative Unit	http://www.montana.edu/mtcfru/

Lower Big Hole Irrigation Infrastructure Survey and Prioritization

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March 2008

Executive Summary

This study provides an inventory of irrigation infrastructure along the lower 44.2 miles of the Big Hole River and prioritizes irrigation infrastructure improvement projects that will lead to improved irrigation efficiency and also benefit in-stream flows. A secondary component of this study is to evaluate the extent of floodplain and streambank alterations due to irrigation diversions, floodplain berms and riprap.

During this assessment, a total of 45 irrigation diversions were identified in the lower Big Hole River, with 34 diversions located on the mainstem of the lower Big Hole River and significant side channels. These 34 diversions are the primary focus of this assessment. This equates to 0.8 diversions per mile or 1 diversion every 1.25 miles. Diversions along the lower Big Hole River divert water through an extensive irrigation ditch network, of which 259 miles were mapped in GIS using color aerial imagery. In addition, a total of 8.0 miles of riprap and floodplain berms were identified within the study area, with streambank alterations covering 18% of the lower 44.2 miles of the Big Hole River, while accelerated streambank erosion was identified along 1.0 miles of the lower Big Hole River.

The results of this assessment were used to develop an irrigation infrastructure improvement priority matrix in which irrigation diversions were ranked based on existing conditions and the potential for improvement, with the goal of providing benefits for both irrigation water management and in-stream flows. Two of the 34 diversions identified on the lower Big Hole River and significant side channels in this study serve two separate ditches. Thus, there are a total of 36 diversions included within the priority matrix. Out of the 36 diversions assessed using the priority matrix, a total of 6 diversions were rated a very high priority, 12 diversions were rated a high priority, 11 diversions were rated a moderate priority and 3 diversions were rated a low priority. Due to a lack of data, four diversions on the mainstem of the lower Big Hole River were not assessed with the priority matrix.

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1.0 Introduction

A study of irrigation infrastructure was undertaken along the lower 44.2 miles of the Big Hole River to identify the condition of existing irrigation infrastructure and to assess the potential for irrigation infrastructure improvements that will increase both irrigation water management efficiency and in-stream flows, while allowing for the continuation of natural channel processes. A secondary component of this study was to evaluate the extent of floodplain and streambank alterations due to irrigation diversions, floodplain berms and riprap. The goals of this study are to:

1. Evaluate the potential for the improvement of irrigation infrastructure while also providing for increased in-stream flows.

2. Evaluate the extent of floodplain and streambank alterations due to irrigation diversions, floodplain berms and riprap.

To accomplish these goals, a detailed inventory and assessment of irrigation diversions and the extent of the irrigation ditch network was conducted, along with an assessment of the extent of riprap and floodplain berms. This data was used to develop an irrigation infrastructure improvement priority matrix in which each diversion was rated based on the following factors:

- Potential for improved water management efficiency
- Potential to benefit in-stream flows
- Existing and future diversion and ditch maintenance requirements
- Influence of diversions on sediment transport and natural channel processes
- Potential to maintain or improve fish habitat
- Level of reach scale impacts
- Ownership, interest level and willingness of responsible parties

2.0 Methods

To inventory and assess irrigation diversions along the lower Big Hole River, a review of the existing data was performed, followed by a "float survey" through the study area and interviews with irrigators. Irrigation diversions, riprap, floodplain berms, log revetments, barbs, accelerated streambank erosion, and fish habitat features were mapped using GPS during the "float survey", which was conducted along the entire lower Big Hole River between Maiden Rock Canyon and the High Road Bridge between November 3rd and November 16th. Once the "float survey" was completed, follow-up meetings with irrigators were conducted on November 27th and 28th and December 6th and 7th, with additional phone interviews conducted in December and February. A description of the methods employed in each phase of this study is provided in the following sections.

2.1 Existing Data Review

During the existing data review, streamflow data from the United States Geological Survey (USGS), Montana Department of Natural Resource Conservation (DNRC) and the Montana Department of Environmental Quality (DEQ) were assessed. Additional information regarding groundwater-surface water interactions was also reviewed from one study performed by the Montana Bureau of Mines and Geology (MBMG) within the project area.

2.2 GIS Analysis

Existing GIS data and color aerial imagery from 2005 (National Agricultural Imagery Program) was used to assess the location of irrigation diversions, the extent of the irrigation ditch network, channel encroachment by roads and structures, and water rights Points of Diversion (POD) and Places of Use (POU). GIS was also used to map the project area and to delineate the current channel margin of the Big Hole River, including side channels and sloughs.

2.2.1 Project Area

For this study, the project area was considered to be the Big Hole River valley bottom between the mouth of Maiden Rock Canyon and the confluence with the Jefferson River, which is referred to as the "Lower Big Hole River Valley" in this report. The delineated project boundary attempts to include all areas that Big Hole River water is used to support agricultural irrigation. Once the valley bottom and river channel were delineated, potential irrigation diversions were identified and maps were created for use during the field assessment portion of the study.

2.2.2 Irrigation Ditch Network

The irrigation ditch network was delineated in GIS using color aerial imagery from 2005. The irrigation ditch network developed through this process was then revised following the field assessment and discussions with irrigators. The irrigation ditch network developed during this assessment should be considered a working GIS layer for future assessments since it is not complete, especially in areas where many small ditches transect fields used for flood irrigation.

2.2.3 Road and Structure Encroachment

Encroachment of the river channel by roads and structures was identified using existing GIS data and color aerial imagery from 2005. Road encroachment was assessed using the Montana Department of Administration road layer (published 02/10/2007). Sections of road not included in this GIS data layer were delineated based on the 2005 color imagery. Structures identified in this assessment include houses and other buildings located within the study area. Structures were delineated using the 2005 color imagery by placing a point on the structure or in the center of a “group of structures”, thus providing a general overview of floodplain development and channel encroachment. Encroachment by roads and structures was then assessed by identifying structures and sections of road that are within 150 feet and 300 feet of the Big Hole River channel margin.

2.2.4 Water Rights

An initial assessment of diversions on the mainstem of the Big Hole River was performed using the Montana DNRC Points of Diversion (POD) and Places of Use (POU) GIS data layers for the Big Hole 4th code HUC. The POD file was queried by source name (SRCNAME) using the “Big Hole River” and source type (SRCTYPE) using “surface water” to identify diversions that use surface water directly from the Big Hole River.

2.3 Field Data Collection

Field data collection consisted of two components: first, a “float survey” using a kayak was conducted between Maiden Rock Canyon and the High Road Bridge; and, second, site visits and phone interviews were conducted with irrigators. During the “float survey” and the follow-up site visits, information on diversion dams, headgates, and the irrigation ditch network was collected. In addition, the extent of riprap, floodplain berms, log revetments, barbs and accelerated bank erosion were assessed during the “float survey”, with an emphasis on streambank alterations associated with irrigation infrastructure. Information on fish habitat and channel features was also collected in the field, with a focus on potential spawning habitat. For the purposes of this assessment, the following terms are defined:

Diversion Feature Types

Initial diversion = diversion dam or weir located upstream of the headgate that directs water down a side channel or diversion channel toward the headgate

Headgate, diversion = headgate associated in close proximity with some sort of diversion dam or weir that directs the flow toward the headgate

Headgate = headgate not associated with flow diversion structure in the immediate vicinity, generally located in a diversion channel, ditch or slough

Streambank Feature Types

Riprap = large angular rocks placed along the bank with the intention of protecting some sort of structure or infrastructure

Riprap, floodplain berm = large angular rocks placed along the bank at an elevation above the floodplain elevation, also applied when the feature only appears to be protecting the floodplain and not associated with any structures

Floodplain berm = gravels and cobbles (channel material) piled on the floodplain to reduce lateral channel migration

Log revetment = logs placed in manner similar to rock riprap

Barb = large angular rocks placed at a single point in channel, intended to deflect the flow away from the bank

Accelerated bank erosion = streambank erosion that appears to be related to irrigation infrastructure

Channel Feature Types

Habitat = habitat feature, primarily observed spawning gravels

2.3.1 Headgates and Diversion Dams

Headgates and diversion dams were mapped during the "float survey" using GPS. Color maps depicting the 2005 aerial imagery with potential diversions identified during the initial phase of this assessment were used in the field as a guide. At each diversion, digital photographs were taken and field notes were recorded. Ditch dimensions and the potential flow were also estimated. Due to the presence of multiple channels in several areas, it was only possible to assess one channel during the "float survey". When multiple channels were encountered, field maps were used to identify which channel should be floated to assess a diversion, though some diversions may have been missed. Additional discussions with irrigators were used to provide information on diversions that may have been missed during the "float survey".

2.3.2 Streambank Alterations

Riprap, floodplain berms, log revetments and barbs were mapped in the field using GPS and digital photographs. Following the "float survey", these streambank alterations were delineated in GIS using color aerial imagery, along with field recorded GPS points and site photos. This assessment technique quantified areas of large and extensive riprap, while areas with "smaller" riprap which may have become re-vegetated may not be accounted for in all circumstances. In addition, it is expected that there is a significant amount of riprap and floodplain berms that have been "abandoned" as the channel course shifted. In general, these features were not assessed, except when still connected to riprap that is adjacent to the channel. Thus, the amount of riprap identified in this assessment should be interpreted as the "minimum" amount. There is likely a much greater amount of "smaller" riprap and historic floodplain berms that were not quantified in this assessment, much of which may not be located along the active channel.

2.3.3 Accelerated Streambank Erosion

This assessment primarily focused on areas of accelerated bank erosion associated with irrigation infrastructure. These features were mapped in GIS using GPS data and digital photographs collected in the field. Naturally eroding banks can be expected in this river system and were not included in this assessment, nor were areas of accelerated bank erosion due to non-irrigation related causes in most instances.

2.3.4 Potential Spawning Sites

While a detailed assessment of fish habitat features was beyond the scope of this assessment, observed potential spawning sites were recorded. This was possible since the "float survey" was performed between November 3rd and November 16th, which coincides with the brown trout spawning period. Potential spawning sites were identified as cleared gravels and redds observed in the appropriate hydrologic areas, which tended to be at the downstream end of pools and glides and upstream of riffles. These sites were most often observed in braided channel areas, where the pool-glide-riffle sequences were most pronounced. Several side channels that are maintained as diversion channels also appeared to provide ideal spawning conditions.

3.0 Results

For the purpose of this assessment, the lower Big Hole River was broken into seven reaches based on the location of Montana Fish, Wildlife and Parks (FWP) Fishing Access Sites (FAS) (**Table 3-1**). The results of this study will be presented within the context of these seven reaches in the following sections.

Table 3-1. Reach Descriptions.

Reach Name	Reach Number	Reach Length (miles)
Maiden Rock to Melrose/Salmon Fly	1	5.8
Melrose/Salmon Fly to Brown's Bridge	2	6.3
Brown's Bridge to Glen	3	7.3
Glen to Notch Bottom	4	7.2
Notch Bottom to Pennington Bridge	5	9.7
Pennington Bridge to High Road Bridge	6	6.2
High Road Bridge to Jefferson River	7	1.8
TOTAL		**44.2**

3.1 Existing Data Review

The results from the existing data review phase of this study are presented below. This information was used to guide the data collection phase of the study and to facilitate the development of the irrigation infrastructure improvement priority matrix.

3.1.1 Streamflow Data

Streamflow data collected by the USGS and Montana DNRC was assessed to provide an estimate of losses to streamflow due to irrigation withdrawals progressing downstream. Where available, streamflow data was reviewed for the July 1st through September 30th timeframe between 2001 and 2007. The complete streamflow dataset is presented in **Appendix A**.

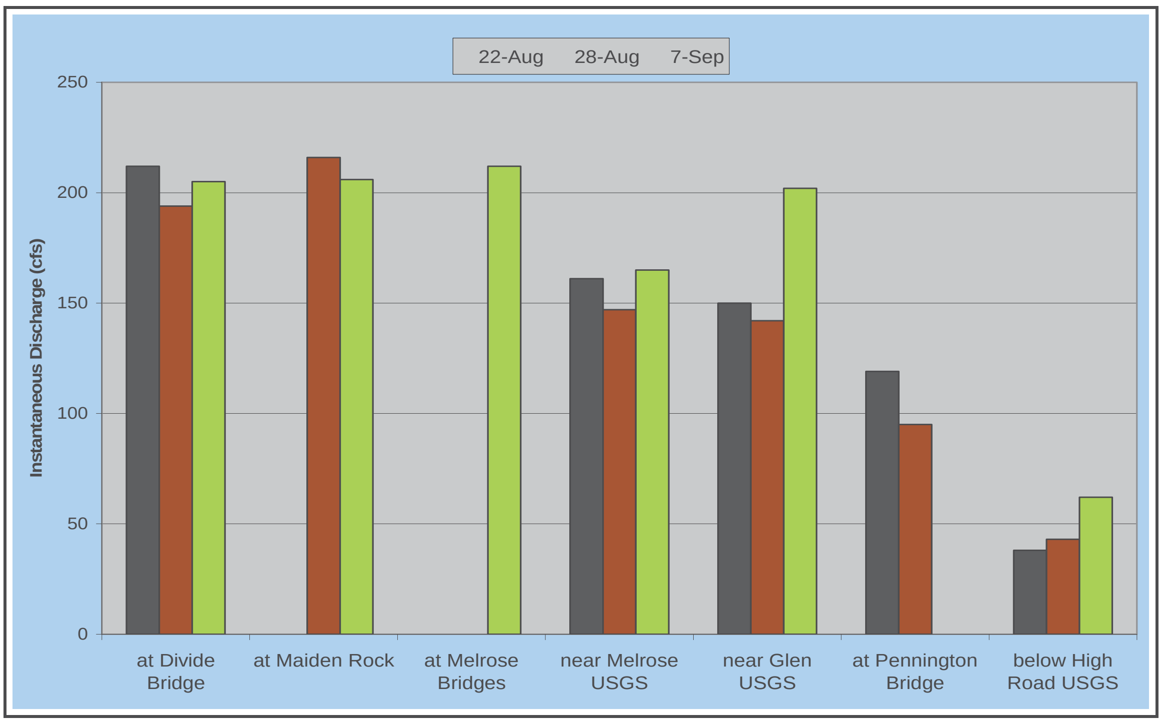
Three USGS gaging stations were included in this assessment:

- near Melrose (06025500)
- near Glen (06026210)
- below Hamilton Ditch near Twin Bridges (06026420)

The USGS near Melrose gage is located just downstream of the Kalsta Bridge, which is approximately 7 miles downstream of the town of Melrose, while the USGS near Glen is located downstream of Notch Bottom, which is approximately 8 miles downstream of the town of Glen. The USGS below Hamilton Ditch near Twin Bridges gage is located downstream of the High Road Bridge. Streamflow data from the USGS near Melrose and near Glen gages was reviewed from 2001-2007, while the USGS below Hamilton Ditch gage came online in 2007, so only one year of data collected by the USGS was available. Additional streamflow data recorded at the High Road Bridge was obtained from Montana DNRC, which maintained a measuring device at this site between 2001 and 2004, while the Jefferson River Watershed Council collected the data in 2005 and 2006. Montana DNRC also operated measuring devices at Divide Bridge and Pennington Bridge in 2007 and made synoptic flow measurements at several sites in August of 2007.

Streamflow measurements performed at the Divide Bridge, at the bridge in Maiden Rock Canyon, at the Melrose Bridge and at the USGS near Melrose gage downstream of the Kalsta Bridge suggest that streamflow remains relatively stable between the Divide Bridge and the Melrose Bridge and then decreases between the Melrose Bridge and the USGS near Melrose gage (**Figure 3-1**). Synoptic streamflow measurements at the Divide Bridge, the bridge in Maiden Rock Canyon, and the Melrose Bridge documented flows of 205, 206 and 212cfs, respectively, on September 7th, 2007. Synoptic streamflow measurements between the Melrose Bridge and the USGS near Melrose gage, recorded a decrease of 47cfs between the two sites on September 7th, 2007. During the summer of 2007, mean daily streamflow decreased by an average of 28cfs between the Divide Bridge and the USGS near Melrose gage (**Table 3-2**).

Figure 3-1. Lower Big Hole River Synoptic Streamflow Measurements, August 2007.



Data and figure provided courtesy of Dave Amman, Montana DNRC

Streamflow data from the USGS near Melrose gage located downstream of the Kalsta Bridge and at the USGS near Glen gage located downstream of Notch Bottom, indicate that streamflows tend to increase between these two sites. USGS gaging station data from 2001-2007 indicate that between July 1st and September 30th mean daily streamflows increased between these two sites in 5 out of the past 7 years, with an average increase in streamflow of 22cfs (**Table 3-2**). During the 2007 synoptic measurements, streamflows decreased slightly between the two sites during the two August monitoring events, but then increased during the September 7th monitoring event (**Figure 3-1**).

Table 3-2. Streamflow Gains and Losses (cfs), July 1-September 30, 2001-2007.

Reach	2001	2002	2003	2004	2005	2006	2007
Divide Bridge to Melrose							-28
Melrose to Glen	+26	+53	+51	+15	-4	-14	+29
Glen to Pennington Bridge							-38
Pennington Bridge to High Road Bridge							-84
Glen to High Road Bridge	-139	-181	-142	-147	-149	-139	-139
Divide Bridge to High Road Bridge							-119

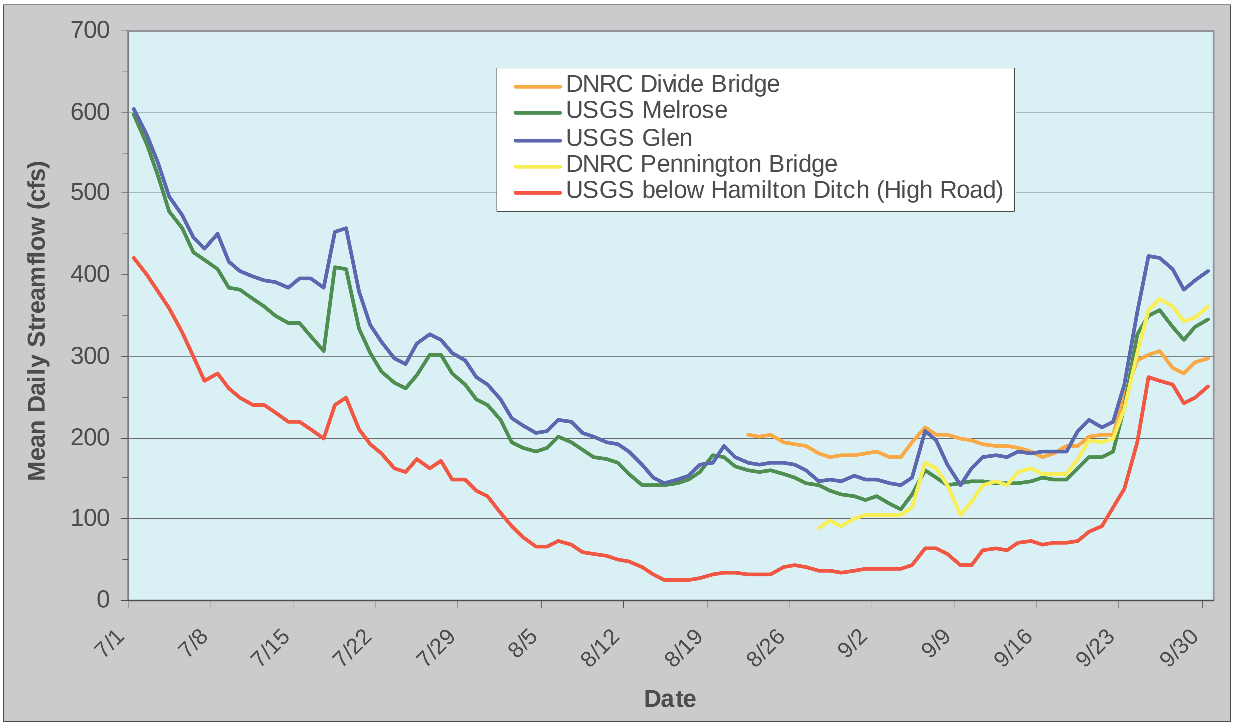
USGS near Melrose gage located downstream of Kalsta Bridge
USGS near Glen gage located downstream of Notch Bottom
USGS below Hamilton Ditch gage located downstream of High Road Bridge
Divide Bridge and Pennington Bridge monitored by Montana DNRC

Streamflow measurements between the USGS near Glen gage, which is located downstream of Notch Bottom, and Pennington Bridge indicate that streamflow decreases in this section of river. Downstream of the USGS near Glen gage, streamflow was observed to decrease during the 2007 synoptic measurements, with flows at Pennington Bridge 31cfs lower than at the Notch on August 22nd and 47cfs lower than at the Notch on August 28th (**Figure 3-2**). In the summer of 2007, mean daily streamflow decreased by an average of 38cfs between the USGS near Glen gage and Pennington Bridge (**Table 3-2**).

Streamflow measurements between Pennington Bridge and the USGS gage below Hamilton Ditch, which is downstream of the High Road Bridge, indicate that streamflow decreases in this section of river. During the 2007 synoptic measurements, streamflow between the two sites decreased by 81cfs on August 22nd and 52cfs on August 28th (**Figure 3-1**). In the summer of 2007, mean daily streamflow decreased by an average of 84cfs between Pennington Bridge and the USGS below Hamilton Ditch gage (**Table 3-2**).

Based on this assessment, streamflows appear to decrease between Maiden Rock Canyon and USGS near Melrose gage and then remain stable or slightly increase between the USGS near Melrose and the USGS near Glen gages (**Figure 3-2**). Downstream of the USGS near Glen gage, mean daily streamflows between 2001 and 2007 decreased by an average of 148cfs, while mean daily streamflow decreased by an average of 119cfs between the Divide Bridge and the High Road Bridge in 2007 (**Table 3-2**).

Figure 3-2. Mean Daily Streamflows, July 1-September 30, 2007.



3.1.2 Ditch Flow Data

In addition to Big Hole River streamflows, measured and estimated flows of several ditches performed by Montana DEQ as part of a temperature study in July of 2006 were also reviewed (Flynn et. al. 2008). Ditch flows are presented relative to USGS gaging stations and DNRC flow measuring sites as discussed in the previous section. Ditch flows utilized to model temperature are described within this section and **Table 3-3.** This data represents measurements and estimates from one week in late July of 2006 that were used to model the relationship between streamflow on water temperature. Additional ditch flow data is required to verify the accuracy of the flows presented in the following discussion.

There are several major diversions between the Divide Creek Bridge and the Melrose Bridge, including Upper McCauley, Lower McCauley and the Melrose Canal, along with an un-named diversion (D19) in Maiden Rock Canyon. There are also several smaller diversions. During temperature monitoring in 2006, Montana DEQ measured 20.7cfs at the Upper McCauley diversion and 16.7cfs at D19. Montana DEQ estimated 10.6cfs was diverted on July 26th at Lower McCauley and 6.5cfs was diverted at the Melrose Canal, for an estimate of approximately 17cfs between the two diversions based on measurements performed at the inlet and overflow of the diversion channel which feeds both of these diversions.

Major diversions between the Melrose Bridge and the USGS near Melrose gage include Pendergast-Spears-McCullough, Gallagher Ditch, Hagenbarth's Big Hole Ditch and Kalsta's. During temperature monitoring in 2006, approximately 21cfs were measured between the

Pendergast-Spears-McCullough and Gallagher ditches on July 27th, with 5.5cfs measured at the Pendergast-Spears-McCullough diversion and 15.7cfs measured in the Gallagher Ditch. It was estimated that 11.8cfs were diverted at Kalsta's and 20.7cfs were diverted at Hagenbarth's Big Hole Ditch.

Major diversions between the USGS near Melrose gage and the USGS near Glen gage include the Garrison/Kilwien diversion, along with Rafferty's Upper and Lower South Side ditches. There are also several smaller diversions. At the Garrison/Kilwien diversion, a flow of 35.3cfs was estimated. A flow of 6.2cfs was measured in Rafferty's Upper South Side ditch on July 29th, 2006, while a flow of 8.4cfs was measured in the Lower South Side ditch, for a combined flow of approximately 15cfs between these two ditches.

The Pageville Canal is the major diversion between the USGS near Glen gage and Pennington Bridge. A flow of 58.0cfs was measured in this diversion during temperature monitoring on July 30th, 2006. A portion of the water used in the Pageville Canal ends up in the Beaverhead River. Other substantial diversions within this reach include JS Ranch (Larson-Naranchich), the Sandy Ditch, and the Naranchich Ditch.

The Big Hole Co-op Ditch is the major diversion between Pennington Bridge and the USGS below Hamilton Ditch gage. This ditch carried a flow of 77.6cfs when measured on July 30th during the 2006 temperature monitoring project. A portion of the water used in the Big Hole Co-op Ditch ends up in the Beaverhead River. Additional ditches in this reach estimated to carry between 5cfs and 10cfs in 2006 include the Orphan Home, Logan-Smith and Lott-Harvey ditches. The Hamilton Ranch ditch also has the capacity to carry a substantial amount of water.

Table 3-3. Ditch Flow Data Collected during the 2006 DEQ Temperature Study.

Site	Diversion Name	Ditch Flows used in Temperature Model (cfs)
DNRC Divide Bridge site		
DNRC Maiden Rock Canyon site		
D18	Upper McCauley	20.7
D19	Meriwether's	16.7
D20	Lower McCauley	10.6*
D21	Melrose Canal	6.5*
D24	Carpenter's	5.8
DNRC Melrose Bridge site		
D11a	Pendergast-Spears-McCullough	5.5
D11b	Gallagher Ditch	15.7
D12	Kalsta's	11.8*
D13	Hagenbarth's Main Ditch	20.7
USGS near Melrose gage		
D14	Hagenbarth's River Field Ditch	6.1
D15	Gainy's	2.5
D16	Garrison/Kilwien	35.3*
D26	Garrison's Wild Hay Ditch	4.0*
D27	Rafferty's Upper South Side	6.2
D28	Rafferty's Lower South Side	8.4
D37	Bryan Ditch	4.3
USGS near Glen gage		
D4	JS Ranch (Larson-Naranchich)	26.5
D2	Sandy Ditch	4.7
D3	Pageville Canal	58.0
D5	Naranchich	21.2*
DNRC Pennington Bridge site		
D6	Big Hole Co-op Ditch	77.6
D8	Orphan Home	9.5
D9	Logan-Smith	6.1*
D10	Lott-Harvey	9.6
D36	Hamilton ("Ranch") Ditch	1.7
USGS below Hamilton Ditch near Twin Bridges gage (High Road Bridge)		

*Estimated

3.1.3 Temperature Data

Montana DEQ assessed the existing thermal regime in the Big Hole River based on temperature and streamflow data collected in July of 2006 using the Heat Source v7.0 model. Areas of concern identified during this assessment include river km-50 near the USGS near Melrose gage and the entire lower 20-km of the river, which includes the area downstream of Notch Bottom. This study concluded that:

> *"Flow alteration is the most significant contributor to warming of the river, and subsequently, the most feasible alternative for returning the Big Hole River to a more natural thermal regime"* (MDEQ 2008).

This study also found that geologic controls in Maiden Rock Canyon and at Notch Bottom lead to a substantial amount of ground water accretion, leading to localized increases in streamflow.

3.1.4 Ground Water Data

Irrigation practices within the Big Hole watershed influence interactions between surface water and ground water in the basin. A study conducted by Montana Bureau of Mines and Geology found that most gains in aquifer storage occurred in May and June when 30,000 acre-feet were added to the aquifer in the lower basin, which the study defined as from Maiden Rock to Notch Bottom (Marvin and Voeller 2000). This study found that ground water storage was near its maximum by July and was relatively stable due to a dynamic equilibrium between irrigation recharge of the aquifer through leaky ditches and ground water discharge to surface water. Ground water storage was found to decline during August and September and most of this water was thought to be lost to evapotranspiration (the sum of evaporation and plant transpiration) rather than discharging to surface water. Once irrigation ceased, an average gain of 90cfs in streamflow was directly attributed to irrigation return flows in October and November between Maiden Rock Canyon and Notch Bottom (Marvin and Voeller 2000).

3.2 GIS Analysis

GIS analysis included the development of an irrigation ditch network, identification of road and structure encroachment, and a review of water rights.

3.2.1 Irrigation Ditch Network

A total of 37 irrigation ditches were identified and 259 miles of irrigation ditch were mapped along the lower Big Hole River (**Table 3-4**). This assessment suggests that the greatest potential to divert water for irrigation purposes exists in Reaches 3, 5, and 6, with the highest potential between Pennington Bridge and High Road Bridge. An overview of the irrigation ditch network in the lower Big Hole River Valley is provided in **Figure 3-3 (Appendix B)**.

Table 3-4. Irrigation Ditch Network.

Reach Name	Reach Number	Reach Length (miles)	Ditch Length (miles)	Ditch Length to Reach Length Ratio
Maiden Rock to Melrose/Salmon Fly	1	5.8	24.1	4.2
Melrose/Salmon Fly to Brown's Bridge	2	6.3	11.9	1.9
Brown's Bridge to Glen	3	7.3	53.0	7.3
Glen to Notch Bottom	4	7.2	15.9	2.2
Notch Bottom to Pennington Bridge	5	9.7	72.2	7.5
Pennington Bridge to High Road Bridge	6	6.2	70.0	11.3
High Road Bridge to Jefferson River	7	1.8	11.9	6.8
TOTAL		**44.2**	**259.0**	**5.9**

3.2.2 Road and Structure Encroachment

Road and structure encroachment was assessed to determine areas where natural channel processes are limited by existing structures and infrastructure. A total of 185.3 miles of road were identified in the lower Big Hole River valley, with 18.7 miles of roads within 150 feet of the river channel and 36.8 miles of road within 300 feet of the river channel (**Figure 3-4** in **Appendix B, Table 3-5)**. A total of 172 structures or "groups of structures" were identified in the Lower Big Hole River Valley. Of these, 23 structures were within 150 feet of the stream channel and 54 structures were within 300 feet of the river channel. This equates to one structure every 1.3 miles, though, in actuality, much of the structure encroachment occurs around the towns of Melrose and Glen. Of the 54 structures within 300 feet of the river channel, 6 (11%) were associated with riprap and floodplain berms mapped during this assessment. Based on this assessment, it appears that encroachment of the river channel by roads likely restricts lateral channel migration to a larger extent than structures at this time. Impacts due to roads are most apparent at bridge crossings which effectively restrict the floodprone area and prevent lateral channel migration.

Table 3-5. Road Encroachment.

Reach Name	Reach Number	Reach Length (miles)	Length of Road within 150 Feet (miles)	Length of Road within 300 Feet (miles)
Maiden Rock to Melrose/Salmon Fly	1	5.8	4.4	7.8
Melrose/Salmon Fly to Brown's Bridge	2	6.3	0.8	2.7
Brown's Bridge to Glen	3	7.3	4.1	7.6
Glen to Notch Bottom	4	7.2	3.6	6.4
Notch Bottom to Pennington Bridge	5	9.7	4.1	8.8
Pennington Bridge to High Road Bridge	6	6.2	1.4	3.1
High Road Bridge to Jefferson River	7	1.8	0.3	0.5
TOTAL		**44.2**	**18.7**	**36.8**

Table 3-6. Structure Encroachment.

Reach Name	Reach Number	Reach Length (miles)	Number of Structures within 150 Feet	Number of Structures within 300 Feet
Maiden Rock to Melrose/Salmon Fly	1	5.8	0	10
Melrose/Salmon Fly to Brown's Bridge	2	6.3	1	2
Brown's Bridge to Glen	3	7.3	15	25
Glen to Notch Bottom	4	7.2	0	4
Notch Bottom to Pennington Bridge	5	9.7	7	12
Pennington Bridge to High Road Bridge	6	6.2	0	1
High Road Bridge to Jefferson River	7	1.8	0	0
TOTAL		**44.2**	**23**	**54**

While providing an indicator of overall floodplain development densities, road and structure encroachment data was deemed unsuitable for use in the irrigation infrastructure improvement priority matrix.

3.2.3 Water Rights

Analysis of the Montana DNRC Points of Diversion GIS data layer indicates there are 257 claimed points of diversion along the lower 44.2 miles of the Big Hole River serving irrigation, stock and other purposes (**Table 3-7**). A total of 227 individual water rights claims and permits and a total of 66 distinct points of diversion were identified in the Points of Diversion GIS data layer, which maps water rights claims and permits based on the section-township-range legal land description. Based on this dataset, the number of claimed points of diversion per mile was calculated for use in the priority matrix. This assessment indicates that Reach 6 has the most claimed points of diversion per mile, with more than twice as many as any other reach. DNRC Points of Diversion that claim Big Hole River surface water as a source are presented in **Figure 3-3 (Appendix B)**.

Table 3-7. DNRC Points of Diversion.

Reach Name	Reach Number	Reach Length (miles)	Claimed Points of Diversion	Claimed Points of Diversion / Mile
Maiden Rock to Melrose/Salmon Fly	1	5.8	35	6.1
Melrose/Salmon Fly to Brown's Bridge	2	6.3	13	2.1
Brown's Bridge to Glen	3	7.3	30	4.1
Glen to Notch Bottom	4	7.2	23	3.2
Notch Bottom to Pennington Bridge	5	9.7	47	4.9
Pennington Bridge to High Road Bridge	6	6.2	108	17.4
High Road Bridge to Jefferson River	7	1.8	1	0.6
TOTAL		**44.2**	**257**	**5.8**

3.3 Field Data Assessment

The field data collection phase of this study involved a "float survey" to map irrigation diversions, riprap, floodplain berms, log revetments, barbs, accelerated streambank erosion, and fish habitat features using GPS. Once the "float survey" was completed, follow-up meetings with irrigators were conducted. Information collected during this phase of the study is provided by reach in the following sections, with accompanying reach scale maps in **Appendix B**. The seven reaches delineated in this study are based on Montana FWP Fishing Access Sites and also roughly correspond to various areas served by specific irrigation ditches.

