This is a digital document from the collections of the *Wyoming Water Resources Data System* (WRDS) Library.

For additional information about this document and the document conversion process, please contact WRDS at wrds@uwyo.edu and include the phrase **"Digital Documents"** in your subject heading.

To view other documents please visit the WRDS Library online at:
http://library.wrds.uwyo.edu

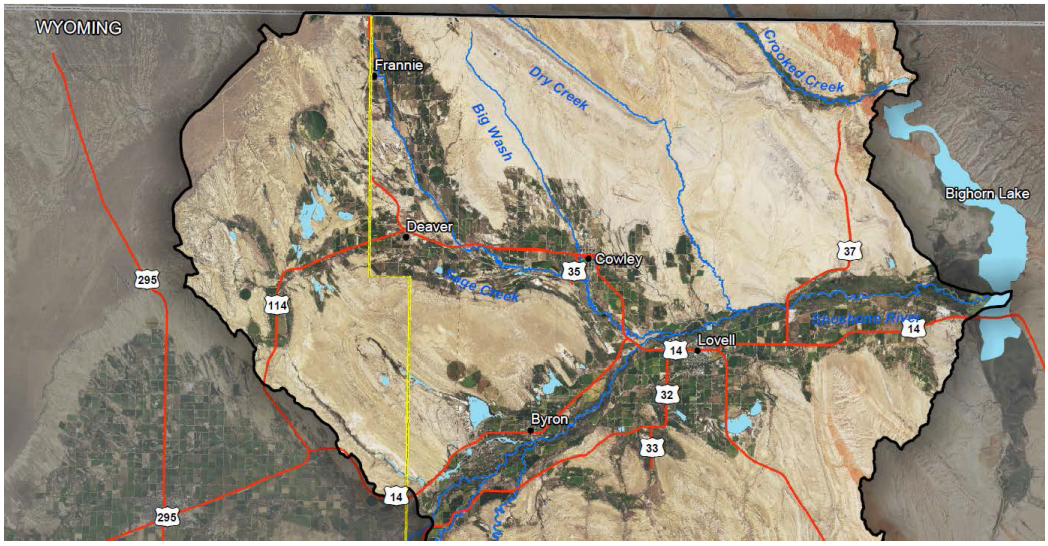
Mailing Address:
Water Resources Data System
University of Wyoming, Dept 3943
1000 E University Avenue
Laramie, WY 82071

Phone: (307) 766-6651

Funding for WRDS and the creation of this electronic document was provided by the Wyoming Water Development Commission (http://wwdc.state.wy.us)

This PDF is intended to represent the document delivered to the Wyoming Water Development Office in hard copy; however variations may exist from the printed version.

LOWER SHOSHONE RIVER LEVEL I WATERSHED STUDY FINAL REPORT



MARCH 11, 2022

PREPARED FOR:
WYOMING WATER DEVELOPMENT COMMISSION
SHOSHONE CONSERVATION DISTRICT

PREPARED BY:
BIOTA RESEARCH AND CONSULTING, INC.

IN ASSOCIATION WITH:
SUNRISE ENGINEERING, INC.

LOWER SHOSHONE RIVER LEVEL I WATERSHED STUDY

WWDC CONTRACT NUMBER 05SC0298344

PREPARED FOR:
WYOMING WATER DEVELOPMENT COMMISSION
SHOSHONE CONSERVATION DISTRICT

PREPARED BY:
BIOTA RESEARCH AND CONSULTING, INC.

IN ASSOCIATION WITH:
SUNRISE ENGINEERING, INC.

Professional Engineer
CHAD BAILEY
17420
Date 3-08-22
WYOMING

Professional Engineer (Civil)
F. DAVID KENNINGTON
9585
Date 3-4-22
WYOMING

When referencing this document please cite:
Biota Research and Consulting, Inc. and Sunrise Engineering, Inc. 2021. Lower Shoshone River Level I Watershed Study. Prepared for the Wyoming Water Development Commission.

MARCH 11, 2022

CONTENTS

1.0 Introduction 1
1.1 Watershed Study Overview 1
1.1.1 Watershed Study Definition 1
1.1.2 The Lower Shoshone River Watershed 1
1.2 Purpose and Scope 3
1.2.1 Review of Existing Data and Digital Library (bibliography) 4
1.2.2 Geographic Information Systems (GIS) 6
1.2.3 Watershed Management and Rehabilitation Plan 7
2.0 Project Meetings 7
2.1 Introduction 7
2.2 Scoping Meeting 7
2.3 Public Project Meetings 8
2.4 Agency/Landowner Coordination 8
3.0 Watershed Descriptions and Inventory 8
3.1 Introduction 8
3.2 Physical Systems 8
3.2.1 Surface Water 9
3.2.2 Geomorphology 32
3.2.3 Groundwater 50
3.2.4 Geology 53
3.2.5 Climate 59
3.3 Biological Systems 63
3.3.1 Fish and Wildlife 63
3.3.2 Land Cover 79
3.4 Anthropogenic Systems 85
3.4.1 Agricultural Water Use 85
3.4.2 Domestic Water Use 92
3.4.3 Water Storage 93
3.4.4 Land 95

4.0 Watershed Management, Development, and Rehabilitation Plan 105
4.1 Key Issues in the Watershed 105
4.2 Overview of Project Opportunities 107
4.2.1 Project Costs and Funding 109
4.2.2 Project Benefits 112
4.3 Potential Water Development Project Opportunities 112
4.3.1 Irrigation and Drainage System Improvement Projects 114
4.3.2 Water Storage Opportunities 116
4.3.3 Upland Wildlife/Livestock Water Development Opportunities 117
4.4 Stream Channel Restoration Opportunities 119
4.4.1 Diversion Improvement Projects 129
4.5 Wetland Development and Enhancement Opportunities 131
4.6 Hydroelectric Power Generation Opportunities 132
4.7 Range and Grazing Management Opportunities 133
4.8 Invasive Species Management Opportunities 134
5.0 . Permitting 135
5.1 NEPA Compliance and Documentation 136
5.1.1 Bureau of Land Management 136
5.1.2 Other State/Federal Agencies 136
5.2 Permitting/Clearances/Approvals 136
5.2.1 USACE Section 404 Permit 136
5.2.2 Endangered Species Act 137
5.3 County Floodplain Permitting 138
5.4 Mitigation 138
5.4.1 Wetlands 138
5.4.2 Sensitive and ESA-Listed Species 138
5.4.3 Sage-Grouse 139
5.4.4 Fisheries 140
5.4.5 Cultural Resources 140
6.0 Economic Analysis and Project Funding 140
6.1 Overview 140
6.2 Local Agencies 142

6.2.1 Shoshone Conservation District....142
6.2.2 Big Horn County Weed and Pest District....142
6.3 State Agencies....142
6.3.1 Wyoming Department of Environmental Quality....142
6.3.2 Wyoming Game and Fish Department....143
6.3.3 Wyoming Office of State Lands and Investments....144
6.3.4 Wyoming Water Development Commission....144
6.3.5 Wyoming Wildlife and Natural Resource Trust....150
6.4 Federal Agencies....151
6.4.1 Bureau of Land Management....151
6.4.2 Bureau of Reclamation WaterSMART....152
6.4.3 Environmental Protection Agency....153
6.4.4 Farm Service Agency....154
6.4.5 Fish and Wildlife Service....154
6.4.6 Natural Resources Conservation Service....155
6.4.7 US Army Corps of Engineers....156
6.4.8 USDA Forest Service....158
6.4.9 Rural Utilities Service....158
6.5 Non-Profit and Other Organizations....159
6.5.1 Ducks Unlimited....159
6.5.2 National Fish and Wildlife Foundation....159
6.5.3 Trout Unlimited....160
6.6 Funding Summary....160
7.0 Conclusions and Recommendations....165
8.0 References....168
Appendix A (Maps) Separate Cover
Appendix B (Project Information)....173

FIGURES

Figure 1.1.1-1. Wyoming Water Development Commission Level I Watershed Studies (Source WWDC 2021). 2

Figure 1.1.2-1. Lower Shoshone River Level I Watershed Study Project Area....3

Figure 3.2.1-1. Mean daily discharge with 80% and 20% values from two USGS gauging stations with long period of record on the mainstem Shoshone River in the Study Area. 12

Figure 3.2.1-2. Mean daily discharge with 80% and 20% values from the Whistle Creek USGS gauge #06284800 in the Study Area. 12

Figure 3.2.1-3. Mean daily discharge flow duration curves developed from three gauging stations in the Study Area. 13

Figure 3.2.1-4. Average monthly discharge (cfs) at Shoshone River near Lovell gauge for dry, normal, and wet years. 16

Figure 3.2.1-5. Average monthly discharge (cfs) at Shoshone River at Byron gauge for dry, normal, and wet years. 18

Figure 3.2.1-6. Average monthly discharge (cfs) at the Sage Creek at Sidon Canal gauge for dry, normal, and wet years. 19

Figure 3.2.1-7. Average daily discharge with 80% and 20% values for the Sage Creek near Lovell gauge. 20

Figure 3.2.1-8. Average monthly discharge at the Whistle Creek near Garland gauge for dry, normal, and wet years. 20

Figure 3.2.1-9. Estimated average monthly discharge (cfs) at the Dry Creek HUC 10 watershed (Shoshone River) for dry, normal, and wet years. 22

Figure 3.2.1-10. Estimated average monthly discharge (cfs) at the Sage Creek HUC10 watershed for dry, normal, and wet years. 23

Figure 3.2.1-11. Peak flow timing at the Shoshone River gauge near Lovell. USGS gauge #06285100 30

Figure 3.2.1-12. Historical peak discharges (cfs) at the Shoshone River gauge near Lovell. USGS gauge #06285100. 31

Figure 3.2.1-13. Historical peak stage levels (ft) at the Shoshone River gauge near Lovell. USGS gauge #06285100. 31

Figure 3.2.2-1. Schematic of the levels of Rosgen geomorphic channel classification. 33

Figure 3.2.2-2. Rosgen Level I geomorphic channel classification schematic. Figure taken from NRCS (2007). 34

Figure 3.2.2-3. Typical relative locations of stream types within a watershed. 35

Figure 3.2.2-4. The influence of independent variables on dependent variables of stream channel morphology. 38

Figure 3.2.2-5. Example evolutionary trajectories in channel form due to initial loss of equilibrium conditions. 48

Figure 3.2.2-6. Lower Shoshone River suspended sediment-flow relationship for the Shoshone River at Kane and the Shoshone River near Lovell gauging stations (USBR 2010). 50

Figure 3.2.3-1. Water-table contours in Quaternary alluvium and terrace deposits along the Lower Shoshone River (Taucher et al., 2012, modified from Plafcan et al., 1993, Figure 3). 51

Figure 3.2.4-1. Map and profiles of the terrace landforms adjacent to the Shoshone River (Mackin 1937). 55

Figure 3.2.5-1. Average high and low temperatures for the Deaver weather station, Shoshone River Watershed. 61

Figure 3.2.5-2. Average high and low temperatures for the Lovell weather station. 61

Figure 3.2.5-3. Average monthly precipitation for NWS weather stations within the Lower Shoshone River Watershed. 62

Figure 3.2.5-4. Yearly total annual precipitation for NWS weather stations within the Lower Shoshone River Watershed. 62

Figure 4.4-1. Network Effects Diagram for Streambank and Shoreline Protection (NRCS, 2011). 121

Figure 4.4-2. Aerial imagery (July 1994) depicting relatively straight single-thread planform. 122

Figure 4.4-3. Aerial imagery (August 2003) depicting lateral channel migration. 122

Figure 4.4-4. Aerial imagery (August 2009) depicting lateral channel migration and downstream meander progression. 123

Figure 4.4-5. Aerial imagery (August 2011) depicting channel avulsions resulting in multi-threaded channel morphology. 123

Figure 4.4.1-1. Aerial imagery depicting conceptual design for the Big Fork Diversion on the Lower Shoshone River. 130

Figure 5.4.3-1. Map depicting greater sage-grouse core areas in the State of Wyoming. 139

PHOTOGRAPHS

Photo 1. Lower Shoshone River near Lovell, WY (Lat: 44.8471611111, Long: -108.408905556) example of C-type channel with entrenchment ratio greater than 2.2, width/depth ratio greater than 12, and sinuosity greater than 1.2 40

Photo 2. Lower Shoshone River between the towns of Byron and Lovell, WY (Lat: 44.8156194444, Long: -108.45855) example of C-type channel with entrenchment ratio greater than 2.2, width/depth ratio greater than 12, and sinuosity greater than 1.2 41

Photo 3. Lower Shoshone River at the highway 37 bridge (Lat: 44.858208334, Long: -108.3315111) example of C-type channel with entrenchment ratio greater than 2.2, width/depth ratio greater than 12, and sinuosity greater than 1.2. 41

Photo 4. Whistle Creek – Stream type B, valley type VIIIa (Lat: 44.756819445, Long: -108.5551222) 42

Photo 5. Coon Creek - Stream type B, valley type VIIIb (Lat: 44.78328333, Long: -108.513) 42

Photo 6. Upper Sage Creek - stream type E, valley type VIIIa (Lat: 45.000213889, Long: -108.62263611).....43

Photo 7. Upper Sage Creek - Stream type E, valley type VIIIa (Lat: 44.95869445, Long: -108.60903889).....43

Photo 8. Big Wash - Stream type B, valley type IV (Lat: 44.9026222, Long: -108.48800556) 44

Photo 9. Dry Creek - Stream type B, valley type II (Lat: 44.8612334, Long: -108.3719333) 44

Photo 10. Crooked Creek - Stream type B valley type VIIIa (Lat: 44.959775, Long: -108.287619445) 45

Photo 11. Example of Wyoming big sagebrush-dominated sagebrush steppe (foreground) and mat saltbush shrubland (around the depressional basin) in the Lower Shoshone River Watershed. 80

Photo 12. Typical Water Storage for Lovell, Byron, Frannie 93

Photo 13. Photograph of American Colloid Company Lovell Bentonite Mill. 101

Photo 14. Instream treatment example: W-weir. 127

Photo 15. Instream treatment example: rock cross vanes. 127

Photo 16. Instream treatment example: rock J-hook vane. 128

Photo 17. Instream treatment example: root wad revetment and bank cover. 128

Photo 18. Instream treatment example: root wad revetment and rock barb.....129

Photo 19. Photograph depicting recently completed diversion improvement project 131

Photo 20. Riparian zone on the Lower Shoshone River dominated by invasive Russian olive trees. 135

TABLES

Table 3.2.1-1. Stream flow gauging stations located within the Study Area. 11

Table 3.2.1-2. Mean annual discharge and total annual yield estimates from regional regression equations for HUC12 sub-basins within the Study Area. 13

Table 3.2.1-3. Mean annual discharge and total annual yield estimates from regional regression equations for HUC10 sub-basins within the Study Area. 14

Table 3.2.1-4. Cumulative streamflow and Dry/Normal/Wet pattern at Shoshone River near Lovell gauge. 14

Table 3.2.1-5. Average monthly discharge (cfs) at the Shoshone River near Lovell gauge for dry, normal, and wet years. 16

Table 3.2.1-6. Cumulative streamflow and Dry/Normal/Wet pattern at the Shoshone River at Byron gauge. 17

Table 3.2.1-7. Average monthly discharge (cfs) at Shoshone River at Byron gauge for dry, normal, and wet years. 18

Table 3.2.1-8. Average monthly discharge (cfs) at the Sage Creek at Sidon Canal for dry, normal, and wet years. 19

Table 3.2.1-9. Average monthly discharge (cfs) at the Whistle Creek near Garland gauge for dry, normal, and wet years. 21

Table 3.2.1-10. Estimated average monthly discharge (cfs) at the Dry Creek HUC10 watershed (Shoshone River) for dry, normal, and wet years. 22

Table 3.2.1-11. Estimated average monthly discharge (cfs) at the Dry Creek – Shoshone River HUC10 for dry, normal, and wet years. 23

Table 3.2.1-12. Protected uses within each Wyoming state water classification. 26

Table 3.2.1-13. Stream classifications in the Lower Shoshone River Watershed Study Area. .28

Table 3.2.2-1. Rosgen Level I geomorphic channel classification description and characteristic parameters. 36

Table 3.2.2-2. Valley types applied during preliminary geomorphic classification in the Lower Shoshone River Watershed. 39

Table 3.2.2-3. Total stream length of dominant valley types in the Lower Shoshone River Watershed. 39

Table 3.2.2-4. Total length and relative percentage of stream types in the Study Area. 46

Table 3.2.2-5. Total length and relative percentage of stream types in sub-basins of the Study Area. 46

Table 3.2.2-6. Typical equilibrium and disequilibrium channel forms associated with various valley types. 47

Table 3.2.2-7. Suspended sediment input loads in tons per day (modified from USBR 2010). 50

Table 3.2.4-1. Soils of the Lower Shoshone River Watershed. 56

Table 3.2.4-2. Surficial Geologic Units of the Lower Shoshone River Watershed. 58

Table 3.2.4-3. Bedrock Geologic Units of the Lower Shoshone River Watershed. 59

Table 3.2.5-1. Summary of temperature and precipitation climate data from NWS stations. .60

Table 3.2.5-2. Comparison of early and late freezes and general growing season derived from NWS Weather Stations within the Lower Shoshone River Watershed. 63

Table 3.3.1-1. Sensitive wildlife species mapped by Wyoming Natural Diversity Database in the Lower Shoshone River Watershed.....63

Table 3.3.1-2. Species found within the Shoshone River Basin (HUC8: 10080014).....67

Table 3.3.1-3. Fish species present within the Yellowstone River Basin. (Information provided by the Wyoming Game and Fish Department). 70

Table 3.3.1-4. In-stream structures within the Study Area. (Information provided by the Wyoming Game and Fish Department). Note that the database is currently being created and does not represent all diversion or in-stream structures within the Study Area. 73

Table 3.3.2-1. A tabulation of NWI wetland and deep-water habitats in the Lower Shoshone River Watershed. 83

Table 3.4.1-1. Irrigation Systems on Lower Shoshone River. 85

Table 3.4.1-2. WWDC 2019 Wyoming Water Irrigation Systems Report #3 Usage and Storage (modified from WWDC 2005; WWDC 2015; WWDC 2017; WWDC 2019).87

Table 3.4.1-3. WWDC 2019 Wyoming Water Irrigation Systems Report #2 Diversions/Conveyance (modified from WWDC 2005; WWDC 2015; WWDC 2017; WWDC 2019). 89

Table 3.4.1-4. Conveyance description for Study Area irrigation diversions (modified from BRS Engineering 2003). 90

Table 3.4.1-5. 2019 National Agricultural Statistics Service (NASS) crop area in acres by Hydrologic Unit Code (HUC) boundary. 91

Table 3.4.2-1. Domestic Water Use. 92

Table 3.4.3-1. Water Storage. 93

Table 3.4.4-1. Physiographic features of the Saline Upland (SU) 5-9” Big Horn Basin Precipitation Zone (modified from NRCS 2021a).....95

Table 3.4.4-2. Physiographic features of the Sandy (Sy) 5-9” Big Horn Basin Precipitation Zone (modified from NRCS 2021b). 96

Table 3.4.4-3. Physiographic features of the Shale (Sh) 5-9” Big Horn Basin Precipitation Zone (modified from NRCS 2021c). 96

Table 3.4.4-4. Physiographic features of the Saline Lowland (SL) 5-9” Big Horn Basin Precipitation Zone (modified from NRCS 2021d). 97

Table 3.4.4-5. Land ownership as percent of total area by Hydrologic Unit Code (HUC) boundary. 98

Table 3.4.4-6. Mapped oil and gas fields with active and inactive wells in the Study Area (source: Wyoming Oil and Gas Conservation Commission & Wyoming State Geological Survey). 100

Table 3.4.4-7. Mapped Bentonite, coal, and sand and gravel mine operations in the Study Area (source: Wyoming State Geological Survey). 102

Table 3.4.4-8. BLM grazing allotments in the Study Area greater than 500 acres. 104

Table 4.2-1. Project costs by project type. 108

Table 4.2.1-1. Project costs by project type. 110

Table 4.2.1-2. Funding potential by project type. 111

Table 4.3.1-1. Irrigation and drainage system improvements potential projects. 114

Table 4.3.2-1. Dam and reservoir potential projects. 117

Table 4.3.3-1. Upland water development potential projects. 117

Table 4.4-1. Channel stabilization potential projects. 120

Table 4.4-2. Applicability of instream restoration and stabilization treatments by Rosgen channel type. 125

Table 4.4-3. Applicability of instream restoration and stabilization treatments by Rosgen channel type. 126

Table 4.5-1. Wetland development and enhancement potential projects. 131

Table 4.6-1. Power Potential of Selected Sites. 133

Table 6.6-1. Funding Sources 161

1.0 INTRODUCTION

This Level I watershed study was prepared for the Wyoming Water Development Commission (WWDC). The watershed plan was sponsored by the Shoshone Conservation District (SCD) and developed for the use by landowners, land managers, and stakeholders in the Lower Shoshone River watershed. The study was completed by Biota Research and Consulting, Inc. (Biota) and Sunrise Engineering, Inc. (Sunrise).

1.1 Watershed Study Overview

Watershed management provides an effective approach to addressing the land management and natural resource challenges. A watershed study is intended to provide the necessary information required to identify projects that will address those challenges to restore and enhance the watershed. The following sections provide a general description of a watershed study and the Lower Shoshone River watershed study area (Study Area, Appendix A).

1.1.1 Watershed Study Definition

A watershed study is a comprehensive and holistic evaluation of a specific drainage basin. Watershed studies provide management and rehabilitation plans for water storage, irrigation systems, and upland water development to assist with the identification of potential projects to enhance the condition of the watershed. The watershed study includes an assessment of many aspects of the natural environment and physical processes in order to ensure that any proposed projects are beneficial to watershed functions. Watershed studies can also be an effective tool to facilitate funding from local, state and federal agencies.

The Lower Shoshone River Watershed Study is one of many Level I watershed studies across the state of Wyoming since the initiation of the watershed program by the WWDC. Currently active and completed watershed projects are shown in Figure 1.1.1-1.

1.1.2 The Lower Shoshone River Watershed

The Shoshone River Watershed (HUC 10080014) covers an area of 944,835 acres located in Big Horn and Park Counties, Wyoming, and Carbon County, Montana. The Lower Shoshone River watershed Study Area covers an area of 406,133 acres primarily in the lower portion of the Shoshone River Watershed in Big Horn and Park Counties, Wyoming (Figure 1.1.2-1 and Map 1). The project area also includes the lower portion of the Crooked Creek drainage in the Big Horn Lake Watershed (HUC 10080010). The Shoshone Conservation District and the Powell Clarks-Fork Conservation District are within the Study Area.

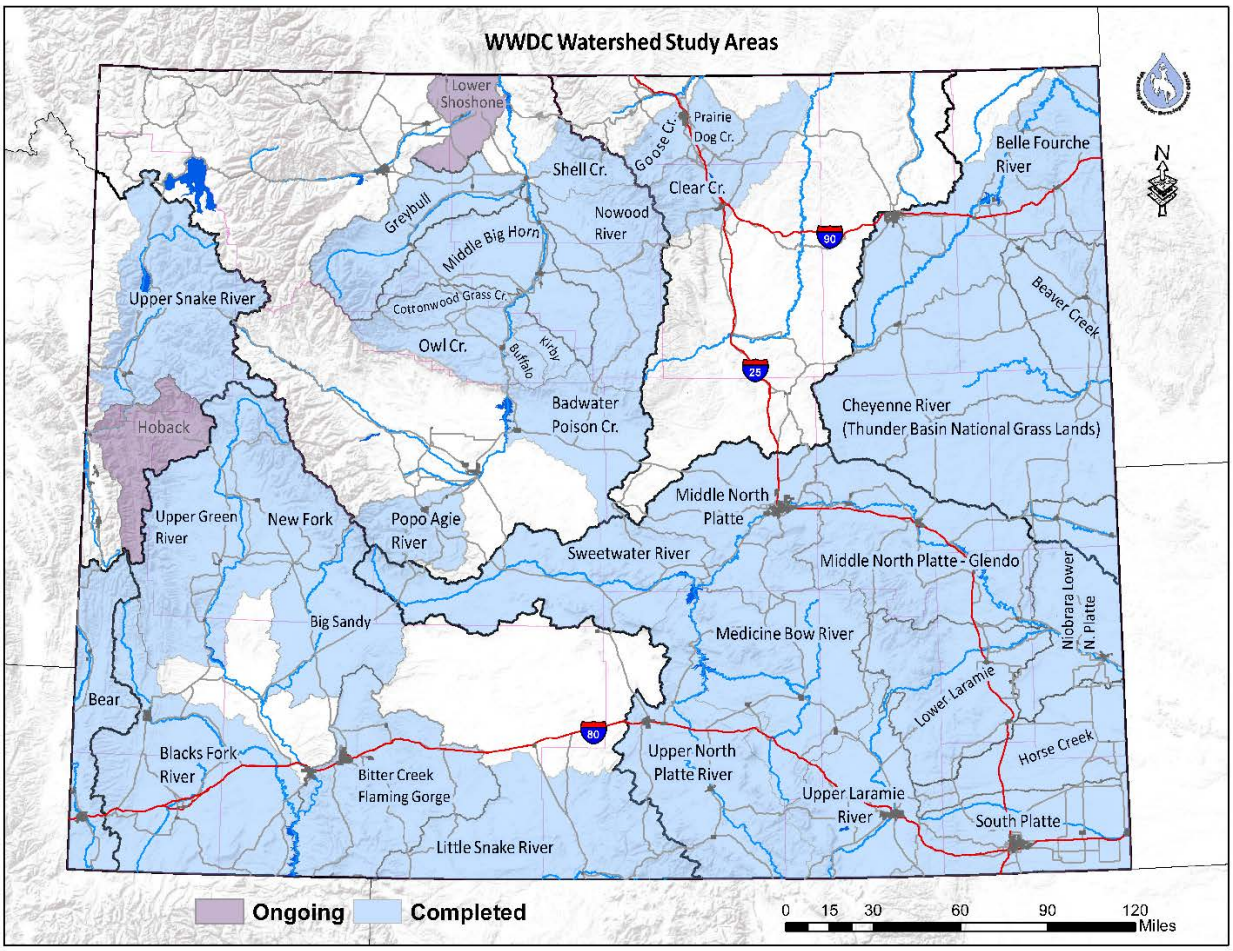


Figure 1.1.1-1. Wyoming Water Development Commission Level I Watershed Studies (Source WWDC 2021).

The Shoshone River flows northeasterly through the study area entering Big Horn Lake which defines the downstream extent of the Study Area. The major Shoshone River tributaries included in the Study Area are Whistle Creek, Coon Creek, Sage Creek, Big Wash, Dry Creek, and Crooked Creek. The communities of Byron, Lovell, Cowley, Deaver, and Frannie are all within the Study Area.

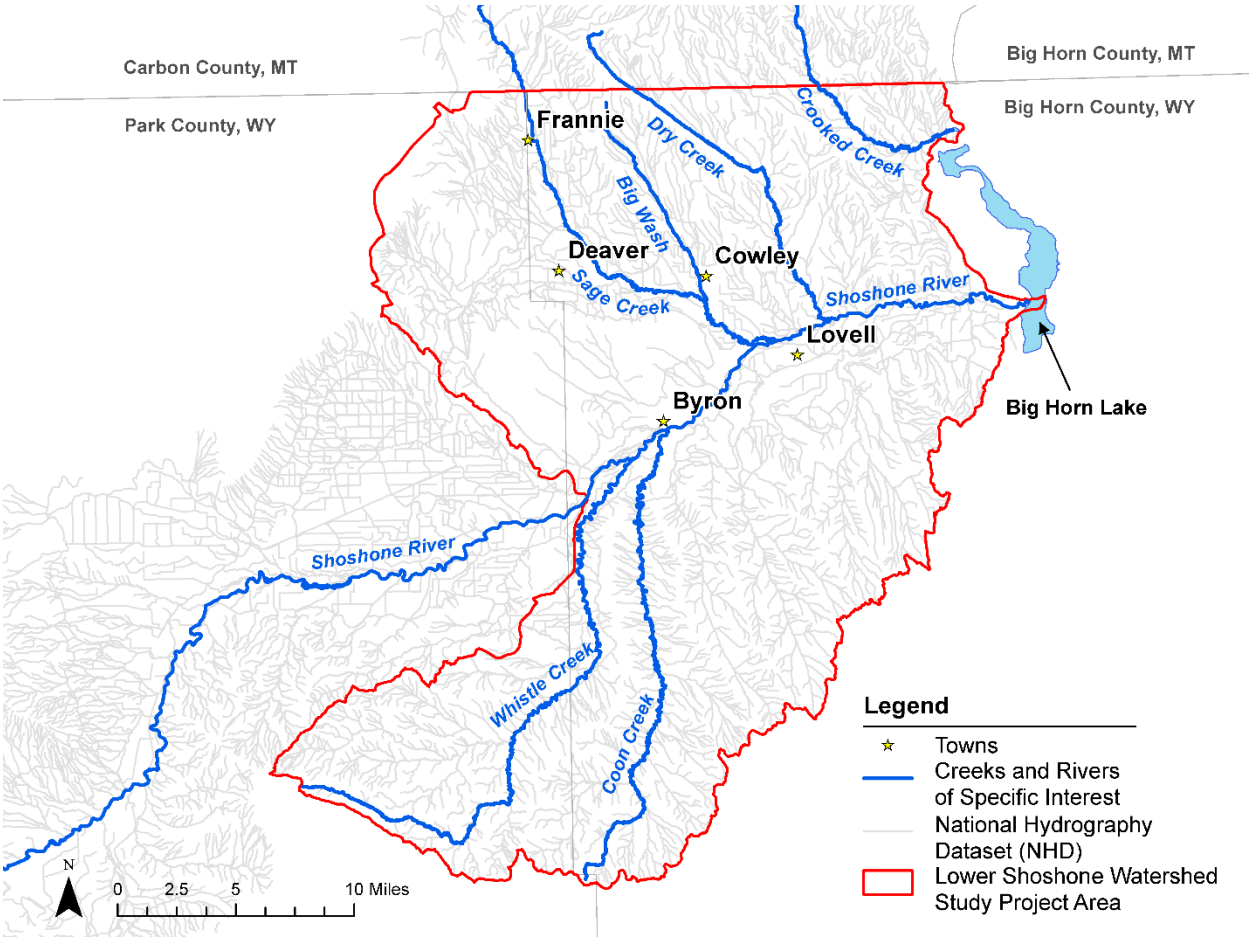


Figure 1.1.2-1. Lower Shoshone River Level I Watershed Study Project Area.

1.2 Purpose and Scope

The purpose of this Level I watershed study and rehabilitation plan is to describe the Lower Shoshone River watershed current conditions and identify resolutions for water-related issues that provide opportunities for improvements. The WWDC objective statement for all watershed studies is as follows:

> *"The objective of a watershed study is to evaluate an individual watershed's existing conditions and, from collaboration with landowners, stakeholders, and public outreach, develop a Watershed Management and Rehabilitation Plan and identify projects that are eligible for funding from WWDC and other sources that may improve or maintain watershed function and systems."*

Specific objectives of the project include the following:

1. Conduct an evaluation and description of the watershed, including quantity and quality of surface water resources, and riparian/upland conditions.
2. Conduct an evaluation of water storage needs and opportunities to augment upland water available for livestock and wildlife.
3. Conduct an irrigation system inventory and develop a rehabilitation plan for those ditches expressing an interest to participate.

4. Promote public participation in the study.
5. Facilitate participation and consensus building with the landowners and the public at large, the SCD, and the WWDC.
6. Identify natural resource issues within the watershed and propose practical economic solutions.
7. Identify permits, easements and clearances necessary for plan implementation.
8. Develop a watershed management and rehabilitation plan describing potential projects and management strategies to address water resource related issues.
9. Develop conceptual-level cost estimates for potential projects identified in the watershed management and rehabilitation plan.
10. Compile spatial data, relevant reports, and collected data into a comprehensive digital library (bibliography with linked pdfs) and geodatabase to be available as a resource for project sponsors, stakeholders, and future studies.
11. Conduct a geomorphic assessment of primary tributary channels within the watershed and identify potential mitigation measures to improve impaired reaches.

1.2.1 Review of Existing Data and Digital Library (bibliography)

A critical first step in a watershed study is to review existing data and reports that describe the current condition of the watershed, identify water-related issues, and describe potential project opportunities. The existing data review provides the foundation for the watershed description and inventory of physical systems, biological systems, and anthropogenic systems. The watershed description and inventory in turn informs the development of the watershed management and rehabilitation plan. The data reviewed for this project included a wide range of topics from variety of sources including academic journals, conservation groups, as well as federal, state, and local agencies. The primary sources of information for this study were published reports and datasets from the following State, federal and local organizations:

- U.S. Environmental Protection Agency (EPA)
- U.S Bureau of Land Management (BLM)
- U.S. Geological Survey (USGS)
- U.S. Fish and Wildlife Service (USFWS)
- U.S. Bureau of Reclamation (USBR)
- U.S. Farm Service Agency (FSA)
- U.S. Forest Service (USFS)
- Natural Resources Conservation Service (NRCS)
- Wyoming Department of Environmental Quality (DEQ)
- Wyoming Game and Fish Department (WGFD)
- Wyoming State Engineer’s Office (SEO)
- Wyoming State Geological Survey (WSGS)
- Wyoming Water Development Commission (WWDC)

The information gathered during the review of existing data is presented in Sections 3, Watershed Description and Inventory. The existing data and reports were compiled into a digital library for ease of access by project sponsors and stakeholders. The digital library includes an index that is hyperlinked to the of all data and documents included in the library.

The information contained in the Water Resources Data System (WRDS) Library was used as a resource during the development of this report. The existing publications primarily deal with water supply systems, hydropower, or groundwater investigations/analysis in the Study Area. With the exception of groundwater studies, municipal water sources and water delivery systems were not evaluated for this project. The complete report of each referenced study can be found at the following web address, or the individual hyperlinks listed below:

http://library.wrds.uwyo.edu/wwdcrept/wwdcrept.html

Byron

Western Water Consultants, Town of Byron Ground Water Development Feasibility Study, Sep, 1982 (62,913 kb)

Western Water Consultants, Exploratory Ground Water Investigation of the Shoshone River Alluvium Near Byron, Wyoming, Apr, 1983 (6,947 kb)

Cowley

Western Water Consultants, Town of Cowley Ground Water Development Feasibility Study, Sep, 1982 (57,018 kb)

Western Water Consultants, Final Report on Drilling and Testing Madison #1 Well for the Town of Cowley, Big Horn County, Wyoming, Oct, 1983 (24,981 kb)

Deaver

Engineering Associates, Deaver Irrigation Rehabilitation Project Level II Study, Final Report, Nov, 2002 (50,595 kb)

Engineering Associates, Deaver Irrigation Rehabilitation Project Level II Study, Executive Summary, Nov, 2002 (844 kb)

Sage Civil Engineering, Deaver Irrigation District Master Plan Update, Level I Study, Final Report, Oct, 2016 (129,877 kb)

Sage Civil Engineering, Deaver Irrigation District Master Plan Update, Level I Study, Executive Summary, Oct, 2016 (2,846 kb)

Frannie

Western Water Consultants, Potential Water-Well Sites for the Towns of Frannie and Deaver, Wyoming, Feb, 1985 (2,438 kb)

Western Water Consultants, Final Report, Drilling and Testing of Frannie-Deaver Test Well #1, Sep, 1986 (22,969 kb)

Falcon Consulting Services L.L.C., Frannie Well Rehabilitation Level II Study (Kirk #1) Frannie, Wyoming, Final Report, Oct, 2005 (31,559 kb)

Lovell

A & H Consulting, Inc., Lovell Irrigation District Hydropower Study Level II, Executive Summary, May, 2003 (651 kb)

A & H Consulting, Inc., Lovell Irrigation District Hydropower Study Level II, May, 2003 (11,329 kb)

Sage Civil Engineering, Lovell Irrigation District Master Plan Level I Study, Final Report, Aug, 2017 (15,165 kb)

Sage Civil Engineering, Lovell Irrigation District Master Plan Level I Study, Executive Summary, Aug, 2017 (3,695 kb)

Shoshone

Sage Civil Engineering, Shoshone Irrigation District Rehabilitation and GIS Level II Study, Final Report, Nov, 2008 (6,846 kb)

Sage Civil Engineering, Shoshone Irrigation District Rehabilitation and GIS Level II Study, Executive Summary, Nov, 2008 (525 kb)

Lidstone and Associates, Inc., Shoshone Ground Water Development Level II Report, Nov, 2008 (330,868 kb)

Lidstone and Associates, Inc., Shoshone Ground Water Development Level II Report, Executive Summary, Nov, 2008 (114 kb)

1.2.2 Geographic Information Systems (GIS)

The geospatial data compiled and collected for this project are included in the project geodatabase. The project geodatabase was developed from the WWDC watershed study geodatabase template. The Geographic Information Systems (GIS) deliverables were developed following the guidelines and standards detailed in the WWDO GIS Standards Technical Memorandum, Version 3 (WWDO 2020). These standards were developed to increase consistency, reduce redundancy for WWDC funded projects.

The existing geospatial data contained in the geodatabase was obtained from a number of sources including the WWDO, SEO, USGS, and SuiteWater GIS. All data in the geodatabase include metadata that provides a detailed description of that data. The geodatabase was delivered in the ESRI ArcGIS 10.8 format, as specified by the WWDO project manager. The coordinate system for the geodatabase is a Geographic Coordinate System (GCS) based on the North American Datum 1983 (NAD83).

Technological advances in GIS and web-based map servers have rapidly expanded the amount of spatial data available to inform watershed studies. The types of data include layers representing transportation, ownership, land use, climate, vegetation, irrigation, agriculture crops, ecological regions, wetlands, soils, geology, hydrology, wildlife, cultural resources among others. A list of available resources for GIS data is listed below:

- SuiteWater GIS https://suitewater.wygisc.org/
- Wyoming Geospatial Hub (WYGISC) https://geospatialhub.org/
- Wyoming Statewide Parcel Viewer https://www.arcgis.com/apps/webappviewer/index.html?id=4bb9a66f7287402b8f650aa9f21d3fa5
- Wyoming State Geological Survey Wyoming State Geological Survey
- USGS TNM Download v2 (nationalmap.gov)
- Wyoming State Water Plan Wyoming State Water Plan GIS Standards and Information

- U.S. Fish & Wildlife Services Wetlands Mapper (fws.gov)
- Wyoming Game & Fish Wyoming Game and Fish Department - Geospatial Data
- NRCS Web Soil Survey Web Soil Survey (usda.gov)
- Nature Serve
  NatureServe | Unlocking the Power of Science to Guide Biodiversity Conservation

1.2.3 Watershed Management and Rehabilitation Plan

The end goal of the WWDC watershed studies is a Development, Management and Rehabilitation Plan (DMRP) for improving watershed function that are practical, technically sound, feasible, sustainable, and cost effective. With that in mind, a primary focus of the Lower Shoshone River Watershed Study was the identification of potential projects and the development of a final report that is clear, concise, and accessible, for all anticipated users.

The conceptual projects included in the watershed management and rehabilitation plan, described in Section 4, were developed by the consultant team (Biota and Sunrise) in collaboration with the SCD, landowners, agencies, the WWDO, and stakeholders. Collaboration was critical in the identification of potential projects in order to ensure that they were feasible given the unique watershed characteristics, constraints, and regulatory framework.

2.0 PROJECT MEETINGS

2.1 Introduction

Several meetings were held with the Biota team, Wyoming Water Development Office (WWDO) staff, SCD staff, and landowners in the community throughout the development of the watershed study to keep project partners informed about progress advances. The meetings held were as follows:

- April 28, 2020 – Kickoff meeting
- September 22, 2020 – Informational public open house, Big Horn County Lovell Annex, Lovell, WY
- September 24, 2020 – Informational public open house, Big Horn County Lovell Annex, Lovell, WY
- September 23, 2020 – Potential projects site visits with landowners
- June 9 to 11, 2021 – Potential projects site visits with landowners
- June 23 and 24, 2021 – Potential projects site visits with landowners
- August 12, 2021 – Potential projects site visits with landowners

2.2 Scoping Meeting

The timing and methods for the initial scoping meeting was modified early in the project process due to the limitations on social gatherings due to the COVID 19 pandemic. In lieu of a traditional scoping meeting, other efforts were completed to get the word out about the project. An

informational flyer was prepared and distributed to facilitate early outreach and encourage public engagement. The SCD provided a mailing list for the informational mailing.

