THE RESEARCH INITIATIVE

2020

REPORT 5

PROTECT • PRESERVE • ENHANCE

FARMS AND FISH: PROJECTS BENEFICIAL TO THE LONG-TERM HEALTH OF THE BIGHORN RIVER

PREPARED FOR:

BIGHORN RIVER ALLIANCE

THE RESEARCH INITIATIVE

PREPARED BY:

Craig Hossfeld, PE
Out West, LLC
craig@outwestllc.com

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PROJECT OBJECTIVES

The Bighorn river watershed is an extensive ecosystem utilized by multiple parties with differing priorities. The objective of this portion of the 2020 BHRA research initiative was to use Out West's background in the farming and ranching industries alongside their technical expertise to research a series of prototype projects and future research avenues that are mutually beneficial to the farm and ranch operators, anglers, and other river users to facilitate a better

I: TURBID RETURNS EXAMINATION

Project Summary

A major point of contention between the agricultural community and the recreational users of the Bighorn River has been high turbidity or “cloudy” return flow to the river as shown in ***Figure 1***. These return flows increase river turbidity which impacts fishable areas and overall river health. These turbid tail waters are also a problem for the agricultural operator as they can carry away valuable topsoil and nutrients that are important for long term productivity and can increase maintenance costs of irrigation infrastructure.

It must first be stated that not all highly turbid inflows are a result of agricultural operations, in fact the inflow displayed in Figure 1 is at the confluence of the Bighorn River and Soap Creek which has relatively low agricultural returns and has a high storm water contribution. Although not all turbidity is a result of agricultural operations, there are projects that can be completed to reduce the agricultural impact to turbidity.

Figure 1: Example of high turbidity flow into Bighorn River with the clear river water on the left and turbid returns from Soap Creek on the right.

Irrigation Return Flow Reduction

For this year’s initial investigation, we focused on the irrigation of lands adjacent to the Bighorn river from the afterbay to the 13 miles access (see Figure 2). Of the approximately 8,600 acres of irrigation on these surrounding lands ~2,500 acres are irrigated pasture or grasslands (Figure 2, red) and ~6,100 acres are irrigated cropland (Figure 2, green). Irrigated cropland will be the biggest driver of high turbidity tail water as the land will have more exposed dirt and be disturbed more frequently.

The best way to reduce turbid tailwater is to eliminate the tailwater completely through sprinkler irrigation. From an agricultural perspective, sprinkler irrigation is desirable as it increases crop yields and utilizes water more efficiently. Currently only 558 acres of the ~6,100 acres of irrigated cropland are under sprinkler irrigation (Figure 2, pink). Through our investigation we found that ~750 of the remaining acres are prime center pivot locations, and ~1,500 acres are prime for either lateral machines or wheel

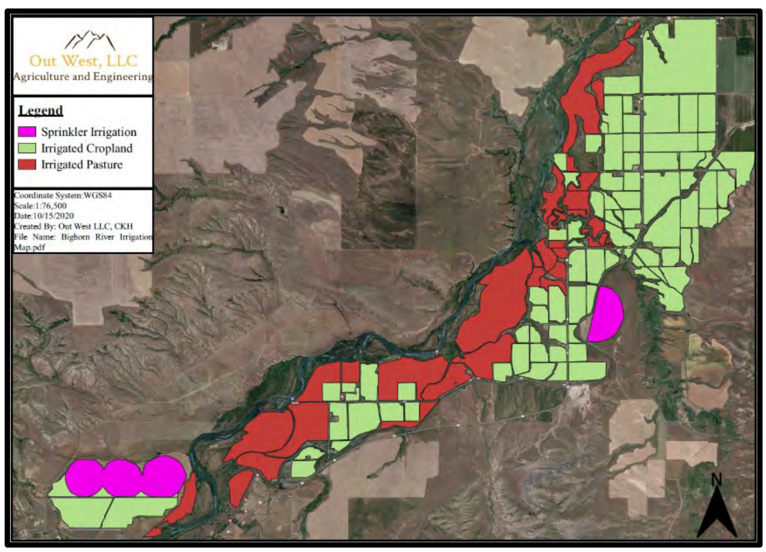


Figure 2: Map delineating the different types of irrigated acres adjacent to the first 13 miles of the Bighorn river. Irrigated grasslands (red) adjacent to the river that are effective at reducing water turbidity. More can be done to reduce turbidity through continued conversion of flood irrigated land (green), into sprinkler irrigated acres (purple) with a joint effort to push through the obstacles that have held up development to date.

line irrigation. Converting these acres would reduce cropland irrigation returns by ~37% and lower the turbidity of the return flow to the river during irrigation season. Please refer to the supporting material in Appendix I for NRCS cost scenarios for converting from flood to sprinkler.

Figure 3: Example of a lateral move irrigation. These machines are built nearly identical to center pivots, but the whole machine moves along in a straight line, either pulling a hose from riser to riser or pulling water directly from a ditch along the field edge. Lateral machines are ideal for conversion of long slender fields into sprinkler irrigation regardless of crop type. *(Source:wallsirrigation.com)*

Flood to sprinkler conversion is not a new concept but unfortunately there are significant roadblocks to these projects. Crop type, high capital investment, fractionated ownership, and relatively short-term leases have all contributed to the low acreage under sprinkler irrigation in the area. For example, any landowner that grows sugar beets or corn cannot irrigate their land through wheel lines and must instead invest in lateral machine (Figure 3) or center pivot irrigation. Although these types of irrigation are more efficient, the capital investment is significantly higher often making the project a nonstarter. Additionally, the land in question is extremely fractionated and may involve 4 or more owners with lease ground. These ownership dynamics have led to shorter term leases that do not allow for financial payback of the capital investment in the timeframe the operator has a secured lease; further, they complicate the ability to get cost share funding.

More research, planning, and cooperation will be required to overcome these hurdles, but the effort will result in significant benefits to all parties involved. Please refer to Section III for our idea on a potential long-term coalition that we believe may help bridge the gap on some of these issues.