A total of 45 irrigation diversions were identified in this study and 41 diversions were assessed. Four additional diversions were not assessed, but are known to exist (D40, D41, D44 and one unnumbered headgate on the Big Hole Ranch). Out of the 45 diversions identified during this assessment, 34 diversions are located along the mainstem of the Big Hole River and significant side channels, averaging 0.8 diversions per mile or 1 diversion every 1.25 miles (**Table 3-8**). These 34 diversions are the primary focus of this study. An additional 11 diversions located within ditches or along sloughs were also reviewed during this assessment, though these only represent a portion of the headgates within the ditch networks.

For the purpose of this assessment, diversions are numbered D1-D44 and diversion names were derived from interviews with irrigators (**Table 3-9**). Diversions were numbered based on the order they were encountered in. When the name of a diversion was in question, the primary irrigators name was used to identify the diversion. A detailed discussion of conditions at each individual diversion is provided in **Appendix C,** while irrigator contact information is presented in **Appendix D**. The database of "point features" mapped during this assessment, including diversions, barbs, and habitat features, is provided in **Appendix E**.

Table 3-8. Diversions, Streambank Alterations and Habitat Features.

Feature Type	Number	Total Length (Feet)	Total Length (Miles)
Diversions on mainstem and side channels	34		
Diversions in ditches and sloughs*	11		
Barbs	15		
Riprap	45	16,635	3.2
Riprap, floodplain berms	20	18,335	3.5
Floodplain berms	4	6,515	1.2
Log revetments	2	802	0.2
Accelerated bank erosion	9	5,126	1.0
Fish habitat (spawning sites)	14		

*There are likely more diversions in ditches not examined in this assessment.

A total of 71 sections of riprap were assessed, including floodplain berms and log revetments. Riprap was numbered R1-R71 (**Table 3-8**). Along the lower 44.2 miles of the Big Hole River, this assessment indicates that approximately 8.0 miles of streambank have been altered by the placement of riprap, floodplain berms and log revetments, covering approximately 18% of the study area. In addition, 1.0 miles of accelerated streambank erosion have been identified. A total of 9 streambanks with accelerated erosion were assessed, covering 1.0 miles. The database of "line features" mapped during this assessment, including riprap, floodplain berms, log revetments, and accelerated bank erosion, is presented in **Appendix F**.

Table 3-9. Irrigation Diversions on the Big Hole River Mainstem Progressing Downstream.

Site	Diversion Name
Maiden Rock to Melrose/Salmon Fly	
D18	Upper McCauley
D19	Meriwether's
D20	Lower McCauley
D21	Melrose Canal
D22	Meriwether's
D44	Meriwether's (Buyan slough)
D23	Carpenter's
D24	Carpenter's
Melrose/Salmon Fly to Brown's Bridge	
D11a	Pendergast-Spears-McCullough
D11b	Gallagher Ditch
none	at Big Hole Ranch
Brown's Bridge to Glen	
D12	Kalsta's
D13	Hagenbarth's Big Hole Ditch
D14	Hagenbarth's River Field Ditch
D15	Gainy's
D39	Smith's
D40	Smith's
Glen to Notch Bottom	
D16	Gainy's
D17a	Garrison
D17b	Kilwien
D25	Glennon's (?)
D26	Garrison's Wild Hay Ditch
D27	Rafferty's Upper South Side
D28	Rafferty's Lower South Side
D37	Bryan Ditch
Notch Bottom to Pennington Bridge	
D4	JS Ranch (Larson-Naranchich)
D1	Copper's (Whitney Ditch)
D2	Sandy Ditch
D3	Pageville Canal
D5	Naranchich
Pennington Bridge to High Road Bridge	
D6	Big Hole Co-op Ditch
D8	Orphan Home
D9	Logan-Smith
D10	Lott-Harvey
High Road Bridge to Jefferson River	
D35	pump at Hamilton Ranch
D36	Hamilton Ranch Ditch

3.3.1 Maiden Rock to Melrose/Salmon Fly

The Maiden Rock to Melrose/Salmon Fly assessment reach is approximately 5.8 miles long (**Figure 3-5** in **Appendix B**). This reach starts in Maiden Rock Canyon at the uppermost diversion (Diversion 18) that is used to irrigate land in the valley downstream (south) of Maiden Rock Canyon. Diversion 19 is also located in the canyon, while Diversions 20 and 21 are located at the mouth of Maiden Rock Canyon. Diversions 22, 23 and 24 occur in succession between the mouth of Maiden Rock Canyon and Melrose, while Diversion 44 is located at the point of the island across from Diversion 22. Thus, a total of 8 diversions were assessed in this reach, all of which are used to irrigate lands between the mouth of Maiden Rock Canyon and Melrose, with the majority of the irrigation water supplied by Big Hole River used to irrigate the area along the east side of the river (**Table 3-10**). There is an average 1.4 diversions per mile in this reach. A detailed discussion of each diversion can be found in **Appendix C.**

Table 3-10. Maiden Rock to Melrose/Salmon Fly.

Feature Type	Number	Sites	Total Length (Feet)	Total Length (Miles)
Diversions on mainstem and side channels	8	D18, D19, D20, D21, D22, D23, D24, D44		
Riprap	6	R42, R44, R45, R46, R47, R67	1,321	0.25
Accelerated bank erosion	1	E3	467	0.09
Fish habitat (spawning sites)	3	H9, H10, H11		

*There are likely more diversions in ditches not examined in this assessment.

Six sections of riprap were identified in this reach covering approximately 1,321 feet (0.25 miles) and 4% of the reach (**Table 3-10**). In addition, the railroad runs along the river left bank in Maiden Rock Canyon and this bank has been altered by the railroad bed. Downstream of Maiden Rock Canyon, the Big Hole River is a multi-channel system flowing through a broad floodplain area. In general, sections of riprap in this reach are relatively short. The section of riprap (R45) along the river left bank downstream of Diversion 24 is leading to approximately 467 feet of accelerated bank erosion (E3) along the river right bank on the next bend downstream. The stream channel is becoming over-widened at this point due to the accelerated rate of streambank erosion.

Three potential spawning sites were identified within this reach, though there are likely more. Two of the sites were located in the multi-channel section of river downstream of the mouth of the canyon. The channel splits twice within this reach, with one split occurring along the Meriwether Ranch upstream of Diversion 22 and the second split occurring upstream of Melrose. These channels provide habitat complexity, though sections of riprap and channel over-widening reduce the habitat complexity. The river may also be in the process of abandoning the right channel at the first split, leading to a reduction in habitat during low streamflow. At the first channel split, the majority of the flow remains in the left channel, while the two channels are divided relatively evenly at the second split. The river right (western) channel was not assessed in either split, though the channel along the Meriwether Ranch (Buyan Slough or “County Line” slough) reportedly once supported extensive spawning.

3.3.2 Melrose/Salmon Fly to Brown's Bridge

The Melrose/Salmon Fly to Brown's Bridge assessment reach is approximately 6.3 miles long and extends between the two fishing access sites (**Figure 3-6** in **Appendix B**). One diversion (D11) along this reach was assessed, while a second diversion used by the Big Hole Ranch was not assessed. Diversion 11 is located in the left (east) channel downstream of Melrose. This diversion serves two ditches, which irrigate land to the east of the river. Two headgates within this ditch network were also assessed as well as a third headgate in a slough that carries return water from these ditches. There is an average of 0.3 diversions per mile in this reach. A detailed discussion of each diversion can be found in **Appendix C.**

Table 3-11. Melrose/Salmon Fly to Brown's Bridge.

Feature Type	Number	Sites	Total Length (Feet)	Total Length (Miles)
Diversions on mainstem and side channels	2	D11, unnumbered diversion at BHR		
Diversions in ditches and sloughs*	3	D29, D30, D31		
Riprap	2	R35, R33	479	0.09
Accelerated bank erosion	1	E5	185	0.04
Fish habitat (spawning sites)	3	H5, H6, H7		

*There are likely more diversions in ditches not examined in this assessment.

Only two sections of riprap were observed within this reach, totaling approximately 479 feet and 1% of the reach. Both sections of riprap were associated with the railroad along the river left bank of the left channel downstream of Melrose. The right channel was not assessed. Accelerated bank erosion was observed along the left bank downstream of Diversion 11, with an estimated length of 185 feet. Additional bank erosion was observed along the river left bank downstream of where the two channels converge, while a third large eroding bank was observed along river left in a field approximately 1.7 miles upstream of Brown's Bridge in the left channel where the channel splits around an island. The second and third eroding banks did not appear to be related to irrigation infrastructure and were not quantified in this assessment.

The left channel downstream of Melrose contained three potential spawning sites, including one site at the Salmon Fly FAS and one site just upstream of Diversion 11. The right channel was not observed, though it likely contains additional habitat potential. Downstream of the convergence of the two channels, the river is relatively straight, with a riffle and run dominated streambed that lacks habitat complexity.

3.3.3 Brown's Bridge to Glen

The Brown's Bridge to Glen assessment reach is approximately 7.3 miles long and extends between the two fishing access sites, with the Glen FAS located in the right (west) channel approximately 1.5 miles downstream of the town of Glen (**Figure 3-7** in **Appendix B**). The left (east) side channel was included in the next reach downstream since the diversions from this channel irrigate area between the Glen FAS and the Notch. A total of five diversions on the Big Hole River mainstem and side channels were assessed within this reach, while a sixth diversion

(D40) along the river right bank downstream of Glen was not assessed. Upstream of the I-15 crossing, Diversion 12 is located along the river left, while Diversion 13 obtains water from a diversion channel along river right. The initial point of diversion for Diversion 14 is located just downstream of the Kalsta Bridge on river right. Diversion 15 is located on the river left bank approximately 1 mile upstream of the town of Glen. Diversions 39 and 40 are located upstream and downstream of the town of Glen, respectively, and both diversions are located on side channels. Diversion 34 is located in the ditch fed by Diversion 12, while Diversion 42 is located at the mouth of Rock Creek in the ditch fed by Diversion 13. There is an average of 0.8 diversions per mile in this reach. A detailed discussion of each diversion can be found in **Appendix C.**

Table 3-12. Brown's Bridge to Glen.

Feature Type	Number	Sites	Total Length (Feet)	Total Length (Miles)
Diversions on mainstem and side channels	6	D12, D13, D14, D15, D39, D40		
Diversions in ditches and sloughs*	2	D34, D42		
Riprap	6	R34, R36, R37, R38, R39, R43	3,366	0.64
Floodplain berms	1	R68	2,458	0.47
Fish habitat (spawning sites)	3	H2, H3, H4		

*There are likely more diversions in ditches not examined in this assessment.

Six sections of riprap were identified, the majority of which is associated with I-15, which crosses the Big Hole River in this reach. There is approximately 3,366 feet (0.64 miles) of riprap, with an additional 2,458 feet (0.47 miles) of floodplain berm located at a bend approximately 1 mile downstream of the Kalsta Bridge. Thus, there is approximately 1.1 miles of streambank alterations within this reach, which amounts to 15% of the reach, much of which is associated with road encroachment.

Potential spawning habitat was observed at three locations. The diversion channel leading to D13 provided extensive habitat, as did the braided section of the Big Hole River mainstem along this diversion channel. Additional potential spawning habitat was observed in the mainstem of the Big Hole River upstream of the town of Glen.

3.3.4 Glen to Notch Bottom

The Glen to Notch Bottom assessment reach is approximately 7.3 miles long and extends between the two fishing access sites (**Figure 3-8** in **Appendix B**). The left (east) side channel upstream of the Glen FAS was included in this reach since the diversions from this channel irrigate the area between the Glen FAS and the Notch. There are a total of 7 diversions on the Big Hole River mainstem and side channels in this reach. In addition, three diversions in ditches and sloughs were identified and two were observed in the field. Diversions 16 and 17 utilize a single diversion channel along the left (east) side of the river. There are two headgates in diversion 17 leading into separate ditches (D17a and D17b). Diversion 25 is located in a side channel along river right, while Diversion 26 is located in a side channel along river left. Diversion 27 is located in a diversion channel on river right and Diversion 28 is also located along river right just upstream of the Notch and across from Diversion 38, which is located along the river left bank at the lower end of Steven's Slough. Diversion 41 is located at the upper end of Steven's Slough and utilizes return flow from the ditch feed by D17a. Diversion 43 is located in the ditch feed by Diversion 28. There is an average of 1.0 diversions per mile in this reach. A detailed discussion of each diversion can be found in **Appendix C.**

Table 3-13. Glen to Notch Bottom.

Feature Type	Number	Sites	Total Length (Feet)	Total Length (Miles)
Diversions on mainstem and side channels	7	D16, D17, D25, D26, D27, D28, D37		
Diversions in ditches and sloughs*	3	D38, D41, D43		
Barbs	1	B15		
Riprap	13	R40, R41, R48, R50, R52, R53, R56, R59, R61, R62, R64, R65, R69	6,044	1.14
Riprap, floodplain berms	4	R49, R55, R57, R58	1,993	0.38
Floodplain berms	2	R60, R63	3,652	0.69
Accelerated bank erosion	2	E4, E8	1,415	0.27
Fish habitat (spawning sites)	4	H8, H12, H13, H14		

*There are likely more diversions in ditches not examined in this assessment.

Seventeen sections of riprap and riprap/floodplain berms were identified in this reach, covering approximately 1.52 miles of streambank. In addition, 0.69 miles of floodplain berms were identified. Thus, there is approximately 2.21 miles of streambank alterations within this reach, which amounts to 31% of the reach. Accelerated bank erosion was identified at two sites, covering 1,415 feet (0.27 miles). Streambank erosion at E4 was included in this assessment since a house was recently constructed near this eroding bank and the bank will likely require stabilization in the future. There was also one barb in this reach.

Potential spawning habitat was observed at three sites, with the upper site (H8) located downstream of Diversion 17 in the diversion channel. Sites H12 and H13 were located in a braided section of river downstream of R63. There is approximately one mile of dynamic braided channels that likely support additional spawning potential within this reach. Potential spawning sites (H14) were also observed in the diversion channel leading down to Diversion 27.

3.3.5 Notch Bottom to Pennington Bridge

The Notch Bottom to Pennington Bridge assessment reach is approximately 9.7 miles long and extends between the two fishing access sites (**Figure 3-9** in **Appendix B**). There are a total of 5 diversions within this reach. While the diversion channel leading to Diversion 5 was observed in the field, the actual point of diversion on the side channel was not observed. Progressing downstream, Diversion 4 is located on river left below the volcanic bluffs downstream of the Notch. Diversion 1 is located along river right. Diversion 2 is located at a geologic nickpoint at the outside of a bend on river left. Diversion 3 is located at the outside of a bend on river right, with the diversion channel for Diversion 5 located approximately 1,200 downstream on river left. In addition, Diversions 32 and 33 are located within the ditch fed by Diversion 3. There is an average of 0.5 diversions per mile in this reach. A detailed discussion of each diversion can be found in **Appendix C.**

Table 3-14. Notch Bottom to Pennington Bridge.

Feature Type	Number	Sites	Total Length (Feet)	Total Length (Miles)
Diversions on mainstem and side channels	5	D1, D2, D3, D4, D5 (primary headgate not assessed)		
Diversions in ditches and sloughs*	2	D32, D33		
Barbs	13	B1-B13		
Riprap	10	R2, R3, R4, R8, R11, R13, R20, R21, R22	3,098	0.59
Riprap, floodplain berms	8	R1, R5, R6, R7, R10, R15, R16, R66	5,947	1.13
Log revetments	2	R9, R14	802	0.15
Accelerated bank erosion	2	E1, E6	1,473	0.28
Fish habitat (spawning sites)	1	H1		

*There are likely more diversions in ditches not examined in this assessment.

A total of 18 sections of riprap and riprap/floodplain berms were identified in this reach, covering approximately 1.72 miles. In addition, log revetments have been used to stabilize two banks. Thus, there are approximately 1.87 miles of streambank alterations within this reach, which amounts to 19% of the reach. Accelerated bank erosion was observed at two sites, with E6 resulting from the diversion dam at Diversion 4 and E1 resulting from the diversion dam at E1.

Potential spawning habitat was identified in a braided section of the river. There are two channels in the lower 1.7 miles of this reach and the left (west) channel was observed to have a very dynamic stream channel, which likely leads to additional spawning potential. The right (east) channel upstream of Pennington Bridge was not assessed, though it also may have a similar character that would likely support additional spawning potential.

3.3.6 Pennington Bridge to High Road Bridge

The Pennington Bridge to High Road assessment reach is approximately 6.2 miles long and extends between the two fishing access sites (**Figure 3-10** in **Appendix B**). There are four mainstem diversions along this assessment reach. Diversion 6 is located along the right bank just downstream of the Pennington Bridge in the right channel, which carries most or all of the flow at low water. Diversion 8 is located along the river right bank in the main channel downstream of Nez Perce Creek. The main channel splits into two channels approximately 1.7 miles upstream of the High Road Bridge and both Diversion 9 and Diversion 10 are located along the river right bank in the right (east) channel. In addition to the mainstem diversions, Diversion 7 is located behind a floodplain berm in an area with ponded water. There is an average of 0.6 diversions per mile in this reach. A detailed discussion of each diversion can be found in **Appendix C.**

Table 3-15. Pennington Bridge to High Road Bridge.

Feature Type	Number	Sites	Total Length (Feet)	Total Length (Miles)
Diversions on mainstem and side channels	4	D6, D8, D9, D10		
Diversions in ditches and sloughs*	1	D7		
Barbs	1	B14		
Riprap	8	R18, R19, R24, R25, R26, R28, R30, R70	2,327	0.44
Riprap, floodplain berms	5	R17, R27, R29, R31, R32	6,682	1.27
Floodplain berms	1	R23	405	0.08
Accelerated bank erosion	3	E2, E7, E9	1,586	0.30

*There are likely more diversions in ditches not examined in this assessment.

A total of 13 sections of riprap and riprap/floodplain berms were identified in this reach, covering approximately 1.71 miles. In addition, one floodplain berm was identified in the left channel downstream of Pennington Bridge, though no other assessments of this channel were performed. Overall, there are approximately 1.79 miles of streambank alterations within this reach, which amounts to 29% of the reach. Riprap in the right channel within this reach is primarily located along the river right (eastern) bank and protects the broad floodplain between the Big Hole and Beaverhead rivers. This riprap appears to be forcing the river toward the west, where the valley is confined by the foothills. This is leading to a large eroding bank (E9) upstream of Nez Perce Creek as the Big Hole River cuts into the foothill bench. This bank is likely a large source of sediment to this reach during spring runoff. A second large eroding bank (E3) is located along the left bank as the river cuts into the foothill just upstream of the High Road Bridge crossing. Riprap on the right bank (R32) upstream is likely leading to this erosion.

3.3.7 High Road Bridge to Jefferson River

The High Road Bridge to the Jefferson River assessment reach is approximately 1.8 miles long and extends from the High Road FAS to where the Big Hole River and Beaverhead River combine to form the Jefferson River (**Figure 3-10** in **Appendix B**). Only the upper portion of this reach was assessed in the field, while the lower portion of the reach was assessed using color aerial imagery. Both Diversions 35 and 36 are fed by a diversion channel leading off to river left downstream of the High Road Bridge. Diversion 35 serves a pump, while Diversion 36 serves a large ditch network. There is an average of 1.1 diversions per mile in this reach. A detailed discussion of each diversion can be found in **Appendix C.**

Table 3-16. High Road Bridge to the Jefferson River.

Feature Type	Number	Sites	Total Length (Feet)	Total Length (Miles)
Diversions on mainstem and side channels	2	D35, D36		
Riprap, floodplain berms	3	R51, R54, R71	3,713	0.70

*There are likely more diversions in ditches not examined in this assessment.

Three sections of floodplain berms were identified within this reach, though only R71, which is along the river right bank downstream of the High Road Bridge was observed during the field assessment.

4.0 Irrigation Infrastructure Priority Matrix

A matrix of potential irrigation infrastructure improvement projects was developed to evaluate the potential for the improvement of irrigation infrastructure while also providing for increased in-stream flows. This matrix will be referred to as the "priority matrix" within this report. Utilizing data collected during this study, along with existing data, several parameters were included in the priority matrix under two main categories:

1. headgate and diversion dam factors
2. cumulative impact factors

In the priority matrix, there is a possible score of 35 points, with 20 possible points for headgate and diversion dam factors and 15 possible points for cumulative impact factors (**Tables 4-1** and **4-2**). Based on the total score, the priority of each diversion was rated based on the following scale:

25-35 Very High Priority
20-24 High Priority
15-19 Moderate Priority
<15 Low Priority

A total of 34 diversions were identified on the lower Big Hole River and significant side channels in this study. Two of these diversions serve two separate ditches: Diversion 11 and Diversion 17. Thus, there are a total of 36 diversions included within the priority matrix. Out of 36 diversions assessed using the priority matrix, a total of 6 diversions were rated a very high priority, 12 diversions were rated a high priority, 11 diversions were rated a moderate priority and 3 diversions were rated a low priority (**Table 4-3**). Due to a lack of data, four diversions on the mainstem of the lower Big Hole River were not assessed with the priority matrix, including: D5, D35, D40 and the unnumbered diversion on the Big Hole Ranch. The 11 headgates identified in ditches and sloughs were not included in the priority matrix.

4.1 Headgate and Diversion Dam Priority Matrix Factors

A total of eight factors were assessed for each individual headgate and diversion dam, including:

- headgate design
- headgate condition
- diversion dam maintenance requirements
- estimated potential flow
- presence of a Parshall flume
- influence on natural channel processes
- fish habitat associated with diversion
- ownership interest level

Headgate design was considered in the priority matrix since different designs vary in their efficiency, as well as in their ease of operation. The priority matrix assumes that metal “screw gates” are preferable to wooden “pin and plank” headgates since they can be more finely adjusted to regulate flow. Thus, “pin and plank” headgates were given a score of “3” and metal “screw gates” were given a score of “1”.

Headgate condition was considered in the priority matrix to identify aging infrastructure that is in need of replacement. Headgates at or near the end of their operational lifespan were given a score of “2”, while headgates in good condition were given a score of “0”.

Diversion dam maintenance requirements were included in the priority matrix to evaluate potential problems with dam failure and sediment accumulation. The level of annual maintenance required was considered for this priority matrix parameter. Diversion dams requiring annual maintenance were given a score of “3”, while diversion dams requiring maintenance semi-annually or less frequently were given a score of “1”.

Estimated potential flow was included to provide an idea of the relative ditch size and its potential to decrease streamflow. Since this assessment was conducted after the irrigation season ended, flow estimates were based on ditch dimensions as estimated during field evaluation. A review of water rights based on the Montana DNRC points of diversion dataset, along with ditch flow measurements and estimates performed by Montana DEQ during the 2006 temperature study, also provided supporting information. In the priority matrix, a score of “3” was given to ditches with an estimated flow capacity of >25cfs. Ditches with lower flow capacity were given lower scores.

The presence of a **flow measuring device** was included in the priority matrix. A Parshall flume was identified as the preferred measuring device where conditions (i.e. slope) permit. Staff gages were not counted as flow measuring devices in the priority matrix, though a staff gage could be used in conjunction with a series of flow measurements to develop a rating curve, which would be a sufficient technique for flow measurement. Ditches with identified Parshall flumes were given a score of “0”, while ditches lacking a Parshall flume were given a score of “3”.

The **influence on natural channel processes** was included in the priority matrix to identify negative influences to lateral channel migration and sediment transport processes stemming from the location and construction of diversion structures. Possible negative impacts include an extensive amount of riprap, accelerated streambank erosion, channel over-widening, restrictions to natural lateral channel migration, and streambed aggradation or degradation due to an imbalance in sediment transport processes. While a detailed assessment of sediment transport processes was beyond the scope of this assessment, it was observed that diversion dams located in areas with relatively wide and flat floodplains that support multiple migrating channels tend to be the most difficult to maintain and have the most negative effect on natural channel processes. In the priority matrix, diversion dams that appeared to negatively influence natural channel migration and sediment transport processes were given a score of “2”.

During the “float survey”, **fish habitat associated with diversion structures** was identified. During this assessment, side channels that are used as diversion channels were often found to support potential spawning habitat. These areas are considered of extra importance to both the fishery and the irrigation system and were given a score of “2” in the priority matrix.

Ownership interest level was also considered in the priority matrix, since willingness of affected parties is a prerequisite for the successful implementation of projects. Ownership interest level was gauged during the irrigator interview process. When an irrigator expressed interest in a project, a score of “2” was assigned in the priority matrix. A list of potential projects identified during meetings with irrigators is presented in **Appendix G.**

Table 4-1. Headgate and Diversion Dam Factors Applied to the Priority Matrix.

Headgate and Diversion Dam Factors	Description	Score
Headgate Construction	wood "pin & plank"	3
	metal "screw gate" and wood	1
	metal "screw gate" and concrete	1
Headgate Condition	maintenance required or beneficial	2
	properly functioning	0
Diversion Dam Maintenance Requirements	annually	3
	semi-annually or less frequently	1
	unknown	0
Estimated Potential Flow	> 25 cfs	3
	10-25 cfs	2
	< 10 cfs	1
Flow Measuring Device (Parshall Flume)	absent	3
	unknown	1
	present	0
Influence on Natural Channel Processes	negative	2
	neutral / unknown	0
Fish Habitat Associated with Diversion Structures	observed	2
	not observed / unknown	0
Ownership Interest Level	interested / potential project identified	2
	potentially interested	1
	un-interested / unknown	0
Maximum Possible Headgate and Diversion Dam Score		**20**

4.2 Cumulative Impacts Priority Matrix Factors

The cumulative impact factors were selected to provide analysis of the amount of irrigation infrastructure development and the extent of streambank and channel alterations at the reach scale. A total of five factors were assessed to identify the cumulative effects of irrigation withdrawals and streambank and channel alterations at the reach scale, including:

- number of individual diversions per mile
- number claimed points of diversion per mile
- ditch length to reach length ratio
- percent of reach with streambank alterations
- analysis of streamflow gains and losses

The **number of individual diversions per mile** is based on diversions identified along the mainstem of the lower Big Hole River and significant side channels during this assessment. In the priority matrix, a score of “3” was assigned to diversions located in reaches with >1.0 individual diversions per mile. Diversions located in reaches with fewer individual diversions per mile were given lower scores.

The **number of claimed points of diversion per mile** is based on the Montana DNRC Points of Diversion GIS data layer and includes water rights claims and permits for both irrigation and stock water. In the priority matrix, a score or “3” was assigned to diversions located in reaches with >10 claimed points of diversion per mile. Diversions located in reaches with fewer claimed points of diversion per mile were given lower scores.

The **ditch length to reach length ratio** provides a measure of the extent of the irrigation network. Diversions located in reaches with a ditch length to reach length ratio of >10:1 were given a score of “3” in the priority matrix, while diversions in reaches with fewer miles of mapped ditch were given lower scores.

The **percent of reach with streambank alterations** provides a measure of restrictions to lateral channel migration. Diversions in reaches with streambank alterations along >20% of the total reach length were given a score of “3” in the priority matrix, while diversions in reaches with fewer streambank alterations were given lower scores.

The **analysis of streamflow gains and losses** provides an indicator of which reaches are most heavily utilized for irrigation purposes and where irrigation withdrawals may lead to critically low streamflows during the late-summer irrigation season. This analysis was based on streamflow measurements at USGS gaging stations as well as measurements performed by Montana DNRC. During this assessment, the section of river between Melrose Bridge and the USGS near Melrose gage, as well as the entire section of river downstream of the USGS near Glen gage, were identified as areas of significant irrigation withdrawals and decreased streamflows. Thus, these reaches were given a score of “3” in the priority matrix. The section of river between Maiden Rock Canyon and the Melrose Bridge was given a “2” since there are several large diversions, though streamflow measurements from 2007 suggest flows remain relatively stable between these two sites. Between the USGS Melrose gage and the USGS Glen gage was given a score of "1" since streamflow was identified to increase between these two sites in 5 out of the past 7 years.

Cumulative impact priority matrix scores for each reach are provided in **Appendix H**.

Table 4-2. Cumulative Impact Factors Applied to Data Matrix.

Cumulative Impact Factors	Description	Score
Individual Diversions/Mile	> 1.0	3
	0.6-1.0	2
	0-0.5	1
Claimed Points of Diversion/Mile	> 10	3
	6-10	2
	0-5	1
Ditch Length to Reach Length Ratio	> 10:1	3
	5:1-10:1	2
	< 5:1	1
Percent of Reach with Streambank Alterations	> 20%	3
	11%-20%	2
	0%-10%	1
Streamflow Gain/Loss Analysis	Melrose Bridge to USGS Melrose gage, USGS Glen gage to Jefferson River	3
	Maiden Rock Canyon to Melrose Bridge	2
	USGS Melrose gage to USGS Glen gage	1
	Maximum Possible Cumulative Impacts Score	**15**

Table 4-4. Priority Matrix Ratings from Very High to Low.

Site	Diversion Name	Priority Matrix Score	Priority Matrix Rating
D6	Big Hole Co-op Ditch	30	Very High
D10	Lott - Harvey	29	Very High
D8	Orphan Home	28	Very High
D9	Logan - Smith	27	Very High
D11a	Pendergast - Spears - McCullough	25	Very High
D11b	Gallagher Ditch	25	Very High
D17a	Garrison	24	High
D17b	Kilwien	24	High
D27	Rafferty's Upper South Side	24	High
D20	Lower McCauley	23	High
D22	Meriwether's	23	High
D44	Meriwether's (Buyan slough)	23	High
D13	Hagenbarth's Big Hole Ditch	23	High
D24	Carpenter's	22	High
D21	Melrose Canal	21	High
D28	Rafferty's Lower South Side	21	High
D36	Hamilton Ranch Ditch	21	High
D2	Sandy Ditch	20	High
D19	Meriwether's	19	Moderate
D23	Carpenter's	18	Moderate
D39	Smith's	18	Moderate
D26	Garrison's Wild Hay Ditch	18	Moderate
D3	Pageville Canal	18	Moderate
D1	Copper's (Whitney Ditch)	17	Moderate
D12	Kalsta's	16	Moderate
D14	Hagenbarth's River Field Ditch	16	Moderate
D16	Gainy's	16	Moderate
D4	JS Ranch (Larson-Naranchich)	16	Moderate
D18	Upper McCauley	15	Moderate
D15	Gainy's	14	Low
D25	Glennon's (?)	14	Low
D37	Bryan Ditch	14	Low
D35	pump at Hamilton Ranch		unrated
D5	Naranchich		unrated
D40	Smith's		unrated
none	BHR		unrated

5.0 Discussion and Summary

The results of this inventory and assessment provide a foundation for selecting irrigation infrastructure improvement projects that benefit both agricultural users and water resources in the lower Big Hole River. The irrigation infrastructure improvement priority matrix developed during this assessment provides a tool for identifying potential projects based on the specific conditions at individual headgates and diversion dams as well as the cumulative effects of reach scale impacts. Addressing conditions at diversion dams and headgates identified in the priority matrix would facilitate improved irrigation water management, which, in-turn, may lead to increased in-stream flows, particularly during the critical mid-to-late summer time period when streamflows are low and water temperatures are warm.

Along the lower Big Hole River, 34 irrigation diversions were identified and 259 miles of irrigation ditch network were mapped. Extensive irrigation withdrawals lead to reduced streamflows throughout the project area, with an average decrease in mean daily streamflow of 119cfs between the Divide Bridge, which is upstream of the study area, and the High Road Bridge near the downstream end of the study area measured between August 22nd and September 30th 2007. Decreases in streamflow are most pronounced downstream of Notch Bottom, with streamflow data from 2001 through 2007 indicating that mean daily streamflows decrease by an average of 148cfs during the summer irrigation season downstream of the USGS near Glen gage. Based on this assessment, it is estimated that an average of 140cfs are withdrawn for agricultural purposes during the irrigation season between Notch Bottom and the confluence with the Jefferson River, with withdrawals decreasing to approximately 100cfs during extreme low flow periods.

The presence of diversion dams, riprap and floodplain berms have the potential to dramatically influence channel patterns within the lower Big Hole River. Diversion dams within the study area often extend well into the channel, which can lead to localized shifts in channel patterns. During this assessment, it was observed that diversion dams located in areas with relatively wide and flat floodplains that support multiple migrating channels tend to be the most difficult to maintain and have the most negative effect on channel processes. Due to the complex multi-channel meandering nature of the lower Big Hole River system, alterations to the channel bed and/or streambanks locally often lead to unexpected consequences upstream or downstream. Overall, this assessment identified 8.0 miles streambank alterations covering 18% of the lower 44.2 miles of the lower Big Hole River, while historic streambank alterations and floodplain berms that have since been abandoned by the active channel may be much more extensive.

5.1 Future Areas of Study

Due to the complex nature of the lower Big Hole River system, the following list of future areas of study is presented:

1. Obtain ditch flow measurements at ditches of interest throughout the irrigation season, both at the point of diversion and at the point of use. Perform a more detailed mapping of the largest diversion networks, including the locations of additional headgates within the ditch networks. Evaluate existing water rights claims and permits relative to current water use.

2. Place a seasonal gaging station at the Melrose bridges to evaluate changes in streamflow between the Divide Creek Bridge and the USGS near Melrose gaging station since synoptic measurements performed in 2007 indicated streamflows remain relatively stable between these three sites. Perform additional synoptic streamflow measurements throughout the study area and continue the seasonal gaging stations at the Divide Bridge and Pennington Bridge.

3. Quantify ditch loss and aquifer recharge between Notch Bottom and the confluence with the Jefferson River to compliment the study performed between Maiden Rock Canyon and Notch Bottom by MBMG.

4. Perform an assessment of ground water and surface water interactions throughout the study area, with an emphasis on ground water upwelling due to geological constrictions in Maiden Rock Canyon and at Notch Bottom as indicted in the 2008 temperature modeling report by Montana DEQ.

5. Assess the impact of diversion dams, riprap, and floodplain berms on channel bed morphology, lateral channel migration, streambed aggradation and degradation, and fish habitat through the use of sediment transport modeling and an assessment of historic channel migration patterns. Identify areas where multi-channel processes can be maintained and/or restored.

6. Perform additional floodplain berm mapping and flood hazard evaluation to determine the extent of floodplain berms and identify sites which may be obsolete and could be removed.

7. Perform additional fish habitat assessments, including identification of critical habitat during various life stages. Evaluate potential entrainment of fish in irrigation systems and monitor selected ditches for fish populations. Utilize this information to incorporate features that will minimize fish loss when designing and implementing headgate and diversion dam improvements.