2.3 Public Project Meetings

Public meetings were conducted to facilitate project coordination and encourage public participation and information gathering to assist with the identification of WWDC Small Water Projects and other water development opportunities. Invitations to the meetings were by postcard, email, or telephone as contact information dictated. The meetings were also advertised in the Lovell Chronicle and the Powell Tribune in September 2020.

The Biota team attended on-site meetings with landowners to evaluate and start the design process for high priority potential water projects. The site visits were delayed from the original schedule due to the COVID 19 pandemic and landowner availability. The majority of the site visits were completed in June 2021.

2.4 Agency/Landowner Coordination

The SCD had direct communication with landowners for field survey access and was the initial point of contact for communications with landowners that had potential projects on their property. After the initial project matrix was developed, the consultants reached out to interested landowners for site visit and additional data collection. Site visits were coordinated with the landowners and performed by the consultants to collected project information such as location, length, type, photographs, and investigate potential additional projects. The SCD assisted with questions from both landowners and the consultants working on the study.

Project data sets were gathered in coordinated with several state and federal agencies including the USFS, BLM, USBR, USGS, USFWS, NRCS, EPA, WGFD, DEQ, SEO, and WyGISC.

3.0 WATERSHED DESCRIPTIONS AND INVENTORY

3.1 Introduction

A Level I watershed study includes both a description of the natural environmental and inventory of water development. The information included in the watershed description spans a wide variety of topic areas including hydrology, water quality, wetlands, wildlife, land use, climate, geology, soils, agricultural practices, and others. The watershed description and inventory is broadly grouped into three categories: 1) Physical Systems (Section 3.2); 2) Biological Systems (Section 3.3); and 3) Anthropogenic Systems (Section 3.4). The following sections provide a description of the Study Area based on the information and data gathered for this project.

3.2 Physical Systems

This section of the report describes the watershed physical systems of the Study Area associated with surface water, geomorphology, groundwater, and geology. The Study Area physical systems inventory and descriptions were focused on characterizing watershed existing conditions, function, and identifying impairments.

3.2.1 Surface Water

The Shoshone River Watershed drains the eastern Absaroka Mountains in northwestern Wyoming, as well as irrigated land and arid mountainous terrain in southern Montana. This study focuses on the Lower Shoshone River watershed from the confluence of Whistle Creek near Byron, Wyoming downstream to Bighorn Lake. The Study Area is bounded to the north by the Montana state border, to the east by the Bighorn River watershed, to the south by the Greybull River watershed, and to the west by the upper reaches of the Shoshone River and the Absoroka Mountains. The maximum elevation of the drainage basin is approximately 10,180 ft at the Sage Creek headwaters, which is outside of the Study Area in Montana. The Study Area contains approximately 26.2 miles of the Shoshone River, and major tributaries including Big Wash, Coon Creek, Sage Creek, Dry Creek, Whistle Creek, and Crooked Creek.

The basin has been largely developed for agricultural irrigation. The Shoshone Reclamation project started in 1904 and is still the largest federal irrigation project in Wyoming. The construction of Buffalo Bill Dam in 1910 altered the flow regime and sediment transport within the Lower Shoshone River. The subsequent construction of four more diversion dams (Corbett, Willwood, Mormon, and Penrose Dams) on the Shoshone River mainstem and numerous anthropogenic barriers on tributaries have furthered the alteration of the natural flow regime. The Shoshone River hydrograph no longer has a natural hydrograph associated with unregulated snow-melt runoff. Peak flows have been attenuated (i.e., lessened) to allow for flows to remain elevated throughout the irrigation season. Flooding still does occur regularly on the Lower Shoshone River. The Buffalo Bill Dam does not eliminate flooding. The hydrology of downstream reaches is most heavily impacted as water is taken from each of the upstream diversions. Reaches of the Shoshone River downstream from irrigation diversion dams can be dewatered when water is being withdrawn for irrigation but before additional water is released from Buffalo Bill Dam for irrigation purposes. The peripheral distribution of Shoshone River waters for irrigation, and the use of tributary channels to route irrigation return flows, has meant that many tributaries which historically flowed ephemerally or intermittently now have perennial flows.

The Shoshone River tailwater studies on hydrology, geomorphology, water quality, and biology in combination with public preferences reinforced one another and converged at a flow recommendation of 440 cfs at USGS gage below Buffalo Bill Reservoir relating to a release of approximately 380 cfs from Buffalo Bill Reservoir (Dey et al., 2003). Winter releases as set forth by the Shoshone Winter flow Agreement-2009 provide for winter releases from 100 to 350 cfs.

Multiple analyses were performed to quantitatively investigate the hydrologic regime within the project area including acquisition of historic stream flow gauge station data and application of multiple regional regression equations that quantify hydrologic discharge parameters based upon catchment attributes.

3.2.1a Hydrography

The Watershed Boundary Dataset developed jointly by the US Geological Survey (USGS) and the USDA Natural Resources Conservation Service (NRCS) was obtained from the NRCS Geospatial Data Gateway. Hydrologic Units (HU) are delineated and presented in the dataset at various scales. Each HU has a unique numerical identifier, or a 2-digit code referred to as a Hydrologic Unit Code. The largest scale of delineated watersheds is identified by 2-digit codes referred to as HUC2s. Additional 2-digit codes are added to the numerical identifier to describe nested sub-watersheds.

The smallest nationwide dataset of delineated HUs are identified by 6 two-digit codes, and are referred to as 12-digit Hydrologic Unit Codes (or HUC12s).

All HUC12s within the Study Area were imported into the project GIS and are depicted in Map 2 with National Hydrography Dataset (water lines) derived at the 1:24,000 scale. The HUC12s are classified as "complete" if a given HUC12 catchment does not receive natural surface water inputs from adjacent HUC12s, or as a "composite" if it receives natural surface water input from one or more adjacent HUC12(s). The sub-basins associated with a composite HUC12 were delineated by merging all individual HUC12s that comprise the associated catchment. These analyses enabled quantification of various attributes (drainage area, maximum and mean elevation, aspect, slope) of sub-basins corresponding to the downstream extent of each HUC12.

3.2.1b Hydrology

Historic and currently active stream gauging stations operated within the Study Area by the USGS or WYSEO are presented in Map 3 with numerical identifier, and gauge station details presented in Table 3.2.1-1. The USGS currently operates 1 stream flow gauge station in the Study Area. There are 8 historic, nonactive gauges in the Study Area. The WY State Engineer's Office currently maintains data on 4 stream flow gauge stations in watercourses and canal systems in the basin (includes the active USGS gauge). The following links connect to the real time State and the USGS stream gauge data; https://seoflow.wyo.gov/. Active and historic USGS gauge data for Wyoming can be found here: https://waterdata.usgs.gov/wy/nwis/r.

Table 3.2.1-1. Stream flow gauging stations located within the Study Area.

Agency	Site ID	Site Name	Drainage Area (sq mi)	Operation Begin	Operation End	Period of Record (yrs)[1]	County
USGS	6284800	Whistle Creek near Garland WY	101	6/1/1958	6/23/1986	21	Big Horn, WY
USGS	6285000	Shoshone River at Byron WY	2345	1/1/1929	9/29/1966	38	Big Horn, WY
USGS	6286000	Shoshone River at Lovell WY	2832	6/1/1897	9/29/1898	1	Big Horn, WY
USGS/ SEO	6285100	Shoshone River near Lovell WY	2350	10/1/1966	active	54	Big Horn, WY
USGS	6285500	Sage Creek near Lovell WY	363	5/1/1951	9/29/1960	10	Big Horn, WY
USGS	6286200	Shoshone River at Kane WY	2989	10/1/1957	9/29/1968	11	Big Horn, WY
USGS	6285400	Sage Creek at Sidon Canal near Deaver WY	341	6/1/1958	9/29/1987	22	Big Horn, WY
USGS	6286260	Crooked Creek near Lovell WY	119	12/1/1964	11/30/1967	n/a	Big Horn, WY
USGS	6286258	Big Coulee near Lovell WY	30.1	4/1/1970	9/29/1978	9	Big Horn, WY
SEO	0315SH08	Globe Canal	n/a	4/27/1998	active	22	Big Horn, WY
SEO	0315SH09	Hunt Canal	n/a	4/17/1998	active	22	Big Horn, WY
SEO	0315SH07	Sidon Canal	n/a	10/1/2007	active	14	Big Horn, WY

[1]period of record for peak streamflow measurements.

Mean daily discharges were obtained from three USGS stream gauging stations in the basin including two on the mainstem Shoshone River with long periods of record; Shoshone River at Byron WY (6285000) and Shoshone River near Lovell WY (6285100), and one on the major tributary of Whistle Creek, Whistle Creek near Garland WY (6284800). Figures 3.2.1-1 and 3.2.1-2 depict mean daily discharge data with 80% and 20% values recorded at these locations. The hydrographs depict the typical timing and magnitude of flows within the Lower Shoshone River Study Area and its tributary system. Elevated flows within the Shoshone River typically occur for about 3 months between May and August during spring snowmelt. Elevated flows appear to last longer within the Whistle Creek tributary from approximately May through October. Late summer and winter flows are heavily influenced by dam release and irrigation activities within the Shoshone River.

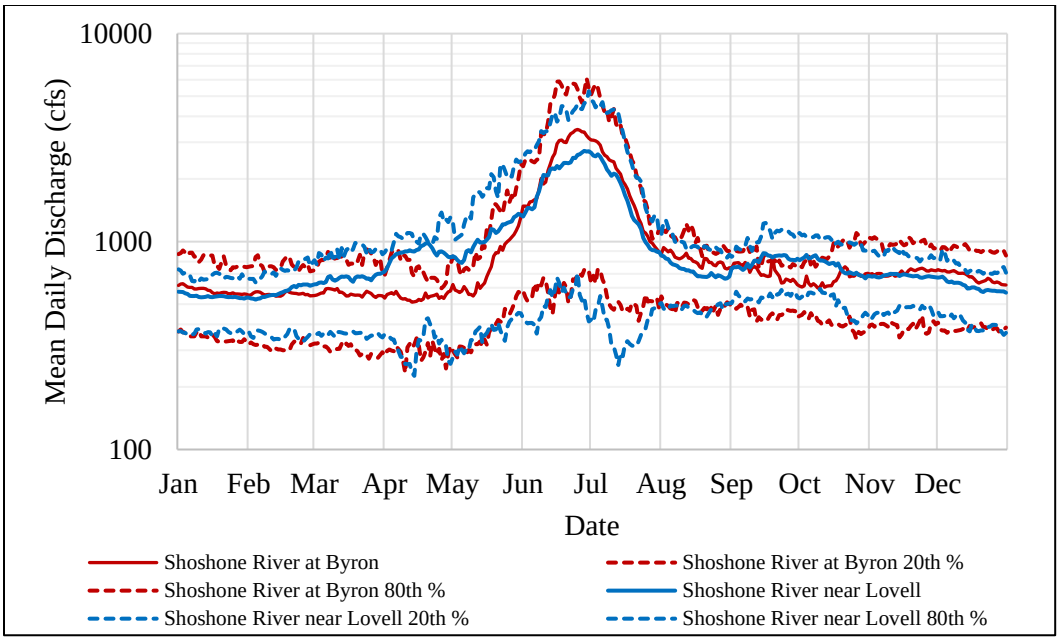


Figure 3.2.1-1. Mean daily discharge with 80% and 20% values from two USGS gauging stations with long period of record on the mainstem Shoshone River in the Study Area.

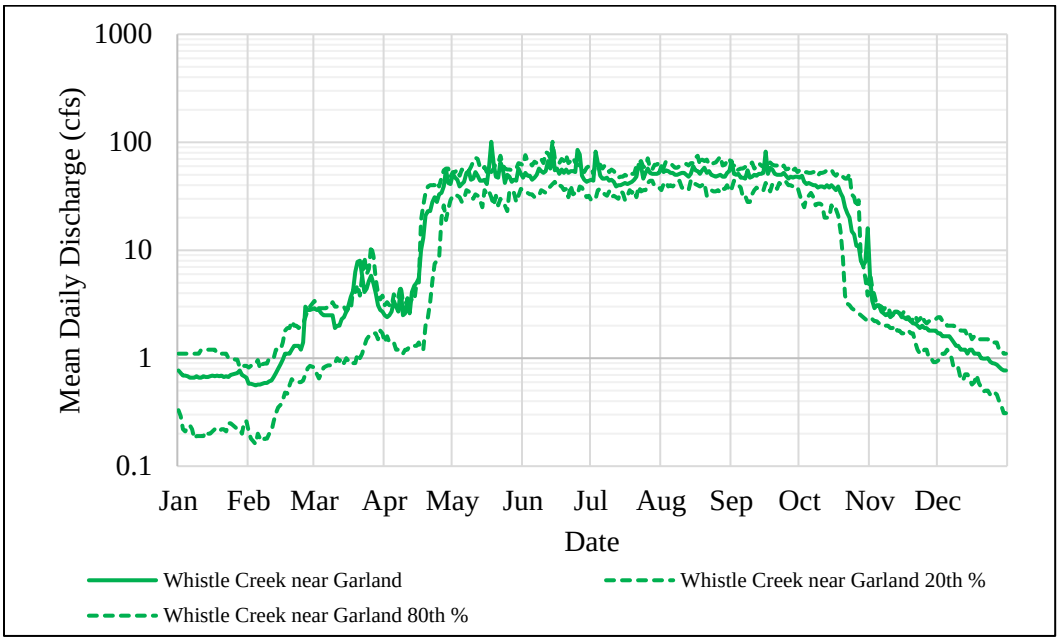


Figure 3.2.1-2. Mean daily discharge with 80% and 20% values from the Whistle Creek USGS gauge #06284800 in the Study Area.

Figure 3.2.1-3 depicts mean daily discharge flow duration curves developed from recorded flow data at the three gauging stations. Flow duration curves from the Shoshone River gauges have similar slopes, reflective of the dam-release, irrigation-driven hydrologic regime in the basin. The Whistle Creek flow duration curve has a relatively steeper slope which may be due to smaller drainage area and less influence from dam-release and irrigation activities.

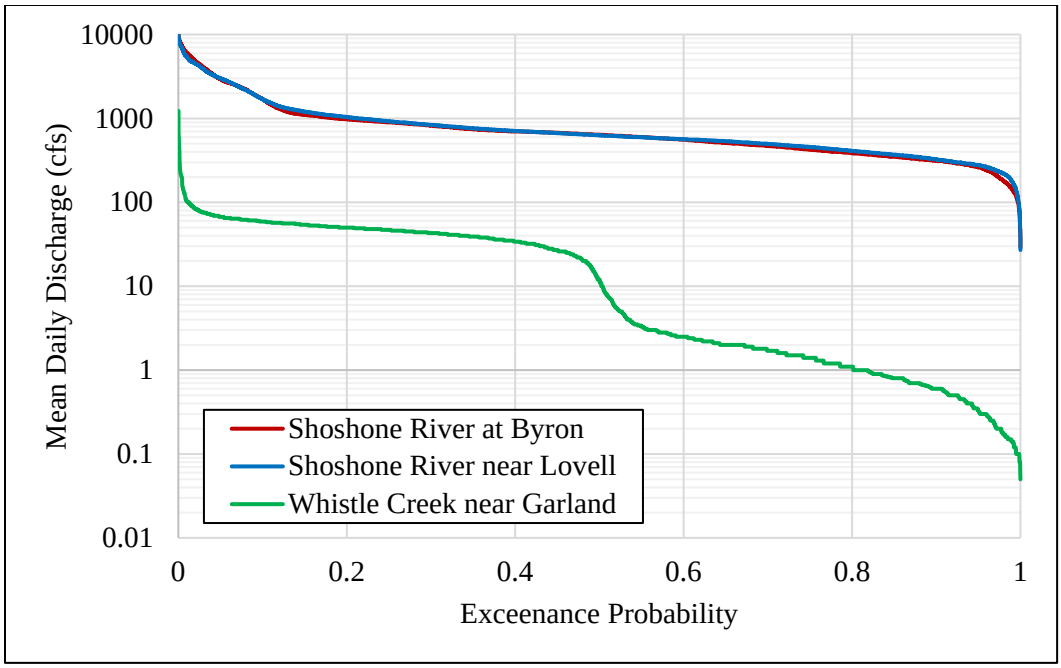


Figure 3.2.1-3. Mean daily discharge flow duration curves developed from three gauging stations in the Study Area.

Mean annual discharge and total annual yield in all HUC12 and HUC10 sub-basins were calculated using an equation from Lowham (1988) that estimates mean annual discharge for streams in the High Desert Region of Wyoming based on drainage area and mean annual precipitation (Tables 3.2.1-2, and 3.2.1-3). The equation has a high standard error of 0.96 which should be considered when interpreting regression equation results. Further quantification of streamflow hydrology including measured and estimated mean annual and mean monthly discharge is presented below.

Table 3.2.1-2. Mean annual discharge and total annual yield estimates from regional regression equations for HUC12 sub-basins within the Study Area.

Total Contributing Drainage Area (sq mi)	HUC 12 #	HUC 12 Name	Mean Annual Discharge (cfs)	Total Yield (acre-ft)
286.6	100800140407	Town of Frannie - Sage Creek	3.1	2,239
40.0	100800140406	Polecat Creek	0.5	396
2,174.2	100800140307	Mantua Draw - Shoshone River	18.4	13,318
101.0	100800140302	Lower Whistle Creek	1.2	894
58.6	100800140301	Upper Whistle Creek	0.8	553
43.8	100800140303	Upper Coon Creek	0.6	429
81.2	100800140304	Lower Coon Creek	1.0	738
28.7	100800140305	Sand Draw	0.4	296
45.2	100800140306	Foster Gulch	0.6	440
42.4	100800140502	Lovell Lakes	0.6	416
2,974.8	100800140504	Horseshoe Reservoir - Shoshone River	28.4	20,571
126.8	100800100405	Sykes Springs - Crooked Creek	1.8	1,281

Total Contributing Drainage Area (sq mi)	HUC 12 #	HUC 12 Name	Mean Annual Discharge (cfs)	Total Yield (acre-ft)
31.8	100800100404	Big Coulee	0.5	379
55.2	100800100402	Lost Water Creek - Crooked Creek	0.9	616
79.6	100800100403	Gypsum Creek - Crooked Creek	1.2	850
58.3	100800140501	Dry Creek	0.9	647
326.6	100800140408	Big Wash - Sage Creek	3.5	2,512
2,826.3	100800140503	Peterson Creek - Shoshone River	23.2	16,776

Table 3.2.1-3. Mean annual discharge and total annual yield estimates from regional regression equations for HUC10 sub-basins within the Study Area.

HUC 10 Area (sq mi)	Total Contributing Drainage Area (sq mi)	HUC 10 #	HUC 10 Name	Mean Annual Discharge (cfs)	Total Yield (acre-ft)
369.3	369.3	1008001404	Sage Creek	3.2	2,330
315.3	2430.3	1008001403	Coon Creek - Shoshone River	70.8	51,233
176.4	2974.5	1008001405	Dry Creek - Shoshone River	84.5	61,203
126.9	126.9	1008001004	Crooked Creek	1.8	1,281

3.2.1c Wet/Normal/Dry Flow at Gauges

Streamflow can be characterized by classifying flows into dry, normal, and wet years based on cumulative streamflow at a gauge site. For this analysis, dry years are defined as the 20% of analyzed years with the lowest cumulative annual streamflow; wet years are defined as the 20% of analyzed years with the greatest cumulative annual streamflow; and normal years are defined as the remaining 60% of years.

Shoshone River near Lovell (#06285100)

The active USGS gauge on the Shoshone River near Lovell (#06285100) was selected for use in this analysis as it contains 54 complete water years of flow data from October 1st to September 30th. The period of record extends from 1967 to 2020 and contains 11 dry years, 32 normal years, and 11 wet years (Table 3.2.1-4). This dry/normal/wet year classification was used as the basis for analysis of all other gauges in the Study Area except for the Shoshone River at Byron gauge (#06285000) and the Sage Creek near Lovell gauge (#0628550), which have periods of record that do not overlap with gauge #06285100.

Table 3.2.1-4. Cumulative streamflow and Dry/Normal/Wet pattern at Shoshone River near Lovell gauge.

Year	Cumulative Flow (acre-feet)	Wet/Normal/Dry
1967	915,982	Wet
1968	577,623	Normal
1969	696,284	Normal

Year	Cumulative Flow (acre-feet)	Wet/Normal/Dry
1970	775,115	Normal
1971	907,382	Wet
1972	816,715	Normal
1973	684,028	Normal
1974	884,149	Normal
1975	847,058	Normal
1976	951,772	Wet
1977	348,916	Dry
1978	795,104	Normal
1979	579,429	Normal
1980	535,919	Normal
1981	635,055	Normal
1982	821,061	Normal
1983	765,249	Normal
1984	639,585	Normal
1985	417,046	Normal
1986	850,535	Normal
1987	424,320	Normal
1988	260,273	Dry
1989	416,284	Normal
1990	549,202	Normal
1991	659,510	Normal
1992	407,457	Dry
1993	407,817	Dry
1994	443,744	Normal
1995	415,931	Dry
1996	1,177,886	Wet
1997	1,201,461	Wet
1998	684,164	Normal
1999	808,993	Normal
2000	492,326	Normal
2001	360,884	Dry
2002	257,779	Dry
2003	388,058	Dry
2004	284,524	Dry
2005	475,442	Normal
2006	392,441	Dry
2007	316,526	Dry
2008	854,937	Normal
2009	920,800	Wet
2010	562,056	Normal
2011	1,300,996	Wet

Year	Cumulative Flow (acre-feet)	Wet/Normal/Dry
2012	471,061	Normal
2013	426,994	Normal
2014	1,112,361	Wet
2015	677,954	Normal
2016	436,660	Normal
2017	1,263,527	Wet
2018	1,385,106	Wet
2019	1,013,470	Wet
2020	775,309	Normal

From 1967 to 2020, average annual discharge during dry, normal, and wet years, respectively, is 482, 884, and 1,525 cfs. Monthly streamflow peaks in June, ranging from 725 cfs in a dry year to 4,078 cfs in a wet year (Figure 3.2.1-4). Monthly streamflow is lowest in January ranging from 429 cfs in a dry year to 563 cfs in a wet year (Table 3.2.1-5).

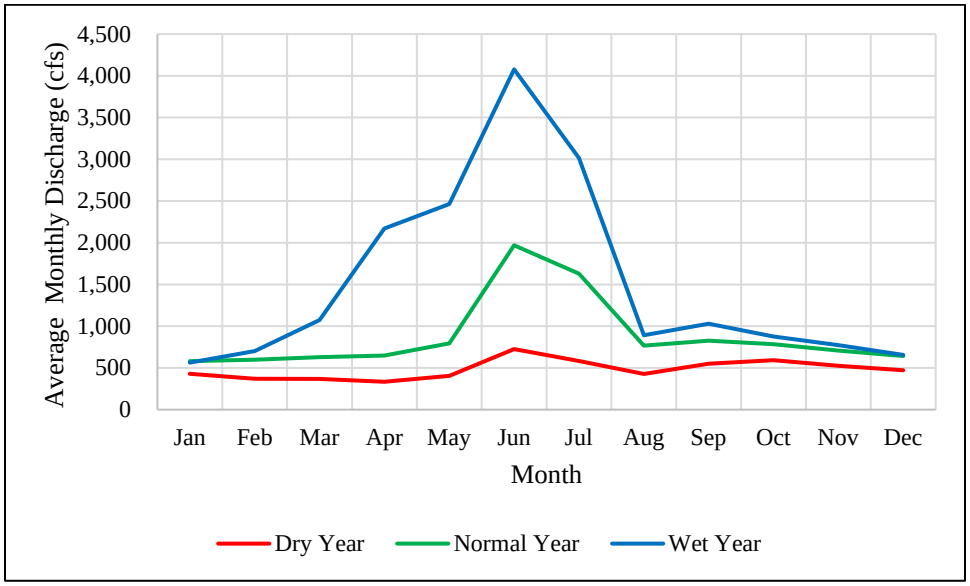


Figure 3.2.1-4. Average monthly discharge (cfs) at Shoshone River near Lovell gauge for dry, normal, and wet years.

Table 3.2.1-5. Average monthly discharge (cfs) at the Shoshone River near Lovell gauge for dry, normal, and wet years.

Shoshone River near Lovell Gauge #06285100	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry Years (n=11)	429	369	367	334	405	725	583	428	549	592	526	472
Normal Years (n=32)	581	598	628	647	793	1,969	1,630	766	825	783	708	641
Wet Years (n=11)	563	701	1,074	2,171	2,464	4,078	3,015	892	1,030	877	773	656

Shoshone River at Byron (#06285000)

The Shoshone River at Byron gauge (#06285000) is located on the mainstem Shoshone River downstream of the confluence with Coon Creek. The gauge has a 38-year period of record spanning 1929 through 1966 including 37 complete water years. Because these years do not overlap with the active Shoshone River near Lovell gauge (#06285100), the Shoshone River at Byron gauge data were analyzed independently to classify years as dry, normal, and wet. The 37-year dataset contains 8 dry years, 21 normal years, and 8 wet years (Table 3.2.1-6).

Table 3.2.1-6. Cumulative streamflow and Dry/Normal/Wet pattern at the Shoshone River at Byron gauge.

Year	Cumulative Flow (acre-feet)	Wet/Normal/Dry
1930	772,084	Normal
1931	453,896	Dry
1932	899,039	Wet
1933	590,541	Normal
1934	333,040	Dry
1935	592,706	Normal
1936	709,742	Normal
1937	607,365	Normal
1938	766,662	Normal
1939	682,104	Normal
1940	472,946	Dry
1941	522,542	Normal
1942	736,370	Normal
1943	1,195,905	Wet
1944	662,917	Normal
1945	644,828	Normal
1946	640,441	Normal
1947	785,948	Normal
1948	796,607	Wet
1949	621,765	Normal
1950	717,888	Normal
1951	1,046,306	Wet
1952	773,294	Normal
1953	455,199	Dry
1954	600,396	Normal
1955	403,131	Dry
1956	714,119	Normal
1957	887,181	Wet
1958	816,322	Wet
1959	333,727	Dry
1960	423,670	Dry
1961	305,728	Dry

Year	Cumulative Flow (acre-feet)	Wet/Normal/Dry
1962	787,551	Wet
1963	731,269	Normal
1964	692,810	Normal
1965	947,246	Wet
1966	483,444	Normal

The observed average annual discharge during dry, normal, and wet years, respectively, is 549, 924, and 1,273 cfs. Monthly streamflow peaks in June ranging from 873 cfs during a dry year to 3,882 cfs during a wet year (Figure 3.2.1-5). Monthly streamflow is lowest in April ranging from 307 cfs during a dry year to 767 cfs during a wet year (Table 3.2.1-7).

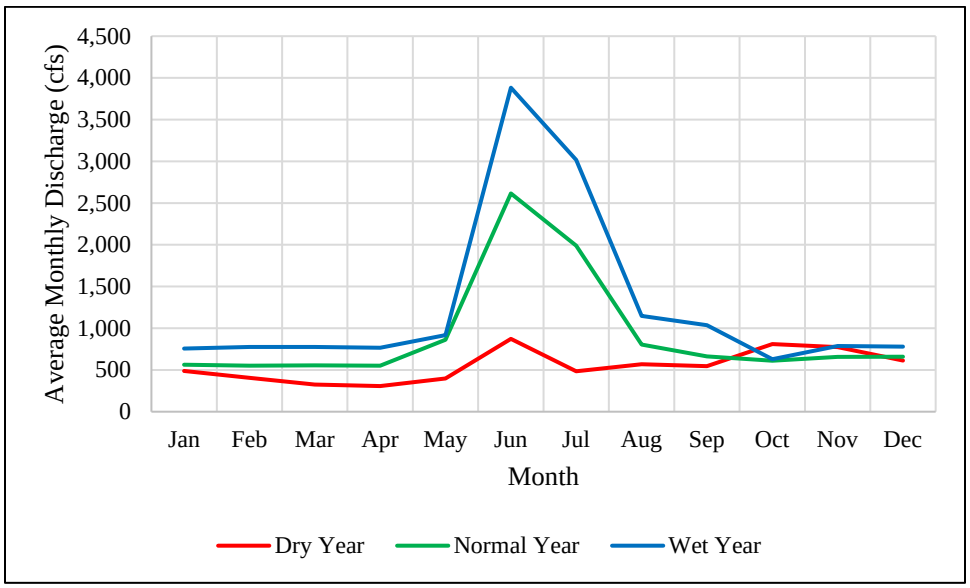


Figure 3.2.1-5. Average monthly discharge (cfs) at Shoshone River at Byron gauge for dry, normal, and wet years.

Table 3.2.1-7. Average monthly discharge (cfs) at Shoshone River at Byron gauge for dry, normal, and wet years.

Shoshone River at Byron Gauge #06285000	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry Years (n=8)	488	405	325	307	399	873	484	569	545	811	774	614
Normal Years (n=21)	563	552	555	551	863	2,615	1,989	804	663	610	657	660
Wet Years (n=8)	756	776	776	767	917	3,882	3,017	1,148	1,036	629	788	780

Sage Creek at Sidon Canal near Deaver (#06285400)

At Sage Creek at Sidon Canal near Deaver gauge (#06285400) the average annual discharge during dry, normal, and wet years, respectively is 48, 66, and 67 cfs. Monthly streamflow peaks twice throughout the growing season, first in June, after which streamflow is lower throughout July likely due to irrigation diversion, and then peaks again in September (Figure 3.2.1-6). Monthly

streamflow in June ranges between 41 cfs during a dry year and 107 cfs during a wet year. Monthly streamflow in September ranges between 76 cfs during a dry year and 134 cfs during a wet year. Monthly streamflow is lowest in January averaging around 13-15 cfs during dry, normal, and wet years (Table 3.2.1-8).

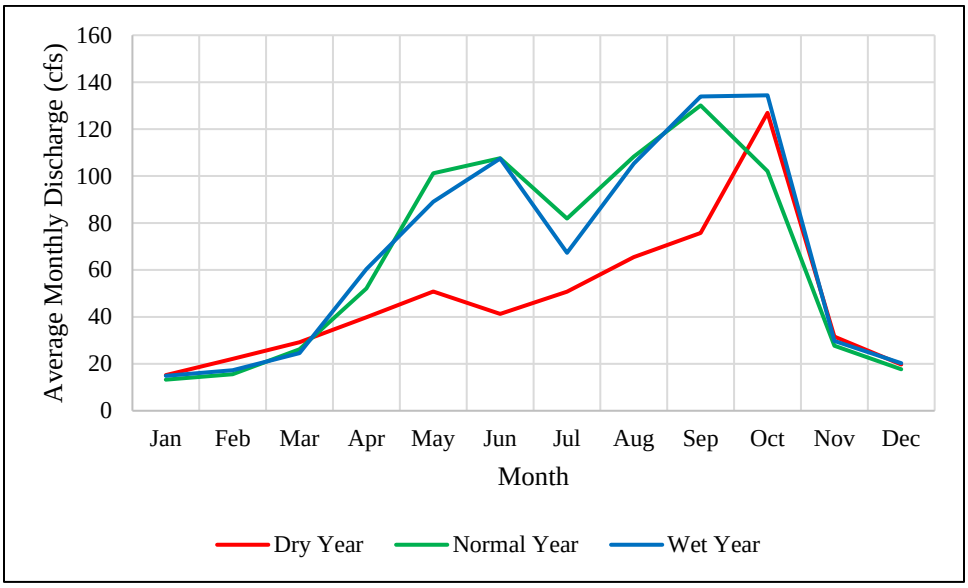


Figure 3.2.1-6. Average monthly discharge (cfs) at the Sage Creek at Sidon Canal gauge for dry, normal, and wet years.

Table 3.2.1-8. Average monthly discharge (cfs) at the Sage Creek at Sidon Canal for dry, normal, and wet years.

Sage Creek at Sidon Canal Gauge #06285400	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry Years (n=1)	15	22	29	40	51	41	51	65	76	127	32	20
Normal Years (n=16)	13	16	26	52	101	108	82	108	130	102	28	18
Wet Years (n=2)	15	17	25	60	89	107	67	105	134	134	30	20

Sage Creek near Lovell (#06285500)

The Sage Creek near Lovell gauge (#06285500) is located approximately 3.6 mi upstream of the confluence with the Shoshone River and has a 363 sq mi drainage area. This gauge is located downstream gauge #06285400 and the confluence with the Big Wash tributary. Due to its location, this gauge captures more flow within the Sage Creek watershed, including irrigation return flows, relative to the Sage Creek at Sidon Canal gauge. However, the gauge contains a relatively short 9-year period of record spanning from 1951 to 1960. The average annual discharge recorded at the gauge is 106 cfs. Average daily discharge statistics are presented in Figure 3.2.1-7.

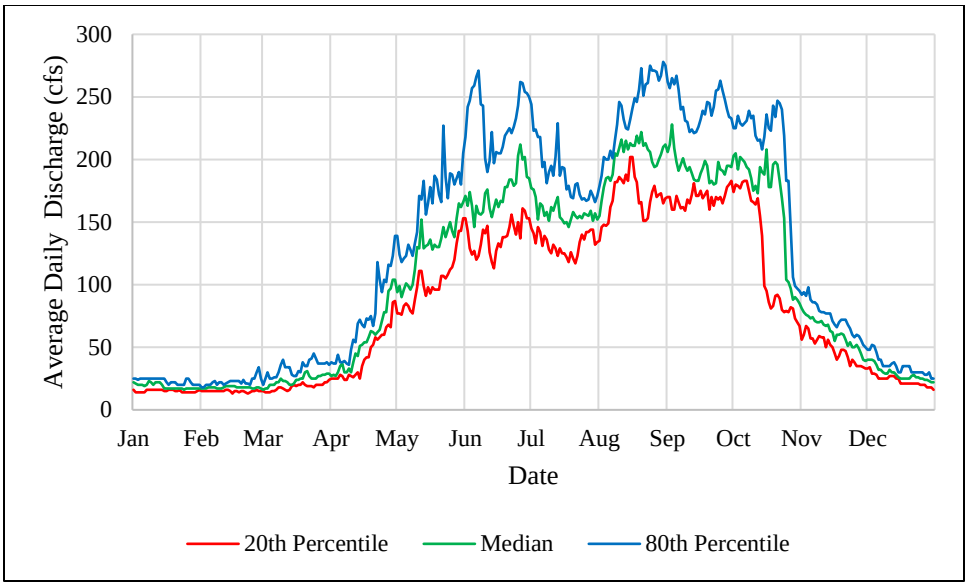


Figure 3.2.1-7. Average daily discharge with 80% and 20% values for the Sage Creek near Lovell gauge.

Whistle Creek near Garland (#06284800)

At the Whistle Creek near Garland gauge (#06284800) the average annual discharge for dry, normal, and wet years, respectively, is 48, 66, and 67 cfs. Monthly streamflow peaks in June ranging from 26.7 cfs during a dry year to 62.2 cfs during a wet year (Figure 3.2.1-8). Monthly streamflow is lowest in January averaging about 0.5 cfs during dry, normal, and wet years (Table 3.2.1-9).

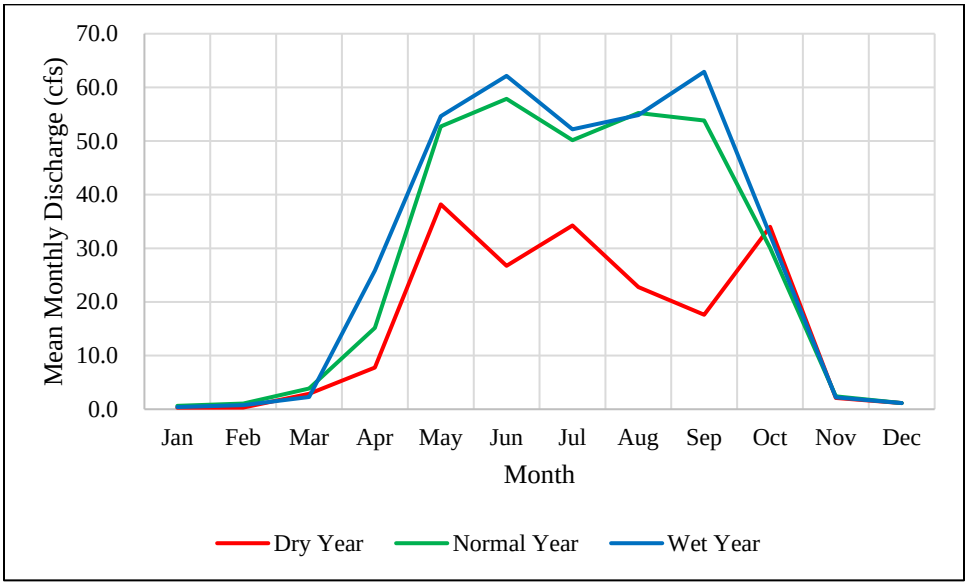


Figure 3.2.1-8. Average monthly discharge at the Whistle Creek near Garland gauge for dry, normal, and wet years.

Table 3.2.1-9. Average monthly discharge (cfs) at the Whistle Creek near Garland gauge for dry, normal, and wet years.

Whistle Creek Gauge #06284800	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry Years (n=1)	0.3	0.3	2.9	7.8	38.2	26.7	34.3	22.8	17.6	34.0	2.1	1.2
Normal Years (n=14)	0.6	1.1	3.9	15.2	52.7	57.9	50.2	55.2	53.8	30.1	2.4	1.2
Wet Years (n=2)	0.4	0.7	2.3	25.8	54.6	62.2	52.2	54.8	62.9	32.5	2.2	1.2

3.2.1d Wet/Normal/Dry Flow at HUC 10 Watersheds

Average annual discharge and average monthly discharge were calculated for three of the four HUC10 watersheds in the Study Area, including Coon Creek (100800140), Dry Creek (1008001405), and Sage Creek (1008001404). Average annual discharge and average monthly discharge were not calculated for Crooked Creek (1008001004) due to a lack of flow data.

Coon Creek HUC 10 Watershed (1008001403)

The active Shoshone River near Lovell gauge (#06285100) is located at the downstream extent of the Coon Creek HUC10 watershed (1008001403). Due to the proximity of the gauge to the downstream extent of the Shoshone River in the Coon Creek HUC 10 watershed, the measured dry/normal/wet year flows presented above are representative of the entire HUC10 watershed. The dry/normal/wet flows in the Coon Creek HUC 10 watershed area are representative of the entire Shoshone River draining to the downstream extent of the HUC 12 boundary.

Dry Creek HUC 10 Watershed (1008001405)

The Dry Creek HUC10 watershed (1008001405) extends from the downstream boundary of the Coon Creek – Shoshone River HUC10 to Bighorn Lake and represents flows from the entire Study Area including Sage Creek and Dry Creek tributaries. The historic USGS gauge Shoshone River at Kane (#06286200) is located within this HUC10 watershed but has a relatively short period of record of 11 years and is located close to the Shoshone River near Lovell gauge, which has a 54-year period of record, that it was not used in this analysis. The active, long-term Shoshone River near Lovell gauge (#06285100) data was used to estimate streamflow for the Dry Creek HUC 10 watershed for analysis of annual and monthly streamflow for dry, normal, and wet years. The Dry Creek HUC 10 area (including the entire Shoshone River watershed drainage area) is 2,974.5 sq mi and the Coon Creek HUC 10 area (including the entire Shoshone River watershed drainage area) is 2,430.3 sq mi. Using the drainage area ratio (see equation below), the Dry Creek HUC 10 watershed is expected to produce approximately 22% more flow than the Coon Creek HUC 10 watershed.

$$Dry\ Creek\ HUC10\ Flow = Coon\ Creek\ HUC10\ Flow\ x\ (\frac{2{,}974.5\ sq\ mi}{2{,}430.3\ sq\ mi})$$

From 1967 to 2020, average annual discharge during dry, normal, and wet years, respectively, is 590, 1,082, and 1,867 cfs. Monthly streamflow peaks in June, ranging between 888 cfs during a dry year and 4,990 cfs during a wet year (Figure 3.2.1-9) Monthly streamflow is lowest in January ranging from 525 cfs during a dry year to 689 cfs during a wet year (Table 3.2.1-10).

