THE RESEARCH INITIATIVE

2019 ANNUAL REPORT
2019 RESULTS • 2020 PLANS

RI

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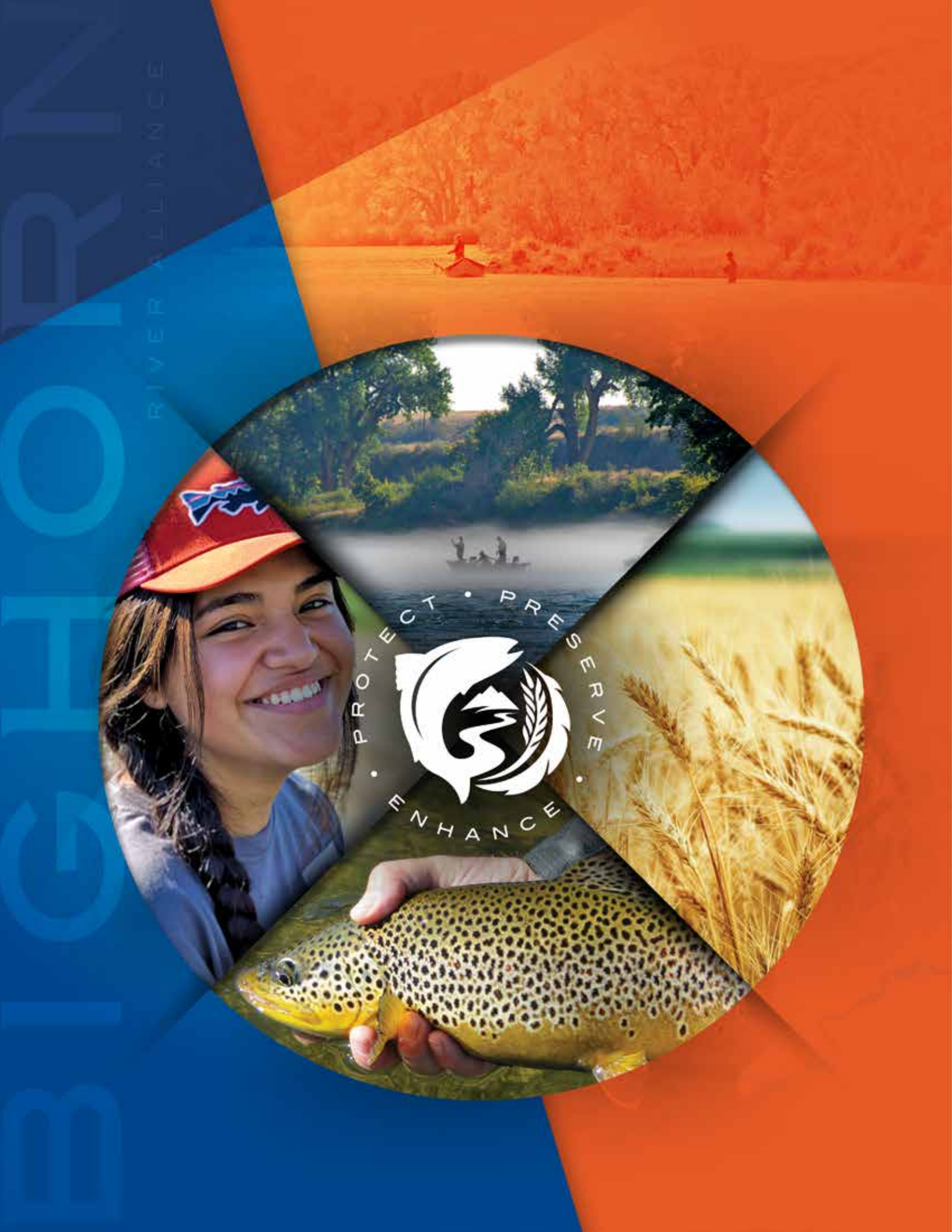
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WELCOME

ANNE MARIE EMERY

BIGHORN RIVER ALLIANCE
Executive Director

On behalf of the Bighorn River Alliance, it is my pleasure to introduce you to the 2019 Annual Report of the Research Initiative of the Bighorn River Alliance. I am beginning my fourth year as Executive Director and am proud of the successes we have had working with stakeholders to examine the way in which the river is managed and enjoyed. We have been blessed with an extraordinary resource, but this abundance of opportunity has too often been taken for granted and today the river faces challenges from both human actions and the natural environment that cannot be ignored. To fulfill the Alliance's goal of being a responsible steward of the river, we need to respond to these challenges, and perhaps, even more importantly, to those challenges yet to be identified. However, the effectiveness of our response depends on the quality and substance of the information base on which our understanding of the river ecosystem depends. The Research Initiative provides the credible scientific research foundation necessary for building future conservation efforts that will benefit the Bighorn River on which the angling community, the farm and ranch operators of the Bighorn Valley and the Crow Nation depend.