8. Identify the potential to develop alternative stock water sources so that when the irrigation season ends, ditches can be closed.

6.0 References

Marvin, R.K., and Voeller, T.L. 2000. Hydrology of the Big Hole Basin and an assessment of the affects of irrigation of the hydrologic budget. *Montana Bureau of Mines and Geology Open File Report 417*. Montana Bureau of Mines and Geology, Butte, Montana.

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Appendix A

STREAMFLOW DATA

Lower Big Hole Irrigation Infrastructure Study

date	USGS Melrose streamflow (cfs)	USGS Glen streamflow (cfs)	High Road streamflow (cfs)	Difference between Melrose and Glen streamflow (cfs)	Difference between Glen and High Road streamflow (cfs)
7/1/01	652	720		68	
7/2/01	593	648		55	
7/3/01	543	594		51	
7/4/01	514	564	383	50	-181
7/5/01	517	580	396	63	-184
7/6/01	519	587	431	68	-156
7/7/01	500	569	430	69	-139
7/8/01	473	540	405	67	-135
7/9/01	439	507	367	68	-140
7/10/01	443	498	330	55	-168
7/11/01	438	500	341	62	-159
7/12/01	440	503	319	63	-184
7/13/01	443	523	361	80	-162
7/14/01	474	548	402	74	-146
7/15/01	480	559	451	79	-108
7/16/01	519	610	498	91	-112
7/17/01	567	657	596	90	-61
7/18/01	590	689	636	99	-53
7/19/01	578	683	636	105	-47
7/20/01	560	673	616	113	-57
7/21/01	530	638	568	108	-70
7/22/01	512	616	524	104	-92
7/23/01	472	568	463	96	-105
7/24/01	445	534	386	89	-148
7/25/01	400	472	327	72	-145
7/26/01	358	421	257	63	-164
7/27/01	328	382	205	54	-177
7/28/01	303	352	175	49	-177
7/29/01	288	334	160	46	-174
7/30/01	280	350	144	70	-206
7/31/01	306	376	141	70	-235
8/1/01	328	390	160	62	-230
8/2/01	321	373	171	52	-202
8/3/01	307	348	155	41	-193
8/4/01	294	325	145	31	-180
8/5/01	298	321	140	23	-181
8/6/01	289	307	133	18	-174
8/7/01	268	286	122	18	-164
8/8/01	246	249	106	3	-143
8/9/01	225	210	78	-15	-132
8/10/01	217	198	75	-19	-123
8/11/01	212	197	71	-15	-126
8/12/01	207	190	69	-17	-121
8/13/01	197	181	63	-16	-118
8/14/01	194	180	63	-14	-117
8/15/01	200	184	63	-16	-121
8/16/01	200	199	65	-1	-134
8/17/01	195	187	61	-8	-126
8/18/01	192	180	58	-12	-122
8/19/01	189	173	56	-16	-117
8/20/01	181	164	55	-17	-109
8/21/01	177	157	53	-20	-104
8/22/01	172	155	52	-17	-103
8/23/01	160	145	51	-15	-94
8/24/01	155	136	49	-19	-87
8/25/01	152	130	48	-22	-82
8/26/01	153	131	42	-22	-89
8/27/01	152	135	41	-17	-94
8/28/01	151	129	40	-22	-89
8/29/01	152	124	33	-28	-91
8/30/01	156	132	32	-24	-100
8/31/01	156	132	28	-24	-104
9/1/01	156	130	27	-26	-103
9/2/01	156	133	27	-23	-106
9/3/01	156	137	29	-19	-108
9/4/01	153	136	30	-17	-106
9/5/01	152	135	30	-17	-105
9/6/01	186	176	35	-10	-141
9/7/01	213	207	44	-6	-163
9/8/01	234	230	51	-4	-179
9/9/01	231	239	64	8	-175
9/10/01	225	236	64	11	-172
9/11/01	214	227	60	13	-167
9/12/01	208	222	58	14	-164
9/13/01	212	223	58	11	-165
9/14/01	212	233	61	21	-172
9/15/01	214	232	63	18	-169
9/16/01	209	230	64	21	-166
9/17/01	208	224	63	16	-161
9/18/01	207	233	64	26	-169
9/19/01	206	233	66	27	-167
9/20/01	206	218	64	12	-154
9/21/01	207	212	61	5	-151
9/22/01	201	201	62	0	-139
9/23/01	203	208	58	5	-150
9/24/01	201	217	60	16	-157
9/25/01	201	221	58	20	-163
9/26/01	200	218	57	18	-161
9/27/01	201	221	58	20	-163
9/28/01	203	213	64	10	-149
9/29/01	208	220	65	12	-155
9/30/01	205	238	78	33	-160

date	USGS Melrose streamflow (cfs)	USGS Glen streamflow (cfs)	High Road streamflow (cfs)	Difference between Melrose and Glen streamflow (cfs)	Difference between Glen and High Road streamflow (cfs)
7/1/02	1480	1580		100	
7/2/02	1280	1400		120	
7/3/02	1110	1240		130	
7/4/02	1060	1170		110	
7/5/02	962	1070		108	
7/6/02	893	983		90	
7/7/02	855	937		82	
7/8/02	881	943		62	
7/9/02	896	938		42	
7/10/02	826	871		45	
7/11/02	766	816		50	
7/12/02	703	761		58	
7/13/02	652	717		65	
7/14/02	615	681		66	
7/15/02	588	645		57	
7/16/02	676	711		35	
7/17/02	743	796		53	
7/18/02	684	752		68	
7/19/02	644	750		106	
7/20/02	629	741		112	
7/21/02	630	708		78	
7/22/02	590	649		59	
7/23/02	547	571		24	
7/24/02	516	544		28	
7/25/02	501	529		28	
7/26/02	508	562		54	
7/27/02	493	566		73	
7/28/02	509	583		74	
7/29/02	473	549		76	
7/30/02	427	490		63	
7/31/02	381	442		61	
8/1/02	331	377		46	
8/2/02	314	354	205	40	-149
8/3/02	296	334	156	38	-178
8/4/02	290	334	148	44	-186
8/5/02	298	348	160	50	-188
8/6/02	290	340	158	50	-182
8/7/02	288	329	152	41	-177
8/8/02	379	411	172	32	-239
8/9/02	426	478	227	52	-251
8/10/02	386	460	233	74	-227
8/11/02	338	403	214	65	-189
8/12/02	318	376	196	58	-180
8/13/02	304	367	184	63	-183
8/14/02	277	343	180	66	-163
8/15/02	254	294	166	40	-128
8/16/02	232	267	147	35	-120
8/17/02	214	247	115	33	-132
8/18/02	213	243	112	30	-131
8/19/02	207	238	99	31	-139
8/20/02	197	228	58	31	-170
8/21/02	208	233	46	25	-187
8/22/02	230	255	43	25	-212
8/23/02	234	264	54	30	-210
8/24/02	226	253	57	27	-196
8/25/02	236	256	57	20	-199
8/26/02	236	262	58	26	-204
8/27/02	256	284	64	28	-220
8/28/02	267	308	81	41	-227
8/29/02	270	328	93	58	-235
8/30/02	283	332	114	49	-218
8/31/02	276	332	121	56	-211
9/1/02	268	318	127	50	-191
9/2/02	261	309	127	48	-182
9/3/02	247	299	119	52	-180
9/4/02	240	276	107	36	-169
9/5/02	232	254	93	22	-161
9/6/02	234	264	91	30	-173
9/7/02	243	287	105	44	-182
9/8/02	267	307	125	40	-182
9/9/02	280	332	137	52	-195
9/10/02	291	346	147	55	-199
9/11/02	285	342	145	57	-197
9/12/02	284	349	144	65	-205
9/13/02	268	335	142	67	-193
9/14/02	260	321	136	61	-185
9/15/02	254	309	127	55	-182
9/16/02	244	290	115	46	-175
9/17/02	256	297	102	41	-195
9/18/02	278	336	149	58	-187
9/19/02	294	349	168	55	-181
9/20/02	289	344	177	55	-167
9/21/02	284	320	175	36	-145
9/22/02	285	308	165	23	-143
9/23/02	285	315	164	30	-151
9/24/02	290	325	170	35	-155
9/25/02	295	327	166	32	-161
9/26/02	301	339	182	38	-157
9/27/02	305	354	205	49	-149
9/28/02	318	371	220	53	-151
9/29/02	318	377	223	59	-154
9/30/02	314	376	223	62	-153

date	USGS Melrose streamflow (cfs)	USGS Glen streamflow (cfs)	High Road streamflow (cfs)	Difference between streamflow (cfs)	Difference between Glen streamflow (cfs)
7/1/03	882	1020		138	
7/2/03	803	944		141	
7/3/03	736	879		143	
7/4/03	682	827		145	
7/5/03	651	787		136	
7/6/03	606	733		127	
7/7/03	579	705		126	
7/8/03	549	672		123	
7/9/03	545	656		111	
7/10/03	513	619		106	
7/11/03	470	582		112	
7/12/03	443	542		99	
7/13/03	424	516		92	
7/14/03	408	498		90	
7/15/03	370	462		92	
7/16/03	362	439		77	
7/17/03	359	436		77	
7/18/03	336	417	217	81	-200
7/19/03	325	406	219	81	-187
7/20/03	314	394	216	80	-178
7/21/03	303	363	214	60	-149
7/22/03	300	306	189	6	-117
7/23/03	299	320	180	21	-140
7/24/03	281	299	174	18	-125
7/25/03	294	323	176	29	-147
7/26/03	333	425	215	92	-210
7/27/03	322	386	222	64	-164
7/28/03	320	368	212	48	-156
7/29/03	304	337	189	33	-148
7/30/03	289	320	164	31	-156
7/31/03	272	307	158	35	-149
8/1/03	250	292	159	42	-133
8/2/03	235	271	150	36	-121
8/3/03	233	258	143	25	-115
8/4/03	256	299	145	43	-154
8/5/03	252	296	147	44	-149
8/6/03	249	293	146	44	-147
8/7/03	259	289	138	30	-151
8/8/03	261	324	141	63	-183
8/9/03	243	303	145	60	-158
8/10/03	234	276	138	42	-138
8/11/03	230	271	133	41	-138
8/12/03	225	277	122	52	-155
8/13/03	212	260	107	48	-153
8/14/03	203	243	102	40	-141
8/15/03	189	222	98	33	-124
8/16/03	185	209	94	24	-115
8/17/03	189	218	91	29	-127
8/18/03	192	225	93	33	-132
8/19/03	188	217	90	29	-127
8/20/03	184	200	85	16	-115
8/21/03	184	201	83	17	-118
8/22/03	184	211	84	27	-127
8/23/03	203	223	85	20	-138
8/24/03	232	252	86	20	-166
8/25/03	222	265	90	43	-175
8/26/03	205	240	92	35	-148
8/27/03	205	239	91	34	-148
8/28/03	209	250	92	41	-158
8/29/03	207	250	95	43	-155
8/30/03	197	243	95	46	-148
8/31/03	190	236	92	46	-144
9/1/03	187	230	89	43	-141
9/2/03	181	225	85	44	-140
9/3/03	180	218	82	38	-136
9/4/03	179	221	82	42	-139
9/5/03	178	216	83	38	-133
9/6/03	177	215	83	38	-132
9/7/03	178	223	83	45	-140
9/8/03	181	226	82	45	-144
9/9/03	181	227	84	46	-143
9/10/03	184	225	86	41	-139
9/11/03	184	216	86	32	-130
9/12/03	188	191	83	3	-108
9/13/03	191	202	84	11	-118
9/14/03	194	209	87	15	-122
9/15/03	195	213	87	18	-126
9/16/03	197	217	89	20	-128
9/17/03	200	218	90	18	-128
9/18/03	212	241	94	29	-147
9/19/03	218	249	97	31	-152
9/20/03	223	251	97	28	-154
9/21/03	229	256	98	27	-158
9/22/03	234	259	105	25	-154
9/23/03	237	270	114	33	-156
9/24/03	239	274	121	35	-153
9/25/03	239	276	137	37	-139
9/26/03	236	273	144	37	-129
9/27/03	233	268	143	35	-125
9/28/03	225	259	142	34	-117
9/29/03	226	249	144	23	-105
9/30/03	223	229	144	6	-85

date	USGS Melrose streamflow (cfs)	USGS Glen streamflow (cfs)	High Road streamflow (cfs)	Difference between Melrose and Glen streamflow (cfs)	Difference between Glen and High Road streamflow (cfs)
7/1/04	1480	1410	1748	-70	338
7/2/04	1570	1540	2176	-30	636
7/3/04	1410	1420	2053	10	633
7/4/04	1330	1320	1755	-10	435
7/5/04	1270	1280	1620	10	340
7/6/04	1200	1220	1489	20	269
7/7/04	1060	1110	1234	50	124
7/8/04	938	1010	968	72	-42
7/9/04	819	903	795	84	-108
7/10/04	750	844	695	94	-149
7/11/04	699	794	629	95	-165
7/12/04	649	732	538	83	-194
7/13/04	594	675	478	81	-197
7/14/04	556	627	419	71	-208
7/15/04	526	575	374	49	-201
7/16/04	507	557	349	50	-208
7/17/04	492	532	327	40	-205
7/18/04	490	532	324	42	-208
7/19/04	535	560	339	25	-221
7/20/04	572	612	398	40	-214
7/21/04	660	691	457	31	-234
7/22/04	637	679	486	42	-193
7/23/04	560	627	439	67	-188
7/24/04	494	552	365	58	-187
7/25/04	464	494	302	30	-192
7/26/04	452	480	285	28	-195
7/27/04	421	441	258	20	-183
7/28/04	395	391	239	-4	-152
7/29/04	370	347	202	-23	-145
7/30/04	350	338	186	-12	-152
7/31/04	325	316	173	-9	-143
8/1/04	302	313	145	11	-168
8/2/04	293	301	148	8	-153
8/3/04	291	307	150	16	-157
8/4/04	294	305	151	11	-154
8/5/04	287	286	146	-1	-140
8/6/04	278	279	140	1	-139
8/7/04	260	263	129	3	-134
8/8/04	242	241	112	-1	-129
8/9/04	230	231	100	1	-131
8/10/04	218	218	86	0	-132
8/11/04	205	203	75	-2	-128
8/12/04	191	190	64	-1	-126
8/13/04	183	180	53	-3	-127
8/14/04	171	167	50	-4	-117
8/15/04	158	156	47	-2	-109
8/16/04	157	155	46	-2	-109
8/17/04	169	165	43	-4	-122
8/18/04	204	203	44	-1	-159
8/19/04	225	223	49	-2	-174
8/20/04	248	243	50	-5	-193
8/21/04	237	236	47	-1	-189
8/22/04	238	240	46	2	-194
8/23/04	282	276	54	-6	-222
8/24/04	326	299	58	-27	-241
8/25/04	340	327	67	-13	-260
8/26/04	360	340	77	-20	-263
8/27/04	381	362	84	-19	-278
8/28/04	371	362	88	-9	-274
8/29/04	355	346	84	-9	-262
8/30/04	331	330	79	-1	-251
8/31/04	296	292	69	-4	-223
9/1/04	281	270	61	-11	-209
9/2/04	275	267	55	-8	-212
9/3/04	286	278	58	-8	-220
9/4/04	287	281	59	-6	-222
9/5/04	292	269	57	-23	-212
9/6/04	314	277	56	-37	-221
9/7/04	290	276	59	-14	-217
9/8/04	273	262	57	-11	-205
9/9/04	261	257	55	-4	-202
9/10/04	258	252	53	-6	-199
9/11/04	245	246	53	1	-193
9/12/04	252	261	55	9	-206
9/13/04	292	310	66	18	-244
9/14/04	348	365	78	17	-287
9/15/04	364	388	93	24	-295
9/16/04	376	398	97	22	-301
9/17/04	376	404	104	28	-300
9/18/04	368	392	102	24	-290
9/19/04	398	421	111	23	-310
9/20/04	478	504	168	26	-336
9/21/04	535	589	330	54	-259
9/22/04	538	604	424	66	-180
9/23/04	518	570	414	52	-156
9/24/04	530	579	403	49	-176
9/25/04	522	570	411	48	-159
9/26/04	521	560	388	39	-172
9/27/04	514	543	412	29	-131
9/28/04	508	528	390	20	-138
9/29/04	504	520	382	16	-138
9/30/04	496	499	370	3	-129

flows above 1000 cfs at High Road not included since flow relationships developed for low flow conditions

date	USGS Melrose streamflow (cfs)	USGS Glen streamflow (cfs)	High Road streamflow (cfs)	Difference between Melrose and Glen streamflow (cfs)	Difference between Glen and High Road streamflow (cfs)
7/1/05	1810	1750		-60	
7/2/05	1590	1560		-30	
7/3/05	1370	1350		-20	
7/4/05	1200	1200		0	
7/5/05	1070	1090		20	
7/6/05	965	986		21	
7/7/05	883	896		13	
7/8/05	827	829	2512	2	1683
7/9/05	788	796	2547	8	1751
7/10/05	780	792	782	12	-10
7/11/05	789	794	689	5	-105
7/12/05	805	810	728	5	-82
7/13/05	767	783	756	16	-27
7/14/05	682	692	666	10	-26
7/15/05	622	623	597	1	-26
7/16/05	580	573	537	-7	-36
7/17/05	545	518	422	-27	-96
7/18/05	509	487	419	-22	-68
7/19/05	471	446	338	-25	-108
7/20/05	438	408	438	-30	30
7/21/05	405	381	210	-24	-171
7/22/05	393	354	173	-39	-181
7/23/05	394	341	164	-53	-177
7/24/05	381	332	158	-49	-174
7/25/05	376	339	154	-37	-185
7/26/05	378	355	156	-23	-199
7/27/05	359	332	138	-27	-194
7/28/05	318	304	125	-14	-179
7/29/05	319	286	120	-33	-166
7/30/05	294	277	109	-17	-168
7/31/05	275	262	99	-13	-163
8/1/05	281	263	91	-18	-172
8/2/05	306	288	88	-18	-200
8/3/05	310	312	98	2	-214
8/4/05	294	301	94	7	-207
8/5/05	279	290	91	11	-199
8/6/05	277	278	86	1	-192
8/7/05	268	271	83	3	-188
8/8/05	265	271	85	6	-186
8/9/05	276	266	86	-10	-180
8/10/05	299	285	88	-14	-197
8/11/05	315	308	99	-7	-209
8/12/05	311	311	101	0	-210
8/13/05	307	331	115	24	-216
8/14/05	299	320	112	21	-208
8/15/05	275	306	107	31	-199
8/16/05	261	277	95	16	-182
8/17/05	245	260	87	15	-173
8/18/05	223	236	80	13	-156
8/19/05	214	228	73	14	-155
8/20/05	206	217	68	11	-149
8/21/05	199	203	61	4	-142
8/22/05	189	191	57	2	-134
8/23/05	187	174	50	-13	-124
8/24/05	185	170	46	-15	-124
8/25/05	182	177	46	-5	-131
8/26/05	178	179	45	1	-134
8/27/05	177	177	45	0	-132
8/28/05	177	175	40	-2	-135
8/29/05	175	171	34	-4	-137
8/30/05	186	176		-10	
8/31/05	191	191		0	
9/1/05	187	190		3	
9/2/05	177	178		1	
9/3/05	174	170		-4	
9/4/05	169	166		-3	
9/5/05	173	168	26	-5	-142
9/6/05	176	169		-7	
9/7/05	174	167		-7	
9/8/05	171	168		-3	
9/9/05	170	170		0	
9/10/05	177	182		5	
9/11/05	192	192		0	
9/12/05	200	195		-5	
9/13/05	209	198		-11	
9/14/05	221	209		-12	
9/15/05	221	207		-14	
9/16/05	219	211		-8	
9/17/05	249	252		3	
9/18/05	280	286		6	
9/19/05	299	306		7	
9/20/05	319	313		-6	
9/21/05	320	313		-7	
9/22/05	309	301		-8	
9/23/05	310	306		-4	
9/24/05	324	342		18	
9/25/05	331	342		11	
9/26/05	336	352	172	16	-180
9/27/05	339	361	190	22	-171
9/28/05	341	362	167	21	-195
9/29/05	337	358	184	21	-174
9/30/05	329	346	180	17	-166

date	USGS Melrose streamflow (cfs)	USGS Glen streamflow (cfs)	High Road streamflow (cfs)	Difference between Melrose and Glen streamflow (cfs)	Difference between Glen and High Road streamflow (cfs)
7/1/06	1080	1010		-70	
7/2/06	1020	959		-61	
7/3/06	983	950		-33	
7/4/06	962	917		-45	
7/5/06	919	875		-44	
7/6/06	940	887		-53	
7/7/06	972	917		-55	
7/8/06	952	904		-48	
7/9/06	877	829	349	-48	-480
7/10/06	811	755	383	-56	-372
7/11/06	767	708	341	-59	-367
7/12/06	736	680	374	-56	-306
7/13/06	736	687	366	-49	-321
7/14/06	725	670	366	-55	-304
7/15/06	684	640	374	-44	-266
7/16/06	620	580	366	-40	-214
7/17/06	557	500	430	-57	-70
7/18/06	488	452		-36	
7/19/06	453	418		-35	
7/20/06	424	400		-24	
7/21/06	394	367		-27	
7/22/06	371	352		-19	
7/23/06	355	344		-11	
7/24/06	342	334	156	-8	-178
7/25/06	325	308	166	-17	-142
7/26/06	324	300	156	-24	-144
7/27/06	315	295	156	-20	-139
7/28/06	299	289	144	-10	-145
7/29/06	278	267	124	-11	-143
7/30/06	262	241	103	-21	-138
7/31/06	252	225	94	-27	-131
8/1/06	250	232		-18	
8/2/06	227	221		-6	
8/3/06	224	214		-10	
8/4/06	214	210		-4	
8/5/06	206	199		-7	
8/6/06	201	194		-7	
8/7/06	194	189	77	-5	-112
8/8/06	185	183	72	-2	-111
8/9/06	186	179	70	-7	-109
8/10/06	180	167	68	-13	-99
8/11/06	167	157	65	-10	-92
8/12/06	163	151	61	-12	-90
8/13/06	164	156	61	-8	-95
8/14/06	161	150	61	-11	-89
8/15/06	157	145	59	-12	-86
8/16/06	166	151	61	-15	-90
8/17/06	165	160	63	-5	-97
8/18/06	166	153	63	-13	-90
8/19/06	164	151	63	-13	-88
8/20/06	156	147	61	-9	-86
8/21/06	154	145	61	-9	-84
8/22/06	147	142	59	-5	-83
8/23/06	140	135	57	-5	-78
8/24/06	141	125	53	-16	-72
8/25/06	142	122	49	-20	-73
8/26/06	151	139	51	-12	-88
8/27/06	152	140	53	-12	-87
8/28/06	150	141	53	-9	-88
8/29/06	153	147	53	-6	-94
8/30/06	150	149	51	-1	-98
8/31/06	151	151	51	0	-100
9/1/06	152	157	53	5	-104
9/2/06	147	155	57	8	-98
9/3/06	139	137	55	-2	-82
9/4/06	141	139	51	-2	-88
9/5/06	140	146	53	6	-93
9/6/06	138	144	53	6	-91
9/7/06	136	130	46	-6	-84
9/8/06	135	130	41	-5	-89
9/9/06	137	137	42	0	-95
9/10/06	137	139	44	2	-95
9/11/06	138	134	44	-4	-90
9/12/06	138	136	44	-2	-92
9/13/06	142	135	42	-7	-93
9/14/06	148	141	41	-7	-100
9/15/06	173	171	46	-2	-125
9/16/06	188	186	55	-2	-131
9/17/06	197	202	63	5	-139
9/18/06	201	211	70	10	-141
9/19/06	207	224	72	17	-152
9/20/06	207	225	75	18	-150
9/21/06	248	245	85	-3	-160
9/22/06	277	287	103	10	-184
9/23/06	280	288	117	8	-171
9/24/06	282	296	124	14	-172
9/25/06	288	295	128	7	-167
9/26/06	292	300	128	8	-172
9/27/06	288	303	132	15	-171
9/28/06	285	315	144	30	-171
9/29/06	284	302	136	18	-166
9/30/06	277	302	113	25	-189

Appendix B

MAPS

Lower Big Hole Irrigation Infrastructure Study

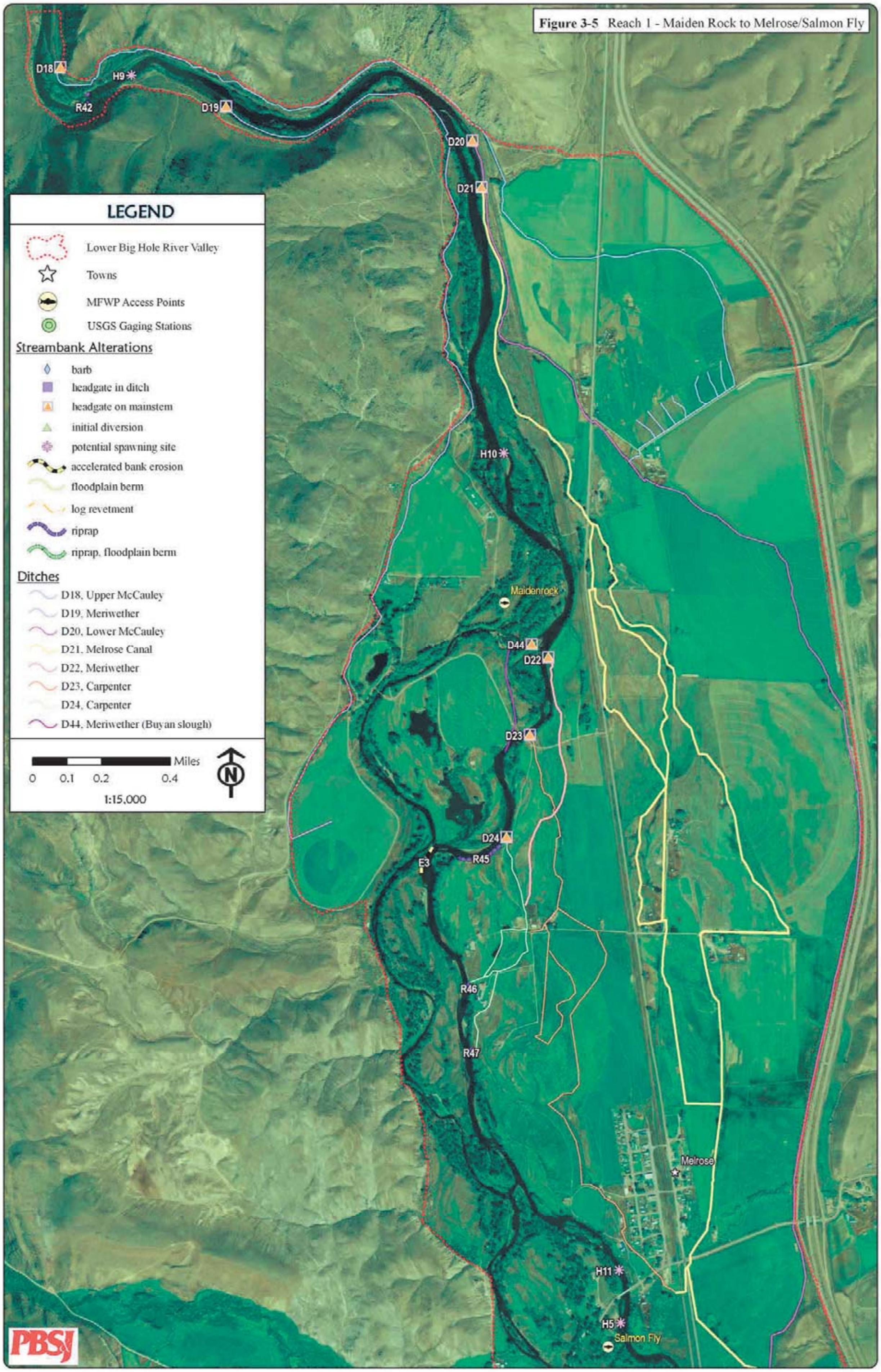


Figure 3-5 Reach 1 - Maiden Rock to Melrose/Salmon Fly
LEGEND
Lower Big Hole River Valley
Towns
MFWP Access Points
USGS Gaging Stations
Streambank Alterations
barb
headgate in ditch
headgate on mainstem
initial diversion
potential spawning site
accelerated bank erosion
floodplain berm
log revetment
riprap
riprap, floodplain berm
Ditches
D18, Upper McCauley
D19, Meriwether
D20, Lower McCauley
D21, Melrose Canal
D22, Meriwether
D23, Carpenter
D24, Carpenter
D44, Meriwether (Buyan slough)
Miles
0 0.1 0.2 0.4
1:15,000
N
D18
H9
R42
D19
D20
D21
H10
Maidenrock
D44
D22
D23
D24
E3
R45
R46
R47
Melrose
H11
H5
Salmon Fly
PBSJ

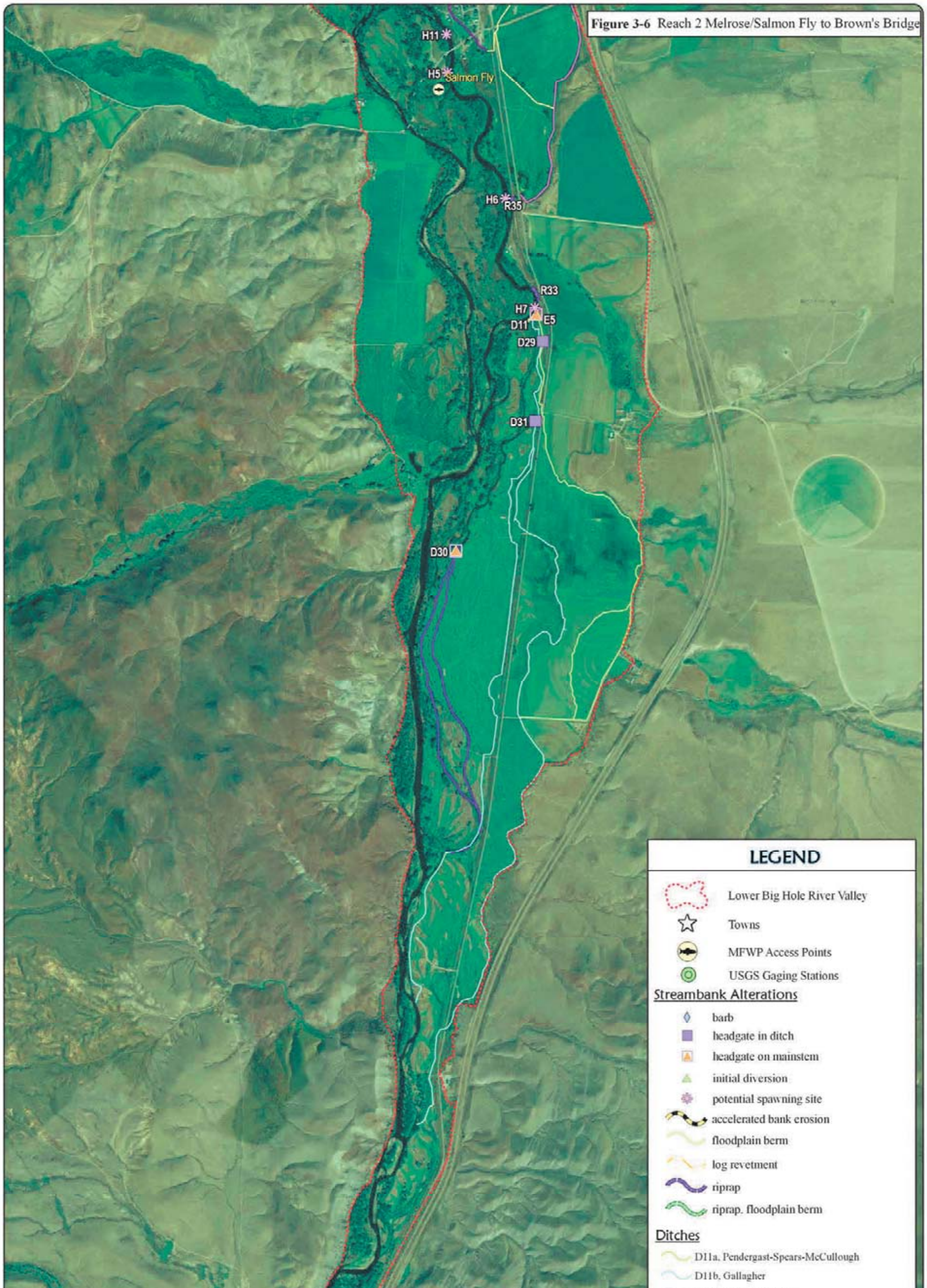


Figure 3-6 Reach 2 Melrose/Salmon Fly to Brown's Bridge

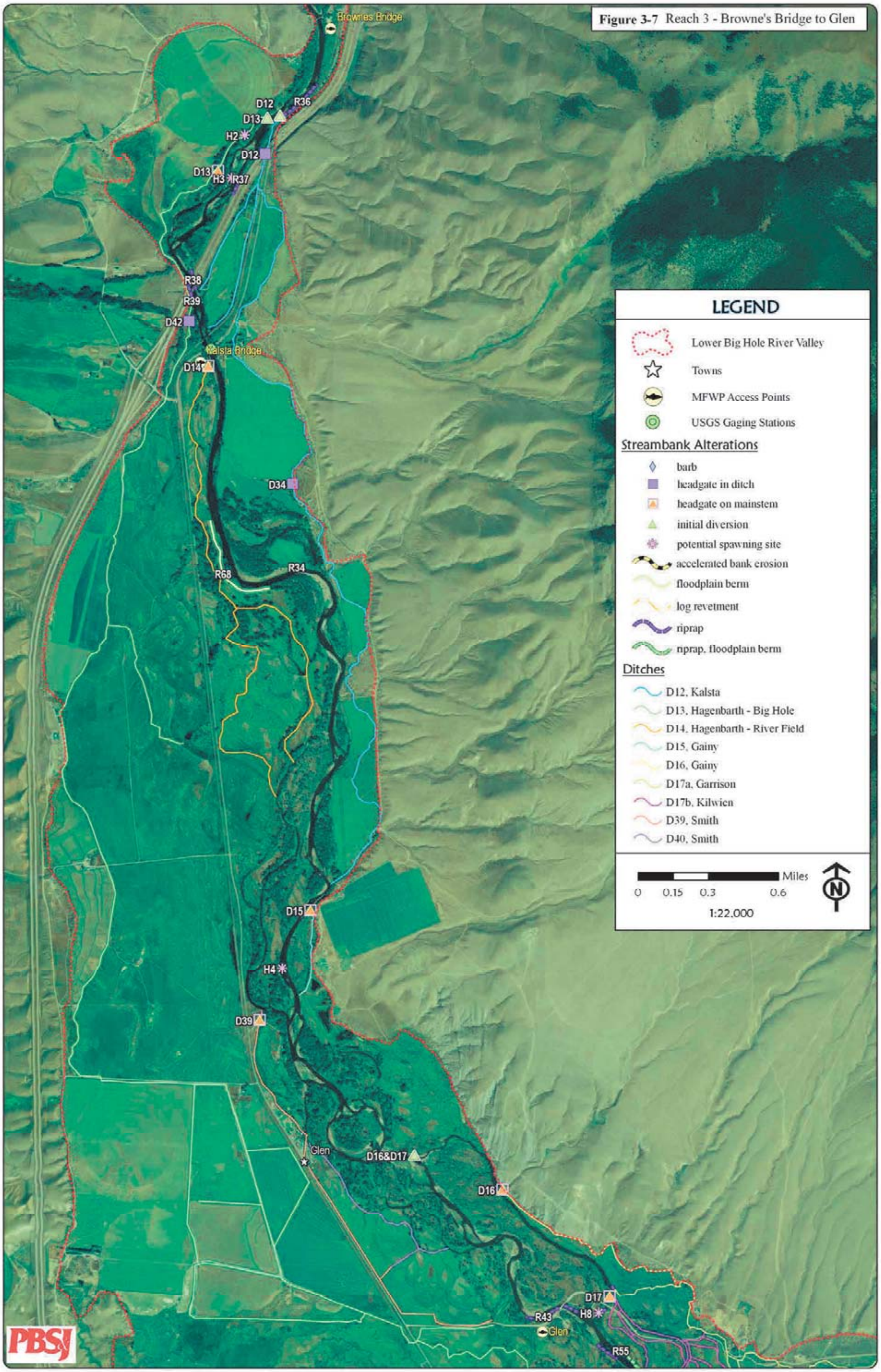


Figure 3-7 Reach 3 - Browne's Bridge to Glen
Brownes Bridge
D12
R36
D13
H2
D12
D13
H3
R37
R38
R39
D42
Kalsta Bridge
D14
D34
R68
R34
D15
H4
D39
Glen
D16&D17
D16
D17
R43
H8
Glen
R55
LEGEND
Lower Big Hole River Valley
Towns
MFWP Access Points
USGS Gaging Stations
Streambank Alterations
barb
headgate in ditch
headgate on mainstem
initial diversion
potential spawning site
accelerated bank erosion
floodplain berm
log revetment
riprap
riprap, floodplain berm
Ditches
D12, Kalsta
D13, Hagenbarth - Big Hole
D14, Hagenbarth - River Field
D15, Gainy
D16, Gainy
D17a, Garrison
D17b, Kilwien
D39, Smith
D40, Smith
Miles
0 0.15 0.3 0.6
1:22,000
N
PBSJ