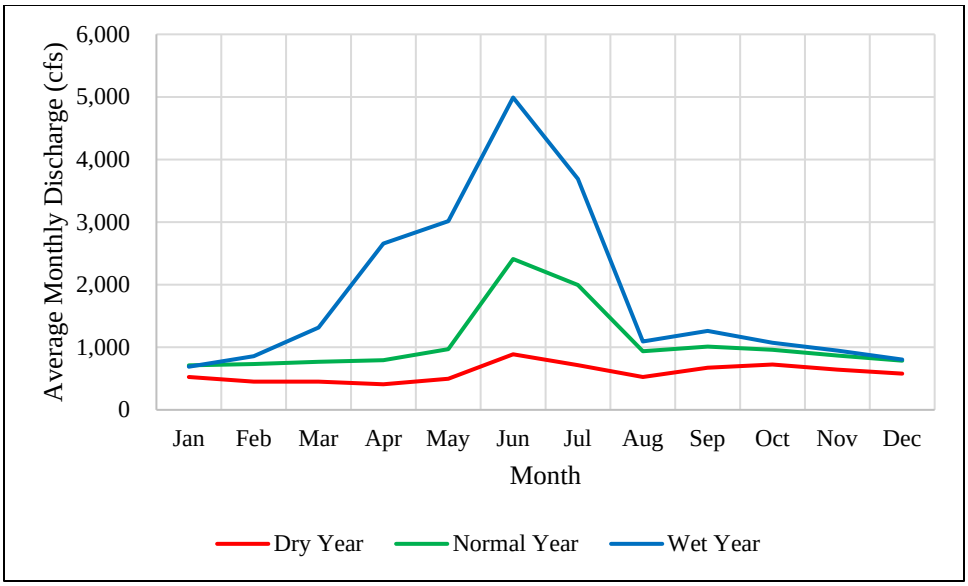


Figure 3.2.1-9. Estimated average monthly discharge (cfs) at the Dry Creek HUC 10 watershed (Shoshone River) for dry, normal, and wet years.

Table 3.2.1-10. Estimated average monthly discharge (cfs) at the Dry Creek HUC10 watershed (Shoshone River) for dry, normal, and wet years.

Dry Creek – Shoshone River HUC10-1008001405	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry Years (n=11)	525	452	450	409	496	888	714	524	672	724	643	578
Normal Years (n=32)	711	732	769	792	971	2,410	1,995	938	1,010	959	867	785
Wet Years (n=11)	689	858	1,314	2,657	3,015	4,990	3,690	1,092	1,260	1,073	947	803

Sage Creek HUC 10 Watershed (1008001404)

The Sage Creek HUC10 watershed (1008001404) includes the entire Sage Creek drainage to its confluence with the Shoshone River. The Sage Creek at Sidon Canal near Deaver gauge (#06285400) has 19 complete water years of recorded data which overlap with the active Shoshone River near Lovell gauge (#06285100), allowing classification of the years into dry, normal, and wet years.

There is 1 dry year, 16 normal years, and 2 wet years. The limited sample size of dry and wet years should be considered when comparing streamflow estimates. The Sage Creek at Sidon Canal gauge is located at the confluence with Polecat Creek several miles upstream of the downstream boundary of the Sage Creek HUC10 watershed and does not record flows from the Big Wash tributary and other inputs such as irrigation return flow. The Sage Creek near Lovell gauge (#06285500), which is located near the downstream end of the Sage Creek HUC10, has 9 water years of data, but those years do not overlap with the active Shoshone River near Lovell gauge and therefore was not used in the dry, normal, wet analysis.

Data from the Sage Creek at Sidon Canal gauge were used to estimate streamflow at the downstream end of the Sage Creek HUC10 watershed based on the ratio of their respective drainage areas. The Sage Creek HUC10 watershed includes the headwaters in Montana to the confluence

with the Shoshone River. The drainage area at the Sage Creek at Sidon Canal gauge is 341.0 sq mi and the drainage area of the Sage Creek HUC10 is 369.3 sq mi, representing a ratio of 1.08. The equation for calculating the Sage Creek HUC 10 watershed flows was as follows:

$$Sage\ Creek\ HUC10\ Flow = Sage\ Creek\ Gauge\ \#06285400\ Flow\ x\ (\frac{369.3\ sq\ mi}{341\ sq\ mi})$$

From 1969 to 1986, average annual discharge during dry, normal, and wet years, respectively, is 52, 71, and 73 cfs. Monthly streamflow peaks twice throughout the growing season, first in June, after which streamflow is lower throughout July likely due to irrigation diversion, and then peaks again in September (Figure 3.2.1-10). Monthly streamflow in June ranges between 45 cfs during a dry year and 116 cfs during a wet year. Monthly streamflow in September ranges between 82 cfs during a dry year and 145 cfs during a wet year. Monthly streamflow is lowest in January averaging around 14-16 cfs during dry, normal, and wet years (Table 3.2.1-11). Note that the average annual discharge estimates are generally lower than observed average at the downstream Sage Creek near Lovell gauge of 106 cfs. This suggests that these estimates likely underpredict average annual and monthly flows in the Sage Creek HUC 10 watershed.

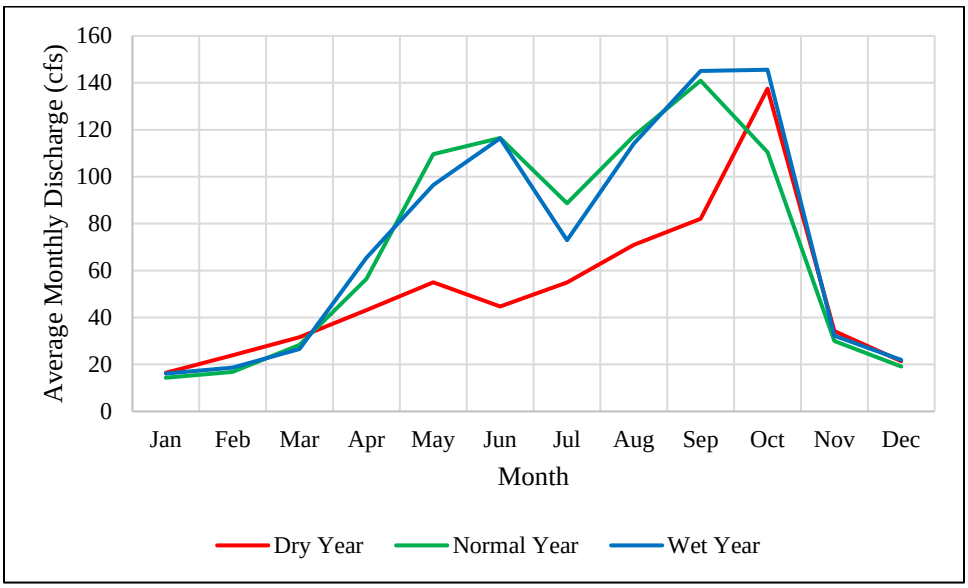


Figure 3.2.1-10. Estimated average monthly discharge (cfs) at the Sage Creek HUC10 watershed for dry, normal, and wet years.

Table 3.2.1-11. Estimated average monthly discharge (cfs) at the Dry Creek – Shoshone River HUC10 for dry, normal, and wet years.

Sage Creek HUC10-1008001404	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry Years (n=1)	16	24	32	43	55	45	55	71	82	137	34	21
Normal Years (n=16)	14	17	28	56	110	117	89	117	141	111	30	19
Wet Years (n=2)	16	19	27	65	96	116	73	114	145	146	32	22

Crooked Creek HUC 10 Watershed (1008001004)

The Crooked Creek near Lovell gauge (#6286260) was only in operation over a period of three years from 1964 to 1967. This amount of data was insufficient to estimate flows dry, normal, and wet years in the Crooked Creek HUC 10 watershed (1008001004).

3.2.1e Water Quality

The following information is derived from the Wyoming Department of Environmental Quality (WDEQ) 2020 Integrated 305(b) and 303(d) Report. The Absoroka Mountains area a volcanic mountain range originating 40-50 million years ago from a group of approximately 25 large volcanoes. Ecoregions within this mountain range include alpine, sub-alpine, and foothills. Soils in these mountains are nutrient rich and consist of highly erosional ash, tuff, basalt, and pumice, which can naturally elevate stream turbidity during precipitation events. The Bighorn Basin lies between the Absoroka, Wind River, and Bighorn Mountain ranges and is divided between Bighorn Basin and Bighorn Salt Desert Shrub Basin ecoregions. The basin is an arid depression characterized by alkaline soils consisting of shale, siltstone, and sandstone.

Land uses in the mountains of the basin include livestock grazing, wildlife habitat, and recreation. Livestock grazing, irrigated cropland, oil and gas production, bentonite mining, and wildlife habitat are the primary land uses in the lower basin.

Water quality is generally good within the mountains of the basin, but gradually declines as streams flow across the lower basin to the Bighorn River because of natural erosional processes that increase sediment and total dissolved solids (TDS) loads. Most of the lower Big Horn Basin has thin soils derived from highly erodible, saline, alkaline, and/or phosphate-rich geologic materials. Much of the precipitation in the lower elevation portion of this arid basin comes from thunderstorms, and these events can cause flash flooding and severe erosion of the sparsely vegetated soils. Accelerated erosion, irrigated agricultural runoff, discharge from oil and gas development, and other human activities may also degrade water quality. Other anthropogenic impacts, thought to date to the 1880s, have affected sediment transport in some of the lower elevation portions of the basin. For example, livestock grazing practices (long-term/high-density grazing) removed native grasses and began a cycle of intense runoff and gullying that exacerbated naturally unstable conditions. The prevalence of dams and other hydrologic modifications have altered the natural flow regime of the basin.

Climate change predictions indicate that water quality indicators such as stream temperature and flow will decline in the Study Area in the future. Changes in streamflow and temperature pose a considerable risk to native fish species particularly where temperatures are currently near survival thresholds and/or where there is considerable competition from non-native species. Recent modeling by the USFS includes predictions of future stream temperature (Isaak et al. 2016) and summer low flow scenarios (USFS 2015) throughout the western U.S. Both the temperature and flow modeling datasets use the global climate model A1B emissions scenario for the future periods, which represents a medium warming scenario. The spatial distribution of the trend towards warmer stream temperatures and lower summer flows is depicted on Map 4.

Big Wash (WYBH100800140408_02) from the confluence with Sage Creek upstream to Sidon Canal was assessed by WDEQ in 2000 following notice from Big Horn County health officials that

children in the Cowley, Wyoming area were contracting gastroenteritis after swimming in a "swimming hole" in this waterbody. In 2000 and 2001, WDEQ collected fecal coliform data at two study sites along Big Wash, and several exceedances of the fecal bacteria criterion protective of the primary contact recreation designated use were detected.

Sage Creek (WYBH100800140408_01) from the confluence with the Shoshone River to a point 14.0 miles upstream was first assessed by WDEQ in 2001, following fecal coliform bacteria monitoring conducted in Big Wash, a tributary to Sage Creek, in 2000. The monitoring results for Sage Creek exceeded the 30-day Water Quality Standard of 200 colony forming units (cfu) per 100 ml. These data indicate that the designated use of Recreation is not being supported on Sage Creek as specified in the Water Quality Division Rules and Regulations. The extent of the non-support, as best determined by the sampling, is from the confluence with the Shoshone River upstream to an undetermined distance above the confluence with Big Wash.

Whistle Creek (WYBH100800140303_01) from the confluence with the Shoshone River to a point 8.7 miles upstream was first assessed by WDEQ in 2001 following a pathogen indicator synoptic study conducted by the USGS in 2000 which reported provisional fecal coliform bacteria and *e.coli* counts in Whistle Creek. The WDEQ monitoring results for Whistle Creek exceeded the Water Quality Standard of 400 cfu per 100 ml. These data indicate that the designated use of recreation is not being supported on Whistle Creek as specified in the Water Quality Division Rules and Regulations. The extent of the non-support, as best determined by this sampling, is from the confluence with the Shoshone River upstream an undetermined distance.

Crooked Creek (WYBH100800100500_01) from the confluence with Bighorn Lake to a point 7.9 miles upstream (Montana border) was assessed by WDEQ in 2005. The resulting report concluded that the dewatered segment of Crooked Creek was not supporting its cold water fish or aquatic life other than fish designated uses.

The Shoshone River (WYBH100800140504_00) from the confluence with Bighorn Lake to a point 9.7 miles upstream was assessed by the USGS in 2000. Assessment included collection of fecal coliform data at three sites along the Shoshone River. Fecal coliform was nearly non-detectable above Demaris Springs, while concentrations at the sites near Lovell and Kane were 4-5 times higher than WDEQ's fecal coliform criterion protective of contact recreation. These data indicate that the designated use of recreation is not being supported in the Shoshone River as specified in the Water Quality Division Rules and Regulations.

Stream Classification

The Wyoming Water Quality Rules and Regulations – Surface Water Standards (specifically Section 4, 33, 34, 35, and Appendix A) explains the background and process by which state classifications are assigned to waters within the state that are named on the USGS 1:500,000 scale hydrologic map or are contained in the WGFD database of state streams and lakes. Each water classification is associated with a specific combination of protected uses, including the following:

1. Agriculture – for purposes of water pollution control, agricultural uses include irrigation or stock watering.
2. Fisheries – use includes water quality, habitat conditions, spawning and nursery areas, and food sources necessary to sustain populations of game and nongame fish.

3. Industry – use protection involves maintaining a level of water quality useful for industrial purposes.
4. Drinking water – use involves maintaining a level of water quality that is suitable for potable water or intended to be suitable after receiving conventional drinking water treatment.
5. Recreation – use protection involves maintaining a level of water quality which is safe for human contact.
6. Scenic value – use involves the aesthetics of the aquatic systems themselves (odor, color, taste, 'settleable' solids, floating solids, suspended solids, and solid waste) and is not necessarily related to general landscape appearance.
7. Aquatic life other than fish – use includes water quality and habitat necessary to sustain populations of organisms other than fish in proportions which make up diverse aquatic communities common to the waters of the state.
8. Wildlife – use includes protection of water quality to a level which is safe for the contact and consumption by avian and terrestrial wildlife species.
9. Fish Consumption – use involves maintaining a level of water quality that will prevent any unpalatable flavor and/or accumulation of harmful substances in fish tissue.

Designated uses that are protected within each state water classification (identified by a unique numeric and alphabetic code) are presented in Table 3.2.1-12. Definitions of water classifications that are applicable to the Study Area are subsequently presented, as quoted from the Water Quality Rules and Regulations, Chapter 1, Wyoming Surface Water Quality Standards (WDEQ, 2013).

Table 3.2.1-12. Protected uses within each Wyoming state water classification.

WDEQ Class	Drinking Water	Game Fish	Non-Game Fish	Fish Consumption	Other Aquatic Life	Recreation	Wildlife	Agriculture	Industry	Scenic Value
1*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2AB	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2A	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
2B	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2C	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3A	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3B	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3C	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
4A	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4B	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4C	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes

* Class 1 waters are not protected for all uses in all circumstances; actual uses on each particular water must be determined independently.

Class 2AB *– waters known to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where a game fishery and drinking water use in otherwise attainable. Class 2AB waters include all permanent and seasonal game fisheries and can be either "cold water" or "warm water" depending upon the predominance of cold water or warm water species present. All Class 2AB waters are designated as cold water game fisheries unless identified as a warm water game fishery by a "ww" notation in the "List". Unless it is shown otherwise, these waters are presumed to have sufficient water quality and quantity to support drinking water supplies and are protected for that use. Class 2AB waters are also protected for nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic value uses.*

Class 2B *– waters are those known to support or have the potential to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where it has been shown that drinking water uses are not attainable pursuant to the provisions of Section 33. Class 2B waters include permanent and seasonal game fisheries and can be either "cold water" or "warm water" depending upon the predominance of cold water or warm water species present. All Class 2B waters are designated as cold water game fisheries unless identified as a warm water game fishery by a "ww" notation in the Wyoming Surface Water Classification List. Uses designated on Class 2B waters include game and nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic value.*

Class 2C *– waters known to support or have the potential to support only nongame fish populations or spawning and nursery areas at least seasonally including their perennial tributaries and adjacent wetlands. Class 2C waters include all permanent and seasonal nongame fisheries and are considered "warm water". Uses designated on Class 2C waters include nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic value.*

Class 3B *– waters or tributary waters including adjacent wetlands that are not known to support fish populations or drinking water supplies and where those uses are not attainable. Class 3B waters are intermittent and ephemeral streams with sufficient hydrology to normally support and sustain communities of aquatic life including invertebrates, amphibians, or other flora and fauna which inhabit waters of the state at some stage of their life cycles. In general, 3B waters are characterized by frequent linear wetland occurrences or impoundments within or adjacent to the stream channel over its entire length. Such characteristics will be a primary indicator used in identifying Class 3B waters.*

Class 4A *– waters are artificial canals and ditches that are not known to support fish populations.*

Stream classifications within the Study Area obtained from the latest Wyoming Surface Water Classification list (WDEQ, 2001) are presented (Table 3.2.1-13) from downstream to upstream, and indented entries are tributary to previous entries.

Table 3.2.1-13. Stream classifications in the Lower Shoshone River Watershed Study Area.

Stream					WDEQ Classification
Big Horn Lake					2AB
	Crooked Creek				2AB
	Shoshone River				2AB
		Dry Creek			3B
		Sand Draw			2AB
		Sage Creek			2AB
			Big Wash		3B
			Polecat Creek		2AB
				South Fork Polecat Creek	3B
Stream					**WDEQ Classification**
				11 3BF Lateral	3B
			Frannie Dr		3B
		Sidon Canal			4A
		Deaver Canal			4A
		Frannie Canal			4A
		Garland Canal			2B
		Foster Gulch			2C
		Coon Creek			2C
		Whistle Creek			3B
			North Branch Whistle Creek		3B
			West Branch Whistle Creek		3B
		Arnoldus Lake			3B
			Arnoldus Drain		2B
		Bitter Creek			2AB
			Alkali Ditch		4A
		Mantua Dr			2AB
		Deer Creek			2AB
		Alkali Creek			2AB
		Eage Nest Creek			2AB
		Buck Creek			2AB
		Iron Creek			2AB
		Idaho Creek			2C
		Sage Creek			2AB

Stream					WDEQ Classification
			Hoodoo Creek		3B
				Horner Creek	2ABWW
			Foster Res		3B
			South Fork Sage Creek		3B
			Horner Creek		3B
		Cottonwood Creek			3B
		Dry Creek			3B
		Beck Lake			2AB
		Trail Creek			3B
		Sulphur Creek			2C
		Loch Katrine			3B

3.2.1f Flooding and Runoff

Flows within the Lower Shoshone River are impacted by a network of dams. Flows within the Lower Shoshone River are controlled by dam and diversion releases overseen by USBR and local irrigation districts. USBR operates, controls, and has the full management authority over the Buffalo Bill Dam. The Shoshone River USGS gauge near Lovell (#06285100) contains peak flow data from 1967 to present. Peak flow timing typically occurs between June 1-July 15, with some outlying peak flow dates occurring in the fall (Figure 3.2.1-11). Historical peak discharge rates and stage levels are presented in Figures 3.2.1-12 and 3.2.1-13. Peak Flows at the Shoshone River near Lovell gauge exceeded the National Weather Service flood stage of 11.0 feet four times within the recorded history of the gauge site. The occurrence of the top four highest recorded discharges in Figure 3.2.1-12 does not correspond to the top four highest recorded peak stages because peak stage at this site occurs during backwater conditions because of damming/partial damming of the river from ice in the wintertime.

The Willwood Dam on the Shoshone River is located between Cody and Ralston, upstream of the Study Area. Built in 1923 by the Bureau of Reclamation, the Willwood Dam supplies irrigation water for downstream users. Since construction of the dam, sediment deposition has occurred on the channel bottom for at least a half mile upstream of the dam. From 1923 to 1958, all sediment deposited upstream of the dam was flushed at the end of the irrigation season (mid-October). These operational practices resulted in annual fish kills and concern over drinking water quality for the Town of Lovell. Operational plans were revised from 1959 to 2011 to minimize the detrimental effects of sediment releases to downstream aquatic life and water users. These operational changes resulted in sediment accumulation upstream of the dam that can be detrimental to dam operations and can result in large sediment releases during dam repairs (WWG 3 2021).

Flood events within tributaries in the Lower Shoshone River watershed typically occur during and after severe thunderstorms and cloudburst events, most often in the mid-summer months. Flash flooding and mud slides has caused damage to buildings, infrastructure, fences, farm equipment, roads, bridges, and crops. Historical flood information for Big Horn County details the dates and

resulting damages of flood events (http://wyofloods.wrds.uwyo.edu/Big_Horn/historicalfloods.html). On July 13, 1967 severe thunderstorms produced 4-6 inches of rain, 6-9 inches of hail, and gusty winds which caused widespread damage and flash flooding in the Cowley, Byron, and Lovell areas. On May 7, 1988 storms and cloudbursts produced 1.73 inches of rain fall in Lovell, 2.4 inches in Cowley, 1.6 inches in Deaver, and 3.3 inches of rain in Frannie. This same storm was responsible for destroying at least 17 bridges and washing out 6 roads in Park County. On June 13, 1988, flash flooding on Crooked Creek, near Horseshoe bend area of Bighorn Canyon National Recreation Area, resulted in mud slides crossing Highway 37 and Lovell Canal overflowing.

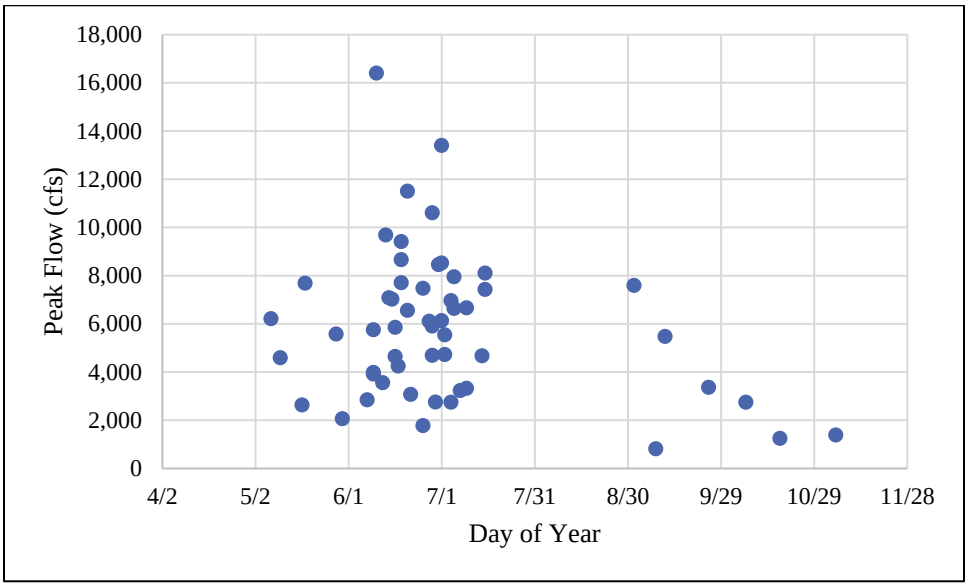


Figure 3.2.1-11. Peak flow timing at the Shoshone River gauge near Lovell. USGS gauge #06285100

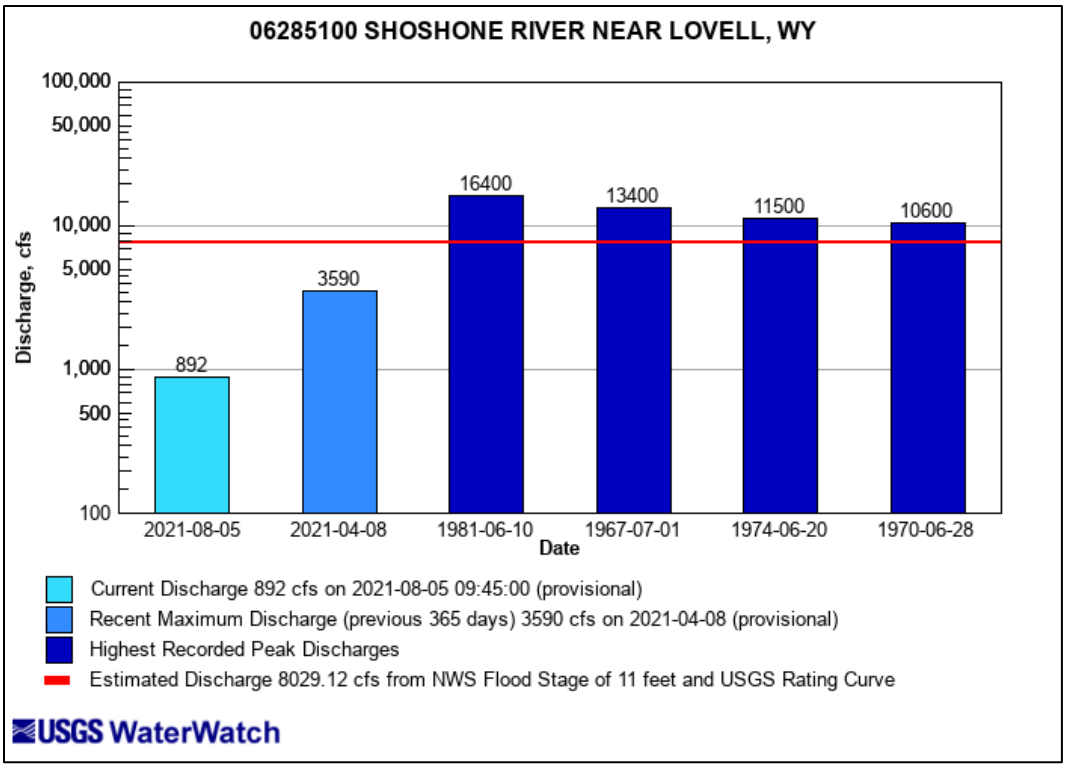


Figure 3.2.1-12. Historical peak discharges (cfs) at the Shoshone River gauge near Lovell. USGS gauge #06285100.

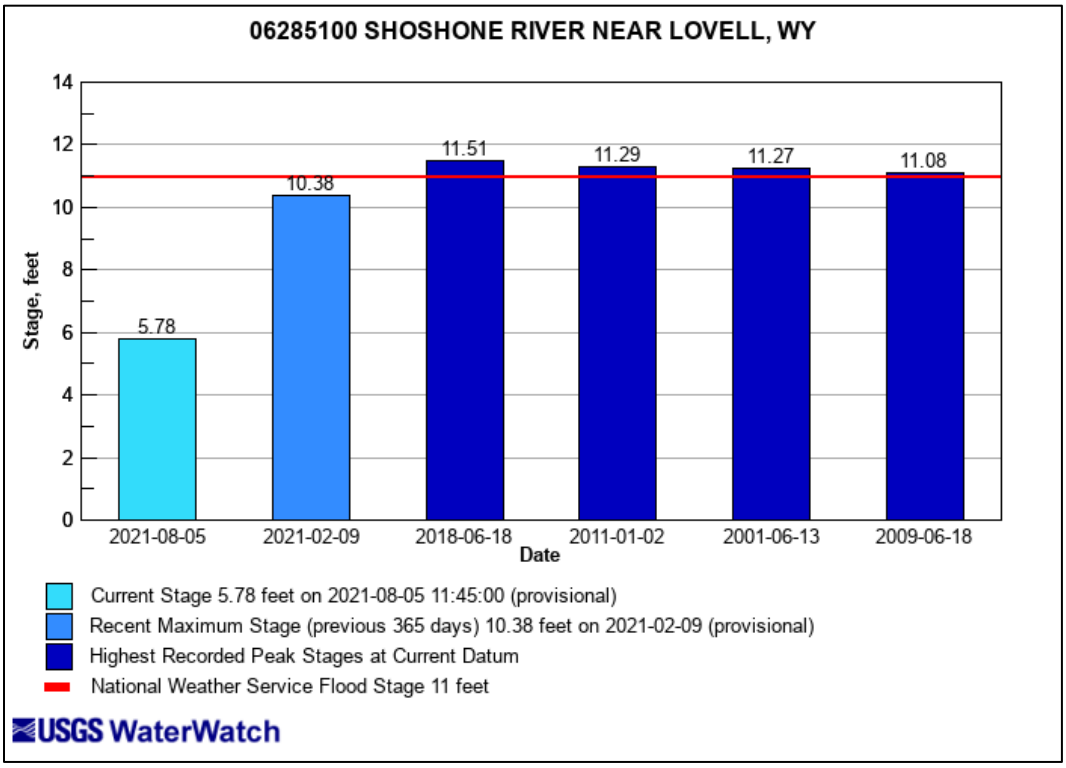


Figure 3.2.1-13. Historical peak stage levels (ft) at the Shoshone River gauge near Lovell. USGS gauge #06285100.

3.2.2 Geomorphology

Fluvial geomorphology is the study of the processes and physical form of riverine systems. Dependent variables such as channel dimension, pattern, and profile are influenced by the riverine system response to independent variables such as hydrologic regime, sediment conditions, and boundary conditions. Stable channel form is achieved when the physical attributes of dependent variables are maintained through time while the stream system conveys hydrologic and sediment inputs. Unstable conditions typically result when independent variables are altered, anthropogenically or naturally, and typically result in sudden changes in channel morphology through aggradation, degradation, lateral migration, or down-cutting.

The objective of the geomorphic classification is to describe channel form in order to better understand channel processes. Based on the concept that channel form reflects processes, physical channel parameters are assessed in order to classify channel type, and the interpretation of channel type within the local setting enables further understanding of channel function, stability, and appropriate management approach.

A subset of sites were visited during the 2021 field season, and field assessment of channel morphology at those locations was completed in order to verify the preliminary classification results. Those sites are discussed in Section 3.2.2a.

3.2.2a Rosgen Stream Classification System (Methods and Results)

A geomorphic classification was completed for the Lower Shoshone River and all major tributaries within the watershed Study Area. Tributaries included: Big Wash, Coon Creek, Sage Creek, Dry Creek, Whistle Creek, and Crooked Creek.

Channel morphology descriptions conformed to the Rosgen Level I classification procedure, which is a broad morphological characterization of channel form based upon landform, lithology, soils, climate, basin relief, valley morphology, and general river pattern (Rosgen 1994). The typical objective of a Level I classification is to use remote sensing technologies, along with some field verification, to describe general valley and fluvial form to enable interpretation of dominant fluvial processes and identification of appropriate management strategies.

A Level II description is a more thorough morphologic description that incorporates substrate material, local slope, and field measurement of channel parameters. A Level III description incorporates riparian vegetation, depositional patterns, confinement, and channel stability to assess stream condition. A Level IV description requires direct measurement of sediment transport, bank erosion, and hydraulic conditions in order to verify classification results. Figure 3.2.2-1 depicts the hierarchy of the Rosgen classification system levels. A Level I geomorphic classification was completed as part of this study; the higher level classifications require thorough field investigations that are beyond the scope of this watershed assessment.

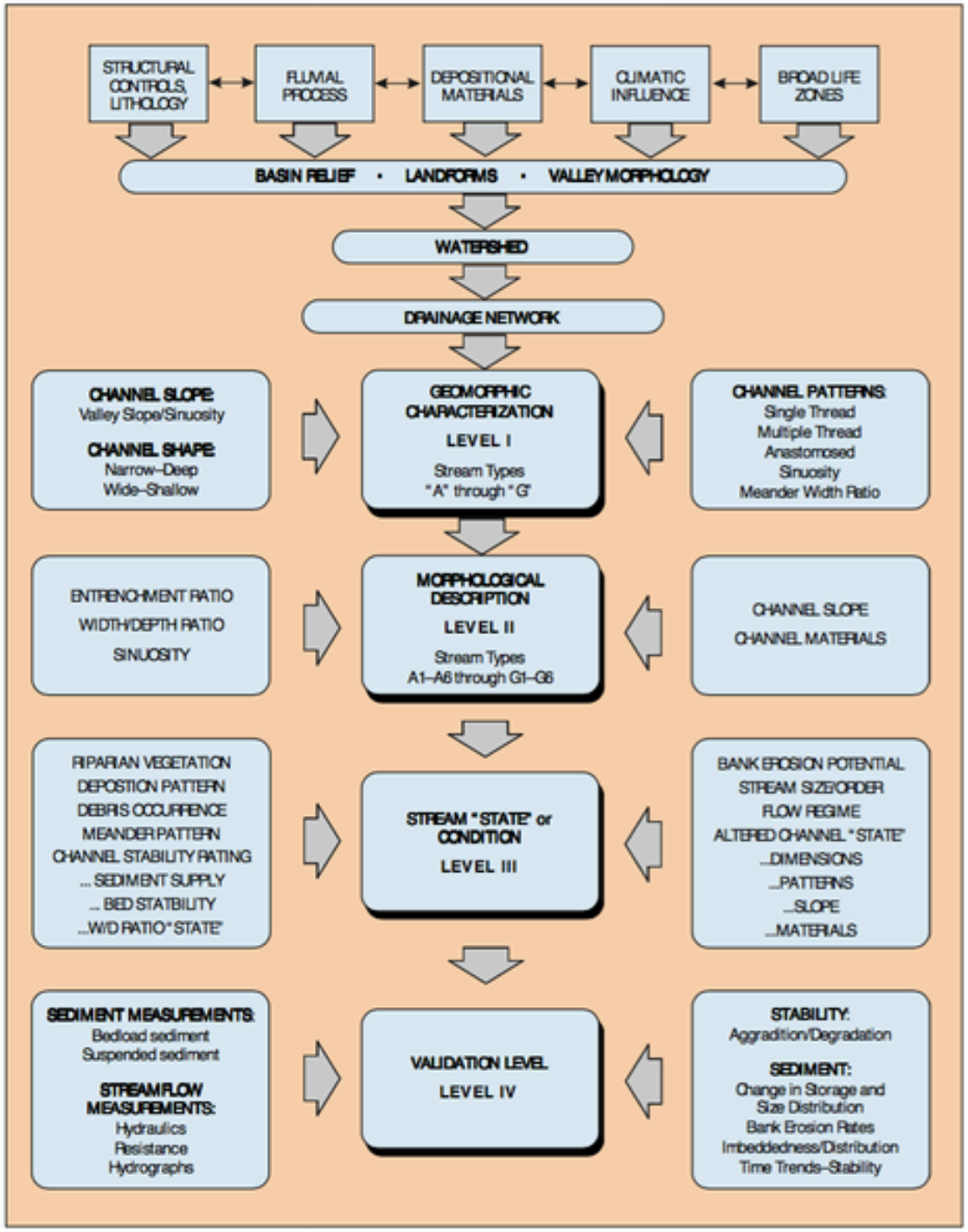


Figure 3.2.2-1. Schematic of the levels of Rosgen geomorphic channel classification.

The Rosgen Level I channel classification describes channel form in 8 general categories referred to by alphabetical identifiers A, G, F, B, E, C, D, and Da, as presented in Figure 3.2.2-2.

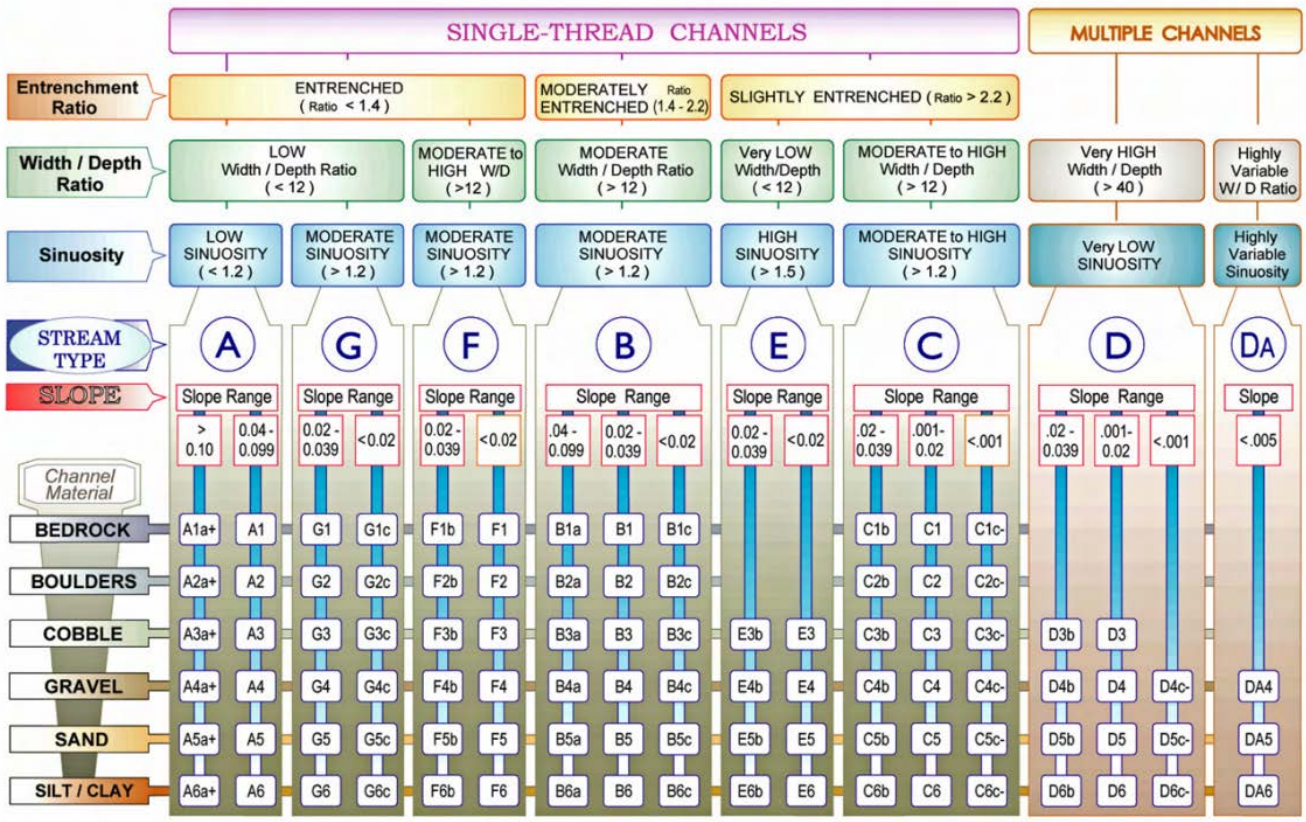


Figure 3.2.2-2. Rosgen Level I geomorphic channel classification schematic. Figure taken from NRCS (2007).

"A" Stream Type - Channel slopes range from 4 to 10 percent, and typically display a step-pool morphology, with plunge or scour pools. "A" stream types are found within valley types with inherent steepness, and exhibit a high sediment transport potential and relatively low sediment storage capacity.

"B" Stream Type - The predominant landforms are narrow and moderately sloping basin, and valley side slopes result in narrow valleys that limit the development of a wide floodplain. Streams are moderately entrenched, have a moderate width/depth ratio, display low channel sinuosity, and exhibit bed morphology dominated by rapids.

"C" Stream Type - Typically located in narrow to wide valleys constructed from alluvial deposition. Channels have a well developed floodplain, slight entrenchment, relatively sinuous, channel slope of 2% or less, and a bedform morphology consisting of riffle/pool configuration.

"D" Stream Type - Multiple channel systems exhibiting braided, or bar-braided pattern, with high channel width/depth ratio and channel slope roughly equivalent to the local valley slope. Landforms typically consist of steep depositional fans, steep glacial trough valleys, glacial outwash valleys, broad alluvial mountain valleys, and deltas. Bank erosion rates are

high, and sediment supply is generally unlimited and bed features are the result of convergence/divergence process of local bed scour and deposition.

"E" Stream Type - Channels are slightly entrenched, have low channel width/depth ratio, and high channel sinuosity. Bedform features are predominantly riffle/pool sequences. These stream types are sensitive to disturbance and rapidly adjust and convert to other stream types as the result of disturbance.

"F" Stream Type - Deeply incised in valleys of relatively low elevation relief with highly erodible materials. Channels have very high width/depth ratio, and bedform features include moderated riffle/pool sequence. Bank erosion rates, lateral extension rates, bar deposition, channel aggradation or degradation, and sediment storage capacities are high.

"G" Stream Type - Gully stream types are entrenched, narrow, and deep, with step/pool bedform and low sinuosity. Channel slopes generally exceed 2%. Channels exhibit high bank erosion rates, low channel width/depth ratios, and high bedload and suspended sediment transport rates. Channel degradation and side-slope rejuvenation processes are typical.

The typical relative locations of stream types within a watershed are presented in Figure 3.2.2-3. Brief descriptions of the Rosgen classification system stream types are included in Table 3.2.2-1.