Ditch Bank Erosion

Irrigation returns are not the only driver of agricultural turbidity. The Bighorn Canal Irrigation System is vast, with miles of ditches that convey the water from the diversion at the afterbay to the individual fields for irrigation, and any return flows back to the river. This large system contains miles of open top ditches cut into the soil. When traveling through ditches, water will naturally “wander” which cuts banks and irrigation structures and causes significant erosion as shown in Figure 4. This ditch erosion causes turbidity and increases the cost of operation for the irrigation users.

Figure 4: Irrigation ditch that shows signs of wandering, bank cutting, and erosion around irrigation structures.

The best solutions to ditch bank erosion remove the water to soil contact; typically, through lining the ditch with either concrete or plastic or converting the ditch into a pipeline. Lining ditches is a major undertaking with large capital investment requirements and long-term maintenance and operation consequences that must be considered. Pipeline conversions also require a high capital investment but are incredibly stable long term and provide additional benefits to the water users.

Ditch to pipeline conversion is a great solution for ditch bank erosion and provides added benefits to the agricultural users through “free” pressurization of the water. As water runs down-hill in a full pipeline, the static pressure in the line will increase. This pressurization of the water allows for water users to convert from flood to sprinkler irrigation more easily as the cost of pressurizing the water is reduced. Additionally, pipeline water systems can reduce operational cost and management difficulties as water in a pipeline is available in more of an “on-demand” manner.

Conversion from a ditch to a pipeline is not always feasible, as pipeline systems are expensive, more complicated, and require additional structures if the ditch both provides water and collects return flow (which will also reduce the pressure available). While these factors limit the possible locations for conversions, we still believe there are applications to reduce ditch bank erosion and provide benefit. To maximize the benefit to all parties, a targeted implementation of ditch to pipeline conversions could begin where there is significant elevation drop from the main canal to the fields, there is no return flow to the ditch, and some (or all) users intend to convert from flood to sprinkler irrigation. See Example Project 1 below for one potential area of conversion.

Example Project 1: Targeted Ditch to Pipeline Conversion

The ditch shown in Figure 4 above is a prime location for a targeted conversion as it has existing sprinkler irrigation, significant drop from the canal to the fields, no return flow from any flood irrigated fields, and additional locations for flood to sprinkler conversion. Figure 5 below displays the aerial view of the ditch with the acres served highlighted in green hashmark and existing sprinkler irrigation noted in pink. The water would flow East to West along the southern edge of the acreage (blue line) and with the 50ft+ drop in elevation from the canal, users at the end could see as much as 20psi in “free” pressurization. Each red star on the pipeline is a location where an outlet structure may be required.

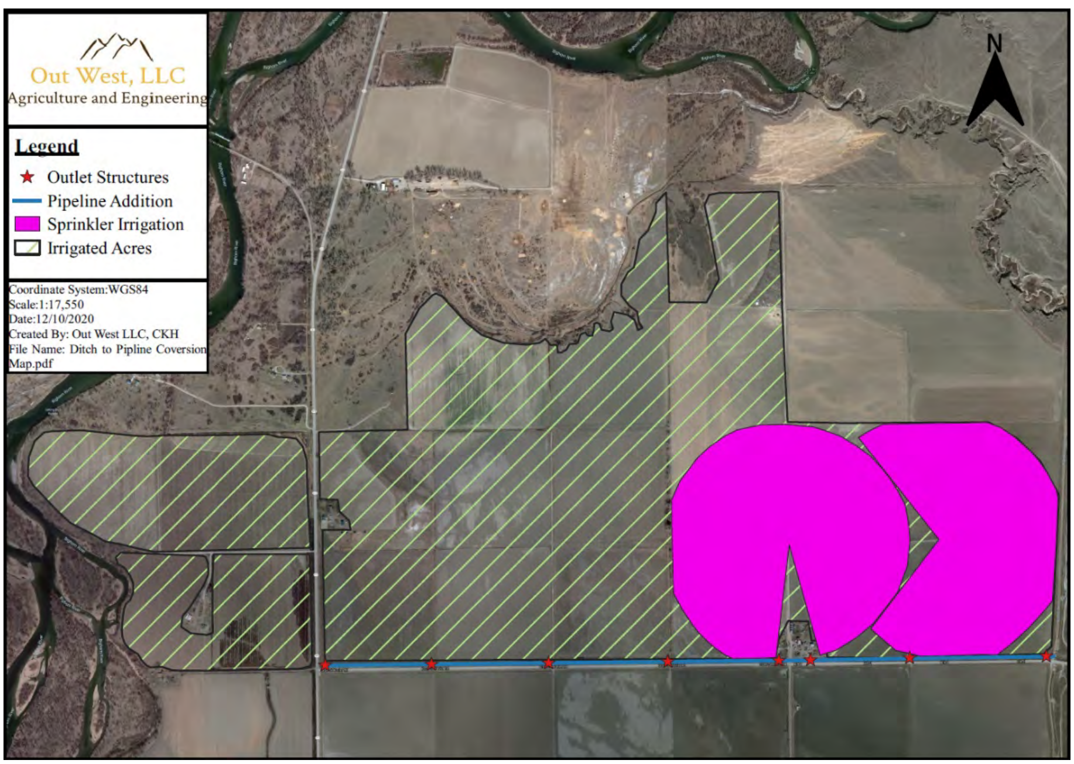


Figure 5: Example ditch to pipeline conversion project map with acres served in green, existing sprinkler irrigation in pink, pipeline path in blue, and potential structure locations for water outlets noted with red stars. This ditch contains: landowners willing to convert to sprinkler irrigation, no return flow to gather, and significant drop from the canal making it an ideal location for a pipeline conversion project.

Significant further research, engineering design, and landowner involvement would be required to fully understand the costs associated with this example project, but pipeline and installation costs alone would push $250,000 without a revised inlet structure, outlet structures, etc. This project would require a high capital investment, significant changes in irrigation practice for the landowners, and cooperation from multiple parties, but the benefits of increased irrigation efficiency, reduced maintenance costs, and reduced turbidity to the river make it a prime project worthy of the effort required.

Other Sources of Turbidity

During our investigation of the canal system, we found that there was noticeable sediment entering the system from adjacent grassland as shown in Figure 6. This sediment appears to be a result of storm events moving large volumes of water through areas with low vegetation density. We are currently working on trial applications of broadcast spreading advanced seed blends that have special coatings and using livestock traffic to bed the seeds in the ground to increase seed germination and vegetation density.