Please join me in celebrating the successful conclusion of Year One of the Research Initiative. It is a milestone for the Alliance, a milestone for the river, and a milestone for the future generations that will benefit from this resource.

JIM CHALMERS

BIGHORN RIVER ALLIANCE
Research Chair

I am very pleased to be able to present this summary of the five studies that were carried out in the first year of the Research Initiative. Many thanks are due -- first, to our Founding Underwriters, without whom this effort would not have been possible; then to Warren Kellogg who has played a key role in helping to structure the Research Initiative and has served as the Research Manager for our Year One studies; and finally to the five contractors who have so ably carried out the Year One studies. The final report for each of the studies is now on the Alliance website at www.bighornalliance.org. In the pages that follow, there is a brief overview of the objectives, findings, and implications of each of the studies.

The 2019 studies can be thought of as foundational. We had to be sure we understood the authorities and operating criteria of all the various public sector and jurisdictional bodies that affect the river. And before jumping into actual monitoring efforts, we needed to carefully think through sampling and analysis plans, both for water quality and macroinvertebrates. We also needed to consolidate various geospatial data bases and historic hydrologic data as a starting point for subsequent analysis of the river ecosystem.

With these efforts in hand, the research activity in 2020 will focus on implementation of monitoring plans and on beginning to identify opportunity areas for policies and projects that can beneficially affect the long term health and viability of the river. An outline of the 2020 work program concludes this Summary Report.

The continued support of those that share our commitment to the river and to the activities that depend on it will be essential to our ability to pursue our mission and to leave this incredible resource in the best possible condition for the enjoyment and use of future generations. ***I hope you will see fit to join us!***

YELLOWTAIL UNIT AND THE BIGHORN RIVER:
GOVERNMENTAL AUTHORITIES AND OPERATING CRITERIA

KEN FRAZER

LEAD SCIENTIST

Ken Frazer has a M.S. in Aquatic Biology and recently retired after a 42 year career as a Fisheries Biologist and Fisheries Program Manager with Montana Fish, Wildlife and Parks. He spent 19 years as the Fisheries Management Biologist on the Bighorn River and Bighorn Lake, and 10 years as the Region 5 Fisheries Manager. For the past 29 years he has been working on stream flow and water management issues in the Bighorn Drainage. He has been directly involved with data collection on the Bighorn system, participating in operational and water management discussions involving all key stakeholders, and in making management recommendations to benefit the river and lake fisheries.

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STUDY OBJECTIVES

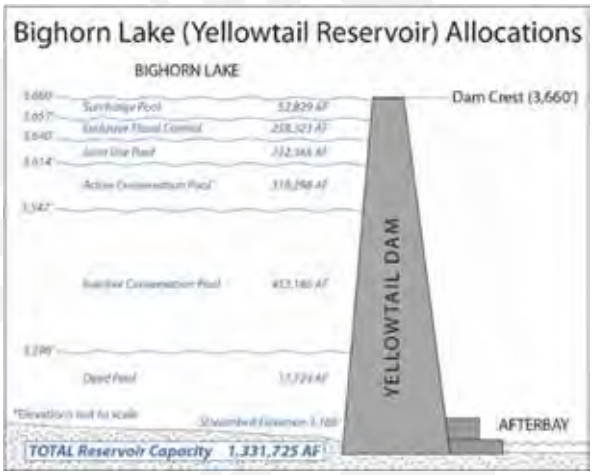
The objectives of this section of the Bighorn River Alliance (BHRA) Research Initiative were to:

- Identify the key partners and stakeholders involved in the operation and management of the Bighorn River and reservoir system and look at the operating criteria they used in managing Yellowtail Dam and the Bighorn River.
- Look at the evolution of changes in these operating criteria over time and recognize factors driving these changes.
- Identify the authority and limitations each management agency has in system operations.

FINDINGS

The Yellowtail Unit, consisting of Yellowtail Dam, the Afterbay Dam and Bighorn Lake (Yellowtail Reservoir) upstream of the dam was authorized under the 1944 Flood Control Act. Yellowtail Dam, closed in 1965, was constructed at the mouth of Bighorn Canyon in Montana with the upper end of Bighorn Lake extending into Wyoming. Before construction, the Bighorn River was a warm, turbid prairie stream contributing a high sediment load to the Yellowstone River. Construction of Yellowtail Dam completely changed the character of the Bighorn River downstream of the dam, creating a world-class tailwater trout fishery which ranks as one of the highest use fisheries in MT, and is an important economic driver in this part of MT. The high sediment load that moved down the Bighorn River is now trapped upstream of the dam and is creating major issues, especially in the upper end of the reservoir in Wyoming.