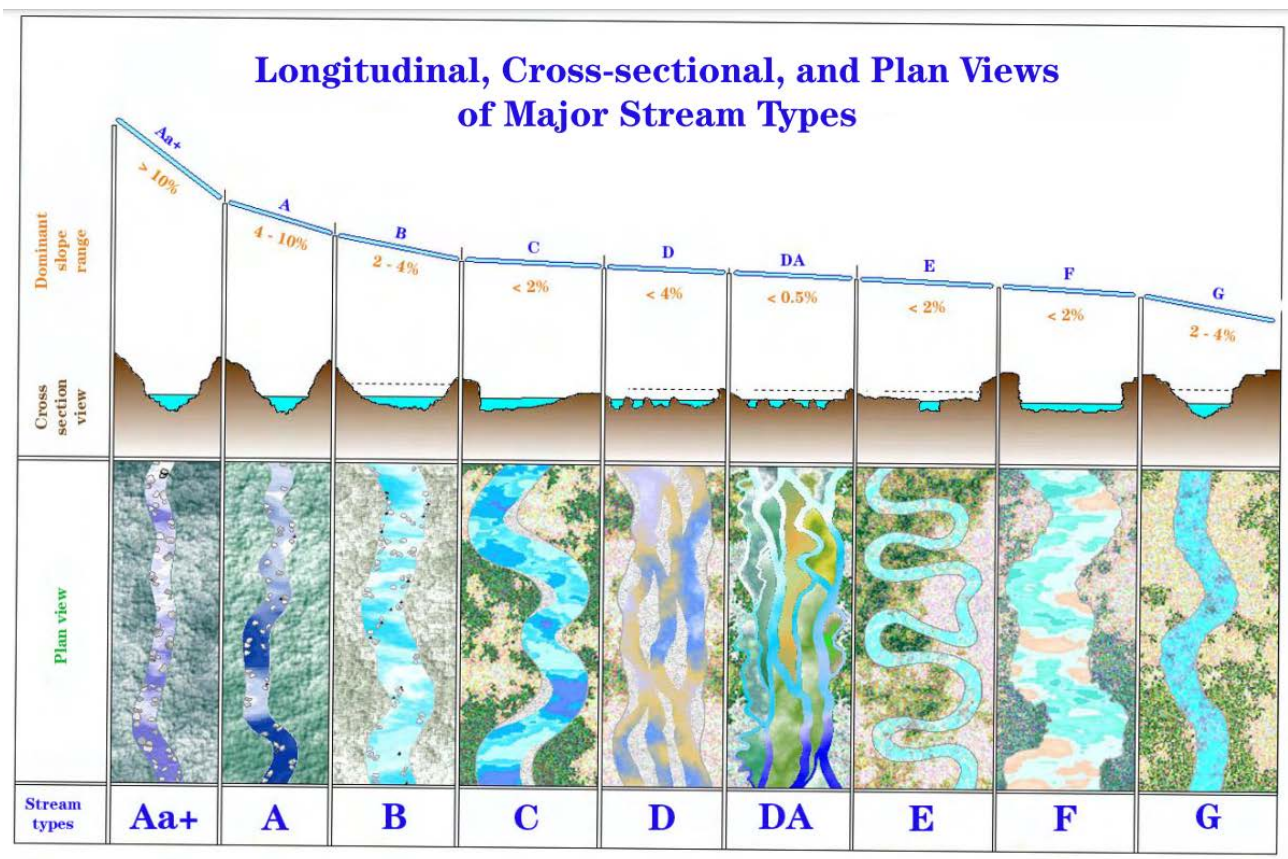


Figure 3.2.2-3. Typical relative locations of stream types within a watershed.

Table 3.2.2-1. Rosgen Level I geomorphic channel classification description and characteristic parameters.

Stream Type	Description	Entrenchment Ratio (ft/ft)	Width/Depth Ratio (ft/ft)	Sinuosity (ft/ft)	Slope (ft/ft)	Landform/Soils/Features
A	Steep, entrenched, stable, step pool streams w/ high energy & debris transport	<1.4	<12	1.0 to 1.2	0.04 to 0.10	High relief; erosional bedrock forms; entrenched & confined streams w/ cascading reaches; frequently spaced, deep pools associated w/ step-pool bed morphology
B	Moderately entrenched, moderate gradient, stable, riffle dominated channels w/ infrequent pools	1.4 to 2.2	>12	>1.2	0.02 to 0.039	Moderate relief, colluvial riffle deposition, and/or residual soils.; moderate entrenchment & width-to-depth ratio; narrow, moderately-sloping valleys; rapids predominate w/ occasional pools
C	Low gradient, meandering, point-bar, riffle-pool, alluvial channels w/ broad defined floodplains	>2.2	>12	>1.4	<0.04	Broad valleys w/ terraces associated w/ floodplains & alluvial soils; slightly entrenched w/ well-defined meandering channel; riffle-pool bed morphology
D	Braided, wide, eroding and unstable channels w/ longitudinal and transverse bars	n/a	>40	n/a	<0.04	Broad valleys with alluvial & colluvial fans.; glacial debris & depositional features; active lateral adjustment w/ abundance of sediment supply
Da	Anastomosing (multiple channels) that are narrow and deep w/ well vegetated floodplains & wetlands w/ stable stream banks	>4.0	<40	variable	<0.005	Broad, low-gradient valleys w/ fine alluvium and/or lacustrine soils; anastomosed (multiple channel) geologic control creating fine deposition w/ well-vegetated bars that are laterally stable w/ broad wetland floodplains; stream type common in estuaries

Stream Type	Description	Entrenchment Ratio (ft/ft)	Width/Depth Ratio (ft/ft)	Sinuosity (ft/ft)	Slope (ft/ft)	Landform/Soils/Features
E	Low gradient, stable, meandering riffle-pool channels w/ low width/depth ratio & little deposition	>2.2	<12	>1.5	<0.02	Broad valley/meadows; alluvial materials w/ floodplain and/or lacustrine soil; highly sinuous w/ stable well-vegetated banks; riffle-pool morphology w/ very low width-to-depth ratio
F	Entrenched meandering riffle-pool channels w/ high width-depth ratio	<1.4	>12	>1.4	<0.02	Entrenched in highly weathered material; gentle gradients usually >0.02 ft/ft, but may range up to 0.04 ft/ft w/ a high width-to-depth ratio; meandering, laterally unstable w/ high bank erosion rates; riffle-pool morphology
G	Entrenched, high energy, gulley channels w/ low width-depth ratio	<1.4	<12	>1.2	0.02 to 0.039	Gully, step-pool morphology w/ moderate slopes & low width-to-depth ratio; narrow valleys or deeply-incised in alluvial or colluvial materials (fans or deltas); unstable w/ grade control problems & high bank erosion rates

The delineation of valley types is integral to properly classifying stream types because valley width, slope, vegetation, hill slope condition, sedimentology, and setting maintain fundamental influence over channel conditions. A given channel morphology may be considered appropriate in one valley type and inappropriate, or unstable, in another valley type; geomorphic channel classification cannot be fully interpreted without consideration of local valley type. The influence of independent variables (e.g., hydrologic regime, sediment conditions, and boundary conditions) on dependent variables of stream morphology is depicted in Figure 3.2.2-4. To inform the channel geomorphic classification process and the interpretation of results, valley types within the watershed Study Area were delineated through remote sensing using various GIS datasets, including USGS 7.5 min quadrangles; current and historic aerial photography; and digital elevation models. Valley types were delineated in accordance with the numerical identifiers and descriptions presented in Table 3.2.2-2 (Rosgen 2012).

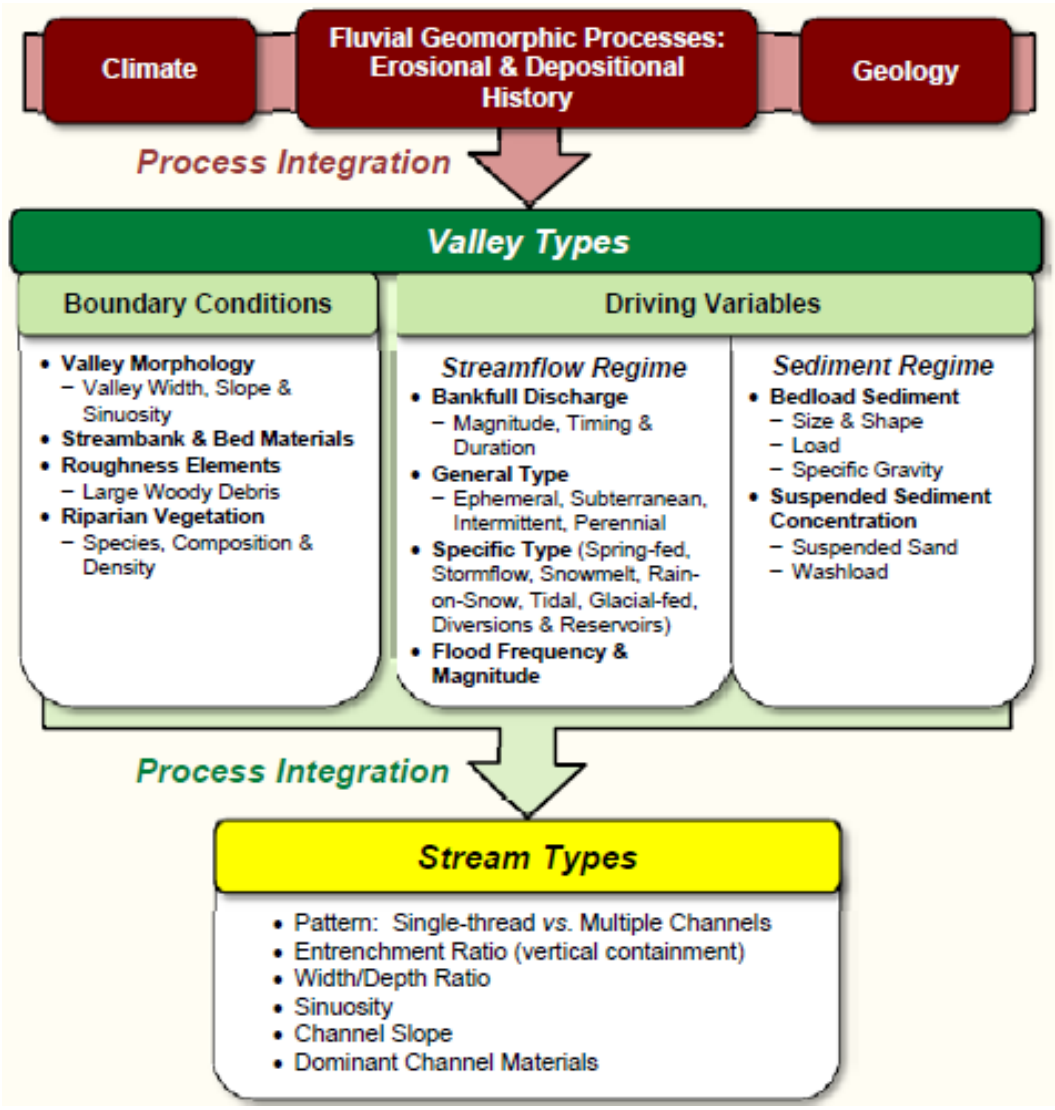


Figure 3.2.2-4. The influence of independent variables on dependent variables of stream channel morphology.

Table 3.2.2-2. Valley types applied during preliminary geomorphic classification in the Lower Shoshone River Watershed.

Valley Type	Name	Description
I	Steep, V-Notched Drainageway	Steep, confined, V-notched valley with rejuvenated side-slopes
II	Colluvial	Moderately steep valley slopes with gentle to moderate side-slopes associated with colluvial deposition of residual soils
IIIa	Alluvial Fan, Active	Actively building fan surface with high sediment supply storage
IIIb	Alluvial Fan, inactive	Non-building stable fan with low sediment supply and generally well established riparian vegetation
IV	Inter-Gorge	Canyons, gorges and confined alluvial valleys with gentle valley floor slopes, steep valley walls, and meandering, entrenched channels
V	Glacial Trough	Moderately steep U-shaped glacial trough valleys
VI	Bedrock	Bedrock controlled valleys with gentle to moderately steep valley slopes
VII	Fluvial Dissected	Steep fluvial dissected, high drainage density, alluvial landscape
VIIIa	Alluvial, Gulch Fill	Narrow valley widths (4 channel widths) with relatively steep valley side-slopes, and valley floor slopes greater than 0.5%
VIIIb	Alluvial Fill	Moderate valley widths (4 to 10 channel widths) with moderately steep valley side slopes and valley floor slopes less than 4%
VIIIc	Terraced Alluvial	Wide valley widths (10 channel widths) with gentle valley floor slopes less than 2% with river or glacial terraces
IX	Glacial Outwash	Broad, gentle valley slopes associated with glacial outwash
X	Lacustrine	Very broad and gentle valley slopes associated with flacio- and non-flacio-lacustrine deposits

Preliminary remote sensing valley type delineation results were corroborated during field investigations at selected sample locations. However, the entire length of all classified valleys and streams within the watershed could not be visited for field verification. Preliminary valley type classification indicates that colluvial river valleys (valley type II) are the most prevalent valley type in the basin, comprising 68.9 miles (41.1%) of the nearly 167 total miles of stream. Table 3.2.2-3 depicts the total stream length of dominant valley types in the basin.

Table 3.2.2-3. Total stream length of dominant valley types in the Lower Shoshone River Watershed.

Valley Type	Stream Length (mi)	Percent of Watershed
I	2.4	1.4%
II	68.9	41.1%
IV	5.9	3.5%
VII	5.2	3.1%
VIIIa	44.2	26.4%
VIIIb	40.9	24.4%

Several previous watershed studies have completed Level I geomorphic classification based primarily on channel sinuosity and slope, presumably because these channel attributes are most readily assessable using remote sensing data sets. However, the Rosgen channel classification system distinguishes channel types based upon physical parameters assessed in the following sequence: number of channels; entrenchment ratio; width/depth ratio; sinuosity; and then slope.

Arguably, the parameters with the most influence over channel process and, therefore, channel form, are entrenchment and width/depth ratio because these parameters dictate hydraulic conditions within the channel during peak flow events, which is when the majority of sediment transport and channel maintenance occur.

A remote sensing approach was used to complete a preliminary geomorphic classification of stream channels within the watershed Study Area. Assessment of primary classification attributes including entrenchment, width/depth ratio, sinuosity, and slope was conducted using current and historic aerial photography, digital elevation models, and GIS data. The preliminary classification effort was completed at a standard channel assessment scale defined as approximately 20 channel widths in length. Isolated changes in channel form were not considered reflective of overall channel morphology unless those changes occurred at the reach level. A subset of sites was visited during the 2021 field season, and field assessment of channel morphology at those locations was completed in order to verify the preliminary classification results. Example photographs from the field verification are presented in the following pages. Generally, initial findings were found to be accurate, and revisions were not necessary. However, the entire length of all classified streams within the watershed could not be visited for field verification, so results of the classification effort should be considered to be based on remote sensing and the data should be used accordingly.

Photo 1. Lower Shoshone River near Lovell, WY (Lat: 44.8471611111, Long: -108.408905556) example of C-type channel with entrenchment ratio greater than 2.2, width/depth ratio greater than 12, and sinuosity greater than 1.2

Photo 2. Lower Shoshone River between the towns of Byron and Lovell, WY (Lat: 44.8156194444, Long: -108.45855) example of C-type channel with entrenchment ratio greater than 2.2, width/depth ratio greater than 12, and sinuosity greater than 1.2

Photo 3. Lower Shoshone River at the highway 37 bridge (Lat: 44.858208334, Long: -108.3315111) example of C-type channel with entrenchment ratio greater than 2.2, width/depth ratio greater than 12, and sinuosity greater than 1.2.

Photo 4. Whistle Creek – Stream type B, valley type VIIIa (Lat: 44.756819445, Long: -108.5551222)

Photo 5. Coon Creek - Stream type B, valley type VIIIb (Lat: 44.78328333, Long: -108.513)

Photo 6. Upper Sage Creek - stream type E, valley type VIIIa (Lat: 45.000213889, Long: -108.62263611)

Photo 7. Upper Sage Creek - Stream type E, valley type VIIIa (Lat: 44.95869445, Long: -108.60903889)

Photo 8. Big Wash - Stream type B, valley type IV (Lat: 44.9026222, Long: -108.48800556)

Photo 9. Dry Creek - Stream type B, valley type II (Lat: 44.8612334, Long: -108.3719333)

Photo 10. Crooked Creek - Stream type B valley type VIIIa (Lat: 44.959775, Long: -108.287619445)

The results of the geomorphic classification are contained within the project GIS, in which spatial data attributes identify valley type and channel type classifications. Map 5 depicts geomorphic stream channel classification of the mainstem Shoshone River and identified tributaries at the reach level. Map 6 depicts geomorphic valley type classification at the reach level. Table 3.2.2-4 depicts total length and relative percentages of the Study Area streams by stream type. Table 3.2.2-5 presents results of the geomorphic classification by sub-basins within the watershed. The headwater reaches of most tributaries within the basin are located in moderately steep, arid terrain comprised of colluvial deposits, bedrock, residuum, and sparsely vegetated landscapes. The dominant stream types in these reaches are A and B stream types. These stream reaches are generally unstable laterally and vertically due to highly erodible soil and bedrock conditions and lack of vegetation.

The headwater streams change character as they enter the lower valley reaches where agriculture dominates the landscape. The headwater reaches are generally steep and entrenched with sparse riparian vegetation. The lower valley reaches have relatively lower slope and a higher density and diversity of riparian vegetation. Entrenchment is common throughout the watershed due to the highly erodible soils and bedrock. The common stable channel types within the lower valley settings are B, C, and E-type channels. B-type channels are the dominant channel type within the project area at 74%.

Table 3.2.2-4. Total length and relative percentage of stream types in the Study Area.

Stream Type	Stream Length (mi)	Percent of Watershed
A	4.2	2.5%
B	123.8	74.0%
C	26.7	16.0%
D	9.4	5.6%
E	3.3	2.0%

Table 3.2.2-5. Total length and relative percentage of stream types in sub-basins of the Study Area.

Subbasin Name	Stream Type	Length (miles)	Percent of Watercourse
Big Wash	A	2.7	24.5%
	B	8.2	75.5%
Coon Creek	B	35.4	100%
Crooked Creek	B	10.8	98.6%
	C	0.2	1.4%
Dry Creek	B	18.8	100%
Sage Creek	B	11.0	43.8%
	C	10.8	43.1%
	E	3.3	13.1%
Shoshone River	B	1.8	6.7%
	C	15.2	57.6%
	D	9.4	35.7%
Whistle Creek	A	1.5	3.9%
	B	37.9	94.6%
	C	0.6	1.5%

3.2.2b Stream Channel Condition and Stability

The morphologic condition of major stream channels in the basin was assessed during the geomorphic classification and associated results analysis. The Level I classification was completed primarily using remote sensing techniques, and the results should accordingly be viewed as general. Additional assessment of fluvial conditions should be completed in order to precisely identify dominant system processes and inform stabilization efforts at the local scale. The watershed level classification does describe channel conditions throughout the basin, and can be used to inform stakeholders regarding general channel conditions and management strategies.

Stream Channel Stability Assessment

The classification of valley types provides context for the assessment of channel morphology and stability. This process is feasible because valley types describe boundary conditions, which dictate equilibrium channel conditions. For example, a braided D-type channel located on an active alluvial fan (valley type IIIa) is a typical condition representative of a system that is naturally storing excess sediment. However, a braided D-type channel located in an alluvial valley (valley type VIII) is

typical of an unstable system that is not in equilibrium. Typical equilibrium and disequilibrium channel forms are identified by valley type in Table 3.2.2-6 (Rosgen 2012).

Table 3.2.2-6. Typical equilibrium and disequilibrium channel forms associated with various valley types.

Valley Type	Typical Equilibrium Channel	Typical Disequilibrium Channel Form
I	A, G	-
II	B	F, G
IIIa	D	A, F, G
IIIb	B	F, G
IV	C, F	-
V	C, D	F, G
VI	A, B, C, F, G	-
VII	A, G	-
VIIIa	B, C, E	A, D, F, G
VIIIb	B, C, E	A, D, F, G
VIIIc	C, E	A, D, F, G
IX	C, D	F, G
X	C, Da, E	F, G

The stability of stream channels in the Study Area can be interpreted in the context of setting, or valley type delineations. The project GIS enables review of geomorphic channel form in the context of valley type at georeferenced locations within the Study Area. Presented information can be used to interpret whether or not a typical equilibrium channel form exists at any given location within the Study Area based upon valley type. An impaired system that has lost equilibrium with hydrologic, sediment, and/or boundary conditions will undergo an evolutionary trajectory in an attempt to regain equilibrium conditions. An example would be a stable C-type channel that was altered through loss of riparian vegetation. The channel could be expected to widen and become a braided D-type channel due to loss of bank stability. The channel would likely cut through historic meanders and straighten in alignment. The increased slope of the straightened channel would then enable down-cutting and the formation of a G-type channel with excessive hydraulic forces. Additional bank erosion would ensue, and ultimately a high width/depth ratio entrenched F-type channel would result. The F-type channel would lose competence to down-cut through existing substrate, but would continue to erode banks and recruit sediment. Excessive sediment inputs would result in the formation of a constrained inset floodplain, and ultimately the regaining of equilibrium conditions through the creation of a C-type channel at the lowered elevation. This evolutionary scenario is depicted as example 3 in Figure 3.2.2-5, which depicts typical observed channel evolutionary sequences (NRCS 2007).

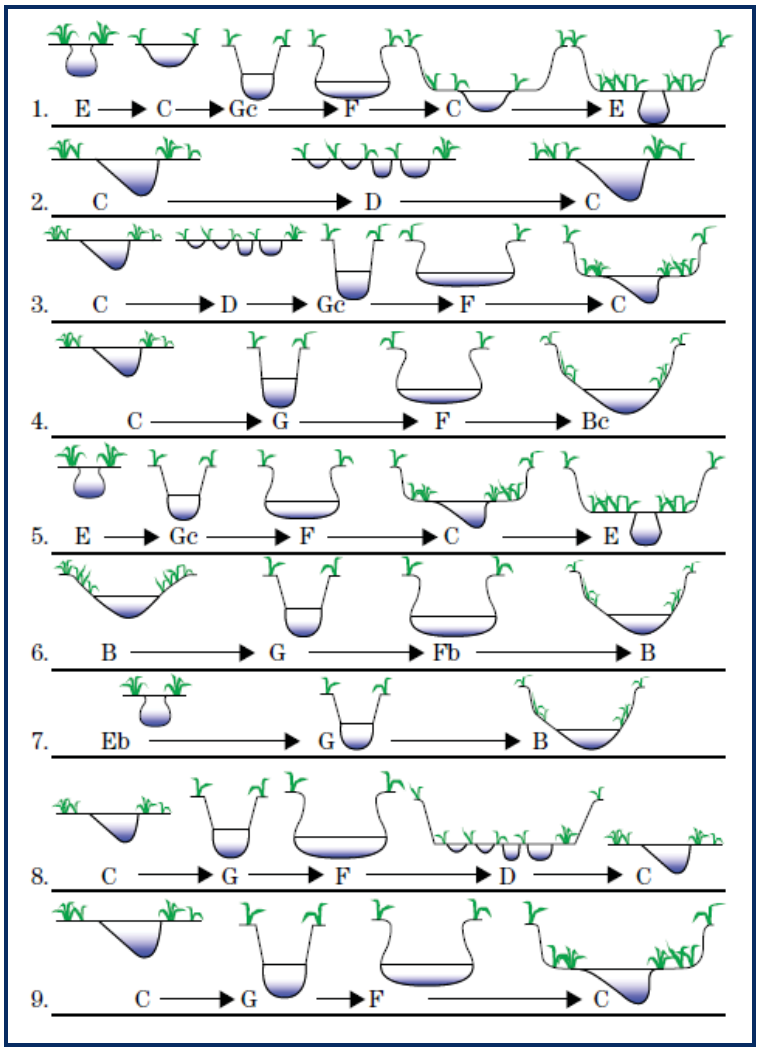


Figure 3.2.2-5. Example evolutionary trajectories in channel form due to initial loss of equilibrium conditions.

3.2.2c Sediment Transport

Sediment related impacts to fisheries and aquatic resources are a primary concern in the Lower Shoshone River and tributaries. Siltation affects water quality, temperature, river channel dynamics, in-stream habitat, riparian conditions, and fisheries resources. Sediment sources include naturally erosive soils, upland soil disturbance (e.g., roads, farming, grazing, development), bank erosion, tributary erosion as a result of irrigation return flows, road and trail erosion, and post-fire erosion, among others. Irrigation diversions periodically and seasonally reduce instream flow levels, reducing sediment transport capacity exacerbating sedimentation issues.

Periodic sediment releases from Willwood Dam have resulted in sedimentation-related impacts to fisheries and aquatic resources. In 2007 and 2016, large quantities of sediment were released resulting in fish kills, loss of aquatic invertebrates, and deposition of large amounts sediment downstream. In 2007, a dam malfunction caused a large sediment plume to be released, killing thousands of fish. In 2016, water levels were lowered for repairs and required maintenance resulting in 96,000 cubic yards of fine sand and silt to be released from the dam (McElroy 2017). Additional repairs are going to be necessary in the future, which will require the sluicing or dredging of large

quantities of sediment. In response to the 2016 sediment release, and the recognized need for future repairs, WDEQ established three working groups with the goal of finding sediment management solutions and managing future sediment releases from the dam.

Cross section surveys and sediment samples downstream of the Willwood Dam following the sediment release in 2016 found approximately 6,600 tons of sediment per river mile near Willwood Dam, decreasing in the downstream direction at a rate of 5 percent per mile with approximately 1,100 tons per mile near Byron, WY. The size of deposited sediments also decreased in the downstream direction from 0.13 mm (very fine sand) near Willwood Dam to 0.03 mm (coarse silt) near Byron, WY (McElroy 2017).

The objectives of the Willwood Dam working groups are to: 1) restore aquatic life and habitat damaged due to a release of accumulated sediment from the Willwood Dam reservoir into the Shoshone River and 2) reduce and/or eliminate the need to release accumulated sediment from the dam in amounts and of duration that are harmful to aquatic life and the aquatic and riparian habitats below the dam (WDAC 2017). A summary of these efforts is available online in two Story Maps: 1) Working Together to Protect the Shoshone River (WWG 3 2021); and 2) Sediment Watershed Plan for the Shoshone River from Buffalo Bill Reservoir to Willwood Dam (WWG 3 2021a).

Willwood Dam working group efforts have included the collection of sediment samples in collaboration with the USGS and the identification of sediment sources for specific drainage areas. The results of these efforts will be published in a forthcoming white paper, expected to be completed in the fall of 2021, that will provide a sediment budget that will guide future Willwood Dam operations and inform sediment reduction strategies. Analysis methods and the current status of working group efforts is also described in the June 21, 2021 presentation titled Managing Sediment at Willwood Dam to Protect Downstream Fisheries (Waterstreet 2021).

Previous studies including the Bighorn Lake Sediment Management Study (USBR 2010) have also evaluated sediment transport in the Study Area. This evaluated sediment gauge data from the Shoshone River at Kane (USGS 06286200) and the Shoshone River near Lovell (USGS 06285100) to develop flow-sediment relationships (i.e., rating curve). The Shoshone River at Kane period of record for sediment data is from 1959-64 while the Shoshone River at Lovell sediment data was collected post-1964 intermittently. In general, there was a wide variation in the measured suspended sediment load versus flow with sediment input loads ranging up to 408,610 tons/day for a flow of 30,000 cfs for the period from 1959-64. The suspended sediment rating curves for the Lower Shoshone River and represented graphically in Figure 3.2.2-6. Table 3.2.2-7 contains the resulting sediment rating curve values for a range of flows from 100 to 30,000 cfs.

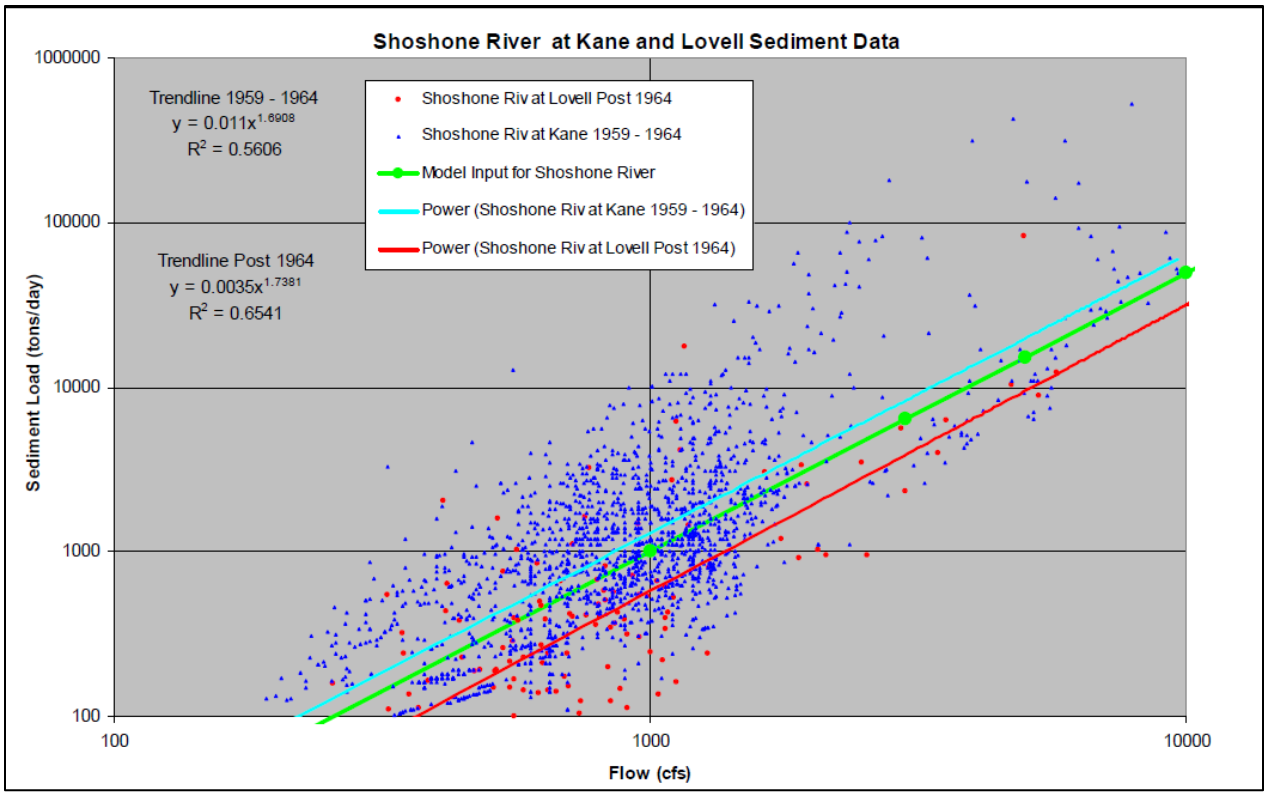


Figure 3.2.2-6. Lower Shoshone River suspended sediment-flow relationship for the Shoshone River at Kane and the Shoshone River near Lovell gauging stations (USBR 2010).

Table 3.2.2-7. Suspended sediment input loads in tons per day (modified from USBR 2010).

Flow (cfs)	Shoshone River at Kane (1959-64)	Shoshone River near Lovell (post 1964)
100	26	10
1,000	1,300	573
3,000	8,327	3,869
5,000	19,752	9,403
10,000	63,767	31,367
15,000	126,569	63,465
20,000	205,861	104,638
25,000	300,213	154,215
30,000	408,610	211,715

3.2.3 Groundwater

Groundwater is contained in the pore spaces and fractures of rock formations and in units of rock or unconsolidated sediments that can yield a usable quantity of water. General groundwater flow patterns, aquifers, springs, and groundwater usage was evaluated throughout the Study Area.

Quaternary-age alluvium, colluvium, pediment, and fan deposits along the Shoshone River and tributaries are the most productive and predictable sources of groundwater in the Study Area. Bedrock aquifers are developed as water supplies in Cenozoic, Mesozoic, Paleozoic, and Precambrian rocks (Plafcan et al., 1993). The principal bedrock aquifers in the Study Area are shown on Map 7.

3.2.3a Aquifers and Springs

Aquifers occur in bedrock, alluvium, colluvium, pediment, and fan deposits along the larger streams and rivers within the Study Area. The depth of these deposits can be as much as 100 ft thick with depth to groundwater generally ranging from 3 to 14 feet below the surface, varying with the amount of irrigation. Most groundwater is within 10 ft of the surface during irrigation season. Generally, the floodplain alluvium deposits are less than 30 ft thick (Plafcan et al., 1993).

Figure 3.2.3-1 shows the water-table elevation in alluvial and terrace deposits in the Study Area. The water-table contour maps in Figure 3.2.3-1 indicate that groundwater in the alluvium and terrace deposits both generally flow in the downstream direction, toward the river (Plafcan et al., 1993).

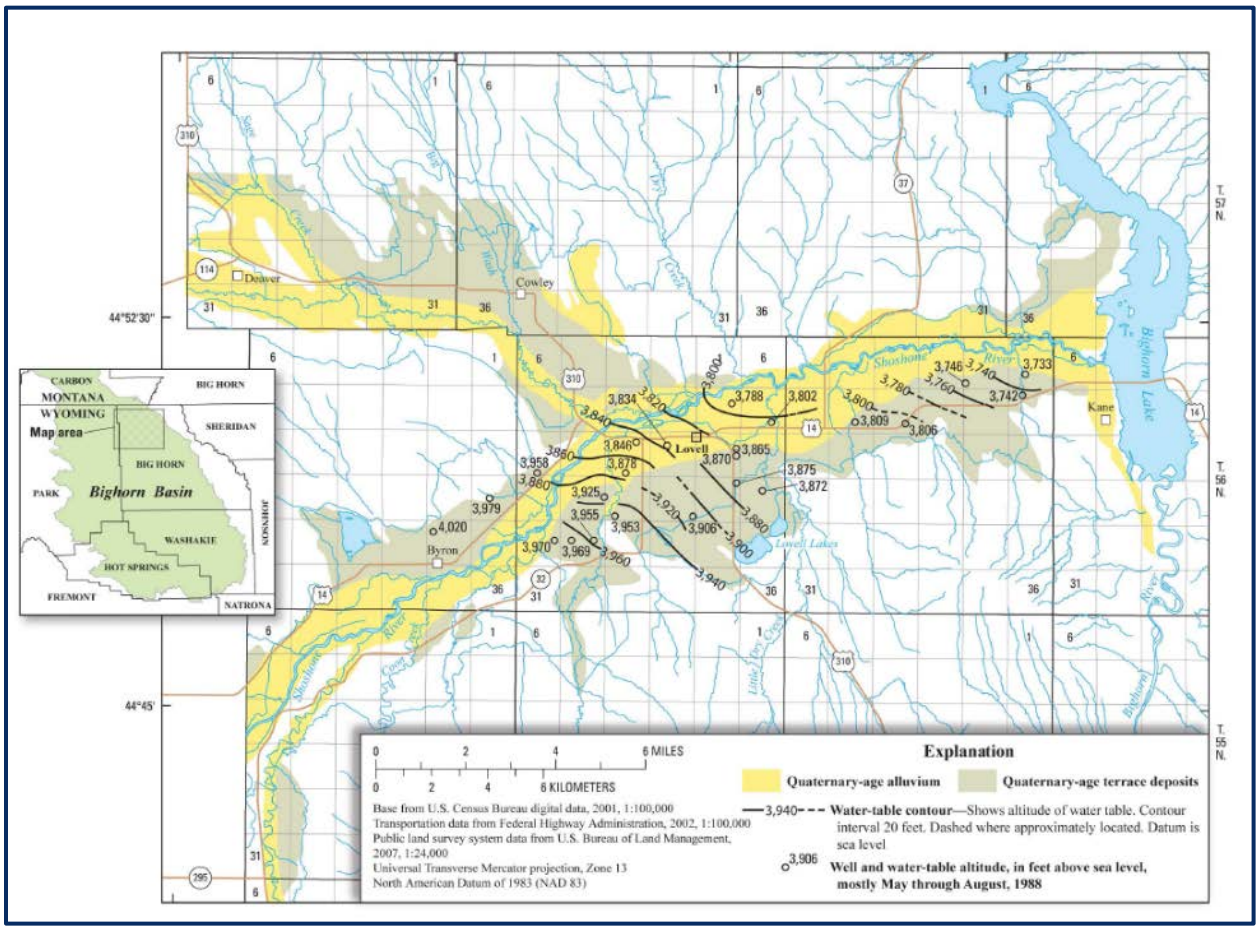


Figure 3.2.3-1. Water-table contours in Quaternary alluvium and terrace deposits along the Lower Shoshone River (Taucher et al., 2012, modified from Plafcan et al., 1993, Figure 3).

The highest water-yielding bedrock aquifers are in the Madison Limestone and Bighorn Dolomite formations. Wells commonly occur in both unconsolidated and bedrock aquifers which may hydraulically connect the aquifers (Plafcan et al., 1993). Quillinan et al., (2012) Plate VIII contains Isopach maps of selected aquifers in the Bighorn Basin including the Madison-Bighorn aquifer, the Tensleep aquifer, the Phosphoria-Goose Egg aquifer, the Gypsum Spring confining unit and aquifer, the Sundance confining unit and aquifer, the Cloverly aquifer, and the Fort Union aquifer.

Existing springs have been mapped by USGS National Water Information System Mapper (NWIS); however, many seeps and springs throughout the Study Area remain unmapped (Map 8). The Wind/Bighorn River Basin Water Plan Update Groundwater Study Level I (Taucher et al., 2012) Plate IX (available at: https://waterplan.state.wy.us/plan/bighorn/2010/gw-finalrept/plate_IX.pdf) contains a summary of well yield, spring discharge, and other hydraulic properties for the Big Horn Basin.

3.2.3b Groundwater Use, Baseflow, and Recharge

Groundwater supplies 89 percent of the water used for domestic purposes and 16 percent of the water used for public supplies in Big Horn County, WY. The distribution of SEO permitted wells in the Study Area is shown in Map 9. Groundwater yields in alluvium and colluvium, as documented by well data, range from about 5 to 140 gallons per minute (gal/min) with most reporting less than 50 gal/min. Depth to water in the alluvium and colluvium ranges from 1.2 to 28.6 ft below the surface. Depth to water in the alluvium and colluvium ranges from 1 to 29 ft below the surface. Groundwater yields from gravel, pediment, and fan deposits range from 3 to 1,600 gal/min with a median of 200 gal/min. Depth to water in gravel, sediment, and fan deposits ranged from 2 to 39 ft (Plafcan et al., 1993).

Discharge from Quaternary unconsolidated-deposit aquifers occurs by evapotranspiration, gaining streams, seeps, drains, and spring flows, as well as withdrawals from wells. Evapotranspiration from Quaternary unconsolidated deposit aquifers is likely to be highest in areas where crops are grown (Taucher et al., 2012).

Recharge to many unconsolidated aquifers is not only from direct infiltration of precipitation and streamflow losses but also from infiltration of diverted irrigation water from unlined irrigation canals and ditches. Recharge rates cannot be directly measured but are estimated using indirect approaches. Most unconsolidated terrace deposits are not saturated prior to irrigation, indicating that recharge of diverted irrigation water likely is the dominant source of recharge to terrace-deposit aquifers. Water levels in many terrace-deposit aquifers are directly related to irrigation diversions. Water levels in terrace-deposit aquifers typically begin to rise with the onset of irrigation and continue to rise after irrigation to a maximum water level in early winter. (Taucher et al., 2012).

Groundwater is recharged from the surface and may be discharged into lakes, rivers, wetlands, and springs as baseflow. Well data in the alluvium and colluvium deposits along the Shoshone River indicate that these deposits lose water by draining to the river (Plafcan et al., 1993). The WSGS has developed a statewide baseflow model based on empirical date from 19 locations throughout Wyoming. Results from that modeling indicate that, similar to many interior basins throughout the state, baseflow recharge values are low or zero in the Study Area due to evapotranspiration equaling or exceeding mean annual precipitation (Taboga and Stafford 2016).