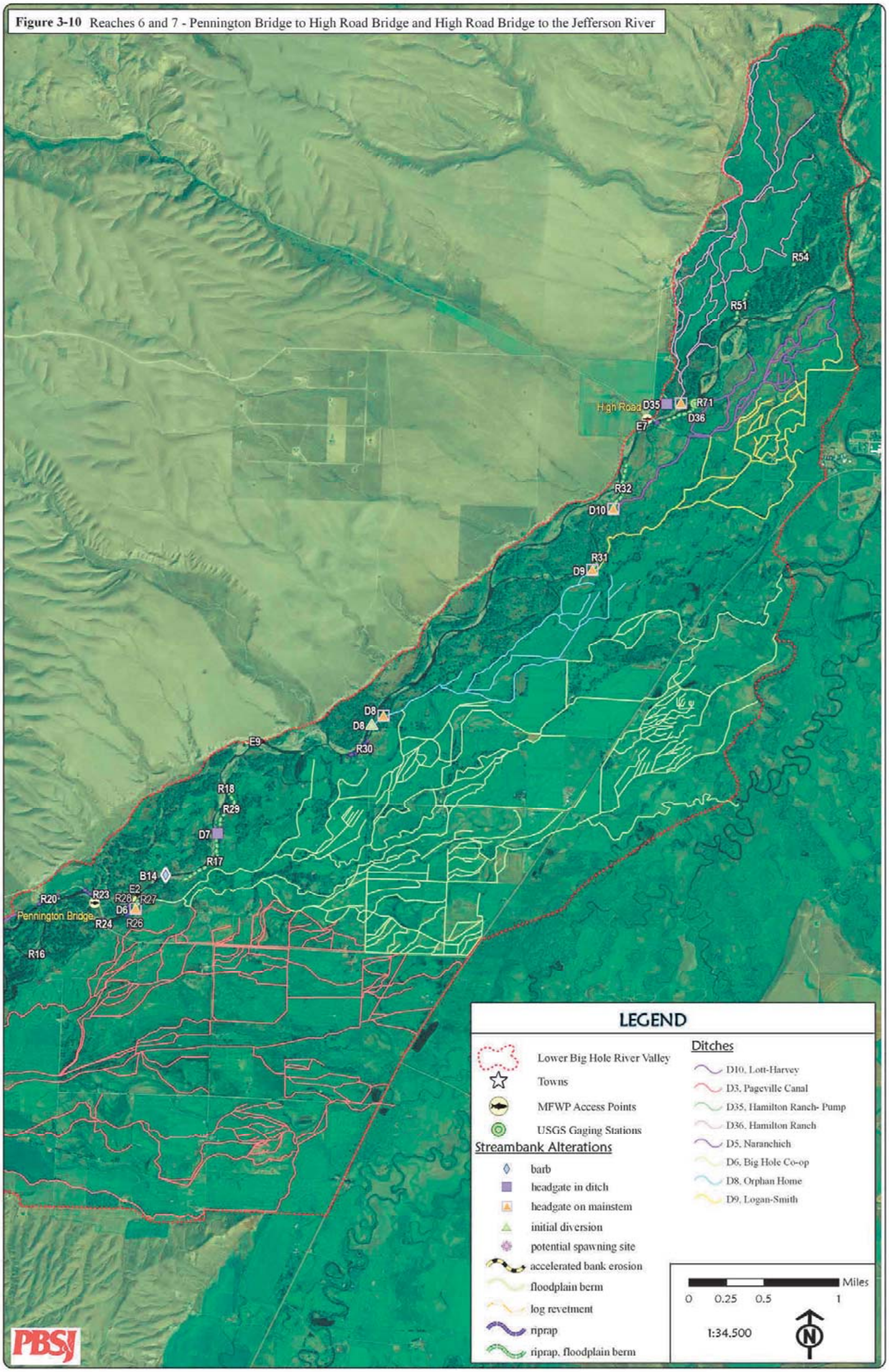


Figure 3-10 Reaches 6 and 7 - Pennington Bridge to High Road Bridge and High Road Bridge to the Jefferson River

Appendix C

DIVERSION DESCRIPTIONS

Lower Big Hole Irrigation Infrastructure Study

MAIDEN ROCK CANYON TO MELROSE/SALMON FLY FAS

Lower Big Hole Irrigation Infrastructure Study

Diversion 18 - Upper McCauley

Diversion 18 (Upper McCauley) is located on the river left bank at the inside of a meander bend in Maiden Rock canyon. The diversion weir is comprised primarily of large cobbles (channel materials) and boulders and extends most of the way across the channel. The weir does not appear to require regular maintenance and appears well-integrated into the natural channel morphology in this naturally confined section of river, though it may be a source of channel over-widening at the point of diversion. Channel confinement is provided by the canyon walls and the railroad on river left, while there is a terrace along river right. The channel bed material is large in this section of river. The diversion channel leads off to river left approximately 300 feet downstream to a headgate. There is a boulder check dam in the overflow channel that raises the water elevation at the headgate. The overflow water discharges through a vegetated gravel bar back into the Big Hole River. The headgate appears old and was comprised a metal “screw gate” in a wooden housing. After the initial diversion, the ditch is situated between the railroad track and the base of the canyon wall along the left side of the river. A portion of the ditch is transported in a pipe, which outlets back into a gravel and sand bottom ditch on river left at the mouth of the canyon. When the ditch enters the valley, it irrigates an area between the river and the interstate to the east of the Big Hole River at the mouth of Maiden Rock Canyon.

Diversion 19 – Meriwether's

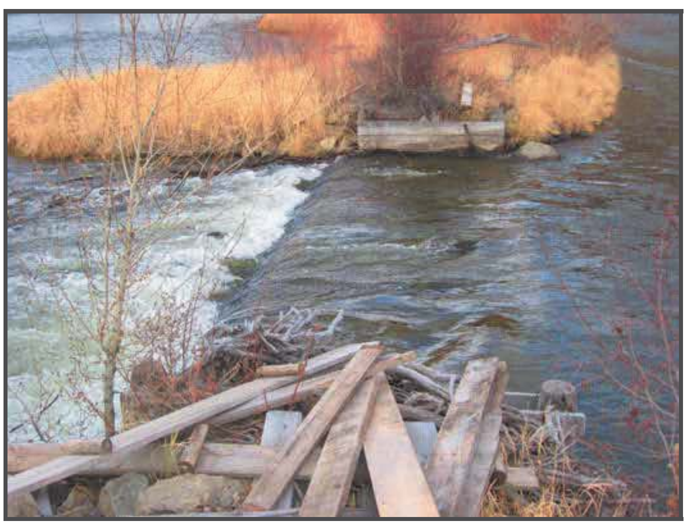
Diversion 19 is located along the river right bank in a relatively straight section of Maiden Rock canyon. There is a very long cobble (channel materials) and boulder weir extending approximately 800 feet from the headgate. The diversion dam starts pulling water at the inside of the bend in a shallow riffle. The diversion dam includes a section of boulders that appears to be abandoned in the channel. The "pin and plank" headgate has two openings and the ditch has a gravel substrate. The ditch flows along the river right side of the canyon and irrigates an area downstream of the mouth of the canyon. There is reportedly a Parshall plume in this ditch.

Diversion 20 – Lower McCauley

Diversions 20 and 21 on the river left bank and are both fed by a large diversion weir located at the outside of a bend in the main channel at the mouth of Maiden Rock canyon. The diversion structure is located in a naturally confined area just before the canyon opens up. The floodplain berm along the railroad on river left also confines the channel. The large cobble (channel material) weir extends most of the way across the channel, where it transitions to boulders with a large boulder “anchoring” it at its farthest extent. This weir diverts water into two diversion channels along river left. The upper diversion (Diversion 20) and the lower diversion (Diversion 21) both serve ditches that run between the river and the railroad and are then directed under the railroad and frontage road where they irrigate the valley to the east of the Big Hole River upstream of Melrose, with the ditch fed by Diversion 20 located along the interstate.

Diversion 20 is a single metal “screw gate” in a wooden housing. Diversion water is partially regulated by a collapsible jack. The wooden housing for the headgate and the collapsible jack is nearing the end of it operational lifespan. This ditch had a sand and gravel bottom where observed, though both of these ditches reportedly have cobble bottoms in the valley. Return flow from both of these ditches reportedly occurs through Camp Creek, with some water passing under the Frontage road and used in the next field to the south.

Diversion 21 – Melrose Canal



Diversions 20 and 21 on the river left bank and are both fed by a large diversion weir located at the outside of a bend in the main channel at the mouth of Maiden Rock canyon. The diversion structure is located in a naturally confined area just before the canyon opens up. The floodplain berm along the railroad on river left also confines the channel. The large cobble (channel material) weir extends most of the way across the channel, where it transitions to boulders with a large boulder "anchoring" it at its farthest extent. This weir diverts water into two diversion channels along river left. The upper diversion (Diversion 20) and the lower diversion (Diversion 21) both serve ditches that run between the river and the railroad and are then directed under the railroad and frontage road where they irrigate the valley to the east of the Big Hole River upstream of Melrose.

Diversion 21 has 3 metal "screw gates" in a concrete housing, though only one headgate (most river right) appears functional. Water was ponded in the ditch below Diversion 21. The overflow channel at Diversion 21 is regulated by a large collapsible jack, which is reportedly difficult to operate when the water is high. Return flow from both of these ditches reportedly occurs through Camp Creek, with some water passing under the Frontage road and used in the next field to the south.

Diversion 22 – Meriwether's

Diversion 22 is located along the river left bank on the inside of a bend in the left channel just downstream of where the Big Hole River splits into two channels at the Meriwether Ranch. The left channel now carries the majority of the flow, though it was formerly known as "County Line Slough". The diversion structure is located in a relatively flat floodplain area and has the potential to dramatically influence channel form in what would naturally be a meandering gravel bed system. At this diversion, water is directed through a short diversion channel to the wooden "pin and plank" headgate. The cobble (channel material) and boulder diversion weir extends approximately a third of the way into the channel, where it meets a riffle. This ditch irrigates an area to the east of the Big Hole River upstream of Melrose.

There is a second un-assessed diversion on the right channel across from Diversion 22. This diversion (D44) is located along the left bank of the right channel (also called "Buyan Slough") near the upstream point of the island. Water from this ditch is used to irrigate the island.

Diversion 23 – Carpenter's

Diversion 23 is the more upstream of the two Carpenter's diversions. This diversion is located just upstream of the "Meriwether Bridge" on the river left bank at the outside of a bend. The diversion structure is located in a relatively flat floodplain area and has the potential to dramatically influence channel form in what would naturally be a meandering gravel-bar system. Water is directed to the wooden headgate via a cobble (channel material) and boulder weir that extends a third of the way into the channel. There is no diversion channel and the headgate is situated in the bank parallel to the flow. The "pin and plank" wooden headgate is adjusted by removing boards and was recently upgraded. The ditch had a gravel bottom and irrigates a relatively small area between the Big Hole River and the frontage road upstream of Melrose.

There is riprap upstream of the diversion along the river left bank. "The Meriwether Bridge" is located just downstream of the diversion.

Diversion 24 – Carpenter's

Diversion 24 is the more downstream of the two Carpenter's diversions. It is located on the river left bank at the outside of a bend. The diversion structure is located in a relatively flat floodplain area and has the potential to dramatically influence channel form in what would naturally be a meandering gravel-bar system. There is a large cobble (channel material) and boulder weir extending most of the way across the channel. This weir reportedly requires maintenance regularly. There is no diversion channel and the headgate is situated in the bank. The headgate is wooded "pin and plank" structure that is need of repair.

There is riprap downstream of the diversion on the river left bank, which is leading to bank erosion along the river right bank on the next meander bend downstream. The channel is becoming over-widened at this eroding bank.

At the time of this assessment, this diversion was scheduled for an upgrade, including a new headgate, modification of the diversion dam, and the addition of a Parshall flume.

MELROSE/SALMON FLY FAS TO BROWN'S BRIDGE FAS

Lower Big Hole Irrigation Infrastructure Study

Diversion 11a - Pendergast–Spears–McCullough

Diversions 11a and 11b are located along the river left bank at the outside of a bend in the left channel downstream of Melrose. The diversion structure was a small man-made island comprised of angular boulders and extended most of the way across the channel. There are two diversion channels, with a wooden headgate (Diversion 11a) on the more upstream channel and a gravel/cobble berm blocking the more downstream diversion channel (Diversion 11b), which prevents it from flowing during the winter. There is a second headgate (Diversion 29) in the Pendergast-Spears-McCullough ditch (11a) that directs water into the Gallagher ditch (11b). Return flow from the Gallagher ditch is directed back into a slough, which is then diverted at Diversion 30 into the Garden ditch.

The Diversion 11a headgate was wooden "pin and plank" structure in a wooden housing that was adjustable by adding/removing boards. There were two openings that could be adjusted. There was an overflow channel with a "collapsible jack" that could be adjusted to raise the water level reaching the headgate. This ditch irrigates an area between Melrose and Brown's Bridge. This ditch was originally located upstream of Melrose, but the diversion was moved after the construction of the railroad eliminated the upper portion of the ditch. It has a very low gradient and is slow and flat all the way.

There was riprap along the railroad track upstream of this diversion on river left leading to confinement along this side of the channel. There was bank erosion occurring downstream of the diversion dam along the river left bank.

Diversion 11b – Gallagher Ditch

Diversions 11a and 11b are located along the river left bank at the outside of a bend in the left channel downstream of Melrose. The diversion structure was a small man-made island comprised of angular boulders and extended most of the way across the channel. There are two diversion channels, with a wooden headgate (Diversion 11a) on the more upstream channel and a gravel/cobble berm blocking the more downstream diversion channel (Diversion 11b), which prevents it from flowing during the winter. There is a second headgate (Diversion 29) in the Pendergast-Spears-McCullough ditch (11a) that directs water into the Gallagher ditch (11b). Return flow from the Gallagher ditch is directed back into a slough, which is then diverted at Diversion 30 into the Garden ditch.

Diversion 11b currently lacks a headgate and is adjusted through manipulation of the gravel berm, which is angled out into the channel during the irrigation season. Additional water from the Pendergast-Spears-McCullough ditch (11a) enters the Gallagher ditch at Diversion 29. This ditch irrigates an area between Melrose and Brown's Bridge.

There was riprap along the railroad track upstream of this diversion on river left leading to confinement along this side of the channel. There was bank erosion occurring downstream of the diversion dam along the river left bank.

Diversion 29 – overflow from Pendergast-Spears-McCullough into Gallagher Ditch

Diversion 29 directs overflow water from the Pendergast-Spears-McCullough ditch (Diversion 11a) into the Gallagher Ditch (Diversion 11b). This diversion is located approximately 500 feet down the ditch from the main diversion on the Big Hole River.

The collapsible jack is nearing the end of its operation lifespan.

Diversion 30 – Garden Ditch

Return flow from the Gallagher Ditch (Diversion 11b) is directed into a slough at Diversion 31 and a portion of the water is then diverted into the Garden Ditch at Diversion 30. This ditch irrigates a relatively small area between the Big Hole River and the Frontage Road.

BROWN'S BRIDGE FAS TO GLEN FAS

Lower Big Hole Irrigation Infrastructure Study

Diversion 12 – Kalsta's

Diversion 12 is located at the outside of a bend on the river left bank underneath the most upstream I-15 over-pass. The diversion weir is made of large cobbles and small boulders and extends across the entire channel and has a "flow through" chute for boat passage. The headgate is located approximately 800 feet downstream the diversion channel. There are two metal "screw gates" in a concrete structure leading into a concrete ditch, which includes a staff gage. This diversion irrigates land above and below Kalsta Bridge along the east side of the Big Hole River.

There is railroad riprap upstream along the river left bank and the headgate is located among the interstate bridge pylons.

Diversion 34 – within Kalsta's Ditch

Diversion 34 is located approximately 1.7 miles down Kalsta's ditch (D12). At this diversion, the main ditch splits into two ditches. The right (west) ditch leads back to the river, flowing through a floodplain area feed by springs. The left (east) ditch flows approximately 2 more miles before returning to the river upstream of Diversion 15.

Diversion 13 – Hagenbarth's "Big Hole" Ditch

Diversion 13 is the located in a diversion channel along the river right bank. The diversion channel is formed by a semi-natural looking gravel bar on river right just downstream of Kalsta's diversion weir. The single wooden headgate is located approximately 1,500 feet down the diversion channel and there is a "blow-off" channel approximately 600 feet down the diversion channel. Water is directed toward the headgate by a gravel berm. This ditch irrigates land on the west side of the Big Hole River downstream of the interstate crossing and upstream of Glen. Flow in this ditch is regulated by a second headgate (Diversion 42) at the mouth of Rock Creek. Water from this ditch then flows into a network of ditches downstream of Glen.

Both headgates are scheduled to be replaced in the spring of 2008. At the upper headgate (Diversion 13), they plan to add a "collapsible jack" to replace the gravel berm currently used. At the second diversion (Diversion 42) where the ditch intercepts Rock Creek, they are also planning to replace the wooden headgate and replace the existing Parshall flume with a 6' Parshall flume.

Diversion 14 – Hagenbarth's "River Field" Ditch

Diversion 14 is located on the river right bank just downstream of the Kalsta Bridge. The diversion dam is comprised of cobbles (channel materials) and is angled directly upstream, but does not extend across a large portion of the channel. There is a deep scour hole below the Kalsta Bridge and sediment deposition downstream of this spot likely leads to gravel accumulations at the entrance of this ditch. There is a single metal headgate in a wooden structure. This gravel bottom ditch flood irrigates land between the Big Hole River and the frontage road.

Diversion 15 – Gainy's

Diversion 15 is located on the river left bank at the outside of a bend. There is a cobble and boulder weir extending out into the channel straight upstream approximately 350 feet from the headgate. This ditch is located where the river meets the foothills along river left, so it is somewhat naturally confined currently, though this is subject to lateral channel migration. The headgate is a metal "screw gate" in a wooden housing and there is an overflow channel with a "collapsible jack". Return flow from this ditch feeds a series of ponds located on the floodplain.

Diversion 39 – Smith's

Diversion 39 comes off a slough on river right and the initial point of diversion is located over a mile upstream. Overflow water from Hagenbarth's "River Field" ditch also feeds this slough. At the headgate, the diversion dam is made of gravel and cobble (channel materials), along with some wood. The single metal "screw gate" is situated in a wooden housing and is approximately 100 feet down a diversion channel. This gravel bottom ditch irrigates land downstream of Glen. There is a Pashall flume, though it reportedly may not function properly since the ditch is relatively flat.

GLEN FAS TO NOTCH BOTTOM FAS

Lower Big Hole Irrigation Infrastructure Study

Diversion 16 and 17 – Diversion Dam for Gainy's and Garrison/Kilwien

Diversion 16 – Gainy's

Diversions 16 and 17 are fed by a large diversion channel on the river left bank, with the initial point of diversion maintained by a gravel and cobble weir constructed out of channel materials in a riffle that is over-widened. Gravels have been piled up on both sides of the entrance to the side channel in an effort to maintain flow into the diversion channel. The initial diversion is located in relatively a broad and flat floodplain area with multiple channels.

Diversion 16 is located on river left bank and has a gravel, cobble and small boulder weir extending all the way across the channel. The diversion dam has also accumulated LWD closer to the headgate. The single headgate is made of metal and wood.

Diversion 17a – Garrison's (Buhrer-Garrison Ditch)

Diversions 16 and 17 are fed by a large diversion channel on the river left bank, with the initial point of diversion maintained by a gravel and cobble weir constructed out of channel materials in a riffle that is over-widened. Gravels have been piled up on both sides of the entrance to the side channel in an effort to maintain flow into the diversion channel. The initial diversion is located in relatively a broad and flat floodplain area with multiple channels.

Diversions 17a and 17b are located along the river left bank in diversion channel at the outside of a bend just upstream of the Burma Road bridge crossing. The floodplain is relatively low and flat, though the bridge downstream is well above the elevation of the floodplain. There is a large gravel and cobble (channel materials) berm across the entire channel, though a flow-through channel is created during the non-irrigation season to prevent the material from washing downstream during spring runoff.

Diversion 17 is comprised of two diversions and the headgates were replaced in 2006 with metal "screw gates". The river left headgate (17a) feeds the Garrison ditch, which runs several miles along the foothills and Burma road an primarily flood irrigates the valley bottom between the foothills and the river, with at least one field irrigated with sprinkler irrigation.

There is a short section of riprap upstream on river left, with additional riprap at the bridge downstream. There are staff gages on both headgates and the potential to add a Parshall flume to Garrison's diversion.

There is currently a design in place to improve this diversion dam. However, concerns have been raised that the river could overflow onto the floodplain here,

Diversion 17b – Kilwien's (Buhrer-Garrison Ditch)

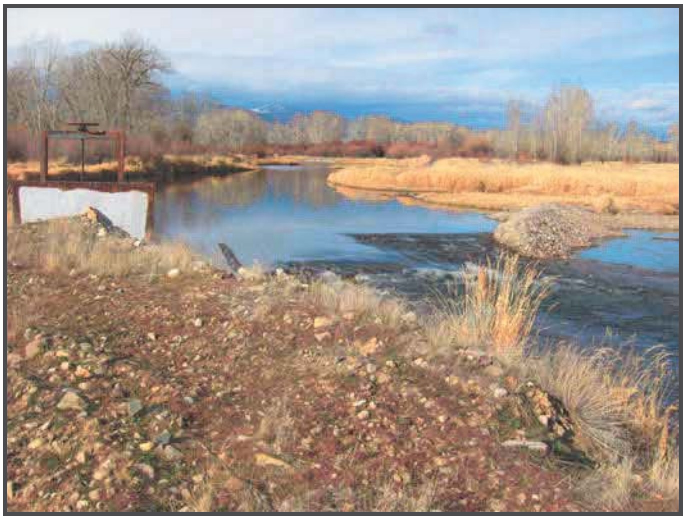
Diversions 16 and 17 are fed by a large diversion channel on the river left bank, with the initial point of diversion maintained by a gravel and cobble weir constructed out of channel materials in a riffle that is over-widened. Gravels have been piled up on both sides of the entrance to the side channel in an effort to maintain flow into the diversion channel. The initial diversion is located in relatively a broad and flat floodplain area with multiple channels.

Diversions 17a and 17b are located along the river left bank in diversion channel at the outside of a bend just upstream of the Burma Road bridge crossing. The floodplain is relatively low and flat, though the bridge downstream is well above the elevation of the floodplain. There is a large gravel and cobble (channel materials) berm across the entire channel, though a flow-through channel is created during the non-irrigation season to prevent the material from washing downstream during spring runoff.

Diversion 17 is comprised of two diversions and the headgates were replaced in 2006 with metal "screw gates". The river right headgate (17b) feeds the Kilwien ditch.

There is a short section of riprap upstream on river left, with additional riprap at the bridge downstream. There are staff gages on both headgates. The Kilwien ditch is relatively flat.

Diversion 25



Diversion 25 is located along the river right bank in the right channel downstream of the Glen FAS. This is a large natural side channel. The diversion weir is made of cobble and gravels (channel materials). It appears that a portion of the diversion dam has washed out, leaving a plume of cobbles downstream. It is a metal "screw gate" in a metal housing surrounded by boulders (riprap) and cobbles.

Diversion 26 – Garrison's "Wild Hay" Ditch

Diversion 26 is located in a diversion channel to the river left of the main channel. The diversion channel reportedly used to be the main channel. The initial point of diversion is maintained by a gravel and cobble (channel materials) weir that extends approximately half way across the channel in a wide and shallow riffle. The diversion weir at the headgate extends across the entire side channel and is made of channel materials with a few boulders. There are two metal headgates in a wooden housing that was recently replaced. The headgate is housed in a large floodplain berm that extends downstream to an area with barbs and riprap.

There is riprap in the side channel and the headgate is located in a large floodplain berm created using gravel and cobble channel materials. There is bank erosion downstream along the river right bank in this over-widened area.

Diversion 27 – Rafferty's "Upper South Side" Ditch

Diversion 27 is located along the river right bank in a side channel to the river right. The original inlet to this diversion has been abandoned and the river eroded away part of the original ditch. The existing point of diversion looks like a natural gravel bar. At the headgate, there is a diversion dam extending across the entire channel. This diversion dam is made primarily of channel materials, with some smaller angular boulders. There are two metal "screw gates" in a wooden housing that were situated parallel ("askew") to the flow. The cobble bottom ditch flows along the base of the foothill and through the Notch, irrigating an area downstream of the Notch.

Diversion 28 – Rafferty's "Lower South Side" Ditch

Diversion 28 is located along the river right bank in the main channel. There is a large cobble and boulder weir extending well upstream and across most of the channel. The single metal "screw gate" is in a wooden housing. The ditch parallels the "Upper South Side" ditch and runs along the river. This ditch carries floodwater during high flows and is regulated by a second headgate where it departs from the river.

Diversion 37 – Bryan Ditch

Diversion 37 comes off a river left side channel across from where Rafferty's "Lower South Side" ditch (D27) comes off on river right. There are two headgates in a row, with a created "spring creek" flowing in-between. The ditch then leads down into a ponded area that also has return flow water from Garrison's diversion (D17a). This ditch irrigates an area downstream of the Notch.

NOTCH BOTTOM FAS TO PENNINGTON BRIDGE FAS

Lower Big Hole Irrigation Infrastructure Study

Diversion 4 – JS Ranch (Larson-Naranchich Ditch)

Diversion 4 is located along the river left bank downstream of Notch Bottom. A diversion channel has been created on river left to direct water toward the headgate. The diversion channel consists of a large vegetated berm with a natural looking gravel bar directing flow from the main channel. The headgate is a metal "screw gate" in a concrete housing and is located approximately 1,500 feet downstream of the initial point of diversion. There is a "collapsible jack" to increase the elevation of the water at the headgate. This ditch irrigates fields to the north of the Big Hole River.

This diversion is leading to bank erosion along the river right bank downstream, along with channel over-widening.

Diversion 1 – Cooper's (Whitney Ditch)

Diversion 1 is located at the outside of a meander bend along the river right bank. There is a vegetated cobble and boulder weir that extends approximately half way across the channel. The weir is vegetated with willows and has captured woody debris. There are two metal "screw gates" in a wooden structure that were fully opened at the time of the site visit.

There was streambank erosion along the river left bank downstream of the diversion dam. There is a Parshall flume in the ditch. Additional irrigation water is supplied to this area by a pump, which withdrawals water from a natural side channel approximately 2 miles downstream.

Diversion 2 – Sandy Ditch

Diversion 2 is located along the river left bank at a bend. There is a geologic nick-point confining the left side of the channel here. The diversion dam is angled upstream and is comprised of boulders. It was rebuilt recently. There is a single metal “screw gate” within a cement structure that situated parallel to the main flow of the river.

This diversion weir may be leading to upstream aggradation as gravel settles out on the bar along river right. There is a high amount of stream power at this sharp bend. Floods and ice reportedly move the rocks comprising the diversion dam.

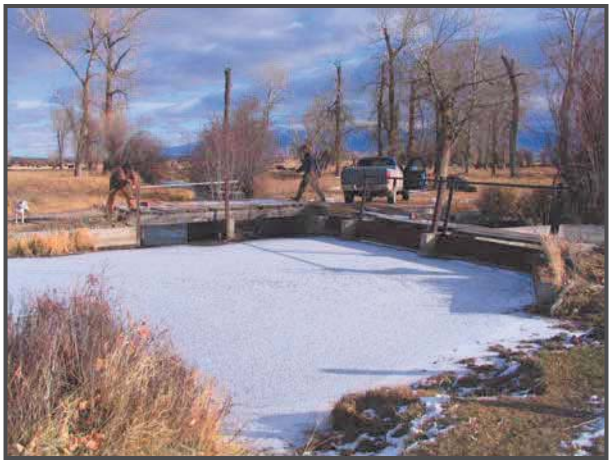
Diversion 3 – Pageville Canal

Diversion 3 is located at the outside of a bend on the river right bank. The ditch appears to utilize what was historically a side channel and is associated with a geologic nick-point that naturally confines the left side of the channel. The diversion dam is comprised of large boulders that were used to fill a deep hole. Since the placement of these boulders, the channel bed has aggraded and the diversion structure now appears assimilated into the streambed. There are 3 metal “screw gates” in a single concrete structure at the initial point of diversion, though the ditch reportedly fills with 2 of the headgates. This ditch splits into 3 ditches at a second diversion (D32) slightly less than a mile downstream of the initial diversion, with the most westerly of the ditches continuing on as the Pageville Canal. The main split (D32) is a concrete structure with metal headgates that sends the majority of the flow to the north through the main ditch, off which the Redfield ditch splits shortly thereafter at Diversion 33.

The Pageville Canal irrigates an area of 3000-4000 acres and serves 20 irrigators between the Big Hole and Beaverhead River. Most of this area is flood irrigated, though there is some sprinkler irrigation, with sprinkler irrigation concentrated at the southern end of the area near the foothills. Waste water goes into the Beaverhead River, California Slough and Owsley Slough.

There is riprap downstream of the headgate along the river right bank. The ditch has a staff gages at the initial point of diversion (D3) as well as at the first split (D32).

Diversion 32 – Pageville Canal splits into 3 ditches



The Pageville Canal (D3) splits into 3 ditches at a second diversion (D32) slightly less than a mile downstream of the initial diversion and headgate, with the most westerly of the ditches continuing on as the Pageville Canal. The main split (D32) is a concrete structure with metal headgates that sends the majority of the flow to the north through the main ditch, off which the Redfield ditch splits shortly thereafter at Diversion 33.

There are staff gages at the initial point of diversion (D3) as well as at the first split (D32).

Diversion 5 – Naranchich

The initial point of diversion consisted of a natural looking gravel bar that diverts flow into a diversion channel to the left of the mainstem slightly downstream of where the Pageville Canal (D3) comes off of river right. The diversion dam in the diversion channel leading to this ditch was not observed in the field and the two "Diversion 5" headgates recorded here are located within the ditch network. There are two metal "screw gates" in a rock and wood housing that supports a driveway and fence and creates a small pond upstream. This ditch runs along Burma Road, irrigating land between the river and road.

PENNINGTON BRIDGE FAS TO HIGH ROAD FAS

Lower Big Hole Irrigation Infrastructure Study

Diversion 6 – Big Hole Co-op Ditch

Diversion 6 is located along the river right bank downstream of the more southerly Pennington Bridge crossing. This is a very large diversion structure utilizing boulders that extend across the entire channel with a chute in the center for floater passage over an approximately 3-foot drop. The headgate is a single mechanism metal unit that is housed in a metal and rock structure. While it opens manually, a backhoe is currently required to "push" the headgate closed. Due to this issue, it is currently difficult to regulate during critical low flow periods.