Overview of Yellowtail Unit Dam Area



Allocated Storage Space in Yellowtail Reservoir

The Bureau of Reclamation (BOR) retains primary authority over the operation and maintenance of the Yellowtail Unit and they control reservoir elevations and flow releases into the Bighorn River. The BOR shares flood control with the US Army Corps of Engineers and recreation management on Bighorn Canyon National Recreation Area with the National Park Service. Yellowtail Dam, part of Bighorn Lake, and the main tailwater section of the Bighorn River are located within the Crow Indian Reservation, and the Crow Tribe has senior rights on the water being released from Yellowtail Dam. The BOR is responsible for establishing Operating Criteria and putting together a management plan under which the Yellowtail Unit operates, while trying to balance their legal obligations and the expectations and interests of a diverse group of stakeholders. Demands and expectations of various user groups have changed over time based on water conditions in the Bighorn Drainage. The BOR has made a sincere effort to involve all interested stakeholders in their water management planning process and have made numerous changes to their operating criteria based on stakeholder input. They continue to look for new ways to improve water management and forecasting, which should benefit the Bighorn River fishery.

IMPLICATIONS

The operation and management of the Yellowtail Dam/Bighorn River system is complicated by the interests of a diverse group of stakeholders who have different interests and expectations related to river and reservoir management. It is important the BHRA understand the authorities, strengths and limitations each of the major management agencies and stakeholders have in the development of a long-term management plan for the Bighorn system. This will help them in forming partnerships with key players while developing and implementing the various programs identified in the Research Initiative. These partnerships will improve funding opportunities and increase the effectiveness of these programs while ensuring that the information collected reaches the proper management agencies where its utilization in developing future operational and management plans for the Bighorn system should provide benefits for all stakeholders.

BIGHORN RIVER AQUATIC MACROINVERTEBRATE MONITORING:

SAMPLING AND ANALYSIS PLAN – 2019

DAVID STAGLIANO
Montana Biological Survey

LEAD SCIENTIST

David Stagliano, M.S. is an Aquatic Ecologist, Fisheries Biologist and Invertebrate Taxonomist who has been performing ecological studies on streams and rivers for the last 26 years, 18 of which have been focused in the western U.S. (Montana, Idaho and Wyoming). Areas of expertise include the field collection, taxonomic analysis and interpretation of aquatic invertebrates, amphibians, mussels and fish communities for use in assessments and monitoring of stream, wetland, and river integrity.

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STUDY OBJECTIVES

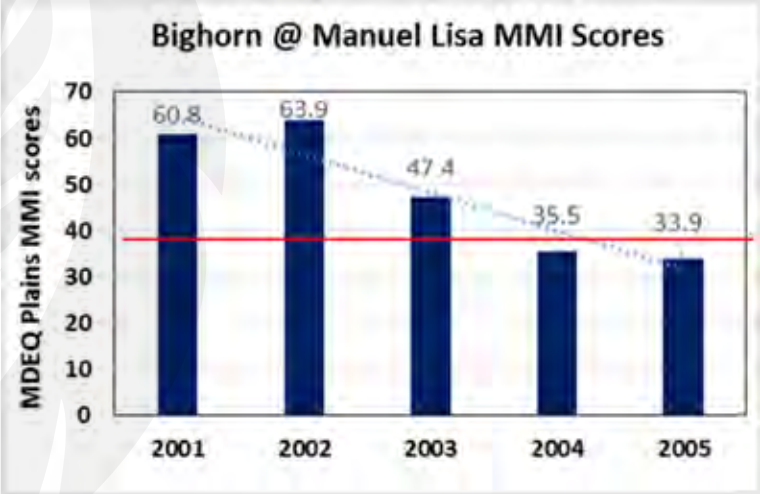
The objective of this portion of the BHRA Research Initiative is to develop a long-term data set on benthic macroinvertebrate populations and community assemblage structures along the study reach of the Bighorn River. The two principal tasks are to determine what macroinvertebrate data has been collected in the past (Literature Review and Historical Analysis) and to develop a sampling and analysis plan (SAP) that will be used going forward. The data on these biological indicators will help define spatial and temporal trends in aquatic habitat health and the way in which they are influenced by macrophyte beds, algae, aquatic invasive species, sedimentation, water quality, dissolved gases, and regulated flows.

Macroinvertebrate community collected with the Hess sampler in the Missouri River near Wolf Creek.

FINDINGS

The goal of a macroinvertebrate sampling and analysis plan (SAP) is to outline a procedure to collect quantitative baseline data using standardized methods and to interpret this information consistently to establish trends leading to an understanding of the overall health of the Bighorn River. We've identified eight Bighorn River sites (four with previous quantitative data) that will give a good representation of the spatial distribution of macroinvertebrate communities from Yellowtail Dam to the Yellowstone River confluence. With the concurrent collection of water quality data, we will be able to better understand causal relationships between the macroinvertebrate and aquatic plant communities and water quality to understand implications for the long-term health of the river.

The goal of the literature review portion is to understand the historical data that has been assembled to better inform the collection of current and future baseline data in the lower Bighorn River area, and to continue assessing this information annually to establish trends that may be causally linked to the overall health of the river. For example, five years of macroinvertebrate data had been collected by MDEQ at the Manuel Lisa FAS (2001-2005). Even in this short time frame, the health of the macroinvertebrate community, as measured by MDEQ's Multi-metric Index (MMI), appears to have biologically declined substantially from "very healthy" in 2001 and 2002 to "impaired" in 2004 and 2005.