The increased vegetation would not only reduce soil erosion but would provide an increase in forage production for grazing livestock. We believe these methods, combined with a prescribed grazing plan would allow for reduced non-farm ground erosion, better pasture and waterway health, and increased forage production for the operator. Further studies and analysis are needed to understand the viability of the potential solution.

Figure 6: Sediment flow from adjacent grassland entering the Bighorn Canal. Increasing vegetation density could dramatically reduce the storm runoff in areas

II: LIVESTOCK ACCESS IMPROVEMENT CONCEPTS

Project Summary

Cattle access to the Bighorn River and surrounding waterways is a critical component of the local livestock industry as they provide consistent, cool, sustainable water for local ranchers and a comfortable environment for the cattle, especially during the hot summer months. Unfortunately, cattle do not always choose ideal locations for access and occasionally use steep, unstable, and highly erodible areas. These access points put the livestock at risk and deteriorate river and ditch banks. Through aerial and on the ground investigation we identified a series of locations where current livestock activity can be controlled to promote access in naturally occurring, ideal locations for the cattle and bank health. Fence lines would be installed to direct cattle movements to more ideal locations and, in some cases, solar water set-ups added to provide ample, clean drinking water to the livestock if a suitable access is not located within the pasture. Implementing these projects will both benefit the livestock industry and the abundant river users, while promoting better health for the river ecosystem.

Figure 7: Livestock access to the Bighorn Canal causing significant ditch bank erosion leading to reduced livestock performance, increased maintenance costs, and turbidity in canal returns to the river.

Method

Through aerial imagery, we analyzed the notable cattle access zones for the Bighorn River from the afterbay to the Yellowstone River and the Bighorn Canal from the diversion to Hardin MT. In many cases it was clear livestock were accessing and utilizing the waterways with minimal negative impacts, but there also exist areas where improving access will improve bank stability and water quality. Out West traveled to the Bighorn Canal and Bighorn River to investigate these locations more closely.

Figure 8: Common cattle access to the Bighorn River where the approach to the water is gradual and naturally rocked. Cattle access in these areas are ideal for cattle and the river health.

On the first trip Justin and Craig Hossfeld met with Doug Greenwalt and traveled the Bighorn canal to identify these cattle damaged locations. While many locations had stable bank access and no notable damage to the canal, there were some areas where cattle were clearly entering and loitering in the canal, causing accelerated erosion and higher water turbidity (see Figure 7). This bank erosion not only raises turbidity of the canal stream that terminates in the Bighorn River, but it also increases the maintenance cost for the users of the canal and can lead to stuck cattle and poor-quality livestock water.

In a second session of field work, James Chalmers, Dennis Fischer, and Craig Hossfeld drifted the first 13 miles of the Bighorn River to investigate cattle access and its impact on this stretch of the river. During this investigation, two types of cattle access were evident. In Figure 8, the cattle access is ideal for both livestock and riverbank health. These access points have a gradual slope and a naturally rocked bank that does not contribute significant erosion or turbidity from cattle movements. There was however a smaller subset of accesses that more closely resemble Figure 9. These access points are steep and have no natural rock or vegetation to stabilize the bank. Access at these points is dangerous for cattle and negatively impacts river users through the creation of localized mud holes.

After investigating and cataloging the different waterway access points. Out West derived two example projects to eliminate poor access points on both the River and Canal and provide a benefit of increased cattle safety to the owner.

Figure 9: Example cattle access in a steep location with little or no vegetation or rock to create a stable access point along the riverbank. Cattle access in these areas is not ideal for cattle and creates local "mud holes" for river users.

Example Project 2: Canal Access Removal with Solar Water Station

In Figure 7 you can see that the consistent cattle access to the canal has caused rapid erosion of the canal bank and a significant mud hole in the canal. These areas are not safe for cattle access and can lead to stuck cattle, poor water quality, and reduced cattle performance. Additionally, the erosion from the cattle access increases turbidity of the canal that eventually terminates at the Bighorn River. Both issues can be eliminated through removing cattle access to the canal, but reliable water is still necessary for the livestock.

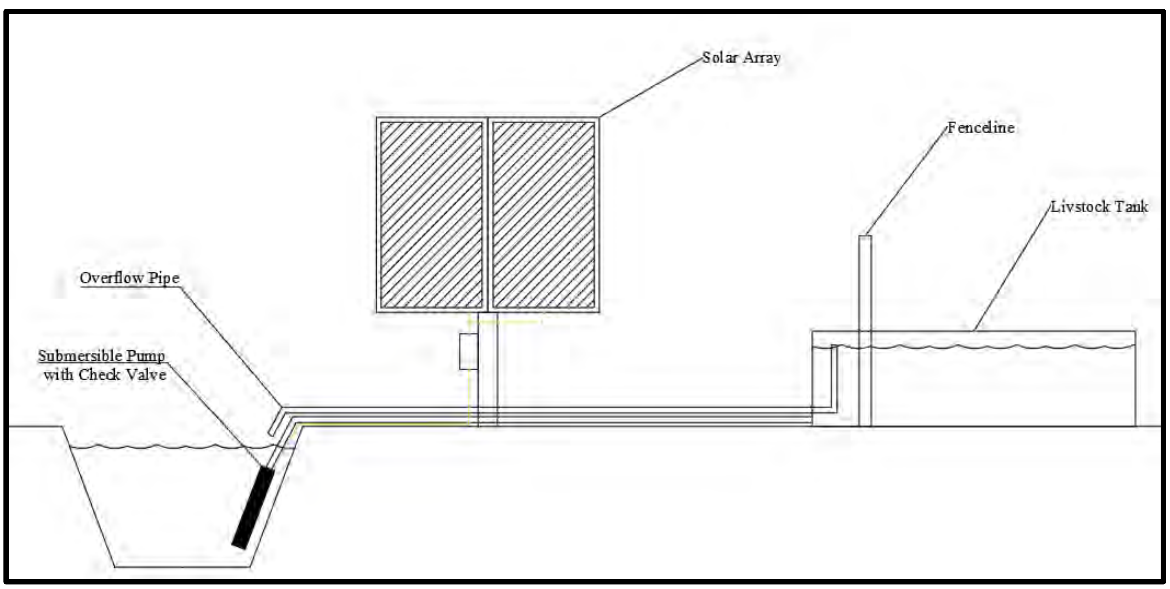


Figure 10: Example solar powered water location with fence line to keep cattle out of the waterway and away from critical solar components. In this design, water pumps from the ditch during the day to fill a tank and provide fresh water for cattle and any excess pumped water returns directly to the ditch for downstream use. These systems can be portable and used in multiple locations as cattle move from pasture to pasture.