The Big Hole Co-op ditch breaks into the Owsley Slough the Schoolhouse Slough and irrigates a large area between the Big Hole and the Beaverhead downstream of the Pennington Road primarily through flood irrigation. This cobble bottom ditch serves 22 irrigators and approximately 4,000 irrigated acres. This ditch discharges into the Beaverhead River, though water returns to the ditch as it moves through the network, so it is used by downstream irrigators.

The floodplain is relatively low here and has been built up around the headgate with a floodplain berm. There is riprap upstream on river right and downstream for a short distance on river left, with a floodplain berm downstream of the headgate on river right and accelerated streambank erosion occurring along river left downstream below the riprap. There is also a deep scour hole downstream of the dam.

There is currently a design for improvement of this diversion underway. There is a large Parshall flume, though it has been removed from the ditch since it ponded water in the ditch, making it more difficult to withdrawal water from the river.

Diversion 8 – Orphan Home




Diversion 8 is located on the river right bank in a relatively straight section of river downstream of a bend where riprap protects a low spot in the floodplain. The initial point of diversion is located in a relatively flat floodplain area and the headgate is located approximately 600 feet down the diversion channel. The initial diversion consists of a gravel berm extend well into the channel in this over-widened and shallow riffle. At the headgate, a small gravel berm has been built up to divert water toward the headgate, which is situated parallel to the flow. The headgate is comprised of wooden boards in a metal structure constructed from an old boiler pipe. There is a floodplain berm along the diversion channel that extends downstream of the headgate.

There is riprap in the channel upstream of the diversion dam suggesting channel migration. There is also a large eroding foothill terrace on river left approximately 1 mile upstream of this site and just upstream of Nez Perce Creek, which is likely leading to increased sediment loads within this section of river. Nez Perce Creek may also be a source of sediment.

This cobble bottom ditch is relatively steep. There is a Parshall flume in the ditch.

Diversion 9 – Hamilton Ranch Logan-Smith Ditch

Diversion 9 is located in the right channel at the outside of a bend on the river right bank, which appears to have less than half the flow. The diversion is located in a relatively flat floodplain area. A gravel berm comprise of channel substrate extends into a riffle deflects flow toward the headgate. It is a wooden “pin and plank” headgate with two openings. The system in place for raising and lower the headgate is reportedly difficult to operate.

This ditch is relatively steep downstream of the headgate.

Diversion 9 – Hamilton Ranch Lott-Harvey Ditch

Diversion 10 is located on the river right bank in the right channel upstream of a large floodplain berm. The diversion is located in a relatively flat floodplain area. The diversion structure includes boulders that create a vegetated peninsula, which leads to a small barb with cobbles extending into the channel. The channel reportedly used to lead directly to the headgate, but now only a slough leads down to it and the channel has migrated to the left. The short diversion channel leads to a wooden “pin and plank” headgate with two openings, while the ditch has a gravel/cobble substrate. The headgate is situated parallel to the flow.

The floodplain berm downstream of this diversion leads to bank erosion along the terrace on river left upstream of the High Road FAS.

HIGH ROAD FAS TO THE JEFFERSON RIVER

Lower Big Hole Irrigation Infrastructure Study

Diversion 36 – Hamilton "Ranch" Ditch, also known as "Hamilton" Ditch

The initial diversion dam serves both Diversions 35 and 36. This diversion dam extends out from the river left bank just upstream of the High Road Bridge. The diversion dam is situated just upstream of the bridge pylon and an eroding bank upstream reportedly deposits sediment at the inlet of the diversion channel. Annual maintenance is reportedly required to keep the inlet of the diversion channel free from grave. Diversion 35 is located upstream of Diversion 36 and serves a pump.

At Diversion 36, a large "collapsible jack" in the side channel directs water into the ditch, with the first headgate located approximately 600 feet down the ditch. This headgate is a metal "screw gate" in a wooden structure and there is a Parshall flume downstream and a "collapsible jack" diverting water down the other channel. There is reportedly a second diversion structure in this network that is similar. This cobble ditch irrigates approximately 1,000-2,000 acres of the Hamilton Ranch to the west of the confluence of the Big Hole and Jefferson rivers.

Bank erosion along the left bank upstream of the diversion dam likely results from the large floodplain berm on river right that starts downstream of Diversion 9.

Appendix D

IRRIGATOR CONTACT INFORMATION

Lower Big Hole Irrigation Infrastructure Study

Appendix E

POINT FEATURE DATABASE

Lower Big Hole Irrigation Infrastructure Study

Appendix F

LINE FEATURE DATABASE

Lower Big Hole Irrigation Infrastructure Study

Appendix G

POTENTIAL PROJECTS

Lower Big Hole Irrigation Infrastructure Study

Diversion Number	Diversion Name	Potential Project	Irrigator/Contact
D20	lower McCauley	replace headgate and collapsible jack	Pendergast, Kearns, Smith
D20	lower McCauley	add Parshall flume	Pendergast, Kearns, Smith
D22	Meriwether's	relocate point of diversion	Ellingson
D44	Meriwether's	re-activate flow in west channel	Ellingson
D11A	Pendergast-Spears-McCullough	replace "pin and plank" headgate with metal screw headgate	Pendergast, Spears, Kearns
D11B	Pendergast-Spears-McCullough	install headgate in second diversion channel and build weir	Pendergast, Spears, Kearns
D11	Pendergast-Spears-McCullough	stabilize eroding bank downstream	Pendergast, Spears, Kearns
D29	Pendergast-Spears-McCullough	replace headgate and collapsible jack	Pendergast, Spears, Kearns
D12	Kalsta's	close off lower 4 miles of ditch and use pumps for fields	Kasta, Gainy
D17a	Garrison/Kilwien	adding Parshall flume to Garrison ditch	Garrison
D16, D17a/b	Gainy's, Garrison/Kilwien	anchor initial point of diversion	Gainy, Garrison, Kilwien, Anderson
D27	Rafferty's Upper South Side	replace headgate	Rafferty
D28	Rafferty's Lower South Side	clear vegetation from left wall of diversion along main channel	Rafferty
D4	JS Ranch (Larson-Naranchich)	stabilize bank downstream on river right	Rafferty
D2	Sandy Ditch	reduce hydrologic impact of diversion dam, improve irrigation withdrawl	Adams, Collins
D6	Big Hole Co-op	replace headgate and reduce drop created by diversion dam	Ashcraft
D8	Orphan Home	replace headgate and deepen diversion channel, remove rocks in mainstem	Ashcraft
D9	Logan-Smith	replace headgate	Trischman
D9	Logan-Smith	add Parshall flume	Trischman
D10	Lott-Harvey	replace headgate	Trischman
D10	Lott-Harvey	add Parshall flume	Trischman
D36	Hamilton Ranch Ditch	improve diversion dam	Trischman
D36	Hamilton Ranch Ditch	stabilize large eroding bank upstream	Trischman

Appendix H

CUMULATIVE IMPACTS PRIORITY MATRIX SCORES

Lower Big Hole Irrigation Infrastructure Study

Individual Diversions/Mile					
Reach Name	**Reach Number**	**Reach Length (miles)**	**Number of Diversions**	**Diversions / Mile**	**Matrix Score**
Maiden Rock to Melrose/Salmon Fly	1	5.8	8	1.4	3
Melrose/Salmon Fly to Brown's Bridge	2	6.3	2	0.3	1
Brown's Bridge to Glen	3	7.3	6	0.8	2
Glen to Notch Bottom	4	7.2	7	1.0	2
Notch Bottom to Pennington Bridge	5	9.7	5	0.5	1
Pennington Bridge to High Road Bridge	6	6.2	4	0.6	2
High Road Bridge to Jefferson River	7	1.8	2	1.1	3
		44.2	**34**	**0.8**	

Claimed Points of Diversion/Mile					
Reach Name	**Reach Number**	**Reach Length (miles)**	**Claimed Points of Diversion**	**Claimed Points of Diversion / Mile**	**Matrix Score**
Maiden Rock to Melrose/Salmon Fly	1	5.8	35	6.1	2
Melrose/Salmon Fly to Brown's Bridge	2	6.3	13	2.1	1
Brown's Bridge to Glen	3	7.3	30	4.1	1
Glen to Notch Bottom	4	7.2	23	3.2	1
Notch Bottom to Pennington Bridge	5	9.7	47	4.9	1
Pennington Bridge to High Road Bridge	6	6.2	108	17.4	3
High Road Bridge to Jefferson River	7	1.8	1	0.6	1
TOTAL		**44.2**	**257**	**5.8**	

Ditch Length to Reach Length Ratio					
Reach Name	**Reach Number**	**Reach Length (miles)**	**Ditch Length (miles)**	**Ditch Length to Reach Length Ratio**	**Matrix Score**
Maiden Rock to Melrose/Salmon Fly	1	5.8	24.1	4:1	1
Melrose/Salmon Fly to Brown's Bridge	2	6.3	11.9	2:1	1
Brown's Bridge to Glen	3	7.3	53.0	7:1	2
Glen to Notch Bottom	4	7.2	15.9	2:1	1
Notch Bottom to Pennington Bridge	5	9.7	72.2	8:1	2
Pennington Bridge to High Road Bridge	6	6.2	70.0	11:1	3
High Road Bridge to Jefferson River	7	1.8	11.9	7:1	2
TOTAL		**44.2**	**259.0**	**6:1**	

Percent of reach with Streambank Alterations					
Reach Name	**Reach Number**	**Reach Length (miles)**	**Length of Streambank Alterations**	**Percent of Reach with Streambank Alterations**	**Matrix Score**
Maiden Rock to Melrose/Salmon Fly	1	5.8	0.3	4%	1
Melrose/Salmon Fly to Brown's Bridge	2	6.3	0.09	1%	1
Brown's Bridge to Glen	3	7.3	1.1	15%	2
Glen to Notch Bottom	4	7.2	2.2	31%	3
Notch Bottom to Pennington Bridge	5	9.7	1.9	19%	2
Pennington Bridge to High Road Bridge	6	6.2	1.8	29%	3
High Road Bridge to Jefferson River	7	1.8	0.7	40%	3
		44.2	**8.0**	18%	

Technical Report
Madison County
Lower Big Hole River Study – River Mile 8.3 through 9.3

Prepared by:

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For:

Madison County

Funded by:

Montana Department of Natural Resources

Renewable Resource Grant and Loan Program Planning Grant

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INTRODUCTION

Madison County has observed degradation due to accelerated rates of erosion and aggradation along the Lower Big Hole River near the Burma Road Crossings and the Pennington Bridge Fishing Access Site (FAS) and boat ramp (Exhibits A and B). In the interest of protecting private land and public infrastructure, the County stabilized 205 feet of eroding bank with 175 cubic yards of rock rip rap along the right bank of the Big Hole River upstream of the Pennington Bridge in 2016. Prior to the stabilization work, observers quantified an average annual bank retreat rate greater than 6 feet per year along the right bank upstream of what is referred to as the Pennington Bridge (Exhibit C) (Boyd 2015). However, this bank is not the only point at which accelerated erosion has occurred in the area. An examination of aerial imagery available through the National Agricultural Imagery Program shows that between 2009 and 2015, an average of five feet of bank has eroded at the Pennington Bridge FAS (Figure 1). Retreat along the right bank is not matched with accretion on the opposing bank, thereby causing a net widening of the channel. Similar widening of the channel has occurred adjacent to the existing riprap upstream of the bridge northwest of the Pennington Bridge (denoted as the “Burma Bridge” for this document). In the secondary channel that flows beneath the Burma Bridge, accelerated aggradation has interrupted flow to downstream irrigation diversions, and has necessitated occasional excavation of accumulated sediment and gravel from the channel.

Figure 1. View looking upstream from left bank at Pennington Bridge Fishing Access. Bridge in foreground is Burma Bridge.

The initial objective of this study is to identify areas of channel change that are suffering the greatest impact on natural resources such as water quality, habitat, water use, and land use along the Big Hole River between river miles 8.3 and 9.3. This was accomplished through review of existing data, along with a site visit to observe site conditions and collect field measurements to develop at least some level of quantitative analysis of the stresses and processes occurring within study area.

Montana Department of Environmental Quality's (MDEQ) 2014 Final Water Quality Integrated Report (MDEQ 2014) lists the lower segment of the Big Hole River (downstream of Divide Creek), which includes the study reach, as impaired under several categories. Those categories include metals contamination, low flow alterations, physical substrate habitat alterations, and water temperature. The sources of these impacts include mine waste, hydromodification (as a result of diversions and irrigation water use), habitat modification, grazing in riparian and shoreline zones, infrastructure, and streambank modifications/destabilization. Sources of impacts to water quality occurring within the study reach include habitat modification, grazing in riparian and shoreline zones, infrastructure, and streambank modifications/destabilization. According to the MDEQ, hydromodification occurs upstream and downstream of the study area due to irrigation water storage and diversions.

Subsequent to cataloging the severity and mechanisms of impacts or threatened impacts within the reach, the second objective involves the development of conceptual designs to improve the condition of natural resources and propose alternative approaches that will mitigate the impacts of observed accelerated erosion and aggradation. Primarily, investigators sought to assess the causes of these impacts with the goal of designing solutions that address the cause, rather than the effect, of these impacts. A cause-based review of resource impacts is much more likely to present project alternatives that will have a lasting and beneficial effect on the resource with limited required cost and maintenance. As mentioned in the 2009 Middle and Lower Big Hole Planning Area TMDLs and Water Quality Improvement Plan (2009 TMDL Document), "the use of riprap or other 'hard' approaches [are] not recommended and is not consistent with water quality protection." The 2009 TMDL document goes on to say that these approaches are necessary in some instances, such as "areas with demonstrated infrastructure threat." The placement of riprap in 2015 was to address a threat to infrastructure and private land. According to the 2009 TMDL document, a reason to avoid riprap includes the observation that "it generally redirects channel energy and exacerbates erosion in other places." Additionally, these stabilization structures have been cited as causing a loss of fish habitat (MDEQ, 2009). As will be discussed in more detail in this report, approximately 25 percent of the left bank and 10 percent of the right bank of the main channel of the within the study are already hardened with riprap.

Mitigation alternatives presented in this report either present prescriptions that address the causes of observed accelerated erosion and deposition, or mitigate these processes such that current or threatened impacts to resources including water quality, habitat, and beneficial uses are avoided or minimized.

Project Location

The study reach extends along the Big Hole River in Madison County approximately 5,200 feet upstream and 1,600 feet downstream of the Pennington Road bridge (Exhibits A and B). This study reach extends from river mile 8.3 through to 9.3. Note that the net length of channel is greater than the one river mile due to increased length associated with channel meanders that have developed in the study reach. The study reach encompasses portions of Sections 10, 11 and 15, Township 4 South, Range 7 West. The project area lies within the floodplain of the Big Hole River and is traversed by Burma Road. The road uses two bridges to cross major channels of the river. The bridge to the east is locally known as the Pennington bridge. For purposes of this report, the authors refer to the western bridge as the Burma bridge.

Ecological Setting

The project area is dominated by a range of wetland and riparian ecological systems. A map of the wetlands is included in the 2016 DNRC RRGL application, as is the Montana Environmental Protection Act checklist, which describes a variety of environmental aspects of the project area. The area hosts a wide variety of waterfowl, mammals, songbirds, fish and insects. The area constitutes habitat for some species of concern and/or threatened or endangered species.

Local Infrastructure and Potential Site Constraints

From a human perspective, the river's primary asset is irrigation water and recreational activities. The downstream end of the project area is delineated by an irrigation diversion that feeds the Owsley Slough, and the channel beneath the Burma Road bridge leads to an irrigation diversions beginning approximately 0.25 river miles downstream.

The "Pennington Bridge" (MDT Bridge No. L29141000+03001) is a steel/concrete triple-span 210-foot bridge that was last repaired/replaced in 1987. The bridge is considered to be in good structural condition (GWE 2016). The "Burma Bridge" (MDT Bridge No. L29141000+05001) is a steel/concrete double-span 150-foot bridge that was last repaired/replaced in 1987. The bridge is considered to be in good structural condition (GWE 2016). Original bridge construction for both bridges pre-dates 1942.

Based on review of Montana cadastral data (Montana State Library 2016) and a phone conversation with Montana Fish, Wildlife, and Parks (FWP) staff (Ray Heagney, FWP Region 3, Regional FAS Manager), the Pennington Bridge FAS and boat ramp is maintained by the FWP on private land through a five-year lease agreement with the landowner.

Channel Morphology

The study began with an assessment of 6,500 linear feet of the Lower Big Hole River. The downstream and upstream extents of the study are identified in Exhibits A, B and C. The study includes consideration of overall watershed conditions including land use and water use upstream of the study reach.

The study reach is largely a single-thread channel at low flow. However, anabranching across the floodplain creates multiple channels during periods of higher flow, one of which passes beneath the Burma Road bridge. Using cross sections developed during previous work in this reach (Great West Engineering, Inc., 2015), the single-thread portion of the channel in the study area is classified as a C4 in the Rosgen system of classification. However, the channel geometry has likely been impacted by the presence of two bridges on the Pennington and Burma Roads, which may affect the interpretation of the classification. Upstream and downstream of the bridges, the river exhibits an anabranching character, with a belt width (meander width) ranging from 1,000 feet in geologically-constricted reaches to well over a mile in the more open portions of the valley. A review of historical aerial photographs revealed that the channel has migrated across the floodplain actively throughout the past 60 years, including within and immediately upstream of the project area.

Investigators reviewed historical aerial photos of the area, the oldest of which are from 1942. Those photos clearly show the channels of the Big Hole having migrated and avulsed. The images were, in some cases, taken many years apart, making the precise determination of the channel history challenging.

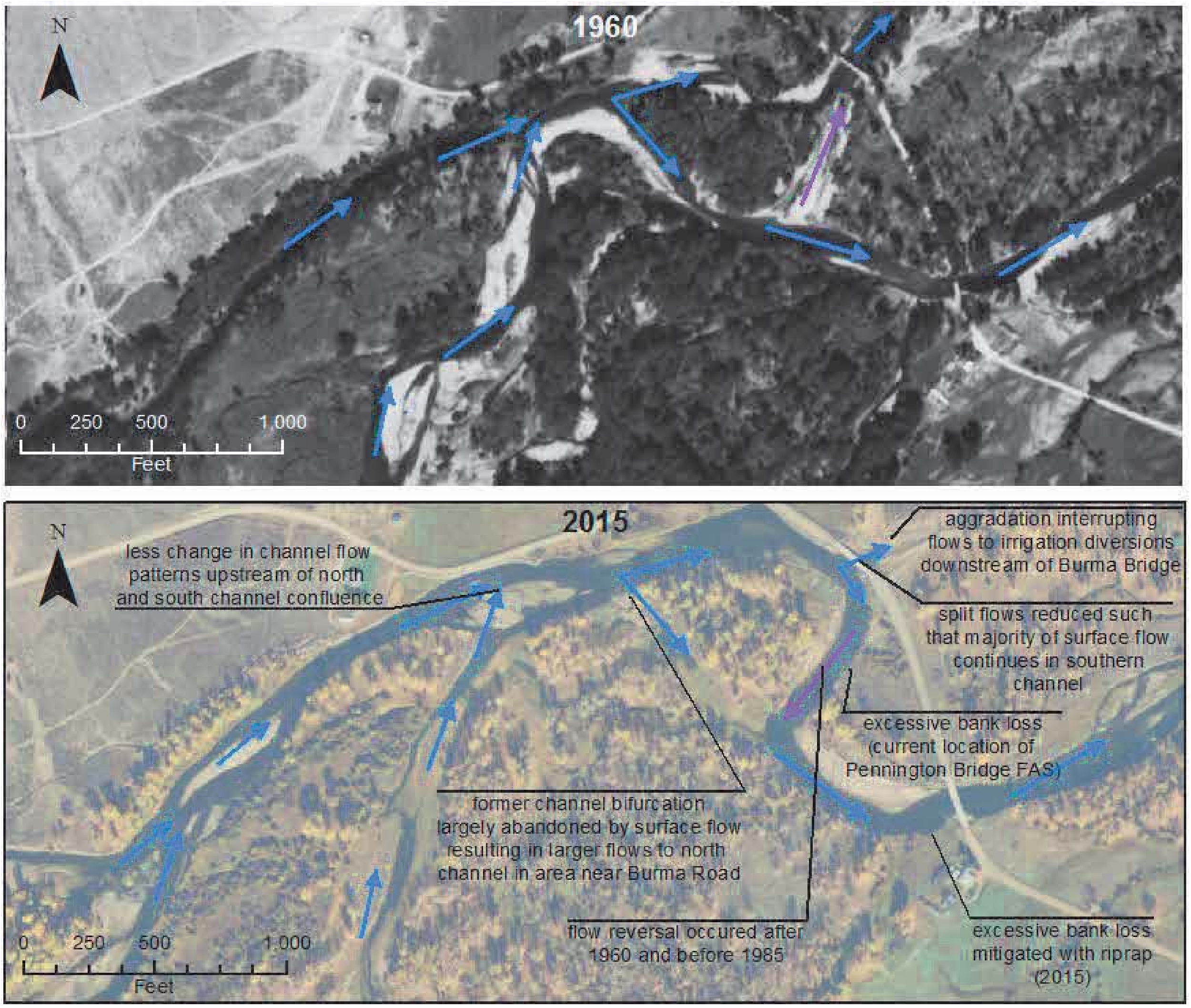


Figure 2. Comparison of past and present channel configuration within study reach (1960 to 2015).

Prior to 1985 the channel upstream of the project area bifurcated approximately 1,000 feet upstream of the Burma bridge, leaving the two distinct channels that the Burma and Pennington bridges crossed. Subsequent photos show that the channel migrated or avulsed significantly.

Prior to about 1965, at a point 900 feet upstream of the Burma Bridge, the flow split into a north and south channel (Figure 2). The northern channel was crossed by the Burma Bridge and the southern channel was crossed by the Pennington Bridge. Approximately 30 to 40 years ago, the southern channel was abandoned by low-flow surface discharges and the majority of flow remained in the northern channel (more precise timing of this change is unknown due to gaps in time between available aerial imagery and poor resolution). As a result, stresses to the left bank of the channel increased, causing significant channel expansion and migration to the north toward Burma road. This caused erosion of the left bank until it reached the Burma Road bed. Riprap applied at the base of the road bed has since halted further migration of the left bank of the northwestern channel of the river in the area north of the Burma Bridge.

The abandonment of the south channel upstream of the Burma Bridge has also resulted in flow reversal at what had historically been an overflow channel emanating from the south channel upstream of the Pennington Bridge. Historically, seasonal high discharges ran into a former overflow channel northward to the Burma Bridge. However, since the majority of water now flows in the north channel, the water from the north channel largely move perpendicular to the Burma Bridge and then flows southward through the same overflow channel. This change resulted in an increase in shear stress and erosion along the area that is now the Pennington Bridge FAS.

Hydrology

At the time of this analysis, areas including the project area is not mapped by the Federal Emergency Management Agency (FEMA). That is, FEMA has not completed a study to determine flood hazard for the location; therefore, a flood map has not been published at this time.

Discharge at the time of the field inspection was roughly 1,850 cubic feet per second (cfs) at the USGS gaging station at Glen, Montana (#06026210), about 13 miles up the valley from the project area. Based on available survey data (Great West Engineering, 2015) and observations taken during the site visit, investigators estimated the discharge through the Pennington Road Bridge to be 1,700 cfs. That estimate is based on a stage-discharge relationship developed from the cross-section data and estimated water-surface slope (Appendix A). Data available from the USGS gaging stations in the area show that peak discharge at the Hamilton Ditch gage on the Big Hole downstream of the project area (#06026420) is typically as much as 90 percent lower than what is reported from the Glen gage. Several large irrigation diversions redirect water from the main channel(s) between the two gages. In addition, some groundwater likely infiltrates the gravels within the valley where it widens approaching the confluence with the Beaverhead and Ruby Rivers. Some water was also moving under the Burma Road bridge, and although the flow was relatively small, it was enough to reduce the estimated flow through the Pennington Road bridge.

SUB-REACH ASSESSMENT AND MITIGATION ALTERNATIVES

Following assessment of the overall study reach, investigators identified areas of concern from a point approximately 1,600 feet upstream of the Burma Bridge at the riprapped left bank downstream to the Pennington Bridge crossing. Field observations, measurements, and identified mitigation options are discussed below. The 3,150-foot reach is divided into five sub-reaches (Exhibit C) Bank erosion and aggradation rates upstream of the five sub-reaches reflect a relatively normal sedimentation process. That upstream area is in less jeopardy of accelerated erosion and deposition because the absence of the hydraulic influence of infrastructure allows for more-natural channel dynamics. Similarly, the stretch of the current main stem of the Big Hole River downstream of Pennington Bridge was not considered for a detailed analysis or mitigation because the channel between Pennington Bridge and the Owlsley Slough appears to be geomorphologically stable and not vulnerable to accelerated erosion or aggradation.

Investigators measured streamflow velocity at several locations throughout the detailed study reach as a means of developing instream characteristics, such as near-bank shear stress. Measurements taken within sub-reaches 1, 2, 3 and 4 ranged from 2.5 to 4.0 feet per second (fps), which is within the range of the stage-discharge characteristics developed for the site. The near-bank shear stresses associated with those velocities range from 0.2 to 0.38 pounds per square foot (psf).

Sub-Reach 1

Sub-Reach 1 begins at the existing riprap on the left bank of the river adjacent to Burma Road and extends downstream to the beginning of the riprap on the left bank upstream of Burma Bridge (Exhibit E).

Existing Conditions

The river channel is a fairly typical riffle, being straight, relatively shallow and fast-moving. The riprap located along the left bank appears to be intact and in good condition (photo inset A, Exhibit E) Investigators observed erosion downstream of the riprap on the left bank (photo inset B, Exhibit E). An eddy has developed downstream of the riprap, which has caused some bank erosion. The bank for 350 to 400 feet downstream of that area of erosion is relatively stable. The floodplain proximal to the left bank is heavily vegetated, hosting sedge, alder and a shrub-scrub riparian community. Downstream of that point the floodplain is still heavily vegetated, but the bank is experiencing some undercutting and erosion (photo inset C, Exhibit E). Such lateral erosion is atypical of riffles, which typically experience relatively little shear stress or lateral scour during discharges of high exceedance probability.

The right bank in Sub-Reach 1 reflects a complex of morphologies associated with anabranching rivers. Part of the right bank includes an active overflow channel associated with a relatively large central bar. Mid sub-reach and to the south is trace of the former “south” channel that has been abandoned. The upstream end of of that channel is clogged with sediment and woody debris (photo inset D, Exhibit E).

The near-bank channel velocity in the center of sub-reach 1 was 3.0 fps at the time of the field inspection.

Conditions within Sub-Reach 2 appear to be relatively stable with no obvious threat of significant erosion, sediment delivery, or aggradation. Bank erosion at areas shown in Photos B and C of Exhibit E is considered moderate to low. Vegetation at these locations are contributing somewhat to bank stability but do not provide much with regard to effective stream shading.

Mitigation Alternatives

The objective of any treatment in Sub-Reach 1 is to reduce bank erosion as a means of preserving the existing floodplain. A more-stable channel in this sub-reach would reduce aggradation downstream, where that process is contributing to overwidening of the channel and increased water temperatures. The right bank does not appear to suffer from any undue shear stress or erosion and does not require treatment.

1. No Action. The no-action alternative would likely result in the continued erosion of the left bank immediately below the riprap parallel to Burma Road. Some additional erosion of the bank just upstream of the riprap near the Burma Road bridge is likely. The advantage of the no-action alternative is that no financial costs are incurred.

2. Bank Hardening. The left bank of Sub-Reach 1 could be hardened by continuing the riprap between the two existing rock revetments. The advantage of such an action would be the elimination of any further erosion. The disadvantage is that riprap is generally not considered to be an enhancement to in-stream habitat. In addition, the bank length is well over 800 feet, so stream mitigation would be required. Installing riprap for that length of reach would be costly, as well. Using the costs incurred from the recently-installed riprap just upstream of the Pennington Bridge of approximately $175 per linear foot, the hardening of the left bank of Sub-Reach 2 could be as much as $140,000. That cost does not consider the cost of in-stream channel mitigation elsewhere in the watershed or the purchase of mitigation credits.

3. "Soft" Bank Protection. Portions of the left bank in Sub-Reach 1 might benefit from the installation of brush bundles, live willow wattles, or other soft protection actions. The advantage of this approach is that it can be as effective as rock revetments, but is aesthetically less intrusive and can provide in-stream habitat enhancements such as stream shading. However, this approach might incur a stream mitigation requirement, which could add considerable cost to the project.

4. Vegetated Soil Lifts. The construction of soil lifts along the left bank, which would be contained by staking and coir fabric, and coinciding placement of seed and transplants within the lifts, would be a reasonable approach. Such structures are resistant to shear stress and do not result in adverse impacts to instream or riparian habitat.

5. Enhancement of Floodplain. Transplanting live willow or other shade-producing shrubs and trees would create shade and some additional stability to the remaining untreated left bank. Investigators are not of the opinion that any adverse impacts would result from adding vegetation to the floodplain on the left bank. A planting program would not incur stream mitigation requirements.

Sub-Reach 2

Sub-Reach 2 begins at the existing riprap located immediately upstream and northwest of the Burma Road Bridge opening; the reach ends at the downstream extent of the riprap at the Pennington Bridge Fishing Access Site (FAS) (Exhibit F).

Existing Conditions

The river channel in this sub-reach is on a meander with an unnaturally small radius of curvature due to the confined left bank along the existing riprap, which extends for 350 feet and ends at the Burma Bridge opening. The riprap located within this sub-reach appears to be intact and in good condition (Photo inset A and B, Exhibit F). The Burma Bridge is located at the downstream end of the meander on the left bank. The abrupt change in direction of flow along the riprap has resulted in a deep, fast-moving flow regime; the thalweg is located near the rip-rapped left bank (Photo inset C, Exhibit F). At the time of the field inspection, water was moving beneath the bridge through an anabranch that supplies irrigation flow to a diversion about 1,400 feet downstream. Historical and recent aerial photographs show that water does not perennially flow in that channel. Anecdotal evidence indicates that the water-right owner regularly excavates accumulated sediment from beneath and immediately downstream of the Burma Bridge to assure flow during the irrigation season. Investigators noted a large submerged sand bar downstream of the bridge on the left side of the anabranching channel.

The riprap downstream of the bridge has also created an area of erosion in a backwater eddy, and that area is part of the Montana Fish, Wildlife and Parks (FWP) Pennington Bridge FAS, and is discussed in further detail as part of Sub-Reach 3.

The right bank of Sub-Reach 2 is fairly typical of a point bar, although the channelization has affected the geometry to some degree. The bridge and road present an obstruction to the natural processes, resulting in the truncation of the point bar.

Investigators obtained a near-bank flow velocity of 3.0 fps at the left bank near the tail of the riprap downstream of the Burma Bridge.

Proposed Alternatives

The objectives of treating the channel and/or banks within Sub-Reach 2 include the improvement of sustainable water access for a downstream irrigation diversion and the reduction of erosion at the tail end of the riprap downstream of the Burma bridge, the latter of which impacts the Pennington FAS and sub-reach 3.

1. No Action. The no-action alternative would result in continued erosion downstream of the riprap. The water-right owner would also be required to regularly excavate sediment from beneath and downstream of the Burma Bridge downstream opening. Taking no action would not require any financial outlay for the County or the RRGL Program.

2. Establish Grade Control. One potential remedy for the loss of flow down the anabranch under the Burma Bridge involves the establishment of a rock grade control near the bridge at an elevation such that water would flow at low discharge regimes. Such an approach would not trigger stream mitigation actions and would likely be relatively inexpensive. The installation of rock across about 100 feet just downstream of the bridge in the anabranching channel would likely cost less than $25,000. The immediate problem with applying this alternative is that the nature of the sediment deposition is not well known at this time. Additional hydrological and sediment-transport studies would be required to determine if such an approach would be effective, which would raise the cost of the treatment.

3. Rock/Log Vane Installation. The geometry of the main channel of the Big Hole within Sub-Reach 2 is such that a rock or log vane installed at the downstream end of the existing riprap would meet the stated objectives. A vane would significantly reduce the near-bank shear stress both upstream and downstream of the downstream end of the existing riprap. A slightly increased water elevation on the left bank upstream of the vane would help to move water and accumulated sediment down the anabranching channel beneath the Burma Bridge at lower flows. The vane would redirect the thalweg more toward the center of the channel and thereby reduce shear stress on the left bank in Sub-Reach 3.

Note that other in-stream applications might achieve an effect similar to that of a vain. For example, a series of driven posts configured to catch brush can slow the water velocity and result in the deposition of sediment that achieves the desired result. However, investigators are unable to find an example of that kind of treatment on a river of the same bankfull-discharge magnitude as the Big Hole.

Sub-Reach 3

Sub-Reach 3 extends from the tail of riprap at the Montana Fish, Wildlife and Parks (FWP) Pennington Bridge FAS to the head of meander downstream of the FAS (Exhibit G).

Existing Conditions

Sub-Reach 3 encompasses all of the Pennington Bridge FAS. The left bank just below the riprap is actively eroding (see Photos A, B, and C of Exhibit G). The bank consists of a 16-inch-thick layer of topsoil underlain by about 10 inches of coarse sand, gravel and cobbles. Beneath the coarse material is an unknown thickness of silty sand with scattered gravel.

The floodplain on the left bank within the FAS appears to consist of primarily non-native grasses. The area is used for parking and as a boat launch for recreational floaters. Both of those elements contribute to the erosion of the bank. The thin, shallow rooting depths do not provide any resistance to undue erosion. The continued foot and boat trailer traffic also degrades the bank, leaving it more susceptible to erosion. Downstream of the FAS, the left bank also shows signs of erosion, but to a much lesser degree due to lower near-bank shear stresses. That part of the sub-reach also appears to be benefitting from a more natural plant community that includes cottonwood, alder and riparian scrub-shrub vegetation.