Groundwater quality for the Study Area is described in the Wind/Bighorn River Basin Groundwater Study (Taucher et al., 2012) and in Volume II-A occurrence and Characteristics of Ground Water in the Bighorn Basin, Wyoming (Libra et al., 1981). Analyses of Quaternary aquifer water quality data has consistently shown high variability with a general increase in Total Dissolved Solids (TDS) in the downstream direction in many drainages. Floodplain deposits along the Lower Shoshone River exhibit TDS ranging from less than 1,210 milligrams per liter (mg/l) with terrace groundwater ranging from 346 to 6,360 mg/l. Irrigation recharge has been found to raise both water level and TDS levels. Swenson and Swenson (1957) concluded that irrigation-related recharge increased leaching of soluble minerals within terrace deposits, resulting in increased TDS.

In 1992, the Wyoming Ground Water Vulnerability Mapping Project was initiated to evaluate the vulnerability of Wyoming groundwater resources to contamination. This effort resulted in the publication of the Wyoming Groundwater Vulnerability Assessment Handbook by the Spatial Data and Visualization Center (SDVC) (Hamerlinck and Arneson, 1998). The project was created to develop GIS-based mapping tools to assess the relative sensitivity and vulnerability of groundwater resources. The results, which are shown on SuiteWater GIS, reflect the relative potential for surface contaminants to migrate to the uppermost groundwater (water table). The highest ranked areas (indicating high sensitivity) are primarily in alluvial deposits adjacent to streams and rivers. The high-ranking areas are the result of a combination of a relatively shallow depth to groundwater and the high porosity of alluvial soils.

3.2.4 Geology

The geologic history of the Study Area is a complex timeline which began with the deposition of transgressive marine sediments onto Precambrian basement rocks during Middle Cambrian time (Taucher et al., 2012). Continuing into the Paleozoic Era, strata were deposited in marine and non-marine transgressive/regressive environments forming limestones, dolomites, sandstones and shales. The early Mesozoic Era brought shallow sea environments and deposition of interbedded sandstone, siltstone, shale, carbonates, and evaporates. The Cretaceous Period of the late Mesozoic Era is where we begin to see some of the dominant lithologies found in Study Area. During the Early Cretaceous Period a thick section of interbedded shale, sandstone, siltstone, and claystone was deposited under terrestrial, shallow marine, and deltaic conditions. During the Late Cretaceous Period sandstone, siltstone, claystone, and shale were deposited in marine, marginal marine, coastal plane, and deltaic environments. Cretaceous formations found in the project area (in ascending order form oldest to youngest) include the Mesaverde, Mowry and Thermopolis Shales, Meeteetsee, Lance, Frontier, and Cody Shale. The Laramide Orogeny, which began in the Late Cretaceous and continued through the early Eocene, resulted in mountain-building compressional deformation of the crust which would eventually raise up massive basement-cored mountain ranges in the region. These uplifted areas were the source of several thousand feet of Tertiary sediments composed of Mesozoic, Paleozoic, and Precambrian rocks that were eroded from the uplifts and deposited in the basins. Tertiary formations found in the project area include the Eocene-age Willwood Formation and the Paleocene-age Fort Union Formation, both of which are composed primarily of fine- to coarse-grained sandstone beds interbedded with shale and other fine-grained rocks, locally with some conglomerate and coal deposits. The Willwood and Fort Union formation

represent the uppermost hydrogeologic units in the lower Tertiary/Upper Cretaceous aquifer system in the Big Horn Basin and make up approximately 33% of the bedrock mapped in the Study Area.

The compressional forces of the Laramide Orogeny ended during the Eocene Epoch, approximately 35-50 million years ago (mya). Subsequently, extensional forces acted on the crust during the late Tertiary period throughout Wyoming causing normal faulting, and erosional forces removed an enormous volume of Tertiary strata, exhuming the Laramide framework and sculpting the present physiography of the Wind and Bighorn River basins. The youngest rock units found in the project area are Quaternary aged deposits of gravel, pediment, sand, alluvium, and colluvium of variable thickness. These deposits, some as much as several hundred feet thick, are composed of conglomerate, gravel, sand, and finer-grained clastic material. The age and occurrence of these deposits have been correlated with recent glacial and interglacial periods (Mackin 1937).

3.2.4a Topography and Landforms

The topography of the Study Area is described as an intermontane plateau which is characterized by wide valleys between mountain ranges that are partially filled with depositional landforms. The Study Area topography is comprised primarily of broad river valleys, large terraces, and rolling foothills. The elevation of the Study Area ranges from a low point of approximately 3,640 ft where the Shoshone River enters Bighorn Lake to a maximum elevation of approximately 6,540 ft in the upper Whistle Creek drainage. The Digital Elevation Model (DEM) shown on Map 10 depicts the Study Area watershed topography.

The Shoshone River is a northeast trending drainage basin that flows into the north oriented Bighorn River which is a Yellowstone River tributary. The Bighorn River alignment was originally established by a south oriented flood flow channel created from floodwaters flowing from the western margin of the North American ice sheet in the region. A flood flow reversal occurred when ice sheet melting allowed the northeast trending Yellowstone River to capture flood flows and establish the present-day Bighorn River orientation. The flood flow reversal of the Bighorn River resulted in headward erosion of the Shoshone River and its tributaries (Clausen 2012). This complex history of glacial and post-glacial drainage patterns is responsible for the current valley topography in the Study Area.

The geomorphic history of the alluvial terrace landforms in the Bighorn basin were first described by Mackin (1937) and Leopold and Miller (1954). The alluvial terraces are indicators of post-glacial adjustments and climatic impacts. Makin (1937) described the geomorphic history divided into two periods. The first period was characterized by relative uplift of the surrounding mountain ranges and with widespread fluvial aggradation of the resulting structural depression, and the creation of the present topography through partial excavation of the basin fill. A series of valley cross sections along the Shoshone River show a trend of decreasing terrace height above the river from west to east (Figure 3.2.4-1).

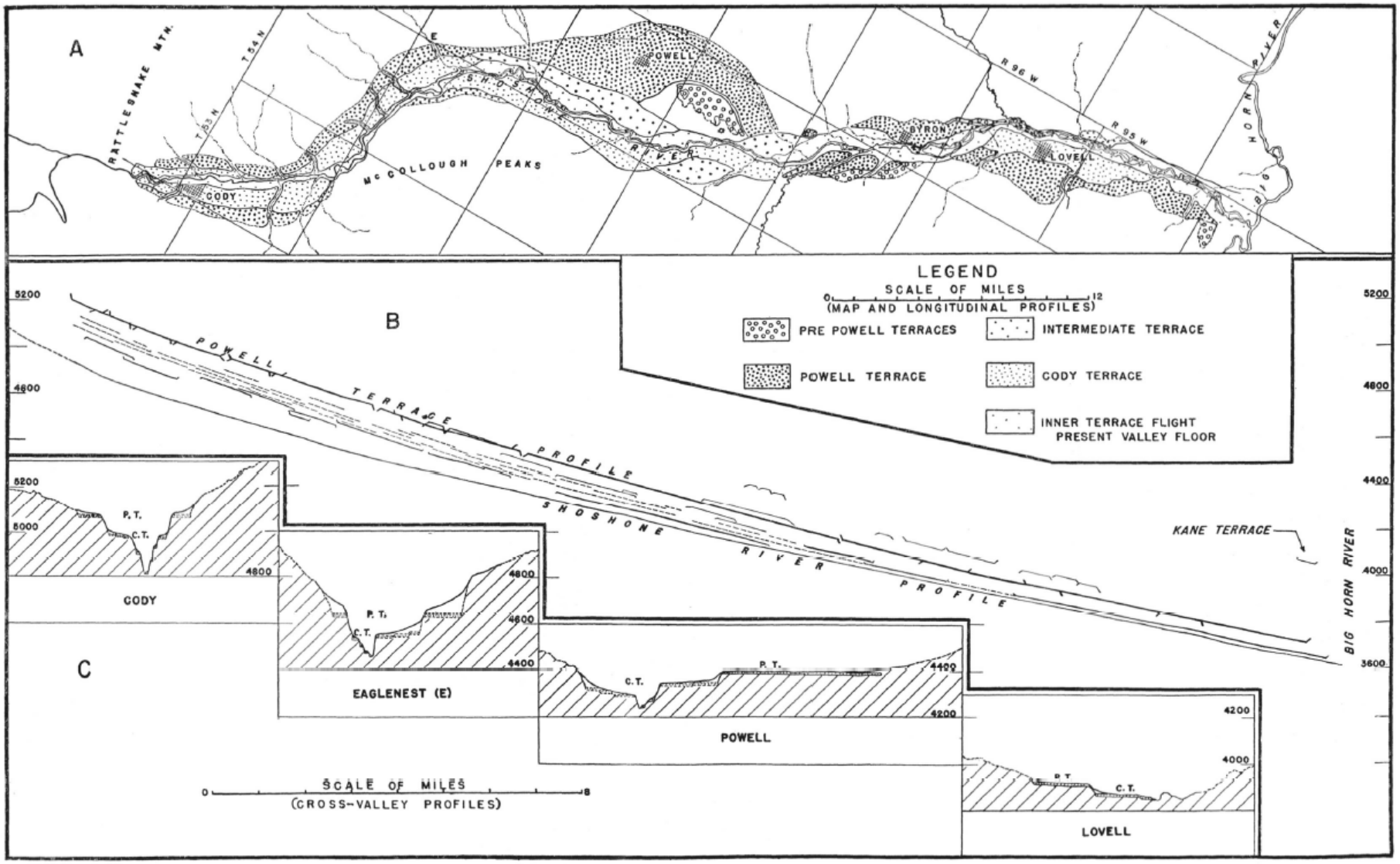


Figure 3.2.4-1. Map and profiles of the terrace landforms adjacent to the Shoshone River (Mackin 1937).

3.2.4b Soils

Soil survey data for the Study Area are available online through the NRCS Web Soils Survey (NRCS 2021). SSURGO soils data were collected at scales ranging from 1:12,000 to 1:63,360 and provide the highest level of thematic detail. SSURGO soils data is intended for natural resource planning and management by landowners, townships, and counties, but is not appropriate for depiction on large scale maps such as those included with this report. SSURGO soils data are available for portions of the watershed, and these data have been incorporated in the GIS dataset included electronically with this report.

STATSGO2 is a broad-based inventory of soils and non-soil areas that can be cartographically shown at the scale mapped of 1:250,000. STATSGO2 soils mapping is designed for broad planning and management uses covering state, regional, and multi-state areas. The dataset was created by generalizing more detailed soil survey maps. Where more detailed soil survey maps were not available, data on geology, topography, vegetation, and climate were assembled and related to Land Remote Sensing Satellite (LANDSAT) images. STATSGO2 data have been used to create the U.S. General Soil Map, which is comprised of general soil association units and is maintained and distributed as a spatial and tabular dataset. The tabular data contains estimates of physical and chemical soil properties, soil interpretations, and static and dynamic metadata. STATSGO2 mapped soils in the Study Area are depicted in Map 11, and the relative abundance of STATSGO2 soil deposits in the watershed is presented in Table 3.2.4-1.

Table 3.2.4-1. Soils of the Lower Shoshone River Watershed.

Unit Symbol	Soil Description	Area (acres)	Study Area (%)
s8949	Youngston-Worland-Persayo-Oceanet-Greybull	211,056	52.0
s8950	Youngston-Uffens-Stutzman-Lostwells-Apron	94,394	23.2
s8951	Youngston-Willwood-Sharland-Preatorson-Lostwells-Garland-Apron	31,631	7.8
s8970	Worland-Rock outcrop-Oceanet-Apron	31,197	7.7
s4462	Travessilla family-Rock outcrop-Midway	16,579	4.1
s4226	Stormitt-Nihill-Neville-Harvey family-Bowbac	9,005	2.2
s8946	Travson-Shingle-Rock outcrop-Midway-Keyner-Hiland-Bowbac	3,617	0.9
s8947	Vonalee-Kishona-Haverdad-Forkwood	3,043	0.7
s8962	Spearfish-Rekop-Neville-Gystrum	2,441	0.6
s8945	Welring-Travson-Spearfish-Shavano-Rock outcrop-Midway-Clifterson	1,444	0.4
s8971	Youngston-Sharland-Garland	1,237	0.3
s4187	Vonalee-Kishona-Haverdad-Forkwood	270	0.1
s8369	Water	106	0.0

The most abundant soils in the Study Area are the Youngston-Worland-Persayo-Oceanet-Greybull series (52%) and the Youngston-Uffens-Stutzman-Lostwells-Apron series (23.2%).

3.2.4c Surficial Geology

The surficial features (landforms) and deposits present in the Study Area are depicted in Map 12. The project area map was created using the Surficial Geology Map of Wyoming (Case et al., 1998). The Surficial Geology map can be used, in conjunction with the Bedrock Geology map, as a guide in siting new facilities or industries in Wyoming. It can also be used to locate geologic hazards, such as landslides and windblown deposits, or to assist in the search for shallow ground water supplies and for construction aggregate. Geologic hazards in the Study Area are depicted in Map 13.

The classification scheme presented here and in the Surficial Geology map is a simplification of the complex multi-phase classification scheme originally developed to describe the units when The Surficial Geologic Map of Wyoming was created. In order to achieve the objectives of the Ground-Water Vulnerability to Pesticide Contamination Project (Hamerlinck and Arneson, 1998), the map authors devised a simplified 25-element classification scheme that delineated simplified mapping units of most significance to contaminant migration. The simplified classification scheme is described in Table 3.2.4-2.

Table 3.2.4-2. Surficial Geologic Units of the Lower Shoshone River Watershed.

Unit Symbol	Geologic Name	Area (acres)	Percentage of Study Area
ai	Alluvium with scattered deposits of terrace, slopewash, eolian, residuum, grus and glacial	19039.1	4.7%
bdi	Dissected bench with scattered deposits of residuum, slopewash, landslide, and eolian	3294.9	0.8%
bi	Bench including eolian, slopewash, outwash, and bench and/or mesa	4513.9	1.1%
ei	Eolian mixed with scattered deposits of residuum, alluvium, and slopewash	2101.3	0.5%
fdi	Dissected alluvial fan and gradational fan deposits mixed with scattered deposits of slopewash and residuum	4723.4	1.2%
fi	Alluvial fan and gradational fan deposits mixed with scattered deposits of slopewash, residuum, and eolian	7219.8	1.8%
li	Landslide mixed with scattered deposits of slopewash, residuum, Tertiary landslides, and bedrock outcrops; landslides too small and numerous to show separately	1023.6	0.3%
ri	Residuum mixed with alluvium, eolian, slopewash, grus, and/or bedrock outcrops	129584.5	32.0%
Ri	Bedrock and glaciated bedrock including hot spring deposits and volcanic necks; mixed with scattered shallow deposits of eolian, grus, slopewash, colluvium, residuum, glacial, and alluvium.	102302.2	25.3%
sci	Slopewash and colluvium mixed with scattered deposits of slopewash, residuum, grus, glacial, periglacial, alluvium, eolian, and/or bedrock outcrops	39747.7	9.8%
tdi	Dissected terrace deposits mixing with alluvium, residuum, eolian, and slopewash	42838.0	10.6%
ti	Terrace deposits mixed with scattered deposits of alluvium, residuum, eolian, slopewash, and outwash	48321.8	11.9%
Lake	Lake surface	365.4	0.1%

3.2.4d Bedrock Geology

Map 14, Bedrock Geology, illustrates the bedrock geologic units of the Study Area. Table 3.2.4-3 lists the bedrock geologic units found in the Study Area along with their respective size (area) and percentage of the overall area. The bedrock geology is composed entirely of Phanerozoic sedimentary rock units which are predominantly made up of shale, sandstone, and siltstone. The valley bottoms are underlain by alluvium and colluvium made up of clay, silt, sand, and gravel in floodplains, fans, terraces, and slopes.

Table 3.2.4-3. Bedrock Geologic Units of the Lower Shoshone River Watershed.

Era	Unit Symbol	Geologic Name	Area (acres)	Percentage of Study Area
Cenozoic	**Quaternary**			
	Qa	Alluvium and colluvium	37641.1	9.3%
	Qt	Gravel, pediment, and sand deposits	49370.1	12.2%
	Tertiary			
	Tfu	Fort Union Formation	43016.1	10.6%
	Twl	Willwood Formation	89481.6	22.1%
Mesozoic	**Cretaceous**			
	Kc	Cody Shale	74731.9	18.5%
	Kf	Frontier Formation	14931.5	3.7%
	Kl	Lance Formation	10806.0	2.7%
	Km	Meeteetse Formation	8406.7	2.1%
	Kmt	Mowry and Thermopolis Shales	18013.2	4.5%
	Kmv	Mesaverde Formation (N) or Mesaverde Group (S)	37206.6	9.2%
	Cretaceous-Jurassic			
	KJg	Cloverly, Morrison, Sundance, and Gypsum Spring Formations	415.1	0.1%
	KJ	Cloverly and Morrison Formations (N, S) or Cloverly Formation (Hartville uplift), or Inyan Kara Group (Black Hills), and Morrison Formation (NE)	9318.2	2.3%
	Jurassic			
	Jsg	Sundance and Gypsum Spring Formations	4547.8	1.1%
	Triassic			
	^c	Chugwater Formation (N, NE), or Chugwater Group or Formation (S)	2553.0	0.6%
Paleozoic	**Permian-Triassic**			
	^Pg	Goose Egg Formation	3063.4	0.8%
	Permian-Mississippian			
	PM	Tensleep Sandstone and Amsden Formation	1065.2	0.3%
	Carboniferous Mississippian			
	Mm	Madison Group (TB), Madison Limestone or Group (N), or Madison Limestone (S)	42.5	0.0%

3.2.5 Climate

The climate in the Study Area is varied based on the diverse topography and elevation. Elevations range from approximately 3,640 to 6,540 feet. The climate within the Study Area is classified as cold semi-arid climate. Within the watershed, 2 weather stations are maintained through cooperative agreements with the National Weather Service (NWS).

National Weather Stations
Deaver (Bighorn Co.)
Lovell (Bighorn Co.)

The locations of the 2 NWS weather stations along with average annual precipitation data for the

period of record are depicted in Map 15. Data used to generate this figure were obtained from the PRISM Climate Group at Oregon State University using the Parameter-elevation Regressions on Independent Slopes Model (PRISM) climate mapping system. Lower elevations along the Shoshone River receive an average of 6.0 to 6.4 inches of precipitation per year. Annual precipitation increases with elevation averaging up to 11 inches per year in the highest regions of the watershed within Wyoming.

Data recorded at NWS stations were obtained from the Western Regional Climate Center and the NRCS. Table 3.2.5-1 provides a summary of temperature and precipitation data collected at the 2 NWS weather stations.

Table 3.2.5-1. Summary of temperature and precipitation climate data from NWS stations.

Station: (485770) Lovell: Period of Record: 1897-2016													
Monthly Averages and Means	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Average High Temperature °F	29.6	36.7	47.6	59.2	69.1	78.9	88.3	85.9	74.0	61.1	44.8	33.0	59.0
Average Low Temperature °F	4.6	10.9	20.7	30.8	41.0	49.0	54.3	51.1	40.8	30.6	18.9	8.4	30.1
Mean Temperature °F	17.2	23.9	34.2	45.0	55.1	63.9	71.3	68.5	57.4	45.8	31.9	20.8	44.6
Mean Precipitation inches	0.3	0.2	0.3	0.6	1.2	1.1	0.6	0.5	0.7	0.6	0.3	0.2	6.6
Mean Snowfall inches	4.1	2.4	2.5	1.2	0.2	0.0	0.0	0.0	0.4	0.7	1.7	3.8	17.1
Mean Snow Depth inches	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
Station: (482415) Deaver: Period of Record: 1916-2016													
Monthly Averages and Means	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Average High Temperature °F	29.5	37.4	48.4	60.2	70.0	79.2	88.8	86.4	74.7	61.3	44.1	32.5	59.4
Average Low Temperature °F	3.7	10.2	19.4	29.3	39.7	48.0	54.4	51.2	41.0	30.0	17.3	7.4	29.3
Mean Temperature °F	16.5	23.8	33.9	44.7	54.9	63.6	71.6	68.9	57.9	45.7	30.7	20.0	59.4
Mean Precipitation inches	0.1	0.1	0.2	0.4	1.0	1.1	0.6	0.5	0.6	0.4	0.2	0.2	5.4
Mean Snowfall inches	3.1	1.7	1.6	1.4	0.2	0.0	0.0	0.0	0.3	0.5	1.4	2.2	12.3
Mean Snow Depth inches	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0

Average high and low temperatures for the period of record of the 2 NWS stations are depicted in Figures 3.2.5-1 and 3.2.5-2. Figure 3.2.5-3 shows the average monthly precipitation and Figure 3.2.5-4 depicts the total annual precipitation for each weather station for their entire respective period of record.

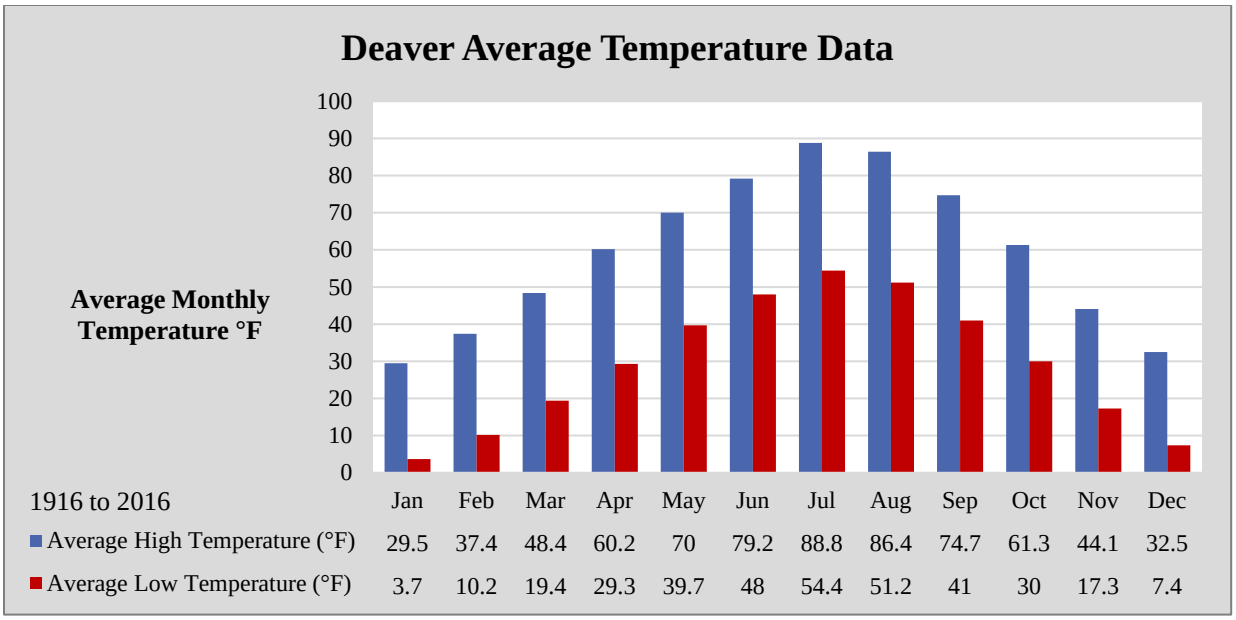


Figure 3.2.5-1. Average high and low temperatures for the Deaver weather station, Shoshone River Watershed.

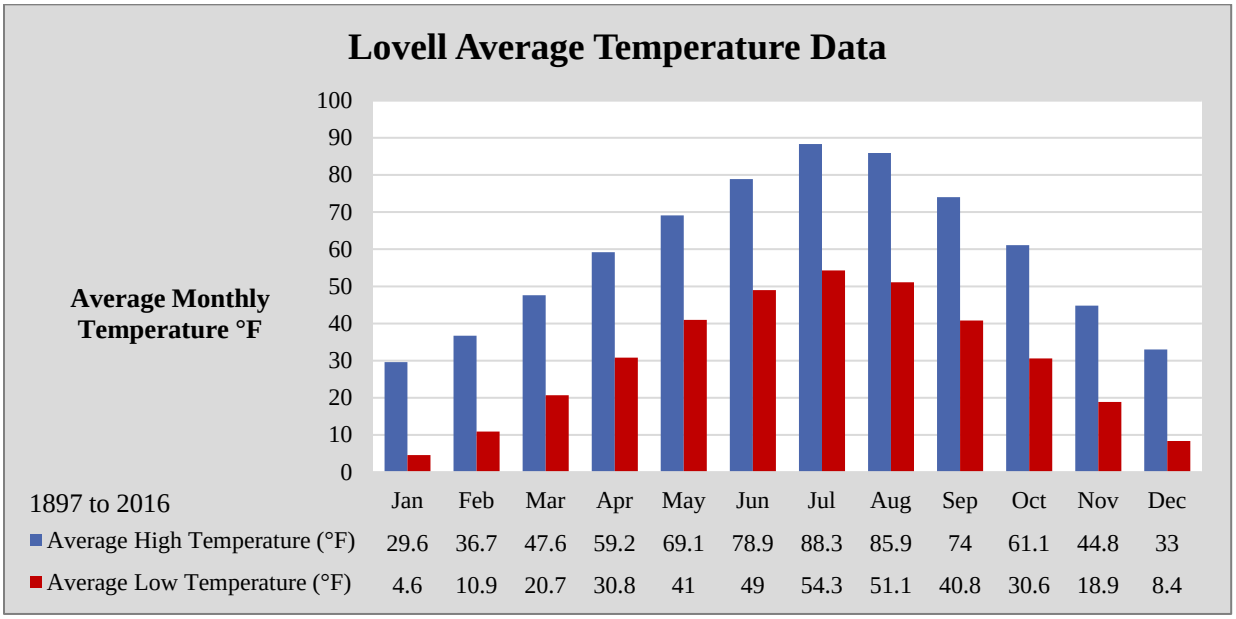


Figure 3.2.5-2. Average high and low temperatures for the Lovell weather station.

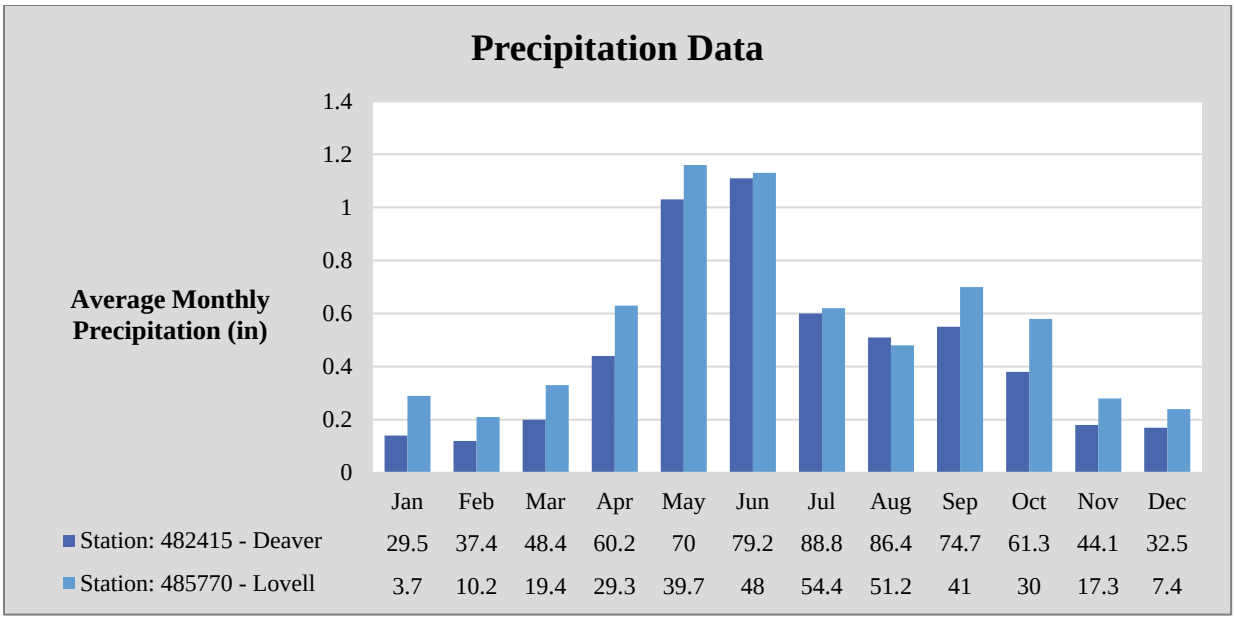


Figure 3.2.5-3. Average monthly precipitation for NWS weather stations within the Lower Shoshone River Watershed.

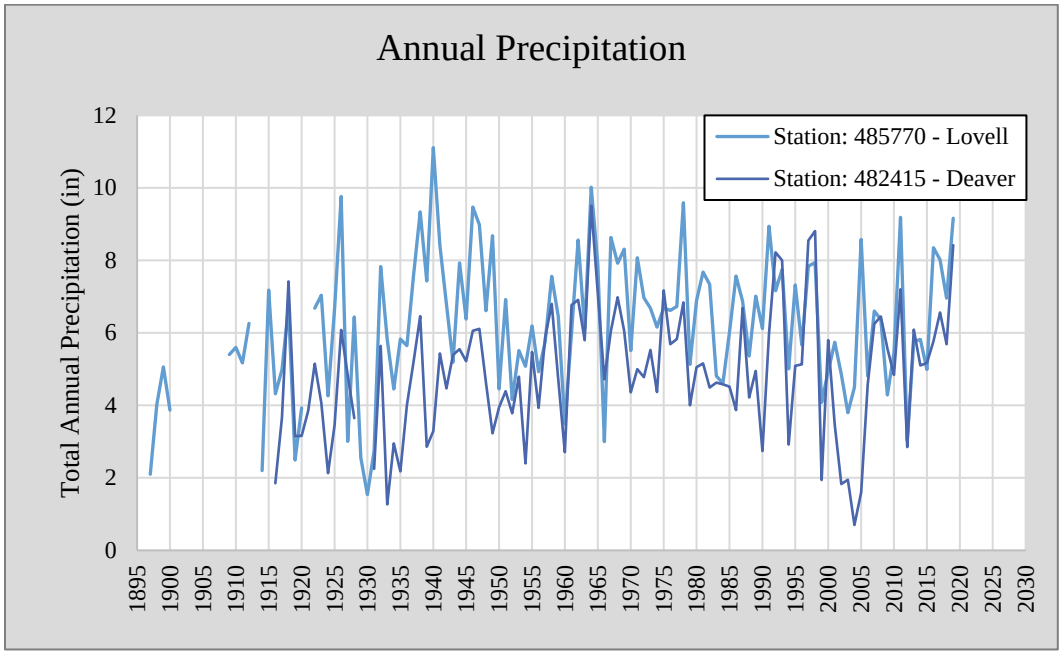


Figure 3.2.5-4. Yearly total annual precipitation for NWS weather stations within the Lower Shoshone River Watershed.

Freezes in mid spring and mid fall are common throughout the Study Area. The average last occurrence of 32.5 degrees and 28.5 degrees in the spring and the average first occurrence of 32.5 degrees and 28.5 degrees in the fall along with the average length of the 32.5 degrees and 28.5 degrees growing season at each weather station is shown in Table 3.2.5-2.

Table 3.2.5-2. Comparison of early and late freezes and general growing season derived from NWS Weather Stations within the Lower Shoshone River Watershed.

Weather Station	Avg. Last Spring Occurrence of 32.5°F	Avg. 1st Fall Occurrence of 32.5°F	Avg. # Days > 32.5°F	Avg. Last Spring Occurrence of 28.5°F	Avg. Last Fall Occurrence of 28.5°F	Avg. # Days >28.5°F
Deaver	21-May	19-Sep	119	8-May	26-Sep	143
Lovell	14-May	20-Sep	129	1-May	3-Oct	154

Data Provided by the Western Regional Climate Center

3.3 Biological Systems

The Study Area provides habitat to various upland, wetland, and aquatic species. Wildlife in Wyoming are managed by the Wyoming Game and Fish Department (WGFD), which uses the State Wildlife Action Plan (SWAP) to provide strategies for managing the ecosystems and wildlife groups present in Wyoming.

3.3.1 Fish and Wildlife

The Wyoming Natural Diversity Database (WYNDD) was queried in order to generate a list of Species of Concern documented from within the Study Area (Table 3.3.1-1). Species of concern are categorized by global and state status of species in Wyoming that are rare, endemic, disjunct, threatened, or otherwise biologically sensitive.

Table 3.3.1-1. Sensitive wildlife species mapped by Wyoming Natural Diversity Database in the Lower Shoshone River Watershed.

Scientific Name	Common Name	Global Rank	State Rank	BLM Sensitive Species	USFS Sensitive Species
Amphibians					
Lithobates pipiens	Northern Leopard Frog	G5	S3	Sensitive	USFS-R2
Anaxyrus boreas	Western Toad	G4	S1	Sensitive	USFS-R2, USFS-R4
Rana luteiventris	Columbia Spotted Frog	G4	S3	Sensitive	USFS-R2, USFS-R4
Spea bombifrons	Plains Spadefoot	G5	S4		
Birds					
Artemisiospiza nevadensis	Sagebrush Sparrow	G5	S3S4	Sensitive	USFS-R2
Athene cunicularia	Burrowing Owl	G4	S3	Sensitive	USFS-R2
Botaurus lentiginosus	American Bittern	G5	S2S3		USFS-R2
Buteo regalis	Ferruginous Hawk	G4	S4S5BS3N	Sensitive	USFS-R2
Calcarius ornatus	Chestnut-collared Longspur	G5	S3		USFS-R2
Charadrius montanus	Mountain Plover	G3	S3	Sensitive	USFS-R2
Chlidonias niger	Black Tern	G4G5	S1		USFS-R2

Scientific Name	Common Name	Global Rank	State Rank	BLM Sensitive Species	USFS Sensitive Species
Lanius ludovicianus	Loggerhead Shrike	G4	S4S5	Sensitive	USFS-R2
Melanerpes lewis	Lewis's Woodpecker	G4	S3		USFS-R2
Numenius americanus	Long-billed Curlew	G5	S3S4	Sensitive	USFS-R2
Rhynchophanes mccownii	Thick-billed Longspur	G4	S3		USFS-R2
Accipiter gentilis	Northern Goshawk	G5	S2S3BS3N	Sensitive	USFS-R2, USFS-R4
Aegolius funereus	Boreal Owl	G5	S2		USFS-R2, USFS-R4
Centrocercus urophasianus	Greater Sage-Grouse	G3G4	S4	Sensitive	USFS-R2, USFS-R4
Coccyzus americanus	Yellow-billed Cuckoo	G5	S1	Sensitive	USFS-R2, USFS-R4
Cygnus buccinator	Trumpeter Swan	G4	S3	Sensitive	USFS-R2, USFS-R4
Falco peregrinus	Peregrine Falcon	G4	S2BS2S3N	Sensitive	USFS-R2, USFS-R4
Haliaeetus leucocephalus	Bald Eagle	G5	S4BS5N	Sensitive	USFS-R2, USFS-R4
Histrionicus histrionicus	Harlequin Duck	G4	S1		USFS-R2, USFS-R4
Gavia immer	Common Loon	G5	S1BS3N		USFS-R4
Picoides dorsalis	American Three-toed Woodpecker	G5	S3		USFS-R4
Strix nebulosa	Great Gray Owl	G5	S2		USFS-R4
Aechmophorus clarkii	Clark's Grebe	G5	S2S3		
Aphelocoma woodhouseii	Woodhouse's Scrub-Jay	G5	S1		
Asio flammeus	Short-eared Owl	G5	S1S2		
Centronyx bairdii	Baird's Sparrow	G4	S1	Sensitive	
Coccyzus erythropthalmus	Black-billed Cuckoo	G5	S2S3		
Dolichonyx oryzivorus	Bobolink	G5	S2S3		
Glaucidium gnoma	Northern Pygmy-Owl	G4G5	S1S2		
Hydroprogne caspia	Caspian Tern	G5	S1		
Junco hyemalis	Dark-eyed Junco	G5	S5BS5N		
Junco hyemalis caniceps	Gray-headed Junco	G5T5	S5BS5N		
Junco hyemalis hyemalis	Slate-colored Junco	G5T5	S5BS5N		

Scientific Name	Common Name	Global Rank	State Rank	BLM Sensitive Species	USFS Sensitive Species
Junco hyemalis mearnsi	Pink-sided Junco	G5T5	S5BS5N		
Junco hyemalis oreganus	Oregon Junco	G5T5	S5BS5N		
Leucosticte atrata	Black Rosy-Finch	G4	S1BS2N		
Pelecanus erythrorhynchos	American White Pelican	G4	S3S4		
Plegadis chihi	White-faced Ibis	G5	S1	Sensitive	
Selasphorus calliope	Calliope Hummingbird	G5	S2		
Setophaga nigrescens	Black-throated Gray Warbler	G5	S2		
Sitta pygmaea	Pygmy Nuthatch	G5	S2S3		
Sphyrapicus thyroideus	Williamson's Sapsucker	G5	S3S4		
Sterna forsteri	Forster's Tern	G5	S1		
Bivalvia (Mussels and Clams)					
Lampsilis siliquoidea	Fatmucket	G5	S3		
Fishes					
Macrhybopsis gelida	Sturgeon Chub	G3	S1		USFS-R2
Oncorhynchus clarkii bouvieri	Yellowstone Cutthroat Trout	G4T4	S2	Sensitive	USFS-R2, USFS-R4
Hybognathus argyritis	Western Silvery Minnow	G4	S2		
Oncorhynchus clarkii	Cutthroat Trout	G4	S2S3		
Scaphirhynchus platorynchus	Shovelnose Sturgeon	G4	S1		
Gastropoda (Snails and Slugs)					
Oreohelix pygmaea	Pygmy Mountainsnail	G1	S1		USFS-R2
Fossaria obrussa	Golden Fossaria	G5	S3		
Gyraulus circumstriatus	Disc Gyro	G5	S3		
Gyraulus parvus	Ash Gyro	G5	S4		
Oreohelix subrudis	Subalpine Mountainsnail	G5	SNR		
Oreohelix yavapai	Yavapai Mountainsnail	G5	SNR		
Oreohelix yavapai extremitatis	A Mountainsnail	G5TNR	SNR		
Physa acuta	Pewter Physa	G5Q	S4		
Physa gyrina	Tadpole Physa	G5	S4		
Physa spelunca	Cave Physa	G1	S1		
Planorbella trivolvis	Marsh Rams-horn	G5	S4		
Insects: Hymenoptera (Bees, Wasps and Ants)					
Bombus occidentalis	Western Bumble Bee	G2G3	SNR		USFS-R2

Scientific Name	Common Name	Global Rank	State Rank	BLM Sensitive Species	USFS Sensitive Species
Insects: Lepidoptera (Butterflies and Moths)					
Phyciodes batesii	Tawny Crescent	G4	SNR		
Insects: Mecoptera (Scorpion Flies, Hangingflies, Scorpionflies, Snowflies)					
Boreus bomari	Snow Scorpionfly	GNR	S4		
Mammals					
Cynomys leucurus	White-tailed Prairie Dog	G4	S2S3	Sensitive	USFS-R2
Lontra canadensis	Northern River Otter	G5	S3S4		USFS-R2
Microtus richardsoni	Water Vole	G5	S1		USFS-R2
Myotis thysanodes	Fringed Myotis	G4	S2S3	Sensitive	USFS-R2
Vulpes velox	Swift Fox	G3	S2	Sensitive	USFS-R2
Corynorhinus townsendii	Townsend's Big-eared Bat	G4	S2BS1N	Sensitive	USFS-R2, USFS-R4
Euderma maculatum	Spotted Bat	G4	S1S2	Sensitive	USFS-R2, USFS-R4
Canis lupus	Gray Wolf	G5	S1		USFS-R4
Antrozous pallidus	Pallid Bat	G4	S2S3		
Gulo gulo	Wolverine	G4	S1S2		
Ictidomys tridecemlineatus	Thirteen-lined Ground Squirrel	G5	S5		
Lepus americanus seclusus	Bighorn Mountains Snowshoe Hare	G5TNR	S1		
Lynx canadensis	Canada Lynx	G5	S1		
Mustela nigripes	Black-footed Ferret	G1	S1		
Myotis yumanensis	Yuma Myotis	G5	S1		
Ochotona princeps	American Pika	G5	S2		
Ochotona princeps princeps	Northern Rocky Mountain Pika	G5TNR	S2		
Sorex haydeni	Hayden's Shrew	G5	S2S3		
Ursus arctos	Grizzly Bear	G4	S1		
Zapus princeps	Western Jumping Mouse	G5	S3S4		
Reptiles					
Charina bottae	Northern Rubber Boa	G5	S2		

G = Global rank assigned by NatureServe: Range-wide probability of extinction (1 = critically imperiled; 2 = imperiled; 3 = vulnerable; 4 = apparently secure; 5 = secure)
S = State-wide probability of extinction (1 = critically imperiled; 2 = imperiled; 3 = vulnerable; 4 = apparently secure; 5 = secure)
T = Trinomial rank: refers to the range-wide probability of extinction for a subspecies or variety (1 = critically imperiled; 2 = imperiled; 3 = vulnerable; 4 = apparently secure; 5 = secure)
B = Breeding rank: indicates the status of a migratory species during the breeding season; applied only to animals
N = Non-breeding rank: indicates the status of a migratory species during the non-breeding season; applied only to animals
H = possibly extinct or extirpated
A = Accidental or vagrant: taxon appears irregularly and infrequently

Q = Taxon has Taxonomic questions
USFS-R2 = Sensitive in Region 2 – Region 2 National Forests in Wyoming: Bighorn, Black Hills, Medicine Bow, and Shoshone National Forests, and Thunder Basin National Grassland
USFS-R4 = Sensitive in Region 4 – Region 4 National Forests in Wyoming: Bridger-Teton, Caribou, Targhee, Wasatch-Cache, and Ashley (including Flaming Gorge National Recreational Area) National Forests.