To solve both problems Out West proposes that the canal could be fenced off from the pasture, and a solar powered pumping unit be added as shown in Figure 10. This solution provides benefit to the rancher (increased cattle safety and performance), the other canal users (reduced canal maintenance), and the river users (lowered turbidity on return) through its reduction in bank erosion. As this problem/solution relates to water quality, it is possible the rancher would be able to receive financial assistance to complete the project. Table 1 breaks down the anticipated costs implementing this solution with NRCS EQIP funding examples to show the potential funding relief that conservation agencies can provide.

Table 1: Cost Breakdown of Example Canal Fence Off Project.

Detail	**Cost**
Barbed Wire Fence with Braces and Gates	$8,900
Livestock Tank	$1,500
Pipe and Fittings	$1,000
Pump, Solar Panels, Controls	$3,500
Pumping Equipment Fencing and Tank Frame	$1,500
Installation	$2,300
Total Cost	$18,700
Potential NRCS EQIP Funding (or similar)	$10,600
Remaining Cost	$8,100

Fencing off the canal from livestock entry is mutually beneficial to all interested parties through increase in livestock performance, lowered canal maintenance, and decreased turbidity, furthermore, as shown in Table 1, the cost of the improvement can remain reasonable. Implementing this improvement along the canals, ditches, and the river itself allows for better livestock and waterway management, while providing a benefit to the waterways themselves.

Example Project 3: Bighorn River Cattle Access Improvement

In our third demonstration project, we turned our attention to a poor access point for cattle directly on the Bighorn River across river from an area known locally as “The Corrals”. As you can see in the top of Figure 11, cattle are utilizing a steep unstable bank for access, causing significant bank erosion, muck holes, and putting themselves in danger in the process. To alleviate this cattle access problem, Out West mapped and investigated the pastures adjacent to the hill and found that there were natural watering points nearby that were ideal for the cattle and for the river, as shown in the bottom image of Figure 11. These points were flat with gradual approaches and a naturally rocked bank. Through the implementation of properly placed fencing, cattle can be directed to the ideal water locations and the access to the steep bank can be removed. This is not only beneficial to the river users, but it increases livestock safety.

Figure 11: *Top:* Existing cattle access point on a steep, unstable location causing bank erosion and unsafe conditions for livestock. *Bottom:* Nearby ideal access location with gradual slope and naturally rocked waterline.

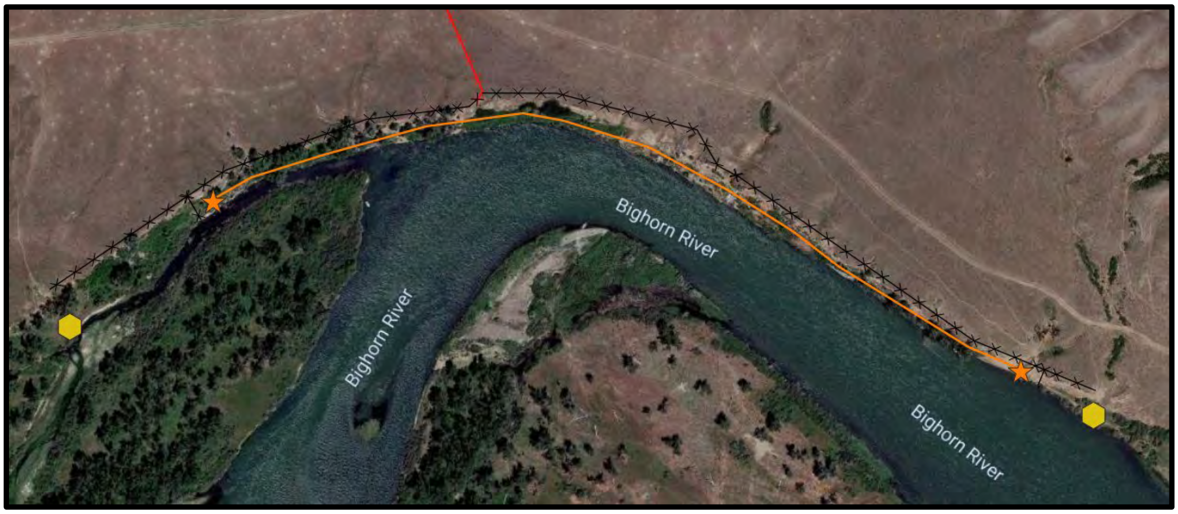


Figure 12: Aerial view of the cattle access where the existing fence (red line) would be expanded to the east and west (black lines) to eliminate current cattle access (between orange stars) and redirect their movements to ideal river access points (yellow hexagons).

Figure 12 demonstrates the fencing additions that would eliminate access on the steep unstable locations and naturally direct the cattle to the safer, more environmentally friendly access points. Again, under the umbrella of water quality, and grazing plan improvement, it would be possible for the landowners to receive funding assistance for the completion of this project. Table 2 breaks down the potential costs of the project and potential funding relief.

Table 2: Cost breakdown of fencing project to redirect cattle from unstable watering locations to more ideal river access.

Detail	**Cost**
Barbed Wire Fences	$8,058
Fence Braces and Gates	$2,875
Staking, Planning, and Project Management	$1,125
Total Cost	$12,058
Potential NRCS EQIP Funding (or similar)	$5,655
Remaining Cost	$6,403

As above with the canal access removal in project 1, utilizing fences to redirect cattle movements is an elegant way to maximize the impact of the money we spend towards mutual benefit of all river users and the river ecosystem itself. Livestock managers benefit through the increased safety of their cattle and management options, river users will see a reduction in localized muck holes, and the river ecosystem will benefit through management of bank erosion.