The top of the bank at the FAS appears to coincide with bankfull flow. The water velocity at the FAS was 3.9 fps at 4.5 feet from the bank, and 3.5 fps at 6.5 feet from the bank, which implies that the near-bank shear stress is higher than the overall shear stress across the channel. A near-bank shear stress model (RIVERMorph, 2012) estimates that the shear stress at that bank is on the order of 0.47 psf, with the ability to initiate motion on particles 3.4 inches in diameter and a potential for eroding more than 375 cubic yards annually (Appendix A). Over the length of the FAS, or about 380 feet, that translates to approximately one-third foot of bank loss annually. That erosion rate does not take into account the effect of the riprap at the upstream end of the sub-reach, which is clearly exacerbating the erosion problem. The left bank at the FAS has receded at least 80 feet since 1995 and close to 35 feet since 2006, which exceeds the predicted erosion rate by an order of magnitude. In spite of the obvious bank loss, the stream bank at the FAS may have some capacity for resisting additional erosion, provided by the more-cohesive silty sand stratum underlying the gravel interval. The right bank is a point bar, consisting of primarily sand and gravel. However, due to the presence of the bridge and riprap, the bar is somewhat truncated.

Proposed Alternatives

The objectives of any action within Sub-Reach 3 include the reduction or cessation of erosion on the left bank and improved access to recreational opportunities from the Pennington FAS. The estimated natural erosion rate of one-third foot per year is being exacerbated by the increased shear stress at the lower end of the riprap in Sub-Reach 2, so some level of treatment in that reach would benefit Sub-Reach 3. Part of the treatment would need to include a strategy to reinforce the bank while still allowing an appropriate location for a boat launch that would not interfere with the bank treatment. The right bank in this reach does not appear to be unstable and requires no action.

1. No Action. The no-action alternative will likely result in the continued erosion of the bank at the Pennington FAS. Note that one prospective action in Sub-Reach 2 (log/rock vane) would likely reduce the shear stress at the FAS. The no-action alternative does not require any financial commitment from the County or the RRGL Program.

2. Bank Hardening. The left bank of Sub-Reach 3 could be hardened to continue the riprap from the end of the riprap in Sub-Reach 2 downstream to the head of the next downstream meander. The advantage of such an action would be the elimination of any further erosion. The disadvantage is that riprap is generally not considered to be an enhancement to in-stream habitat. The bank length is about 560 feet, so stream mitigation would be required. Installing riprap for that length of reach would be costly, as well. Using the costs incurred from the recently-installed riprap just upstream of the Pennington Bridge of approximately $275 per linear foot, the hardening of the left bank of Sub-Reach 2 would likely require over $150,000 for design and construction. That cost does not consider the requirement of in-stream channel mitigation elsewhere in the watershed or the purchase of mitigation credits. Also, some alteration in the typical riprap design will be required to accommodate access for rafts and boats.

3. “Soft” Bank Protection. Portions of the left bank in Sub-Reach 1 might benefit from the installation of brush bundles, live willow wattles, or other soft protection actions. The advantage of this approach is that it can be as effective as rock revetments, but is aesthetically less intrusive and can provide in-stream habitat enhancements. The presence of a somewhat less erodible soil stratum underlying the gravel, the slope can be reduced to allow for better establishment of vegetation and an improved prospect for longer-term success. However, several problematic elements to the installation of brush bundles or live willow wattles present a challenge. The presence of human activities at the FAS that might interfere with the long-term success of the treatment. Also, as with alternative 2, some accommodation would be required for launching boats and rafts for recreational purposes.

4. Vegetated Soil Lifts. The construction of soil lifts along the left bank, which would be contained by staking and coir fabric, and coinciding placement of seed and transplants within the lifts, would be a reasonable approach. Such structures are resistant to shear stress and do not result in adverse impacts to instream or riparian habitat. They would have excellent prospects for long-term success because the stratigraphy of the soil is quite favorable for this approach, in spite of a fairly high-energy flow regime.

FAS Relocation. As a means of reducing costs and enhance the potential for the success of any treatment on the left bank of Sub-Reach 3, the County and RRGL Program might consider working with Montana FWP to relocate the FAS. Below is a list of three identified relocation alternatives. A FWP representative has expressed interest in moving the site not only because of the eroding bank, but because the water velocity is high enough to make boat and raft access difficult.

- **Location 1 -** The left bank upstream of the Pennington Bridge. Moving the FAS to the proposed location would put it on the inside of a meander where near-bank shear stresses are lower and the point bar deposits have a lower-grade slope to more easily facilitate launching recreational watercraft. Relocating the FAS to this location would require a land survey, wetland delineation, and plan to insure that any sanitary facilities were properly designed and constructed above the 100-year flood level. Disadvantages to this location include proximity to a residential property (across the river). The landowner of the parcel is the same as the homeowner across the river and has expressed disfavor of this alternative and unlikely willingness to enter into an agreement with the Montana FWP to move the FAS to this location.
- **Location 2** – The left bank upstream of the riprap located at the upstream portion of Sub-Reach 2. The effort involved in relocating the FAS would require a land survey, a wetland delineation, and a plan to insure that any sanitary facilities were properly designed and constructed above the 100-year flood level. Vegetation cover observed in the field include those indicative of wetland areas. As a result, investigators suspect this site is not favorable due to the potential for impacting wetlands when other project alternatives that would likely avoid wetlands are feasible (see Location 3).
- **Location 3** – The left bank downstream of the existing FAS, within the parcel directly south of the existing FAS. The left bank at this location is relatively stable because it is located at the inside of the beginning of a meander where shear stress and stream currents are reduced. Relocating the boat ramp and FAS to this location would include retaining an access corridor through the eastern and southern portions of the existing FAS and retention of the existing sanitary facility. Relocating the boat ramp and FAS to this location would require a land survey and wetland delineation. The landowner at this location has indicated that he would be willing to entertain the prospect, with the understanding that the project includes the right bank in Sub-Reach 4, which is also his property.

Relocating or redesigning stream access within the FAS will require close coordination between local landowners, Madison County, and the Montana Department of Fish, Wildlife and Parks. One landowner has expressed a willingness to engage in planning efforts with the County and FWP, and the FWP has expressed a desire to address the problems with other stakeholders.

Sub-Reach 4

Sub-Reach 4 begins at the head of meander downstream of Sub-Reach 3 and continues to the upstream limit of newly-placed riprap located on the right bank upstream of Pennington Bridge (Exhibit H).

Existing Conditions

Sub-Reach 4 constitutes a migrating meander. Since 1995, the right bank of the meander has migrated south by 150 feet, with the consequent expansion of the point bar on the left bank. This measured erosion rate averages out to over seven feet per year since 1995, although an argument can be made that the long-duration flood event of 2011 yielded more erosion than might ordinarily be seen (Boyd 2015).

The right bank is about 1.8 feet higher in Sub-Reach 4 than the left bank in Sub-Reach 3, so the top of bank is above bankfull. The bank material consists of 1.2 feet of topsoil underlain by gravelly coarse sand with cobbles. The bank is vertical or undercut from the top of bank down about three feet (see photos A and B in Exhibit H).

Four feet from the right bank, the water velocity at a depth of 1.2 feet was 2.9 fps at the time of the site visit. An estimated 2,076 cubic yards of soil is removed from the right bank of the sub-reach annually based on analysis of the near-bank stress conditions. Data for that evaluation included field measurements and a previously-measured river cross section completed for the design phase of the riprap. Over 480 feet of the bank length and assuming a channel depth of five feet, the potential erosion rate is 0.75 feet per year (Appendix A). Based on the observed past erosion rates, however, the right bank in Sub-Reach 4 is clearly more vulnerable to erosion than reflected in that estimate.

The left bank in Sub-Reach 4, as noted above, is a point bar on the inside of a meander. The bar is typical of the Big Hole River, consisting of a range of silt- to cobble-sized deposits hosting little vegetation. The interior of the meander has a relatively small crescent of forested riparian area, with upland plant species occurring between that crescent and the road.

Proposed Alternatives

1. No Action. Without some level of treatment, the right bank will likely continue to erode at a minimum rate of 0.75 feet per year. Higher erosion rates will result from unusually high or long-duration periods of high discharge. The left bank is unlikely to be affected, and will continue to aggrade as a point bar.

2. Bank Hardening. The left bank of Sub-Reach 4 could be hardened to continue the riprap upstream from the recently-completed structure in Sub-Reach. The advantage of such an action would be the elimination of any further erosion. The disadvantage is that riprap is generally not considered to be an enhancement to in-stream habitat. The bank length is about 550 feet, so compensatory stream mitigation would likely be required. Installing riprap for that length of reach would be costly, as well. Using the costs incurred from the recently-installed riprap just upstream of the Pennington Bridge of approximately $275 per linear foot, the hardening of the left bank of Sub-Reach 2 would likely require over $150,000 for design and construction. That cost does not consider the requirement of in-stream channel mitigation elsewhere in the watershed or the purchase of mitigation credits.

3. “Soft” Bank Protection. Portions of the left bank in Sub-Reach 4 would benefit from the installation of brush bundles, live willow wattles, or other soft protection actions. The advantage of this approach is that it can be as effective as rock revetments, but is aesthetically less intrusive and can provide in-stream habitat enhancements such as shading and protective cover. However, several problematic elements to the installation of brush bundles or live willow wattles present a challenge. The presence of cattle grazing might interfere with the long-term success of the treatment. To ensure success of the project, exclusionary riparian fencing to prevent browse and trampling is recommended.

4. Vegetated Soil Lifts. The construction of soil lifts along the left bank, which would be contained by staking and coir fabric, and coinciding placement of seed and transplants within the lifts, would be a reasonable approach. Such structures are resistant to shear stress and do not result in adverse impacts to instream or riparian habitat. While the soils in Sub-Reach 4 are not as favorable as those in Sub-Reach 3, the additional bank height would allow for the importation of local soils to facilitate construction.

Sub-Reach 5

Sub-Reach 4 begins at the recently-placed riprap upstream of the Pennington Bridge and extends to the opening of the Pennington Bridge (Exhibit I). The riprap current located along the right bank at this sub-reach was placed in the Fall of 2015. Prior to placement, existing riprap had been flanked and significant bank erosion and sloughing had occurred as the result of high shear stresses associated with the shifted alignment of the channel. Total later bank loss was estimated at up to 75 feet and the stream alignment is no longer normal (perpendicular) to the bridge. The riprap design was determined to be necessary to ensure further bank loss would not compromise the foundation of the bridge and to prevent further property loss. During the April 2016 field visit the riprap appears to be intact and stable (see Photos A and B in Exhibit I). The majority remnant failed riprap material located within the channel (Figure 3) was removed at the time of the bank stabilization work in the Fall of 2015.

Figure 3. Right bank of Sub-Reach 5 in September 2015, prior to bank stabilization (riprap) placement. View from upstream rail of Pennington Bridge.

The left bank in Sub-Reach 5, similar to Sub-Reach 4, is a point bar on the inside of an expanding meander. The bar is typical of the Big Hole River, consisting of a range of silt- to cobble-sized deposits hosting little-to-no vegetation. The interior of the meander has a relatively small crescent of forested riparian area, with upland plant species occurring between that crescent and the Burma Road.

Proposed Alternatives

Investigators will not propose any additional work on Sub-Reach 5. The erosion on the right bank of that reach has been addressed with the riprap (Figure 4).

Figure 4. Right bank of Sub-Reach 5 in April 2016, following placement of bank stabilization (riprap). View is from upstream rail of Pennington Bridge.

ADDITIONAL PROJECT ALTERNATIVES

As previously noted, investigators observed no locations upstream of Sub-Reach 1 where human intervention would accomplish the stated goals of maintaining, enhancing or restoring natural resources within the Big Hole River corridor. However, some additional characteristics of the river, its behavior and its geometry present a few options for projects that might help to accomplish the objectives.

1. Restore Historic Flow Patterns. A review of historical aerial photographs shows that the main channel of the Big Hole formerly ran more toward the center of the meander zone and bifurcated approximately 1,000 feet southwest of Sub-Reach 4. The channels then ran toward the bridges, with the left-hand channel flowing in the opposite direction than it currently does at Sub-Reach 3. Restoring that configuration would assure water to both of the irrigation diversions downstream of the bridges. However, the diversion of channels would have to extend some 2,800 feet up the valley to intercept the existing channel. The reconfigured channel would have to be stabilized in some way to prevent future avulsions, and considerable excavation would be required to recreate the channel and the bifurcation. The authors do not see such a plan as feasible from the perspectives of cost, permitting or long-term significant contributions toward reducing sedimentation and temperature issues.

2. Restore the Channel Between Sub-Reach 1 and Sub-Reach 4. An abandoned channel between the aforementioned sub-reaches affords an opportunity address a number of the project's objectives. By constructing a grade-control point on the right bank in Sub-Reach 1 at a point about 100 feet downstream of the end of the riprap on the left bank, that channel could accommodate additional flow. While investigators did not survey the described area, visual observations clearly demonstrated that the abandoned channel lies at a lower elevation than the main channel. Without a grade control structure, the channel would likely head-cut into the main channel, risking the possibility that the entire flow would be captured. However, if properly surveyed, designed and constructed, this alternative would allow for reduced stress on all of the downstream banks, yet still keep enough water to allow continued use of the Pennington FAS. A grade control structure would have to be over 200 feet long, but that distance would not require any stream mitigation. However, the authors contend that more than just grade control might be required. The reduced flow in Sub-Reach 2 might well exacerbate the issue of maintaining sufficient flow downstream of the Burma Bridge for the irrigation diversion. In short, the nature of the Big Hole River in this area is such that numerous hardened structures would be required to keep the channel from further avulsion, aggradation or degradation. The cost of survey, modeling, design and permitting to complete such a project would likely be prohibitive.

CONCLUSIONS AND RECOMMENDATIONS

Investigators confirmed that observed erosion, bank instability, and aggradation along the river at the study location constitutes an existing threat to renewable resources of the area for several reasons, including the following:

- Bank erosion is delivering excessive sediments and nutrients to the river, thereby impacting water quality.
- Bank erosion continues to leave large areas of exposed soil and sediment with little vegetation to increase bank resilience to erosion. This degrades fish habitat due to lack of shade and protective cover. Reduced shading and shallow water depths contribute to increased water temperatures above natural background conditions (MDEQ 2009).
- Accelerated erosion rates have resulted in channel widening and filling of pools within the channel which further impacts habitat and water quality. The shallower depths and wider channel within sub-sections of the river can be attributed to increased water temperatures (MDEQ 2009).
- Excessive bank loss and deposition of material has resulted in impacts to irrigation flows and infrastructure.

Except for Sub-Reach 5, proceeding with the no-action alternatives within the evaluated sub-reaches will result in continued erosion along affected banks. Specifically, no action will result in continued adverse impacts to renewable resources, including the following specifics listed by sub-reach:

- Sub-reach 1 – Continued erosion of left bank downstream of existing riprap. See Exhibit E for location of existing riprap at sub-reach 1. This will result in continued widening of the channel which is associated with elevated water temperatures and reduced habitat quality.
- Sub-reach 2 – Continued erosion of left bank downstream of riprap located downstream of Burma Bridge. See Exhibit F for location of existing riprap at Sub-Reach 2. This will result in continued widening of the channel within Sub-reach 3, which is associated with elevated water temperatures and reduced habitat quality. No action along this reach will also result in continued aggradation beneath and downstream of the Burma Street Bridge, which interrupts flows to existing irrigation diversions.
- Sub-reach 3 – Continued erosion of the left bank at the FAS and boat ramp. See Exhibit G for location of the existing FAS. Erosion due to increased shear stress from the upstream riprap combined with ongoing recreation use will inhibit the establishment of vegetation. That erosion and lack of vegetation will exacerbate the channel widening, which is associated with elevated water temperatures and reduced habitat quality.
- Sub-reach 4 – Continued erosion of the right bank. See Exhibit H for photos of bank. This will result in continued widening of the channel which is associated with elevated water temperatures and reduced habitat quality. Grazing and water access by cattle will also inhibit vegetation regeneration along the banks.

We have the following general recommendations:

- Sub-Reach 1—No action at present. The left bank in this sub-reach is experiencing some erosion, but the magnitude is significantly lower than subsequent downstream reaches. A subsequent treatment may be justifiable in the future.

- Sub-Reach 2—Add a vane at the end of the riprap downstream of the Burma Bridge. That action would improve the water supply to the water-right owner and reduce near-bank stress within Sub-Reach 3.

- Sub-Reach 3—Treat 190 feet of the left bank with a vegetated soil lift through the FAS area and restore a corridor of riparian vegetation. The substrate is conducive to such a treatment and the action would significantly reduce bank loss. We also recommend that the FAS be either relocated or redesigned to place the boat launch area in a portion of the reach with lower shear stress, however that element will likely have to constitute a subsequent phase of these recommendations.

- Sub-Reach 4—Treat 500 feet of the right bank with a vegetated soil lift, restore the riparian vegetation corridor, and erect fencing to exclude livestock from the banks. Doing so would greatly reduce bank loss and sedimentation.

While we have recommended the relocation or redesign of the FAS in Sub-Reach 3, we realize that such an action cannot be supported within the scope of the upcoming grant application for which this report has been generated. The coordination and facilitation of such discussions exceeds the time available for the inclusion of any resulting action plan within this document or the 2016 RRGL Application. Nonetheless, we strongly encourage the local stakeholders and watershed organizations to collaborate so a solution to the problems at the Pennington FAS can be addressed. Our investigation revealed a desire and willingness on the part of stakeholders to explore solutions, and we urge those organizations, agencies and individuals to pursue that path.

Considerations for Cost and Permitting Feasibility

Implementing a passive restoration approach such as riparian fencing would have minimal associated costs and no riparian permitting requirements. Costs would be limited to coordination with the land owners, materials, and installation. Work along the banks of the river, such as bank stabilization work would involve permitting and possibly environmental review. The projects would have to be designed in such a manner as to avoid incurring compensatory stream mitigation debits.

Relocation of the FAS will require negotiation of agreements with the participating landowner, Montana FWP, and Madison County, which, as noted above, is beyond the time frame and scope of this investigation and the associated RRGL Application. Surveying for road relocation, removal and placement of fencing, and wetland delineation and avoidance should all be accounted for in planning involved with this subsequent project opportunity.

Consultations

The following stakeholder groups were consulted during the evaluation of project alternatives:

- Montana Fish, Wildlife, and Parks (FWP) staff - Ray Heagney, FWP Region 3, Regional FAS Manager
- Landowners and/or landowner representatives of properties adjacent to the study area
- Water Right holders downstream of the study area
- Big Hole River Foundation - http://www.bhrf.org/
- Big Hole Watershed Committee – Lower Big Hole River Landscape Scale Restoration https://bhwc.org/projects/hosted-projects/

REFERENCES

Boyd, 2015: unpublished correspondence to Andrew Suenram (local landowner).

Great West Engineering, Inc., 2015: unpublished revetment design and permitting for the Pennington Bridge, Madison County, Montana.

Great West Engineering (GWE) 2016, Madison County Bridge Evaluation: unpublished technical report.

Montana Department of Environmental Quality (MDEQ), 2009, Middle and Lower Big Hole Planning Area TMDLs and Water Quality Improvement Plan: MDEQ publication M03-TMDL-02A, 755p.

Montana Department of Environmental Quality (MDEQ), 2014, Final Water Quality Integrated Report: http://deq.mt.gov/Water/WQPB/cwaic/reports

Montana State Library, 2016, Montana Cadastral Mapping Project: http://svc.mt.gov/msl/mtcadastral/

RIVERMorph, 2012, RIVERMorph stream restoration software: v. 5.1.8, Professional Edition, RIVERMorph, LLC.

EXHIBITS

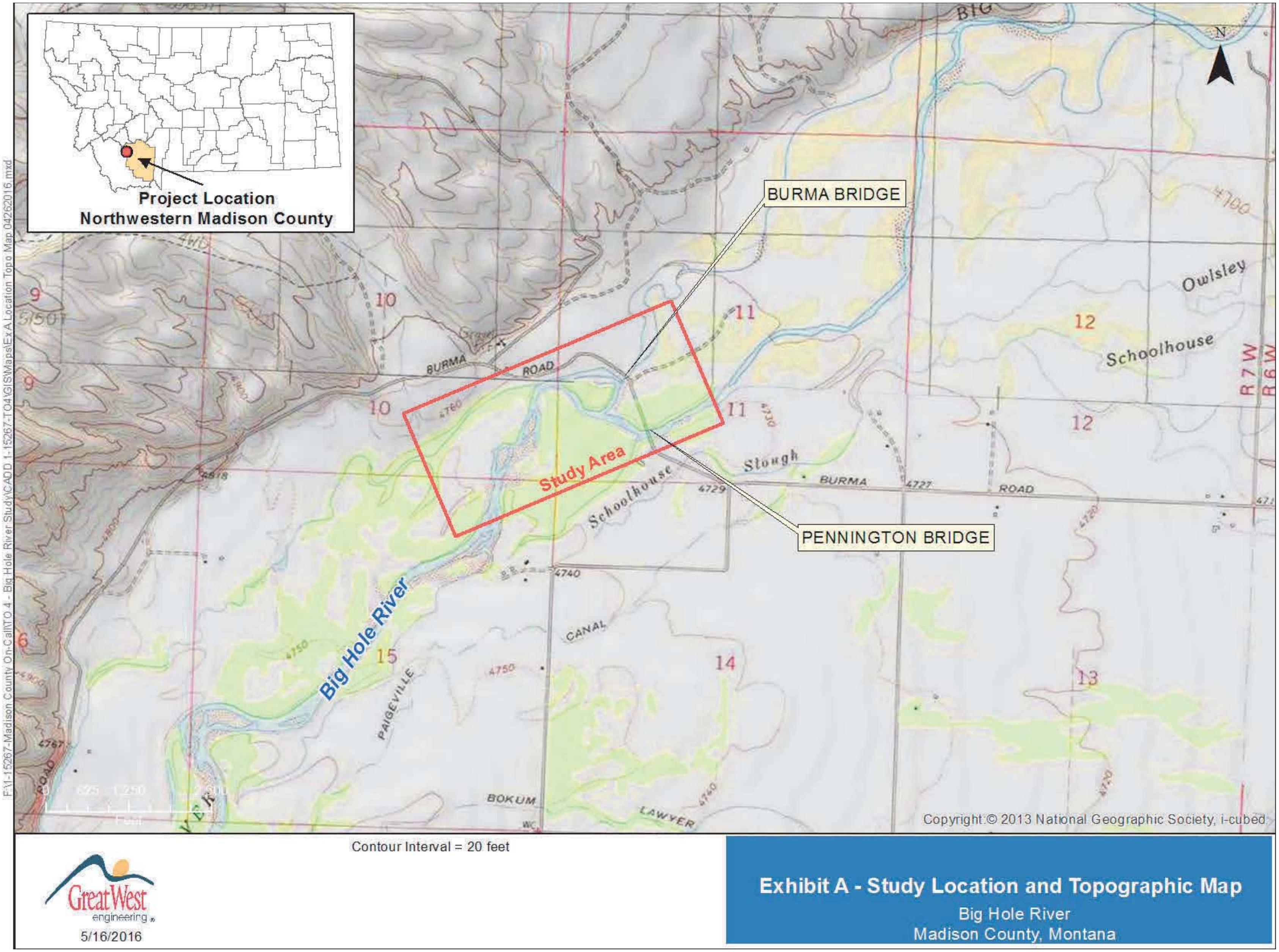


Exhibit A - Study Location and Topographic Map

Big Hole River

Madison County, Montana

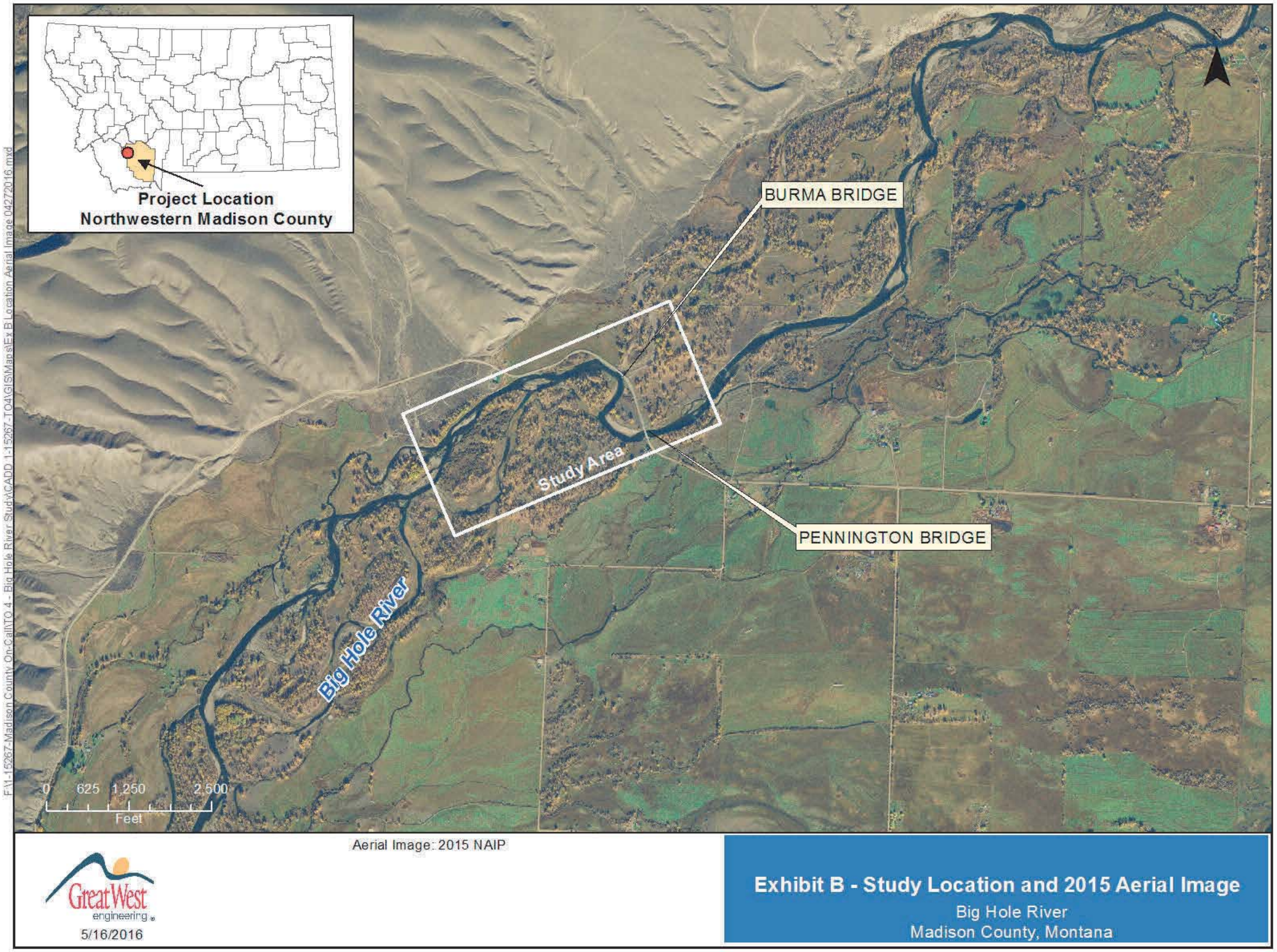
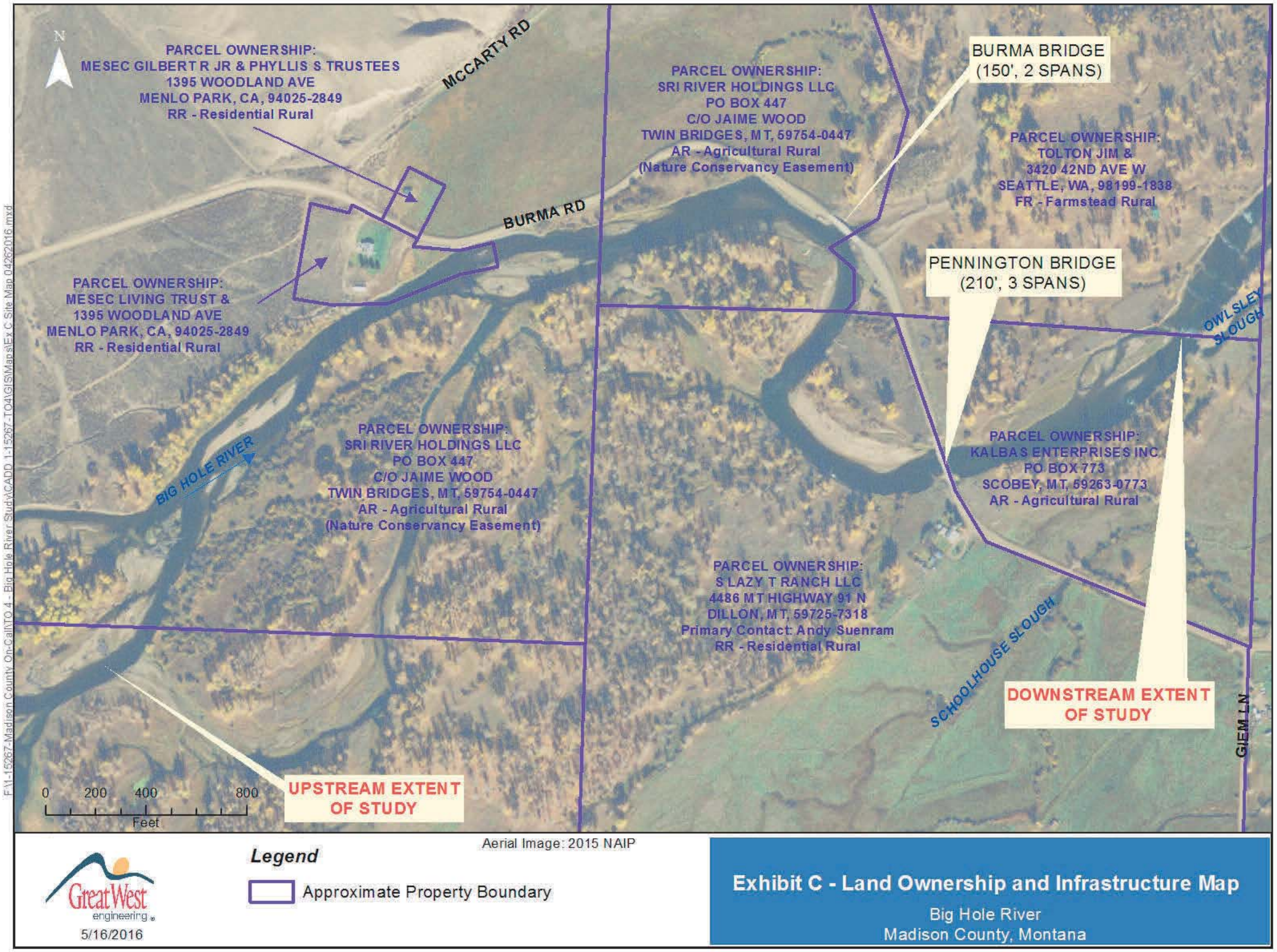
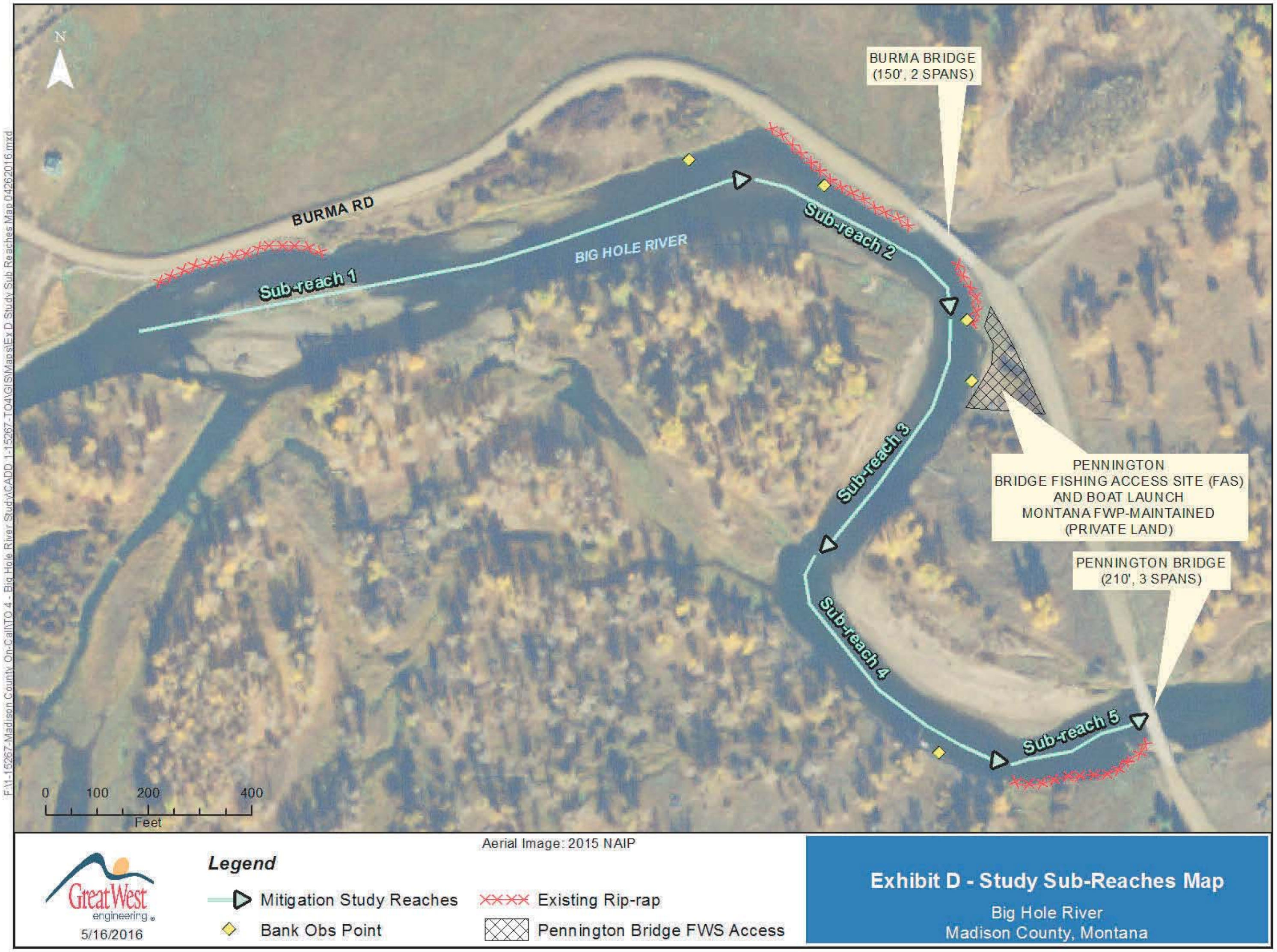