The Wyoming Game and Fish Department's Basin Management Plan (BMP) for the Shoshone River Basin (HUC8: 10080014) provides the following table detailing the common name, scientific name, and native species status for fish, reptiles, crustaceans, and mollusks present within the basin (Table 3.3.1-2).

Table 3.3.1-2. Species found within the Shoshone River Basin (HUC8: 10080014)

Common Name	Scientific Name	Status
Fish		
Butbot	*Lota lota*	NSS3; Bb
Brook Trout	*Salvelinus fontinalis*	nonnative
Black Bullhead	*Ameiurus melas*	NSS5; Cc
Black Crappie	*Pomoxis nigromaculatus*	nonnative
Bluegill	*Lepomis macrochirus*	nonnative
Brown Trout	*Salmo trutta*	nonnative
Bonneville Cutthroat Trout	*Oncorhynchus clarkii utah*	NSS3; Bb
Channel Catfish	*Ictalurus punctatus*	NSS5; Cc
Carp	*Cyprinus carpio*	nonnative
Flathead Chub	*Platygobio gracilis*	NSS4; Bc
Flathead Minnow	*Pimephales promelas*	NSS7; Dd
Fall Rainbow	*Oncorhynchus mykiss*	nonnative
GSF x BLG Hybrid		nonnative
Grass Carp	*Ctenopharyngodon idella*	nonnative
Green Sunfish	*Lepomis cyanellus*	nonnative
Lake Trout	*Salvelinus namaycush*	nonnative
Lake Chub	*Couesius plumbeus*	NSS5; Cc
Largemouth Bass	*Micropterus salmoides*	nonnative
Longnose Dace	*Rhinichthys cataractae*	NSS7; Dd
Longnose Sucker	*Catostomus catostomus*	NSS5; Cc
Mountain Sucker	*Catostomus platyrhnchus*	NSS5; Cc
Mountain Whitefish	*Prosopium williamsoni*	NSS4; Bc
Shorthead Redhorse	*Moxostoma macrolepidotum*	NSS5; Cc
Plains Killifish	*Fundulus zebrinus*	NSS4; Cb
Plains Minnow	*Hybognathus placitus*	NSS3; Bb
Rainbow Trout	*Oncorhynchus mykiss*	nonnative

Common Name	Scientific Name	Status
River Carpsucker	*Carpiodes carpio*	NSS5; Cc
RBT x CUT hybrid		nonnative
Sand Shiner	*Notropis stramineus*	NSS7; Dd
Western Silvery Minnow	*Hybognathus argyritis*	NSS2; Ab
Splake		nonnative
Snake River Cutthroat Trout	*Oncorhynchus clarkii ssp*	NSS4; Cb
Stonecat	*Noturus flavus*	NSS5; Cc
Brook Stickleback	*Culaea inconstans*	nonnative
Spottail Shiner	*Notropis hudsonius*	nonnative
Walleye	*Sander vitreum*	nonnative
White Sucker	*Catostomus commersoni*	NSS7; Dd
Yellow Perch	*Perca flavescens*	nonnative
Yellowstone Cutthroat Trout	*Oncorhynchus clarkii bouveri*	NSS3; Bb
Amphibians		
Boreal Chorus Frog	*Pseudacris maculata*	NSS5
Northern Leopard Frog	*Lithobates pipiens*	NSS4; Bc
Plains Spadefoot	*Spea bombifrons*	NSS4; Bc
Western Tiger Salamander	*Ambystoma mavortium melanostictum*	NSS4; Bc
Rocky Mountain Toad	*Anaxyrus woodhousii*	NSS5
Reptiles		
Bullsnake	*Pituphis catenifer sayi*	NSS5
Red-Sided Gartersnake	*Thamnophis sirtalis parietalis*	NSSU
Eastern Snapping Turtle	*Chelydra serpentina serpentina*	NSS5
Eastern Yellow-Bellied Racer	*Coluber constrictor flaviventris*	NSS5
Greater Short-Horned Lizard	*Phrynosoma hernandesi*	NSS4; Bc
Wandering Gartersnake	*Thamnophis elegan vagrans*	NSS5
Northern Rubber Boa	*Charina bottae*	NSS3; Bb
Northern Sagebrush Lizard	*Sceloporus graciosus graciosus*	NSS5
Plains Hog-Nosed Snake	*Heterodon nasicus*	NSSU
Pale Milksnake	*Lampropeltis triangulum multistriata*	NSS3
Prairie Rattlesnake	*Crotalus viridis*	NSS4
Western Painted Turtle	*Chrysemys picta bellii*	NSS4
Western Spiny Softshell	*Apalone spinifera hartwegi*	NSS4
Crustaceans		
Calico Crayfish	*Oronectes immunis*	NSS4
Virile Crayfish	*Onconectes virilis*	NSS7

Common Name	Scientific Name	Status
Mollusks		
Aquatic snails		NSSU
New Zealand Mud Snails	*Potamopyrgus antipodarum*	nonnative

3.3.1a Fisheries

Fisheries within the greater Shoshone River watershed are diverse and management and conservation are important to the overall quality of the environment and life within the basin. The Shoshone River upstream of the Study Area is classified by Wyoming Game and Fish as a Blue Ribbon trout stream between Buffalo Bill Dam and the Elk-Lovell Canal meaning these are premium trout waters and fisheries of national importance. However, there is a drastic change in fisheries quality downstream of the Elk-Lovell Canal within the Study Area where the Shoshone River is classified as Green Ribbon, meaning low-production water and fisheries of local importance with trout production of less than 50 pounds of trout per mile. Changes in fisheries quality may be partially driven by a natural change in climate and vegetation as the Lower Shoshone River represents a transitional zone towards warm water species and habitats. However, land use and resource management also play a role in affecting the quantity and quality of instream flows.

The construction of the Buffalo Bill Dam and four diversion dams (Corbett, Willwood, Mormon, and Penrose) have fragmented the fish populations by blocking access to spawning tributaries. Additionally, dam construction has limited gravel recruitment in the Lower Shoshone River and resulted in an armored channel of course substrates that no longer provide adequate salmonid spawning habitat to maintain a self-sustaining Shoshone River fishery (BMP). Sedimentation and associated turbidity are a major factor limiting fish production and recruitment in the basin. Sedimentation is a result of several sources. Precipitation falling on naturally erosive soils can contribute sediment to the Lower Shoshone River. Poor grazing practices, tillage and cropping practices, road development, resource extraction, and urban and suburban development have removed terrestrial vegetation and increased upland and stream bank erosion. The water delivery system associated with agricultural irrigation in the basin utilizes some natural stream channels as wastewater conduit. The addition of water to these small stream networks leads to imbalanced sediment budgets, channel incision and widening, and deposition of these sediments into the downstream Shoshone River. Sediment flushing from behind Willwood Dam has resulted in large scale fish kills in the Lower Shoshone River.

Yellowstone Cutthroat Trout are considered a species of concern within the watershed. As a trout fishery the Shoshone River drainage was historically and exclusively native Yellowstone Cutthroat trout range. Introductions of Brown, Lake, Rainbow, and Brook trout have been stocked and become naturalized in the Shoshone River and reservoirs upstream of the Study Area. The earliest recorded stocking of exotic salmonids (Rainbows) occurred in 1915 (Shoshone River Watershed Plans Issues and Concerns). The Lower Shoshone River corridor is identified as an Aquatic Conservation Area in the 2010 State Wildlife Action Plan.

Fisheries within the Yellowstone Basin consist of a mix of 7 species of native game fish, 15 species of native non-game fish, 20 species of non-native game fish, and 10 species of non-native non-

game fish. There are 10 species designated by WGFD as "Species of Greatest Conservation Need (SGCN)," including one salmonid species: Yellowstone Cutthroat Trout.

Table 3.3.1-3. Fish species present within the Yellowstone River Basin. (Information provided by the Wyoming Game and Fish Department).

Native Game Fish	Native Nongame Fish	Nonnative Game Fish	Nonnative Nongame Fish
Butbot*	Flathead Minnow	Black Bullhead	Brook Stickleback
Channel Catfish	Flathead Chub*	Black Crappie	Common Carp
Mountain Whitefish	Lake Chub	Bluegill	Grass Carp
Stonecat	Longnose Dace	Brook Trout	Plains Killifish
Yellowstone Cutthroat Trout*	Longnose Sucker	Brown Trout	Spottail Shiner
	Mountain Sucker	Green Sunfish	
	Plains Minnow*	Lake Trout	
	River Carpsucker	Largemouth Bass	
	Sand Shiner	Rainbow Trout	
	Shorthead Redhorse	Snake River Cutthroat Trout	
	Western Silvery Minnow*	Walleye	
	White Sucker	Yellow Perch	

* denotes Species of Greatest Conservation Need

WGFD has identified 5 fish species as Species of Greatest Conservation Need in their Basin Management Plan (BMP) for the Shoshone River Basin, listed below. Burbot are rarely found in the Shoshone River below Penrose Dam. Flathead chub are common to abundant in the Shoshone River and several lower elevation tributaries. Yellowstone cutthroat trout and mountain whitefish are the only native salmonids in the basin. Mountain whitefish are still abundant in portions of the Shoshone River, however habitat degradation and fragmentation likely have reduced populations from historic levels. Viable populations of Yellowstone cutthroat trout have been eliminated from the basin due to habitat degradation and the introduction of nonnative trout. Occasionally Yellowstone cutthroat trout are collected and probably come from Buffalo Bill Reservoir spill events. Western silvery minnows may have been present in the Shoshone River below Penrose Dam, but have not been captured recently and may no longer be present in the basin.

Species	Abundance	Status
Burbot	Rare	NSS3(Bb)
Yellowstone Cutthroat Trout	Rare	NSS3(Bb)
Flathead Chub	Rare	NSS4(Bc)
Plains Minnow	Rare	NSS3(Bb)
Western Silvery Minnow	Rare	NSS2(Ab)

NSS2(Ab): Native Species Priority 2 Imperiled (severe)

NSS3(Bb): Native Species Priority 3 Vulnerable (severe)

NSS4(Bc): Native Species Priority 4 Vulnerable (moderate)

Conservation actions described in the SWAP for native species identified as NSS1-NSS4 are presented below.

- Flathead Chub NSS4 (Bc)
    - Continue efforts to reduce land and water uses which exacerbate stream channel drying.
- Yellowstone Cutthroat Trout NSS3 (Bb)
    - Develop and implement a public outreach effort specifically addressing Yellowstone Cutthroat Trout conservation in Wyoming
    - Continue to build and maintain range wide database so that information can readily be shared between and among jurisdictions.
    - Complete genetic analyses on known or potential populations to detect hybridization. A reference collection of fish or DNA from the entire five-state area should be developed and maintained in conjunction with the genetic monitoring program.
    - Construct in-channel barriers, where feasible, to prevent the invasion of nonnative fish.
    - Continue efforts to remove competing and hybridizing nonnative species to secure, enhance and restore populations.
    - Continue to remove anthropogenic barriers limiting gene flow and the expression of fluvial life history strategies.
    - File for instream flow water rights to protect habitat of conservation populations.
    - Continue regulations to restrict harvest of vulnerable populations.
    - Prevent stocking of public or private waters with non-native species that may impact conservation populations.
    - Protect and manage riparian areas for native riparian vegetation, that will filter runoff, maintain a higher water table, provide late season stream recharge, and stabilize stream banks. Use riparian fencing, grazing management, fire management, and invasive species control to promote native vegetation.
    - Identify and characterize all populations within their native range in Wyoming.
    - Develop refugia for pure populations in lakes or streams to act as backup for hatchery brood sources.
- Burbot (NSS3; Bb).
    - Entrainment in canals needs evaluation.
    - A better understanding of juvenile habitat requirements is needed.
    - A better understanding of the habitat and flow requirements of this species is needed to assess the impacts of water and land use activities.
    - A better understanding of the “source and sind dynamics” of natural recruitment maintaining various stocks is needed.
    - Isolate sources of production in the Bighorn-Wind watershed by examining drift/migration patterns.
    - Continue efforts to maintain flows and connectivity.
    - Determine the effects that nonnative species are having on native burbot populations.

- Western Silvery Minnow (NSS2)
    - Continue efforts to educate landowners and the public about the importance of native fish and their habitats.
    - Continue efforts to maintain flows and connectivity.
    - Continue efforts to prevent the colonization and spread of nonnative fishes throughout the Powder River basin through the maintenance of natural flow process.

WGFD classifies rivers and streams based on the relative productivity of each reach's trout fishery. Five classifications are used to describe the quality of each river reach that has been assessed. See Map 17 for the WGFD's trout stream classification within the Study Area.

Blue Ribbon: Premium trout waters and fisheries of national importance with trout production greater than 600 pounds of trout per mile

Red Ribbon: Very good trout waters and fisheries of statewide importance with trout production of 300 to 600 pounds of trout per mile

Yellow Ribbon: Important trout waters and fisheries of regional importance with trout production of 50 to 300 pounds of trout per mile

Green Ribbon: Low-production water and fisheries of local importance with trout production of less than 50 pounds of trout per mile.

Orange Ribbon: Any cool/warm water fish present.

Clear: No trout present.

The watershed consists of mostly "Clear" stream segments, which indicate that there are no trout present. Sage Creek and the Shoshone River are classified as Green Ribbon stream segments, which indicates low fish production. Crooked Creak is classified as Yellow Ribbon, which indicates important trout waters with production of 50 to 300 lbs of trout/mile. There are no reaches classified as Blue Ribbon.

Deaver reservoir is annually stocked with fingerling Walleye and Rainbow Trout. Additionally, trout brood culls are stocked in the Deaver reservoir periodically. The upper reaches of the Shoshone River above Penrose dam are stocked with trout to provide a fishery as natural recruitment is limited. The trout fishery below Penrose Dam in the Study Area exists as a result of fish drifting downstream and from a small Brown Trout population that is self-sustaining.

The BLM maintains a list of sensitive fish species and the following species are listed as sensitive: Yellowstone cutthroat trout, fine spotted snake river cutthroat trout (non-native), and colorado river cutthroat trout (non-native).

The Shoshone River, Sage Creek, and Crooked Creek are listed as Class 2AB waters by the Wyoming DEQ Water Quality Division (WDEQ 2001a). Class 2AB waters are defined as those waters known to support game fish populations or spawning and nursery areas at least seasonally, perennial tributaries and adjacent wetlands, and areas in which game fishery and drinking water use is otherwise attainable. Additional protections of Class 2AB waters include "non-game fisheries, fish consumption, aquatic life other than fish, primary contact recreation, wildlife, industry, agriculture and scenic values". Whistle Creek, Big Wash, and Dry Creek are listed as 3B

waters by WDEQ. Class 3B waters are defines as those waters that are not known to support fish populations or drinking water supplies and where those uses are not attainable. Canals including the Sidon, Deaver, and Frannie Canals are listed as Class 4A waters meaning they are artificial canals and ditches that are not known to support fish populations.

Other water quality designations within the Study Area include Class 2B and Class 2C waters. Class 2B waters include waters known to support or have the potential to support game fish populations or spawning and nursery areas at least seasonally. Class 2B waters within the project area are limited to the Garland Canal and Arnoldus Drain. Class 2C waters include waters shown as having only nongame fish species present. Class 2C waters within the project area are limited to Sulphur Creek, Idaho Creek, Coon Creek, and Foster Gulch.

There are currently no instream flow filings within the project area.

The Wyoming Game and Fish Department is currently building a database composed of in-stream structures throughout the state which includes structure name, type, probability for fish passage, and descriptions for all in-stream structures (see Table 3.3.1-4 and Map 18).

Table 3.3.1-4. In-stream structures within the Study Area. (Information provided by the Wyoming Game and Fish Department). Note that the database is currently being created and does not represent all diversion or in-stream structures within the Study Area.

ID	Structure Name	Stream Name	Structure Type	Passage Probability	Structure Description
730	Unknown diversion No.1, Russell Boardman's property	Sage Creek	Diversion	N/A	N/A
457	Hunt-Godfrey Canal Diversion	Shoshone River	Diversion	Passable, Many Species	There is a small instream diversion with rock rubble. A low rock dike goes across the river and diverts water towards the headgate. The rock dike is relatively new within 15 to 20 years old.
498	Big Fork Canal	Shoshone River	Diversion	Passable, Many Species	Instream diversion takes water out of the main fork of the Shoshone River. The POD inlet is 30 to 40 ft wide.
455	Globe Canal Diversion	Shoshone River	Diversion	Passable, Many Species	This diversion structure is comprised of three headgates that are 4' wide by 4' tall. The depth of the channel just in front of the headgates was 2.7'. There are no screens on this canal to prevent fish entrainment.
612	D-56 lateral ditch	Sage Creek	Diversion	N/A	Water is diverted out of Sage Creek by a concrete diversion dam that spans the width of the dam. The diverted water is taken out through 4' screw-type headgate.

3.3.1b Wildlife

In addition to wildlife species of concern identified through WYNDD, the most current WGFD-mapped seasonal range, crucial range, parturition areas, and migration corridors for native big game species occurring in the vicinity of the Study Area was reviewed. Greater sage-grouse lek sites and Sage-Grouse Core Area mapping are presented in an overview figure and described below, as are the 2020 WGFD Habitat Priority Areas per the 2020 Statewide Habitat Plan.

3.3.1c Big Game

Although big game utilize habitat in the Study Area, no crucial range, parturition areas, major migration routes or migration barriers have been identified by the WGFD. White-tailed deer are the most abundant big game species in the Study Area and are concentrated in agricultural fields and along riparian corridors in the valley bottom (J. Altermatt, personal communication, September 2021). Mule deer and pronghorn antelope also utilize habitat in the Study Area but to a lesser extent, and moose are occasionally present.

White-tailed deer are generally concentrated in riparian, agricultural, and residential areas. They are highly adaptable to human activities and have replaced mule deer in residential and agricultural areas across the west. White-tailed deer eat a variety of grasses, forbs, and hay crops as well as shrubs and trees, including red-osier dogwood, serviceberry, chokecherry, and immature cottonwoods. WGFD does not identify crucial white-tailed deer habitat.

Mule deer in Wyoming are found in a wide variety of habitat types, from irrigated agricultural fields to subalpine meadows. Sawyer et al. (2014) found that more than 90 percent of Wyoming ungulates (including mule deer, elk, pronghorn, moose, bighorn sheep, mountain goat, bison, and white-tailed deer) are migratory.

Pronghorn antelope are sagebrush obligate species that depend on sagebrush steppe ecosystems for survival. They primarily feed on shrubs, especially sagebrush, in the winter months but will also utilize some grasses and forbs in the spring and summer months.

3.3.1d Greater Sage-grouse

In 2010, the USFWS found that the greater sage-grouse was warranted for protection and identified it as a candidate for listing as a threatened or endangered species under the Endangered Species Act of 1973 (ESA). In 2015, a combination of new information about the status of the species, implementation of conservation efforts and regulatory mechanisms, and evaluation of on-going potential threats resulted in USFWS determining that listing greater sage-grouse as threatened or endangered under the Act was not warranted. Greater sage-grouse in large part avoided listing due to conservation efforts implemented by Federal, State, and private landowners. In 2008, the Governor of Wyoming implemented a Core Area Protection strategy for greater sage-grouse by executive order. The executive order was designed to implement protective measures for sage-grouse habitats, populations and connectivity areas to conserve sage-grouse and preclude the need for listing the bird as a threatened or endangered species. The Executive Order was updated in 2017 and again in 2019 to add further detail (SOW 2019). Map 19 depicts known active leks (2) and

current Sage-Grouse Core Area mapping in the Study Area. Sage-Grouse Core Area comprises 8,376 acres (2%) of the Study Area.

3.3.1e Threatened, Endangered, and Sensitive Species

Sensitive Species

The list of documented occurrences of rare, endemic, disjunct, threatened, or otherwise biologically sensitive species provided by WYNDD includes wildlife species organized in seven common taxonomic groupings including amphibians (n=4), birds (n=43), mussels/clams (n=1), slugs/snails (n=11), insects (3), mammals (n=20), and reptiles (n=1). The ranking system presented in Table 3.3.1-1 denotes the global rank (G) indicating range-wide probability of extinction and a state rank (S) reflecting degree of sensitivity assigned by WYNDD biologists for species in peril within the state. The ranks indicate a numeric score from 1-5, with 1 being critically imperiled and 5 being demonstrably secure. More than 50% of the sensitive wildlife species have life history requirements tied directly to some form of aquatic habitat, whether wetland, riparian or open water. Birds make up the largest percentage (50%) of the rare or sensitive species identified by WYNDD. These species rely heavily on the riparian and wetland habitats along the Shoshone River.

Threatened and Endangered Species

A query of the US Fish and Wildlife Service Information, Planning and Conservation System (IPAC) on September 8, 2021 provided the most up-to-date information regarding federal Natural Resources of Concern including threatened and endangered species within the Study Area. There are no animal species listed as endangered under the Endangered Species Act (ESA) that either occur or have protected habitat within the watershed Study Area. One mammal listed as threatened under the ESA, grizzly bear, is known or expected to occur within the Study Area. Grizzly bears were listed as threatened under the Endangered Species Act in the lower 48 states in 1975 and have since gone through a series of delisting and relisting. Grizzly bears have been documented in the Study Area by WGFD, but grizzly bear use of habitat in the Study Area is incidental and becoming less so (J. Altermatt, personal communication, September 2021).

Candidate Species

The monarch butterfly was recently added as candidate for listing under the ESA due to a precipitous population decline. On December 15, 2020, the USFWS announced that listing the monarch as endangered or threatened under the ESA was warranted but precluded by higher priority listing actions. Milkweed, a habitat requirement for monarchs, is abundant in portions of the Study Area, and monarchs are likely present on a seasonal basis.

3.3.1f WGFD Priority Habitat Areas

The 2020 WGFD Statewide Habitat Plan (SHP) informs the implementation of habitat conservation and restoration across all departments within WGFD and through coordination with partners. The management of wildlife is inseparable from the habitat that sustains it, and WGFD's ability to sustain quality wildlife habitat is contingent upon working in partnership with private landowners and public land managers; conservation organizations; local, state, and federal governmental agencies; and the public. The SHP identifies crucial, restoration, and connectivity habitat priorities

for the state. Aquatic and terrestrial crucial habitat priorities and aquatic connectivity habitat priorities are identified in the Study Area (Map 16). No habitat restoration priority areas were identified in the Study Area. The web-based Statewide Habitat Plan 2020 Priority Areas story map developed by WGFD provides detailed descriptions for each habitat priority in the Study Area (https://wgfd.maps.arcgis.com/apps/MapSeries/index.html?appid=4f325cb8a9b247df8753fd37919b727e).

Crucial Habitat Priority Areas

Per the SHP, *Crucial Habitat Priority Areas are based on significant biological or ecological values. These are areas that need to be protected or managed to maintain viable healthy populations of terrestrial and aquatic wildlife for the present and future. They represent habitat values and identify where those values occur on the landscape. Examples of values include crucial winter range, sage grouse core area seasonal habitats, Species of Greatest Conservation Need (SGCN) diversity and uniqueness, quality and condition of vegetative communities, quality of watershed hydrologic function, etc. The Department will concentrate habitat protection and management activities in these areas.* The terrestrial crucial habitat priority areas in the Study Area are classified as Bighorn Mountains Riparian and Aspen Communities and are located along the Lower Shoshone River, lower Crooked Creek, and the west side of Bighorn Lake. The aspen and tall willow communities have been declining in these areas. Management actions recommended by WGFD for these areas include:

- Cooperate with public land managers to maintain wildlife and livestock densities at levels that allow willow and aspen regeneration.
- Support herbivore management strategies with private lands cooperators that perpetuate aspen and willow communities
- Assist public awareness efforts to gain support to address problems
- Promote treatments to retain or expand aspen, riparian aspen, and willow communities where herbivore management allows.
- Cooperate with land managers to research management issues and monitor management trends.
- Cooperate with land managers to transplant beaver to suitable, but unoccupied habitats when natural immigration from nearby sources appears unlikely.
- Retain and manage beaver populations to enhance channel and riparian connectivity, augment bank storage, and increase food and cover for fish and other wildlife.
- Promote allowing prescribed natural fire management on public lands where aspen and willow expansion are likely.
- Promote timber management practices that expand aspen and riparian communities and protect watershed hydrologic function.

- Implement passive riparian rehabilitation strategies to improve degraded riparian systems such as riparian fencing, off stream livestock water development, or other alternatives to reduce livestock impact to riparian areas
- Implement low-tech riparian restoration practices, such as Beaver Dam Analogs, Zeedyk structures, or similar practices where forage resources are not present to accommodate beaver transplants and/or floodplain connectivity is altered, to promote suitable conditions for willow and aspen establishment.

The aquatic crucial habitat priority areas in the Study Area are classified as Lower Shoshone River Riparian Habitat and Lower Bighorn River Complex. The Lower Shoshone River Riparian Habitat priority habitat encompasses the entirety Study Area reach of the mainstem Shoshone River. The riparian habitats in this reach contain diverse and productive riparian and wetland habitats for a wide range of terrestrial and aquatic species, including many Species of Greatest Conservation Need (SGCN) identified in the Comprehensive Wildlife Conservation Strategy report. The area faces a number of threats (altered flood regimes, invasive species, improper grazing/browsing by livestock and wildlife, fire, accelerated bank erosion, conversion to agricultural cropland and residential development) so recognizing and conserving the existing values are important. Management actions recommended by WGFD for the Lower Shoshone River Riparian Habitat areas include:

- Mechanically, chemically, and biologically treat invasive species, including Russian olive and tamarisk that compete with native vegetation.
- Leave riparian buffers undisturbed and restore disturbed riparian areas whenever possible. Fence riparian areas out of pastures, farm fields, and high human use areas.
- Protect riparian habitat from frequent wildfires resulting from the burning of irrigation ditches or leftover crop residue. Frequent burning can result in invasive species replacing the more desirable native vegetation.
- Work with County Planning and Zoning to recognize the importance of riparian zones and limit actions/developments within this valuable habitat type.
- Utilize best management practices for timber management, fire management, grazing, farming, road management, and urban development. Manage riparian zones for healthy riparian communities including sedges, deep-rooted grasses, willows, aspen, and cottonwood.
- If management changes are not adequate to restore riparian vegetation, then plant riparian grasses, shrubs, and trees appropriate for the location’s elevation.
- Work with agencies, irrigation districts, and private landowners to maintain stream flows to maintain water tables, and healthy riparian vegetation.
- Reconnect abandoned stream habitats (oxbows, side channels and backwaters) to increase stream edge and raise the water table, which will provide more and healthier riparian vegetation.

- Seek conservation easements and develop partnerships and agreements with federal land management agencies, State Land Board and private landowners, etc. to protect riparian habitat.
- Implement management strategies outlined in the Yellowtail Wildlife Habitat Management Area (WHMA) managed land summary.
- Protect and manage for native riparian vegetation to filter runoff, maintain water tables, provide late season stream recharge, and stabilize stream banks. Use riparian fencing, grazing management, fire management, and invasive species control to promote native vegetation. Remove Russian olive and tamarisk.
- Reduce erosion sediment deposition in the Shoshone River. Utilize filter strips, wetlands, silt detention ponds, minimum till practices, efficient irrigation systems, off-site livestock water, plus best management practices for riparian, municipal storm and sewer water, farming, grazing, and road management. Encourage the wise use of water that reduces sediment laden wastewater return to the Shoshone River. Replace push-up dams affecting water quality with fish-friendly permanent solutions.

The Lower Bighorn River Complex supports the highest fish diversity in the Cody Region. The Lower Bighorn River Complex has over 90 miles of connected habitat for migratory species. The tributaries provide high water refuge, spawning, and nursery habitat. Bighorn Lake provides important winter habitat, nursery habitat, refuge from low water conditions, and a tremendous food source for fast growth. Management actions recommended by WGFD for the Lower Bighorn River Complex include:

- Improve stream flows, stream habitat, riparian vegetation, and fisheries through improved water management and efficient irrigation systems, e.g., seal canals, surge valves, sprinklers.
- Improve upstream passage at diversions and culverts. Investigate the feasibility of use screens to reduce entrainment loss.
- Reconnect oxbows, side channels, and backwaters.
- Obtain stream maintenance flows and flood flows for cottonwood establishment.
- Protect and manage for native riparian vegetation to filter runoff, maintain water tables, provide late season stream recharge, and stabilize stream banks. Use riparian fencing, grazing management, fire management, and invasive species control to promote native vegetation. Remove Russian olive and tamarisk.
- Reduce erosion and silt loading. Utilize filter strips, wetlands, silt detention ponds, minimum till practices, efficient irrigation systems, off-site livestock water, plus best management practices for riparian, municipal storm and sewer water, farming, grazing, and road management. Replace push-up dams affecting water quality with fish-friendly permanent solutions.
- Maintain Big Horn Lake water levels to provide quality fish habitat, forage production, and public recreation.

- Determine the cause of Eastern Spiny Softshell turtle declines in the area by identifying habitat requirements, critical habitat areas, and factors limiting the population.

Connectivity Habitat Priority Areas

Per the SHP, *Connectivity Habitat Priority Areas were developed to reflect the high importance that issues related to connectivity among fish and wildlife populations have gained in recent years. These areas are meant to promote protecting connectivity where it currently occurs and focus attention on enhancing fish passage and wildlife migrations to improve connectivity. Officially designated wildlife migration corridors as well as informally identified migration routes are included under this goal. Likewise, fish passage areas are included. A sampling of issues addressed under this goal include road crossings that impede fish or wildlife, diversion dams that block fish, the location and accessibility of ungulate stopover areas, diversions that entrain high numbers of fish, and fences that block or impede migrations.* The SHP identifies Aquatic Connectivity Habitat Priority Areas along the Lower Shoshone River in the Study Area (Map 16). Actions to address aquatic connectivity values and issues include conservation easements, commenting on development proposals through the WGFD's Habitat Protection Wildlife Environmental Review (WER) system and the NRCS IRMA program, and directly addressing issues through projects that improve passage at obstructions. Examples include replacing irrigation push up dams with one or more low-head rock vanes, providing fish ladders or other fishways at dams, replacing narrow culverts with bridges or wider, natural-bottom box culverts projects to rehabilitate irrigation infrastructure. Fish screening options should be explored in cases where substantial fish loss occurs and where reasonable and affordable screen maintenance options exist. Finally, water management options can be pursued to influence the amount and timing of water availability to facilitate passage.

3.3.2 Land Cover

USGS Northwest Regional Gap Analysis Project (NWGAP), National Land Cover Database (NLCD), and LANDFIRE land cover datasets were used to identify and describe common plant communities and ecological systems found within the Study Area. The National Land Cover Database (NLCD) is a nationwide spatial dataset based on Landsat satellite data that provides a generalized characterization of 16 land surface classes at a 30-meter resolution. NLCD Land Cover identified within the Study Area can be viewed on Map 20. Landscape Fire and Resource Management Planning Tools (LANDFIRE) provides landscape-scale vegetation and canopy characteristics (Map 21). The LANDFIRE program was developed to support fire and fuels management planning and is a shared effort between the wildland fire management and research and development programs of the USDA and US Department of the Interior (USDI). The LANDFIRE Existing Vegetation Type (EVT) layer describes vegetation communities at a high level of thematic detail and represents the species composition currently present at a given site. Vegetation map units are primarily derived from NatureServe's Ecological Systems classification, which is a nationally consistent set of mid-scale ecological units. The USGS GAP National Land Cover (GAP) dataset provides detailed information on vegetation and land use patterns based on satellite imagery (Map 22). This national dataset combines land cover data generated by regional GAP projects with LANDFIRE data and incorporates the Ecological System classification system

developed by NatureServe. At the Ecological System level, the GAP dataset describes vegetation communities at a high level of thematic detail, which is typically not appropriate for display at scales larger than 1:100,000. To facilitate display at a larger scale, the ecological systems have been cross-walked to the five highest levels of the National Vegetation Classification Standard (NVCS).

3.3.2a Vegetation and Plant Communities

The following descriptions, adapted from Nature Serve Explorer, provide a general overview of the dominant ecological systems/plant communities within the Study Area. Comprising more than 65% of the Study Area, Inter-Mountain Basins Big Sagebrush Steppe and Inter-Mountain Basins Mat Saltbush Shrubland are the dominant ecological systems in the watershed.

Inter-Mountain Basins Big Sagebrush Steppe – 49.8%

This widespread ecological system comprises approximately half of the watershed and is characterized by open sagebrush steppe. Wyoming or basin big sagebrush (*Artemisia tridentata*), antelope bitterbrush (*Purshia tridentata*) or other shrubs typically comprise about 25% of the ground cover, and native bunchgrasses comprise an additional 25% of the groundcover. This system occurs throughout the western U.S. and is dominant in the northwestern Great Plains of Wyoming and Montana. The natural fire regime in this ecological system maintains a patchy distribution of shrubs. Many plant and animal species such as pronghorn antelope, sage grouse, pygmy rabbit, and sage sparrow utilize native sagebrush steppe as their primary habitat. An example of this habitat type is depicted in Photo 11. The invasion of cheatgrass into thousands of acres of sagebrush steppe across the west, including portions of the Study Area, has altered the fire regime and resulted in conversion of the plant community to low-diversity, annual grasslands that provide low-quality habitat for native plants and wildlife and poor forage for livestock.

Photo 11. Example of Wyoming big sagebrush-dominated sagebrush steppe (foreground) and mat saltbush shrubland (around the depressional basin) in the Lower Shoshone River Watershed.

Inter-Mountain Basins Mat Saltbush Shrubland – 15%

This ecological system occurs on gentle slopes and rolling plains in arid, windswept basins in eastern Wyoming where soils are comprised of shallow saline or alkaline clays and silts with low infiltration rates. The plant community is characterized by dwarf-shrublands comprised of relatively pure stands of saltbush (*Atriplex gardneri*). Other dominant or codominant dwarf shrubs within this system may include long-leaved sage (*Artemisia longifolia*) and bird-foot sage (*Artemisia pedatifida*). Localized patches of Wyoming big sagebrush or basin big sagebrush can also be found in areas with substrates that are less saline or alkaline. The herbaceous layer is comprised of scattered perennial forbs and perennial grasses and is typically sparse.

Inter-Mountains Basins Shale Badland – 5%

This ecological system is composed of barren and sparsely vegetated substrates with 10% or less plant cover. It is typically derived from marine shales but also includes substrates derived from siltstones and mudstones. The landforms associated with this system are typically rounded hills and plains forming an undulating topography. The harsh soil properties and high rate of erosion and deposition are driving environmental variables supporting sparse dwarf-shrubs and herbaceous vegetation.

Inter-Mountain Basins Mixed Salt Desert Scrub – 3.7%

This ecological system includes open-canopied shrublands typically occurring in saline basins and on alluvial slopes and plains across the intermountain western U.S. Substrates are typically saline and calcareous, medium- to fine-textured soils but include some coarser-textured soils. The vegetation is characterized by an open to moderately dense shrubland composed of one or more saltbush species. In Wyoming, occurrences are typically a mix of shadscale saltbush, hop sage, basin big sagebrush, greasewood, winterfat, and various rabbitbrush species. Some zones contain a mix of saltbush and basin big sagebrush. The herbaceous layer varies from sparse to moderately dense and is dominated by perennial graminoids and forbs.

Inter-Mountain Basins Greasewood Flat – 2%

This ecological system occurs throughout much of the western intermountain basins and extends onto the western Great Plains and into central Montana. It typically occurs near drainages on alluvial terraces and flats. Sites typically have saline soils, a shallow water table and flood intermittently but remain dry for most of the growing season. The water table remains high enough to maintain vegetation, despite salt accumulations. This system is comprised of open to moderately-dense shrublands dominated by greasewood. It is typically intermixed with other ecological systems such as mixed salt desert scrub or big sagebrush shrublands. In high salinity areas, greasewood often grows in nearly pure stands, and on less saline sites it commonly grows with other shrub species and has a grass understory. The herbaceous layer, if present, is usually dominated by graminoids.

Other Covertypes

The remainder of the Study Area is comprised of irrigated hayland/pastureland, cultivated cropland, and disturbed areas. These covertypes occur in or near the valley bottoms where irrigation water is available.

3.3.2b Wetlands and Riparian Areas

Wetlands are among the most important ecosystems on Earth and they play an essential role in the landscape by providing important ecological services and productive and unique habitats for a diverse array of plants and animals (Mitsch and Gosselink 1986). This is especially true in the semiarid and arid portions of the Intermountain West, where precipitation is highly variable and strongly dependent on topography and elevation. Ecological processes associated with wetlands provide a variety of environmental maintenance functions on global, regional, and local scales. These functions include but are not limited to: water quality improvement (e.g., nutrient uptake and sediment retention), erosion control, groundwater discharge/recharge, shoreline stabilization, flood attenuation, and fish and wildlife habitat. Landscape position and hydrologic interactions help to determine prominent functions for each particular wetland.

Approximately 90% of the wildlife species in Wyoming utilize wetlands and riparian habitats at some point during their life cycle, and about 70% of Wyoming bird species are wetland or riparian obligates (Nicholoff 2003). As is common for arid basins throughout the intermountain west, wetlands in the Lower Shoshone River watershed are concentrated along natural watercourses and manmade water features, such as irrigation ditches and stock ponds. Wetlands found in the Study Area are largely associated with natural watercourses (Map 23). The most diverse and highest quality wetlands occur near Big Horn Lake and along the Shoshone River in the Yellowtail Wildlife Habitat Management Area. These riparian wetlands provide valuable habitat waterfowl and shorebirds.

Large expanses of flood-irrigated agricultural meadows exist within the Study Area. Traditional agricultural practices include flood irrigation in late spring and early summer, harvesting in late July through the beginning of August, and additional flood irrigation in late summer/fall prior to grazing in the dormant season. These agricultural practices and associated irrigation activities create irrigation-induced wetlands that provide high quality feeding and stopover habitat for a diverse array of migrating waterbirds and waterfowl. Residual vegetation from the previous growing season provides nesting habitat in the vegetation surrounding the agricultural meadows. Common plant species in these wetland habitats include sedges (*Carex* spp.), rushes (*Juncus* spp.), bulrushes (*Schoenoplectus* spp.), cattails (*Typha* spp.), reed canarygrass (*Phalaris arundinacea*), and Garrison creeping foxtail (*Alopecurus arundinaceus*).

Yellowtail Wildlife Habitat Management Area

The Yellowtail Wildlife Habitat Management Area (WHMA), located approximately 6 miles east of Lovell, WY, is a large complex of State and Federal lands that comprises more than 19,000 acres along the Lower Shoshone River that extends to Bighorn Lake, and the Bighorn River. Approximately 7,000 acres of the Yellowtail WHMA, including many acres of palustrine and riverine wetlands, falls within the eastern portion of the Study Area. According to the WGFD, Yellowtail was established in the early 1960s through a cooperative agreement between Wyoming Game and Fish Commission, National Park Service, U.S. Bureau of Reclamation and U.S. Bureau of Land Management to enhance waterfowl habitat and is home to more than 160 species of birds including: Bald Eagle, Lazuli Bunting, Willet, Wilson's Phalarope, Hooded Merganser, Lark Bunting, American White Pelican, and Sandhill Crane. The Yellowtail WHMA consists of mostly

riparian river bottom and wetlands. It has what is suspected to be one of the largest cottonwood riparian systems in Wyoming and supports one of the richest concentrations of wildlife species in the state (WGFD 2019). In addition to waterfowl, the Yellowtail WHMA has a substantial population of white-tailed deer, mule deer, ducks, geese, cottontail rabbits, wild turkeys, pheasants, and mourning doves.