III: LONG-TERM WORKING GROUP FORMATION

Group Formation Process

Accomplishing the joint goals of all river users is a monumental task that cannot be tackled in one year by a small group of people. Through our investigation of funding avenues available, we found multiple opportunities to maximize both funding and the overall impact of a collaborative effort (see below). We believe that a long-term working group could be established with representation from all watershed users with the long-term goal of partnering with the NRCS in the Regional Conservation Partnership Program (RCPP) to access a portion of the $300 million-dollar annual budget and maximize the impact we can all have on the Bighorn River, river users, and surrounding industries.

Creating a working group with representation of all watershed users will be a difficult task that we believe is best completed in a multistep process as shown in the flow chart in Figure 13. Initially, the group could incorporate a small subset of users that believe in the overall goal and complete smaller projects like those detailed in Sections I and II in high visibility areas to increase awareness, gain membership, and prove the concept to funding agencies. These projects have a great funding pool of the NRCS Environmental Quality Incentives Program (EQIP) but will also require the financial support of the group for completion (NRCS funding is a cost share program where the landowner must provide funding to the projects as well as the NRCS). With the successful completion of multiple smaller projects, and the relationships built along the way, the working group could increase its scope and aim to complete larger projects applying for grants and other large-scale funding as detailed in the Major Funding Avenues section below.

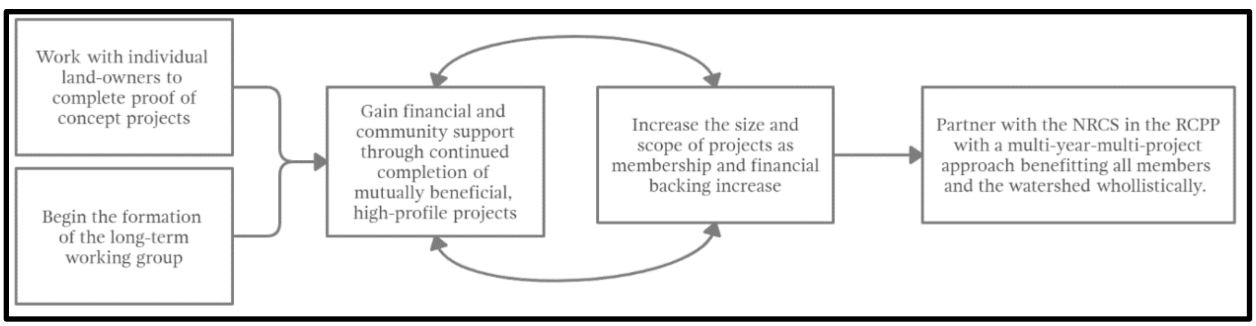


Figure 13: Workflow for the formation of a working group to overcome the obstacles that have stood in the way of sweeping changes along the upper Bighorn River.

The politics of groups of this magnitude can be the greatest obstacle to their success. The Bighorn watershed has many users with diverse background and goals. These groups include anglers, agricultural operators, The Crow Tribe, livestock operators, the city of Hardin, boaters, outdoorsmen, state, local, and federal agencies, and more. The sheer number of involved parties will lead people to believe that a functional group is not possible. This is why we believe utilizing a small step by step process will be highly valuable as it will allow for flexibility both in process and proof of concept to skeptical individuals.

Major Funding Avenues

Natural Resource Conservation Service (NRCS)

The NRCS is the premier funding opportunity for projects involving natural resource conservation that tie to livestock and agricultural operations. They have a wide variety of programs from single year low-cost upgrades to multiyear multimillion-dollar projects. Local agricultural producers will be used to dealing with the NRCS and may already have a good existing relationship. The only potential drawback to NRCS projects is they require the producer to provide information for application and they have some regulations on what materials and methods can be used. The NRCS uses a scoring system to prioritize the funding of projects and often has more applications than funds, so matching the project with the current focus of the NRCS can be beneficial. Below are three of the more applicable programs in the NRCS for the type of projects the BHRA is interested in completing:

Environmental Quality Incentives Program (EQIP): EQIP is a program through the NRCS that provides technical and financial assistance to agricultural producers to address environmental concerns such as water, air, and soil quality. This voluntary program is widely used by producers in the agriculture industry to implement upgrades to their operation without having to bear the full cost. This is the funding pool we used to show potential funding on the example projects. They currently are focused on conversion from flood to sprinkler, and those projects would score highly in their system.

Conservation Innovation Grant (CIG): Another program within the NRCS that has promise to provide significant funding and increase awareness is the Conservation Innovation Grant program (CIG). The CIG program exists to promote innovative conservation methods and provide them with the funding required to begin implementation. The CIG program specifically notes one of their goals to be improving water quality while improving agricultural operations, a perfect alignment with the proposed working group. Funding through the CIG would also serve to increase exposure and can lead to increased awareness and funding pools available for the group efforts.

Regional Conservation Partnership Program (RCPP): An example of these funding avenues is the NRCS Regional Conservation Partnership Program (RCPP). The RCPP promotes coordination of the NRCS conservation goals with motivated cooperators to maximize positive impact and return on investment. Within the RCPP, there exists the ability to get incorporated as an Advanced Funding Arrangement project (AFA) that functions more like a grant and unlocks significant funding pools (year 2020 AFA's averaged $5 million per project in funding from the NRCS).

It is typical for NRCS funding opportunities to require that the entity receiving the funding also provide financial assistance to the project, often in a one-to-one ratio (up to 70% NRCS – 30% landowner). This assures that everyone is fully committed to the goals, but it will require that all members of the working group would reach out to other members of their industry or discipline to create an internal funding pool.

Other Potential Funding Resources

Conservation Groups (Ducks Unlimited, Rocky Mountain Elk Foundation, Mule Deer Foundation, etc.): There are many outdoor foundations that are eager to aid in implementing projects or programs that directly benefit natural resources. Local producers may be willing to provide controlled access to their lands to facilitate a relationship with these groups. Funding from these groups could potentially be combined with the cost sharing avenues to completely fund some projects.

National Fish and Wildlife Foundation (NFWF) Grants: NFWF awards grants to entities looking to perform conservation activities that align with their current conservation objectives. The grants are awarded competitively and must follow their specific guidelines to apply. The NFWF partners with multiple other state and federal entities as well a private corporation to supply funding to these projects. Two current NFWF objectives that may align with the goals of the long-term working group are:

- The Conservation Partners Program: This program provides funding to support organizations that are assisting private landowners to maximize the benefits of the Farm Bill.
- The Rocky Mountain Rangelands Program: This program focuses on the conservation of rangeland in the rocky mountain region as it pertains to sagebrush rangelands, wetland birds, and native fish.