Macroinvertebrate Community Health as measured by the MDEQ Plains MMI 2001-2005. Red line is the impairment threshold (score of <37.0).

IMPLICATIONS

Among other things, the proposed SAP will document the current status of the macroinvertebrate community at the Manuel Lisa FAS site which has not been sampled in 14 years. Did the macroinvertebrate trends seen in the historical data continue or were they altered by changing environmental conditions?

BIGHORN LAKE AND BIGHORN RIVER WATER QUALITY MONITORING:

SAMPLE AND ANALYSIS PLAN - 2019

WARREN KELLOGG
Stream and Watershed Consulting

LEAD SCIENTIST

Warren Kellogg is the founder of Stream and Watershed Consulting, a natural resource consulting business based in Clancy, Montana. Warren Kellogg has an extensive background in river management with over 40 years of experience in stakeholder relations, public facilitation, watershed planning, river assessments, and restoration project implementation.

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STUDY OBJECTIVES

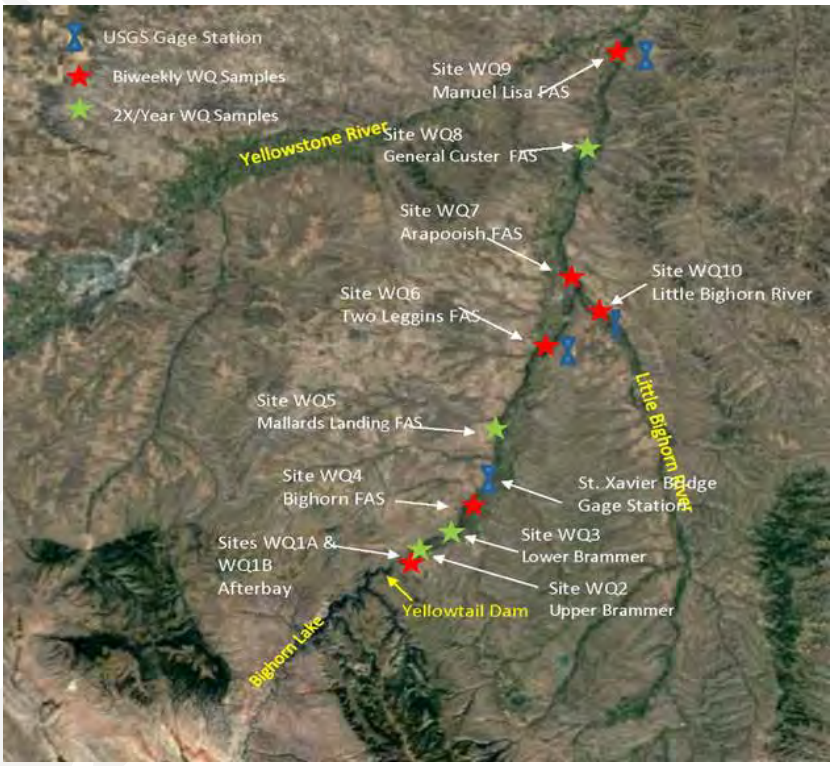
Monitoring water quality in the Bighorn Lake and Bighorn River will provide an understanding of how the lake's water quality influences the water quality found in the river. The first step to a long-term monitoring program is the development of a Sampling and Analysis Plan (SAP) that answers the following questions:

1. What factors are responsible for the frequency, extent, duration, and timing of high turbidity in the Bighorn River?
2. What are the physical, chemical, and biological constituents in the water column that affect aquatic plant and algae growth?
3. How does Bighorn Lake destratification and Yellowtail Dam flow releases influence water quality in the Bighorn River?
4. What effects do irrigation withdrawals, irrigation returns, and tributaries have on the water quality in the Bighorn River?
5. What effect do the Afterbay Dam releases (quantity, timing, and gate) have on total gas saturation (PSAT) levels in the river from the dam to the Saint Xavier Bridge?
6. What are the long-term trends in water quality in the Bighorn River?

FINDINGS

The water quality of the Bighorn River is primarily determined by Yellowtail Dam releases from Bighorn Lake. The SAP proposes a monitoring site in the lake next to Yellowtail Dam. Field measurements and water samples will be taken along a 400-foot depth profile twice per month from April through October. Below Yellowtail Dam, ten sites will be established on the Bighorn River to fully characterize long-term changes in water quality from the Afterbay Dam to the Yellowstone River confluence. An additional monitoring site will be set up on the Little Bighorn River upstream from where it joins the Bighorn River. Most river sites will be monitored on the same schedule as the lake site. Suspended solids (sediment and algae), nutrients, dissolved oxygen, turbidity, and selenium are the major parameters that will be analyzed

A water quality sonde will be used to instantaneously measure multiple parameters at each monitoring site



Water quality monitoring sites and USGS gage station locations

IMPLICATIONS

The water quality monitoring program will begin in April 2020 and continue indefinitely to create a database that documents the Bighorn River's water quality both spatially (Afterbay Dam to the Yellowstone River – 86 miles) and temporally (seasonally and yearly). It will also provide a foundation for explaining and predicting how the river's water quality affects other important ecological features (i.e. fisheries, benthic macroinvertebrates, aquatic plant growth, etc.). The SAP will be reviewed periodically to determine if the plan should be revised to more effectively address the study's objectives.