Exhibit B - Study Location and 2015 Aerial Image
Big Hole River
Madison County, Montana



PARCEL OWNERSHIP:
MESEC GILBERT R JR & PHYLLIS S TRUSTEES
1395 WOODLAND AVE
MENLO PARK, CA, 94025-2849
RR - Residential Rural
MCCARTY RD
BURMA RD
PARCEL OWNERSHIP:
MESEC LIVING TRUST &
1395 WOODLAND AVE
MENLO PARK, CA, 94025-2849
RR - Residential Rural
BIG HOLE RIVER
PARCEL OWNERSHIP:
SRI RIVER HOLDINGS LLC
PO BOX 447
C/O JAIME WOOD
TWIN BRIDGES, MT, 59754-0447
AR - Agricultural Rural
(Nature Conservancy Easement)
PARCEL OWNERSHIP:
SRI RIVER HOLDINGS LLC
PO BOX 447
C/O JAIME WOOD
TWIN BRIDGES, MT, 59754-0447
AR - Agricultural Rural
(Nature Conservancy Easement)
BURMA BRIDGE
(150', 2 SPANS)
PARCEL OWNERSHIP:
TOLTON JIM &
3420 42ND AVE W
SEATTLE, WA, 98199-1838
FR - Farmstead Rural
PENNINGTON BRIDGE
(210', 3 SPANS)
OWLSLEY SLOUGH
PARCEL OWNERSHIP:
KALBAS ENTERPRISES INC
PO BOX 773
SCOBEY, MT, 59263-0773
AR - Agricultural Rural
PARCEL OWNERSHIP:
S LAZY T RANCH LLC
4486 MT HIGHWAY 91 N
DILLON, MT, 59725-7318
Primary Contact: Andy Suenram
RR - Residential Rural
SCHOOLHOUSE SLOUGH
DOWNSTREAM EXTENT OF STUDY
GIEM LN
UPSTREAM EXTENT OF STUDY
0 200 400 800
Feet
Aerial Image: 2015 NAIP
Legend
Approximate Property Boundary
GreatWest engineering
5/16/2016
Exhibit C - Land Ownership and Infrastructure Map
Big Hole River
Madison County, Montana


N
BURMA RD
BURMA BRIDGE
(150', 2 SPANS)
BIG HOLE RIVER
Sub-reach 1
Sub-reach 2
Sub-reach 3
Sub-reach 4
Sub-reach 5
PENNINGTON
BRIDGE FISHING ACCESS SITE (FAS)
AND BOAT LAUNCH
MONTANA FWP-MAINTAINED
(PRIVATE LAND)
PENNINGTON BRIDGE
(210', 3 SPANS)
0 100 200 400
Feet
Aerial Image: 2015 NAIP
Legend
Mitigation Study Reaches
Bank Obs Point
Existing Rip-rap
Pennington Bridge FWS Access
GreatWest engineering
5/16/2016
Exhibit D - Study Sub-Reaches Map
Big Hole River
Madison County, Montana

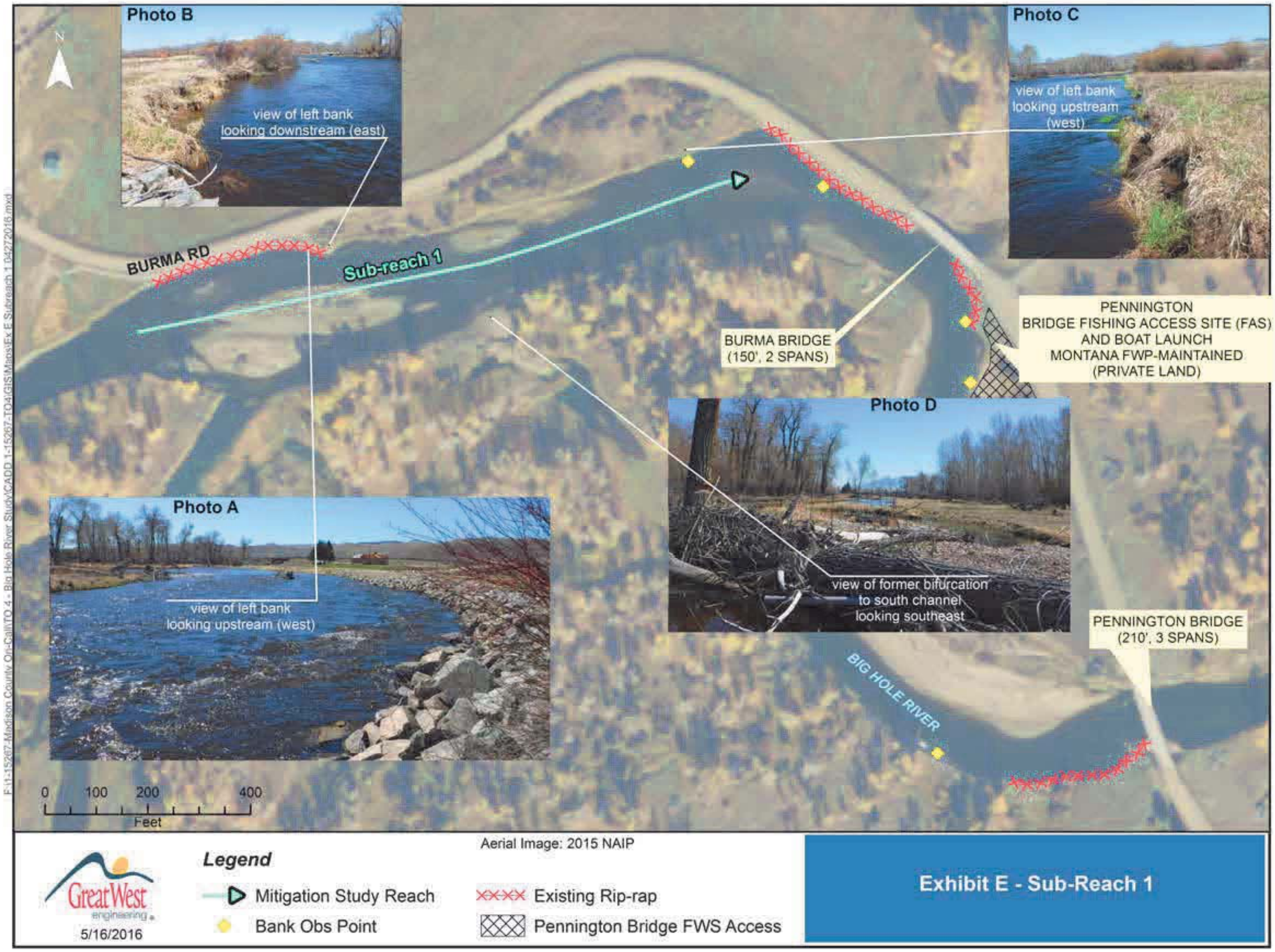


Photo B
view of left bank
looking downstream (east)
Photo C
view of left bank
looking upstream
(west)
BURMA RD
Sub-reach 1
BURMA BRIDGE
(150', 2 SPANS)
PENNINGTON
BRIDGE FISHING ACCESS SITE (FAS)
AND BOAT LAUNCH
MONTANA FWP-MAINTAINED
(PRIVATE LAND)
Photo D
view of former bifurcation
to south channel
looking southeast
Photo A
view of left bank
looking upstream (west)
PENNINGTON BRIDGE
(210', 3 SPANS)
BIG HOLE RIVER
0 100 200 400
Feet
GreatWest engineering
5/16/2016
Legend
Mitigation Study Reach
Bank Obs Point
Aerial Image: 2015 NAIP
Existing Rip-rap
Pennington Bridge FWS Access
Exhibit E - Sub-Reach 1

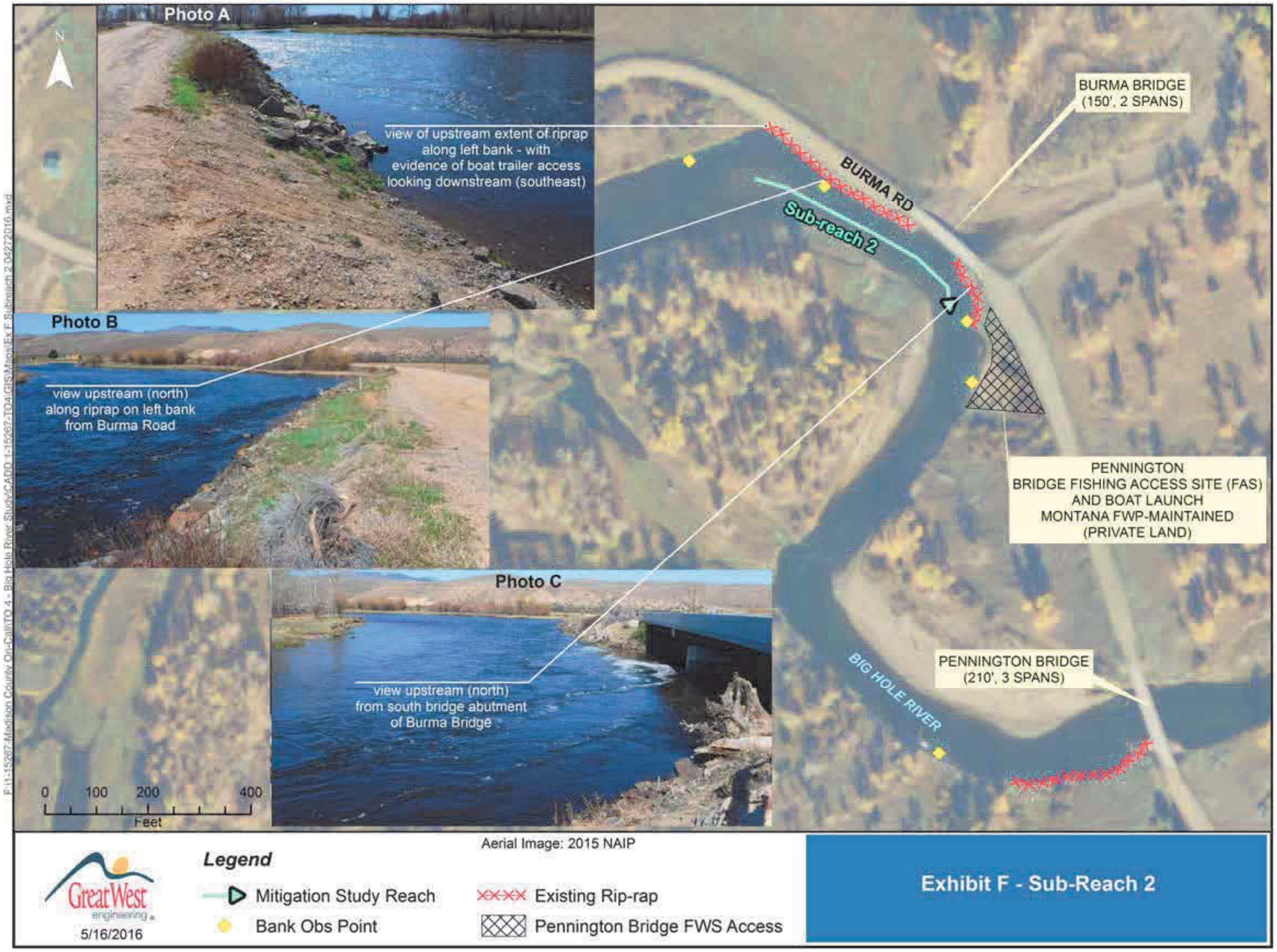


Photo A
view of upstream extent of riprap along left bank - with evidence of boat trailer access looking downstream (southeast)
Photo B
view upstream (north) along riprap on left bank from Burma Road
Photo C
view upstream (north) from south bridge abutment of Burma Bridge
BURMA BRIDGE (150', 2 SPANS)
BURMA RD
Sub-reach 2
PENNINGTON BRIDGE FISHING ACCESS SITE (FAS) AND BOAT LAUNCH MONTANA FWP-MAINTAINED (PRIVATE LAND)
PENNINGTON BRIDGE (210', 3 SPANS)
BIG HOLE RIVER
0 100 200 400
Feet
Aerial Image: 2015 NAIP
GreatWest engineering
5/16/2016
Legend
Mitigation Study Reach
Bank Obs Point
Existing Rip-rap
Pennington Bridge FWS Access
Exhibit F - Sub-Reach 2

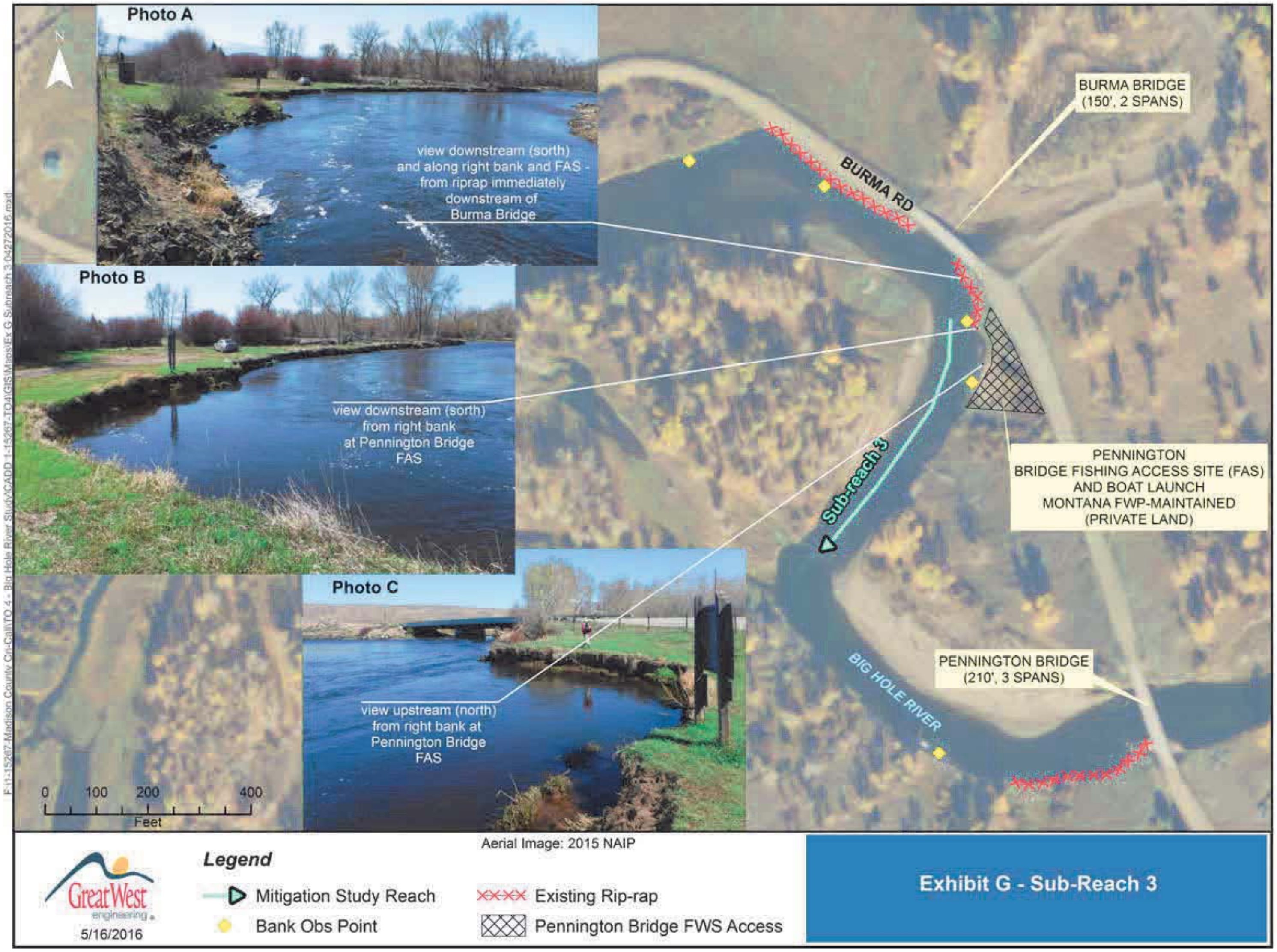


Photo A
view downstream (sorth) and along right bank and FAS - from riprap immediately downstream of Burma Bridge
Photo B
view downstream (sorth) from right bank at Pennington Bridge FAS
Photo C
view upstream (north) from right bank at Pennington Bridge FAS
BURMA BRIDGE (150', 2 SPANS)
BURMA RD
PENNINGTON BRIDGE FISHING ACCESS SITE (FAS) AND BOAT LAUNCH MONTANA FWP-MAINTAINED (PRIVATE LAND)
Sub-reach 3
PENNINGTON BRIDGE (210', 3 SPANS)
BIG HOLE RIVER
0 100 200 400
Feet
Aerial Image: 2015 NAIP
Legend
Mitigation Study Reach
Bank Obs Point
Existing Rip-rap
Pennington Bridge FWS Access
GreatWest engineering
5/16/2016
Exhibit G - Sub-Reach 3


Photo A
view downstream (east)
from right bank
(Pennington Bridge
in foreground)
Photo B
view downstream (east)
from right bank upstream of
riprap (Pennington Bridge
in foreground)
BURMA BRIDGE
(150', 2 SPANS)
BURMA RD
PENNINGTON
BRIDGE FISHING ACCESS SITE (FAS)
AND BOAT LAUNCH
MONTANA FWP-MAINTAINED
(PRIVATE LAND)
PENNINGTON BRIDGE
(210', 3 SPANS)
Sub-reach 4
BIG HOLE RIVER
0 100 200 400
Feet
Aerial Image: 2015 NAIP
Legend
Mitigation Study Reach
Bank Obs Point
Existing Rip-rap
Pennington Bridge FWS Access
GreatWest engineering
5/16/2016
Exhibit H - Sub-Reach 4

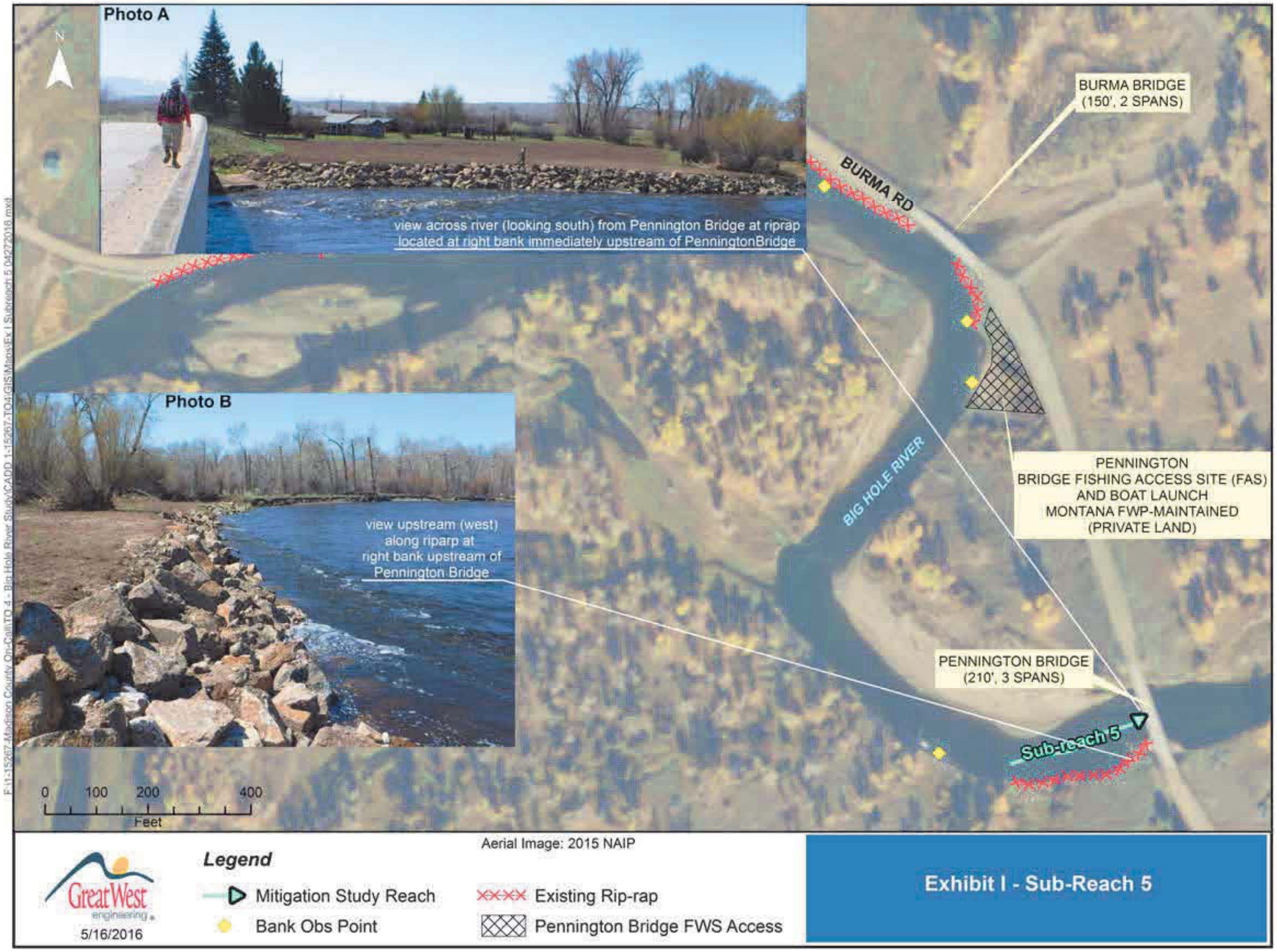


Photo A
view across river (looking south) from Pennington Bridge at riprap located at right bank immediately upstream of PenningtonBridge
Photo B
view upstream (west) along riparp at right bank upstream of Pennington Bridge
BURMA BRIDGE (150', 2 SPANS)
BURMA RD
BIG HOLE RIVER
PENNINGTON BRIDGE FISHING ACCESS SITE (FAS) AND BOAT LAUNCH MONTANA FWP-MAINTAINED (PRIVATE LAND)
PENNINGTON BRIDGE (210', 3 SPANS)
Sub-reach 5
N
0 100 200 400
Feet
Aerial Image: 2015 NAIP
Legend
Mitigation Study Reach
Bank Obs Point
Existing Rip-rap
Pennington Bridge FWS Access
GreatWest engineering
5/16/2016
Exhibit I - Sub-Reach 5

Appendix A. River Channel Analysis Documentation

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                RIVERMORPH STREAM CHANNEL CLASSIFICATION

----------------------------------------------------------------------

River Name:    Big Hole River
Reach Name:    Reach 1 <-- This is not a Reference Reach
Drainage Area: 2790 sq mi
State:         Montana
County:        Madison
Latitude:      49.4995
Longitude:     112.3942
Survey Date:   04/20/2016

----------------------------------------------------------------------

Classification Data

Valley Type:                       Type VIII(c)
Valley Slope:                         0.00265 ft/ft
Number of Channels:                    Single
Width:                                    125 ft
Mean Depth:                               2.9 ft
Flood-Prone Width:                       1000 ft
Channel Materials D50:                     40 mm
Water Surface Slope:                    0.002 ft/ft
Sinuosity:                                1.2
Discharge:                               1500 cfs
Velocity:                                   4 fps
Cross Sectional Area:                     375 sq ft
Entrenchment Ratio:                         8
Width to Depth Ratio:                    43.1
Rosgen Stream Classification:             C 4
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                    RIVERMORPH BEHI SUMMARY REPORT

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River Name: Big Hole River
Reach Name: Reach 1

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Table 1.  Bank Identification Summary

Bank      Name
 1        Pennington Bridge FAS left bank
 2        Above Riprap Right Bank



----------------------------------------------------------------------
Table 2.  Predicted Annual Bank Erosion Rates

      BEHI    BEHI      NBS
      Numeric Adjective Adjective   Length      Loss    Loss
Bank  Rating  Rating    Rating          ft cu yds/yr tons/yr

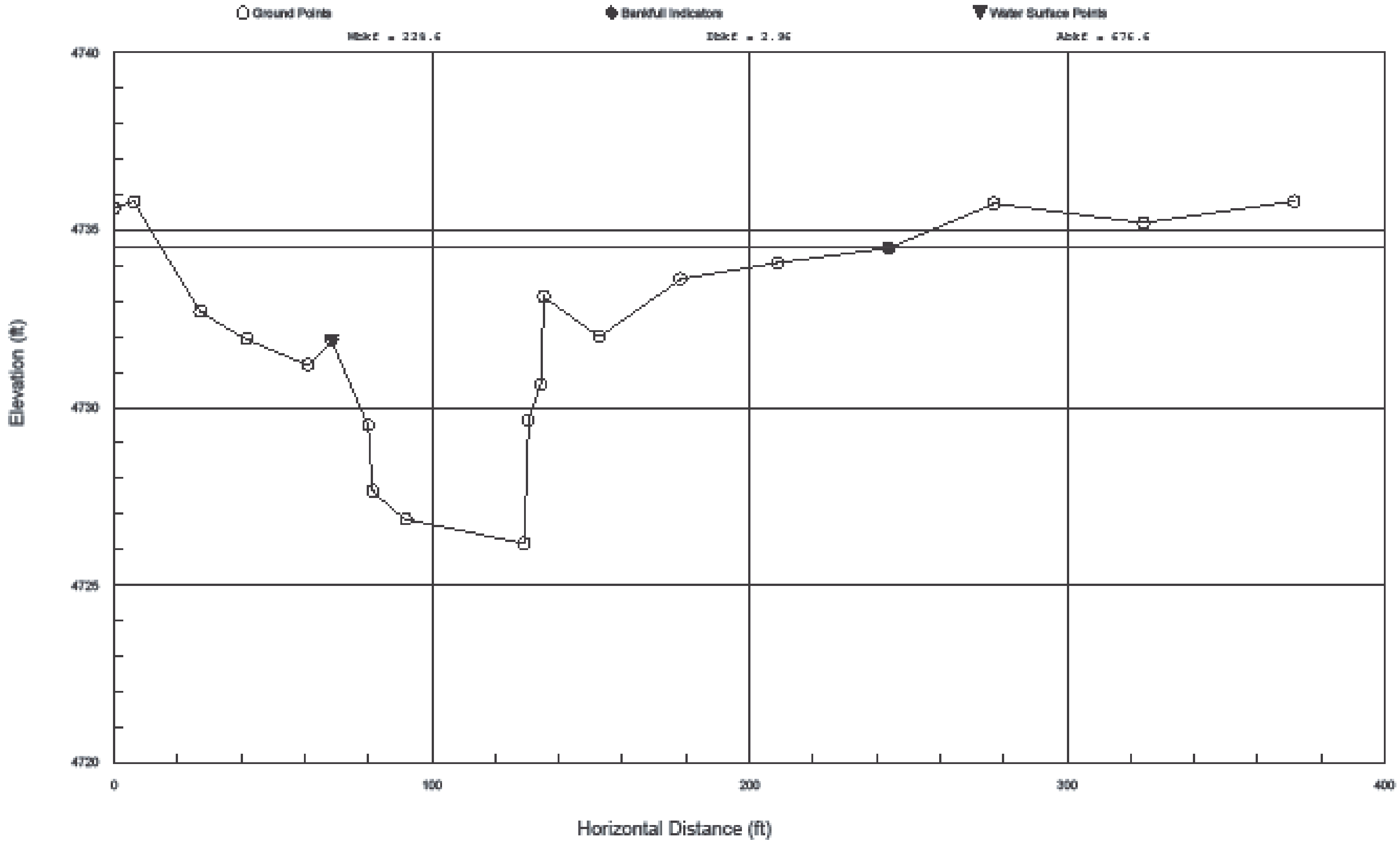
1     47.8    Extreme   Very High      380  375.8144488.5587
2     57.4    Extreme   Extreme        480 2076.53332699.4933