IV: CONCLUSIONS

Marrying the goals and actions of all river users is the best way to both foster productive relationships and support the healthiest ecosystem for the river. We were tasked by the BHRA to seek out projects and research avenues that would mutually benefit all parties and help foster a productive relationship.

Our first avenue of research was to investigate the turbid return flows into the river, often attributed to the irrigation practices of the watershed. While not all the turbid returns are a direct result of farm and ranch activities, we did outline methods that can be used to lower the impact of agricultural operations. Unfortunately, we also found that there have been significant roadblocks to the implementation of these concepts that still stand today. Cooperation and additional research will be required to help move past these obstacles and continue the evolution of the agricultural operations of the watershed.

Second, we analyzed the cattle access of the Bighorn River and Bighorn Canal system and found that in most cases existing access points are well designed and create safe and environmentally friendly locations for livestock to water and enjoy the natural landscape alongside river users. It is clear however that there does exist access points that are not safe for cattle and create undesirable situations. Controlling or eliminating these access points through fencing and solar powered water systems would be a positive step forward in these ecosystems and the partnership between local industry and recreational users.

Finally, we researched potential funding avenues for these projects and determined that creating a long-term working group with representation from all users of the water shed could unlock significant funding and impact real change for the river and its users. Many of the projects that can make an impact are both technically and financially daunting, often overwhelming individual owners or small groups and slowing progress. A larger group can divide the burden and make these projects more attainable. It should be noted that while the problems associated with each individual project do not appear to contribute large negative consequences to water quality or river use, combining these projects as part of a wholistic plan can contribute to significant overall improvement that benefits all users of our precious natural resources.

V: REFERENCES

Natural Resources Conservation Service. (n.d.). Retrieved January 15, 2021, from https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/

NFWF. (n.d.). Retrieved January 15, 2021, from https://www.nfwf.org/

W. (2021). Irrigation Systems. Retrieved January 15, 2021, from https://www.wallsirrigation.com/irrigation-systems/

Appendix I: Supporting Material

Attached:

Bighorn River Irrigation Map

Ditch to Pipeline Conversion Map

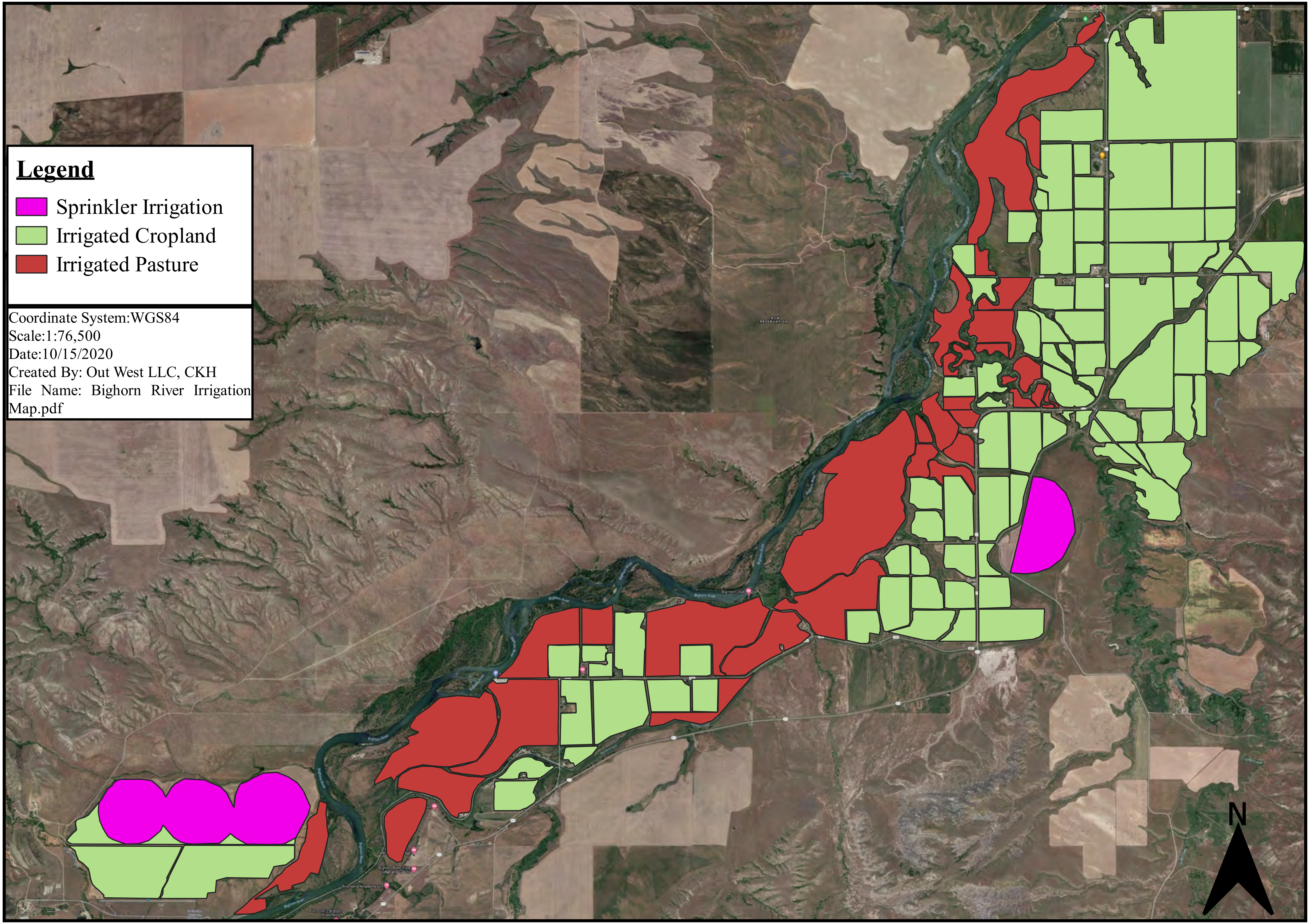
USDA NRCS Center Pivot Sprinkler System Scenario