CHARACTERIZATION OF

BIGHORN RIVER HYDROLOGIC ALTERATIONS BELOW YELLOWTAIL DAM

KARIN BOYD
Applied Geomorphology, Inc.

LEAD SCIENTIST

Karin Boyd, P.G. is a registered professional geologist with 31 years of experience in applied fluvial geomorphology. As a Principal Geomorphologist for Applied Geomorphology, Inc. (AGI), Karin specializes in the development of process-based strategies for aquatic resource management and restoration design.

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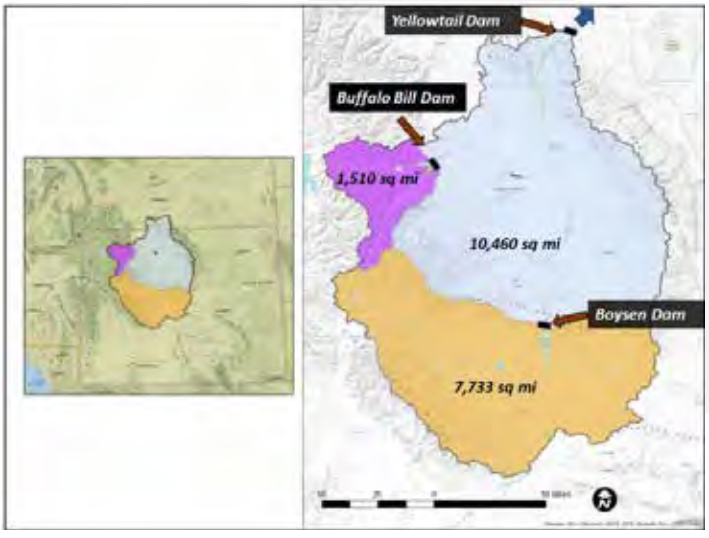
STUDY OBJECTIVES

The evaluation of flow patterns will help the BHRA understand how the river's hydrology has changed through time, and how flow management can affect river health. The first study objective is to provide historical context as to how flows on the Bighorn River have been fundamentally altered by dams. The second objective is to look at more recent flow patterns with respect to how the dam is operated, and to consider how operational patterns may affect water quality conditions downstream. And lastly, available information regarding the fishery was compared to flow patterns over the past few decades to consider how trends of trout recruitment and habitat quality may relate to flows. The results are intended to provide a baseline understanding of flow patterns, data availability, and data analysis opportunities so as more information is developed it can easily be given a hydrologic context.



Map showing Bighorn River Watershed above Yellowtail Dam, with contributing watershed areas above Boysen Dam and Buffalo Bill Dam highlighted.

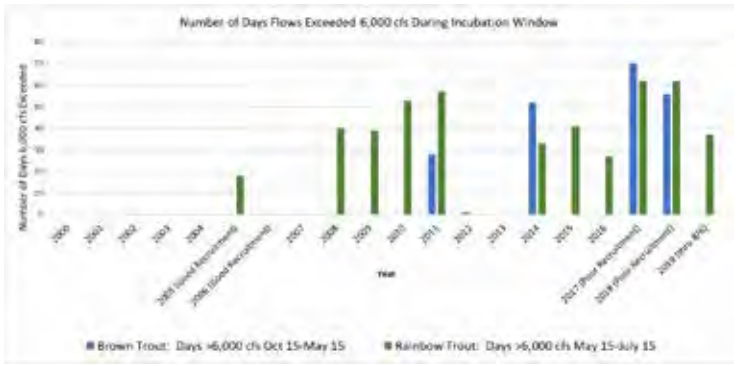
FINDINGS

The hydrology of the Bighorn River below Yellowtail Dam has been substantially altered by human development over the past century. Although this development is entirely responsible for creating the blue ribbon tailwater fishery of the river, it has also resulted in complex responses related to river geomorphology, habitat, and water quality.

Long-term trends show that dam construction has reduced spring flooding while increasing flows in fall and winter. Boysen Dam, which was built between 1947 and 1952, had a major impact on river flows prior to Yellowtail Dam completion in 1966. Once Yellowtail Dam was closed, flows became increasingly simplified downstream, with a lower range in flows resulting in less variability, less flooding, and fewer low flow periods. This effectively created the tailwater fishery we see today. Since then, there have been periods of drought coupled with changes in operating criteria that affected flow patterns on a decadal scale. The core drought years of 2000-2008 occurred before modern operating criteria were established, and this timeframe has a distinct hydrologic signature including persistently low flows and a dominance of flow releases through the dam powerhouse. Since 2009, flows have been consistently higher, resulting in an increased use of the dam spillway supplemental to the powerhouse. Whereas spillway flows are relatively warm, the occasional use of the lowermost river release appears to effectively drop temperatures, especially in late summer.