3.3.2c Wetland Types and Distribution

A wetland analysis was conducted via a review of remotely sensed data for the watershed including aerial imagery, US Fish and Wildlife Service's National Wetland Inventory (NWI) data, and USGS NWGAP data. Although the NWI data is based on interpretation of aerial photographs and the accuracy is variable, these data provide a coarse overview of wetland presence and classification within the Study Area.

The NWI was established by the USFWS in 1974 to conduct a nationwide inventory of wetlands and produce a series of topical maps to depict wetlands and deep-water habitats. NWI mapping is based on interpretation of aerial photography and is generally considered to provide a conservative estimate of wetland area. NWI mapping of larger, wetter wetlands is typically accurate; however due to limitations associated with photointerpretation, wetlands with a drier hydrologic regime and other wetlands that are difficult to interpret from aerial imagery (e.g., farmed wetlands, grazed wetlands, and forested wetlands) may be omitted (Tiner 1997).

NWI mapping provides the most comprehensive spatial dataset for wetland distribution in the Study Area. In the absence of a site-specific ground-truthing effort, it is not feasible to determine the accuracy of NWI mapping within the Study Area. Therefore, the NWI data should be considered a conservative estimate of wetlands. According to the NWI, 3.5% (14,078 acres) of the Study Area is comprised of wetlands and deep-water habitats (Table 3.3.2-1; Map 22). The NWI depicts 44 unique wetland classifications (per Cowardin et al 1979) for mapped wetlands within the Study Area, all of which are broadly defined as freshwater emergent wetlands or freshwater forested/shrub wetlands.

Table 3.3.2-1. A tabulation of NWI wetland and deep-water habitats in the Lower Shoshone River Watershed.

Habitat Type	Area	
	Acres	Percent of Watershed
Wetlands		
Freshwater Emergent Wetland	5,391	1.33%
Freshwater Forested/Shrub Wetland	2,196	0.54%
Subtotal	**7,587**	**1.87%**
Deep Water		
Freshwater Pond	364	0.09%
Lake	1,049	0.26%
Riverine	5,077	1.25%
Subtotal	**6,491**	**1.60%**
Total Wetlands and Deepwater Habitat	**14,078**	**3.47%**

Riparian/wetland vegetation plays an important role in stabilizing streambanks and mitigating erosion and sedimentation impacts. Riparian vegetation communities within the Study Area were identified using the NWGAP dataset. Analysis of the remote sensing data identified six riparian/wetland vegetation communities within the Study Area. The following ecological system descriptions, adapted from Nature Serve Explorer-Terrestrial Ecological Systems, provide a general overview of the dominant riparian/wetland communities identified within the Study Area.

Western Great Plains Open Freshwater Depression Wetland

This Great Plains emergent marsh ecological system is composed of lowland depressions and typically occurs along lake/pond shorelines that have open basins and a reliable water source throughout most of the year. The system includes submergent and emergent marshes and associated wet meadows and wet prairies. The Western Great Plains Open Freshwater Depression Wetland system typically has a large watershed and/or significant connection to the groundwater table. A variety of plant species are part of this system, including *Typha, Carex, Eleocharis, Juncus, Spartina, and Schoenoplectus.*

Western Great Plains Closed Depression Wetland

This system is characterized by circular upland depressional basins with an impermeable layer such as dense clay (i.e., clay pan). Soils are hydric and fine-grained, which slows infiltration and promotes retention of water. Hydrologic support for these systems is usually provide by precipitation and runoff from a small catchment. They are rarely linked to outside groundwater sources and do not have an extensive watershed. Species diversity can vary considerably among individual sites. Adjacent land use such as agriculture influences these systems and may introduce nutrient and/or herbicide runoff. Dynamic processes that affect these depressions are hydrological changes, grazing, and conversion to agricultural use.

Western Great Plains Saline Depression Wetland

This ecological system is very similar to the two previously described systems, Western Great Plains Open Freshwater Depression Wetland and Western Great Plains Closed Depression Wetland, but the soils and water are mildly to strongly saline. The saline soils can cause both shallow lakes/ponds and depressions to be brackish. This salt leaches from the soils and rarely comes from saline groundwater. Salt encrustations can occur on the surface in some examples of this system. Species found in this system are salt-tolerant and halophytic species such as *Halogeton* spp.

Western Great Plains Riparian Woodland and Shrubland

This ecological system is commonly found along medium to small rivers and streams located in the Western Great Plains. It is most commonly found on alluvial soils in highly variable landscape settings, from deep cut ravines to wide, braided streambeds (NatureServe Explorer. 2014). This system is hydrologically supported by undeveloped floodplains that may go dry during a portion of the year. Riparian woodlands, shrublands, tallgrasses and mixed grass wet meadows dominate the vegetation in this system. The representative plant community can be diverse and may not always contain trees or shrubs.

3.4 Anthropogenic Systems

This section of the report describes those systems affected by or resulting from human activity. The specific anthropogenic systems described are associated with agricultural water use, domestic water use, water storage, and land management. Each category has been evaluated as it relates to the impact of human activity on the relative physical and biological systems within the Study Area.

3.4.1 Agricultural Water Use

Agriculture in the Bighorn Basin blossomed with the completion of the Buffalo Bill Dam and the associated Shoshone Projects. Four irrigation divisions include the Frannie Division operated by the Deaver Irrigation District, the Garland Division by the Shoshone Irrigation District, the Heart Mountain Division operated by the Heart Mountain Irrigation District, and the Willwood Division by the Willwood Irrigation District. Of these Districts the Deaver and Willwood extend into the Study Area. Each of these districts hold storage rights in the Buffalo Bill Reservoir. The other canals located in the Study Area do not hold storage rights but rather rely on return flows to supply their irrigation demands. Table 3.4.1-1 outlines the diversions identified in the WWDC 2019 Wyoming Irrigation Systems survey.

Table 3.4.1-1. Irrigation Systems on Lower Shoshone River.

Entity	Surface Source	Diversion Capacity (cfs)	Number of Users	Storage (ac. Ft.)
Deaver Irrigation District	Shoshone River	312	205	456,593 Buffalo Bill Res.
Elk Water Users	Shoshone River	300	13	N/A
Hunt Canal Irrigation District	Shoshone River	150	50	N/A
Globe Canal	Shoshone River	40 - 80	55	N/A
Lovell Irrigation District	Shoshone River	350-400		N/A
Sidon Irrigation District	Shoshone River and Bitter Creek	400	200	N/A
Farmers Protective Association	Shoshone River	92	6	N/A

Approximately 75,000 acres (including roads and riparian areas) are in the lower elevations. After deducting roads and river bottoms the irrigated area is about 54,000 acres.

According to the USBR, principal crops grown are beans, alfalfa, pasture, oats, corn, barley, and sugar beets. Other crops include millet, safflower, sorghum, and sunflower.

The primary method of irrigation delivery is open channel with gated pipe used for on-farm distribution. Interest in sprinkler irrigation such as center pivots is growing and recognized as a way to improve efficiency and reduce accumulation of salts. A small proportion of the irrigation systems in operation in the Study Area include pivots. Maintenance of drains and preservation of surface drainage on low gradient ground is a challenge that could be addressed to some degree by piped sprinkler systems.

3.4.1a Irrigated Lands

There are two statewide datasets representing irrigated lands in the state of Wyoming. The first was developed in 2007 for the Wyoming Water Development Commission Framework Water Plan (Greenwood Mapping 2007). The second irrigated lands dataset was developed by WWDC utilizing an automated delineation system based on the Normalized Difference Vegetation Index (NDVI) from Landsat satellite imagery. The NDVI is a remote sensing indicator to identify green vegetation. The irrigated lands dataset can be updated periodically using a Google Earth Engine script. Forested areas, developed areas, snow/ice and open water were removed from the irrigated lands layer; however, the wetland land cover type was not removed which may result in an over-estimation of irrigated lands (Wenck 2019). The most recent version of the WWDC irrigated lands dataset is shown on Map 24. The total area of irrigated lands in the Study Area based on this dataset is 53,597 acres.

Irrigated lands information is also reported to WWDC and stored in a database. A survey is conducted approximately every two years for irrigation districts to provide information to update the database.

Table 3.4.1-2. WWDC 2019 Wyoming Water Irrigation Systems Report #3 Usage and Storage (modified from WWDC 2005; WWDC 2015; WWDC 2017; WWDC 2019).

Year	Entity	Total Acres	Irrigated Acres	Number of Individual Operations/Water Users	Name or Reservoir with Account	Amount of Storage (af)
2019	Deaver Irrigation District	53,00	15,545	205	Buffalo Bill Reservoir 4	456,593
2015	Elk Water User's Association	--	4,250	13	--	--
2017	Farmers Protective Agency	Maybe 5,000	3,000	6	Buffalo Bill Reservoir	0
2019	Hunt Canal Irrigation District	8,398	4,030	50	--	--
2005	Lovell Irrigation District	--	--	--	--	--
2017	Shoshone Irrigation District	36,009	35,500	1,230	Buffalo Bill Reservoir	330,710
2019	Sidon Irrigation District	13,600	13,303	Approx. 200	No Storage	0
2017	Willwood Irrigation District	11,464	11,464	184	Buffalo Bill Reservoir	33,710

--Not reported

3.4.1b Irrigation Systems

Irrigation systems in the Study Area are managed by several irrigation districts including the Shoshone Irrigation District, Deaver Irrigation District, Sidon Irrigation District, Lovell Irrigation District (formerly part of Elk-Lovell Irrigation District), Elk Water User's Association (formerly part of Elk-Lovell Irrigation District), and Willwood Irrigation District (Whistle Creek irrigation system only).

Irrigation system infrastructure is also described in detail in the following WWDC studies:

- Deaver Irrigation District Master Plan Update Level I Study (Sage 2016)
- Deaver Irrigation Rehabilitation Project Level II Study (Engineering Associates 2002)
- Globe Canal Investigations Level II Study (James Gores and Associates 1990)
- Lovell Irrigation District Master Plan Level I Study (Sage 2017)
- Shoshone Irrigation District Rehabilitation and GIS Level II Study (Sage 2008)
- Sidon Canal Rehabilitation Level II Project (Inberg-Miller Engineers 1994)
- Willwood Irrigation District Master Plan Update Level I Study (Sage 2015)
- Willwood Irrigation District Rehabilitation and GIS Level II Study (Engineering Associates 2009)

Irrigation efficiency, or the ratio between the water utilized for agriculture to the amount supplied through the irrigation system, is a primary concern in the Study Area. Irrigation efficiency has been evaluated in each of the irrigation districts master plan reports. In any irrigation system some amount of water is being lost within the distribution system. In the Study Area, crop consumptive use requirements are substantially lower than the mean flows supplied by the system. Estimates indicate that the Deaver Irrigation District consumptive use is approximately half (48% to 57 %) of the supplied flows (Sage 2016). For the Elk Lovell system, estimated consumptive use is approximately one-third (32%) of the supplied flows (Sage 2017).

Identified major losses associated with surface water distribution systems include:

- Over-watering
- Soil and water surface evaporation
- Runoff
- Seepage

Improvements to the delivery system such as converting open laterals to pipelines, ditch lining, ditch realignment, or other improvements can address evaporation and seepage losses. System management improvements that reduce over-watering and runoff can result in increased irrigation efficiency.

Flood irrigation, or conventional furrow method, is common within the Study Area. The irrigation efficiency of the furrow method varies by distribution system, but typically has one of the lowest irrigation application efficiencies. Considerable irrigation efficiencies could be gained from converting open ditch to gated pipe and flood irrigation to sprinkler systems (Sage 2017).

The primary data source for irrigation systems spatial data was the statewide datasets developed by WWDC. These spatial datasets include groundwater, reservoir, and surface water Points of

Diversion (POD), Places of Use (POU), conveyance systems (i.e., canals, pipelines, ditches, pipes, and open laterals), and reservoirs, as shown on Map 25. The primary irrigation water delivery systems in the Study Area include, Bench Lateral, Deaver Canal, Elk-Lovell Canal, Frannie Canal, Globe Canal, Lewis Supply Ditch (No. 1 and 2), Lovell Canal, Moncur Lateral, Sand Draw, and Teeples Ditch. A complete description including operation details for the Deaver, Elk-Lovell, Frannie, Globe, Sidon, and Willwood irrigation diversions is contained in the Water Plan Irrigation Diversion Operation and Description Memoranda (BRS Engineering 2003). Conveyance descriptions for select Study Area irrigation diversions are contained in Table 3.4.1-3. The most recent results for irrigation system diversions and conveyance from the WWDC irrigation district surveys are shown in Table 3.4.1-4.

Table 3.4.1-3. WWDC 2019 Wyoming Water Irrigation Systems Report #2 Diversions/Conveyance (modified from WWDC 2005; WWDC 2015; WWDC 2017; WWDC 2019).

Year	Entity	Surface Source	Type of Diversion	Capacity of Diversion (cfs)	Type of Conveyance	Capacity of Conveyance(cfs)	Miles	Conveyance Losses
2019	Deaver Irrigation District	Shoshone River	Gravity Headgate	312	Canal	800	175	20%
2015	Elk Water User's Association	Shoshone River	Dam	--	Ditch	500	12	20%
2017	Farmers Protective Agency	Shoshone River	Headgate	92	Piped, lined, dirt	100	10	20%
2019	Hunt Canal Irrigation District	Shoshone River	Headgate	150	Ditch	150	13	None
2005	Lovell Irrigation District	Shoshone River	Dam	350-400	Ditch	350-400	45	--
2017	Shoshone Irrigation District	Shoshone River	Dam and Headgate	900	Ditch	900	260	15%
2019	Sidon Irrigation District	Shoshone River & Bitter Creek	Headgate	400	Canal	500	39	25%
2017	Willwood Irrigation District	Shoshone River via Buffalo Bill Reservoir	Diversion dam	400	Canal and laterals	400	82	20%

--Not reported

Table 3.4.1-4. Conveyance description for Study Area irrigation diversions (modified from BRS Engineering 2003).

Diversion Name	Priority Date	Permit Number	Permit Use[1]	Acres	Flow (cfs)	Cumulative Flow (cfs)
Deaver Canal	5/22/1899	2111	Dom.,Irr.,Stk.	14,597	208.5	208.5
Deaver Canal	1/08/1910	10138	Dom.,Irr.,Stk.	5,535	79.1	287.6
Elk Ditch	9/01/1887	Terr.	Irr.	485	6.9	6.9
Frannie Canal	5/22/1899	2111	Dom.,Irr.,Stk.	14,597	208.5	208.5
Frannie Canal	1/08/1910	10138	Dom.,Irr.,Stk.	5,535	79.1	287.6
Globe Canal	6/19/1894	746	Irr.,Dom.,Mun.	233	3.4	3.4
Globe Canal	6/03/1896	210E	Irr.	358	5.1	8.5
Globe Canal	5/31/1899	422E	Irr.,Dom.,Mun.	1,833	26.5	35.1
Globe Canal	1/25/1909	2056E	Irr.	30	0.4	35.5
Globe Canal	1/22/1988	6883E	Irr.	67	1.0	36.5
Globe Canal	1/22/1988	6884E	Irr.	3.9	0.1	36.5
Globe Canal	1/22/1988	6885E	Irr.	16	0.2	36.8
Sidon Canal	4/24/1900	2568	Irr.,Dom.	11,551	164.2	164.2
Sidon Canal	11/30/1906	7559	Irr.	129	1.8	166.1
Sidon Canal	11/30/1906	7560	Irr.	16	0.2	166.3
Sidon Canal	1/25/1915	3113E	Irr.	5	0.1	166.4
Sidon Canal	5/9/1916	3601E	Irr.,Dom.,Stk.	431	6.2	172.5
Willwood Canal	5/22/1899	2111	Dom.,Irr.,Stk.	5,204	74.4	74.4
Willwood Canal	4/12/1904	1191E	Dom.,Irr.,Stk.	6,123	87.5	161.8
Willwood Canal	10/15/1975	6579E	Irr.	43	0.6	162.4

[1]Permit use Dom = Domestic, Irr = Irrigation, Stk = Stock

3.4.1c Agricultural Crops

Hay, grassland/pasture, and alfalfa are the primary crops in the Study Area. Additional crops include barley, corn, dry beans, oats, spring wheat, winter wheat, sorghum, and sunflower. The National Agricultural Statistics (NASS) program 2019 crop area estimates are presented in Table 3.4.1-5. The statistical data were obtained from SuiteWater GIS by HUC. A variety of HUC 10 watersheds and HUC 12 subwatersheds were used in the analysis to represent the Study Area. Study area total crop acreage was calculated in GIS utilizing the 2019 NASS dataset, shown in Map 26.

Table 3.4.1-5. 2019 National Agricultural Statistics Service (NASS) crop area in acres by Hydrologic Unit Code (HUC) boundary.

HUC #	HUC Name	2019 National Agricultural Statistics (NASS) Crop Area (acres)														
		Alfalfa	Barley	Corn	Dry Beans	Fallow/Idle Cropland	Grassland/Pasture	Oats	Hay/Non Alfalfa	Sod/Grass Seed	Sorghum	Spring Wheat	Sugarbeets	Sunflower	Triticale	Winter Wheat
1008001405 (HUC 10)	Dry Creek-Shoshone River	8,634	1,505	939	197	36	11,091	63	525	81	317	8	693	66	12	32
1008001403 (HUC 10)	Coon Creek-Shoshone River	5,569	2,632	1,129	399	8	5,592	20	998	17	46	2	758	238	5	418
100800140406 (HUC 12)	Polecat Creek	2,592	379	91	41	12	459	27	723	23	1	1	156	1	--	22
100800140407 (HUC 12)	Town of Frannie-Sage Creek	4,161	867	300	110	13	523	38	1,142	17	--	1	201	33	--	5
100800140408 (HUC 12)	Big Wash-Sage Creek	3,687	776	280	73	19	1,674	23	341	13	28	41	514	18	8	3
100800100405 (HUC 12)	Sykes Springs-Crooked Creek	51	26	1	--	2	1,607	4	13	1	1	--	1	--	--	3
100800100403 (HUC 12)	Gypsum Creek-Crooked Creek	338	16	5	7	4	618	1	67	1	--	--	4	--	1	--
100800100404 (HUC 12)	Big Coulee	2	1	--	--	--	1,787	1	5	--	--	--	--	--	--	--
Study Area (calculated in GIS)		**25,486**	**4,458**	**3,662**	**1,775**	**504**	**23,078**	**761**	**4,905**	**116**	**406**	**60**	**2,406**	**353**	**33**	**46**

Source: SuiteWater GIS Application. HUC 12 areas were selected that were most representative, although not coincident with the Study Area boundary. Study Area totals calculated from 2019 NASS GIS dataset.

3.4.2 Domestic Water Use

The Lower Shoshone Watershed includes the cities of: Lovell, Byron, Cowley, Deaver, and Frannie. Potable water is supplied through the Shoshone Municipal Pipeline to each community with the exception of Cowley. The Shoshone Municipal Pipeline (SMP) was created by the local communities to supply water as it was becoming an increasing concern in the 1980's. The current pipeline system has been in use since 1991. Cowley is the only community in the area that has a non SMP system. Cowley has a 2,300 foot deep artesian well drawing from the Madison Limestone formation.

The Shoshone Municipal Pipeline (SMP) provides treated water to the city owned water systems of Lovell, Byron, Deaver, and Frannie. For residences outside of municipal limits, SMP services them individually on the Northwest Rural Water District. The Town of Cowley does not receive services from SMP. Cowley has a municipal system that is fed by an artesian well.

Table 3.4.2-1 summarizes the community water sources, usage, and populations.

Table 3.4.2-1. Domestic Water Use.

Community	Water Source	Annual Water Usage	Population
Cowley	Artesian Well	69.4 Million Gallons	623
Byron	SMP	17.5 Million Gallons	519
Lovell	SMP	94 Million Gallons	2,237
Deaver	SMP	6.3 Million Gallons	140
Frannie	SMP	13.3 Million Gallons	149
Northwest Rural Water District	SMP	229 Million Gallons	7,000
Total		429.4 Million Gallons	11,005

The Town of Frannie does have a secondary raw water irrigation water system created by re-purposing the old domestic water system. The secondary irrigation system is of limited value due to the condition of the system and the lack of adequate volumes of source water (Kirk #1 Well). The town conducted the Frannie Raw Water Level II study in 2008 and identified several potential sources of water, however none of those sources has been secured to date.

The Town of Byron also has an irrigation system in the form of open ditches that carry water from the Sidon Canal throughout the town. Pumps placed in the ditches are the typical method for users to access the water.

3.4.3 Water Storage

The communities have local water storage in both ground mounted tanks and water towers as shown below. The tanks maintain pressure and buffer flow fluctuations in the supply pipeline.

Table 3.4.3-1. Water Storage.

Community	Water Storage	Source	System
Cowley	500,000 Gallons	Artesian Well	Water Tower
Byron	400,000 Gallons	SMP	Water Tower
Lovell	1,400,000 Gallons	SMP	1,000,000 Gallon Tank and 400,000 Gallon Tower
Deaver	350,000 Gallons	SMP	Water Tower
Frannie	250,000 Gallons	SMP	Water Tower
Shoshone Municipal Pipeline	5,000,000 Gallons	SMP	5,000,000 Gallon Tank
Total	7,830,000 Gallons		

Photo 12. Typical Water Storage for Lovell, Byron, Frannie

3.4.3a Reservoirs

The Buffalo Bill Reservoir is located southwest (upstream) of the Study Area, about 6 miles from Cody, Wyoming. The local communities receive irrigation, potable water, and hydroelectric power from the reservoir. The reservoir contains 646,565 acre-feet of water. Presently, there is additional water in the State account for domestic or irrigation use. The relatively long-term existence of the Buffalo Bill reservoir has fulfilled water demands and likely suppressed the pursuit of further large reservoirs within the watershed. No recent (within the last 100 years) reservoir sites have had

published studies prepared based on an electronic document search and discussions with the local Assistant Superintendent.

The Shoshone Municipal Pipeline uses treated water from the Buffalo Bill Reservoir to supply communities on its system including most incorporated communities in the Study Area.

The Deaver, Shoshone, Heart Mountain, and Willwood Districts also access Buffalo Bill water. Other districts located in the Study Area indirectly benefit from the Buffalo Bill Reservoir by relying on return flow from the upper districts to supply their needs. Should additional water be required by users, application to the State may be made to access water held in the State account.

Other sizeable water bodies exist within the Study Area including the Lovell Lakes, Deaver Reservoir, and ponds or lakes associated with mineral extraction. The surface acres of the largest lake associated with Merritt Energy near Byron is about 330 acres followed by the Lovell Lakes at 320 combined acres and Deaver reservoir at 70 acres. Each of the lakes are relatively shallow (<10 feet) and enjoyed by those living in the region but not recognized recreation destinations outside of the region. Other small on-farm ponds exist throughout the watershed.

Numerous small stock reservoirs exist throughout the watershed and are discussed further in Section 4.

3.4.3b Upland Wildlife and Livestock Water Sources

The Study Area supports all or portions of forty-seven grazing allotments on BLM administered land (Map 36). These allotments are generally upland areas away from the Lower Shoshone River bottoms and serve as summer and early fall range for the adjacent ranches. The allotment sizes range from a portion of the Peaks 1064 allotment up to the 39,878-acre Sand Draw allotment. The BLM allotments represent about 35% of the entire watershed. Extensive work has been done within the watershed to provide upland water sources for livestock and wildlife. The locations of developed water features that are functional (Map 28) and nonfunctional (Map 29) were identified. The most common method is small earthen dams constructed in the upper reaches of the drainages where the water volume can be managed by smaller outlet pipes and embankments. Map 9 shows wells permitted by the State Engineer. Some of these wells are used for upland watering. Many are for irrigation and domestic use. At least 56 wells are on BLM allotments. Map 28 depicts source viability based on an aerial review. Of note are the gaps in coverage such as lower Coon Creek. Map 29 shows identified non-functional water sources. Comparing Map 29 with Map 28 reveals that several of the non-functional water sources fall within gaps between existing water sources.

Many of the allotments have small water improvements constructed by resource agencies or the permit holder. The facilities are generally described as being within one or more of the following categories:

- Wells
- Springs
- Earthen Catchments (Reservoirs)
- Troughs

In addition, there are some natural features such as ponds and pits that also serve to water livestock.

3.4.4 Land

This section describes the land in the Study Area in terms of land ownership, use, management, and cultural resources. The land assessment utilized existing information from the Natural Resource and Energy Explorer (NREX), NRCS Ecological Site Descriptions (ESD), and a number of GIS data sources.

NRCS ESD classifications provide a consistent structure for describing rangeland and forestland soils and vegetation to determine how lands will respond to management activities or disturbance. ESD information for the Study Area includes site characteristics, plant communities, site interpretations, and supporting information for each ESD classification type. The distribution of Study Area ESD are shown on Map 30.

The most common ESD, comprising 15.9 percent of the Study Area is the Saline Upland (SU) 5-9" Big Horn Basin Precipitation Zone. A completed description of this ESD is included in the NRCS Ecological site description (NRCS 2021a). Table 3.4.4-1 contains a summary of representative physiographic features for this ESD.

Table 3.4.4-1. Physiographic features of the Saline Upland (SU) 5-9" Big Horn Basin Precipitation Zone (modified from NRCS 2021a).

Physiographic Features	
Landforms	(1) Hill (2) Alluvial Fan (3) Stream Terrace
Flooding Duration	Extremely brief (0.1 to 4 hours) to brief (2 to 7 days)
Flooding Frequency	Very rare to rare
Ponding Frequency	None
Elevation	3,700 – 6,000 ft
Slope	0 – 15%
Pond Depth	0 inches
Aspect	Aspect is not a significant factor

The second most common ESD, comprising 13.2 percent of the Study Area, is the Sandy (Sy) 5-9" Big Horn Basin Precipitation Zone. A completed description of this ESD is included in the NRCS Ecological site description (NRCS 2021b). Table 3.4.4-2 contains a summary of representative physiographic features for this ESD.

Table 3.4.4-2. Physiographic features of the Sandy (Sy) 5-9" Big Horn Basin Precipitation Zone (modified from NRCS 2021b).

Physiographic Features	
Landforms	(1) Alluvial Fan (2) Hill (3) Plateau
Flooding Duration	Brief (2 to 7 days)
Flooding Frequency	None to rare
Ponding Duration	Very brief (4 to 48 hours)
Ponding Frequency	None to rare
Elevation	3,700 – 6,000 ft
Slope	0 – 20%
Pond Depth	0 inches
Aspect	Aspect is not a significant factor

The Shale (Sh) 5-9" Big Horn Basin Precipitation Zone comprises 5.6 percent of the Study Area. A completed description of this ESD is included in the NRCS Ecological site description (NRCS 2021b). Table 3.4.4-3 contains a summary of representative physiographic features for this ESD.

Table 3.4.4-3. Physiographic features of the Shale (Sh) 5-9" Big Horn Basin Precipitation Zone (modified from NRCS 2021c).

Physiographic Features	
Landforms	(1) Hill (2) Ridge (3) Escarpment
Flooding Frequency	None
Ponding Frequency	None
Elevation	3,700 – 6,000 ft
Slope	0 – 60%
Pond Depth	0 inches
Aspect	Aspect is not a significant factor

The Saline Lowland (SL) 5-9" Big Horn Basin Precipitation Zone comprises 5.2 percent of the Study Area. A completed description of this ESD is included in the NRCS Ecological site description (NRCS 2021b). Table 3.4.4-4 contains a summary of representative physiographic features for this ESD. The remaining ESD shown on Map 30 comprise less than 5 percent of the Study Area each.

Table 3.4.4-4. Physiographic features of the Saline Lowland (SL) 5-9" Big Horn Basin Precipitation Zone (modified from NRCS 2021d).

Physiographic Features	
Landforms	(1) Alluvial Fan (2) Drainageway (3) Stream Terrace
Flooding Duration	Brief (2 to 7 days)
Flooding Frequency	None to occasional
Ponding Duration	Brief (2 to 7 days)
Ponding Frequency	None to rare
Elevation	3,700 – 6,000 ft
Slope	0 – 10%
Pond Depth	0 inches
Water Table Depth	30 – 60 inches
Aspect	Aspect is not a significant factor

3.4.4a Land Ownership

There is a mixture of public (70.2%) and privately owned land (29.8%) in the Study Area. Public lands are owned by the Bureau of Land Management (BLM), the U.S. Bureau of Reclamation (BOR), U.S. Department of Defense (DOD), State, and local governments. State lands include lands administered by the WGFD. Lands administered by the BLM account for over half of the Study Area (54.1%). The remaining lands administered by the federal government account for a total of 10.6 percent of the Study Area. Table 3.4.4-5 contain land ownership percentages by HUC and for the Study Area. The distribution of Study Area land ownership is shown on Map 31.

Table 3.4.4-5. Land ownership as percent of total area by Hydrologic Unit Code (HUC) boundary.

HUC #	HUC Name	Land Ownership (percent of total)[1]							
		BLM	BOR	DOD	GOV	NPS	PVT	ST	WGFD
1008001405 (HUC 10)	Dry Creek-Shoshone River	52.8%	5.2%	3.2%	1.5%	1.3%	28.2%	4.0%	2.7%
1008001403 (HUC 10)	Coon Creek-Shoshone River	72.9%	6.9%	--	0.1%	--	15.5%	4.2%	--
100800140406 (HUC 12)	Polecat Creek (HUC 12)	22.7%	12.7%	--	0.2%	--	59.9%	4.5%	--
100800140407 (HUC 12)	Town of Frannie-Sage Creek	2.8%	13.6%	--	0.3%	--	80.9%	2.2%	--
100800140408 (HUC 12)	Big Wash-Sage Creek	10.8%	29.6%	--	1.0%	--	56.3%	2.3%	--
100800100405 (HUC 12)	Sykes Springs-Crooked Creek	37.1%	--	--	--	43.7%	13.4%	4.8%	0.1%
100800100403 (HUC 12)	Gypsum Creek-Crooked Creek	60.3%	--	--	--	--	39.5%	--	--
100800100404 (HUC 12)	Big Coulee	90.2%	--	--	--	7.1%	2.6%	--	--
	Study Area (calculated in GIS)	54.1%	8.6%	0.8%	0.5%	1.2%	29.8%	4.5%	0.7%

Source for land ownership by HUC: SuiteWater GIS Application. Study Area land ownership percentages calculated in GIS using Big Horn and Park County ownership data.

[1]Land ownership types: Bureau of Land Management (BLM); Bureau of Reclamation (BOR); Department of Defense (DOD; Local Government (GOV); National Park Service (NPS); Private Land (PVT); State of Wyoming (ST); and Wyoming Game and Fish Department (WGFD).

3.4.4b Land Use and Management

The primary types of land use and land management were evaluated throughout the Study Area. Specific land uses including communication and transportation, mining, oil and gas, agriculture, and grazing were evaluated in more detail. Land use was evaluated by level of development and land use type with a focus on relative water use.

Transportation and Communication

The communications and transportation infrastructure of the Study Area is shown on Map 32. The area is serviced by several major highways including US 301 (WY 789), US 14 Alt, WY 32, WY 33, WY 35, WY 37, WY 114, and WY 295. A network of municipal, county, private, and federal roads extend throughout the Study Area. The Burlington Northern Santa Fe Railway bisects the Study Area running through Frannie, Deaver, Lovell and along the Lower Shoshone River to Bighorn Lake. The Northern Big Horn County Airport, located near Cowley, is the only airport in the Study Area. The airport runway is of sufficient length to accommodate general aviation, corporate aircraft, or large cargo aircraft.

The communications infrastructure of the Study Area includes a network of structures, shown in Map 32, that includes radio and microwave towers, antennas, and cellular structures. The cellular structures identified on Map 32 were obtained from USGS ScienceBase Catalog, and are assumed to be under-represented due to the rapidly expanding cellular networks

Oil and Gas, Coal, and Mining Industries

Industrial water use is described and quantified in the Wind-Bighorn Basin Plan (BRS 2003) and expanded on in the Industrial and Mining Water Use Technical Memorandum (MWH 2010). A majority of the industrial water use is from mining and oil operations. Water use for mining facilities is typically derived from groundwater aquifers, with water being reused for non-potable purposes such as dust control. Industrial groundwater use is from permitted wells that account for 20% to 22% of the total groundwater withdrawals in the Wind-Bighorn Basin. Industrial surface water obtained via surface water rights account for 20% of the total freshwater withdrawals in the Basin (MWH 2010).

Wastewater from industrial facilities is regulated for pollutants by the Wyoming Pollutant Discharge Elimination System (WYPDES) Program. Industrial facilities with a point source discharge are required to receive coverage under a WYPDES discharge permit. The permits are intended to assure that state water quality standards are protected. The distribution of WYPDES discharge permits within the Study Area is shown on Map 33.

Oil and gas production is a major industry in Wyoming and an important economic driver. Big Horn County and Park County produced 1.3% and 5.1% of oil in the state, respectively, and 0.1% and 0.4% of gas respectively in 2020 (WOGCC 2020). There are a total of 16 mapped oil and gas fields with 520 active wells and 716 inactive wells in the Study Area (Table 3.4.4-6), shown on Map 34. There are seven (7) major oil and gas pipelines in the Study Area, extend for over 200 miles, as shown on Map 34.

The largest oil and gas operation is in the Garland Oil Field which is 12,162 acres in size with 343 active wells. In 2016 Marathon Oil Corporation sold all of its Wyoming operations, including Garland Oil Field, to Merit Energy Company. The Garland Field – Garland Battery #1 WYPDES (WY-0001759) has 5 discharge points into Arnoldus Lake, through a conveyance system, and into the Shoshone River. Discharge samples from 2019 indicate the only pollutant exceeding water quality standards was Sulfide-Hydrogen Sulfide with a standard of 2 mg/L and a measured value of 34 mg/L (Merit Energy Company 2020). Total sulfide is being monitored per WYDEQ Water Quality Division requirements and outfall relocation plans are proposed to reduce the total hydrogen sulfide levels.

Mining is also a major industry in Wyoming and an important economic driver. The mapped coal fields, coal, Bentonite, and sand and gravel mines within the Study Area are shown on Map 35. There are currently no active coal mines in the Study Area. The 5 inactive coal mines were located in the Garland Coal field. There are currently 7 active and 4 inactive sand and gravel mining operations within the Study Area.

Since 2012, Wyoming has led the nation in Bentonite production. In 2012, Wyoming produced well over 90% of the Bentonite mined in the United States and 48% of the world production (Sutherland 2014). Bentonite is commonly used in oil and gas development but also currently has many other industrial and manufacturing uses including as a sealer for ditches, slopes, and reservoirs. Bentonite is used in cat litter, pharmaceuticals and medical products, petroleum and cement products, ceramics, refractory materials, paper, cosmetics, water softeners, sealing agents, paints, and roofing materials (Sutherland 2014). The 4 Bentonite mines and 3 mills in the Study Area are within what is referred to as the Eastern Bighorn Basin District. The American Colloid Company Lovell Bentonite Mill is shown in Photo 13.

Table 3.4.4-6. Mapped oil and gas fields with active and inactive wells in the Study Area (source: Wyoming Oil and Gas Conservation Commission & Wyoming State Geological Survey).

Field Name	Area (ac)	Active Wells	Inactive Wells
Coon Creek	503	4	2
Cowley	586	4	6
Deaver	344	0	4
Deaver North	1,210	7	15
Foster Gulch	220	0	1
Frannie	3,438	89	101
Garland	12,162	343	271
Goose Egg	193	0	1
Homestead	1,236	8	14
Little Polecat	704	3	0
North Danker	667	6	6
Sage Creek	3,060	27	40
Sage Creek West	1,501	7	27

Field Name	Area (ac)	Active Wells	Inactive Wells
Siddon	411	0	4
Whistle Creek	710	9	5
Whistle Creek South	474	0	5
Unmapped	--	13	214
Total	**27,419**	**520**	**716**

Photo 13. Photograph of American Colloid Company Lovell Bentonite Mill.

Table 3.4.4-7. Mapped Bentonite, coal, and sand and gravel mine operations in the Study Area (source: Wyoming State Geological Survey).

Mine Name	Industrial Mineral	Mine Type	Status
ACC Lovell bentonite mill	Bentonite	Surface mill	Active
Unnamed large bentonite mine	Bentonite	Surface mine, pit	Active
Unnamed large bentonite mine	Bentonite	Surface mine, pit	Active
Unnamed bentonite mine	Bentonite	Surface mine, pit	Active
Unnamed large bentonite mine	Bentonite	Surface mine, pit	Active
Wyo-Ben, Inc. - Sage Creek Mill	Bentonite	Surface mill	Active
BPM Lovell Mill	Bentonite	Surface mill	Active
Leonhardt gravel pit	Sand and gravel	Surface mine, pit	Active
Hopkins sand and gravel pit	Sand and gravel	Surface mine, pit	Active
Lulu gravel pit	Sand and gravel	Surface mine, pit	Inactive
Landfill sand and gravel pit	Sand and gravel	Surface mine, pit	Inactive
Nicholls & Lewis S&G pit	Sand and gravel	Surface mine, pit	Inactive
sand and gravel pit	Sand and gravel	Surface mine, pit	Active
sand and gravel pit	Sand and gravel	Surface mine, pit	Active
Mountain Construction gravel pit	Sand and gravel	Surface mine, pit	Active
Unnamed gravel pit	Sand and gravel	Surface mine, pit	Active
Reclaimed gravel pit	Sand and gravel	Surface mine, pit	Active
Polecat sand & gravel pit	Sand and gravel	Surface mine, pit	Inactive
Duncan	Coal	Underground mine, shaft	Inactive
Honeysett	Coal	Underground mine, Adit	Inactive
Hopkins (Park)	Coal	Underground mine, shaft	Inactive
Mike Rachelski	Coal	Underground mine, shaft	Inactive
Sarver	Coal	Underground mine, shaft	Inactive

Grazing Management and Range Conditions

Livestock grazing occurs on federal, state, and private land within the Study Area, and associated land and livestock management practices vary widely. The majority of grazing within the Study Area occurs on State and federal (BLM) grazing allotments, as shown on Map 36. The BLM grazing allotments comprise 62% of the Study Area while the State Lands grazing allotments comprise 3.6%. As is typical in sagebrush grasslands of the arid west, livestock and wildlife use is generally concentrated around waterways and riparian areas. Unless measures are taken to disperse livestock and wildlife from riparian areas, range health in these areas often suffers. Riparian vegetation is often overgrazed and/or grazed late in the season when perennial plants need to store and transfer carbohydrate reserves to root systems to prepare for the dormant season. Overgrazing often results in reduced vigor, productivity and poor health within these plant communities. Animal concentration in these areas can contribute to soil compaction, which further inhibits plant productivity. Additionally, many upland areas are underutilized due to their relative isolation from watering sites.

There are a total of 44 BLM grazing allotments in the Study Area, and grazers include cattle, sheep, horses, and goats. The management and administration of these leases occurs in field and district offices with support from the BLM Wyoming State Office.

The names and ID numbers for BLM grazing allotments greater than 500 acres are shown in Table 3.4.4-8. Since the passage of the Federal Land Policy and Management Act (FLPMA) in 1976, numerous laws, regulations, and policies have directed the BLM to manage its riparian and wetland areas. The purpose of these standards and guidelines are to achieve the four fundamentals of rangeland health outlined in the grazing regulations which are: 1) watersheds are functioning properly; 2) water, nutrients, and energy are cycling properly; 3) water quality meets State standards; and 4) habitat for special status species is protected.

To address the health, productivity, and sustainability of BLM-administered lands in Wyoming, the BLM established 6 Standards for Healthy Rangelands. The standards are outlined below.

> Standard #1 – Within the potential ecological site (soil type, landform, climate, and geology), soils are stable and allow for water infiltration to provide for optimal plant growth and minimal surface runoff.
>
> Standard #2 – Riparian and wetland vegetation has structural, age, and species diversity characteristic of the stage of channel succession and is resilient and capable of recovering from natural and human disturbance in order to provide forage and cover, capture sediment, dissipate energy, and provide for groundwater recharge.
>
> Standard #3 – Upland vegetation on each ecological site consists of plant communities appropriate to the site which are resilient, diverse, and able to recover from natural and human disturbance.
>
> Standard #4 – Rangelands are capable of sustaining viable populations and a diversity of native plant and animal species appropriate to the habitat. Habitats that support or could support threatened species, endangered species, species of special concern, or sensitive species will be maintained or enhanced.
>
> Standard #5 – Water quality meets State standards
>
> Standard #6 – Air quality meets State standards

In addition to these standards, the BLM has developed guidelines for livestock grazing management on BLM-administered lands. If livestock grazing practices are found to be among the contributing factors to not meeting a standard, then corrective actions consistent with the livestock management guidelines are developed and implemented.