Totals                                 860 2452.34773188.052

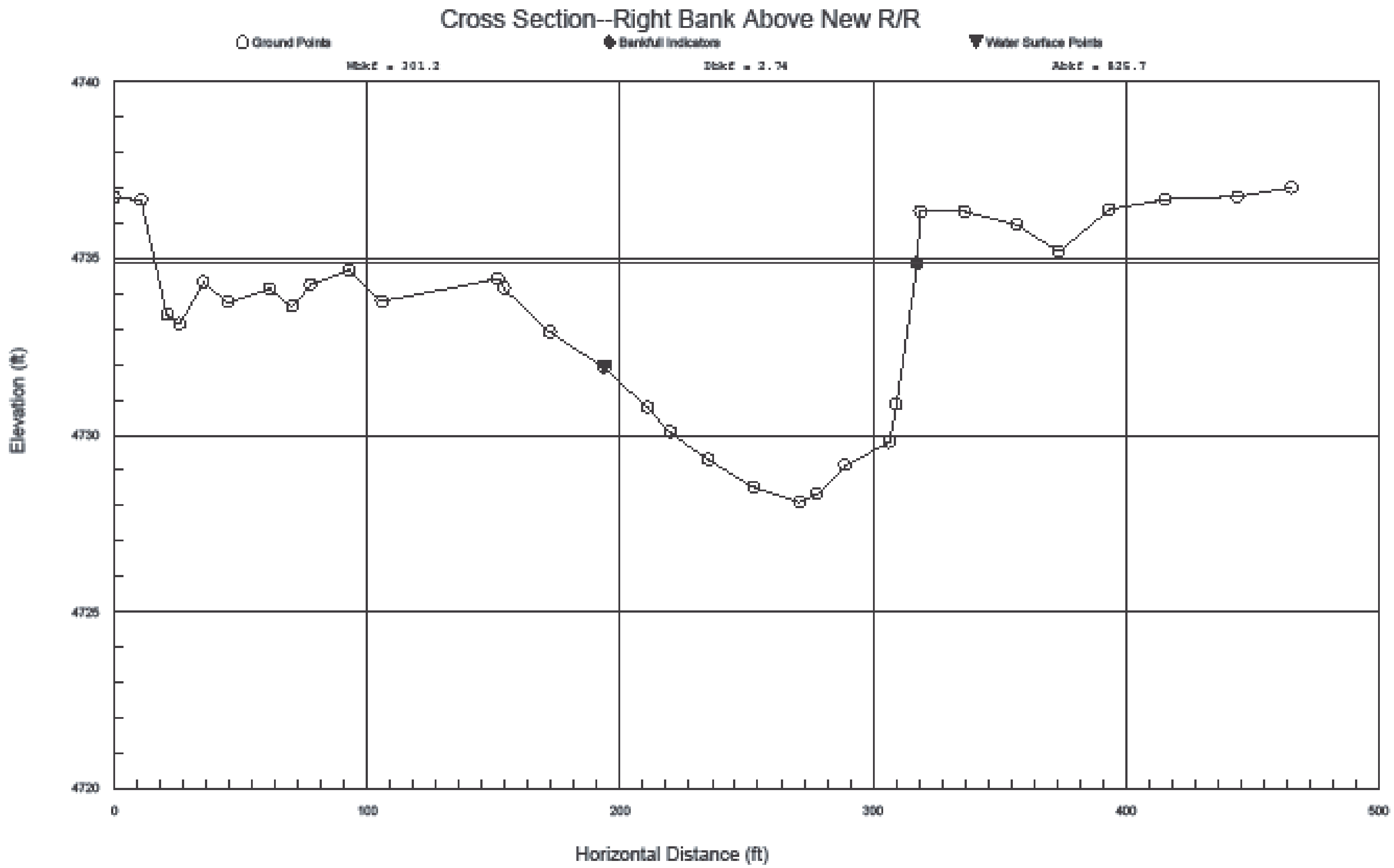

Total Reach Ln: 480     Total Loss (tons/yr) per ft of Reach: 6.6418
```

ELEV (ft)	DEPTH (ft)	AREA (sq ft)	WET PER (ft)	WIDTH (ft)	HYD RAD (ft)	MEAN D (ft)	SLOPE (ft/ft)	ROUGH [n] (ft^(1/6))	R/D84	VELOCITY (fps)	U/U*	U^2/2g (ft)	DISCHARGE (cfs)	SHEAR (psf)	POWER (lb/s)	POWER/W (lb/ft/s)	FROUDE	TRANSPORT (lb/s)	
4726.28	0.1	0.28	5.68	5.61	0.05	0.05	0.002	0	0.19	0	0	0	0	0.01	0	0	0	0	
4726.38	0.2	1.12	11.35	11.22	0.1	0.1	0.002	0.19604	0.38	0.07	0.91	0	0.08	0.01	0.01	0	0.04	0	
4726.48	0.3	2.52	17.03	16.82	0.15	0.15	0.002	0.10015	0.57	0.19	1.91	0	0.47	0.02	0.06	0	0.09	0	
4726.58	0.4	4.49	22.7	22.43	0.2	0.2	0.002	0.07665	0.76	0.3	2.61	0	1.33	0.03	0.17	0.01	0.12	0	
4726.68	0.5	7.01	28.38	28.04	0.25	0.25	0.002	0.06576	0.95	0.4	3.16	0	2.81	0.03	0.35	0.01	0.14	0	
4726.78	0.6	10.09	34.06	33.65	0.3	0.3	0.002	0.05937	1.14	0.5	3.61	0	5.06	0.04	0.63	0.02	0.16	0	
4726.88	0.7	13.72	38.45	37.97	0.36	0.36	0.002	0.05445	1.37	0.62	4.06	0.01	8.48	0.04	1.06	0.03	0.18	0	
4726.98	0.8	17.58	39.86	39.31	0.44	0.45	0.002	0.0502	1.68	0.77	4.55	0.01	13.47	0.05	1.68	0.04	0.2	0	
4727.08	0.9	21.58	41.28	40.65	0.52	0.53	0.002	0.04735	1.98	0.91	4.96	0.01	19.59	0.06	2.45	0.06	0.22	0	
4727.18	1	25.71	42.69	41.99	0.6	0.61	0.002	0.04528	2.29	1.04	5.31	0.02	26.85	0.07	3.35	0.08	0.24	0	
4727.28	1.1	29.98	44.1	43.34	0.68	0.69	0.002	0.04371	2.59	1.18	5.62	0.02	35.26	0.08	4.4	0.1	0.25	0	
4727.38	1.2	34.38	45.51	44.68	0.76	0.77	0.002	0.04246	2.9	1.3	5.89	0.03	44.83	0.09	5.59	0.13	0.26	0	
4727.48	1.3	38.92	46.92	46.02	0.83	0.85	0.002	0.04156	3.16	1.41	6.11	0.03	54.98	0.1	6.86	0.15	0.27	0	
4727.58	1.4	43.58	48.33	47.36	0.9	0.92	0.002	0.0408	3.43	1.52	6.31	0.04	66.2	0.11	8.26	0.17	0.28	0	
4727.68	1.5	48.38	49.39	48.33	0.98	1	0.002	0.04005	3.73	1.64	6.52	0.04	79.23	0.12	9.89	0.2	0.29	0	
4727.78	1.6	53.22	49.63	48.45	1.07	1.1	0.002	0.03934	4.08	1.77	6.73	0.05	94.08	0.13	11.74	0.24	0.3	0	
4727.88	1.7	58.07	49.86	48.56	1.16	1.2	0.002	0.03873	4.42	1.89	6.93	0.06	110.04	0.14	13.73	0.28	0.3	0	
4727.98	1.8	62.93	50.09	48.68	1.26	1.29	0.002	0.03815	4.8	2.03	7.14	0.06	127.92	0.16	15.96	0.33	0.32	0	
4728.08	1.9	67.81	50.33	48.79	1.35	1.39	0.002	0.0377	5.14	2.15	7.31	0.07	146.07	0.17	18.23	0.37	0.32	0	
4728.18	2	72.69	50.56	48.91	1.44	1.49	0.002	0.03729	5.49	2.27	7.46	0.08	165.23	0.18	20.62	0.42	0.33	0	
4728.28	2.1	77.59	50.79	49.03	1.53	1.58	0.002	0.03694	5.83	2.39	7.61	0.09	185.42	0.19	23.14	0.47	0.34	0	
4728.38	2.2	82.5	51.03	49.14	1.62	1.68	0.002	0.03661	6.17	2.5	7.75	0.1	206.62	0.2	25.79	0.52	0.34	0	
4728.48	2.3	87.42	51.26	49.26	1.71	1.77	0.002	0.03632	6.51	2.62	7.89	0.11	228.79	0.21	28.55	0.58	0.35	0	
4728.58	2.4	92.35	51.49	49.37	1.79	1.87	0.002	0.03609	6.82	2.72	8	0.11	250.81	0.22	31.3	0.63	0.35	0	
4728.68	2.5	97.29	51.73	49.49	1.88	1.97	0.002	0.03584	7.16	2.83	8.12	0.12	274.86	0.23	34.3	0.69	0.35	0	
4728.78	2.6	102.25	51.96	49.61	1.97	2.06	0.002	0.03562	7.51	2.93	8.23	0.13	299.89	0.25	37.43	0.75	0.36	0	
4728.88	2.7	107.21	52.19	49.72	2.05	2.16	0.002	0.03544	7.81	3.03	8.33	0.14	324.57	0.26	40.51	0.81	0.36	0	
4728.98	2.8	112.19	52.43	49.84	2.14	2.25	0.002	0.03524	8.15	3.13	8.44	0.15	351.42	0.27	43.86	0.88	0.37	0	
4729.08	2.9	117.18	52.66	49.96	2.23	2.35	0.002	0.03507	8.5	3.24	8.54	0.16	379.19	0.28	47.32	0.95	0.37	0	
4729.18	3	122.18	52.89	50.07	2.31	2.44	0.002	0.03492	8.8	3.33	8.63	0.17	406.48	0.29	50.73	1.01	0.38	0	
4729.28	3.1	127.2	53.13	50.19	2.39	2.53	0.002	0.03478	9.11	3.42	8.71	0.18	434.62	0.3	54.24	1.08	0.38	0	
4729.38	3.2	132.22	53.36	50.3	2.48	2.63	0.002	0.03463	9.45	3.52	8.8	0.19	465	0.31	58.03	1.15	0.38	0.01	
4729.48	3.3	137.26	53.59	50.42	2.56	2.72	0.002	0.03451	9.75	3.6	8.88	0.2	494.8	0.32	61.75	1.22	0.39	0.01	
4729.58	3.4	142.32	54.12	50.86	2.63	2.8	0.002	0.03441	10.02	3.68	8.94	0.21	523.89	0.33	65.38	1.29	0.39	0.02	
4729.68	3.5	147.43	54.82	51.51	2.69	2.86	0.002	0.03433	10.25	3.75	9	0.22	552.25	0.34	68.92	1.34	0.39	9.96	
4729.78	3.6	152.63	55.7	52.36	2.74	2.91	0.002	0.03426	10.44	3.8	9.05	0.22	579.92	0.34	72.37	1.38	0.39	2.11	
4729.88	3.7	157.9	56.57	53.21	2.79	2.97	0.002	0.0342	10.63	3.85	9.09	0.23	608.37	0.35	75.92	1.43	0.39	0.46	
4729.98	3.8	163.27	57.44	54.06	2.84	3.02	0.002	0.03413	10.82	3.91	9.13	0.24	637.72	0.35	79.59	1.47	0.4	0.11	
4730.08	3.9	168.72	58.31	54.91	2.89	3.07	0.002	0.03407	11.01	3.96	9.18	0.24	667.9	0.36	83.35	1.52	0.4	0.03	
4730.18	4	174.25	59.19	55.76	2.94	3.13	0.002	0.03401	11.2	4.01	9.22	0.25	698.93	0.37	87.23	1.56	0.4	0.01	
4730.28	4.1	179.87	60.06	56.61	2.99	3.18	0.002	0.03396	11.39	4.06	9.26	0.26	730.85	0.37	91.21	1.61	0.4	0	
4730.38	4.2	185.57	60.93	57.45	3.05	3.23	0.002	0.03389	11.62	4.13	9.31	0.26	765.55	0.38	95.54	1.66	0.4	0	
4730.48	4.3	191.36	61.81	58.3	3.1	3.28	0.002	0.03384	11.81	4.18	9.35	0.27	799.3	0.39	99.75	1.71	0.41	0	
4730.58	4.4	197.23	62.68	59.15	3.15	3.33	0.002	0.03379	12	4.23	9.39	0.28	833.93	0.39	104.07	1.76	0.41	0	
4730.68	4.5	203.19	63.44	59.87	3.2	3.39	0.002	0.03374	12.19	4.28	9.43	0.28	869.49	0.4	108.51	1.81	0.41	0	
4730.78	4.6	209.2	64.04	60.39	3.27	3.46	0.002	0.03367	12.46	4.35	9.48	0.29	910.05	0.41	113.57	1.88	0.41	0	
4730.88	4.7	215.26	64.64	60.91	3.33	3.53	0.002	0.03361	12.69	4.41	9.52	0.3	949.42	0.42	118.49	1.95	0.41	0	4/22/2016
4730.98	4.8	221.38	65.24	61.44	3.39	3.6	0.002	0.03356	12.92	4.47	9.57	0.31	989.71	0.42	123.52	2.01	0.42	0	
4731.08	4.9	227.55	65.83	61.96	3.46	3.67	0.002	0.0335	13.18	4.54	9.62	0.32	1033.14	0.43	128.94	2.08	0.42	0	
4731.18	5	233.77	66.43	62.48	3.52	3.74	0.002	0.03344	13.41	4.6	9.66	0.33	1075.24	0.44	134.19	2.15	0.42	0	
4731.28	5.1	240.17	70	65.97	3.43	3.64	0.002	0.03352	13.07	4.51	9.6	0.32	1083.28	0.43	135.19	2.05	0.42	0	
4731.38	5.2	246.97	74.31	70.2	3.32	3.52	0.002	0.03362	12.65	4.4	9.52	0.3	1086.8	0.41	135.63	1.93	0.41	0	
4731.48	5.3	254.2	78.63	74.43	3.23	3.42	0.002	0.03371	12.31	4.31	9.45	0.29	1095.52	0.4	136.72	1.84	0.41	0	

Cross Section--Downstream of FAS



ELEV	DEPTH	AREA	WET PER	WIDTH	HYD RAD	MEAN D	SLOPE	ROUGH	R/D84	VELOCITY	U/U*	U^2/2g	DISCHARGE	SHEAR	POWER	POWER/W	FROUDE	TRANSPORT	
(ft)	(ft)	(sq ft)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	[n] (ft^(1/6))		(fps)		(ft)	(cfs)	(psf)	(lb/s)	(lb/ft/s)		(lb/s)	
4728.21	0.1	0.37	7.43	7.42	0.05	0.05	0.002	0	0.19	0	0	0	0	0.01	0	0	0	0	
4728.31	0.2	1.48	14.85	14.85	0.1	0.1	0.002	0.19604	0.38	0.07	0.91	0	0.11	0.01	0.01	0	0.04	0	
4728.41	0.3	3.29	20.89	20.88	0.16	0.16	0.002	0.09346	0.61	0.21	2.07	0	0.69	0.02	0.09	0	0.09	0	
4728.51	0.4	5.66	26.58	26.57	0.21	0.21	0.002	0.07389	0.8	0.32	2.73	0	1.8	0.03	0.22	0.01	0.12	0	
4728.61	0.5	8.53	30.65	30.63	0.28	0.28	0.002	0.06159	1.07	0.46	3.44	0	3.94	0.03	0.49	0.02	0.15	0	
4728.71	0.6	11.78	34.3	34.27	0.34	0.34	0.002	0.05587	1.3	0.58	3.92	0.01	6.83	0.04	0.85	0.02	0.18	0	
4728.81	0.7	15.39	37.96	37.92	0.41	0.41	0.002	0.05158	1.56	0.71	4.38	0.01	11.0	0.05	1.37	0.04	0.2	0	
4728.91	0.8	19.36	41.61	41.57	0.47	0.47	0.002	0.04901	1.79	0.82	4.71	0.01	15.9	0.06	1.98	0.05	0.21	0	
4729.01	0.9	23.7	45.26	45.22	0.52	0.52	0.002	0.04735	1.98	0.91	4.96	0.01	21.5	0.06	2.69	0.06	0.22	0	
4729.11	1	28.41	48.92	48.87	0.58	0.58	0.002	0.04574	2.21	1.01	5.23	0.02	28.7	0.07	3.58	0.07	0.23	0	
4729.21	1.1	33.5	53.38	53.33	0.63	0.63	0.002	0.04464	2.4	1.09	5.43	0.02	36.7	0.08	4.58	0.09	0.24	0	
4729.31	1.2	39.08	58.39	58.33	0.67	0.67	0.002	0.04388	2.55	1.16	5.58	0.02	45.3	0.08	5.66	0.1	0.25	0	
4729.41	1.3	45.15	63.04	62.98	0.72	0.72	0.002	0.04305	2.74	1.24	5.76	0.02	56.0	0.09	6.99	0.11	0.26	0	
4729.51	1.4	51.68	67.69	67.62	0.76	0.76	0.002	0.04246	2.9	1.3	5.89	0.03	67.4	0.09	8.41	0.12	0.26	0	
4729.61	1.5	58.67	72.33	72.26	0.81	0.81	0.002	0.0418	3.09	1.38	6.05	0.03	81.1	0.1	10.12	0.14	0.27	0	
4729.71	1.6	66.13	76.98	76.91	0.86	0.86	0.002	0.04122	3.28	1.46	6.2	0.03	96.5	0.11	12.04	0.16	0.28	0	
4729.81	1.7	74.05	81.39	81.31	0.91	0.91	0.002	0.0407	3.47	1.53	6.34	0.04	114	0.11	14.18	0.17	0.28	0	
4729.91	1.8	82.29	83.61	83.51	0.98	0.99	0.002	0.04005	3.73	1.64	6.52	0.04	135	0.12	16.82	0.2	0.29	0	
4730.01	1.9	90.76	85.83	85.7	1.06	1.06	0.002	0.03941	4.04	1.75	6.71	0.05	159	0.13	19.86	0.23	0.3	0	
4730.11	2	99.43	87.92	87.77	1.13	1.13	0.002	0.03892	4.31	1.85	6.87	0.05	184	0.14	22.99	0.26	0.31	0	
4730.21	2.1	108.29	89.47	89.31	1.21	1.21	0.002	0.03843	4.61	1.96	7.04	0.06	213	0.15	26.55	0.3	0.31	0	
4730.31	2.2	117.3	91.03	90.84	1.29	1.29	0.002	0.03799	4.91	2.07	7.19	0.07	243	0.16	30.35	0.33	0.32	0	
4730.41	2.3	126.46	92.59	92.38	1.37	1.37	0.002	0.0376	5.22	2.18	7.34	0.07	276	0.17	34.42	0.37	0.33	0	
4730.51	2.4	135.77	94.15	93.91	1.44	1.45	0.002	0.03729	5.49	2.27	7.46	0.08	309	0.18	38.52	0.41	0.33	0	
4730.61	2.5	145.24	95.7	95.45	1.52	1.52	0.002	0.03697	5.79	2.38	7.6	0.09	345	0.19	43.08	0.45	0.34	0	
4730.71	2.6	154.86	97.26	96.98	1.59	1.6	0.002	0.03672	6.06	2.47	7.71	0.09	382	0.2	47.67	0.49	0.34	0	
4730.81	2.7	164.64	98.86	98.56	1.67	1.67	0.002	0.03645	6.36	2.57	7.83	0.1	423	0.21	52.75	0.54	0.35	0	
4730.91	2.8	174.58	100.63	100.31	1.73	1.74	0.002	0.03626	6.59	2.64	7.92	0.11	461	0.22	57.56	0.57	0.35	0	
4731.01	2.9	184.7	102.37	102.02	1.8	1.81	0.002	0.03606	6.86	2.73	8.01	0.12	504	0.22	62.88	0.62	0.36	0	
4731.11	3	194.98	104.1	103.73	1.87	1.88	0.002	0.03587	7.12	2.81	8.11	0.12	549	0.23	68.45	0.66	0.36	0	
4731.21	3.1	205.44	105.84	105.44	1.94	1.95	0.002	0.03569	7.39	2.9	8.2	0.13	595	0.24	74.28	0.7	0.37	0	
4731.31	3.2	216.07	107.58	107.15	2.01	2.02	0.002	0.03553	7.66	2.98	8.28	0.14	644	0.25	80.37	0.75	0.37	0	
4731.41	3.3	226.87	109.31	108.86	2.08	2.08	0.002	0.03537	7.92	3.06	8.37	0.15	695	0.26	86.71	0.8	0.37	0	
4731.51	3.4	237.84	111.05	110.57	2.14	2.15	0.002	0.03524	8.15	3.13	8.44	0.15	745	0.27	92.98	0.84	0.38	0	
4731.61	3.5	248.98	112.79	112.28	2.21	2.22	0.002	0.0351	8.42	3.21	8.52	0.16	800	0.28	99.84	0.89	0.38	0	
4731.71	3.6	260.3	114.52	113.99	2.27	2.28	0.002	0.03499	8.65	3.28	8.58	0.17	854	0.28	106.6	0.94	0.38	0	
4731.81	3.7	271.78	116.26	115.7	2.34	2.35	0.002	0.03487	8.91	3.36	8.66	0.18	913	0.29	113.99	0.99	0.39	0	
4731.91	3.8	283.44	118	117.41	2.4	2.41	0.002	0.03476	9.14	3.43	8.72	0.18	972	0.3	121.26	1.03	0.39	0	
4732.01	3.9	295.29	120.32	119.71	2.45	2.47	0.002	0.03468	9.33	3.48	8.77	0.19	1029	0.31	128.38	1.07	0.39	0	estimated 4/20/2016
4732.11	4	307.38	122.71	122.07	2.5	2.52	0.002	0.0346	9.52	3.54	8.82	0.19	1088	0.31	135.76	1.11	0.39	0	
4732.21	4.1	319.7	125.1	124.44	2.56	2.57	0.002	0.03451	9.75	3.6	8.88	0.2	1152	0.32	143.83	1.16	0.4	0	
4732.31	4.2	332.27	127.49	126.8	2.61	2.62	0.002	0.03444	9.94	3.66	8.93	0.21	1216	0.33	151.74	1.2	0.4	0	
4732.41	4.3	345.06	129.88	129.17	2.66	2.67	0.002	0.03437	10.13	3.71	8.97	0.21	1281	0.33	159.92	1.24	0.4	0	
4732.51	4.4	358.1	132.27	131.53	2.71	2.72	0.002	0.0343	10.32	3.77	9.02	0.22	1349	0.34	168.37	1.28	0.4	0	
4732.61	4.5	371.37	134.67	133.9	2.76	2.77	0.002	0.03423	10.52	3.82	9.06	0.23	1419	0.34	177.09	1.32	0.4	0	
4732.71	4.6	384.88	137.06	136.27	2.81	2.82	0.002	0.03417	10.71	3.87	9.11	0.23	1491	0.35	186.09	1.37	0.41	0	
4732.81	4.7	398.62	139.45	138.63	2.86	2.88	0.002	0.03411	10.9	3.93	9.15	0.24	1565	0.36	195.36	1.41	0.41	0	
4732.91	4.8	412.61	141.84	141	2.91	2.93	0.002	0.03405	11.09	3.98	9.19	0.25	1642	0.36	204.93	1.45	0.41	0	probable Q based on Glen gage
4733.01	4.9	426.8	143.6	142.73	2.97	2.99	0.002	0.03398	11.32	4.04	9.24	0.25	1725	0.37	215.32	1.51	0.41	0.01	
4733.11	5	441.15	145.29	144.4	3.04	3.06	0.002	0.0339	11.58	4.12	9.3	0.26	1815	0.38	226.56	1.57	0.41	0.01	
4733.21	5.1	455.72	148.63	147.7	3.07	3.09	0.002	0.03387	11.7	4.15	9.32	0.27	1889	0.38	235.8	1.6	0.42	0.01	
4733.31	5.2	470.71	153.05	152.09	3.08	3.09	0.002	0.03386	11.73	4.16	9.33	0.27	1956	0.38	244.16	1.61	0.42	0.01	
4733.41	5.3	486.14	157.48	156.49	3.09	3.11	0.002	0.03385	11.77	4.17	9.34	0.27	2026	0.39	252.79	1.62	0.42	0.01	



Cross Section--Right Bank Above New R/R
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 301.2
Dbkf = 2.74
Abkf = 825.7
Elevation (ft)
4740
4735
4730
4725
4720
0
100
200
300
400
500
Horizontal Distance (ft)

Appendix B. Applied Geomorphology Report

RECEIVED FEB 12 2015

Karin Boyd, P.G.
Applied Geomorphology, Inc.
Specializing in Fluvial Geomorphology

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Bozeman, MT 59715
(406) 587-6352

February 5, 2015
Andrew P. Suenram
Erb and Suenram, PLLC
P.O. Box 1366
117 S. Idaho St, 2nd Floor
Dillon, MT 59715

RE: Big Hole River Bank Erosion

Dear Mr. Suenram

In early November, Pat Redmond and I were working out on the Big Hole River, and he asked if I would have a look at your bank erosion issue on the right bank of the river (as viewed downstream) just upstream of Pennington Bridge. I also have a GIS project for the Big Hole River with historic air photos that let me evaluated conditions through time. I wanted to write you a letter to provide you with some basic impressions and recommendations from our quick site visit.

The Pennington Bridge Site consists of two bridges, each of which spans a dominant channel of the Big Hole River. The flow split just upstream of the bridge has been there at least since 1942 (Figure 1). At that time, it appears as though the northern channel carried water at fairly low flows; there is no apparent dominant channel visible downstream of the bridge in Figure 1. In contrast, the 2013 photo shows that the southern channel has become dominant. The north channel now carries water at relatively high flows, indicating that it has transitioned from a primary to a seasonal channel. The air photo shown in Figure 3 was taken at high water in 2011 and shows seasonal activation of the north channel. The importance of this shift of the north channel from a primary thread to a seasonal high flow channel is the potential for increased bank erosion in the southern channel as it becomes the main thread.

Figure 3 shows the river bankline in 1995 (blue) overlain on a 2011 air photo. Approximately 100 feet of bank erosion has occurred on the right bank upstream of the bridge since 1995, which is an average annual bank retreat rate of over 6 feet per year. Much of this erosion probably happened during the 2011 flood, which had not only high flows but a particularly long duration of those flows; in 2011, the river peaked at 11,200 cfs near Twin Bridges, and high flows of over 5,000 cfs were sustained for about two months (Figure 4). However, more erosion has occurred since 2011, as shown by a Google Earth image from fall 2014 (Figure 5). This recent scalloping of the bank has increased the potential for the flanking of a rock barb just upstream of the bridge. If that barb flanks, it will create severe bank instability at the right bridge abutment and will require repair.

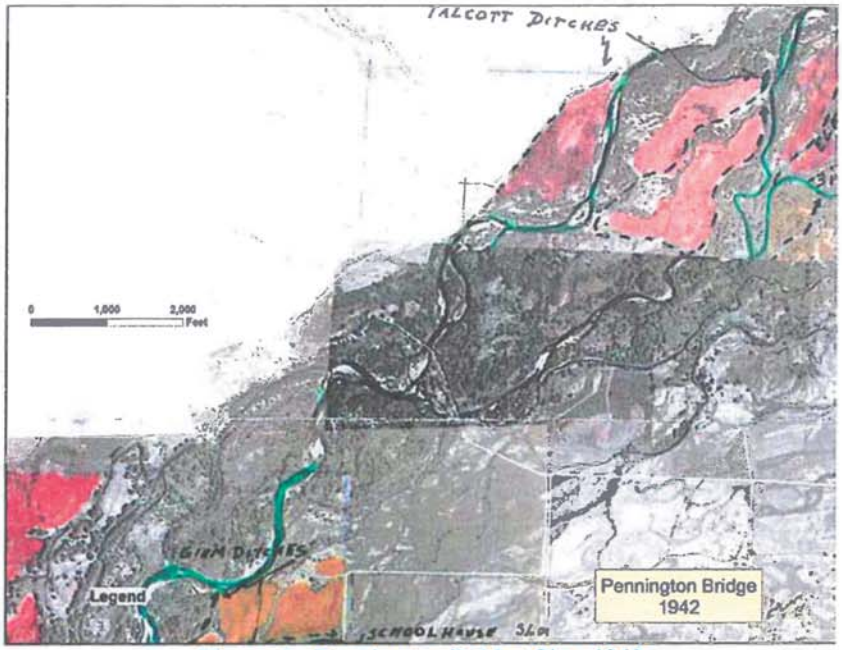

Figure 1. Pennington Bridge Site, 1942

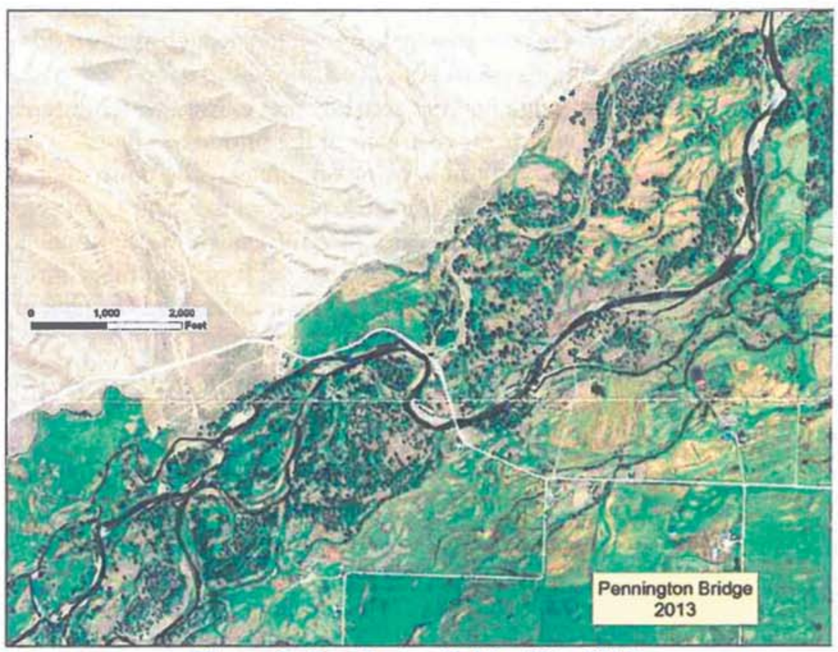

Figure 2. Pennington Bridge Site, 2013.

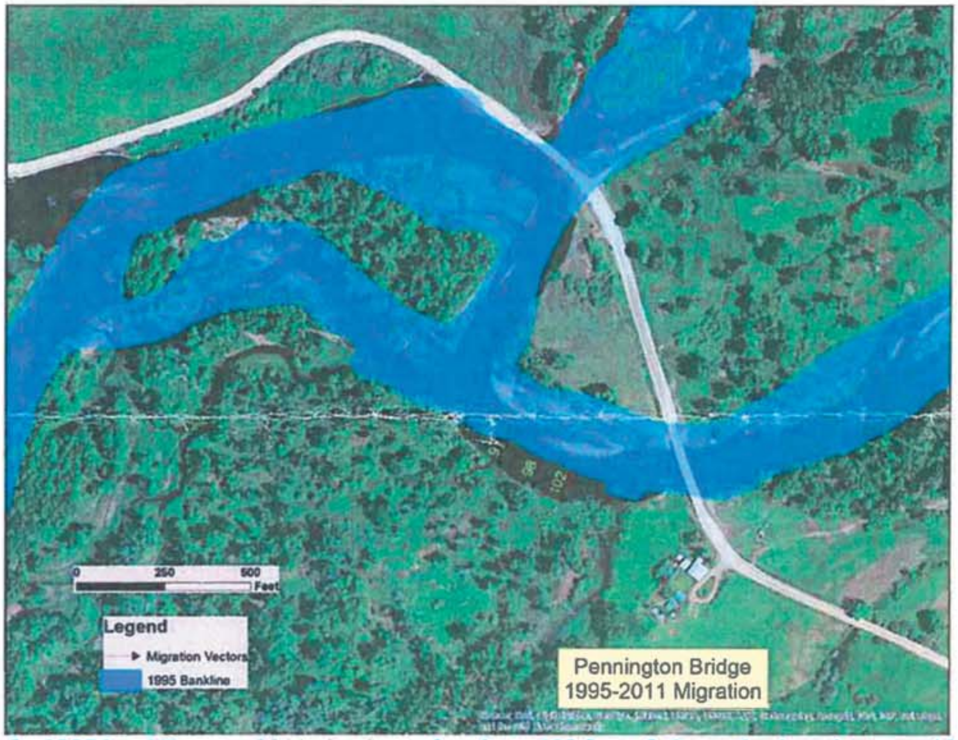

Figure 3. 1995 banklines on 2011 air photo showing ~100 feet of channel migration over 16 years.

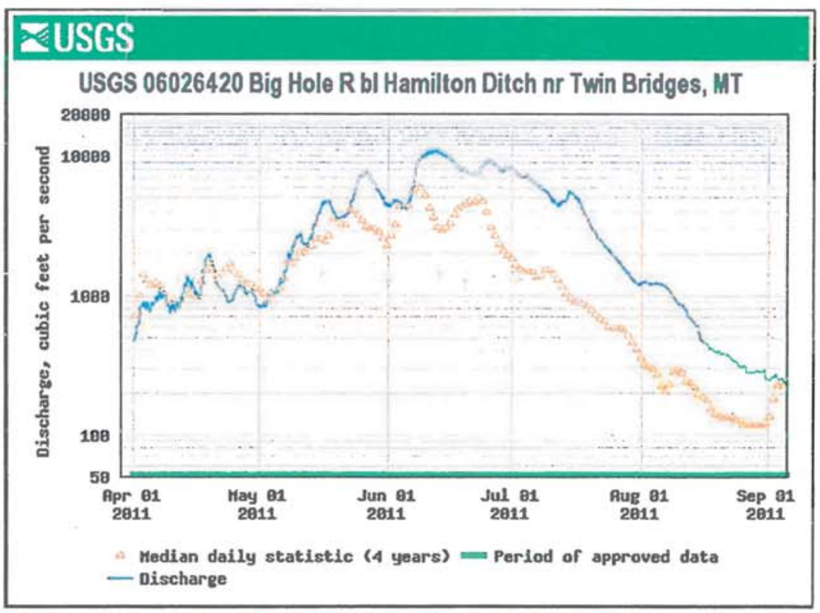

Figure 4. 2011 hydrograph (blue) and median daily flows (orange), Big Hole River near Twin Bridges.

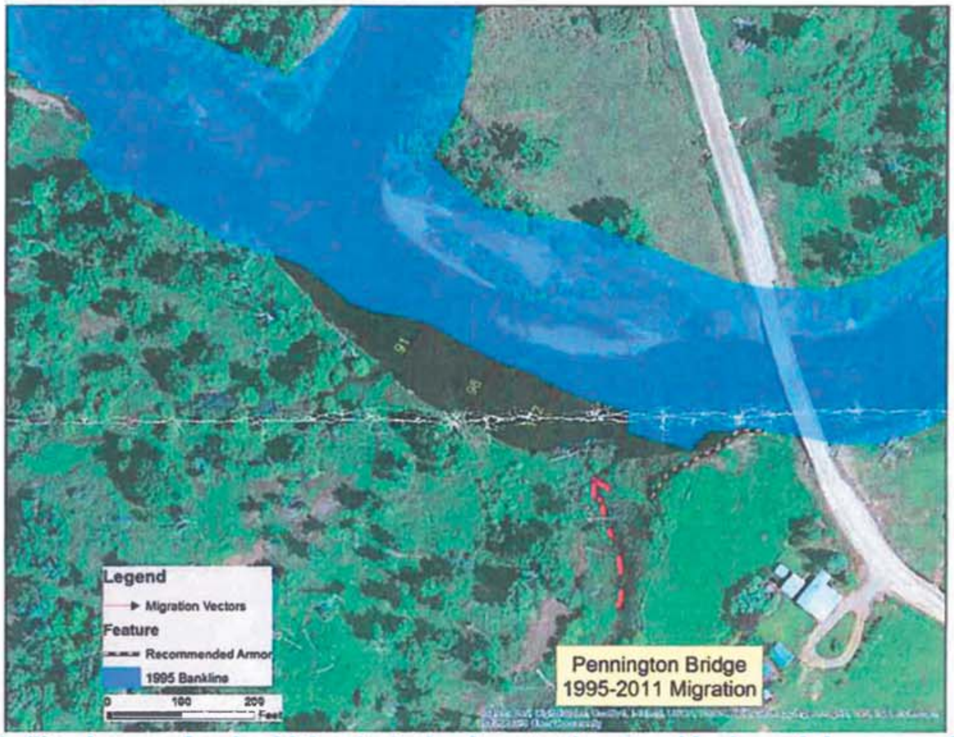

Figure 6. Site close-up showing high priority bank protection site; side channel shown as red arrow.

Please keep in mind that these recommendations are based on a very cursory review of the site, and that additional engineering input is critical in the design and implementation of any bank treatment. Pat and I discussed conditions at the site and we agreed as to the proposed short-term solution described here. What happens in the long term is difficult to predict; for example if the bendway just upstream of both bridges (Figure 3) completely cuts off, erosion patterns will change. Monitoring these changes will be important so you can continue to most cost-effectively protect your home. You may also want to consider bioengineered bank treatments, however I would suggest that such treatments at this site should consist of an engineered rock toe and bioengineered upper bank where erosive stresses are markedly lower.

Please give me a call with any questions, and good luck managing that bank.

Thank you,

Karin Boyd, P.G.
406-587-6352
kboyd@appliedgeomorph.com

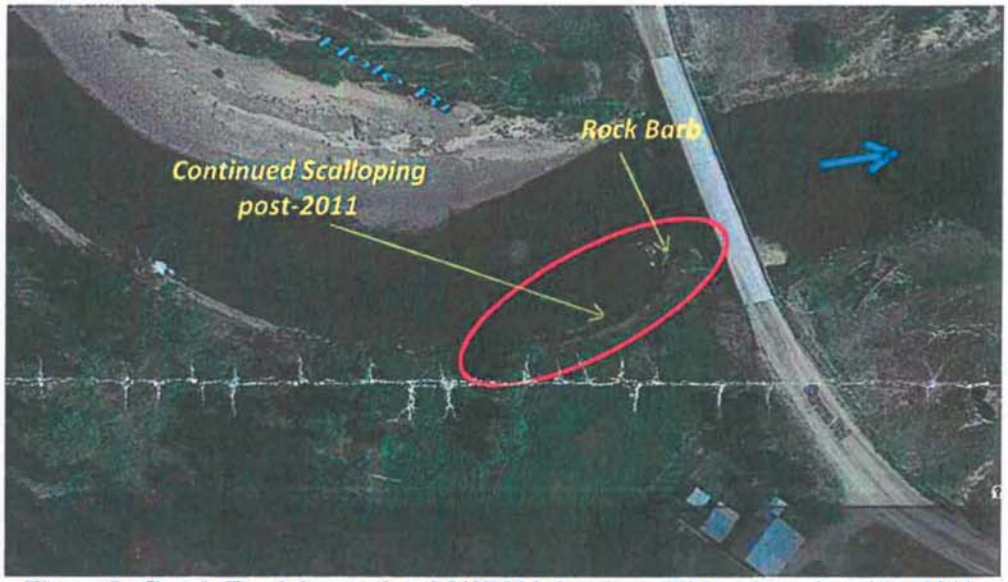

Figure 5. Google Earth image dated 9/4/2014 showing additional erosion since 2011.

From my perspective, the severity of bank erosion at the site does not necessarily warrant bank armor that may impede natural channel process. My approach has always been to avoid armoring banks unless it is demonstrably necessary, because the cumulative impacts of extensive bank armor can be so detrimental to the long term ecological sustainability of dynamic rivers such as the Big Hole. In this case, however, the erosion is posing a real threat to both your home and the performance of the bridge. Considering the rapid rate of movement, and the associated changes in orientation of the river to the bridge, I would recommend armoring the right bank upstream of the bridge as shown in Figure 6. Just upstream of the recommended armor extent, a high flow channel returns to the river. I would recommend that you avoid blocking that side channel to the greatest extent possible. If the armor needs to be extended, it could follow the right bank of the side channel rather than block it.