USDA NRCS Linear Move System Scenario

USDA NRCS Wheel Line System Scenario

River Access Example Map

Solar Powered Livestock Tank Unit Diagram


Legend
Sprinkler Irrigation
Irrigated Cropland
Irrigated Pasture
Coordinate System:WGS84
Scale:1:76,500
Date:10/15/2020
Created By: Out West LLC, CKH
File Name: Bighorn River Irrigation Map.pdf
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Legend
Outlet Structures
Pipeline Addition
Sprinkler Irrigation
Irrigated Acres
Coordinate System:WGS84
Scale:1:17,550
Date:12/10/2020
Created By: Out West LLC, CKH
File Name: Ditch to Pipline Coversion Map.pdf
Bighorn River

Practice: 442 - Sprinkler System

Scenario: #4 - Center Pivot, >/=1,200 feet

Scenario Description:

Installation of a low pressure center pivot system. Resource concerns include: Soil Erosion (Concentrated flow erosion e.g. irrigation induced), Insufficient Water (Inefficient use of irrigation water), Water Quality Degradation (Excess nutrients in surface and ground waters, Excessive salts in surface and ground waters, Excess pathogens and chemicals from manure, bio-solids or compost applications). Associated Practices: Irrigation Pipeline (430), Pumping Plant (533), Irrigation Water Management (449)

Before Situation:

A 180 acre field is flood irrigated. Application of irrigation water is inefficient and non-uniform. Irrigation water is typically over applied in some parts of the field, and under applied in others. Deep percolation from the excess irrigation delivers excess nutrients salts, and chemicals to the ground water. Runoff from the field contains excess nutrients and degrades the receiving waters. Irrigated induced erosion is excessive.

After Situation:

The existing surface irrigation system is converted to a 1380 linear foot low pressure center pivot. The pivot covers 137 acres and an endgun addes 10 more acres for a total of 147 acres. Pivot includes pressure regulators and low pressure sprinklers on drops, end gun with pump. The new irrigation system has a coefficient of uniformity above 85%. Irrigation water is efficiently and uniformly applied to maintain adequate soil water for the desired level of plant growth. Deep percolation and field runoff is eliminated and there are no excess nutrients, salts or pathogens delivered to the receiving waters. Irrigation induced runoff is eliminated. This center pivot scenario includes all hardware from the pivot point, including the concrete pad the pivot is placed on, and the end gun.

Feature Measure: Acres under Center Pivot

Scenario Unit: Acres

Scenario Typical Size: 147.0

Scenario Total Cost: $86,858.46

Scenario Cost/Unit: $590.87

Cost Details:

Component Name	ID	Description	Unit	Cost	QTY	Total
Materials						
Irrigation, Center pivot system with appurtenances, fixed cost portion	317	Fixed cost portion of the center pivot system with appurtenances. This portion includes the following items: pivot point, pipe, towers, pad, controls, sprinklers, installation.	Each	$5,408.72	1	$5,408.72
Irrigation, Center pivot system with appurtenances, variable cost portion	318	Variable cost portion of the center pivot system with appurtenances. This portion includes the following items: pivot point, pipe, towers, pad, controls, sprinklers, installation.	Feet	$58.84	1380	$81,199.20
Mobilization						
Mobilization, medium equipment	1139	Equipment with 70-150 HP or typical weights between 14,000 and 30,000 pounds.	Each	$250.54	1	$250.54

Practice: 442 - Sprinkler System

Scenario: #7 - Linear Move System

Scenario Description:

Installation of a linear or lateral move sprinkler system with sprinklers on drops with or without drag hoses to improve irrigation efficiency and reduce soil erosion. Payment rate is figured per foot of installed hardware length. Resource concerns include: Soil Erosion (Concentrated flow erosion e.g. irrigation induced), Insufficient Water (Inefficient use of irrigation water), Water Quality Degradation (Excess nutrients in surface and ground waters, Excessive salts in surface and ground waters, Excess pathogens and chemicals from manure, bio-solids or compost applications), Inefficient Energy Use (Equipment and facilities e.g. pumping). Associated Practices: Irrigation Pipeline (430), Pumping Plant (533), Irrigation Water Management (449)

Before Situation:

A 76 acre field is flood irrigated. Application of irrigation water is inefficient and non-uniform. Irrigation water is typically over applied in some parts of the field, and under applied in others. Deep percolation from the excess irrigation delivers excess nutrients salts, and chemicals to the ground water. Runoff from the field contains excess nutrients and degrades the receiving waters. Irrigated induced erosion is excessive.

After Situation:

A typical unit is approximately 76 acres in size with the sprinkler system up to 1280 feet in length with drop tubes that have a minimum of 30" spacing. The new irrigation system has a coefficient of uniformity above 85%. Irrigation water is efficiently and uniformly applied to maintain adequate soil water for the desired level of plant growth. Deep percolation and field runoff is eliminated and there are no excess nutrients, salts or pathogens delivered to the receiving waters. Irrigation induced runoff is eliminated. End gun is included in price

Feature Measure: Length of Linear Move Lateral

Scenario Unit: Feet

Scenario Typical Size: 1,280.0

Scenario Total Cost: $143,714.48

Scenario Cost/Unit: $112.28

Cost Details:

Component Name	ID	Description	Unit	Cost	QTY	Total
Materials						
Linear Move System with appurtenances	322	Linear/lateral move system including: central tower, lateral towers, pipes, sprinklers, controllers, installation.	Acres	$1,890.98	76	$143,714.48

Practice: 442 - Sprinkler System

Scenario: #8 - Wheel Line System

Scenario Description:

A 1,280 foot wheel line (also called side roll, wheelmove, or lateral-roll) with 5-7 foot diameter wheels and five inch diameter supply pipeline. A wheel line consists of the mover, lateral pipe, wheels, sprinklers, couplers, and connectors to the mainline supply. Resource concerns include: Soil Erosion (Concentrated flow erosion e.g. irrigation induced), Insufficient Water (Inefficient use of irrigation water), Water Quality Degradation (Excess nutrients in surface and ground waters, Excessive salts in surface and ground waters, Excess pathogens and chemicals from manure, bio-solids or compost applications), Inefficient Energy Use (Equipment and facilities e.g. pumping). Associated Practices: Irrigation Pipeline (430), Pumping Plant (533), Irrigation Water Management (449)

Before Situation:

Cropland that is flood irrigated and has poor irrigation efficiency and distribution uniformity. The slope and irregular shape of the field limit the potential for improved management to improve the irrigation efficiency or the distribution uniformity. Irrigation water moves both within the field and off it, resulting in wet areas, runoff and deep percolation. Parts of the field are over-irrigated, and other sections are under-irrigated. Runoff from the field flows into streams, water courses, and other water bodies. Excess applied irrigation water infiltrates into ground water causing degradation to the receiving waters.