Defining optimal flows specifically in support of the tailwater fishery is challenging due to the complexity of processes supporting that fishery. Moderately high flows can rejuvenate side channels but can also scour spawning beds. Low flows can dry out side channels and desiccate redds. Temperature is affected by flow release mechanisms, with river releases from lower in the dam providing cold water pulses to the river. And gas supersaturation appears related to the nature of flow management at Yellowtail and Afterbay Dams, and may also be influenced by water quality in the reservoir.

Mean annual hydrographs for Bighorn River near St Xavier showing flow patterns for three timeframes: pre-Boysen Dam (1935-1952), Boysen Dam to Yellowtail Dam (1953-1966), and Yellowtail Dam to present (1967-2019). The comparison shows that Boysen dam strongly impacted Bighorn River flows prior to the completion of Yellowtail Dam.



Number of days mean daily flow exceeded 6,000cfs during incubation windows by year. Results show recent years of high water may have strongly impacted both brown and rainbow trout recruitment rates.

IMPLICATIONS

The Bighorn River tailwater fishery owes its existence to a highly managed flow scenario and associated dam operations. Whereas the underpinning for the blue-ribbon fishery is the dam, there are aspects of flow management that may contribute to, or detract from, the health of the system. Identifying those relationships will help the BHRA optimize conditions for the fishery while also understanding other process that may indirectly support the fishery or the needs of other stakeholders. With additional water quality sampling and analysis, information will become increasingly available to help the BHRA evaluate cause and effect relationships between natural system hydrology, dam management, and river health.

SPATIAL IMAGERY CONSOLIDATION AND CHANNEL FEATURE DELINEATION

TONY THATCHER
DTM Consulting

LEAD SCIENTIST

Tony Thatcher is the founder of DTM Consulting, a Bozeman, Montana-based GIS and natural resource consulting company, specializing in river and watershed analysis. Tony has over 25 years of experience collecting, analyzing and presenting spatial and non-spatial data using Geographic Information Systems (GIS), Remote Sensing, CAD, GPS, and various other digital techniques.

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STUDY OBJECTIVES

This study consisted of three primary tasks, with one additional task (#4) added during the study:

1. Identify and compile available data and aerial photography for use in GIS.
2. Map banklines and physical features.
3. Analyze data and summarize results.
4. Create a Bighorn River Atlas.

The resulting data and maps provide the spatial context for assessing historic and current conditions throughout the river corridor.

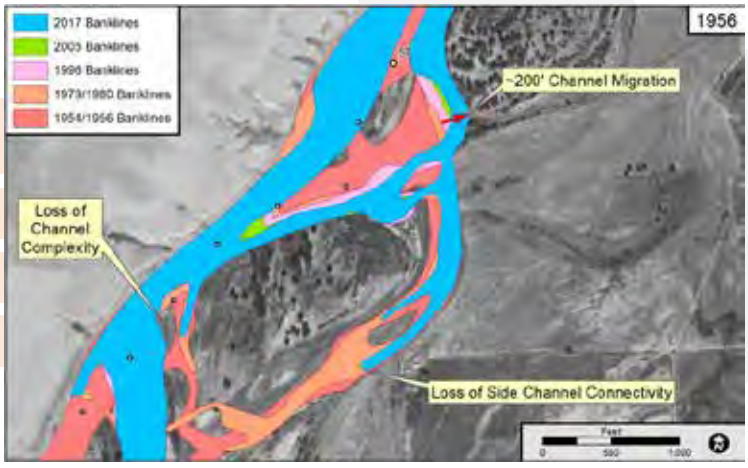

Figure 1. Bankline mapping showing changes through time.

FINDINGS

To assess historic river locations, migration, and conditions, banklines were digitized from the 1954/1956, 1979/1980, 1996, 2005, and 2017 imagery (Figure 1). Additionally, river channel centerlines, including secondary channels, were digitized from the 1954/1956 and 2017 imagery.

High-resolution LiDAR elevation data was collected in Fall 2018 by the NRCS for the Bighorn River corridor from Yellowtail Dam to the confluence with the Yellowstone River. These data were mosaicked into a single Digital Elevation Model (DEM) and used to create a Relative Elevation Model for the corridor (Figure 2). The data is useful for assessing connectivity of side channels, inundation potential, and avulsion risk (Figure 3).

Figure 3 displays a topographic cross section through the Juniper side channel (see Figure 2 for cross section location). The main river channel and the smaller Juniper Channel, along with various perched historic swales are clearly visible. These data are key for a variety of tasks such as understanding channel connectivity and potential for reactivation.

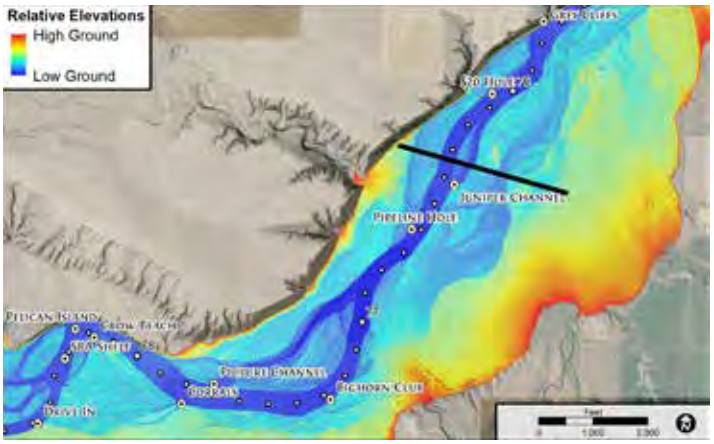

Figure 2. Relative Elevation Modeling using LiDAR elevation data with cross section location (Figure 3).

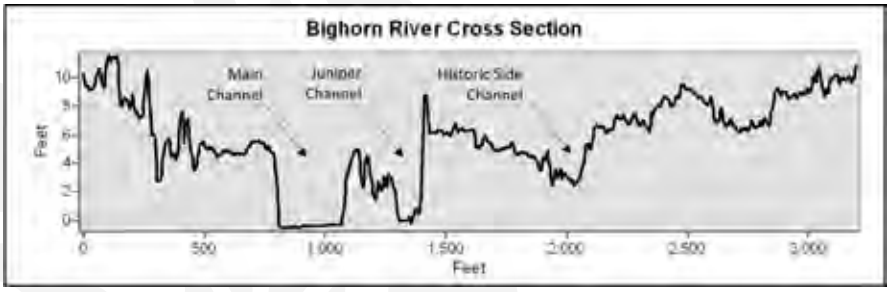

Figure 3. LiDAR cross section showing multiple channels.

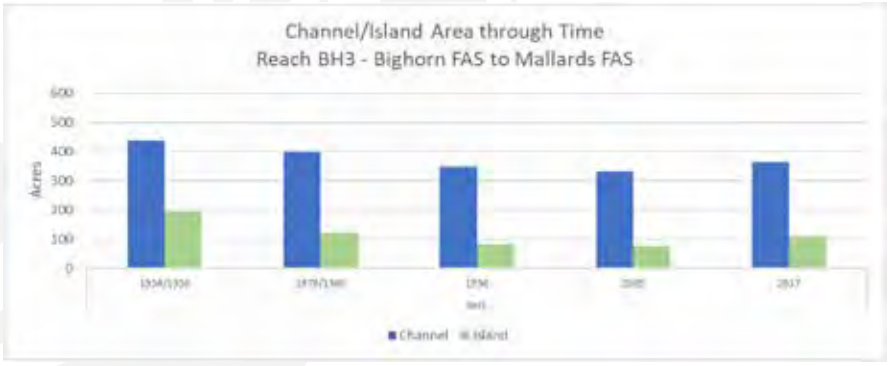

Figure 4. Change in channel and island area through time.

The study area is divided into seven defined reaches numbered upstream to down. These reaches are used to analyze changes in channel morphology through time as defined by the bankline and centerline mapping. The following are some preliminary findings of the analysis.

1. Visual inspection of the imagery indicates a clear loss of open bar area and channel complexity through time.

2. Bankline mapping shows a consistent loss in both channel and island area from the mid-1950s to 2005, with a slight rebound in 2017. Figure 4 presents the bankline mapping data for reach BH3 (Bighorn FAS to Mallards FAS), showing the loss of both channel and island area.

3. Approximately 13.8 miles of secondary and anabranching channel length has been lost between the mid-1950s and 2017 between the Afterbay Dam and the Yellowstone River.

IMPLICATIONS

The work completed under this part of the Research Initiative provides a foundation for future research efforts related to aquatic and floodplain habitats, channel stability, bank erosion, armoring effects, side channel evolution, and agricultural land loss. The data provide some historic context regarding longer-term system evolution as well as a modern snapshot of river conditions. The results are intended to help guide the development of effective management/restoration strategies as well as identify optimal locations for specific project implementation.

PROPOSED 2020

WORK PROGRAM

1 BENTHIC MACROINVERTEBRATE MONITORING

Lead Scientist
David Stagliano, M.S., Montana Biological Survey

Description and Objectives
The proposed monitoring plan is described in detail in "Bighorn River Aquatic Macroinvertebrate Monitoring: Sampling and Analysis Plan—2019," Montana Biological Survey, September 15, 2019. It proposes eight sampling sites, four of which have previously been sampled and will be suitable for historical trend analysis, and four of which are new sites. The sites are spread along the lower river from just below the Afterbay Dam to the Manuel Lisa FAS near the confluence with the Yellowstone River. Each site will be sampled twice, once in April and once at the end of September.