After Situation:

A 1,280 foot wheel line with 7 foot diameter wheels and five inch diameter supply pipeline. Sprinklers are spaced along the wheel line at 40-foot intervals and risers are spaced at 60-foot increments along the mainline. The wheel line irrigates 40 acres of cropland. The wheel line improves distribution uniformity. Irrigation application efficiency improves to 75%. Water application rates meet the consumptive use of the crop and matches soil intake rates in order to prevent irrigation induced erosion, runoff, and deep percolation.

Feature Measure: Length of Wheel Line Lateral

Scenario Unit: Feet

Scenario Typical Size: 1,280.0

Scenario Total Cost: $24,656.06

Scenario Cost/Unit: $19.26

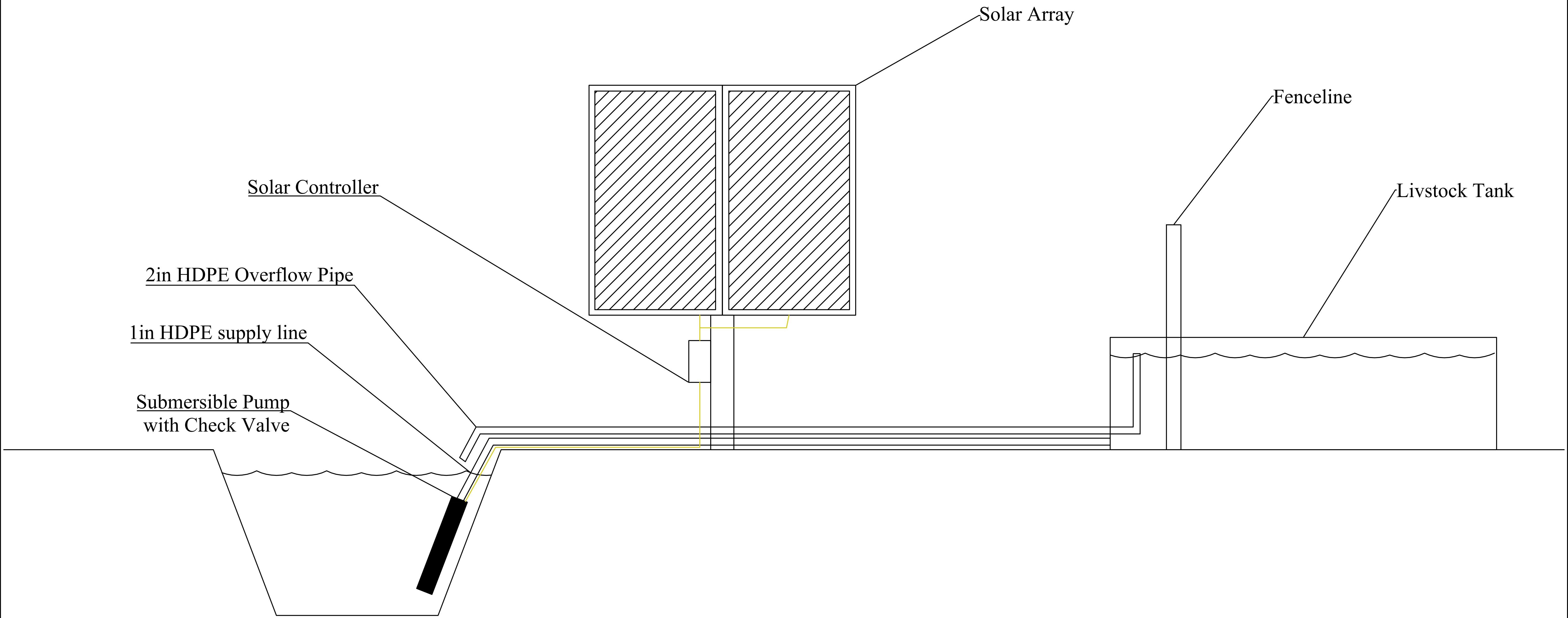
Cost Details:

Component Name	ID	Description	Unit	Cost	QTY	Total
Materials						
Irrigation, Wheel line with appurtenances, fixed price portion.	325	Fixed cost portion of the wheel line system with appurtenances. This portion includes the following items: mover, pipe, sprinklers, wheels, installation.	Each	$6,744.64	1	$6,744.64
Irrigation, Wheel line with appurtenances, variable price portion.	326	Variable cost portion of the wheel line system with appurtenances. This portion includes the following items: pipe, sprinklers, wheels, installation. Does not include a mover.	Feet	$13.73	1280	$17,574.40
Mobilization						
Mobilization, small equipment	1138	Equipment <70 HP but can't be transported by a pick-up truck or with typical weights between 3,500 to 14,000 pounds.	Each	$168.51	2	$337.02

Legend

- Unstable/Unsafe Livestock Access
- Ideal Livestock Acceses to Water
- Existing Fence
- New Fence Additions

Coordinate System:WGS84
Scale:1:4,200
Date:12/23/2020
Created By: Out West LLC, CKH
File Name: River Access Example Map.pdf



Notes:
-Tank size can be tailored to cattle numbers, portability, pump performance, etc. Storage tanks may also be added as needed.
-Lines can be placed above ground for portable systems or buried for permanent locations to protect pipe.
-Self draining systems can be implemented for use in freezing weather.
-Isolated systems that only pump when livestock are drinking and do not return water to the waterway are possible if needed.

Out West, LLC
Agriculture and Engineering

	Rev. Note		

Revisions

Drawn On	23-Dec-20
Checked	CKH
Client	Big Horn River Alliance

Project	AG/River Projects
Drawing	Solar Powered Tank Unit