The monitoring data will provide critical information on temporal and spatial trends in these important biological indicators of aquatic habitat health and provide the basis for how we will study the way in which they are influenced by aquatic macrophyte beds, algae, aquatic invasive species, sedimentation, water quality and regulated flows.

Estimated Cost: $14,000

2 WATER QUALITY MONITORING

Lead Scientist
Anne Camper, Ph.D., MSU College of Engineering (retired)
Dr. Camper will be assisted by Emery Three Irons, a recent MSU M.S. graduate who will do the actual sample collection.

Description and Objectives
The proposed monitoring plan is described in detail in "Bighorn Lake and Bighorn River: Water Quality Monitoring: Sampling and Analysis Plan—2019," Stream and Watershed Consulting, September 15, 2019. Samples from the Lake will be taken from a 400-foot depth profile twice a month from April through October. Ten sites along the river will be sampled on the same schedule. One additional site will be on the Little Bighorn River just above the confluence with the Bighorn. Suspended solids (both organic and inorganic), nutrients, dissolved oxygen, turbidity, specific conductivity, chlorophyll-a, temperature, and selenium are the major parameters that will be analyzed.

The objective is to develop a data base that—1, describes both spatial and temporal trends in key water quality parameters known to be central to the overall health of the aquatic habitat and 2, helps us understand how water quality is affected by lake stratification, regulated flows and release patterns from the lake, irrigation withdrawals and returns, and other influences affecting the river.

Estimated Cost: $74,000
About one third of this total is one-time equipment purchase, one third is labor and one third is lab processing.

3 IDENTIFICATION OF PROJECTS MUTUALLY BENEFICIAL TO FARM AND RANCH OPERATORS IN THE BIGHORN VALLEY AND TO THE LONG-TERM HEALTH OF THE RIVER

Lead Investigator
Craig Hossfeld, P.E., Out West, LLC

Description and Objectives
The BHRA recognizes the significance of the Bighorn River to the farm and ranch operators of the Bighorn Valley. The objective of this study is to identify potential projects that would mutually benefit the agricultural operator and the river. The first step would be to identify potential sources of funding for demonstration projects that could potentially benefit the agricultural operator and the overall health of the river. Field research with agricultural operators and conservation oriented organizations will then identify a preliminary list of project opportunities. These will then be prioritized and the top five ideas will be detailed in short but detailed summary reports including maps, concept engineering designs, materials sourcing and estimated budgets, time frames, and potential funding strategies.

Estimated Cost: $10,000

4 CHANNEL MIGRATION AND INUNDATION ZONE MAPPING

Lead Investigator
Karin Boyd, Applied Geomorphology, Inc.
Important support in this task will also be provided by Tony Thatcher of RTM Consulting, Inc.

Description and Objectives
The primary objective is a series of Channel Migration Zone maps that extend from Afterbay Dam to the Yellowstone River, supported by public outreach that will focus on implications for the agricultural, tribal, and recreational sectors along the river. The maps will be built on work performed to date including air photo compilation and bankline digitization. The digitized banklines will be used to measure rates of channel migration, and we anticipate making hundreds of measurements where movement exceeds a certain minimum threshold. The rates will be statistically summarized to identify areas and extents of anticipated erosion over the next century. The resulting maps will include specific map units for the modern channel, historic channel footprint, erosion hazard areas, and avulsion hazard areas (floodplain areas where the river could rapidly create a new channel). The report will include the maps and a summary of methods and results. As resources allow, the processes influencing channel migration will be evaluated, such as floods and land use.

Estimated Cost: $17,000

SUMMARY OF THE 2020 WORK PROGRAM

The four activities described above represent our current plans for 2020. Contracts and detailed scopes of work will be developed later this fall, but the general outline and costs totaling approximately $115,000 are an accurate representation of our thinking at the present time.

SPECIAL THANKS TO OUR RESEARCH INITIATIVE FOUNDING UNDERWRITERS:

- Bill and Jane Anderson Memorial
- Frans and Dana Andersson
- Jim and Josie Chalmers
- Dr. Sam and Barbara Jampolis
- Montana DNRC Watershed Management Grant
- Allen and Michelle Neelley
- Patagonia
- Jim and Chris Scott
- Sunlight Ranch Corporation

SO, YOU ARE PROBABLY WONDERING HOW YOU CAN HELP

Contributors at the $10,000 level up to 12/31/2019 will be recognized as "Founding Underwriters." Contributors at this level subsequent to this date will be recognized as "Underwriters."

Contributors at the level of $5,000 will be recognized as Patrons of the Research Initiative.

Contributors at the level of $2,500 will be recognized as Benefactors of the Research Initiative.

Contributions at other levels are much appreciated and critical to the work of the Alliance but will not be restricted to support of the Research Initiative unless otherwise specified.

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Comments and suggestions on the Research Initiative are always welcome. *They can be directed to:*

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EXECUTIVE DIRECTOR
emery@bighornriveralliance.org

or to:

JIM CHALMERS
RESEARCH CHAIR
jameschalmers@vcn.com