The majority of State Lands in the Study Area are leased for grazing. In total there are 37 leases with a total of 14,771 acres of grazing. These leases are typically issued to private ranchers by the Board of Land Commissioners and administered by the Office of State Lands and Investments. Grazing management, practices, and improvements on state lands are usually established and implemented and paid for by the lessee. Grazing practices on private lands are typically developed by the landowner often with technical assistance from local NRCS staff, conservation districts, other conservation groups.

Table 3.4.4-8. BLM grazing allotments in the Study Area greater than 500 acres.

Allotment Name	Allotment Number	Area (acres)	Percent of Study Area (%)
Sand Draw	1006	37978	9.4
East/West	1060	37479	9.2
Foster Gulch	1039	27074	6.7
Whistle Creek	1002	26588	6.5
North Shoshone 1036	1036	17170	4.2
Sand Hills 1043	1043	16213	4.0
Gypsum Creek	1008	14731	3.6
Gravel Crossing	1005	8277	2.0
Sand Hills 1054	1054	7236	1.8
Firing Range	1038	6978	1.7
Individual 1061	1061	6217	1.5
Polecat-Frannie	1057	5944	1.5
Airport	1004	5398	1.3
South Lovell Group	1052	5120	1.3
Himes-Spence	1037	5103	1.3
Kane	1056	3305	0.8
North Shoshone 1035	1035	2967	0.7
Crooked Creek 2	4134	2635	0.6
Lovell Group 5	1050	2546	0.6
Stateline	1003	2467	0.6
Coon Creek	1007	2079	0.5
Black Draw	1058	1302	0.3
Sidon Canal	1055	1184	0.3
Thumper	1059	933	0.2
Peaks 1069	1069	896	0.2
Little Sheep Mountain	1053	836	0.2
Polecat Bench	1071	778	0.2
Race Track	1040	577	0.1

3.4.4c Cultural Resources

State Historic Preservation Office - SHPO

The Wyoming State Historic Preservation Office (SHPO) maintains a database of inventoried cultural resources and historic sites within Wyoming. In response to a query of cultural resources and historic sites within the Study Area, SHPO provided a spatial data file that provided the general location (to a per section level accuracy) of cultural and historic resources. Map 37 depicts the results of the database query, and each square mile section within the Study Area has been color-coded based on the number of cultural resources occurring within the area determined to be eligible for inclusion on the Register.

National Register of Historical Places - NRHP

The National Register of Historic Places (Register) is the nation's official list of cultural resources worthy of preservation. The Register is administered on a federal level by the National Park Service and managed locally by the SHPO. The Register is part of a program to coordinate and support both public and private efforts to identify, evaluate, and protect historic and archeological resources. The Register recognizes the accomplishments of those who have contributed to the history and heritage of the United States, the state, and local communities. A determination of each site's eligibility for inclusion in the Register is included in the database of inventoried cultural resources and historic sites within Wyoming. The registered historic sites within the Study Area include The Hyart Theater, Bad Pass Trail, and the EJZ Bridge over the Shoshone River, and are depicted in Map 38. A total of 3 sites within the Study Area are included in the Register, and a brief description of each site was provided by the Wyoming State Preservation Office website at: https://wyoshpo.wyo.gov/index.php/programs/national-register/wyoming-listings/view-full-list .

4.0 WATERSHED MANAGEMENT, DEVELOPMENT, AND REHABILITATION PLAN

An objective of the watershed study was to develop a feasible watershed management plan using recommendations of landowners and lessees. The investigative phase of this study focused on an assessment of the key issues in the watershed, and the identification and evaluation of opportunities to address identified watershed issues.

4.1 Key Issues in the Watershed

Key issues in the Lower Shoshone River watershed have been identified collaboratively with the SCD, landowners, land managers, agencies, and stakeholders throughout the development of the watershed study. Among the key issues identified in the Lower Shoshone River watershed are water quality concerns, including *E. Coli* and sediment-related impacts. Substantial sediment sources in the Study Area are derived from naturally erosive soils, upland soil disturbance from land management on both private and BLM-administered lands, Shoshone River bank erosion, tributary erosion as a result of irrigation return flows, road and trail erosion, and post-fire erosion, among others. Property loss due to Shoshone River channel migration through bank erosion was identified as a key issue for landowners.

A well-recognized sediment source for the Lower Shoshone River is related to the ongoing operation and maintenance of the Willwood Dam. Large sediment releases and associated fish kills (and aquatic habitat loss) during a Willwood Dam malfunction in 2007 and maintenance operations in 2016 prompted an inter-agency effort to evaluate potential options for improving operation and maintenance of the dam. Project partners include DEQ, WGFD, WWDO, the U.S. Bureau of Reclamation (USBR), SEO, and other partners. The collaborative group established three working groups operating under the leadership and direction of an executive committee. The three working groups and their specified objectives include: cleanup and flushing flow below Willwood Dam (Working Group 1); development of alternatives for the long-term management of sediment above

Willwood Dam (Working Group 2), and evaluation of water quality standards and addressing sediment sources upstream of Willwood Dam (Working Group 3). The ongoing efforts of the three working groups are documented in a series of reports, online ArcGIS Story Maps, and project summary updates.

A noticeable irrigation practice that accentuates the sediment-related impacts to the Lower Shoshone River is the practice of over allocating water to diversions and canals, and then spilling this excess water into ephemeral draws or streams. Historically these draws were not situated to contain these flows, resulting in degradation and headcutting within these drainages. In many instances, these spill locations have resulted in severe headcuts back to erosive resistant bedrock, creating a waterfall and plunging flows. These spills continue to destabilize channel beds and banks introducing erosive forces to the fine grained soil channel banks and undersized bed sediment, which is then transported downstream to the mainstem river. The magnitude and duration of these practices should be reevaluated to alleviate the erosive conditions and production of sediment to downstream receiving waters.

Public outreach occurred throughout the development of this watershed study. Project announcement mailings were sent to landowners and stakeholders early in the process to encourage community involvement. Public meetings were held to identify concerns and potential project opportunities in the watershed. Landowners, ranchers, agencies, and private citizens were invited to identify potential water development projects that would provide benefit and address key watershed issues. Site visits were performed for potential water development projects and assessment of watershed conditions. The following list summarizes the recurring key issues identified in the agency meetings, public meetings, and site visits.

- Restore aquatic life and habitat damaged due to the release of accumulated sediment from the Willwood Dam reservoir into the Shoshone River
- Reduce and/or eliminate future need to release accumulated sediment from the dam in amounts and of duration that are harmful to aquatic life and the aquatic and riparian habitats downstream of the dam.
- Support the ongoing survey, monitoring, and data analysis efforts of the three Willwood Dam working groups.
- Support land use management improvements on federal and private lands that reduce sediment inputs and improve aquatic and riparian habitat conditions.
- Continue to address water quality impairments through the DEQ Water Quality Department (WQD) administration of the Clean Water Act (CWA) regulations.
- Develop a comprehensive Geographic Information System (GIS) dataset to be accessible by all stakeholders working in the area.
- Identify opportunities for water conservation, reuse, and recycling.
- Planning for future growth to properly manage and allocate water resources.
- Consider non-consumptive and aesthetic water uses and needs in planning.

- Irrigation water management and optimization is needed to improve the conveyance, use, distribution, and application of irrigation water in a more beneficial and efficient process.
- Irrigation districts and drainage districts communication is necessary to operate the irrigation supply and drainage in a more holistic manner.
- Stream stabilization is needed in specific areas to protect irrigation infrastructure and production land.
- There are irrigation improvements needed to minimize sedimentation to streams and irrigation infrastructure, reduce irrigation water supply loss, and enhance water quality.
- Use of canal spills or overflows should be minimized to reduce impacts to historically ephemeral drainages and draws to reduce scour and sedimentation in downstream drainages.
- Identify and pursue water storage opportunities to improve the reliability of existing late season water supplies for livestock watering and grazing improvements.
- Use of pipes and drains to minimize sub water and canal seepage with associated evaporation and salt accumulation.

4.2 Overview of Project Opportunities

Potential projects identified during the study were organized into the six general categories described below. Table 4.2-1 contains a summary of potential projects organized by project type. Map 39 shows the distribution of potential project opportunities throughout the Study Area.

- **Irrigation and Drainage System Improvements and Rehabilitation:** Local stakeholders and property owners have identified improvements for irrigation and drainage systems throughout the watershed production lands. Potential improvements varied from converting dirt ditch or damaged cement ditch to gated pipe, lining of canals, replacement or rehabilitation of diversions and headgates, reuse of irrigation wastewater, new irrigation pipe opportunities, solar pump or well installations, storage settling ponds, convert flood irrigation to higher efficiency sprinklers, remove redundant or parallel infrastructure, and bury or regrade waste water drains to improve soil health or improve drainage efficiency.
- **Water Storage Opportunities:** The primary source of existing water storage for the watershed and irrigation districts is the Buffalo Bill Reservoir located upstream of Cody within the Buffalo Bill State Park. Several relic BLM reservoirs have been identified for reclamation to retain upland water runoff. In addition, several other locations have been identified to develop a local reservoir for livestock water, crop irrigation, and flood mitigation on a local scale.
- **Upland Wildlife/Livestock Water Development Opportunities:** Stakeholders have identified numerous upland grazing areas that have opportunities to impound local intermittent water sources or route lowland water for improved livestock and wildlife watering during wintering grazing periods. Potential upland water development projects

were identified based on an evaluation of existing water sources, upland grazing conditions, and input from landowners.

- **Stream Channel Restoration:** Current and historic irrigation spills and overflows have introduced channel destabilization and headcut migration. Specific projects were identified to eliminate or mitigate these issues and reduce sediment erosion and migration in the watershed. Shoshone River channel migration and bar formation have developed numerous locations with riverbank instability concerns that threaten existing irrigation infrastructure or threaten the loss of production land. Stream channels within the watershed were characterized with respect to their condition and stability. Impaired channels were identified for further evaluation and alternative improvements developed.
- **Wetland Development and Enhancement:** One project was identified to develop an existing wetland into a reliable watering source while excluding cattle from disturbing the soft soils and wetland vegetation. An additional project was identified to continue the enhancement of an existing wetland, increase forage production, and manage invasive vegetation.
- **Hydroelectric Power Generation:** Two potential hydropower projects were identified on the Elk-Lovell canal siphons.
- **Invasive Species Management:** No specific projects were identified, but invasive species management is on-going in the watershed and is an important watershed improvement tool.

Table 4.2-1. Project costs by project type.

Project Type	Total # of Projects
SWPP-Irrigation	32
Pipe Conversion	15
Ditch-Canal	6
Dam-Reservoir	5
SWPP-Channel stabilization	7
Other	5
SWPP-Well	3
SWPP-Environmental	2
SWPP-Spring development	1
Total	**76**

Each category, as discussed above, is influenced by different project types. The Irrigation and Drainage System Improvements and Rehabilitation category includes drainage improvements, ditch conversions, pipeline projects, sprinklers, canal lining, drain piping, and diversion improvements. The Water Storage Opportunities category includes small surface water storage and silt dam projects. The Upland Wildlife/Livestock Water Developments category includes well and spring projects, wetland development, winter water holding ponds, and livestock pipeline projects. The Stream Channel Restoration category includes bank stabilization and channel crossing projects. The Wetland Development and Enhancement category includes a project to improve

wetland crossing mitigation and habitat enhancement. The Hydroelectric Power Generation category included two suggested generation projects on canal siphons but were determined to not be feasible based on-site constraints. In addition, hydroelectric projects are not eligible for WWDC project funding.

Each section below details the project type. Provided details for each project type are for typical construction based on site visits and aerial imagery which may not reflect final site survey and design. The following development options have been assessed for each project type. These topics are included in each of the project reports for local stakeholders to be able to advance their projects. Prioritization ranking criteria defined by Biota and WWDC were used in the ranking and selection of potential projects; these are shown below:

- Required water rights (Low/Med/High)
  - Low – none; SEO permit approved and not required
  - Medium – routine water rights permitting required with SEO
  - High – significant SEO permitting effort
- Feasibility (Low/Med/High)
  - Implementation difficulty
  - Land ownership
  - Overall scale of the project
- SWPP Eligible (Yes/No/Partial)
  - Yes – All project components are SWPP eligible
  - No – No project components are SWPP eligible
  - Partial – Some project components are SWPP eligible
- Cost Benefit (Low/Med/High)
  - Public benefit
  - Water resource benefit
  - Ancillary benefits
  - Number of beneficiaries
  - Relative project cost

The prioritization ranking and details for individual projects are included in the Appendix B. Project stakeholders can use the information developed for their respective projects to investigate funding opportunities and project advancement. The project summaries also designate a public sponsor and project details for each project. Potential projects that were not developed in detail due to feasibility concerns or a lack of information are also identified in the prioritization matrix.

4.2.1 Project Costs and Funding

Table 4.2.1-1 lists the cost and quantity of the projects by project type. There is significant variation in the costs of some project types due in part to the unique characteristics or size of each project and its associated details. Each project type includes new projects and rehabilitation of existing infrastructure. Costs are detailed in the Project Information (Appendix B). Cost estimates were

based on estimated project components and quantities, as shown. The majority of the costs are based on previous project experience.

Table 4.2.1-1. Project costs by project type.

Project Type	# of Analyzed Projects	Estimated Minimum Cost	Estimated Maximum Cost
Dam-Reservoir	4	$82,159	$874,076
Ditch-Canal	5	$113,705	$2,875,848
Pipe Conversion	12	$9,774	$179,403
SWPP-Irrigation	24	$10,525	$255,557
SWPP-Spring Development	1	$59,565	$59,565
SWPP-Well	3	$33,101	$73,649
SWPP-Channel Stabilization	4	$36,308	$332,904
SWPP-Environmental	2	$15,565	$34,000
Other	3	$23,463	$614,892

* - Project item material cost based on estimates at the time of development. Cost may fluctuate depending on material supply and economic conditions at the time of project construction.

Potential funding sources were identified for each of the project types shown in Table 4.2.1-2. Details on each funding source are described in Section 6 below. In many cases, a combination of funding sources may be necessary and beneficial to meet the funding needs of the project. It is not guaranteed that funding will be approved or accessible for any of the particular projects shown.

Table 4.2.1-2. Funding potential by project type.

Project Type	Shoshone Conservation District (SCD)	Wyoming Office of State Lands and Investments (WOSLI)	Wyoming Water Development Commission (WWDC)*	Wyoming Game and Fish Department (WGFD)	Natural Resources Conservation Service (NRCS)	Bureau of Land Management (BLM)	Conservation Reserve Program (CRP)	Non-Profit
Dam-Reservoir			x			x		
Ditch-Canal	x	x	x		x			
Pipe Conversion	x	x	x		x	x		x
SWPP-Irrigation	x	x	x		x			x
SWPP-Spring Development	x		x	x	x	x		x
SWPP-Well	x	x	x			x		
SWPP-Channel Stabilization	x		x	x	x		x	x
SWPP-Environmental	x		x	x			x	x

* - Not all projects will be eligible for funds from the Small Water Projects Program (SWPP), including: pivots, gated pipe, and other appurtenances

4.2.2 Project Benefits

Proposed water development projects will have multiple benefits in most instances. Increased irrigation efficiency can result in less water loss through infiltration and over supply due to flood irrigation. The higher efficiency can result in less water being diverted from the Shoshone River and less irrigation return water induced erosion within the tributaries. These projects could result in the protection of future streamflow and water availability for irrigation, grazing, wildlife, and supply to the Bighorn Lake and Yellowtail Wildlife Management Area, as well as increased groundwater recharge. Projects increasing bank stability should benefit water quality and fisheries health through the reduction of sediment input, improved bank shading for reduced water temperature and improved fisheries cover, and potential reduction of bar development producing additional channel migration and bank erosion downstream. Wetland enhancement could improve habitat and increase overbank water filtration, improving instream water quality. Projects reducing surface evaporation from the soil will reduce deposition of salts and improve land quality. Some projects may have negative effects to rivers and wetlands if implemented, such as reducing irrigation water quantity through the use of sprinklers may reduce the amount of water supporting anthropogenic wetlands in drains and other man-made depressions. It is crucial to consider and evaluate all potential effects to the watershed health, both negative and positive, for these projects prior to pursuing funding and implementation.

4.3 Potential Water Development Project Opportunities

Considerable work has been performed within the watershed to provide upland water sources for both livestock and wildlife. Most features capture snow melt and other precipitation runoff in the upper reaches of the basin before the drainage area grows to a size that is unmanageable for a small dam. Remote sensing methods were utilized to identify 511 functional lakes, ponds, and stock tanks related to upland water identified during this study. In addition, numerous municipal and industrial water features exist throughout the basin. Of the upland water features identified, about 81 were non-functional based on embank breaches and/or sedimentation. A significant percentage of the functional stock tanks appeared impaired due to sedimentation.

There are gaps in the distribution of water features however, many of these gaps are understandable due to rugged terrain, lack of forage, and or lack of water.

Opportunities to develop additional water sources do exist. Potential water sources that would provide at least seasonal water on underutilized rangelands include enlargement and/or rehabilitation of existing permitted stock reservoirs and wells. New or enlarged stock reservoirs will likely require more work and are inherently more expensive to design, permit, and construct.

The following is a partial list of possible upland water development projects.

- Stock pond rehabilitation
- Storage reservoirs with distribution pipeline to troughs
- Spring developments

- Existing wells with conventional windmills, wind turbines and combined solar/wind systems
- New wells with conventional windmills, wind turbines and combined solar/wind systems
- Guzzlers/raintraps
- Pipeline/tank distribution systems

The topography throughout a substantial portion of the watershed make existing water sources (both water development and natural) capable of providing water to livestock and wildlife within a one-mile radius. This same one-mile buffer has been used in a variety of previously prepared WWDC-funded watershed studies, and for the purposes of this Level I study, this radius was assumed to be reasonable for the Study Area. However, the effective radius around a given water source could be smaller depending on factors such as topography, water quality, fences, roads, and grazing allotment boundaries.

To this end, one-mile buffers were drawn around documented water sources depicted in Map 28 for water development features, and Map 29 for nonfunctional features. Map 27 depicts all functional and nonfunctional water development features. The figures may not represent a complete list of all water development and natural water sources within the Study Area. In addition, water co-produced during gas and oil production can sometimes provide a source for upland wildlife/livestock usage depending upon its water quality. Because one objective of this study was to evaluate alternative water sources for wildlife and livestock other than perennial and intermittent streams, these streams were not buffered in Map 27 and Map 28.

An examination of these figures shows that much of the grazing lands in the watershed appear to be within one mile of a water source. However, the more rugged and broken areas have fewer water sources than the remaining portion of the watershed. Although it is possible that some undetected upland water features exist in these rugged areas, these figures suggest that most of the grazed portion of the watershed has upland water sources. The lower Coon Creek drainage is one area with few if any developed water sources that could benefit from additional water sources.

The 1-mile buffer is based on a relatively gentle slope that can be traversed by cattle with little difficulty. The varied and steep topography in many parts of the basin limits the effective radius a given water source may service. In addition, seasonal variability and equipment breakdowns eliminate many sources, thereby increasing travel distances and limiting the practical ability to graze certain areas. The completeness of the buffer coverage must consider the loss of certain sites through much of the year.

Each of these sites plays a critical role in the grazing management plan. Not only in terms of water being available, but also in the ability of the operator to control sites when this water is, or is not, available.

Future planning and design of additional upland wildlife/livestock water sources should include onsite consultation with landowners or land managers (if federal lands are involved), allotment permittees, NRCS, and the Shoshone Conservation District to verify location of the planned

improvements in relation to existing sources. Additional upland water development may be desirable in areas appearing well watered because topography, physical barriers and other limiting factors were not considered during the analysis. Various types of upland water development projects identified during this study are tabulated and detailed in Appendix B.

4.3.1 Irrigation and Drainage System Improvement Projects

Review of the irrigation projects identified by landowners shows there are several common themes to the types of suggested projects. Most projects fit into one of the following general categories:

- Water Conveyance Efficiency
- Operational Efficiency
- Erosion-Sedimentation
- Seepage and Land Quality
- Expansion of Operations

Most of these categories are interrelated and suggested projects will often have benefits in more than one area. Table 4.3.1-1 contains the list of irrigation and drainage system potential projects identified.

Table 4.3.1-1. Irrigation and drainage system improvements potential projects.

Project Number	Project Name	Project Type	Development Type
1	Dike Ditch	SWPP-irrigation	Rehab
7	Coon Creek Headgate	SWPP-irrigation	New supply and rehab
10	Pasture near gravel pit	SWPP-irrigation	New
11	Gravel pit pivot	SWPP-irrigation	New
13	Wetland development	SWPP-irrigation	New
16	Globe Canal Headgate and Diversion	SWPP-irrigation	Rehab
17	Diversion Canal Erosion	Ditch-canal	Rehab
19	Moss Ranch Ditch Rehab	Pipe conversion	Rehab
20	Buried Pipeline into Surface Irrigation	SWPP-irrigation	Rehab
22	Dry Creek Cow Watering	Other	New
23	Sidon Canal Reuse Water Project	Ditch-canal	New supply and rehab
24	Bubbler and Gated Pipe	Pipe conversion	Rehab
26	Pipe Irrigation Improvements North of House	SWPP-irrigation	Rehab
32	Irrigation Water Improvement	SWPP-irrigation	Rehab
35	Pipeline to Control Seepage	Pipe conversion	Rehab
36	Pivot Feasibility	SWPP-irrigation	Rehab
37	Convert Ditch to Gated Pipe	Pipe conversion	Rehab
38	Irrigation Improvements	SWPP-irrigation	Rehab
39	Water Use Improvement Project	SWPP-irrigation	Rehab
40	Chris Wambeke Short Rows	SWPP-irrigation	Rehab
42	Despain Gated Pipe	SWPP-irrigation	Rehab
44	Sidon Diversion Lateral	Ditch-canal	New

Project Number	Project Name	Project Type	Development Type
48	Ditch Piping	Pipe conversion	Rehab
50	Line or Pipe Hunt Canal	Ditch-canal	Rehab
52	Rainfall Runoff Analysis, East Lovell Catchment	SWPP-environmental	New
53	Bury lateral and Replace parallel ditches	Ditch-canal	Rehab
56	Convert Ditch to Gated Pipe	Pipe conversion	Rehab
57	Convert Ditch to Gated Pipe	Pipe conversion	Rehab
58	Lateral Sidon to South Neighbors	Pipe conversion	Rehab
59	Lateral Sidon to Lower Field at Wormington	Pipe conversion	Rehab
62	Ditch to Pipe	Pipe conversion	Rehab
63	Ditch to Pipe	Pipe conversion	Rehab
64	Ditch to Pipe	Pipe conversion	Rehab
65	Center Pivot	SWPP-irrigation	Rehab
66	Center Pivot see 65	SWPP-irrigation	Rehab
67	Irrigation Improvements	Pipe conversion	Rehab
69	Bury Drains for Center Pivot	SWPP-irrigation	Rehab
70	Sprinkler System	SWPP-irrigation	Rehab
72	Estes 80	SWPP-irrigation	Rehab
73	Estes Corner 40	SWPP-irrigation	Rehab
74	Estes Home Place	SWPP-irrigation	New
75	Wambeke Home Place	SWPP-irrigation	Rehab
76	Levi Miller Gated Pipe	Pipe conversion	Rehab
78	Lateral Pipeline from Lovell Canal Bench #1	SWPP-irrigation	New
79	Gated Pipe Extension	SWPP-irrigation	New
80	Pipeline Through Moncur Lateral Stopped Short	SWPP-irrigation	New
81	Eagle Rock Transmission Pipe	SWPP-irrigation	Rehab

Seepage from existing concrete and earthen ditches has been a source of concern from a salt accumulation and water efficiency perspective. In some instances, seepage has impacted neighboring lands. Most of the irrigation projects identified, involved piping existing concrete or earthen ditches with transfer pipe. These pipe projects are also intended to reduce maintenance from clogging or erosion and generally improve control of the water. Some of the proposed pipe projects are larger serving multiple users and beyond the scope of the small water program. In most cases the proposed pipelines will be in the 15-inch to 18-inch range and simply replace existing ditches serving one or two users in the current location. However, some projects propose a larger scale effort. For instance, project (#44) includes 27-inch pipe and several significant road and railroad crossings. This project will change how and where water arrives at the delivery points and although costly, its benefits in terms of water conservation are much greater to the larger canal network. A project of this type would likely be sponsored by the respective irrigation district rather than the conservation district and funded with the traditional process of Level 2 planning followed by Level 3 construction.

Several projects involved the installation of center pivots. Center pivots are considered on-farm improvements and are not eligible for SWPP grant funding. Center pivots relieve irrigators with

respect to water management and improve the overall distribution and control of water to the crops. Most center pivots identified were for smaller fields utilizing a pump installed in a sump supplied by ditch or canal. Other efficiency type opportunities include new headgate structures, gated pipe, transfer pipe, bank stabilization etc.

Several irrigation projects involve bringing new lands into production. These lands generally lie near existing canals but did not access canal water in the past due to topographical obstacles. New pipe and or pumps can reach these lands with a relatively short pipeline. Center pivot technology will allow efficient irrigation of these lands once thought impractical or impossible to reach with open channel methods. Since center pivots are not eligible for SWPP funding, NRCS Environmental Quality Incentives Program (EQIP) and the Agricultural Water Enhancement Program (AWEP) may grant funds to provide financial and technical assistance to producers wanting to install conservation practices on their land.

Several landowners identified impacts of salt accumulation in areas of seepage from canals and sub-water. Under field drain tiles have been installed in years past to alleviate excess water and or prevent salt accumulation from sub-water and to allow equipment to operate on the fields. Several of these drains have become inoperable due to sedimentation or pipe tile failure. Some projects include the installation of new sub-surface drains to replace failed drains. New drain technologies allow the plowing of continuous coil drain product.

The watershed soils are susceptible to erosion and headcutting. Several impressive head cuts and high banks were identified by landowners during the course of the project. Several of the larger head cuts were associated with natural processes while others were caused by the configuration of manmade features. Drains and spills from the canals were also locations of erosion. Several projects were suggested to address erosion and sedimentation. Erosion and sedimentation tie back to the operation efficiency and conveyance efficiency projects.

4.3.2 Water Storage Opportunities

The Study Area has several locations where small water storage opportunities exist. These sites are generally small ephemeral drainages in upland areas. However, some sites identified by landowners are in lower reaches of the basin and capture larger areas and or ground water seeps. The sites generally serve one or perhaps two landowners by providing stock water at the site or potentially distributed to a larger area by solar pump and trough system. The sites are not configured for regular release of water. Section 3.4.3b discussed these upland sites in more detail. Table 4.3.2-1 contains potential dam and reservoir projects.

In some areas canals circumvent large arroyos or siphon across. At these locations water from the canal could be stored behind a dam with a high-water elevation equal to that of the canal. Releases from this storage would be to elevations below the canal and downstream of the arroyo storage site. Drainage from the arroyo could also be diverted during wet periods when the pool is full into the canal.

The water would have limited ability to continue down the canal once stored but it would potentially offset irrigation demands at that location and allow water that would have otherwise been turned out to continue down the canal.

Table 4.3.2-1. Dam and reservoir potential projects.

Project Number	Project Name	Project Type	Development Type
25	Reservoir	Dam-reservoir	New
43	Sage Creek Settling Dam	Dam-reservoir	New
45	Storage Settling Pond	Dam-reservoir	New
60	Building of Reservoir on Marchants Coulee	Dam-reservoir	New

Project #43 was proposed as a large settling basin as well as a storage dam on Sage Creek. The primary benefit of this project is settling sediments; however, at certain times of the year when it is full the settling basin will allow water from Sage Creek to enter the Sidon Canal reducing the amount that must be diverted upstream.

4.3.3 Upland Wildlife/Livestock Water Development Opportunities

One of the tasks of this Level I study was to meet, on a voluntary basis, with various landowners and permit holders to tabulate and discuss their recommendations regarding upland water development.

A list of interested landowners and allotment permittees was generated based upon input obtained at project meetings and from input obtained through project team member activities and interviews conducted during the completion of the project. Individual meetings with the landowners were scheduled and completed to gain their input on the water needs of their respective geographical areas of interest. Based upon the results of these interviews, and the information presented above pertaining to existing water supplies and areas in need of upland water development, numerous conceptual water development projects were identified. Table 4.3.3-1 summarizes the results of the upland water landowner consultation.

Table 4.3.3-1. Upland water development potential projects.

Project Number	Project Name	Project Type	Development Type
5	Seep Development	SWPP-spring development	New
9	BLM Solar Pump	SWPP-well	Rehab
12	Solar well	SWPP-well	New
28	Whistle Creek Livestock Pipe	Other	New
41	Solar Pump Water Cattle	SWPP-well	New

Most projects are identified geographically using decimal degree locations on the individual project cost estimates. Some suggested projects such as tank restorations have numerous locations across the watershed and are not individually identified. Appendices A and B contain additional maps of greater detail for the sites. Also found in Appendix B are detailed cost estimates for each of the individual projects.

The sites visited during this study were selected for review precisely because they could be improved. The basin also contains numerous upland sites that are operating smoothly as intended.

The condition of the facilities reviewed varies from good working order to inoperable. Even when in good condition, there may be need for improvements, better reliability and to ease operation by using modern technology. Further improvements and repairs are intended to provide higher quality and quantities of water that will reduce travel distances and allow better control over animal distribution. Several themes or goals are common among most of the permit holders.

4.3.3a Reliability

Some of the facilities are developed to less than their potential. Consequently, the water becomes scarce sooner than it might otherwise. Springs and earthen catchments identified for improvement are examples of structures that, because of wear and tear, no longer meet their full potential, or were never originally constructed to meet their full potential. In other cases, outdated equipment and corrosion reduce the effective use of the water that is available.

4.3.3b Distribution of sites

The distance to water limits the use of some areas and also causes lengthy travel distances to water. Additional reliable sources will allow better distribution of animals and reduce travel damage occurring along the current trails. Several of the proposed pipeline projects will also allow a single source to serve multiple troughs and allowing isolation of certain troughs to move cattle while still using the same source. This distribution and control will facilitate more even use of natural forage, reduce over grazing, and promote regeneration.

4.3.3c Maintenance labor and equipment costs

Wells and tanks tend to require regular effort to ensure operation. Spring boxes and catch basins also require effort but that effort tends to be at longer intervals even years and decades. Reducing project components and operator effort should be a goal of any design. For instance, if a tank can be allowed to overflow when full, it eliminates the need to shut off a solar source pump and simplifies communication between the tank and pump and the pump controls. Every installation will have unique requirements that determine the level of control.

Plugged trough drains or overflows are a common issue. During field contacts several operators pointed out that trough overflow lines should be at least three inches to reduce plugging by grass.

Placement of source pumps and storage tanks should be as near to existing roads as possible to provide easy access for construction and maintenance. Trough locations on the other hand are driven by the desired animal distribution and movement patterns.

4.3.3d Permit Risk

Each of the allotments is at risk of being lost in the future for reasons beyond the control of the current permittee. Interest groups range from those with common goals of improving habitat for

wildlife and the public to others with stated opposition to use of public land for grazing, development, or resource extraction. Philosophies of future policy makers at the Federal level may at some point be influenced by or support those opposed to use of public lands. Consequently, the permittee may be reluctant to invest significant dollars on a project to repair or improve upland water sources. However, projects to improve watershed health and functionality could arguably help secure future use of allotments.

4.3.3e Wildlife

Upland stock watering sites provide critical water to Wyoming wildlife. Big game, upland birds, songbirds, and predators rely on the stock water maintained by the permit holder.

It should be noted that additional opportunities for upland water development and range improvement may exist and should not be assumed to be invalid because they are not included in this report. The projects presented in this report were developed based upon input received from the interested landowners and do not represent a comprehensive list of watershed needs.

The objective of this effort was to identify reliable water sources for livestock and wildlife in water-limited areas. In Appendix B alternatives are presented at the conceptual level. For each project, a conceptual design is also presented. It must be kept in mind that these designs are conceptual only and if implemented, detailed design would be required.

Several of the upland water development projects may require coordination as appropriate with the NRCS, SCD, and the BLM (if federal lands are involved) in order for construction to occur. Written agreements will be required which define the maintenance responsibility and ownership liability associated with each project.

The BLM and State administer most of the public land on which the proposed upland water projects are located. The maintenance of existing projects generally falls on the permittee. In the case of the BLM, some funds are available to help with major BLM directed maintenance tasks such as relocation of a well or installation of power source. Typically, maintenance activities do not require National Environmental Policy Act (NEPA) review. Numerous (40+) nonfunctional water sources were identified as part of the upland water review. Repair of these existing structures will require notification to the administrative agency that the repair will be taking place. New projects instigated by the permittee are the permittees responsibility. The NEPA must be followed for all projects. The BLM can help with some NEPA tasks and ultimately issues the “Decision”, however, BLM scheduling may not meet the project goals. Use of a third party to prepare the NEPA documents is an alternative to expedite the process.

4.4 Stream Channel Restoration Opportunities

The watershed study and management plan includes conservation practices and BMPs such as installation of mitigation measures to address stream channel incision and streambank erosion. Practices were developed based upon site-specific evaluation of conditions along with routine monitoring of completed stream projects to identify the effectiveness of various treatments.

Appropriate measures could be 'hard' engineering, 'soft' approaches, or combinations of both. Streambank and shoreline protection is the stabilization and protection of streambanks, constructed channels, and shorelines of lakes and reservoirs. Table 4.4-1 contains the identified channel stabilization potential projects.

Table 4.4-1. Channel stabilization potential projects.

Project Number	Project Name	Project Type	Development Type
14	Shoshone River Bank Stabilization Lower Site	SWPP-channel stabilization	New
15	Shoshone River Bank Stabilization Upper Site	SWPP-channel stabilization	New
18	Streambank Erosion and Drain Protection	SWPP-channel stabilization	Rehab
47	Sand Draw Erosion Control	SWPP-channel stabilization	New

Strategies for applying streambank and shoreline protection involve:

- Streambanks of natural or constructed channels and shorelines of lakes and reservoirs where they are susceptible to erosion.
- Various materials may be used for protection of streambanks and shorelines.
- A site-specific assessment should be conducted to determine if the causes are local or systemic and used to select appropriate treatment to achieve the desired objective.
- Functional and stable treatments for design flows and sustainable for higher flows.
- Preventing the loss of adjacent land or damage to land uses or other facilities.
- Protecting historical, archeological, and traditional cultural properties.
- Reducing the offsite or downstream effects of sediment resulting from bank erosion.
- Improving the stream corridor for fish and wildlife habitat, aesthetics, and recreation.

The benefits of implementing streambank and shoreline protection and associated BMPs and conservation practices are numerous and are displayed in the NRCS's Network Effects Diagram (NED, Figure 4.4-1). As shown in this figure, direct and indirect benefits associated with this work include:

- Decreased streambank and/or shoreline erosion
  - Increased soil quality
  - Decreased sedimentation
- Increased flow capacity of streams and channels
- Increased streambank vegetation and root matrices
  - Increased soil quality
  - Increased native plant recruitment
  - Decreased invasive/noxious species

Cumulative benefits of implementing streambank and shoreline protection could include:

- Positive impacts to income and stability of individual producers and the community,

- Improved water quality and aquatic and/or terrestrial habitat,
- Improved recreational opportunities.

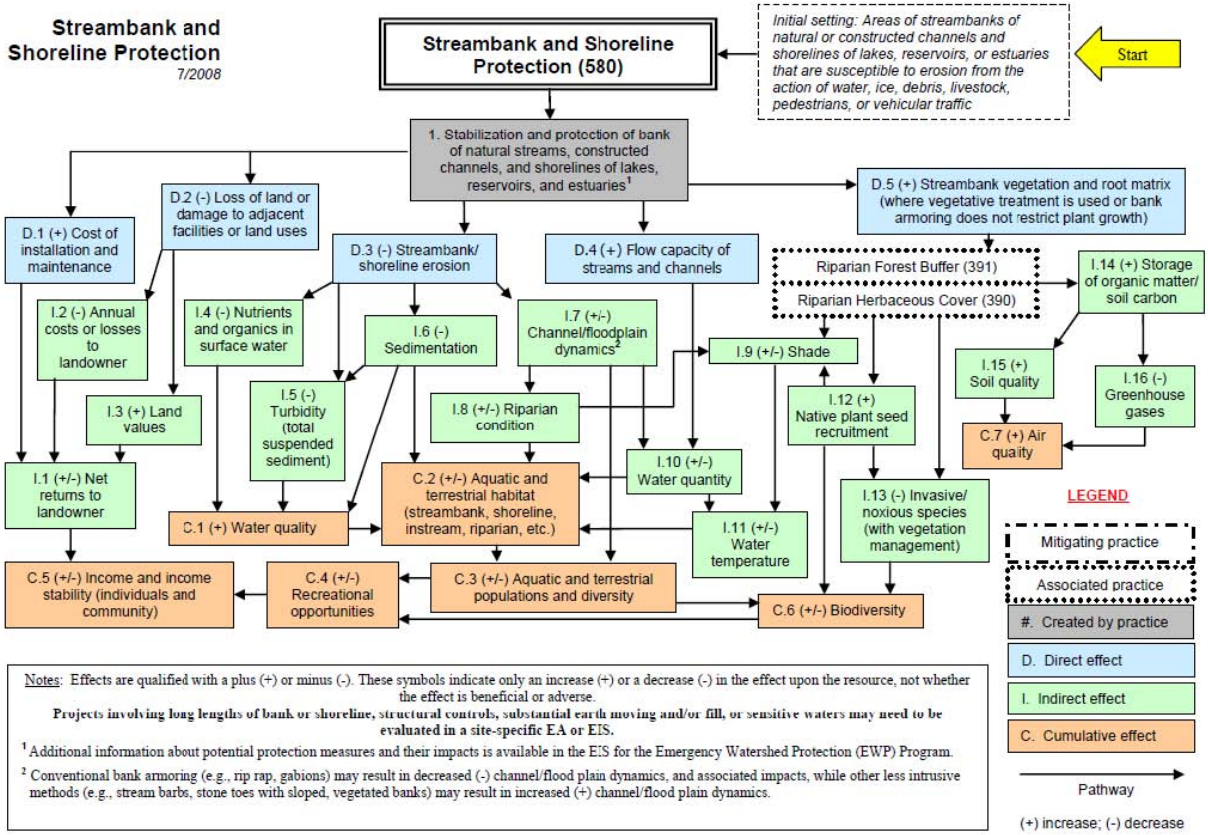


Figure 4.4-1. Network Effects Diagram for Streambank and Shoreline Protection (NRCS, 2011).

Several projects identified within the watershed include efforts associated with headgate diversion function, severe streambank erosion, and irrigation infrastructure protection projects. These proposed projects will stabilize several highly erodible banks, resulting in reduced sediment input, protection of important irrigation infrastructure and production land, along with improving shading and habitat for fish and other aquatic species. The stabilization is proposed with non-erodible toe protection and bio-engineered bank protection. Some projects include the creation of a bankfull bench to improve floodplain function and reduce peak flow shear stress. Conceptual designs for these projects are provided in Appendix B.

Channel migration in the Lower Shoshone River is dominated by lateral channel migration and downstream progression of meanders with periodic channel avulsions. Straightened reaches do not tend to persist for long periods without stabilization. A good example of this process can be found approximately 2 miles upstream of the Highway 37 bridge (Figures 4.4-2 to 4.4-5). Channel avulsions such as the one depicted in Figure 4.4-5 can contribute massive amounts of sediment and result in greatly increased channel instability downstream. For channel and bank restoration projects, it is important to recognize the channel migration processes that are occurring in the

project area, to recognize the potential for periodic pulses of sediment and wood, and to account for those constraints during the design development process.

Figure 4.4-2. Aerial imagery (July 1994) depicting relatively straight single-thread planform.

Figure 4.4-3. Aerial imagery (August 2003) depicting lateral channel migration.

Figure 4.4-4. Aerial imagery (August 2009) depicting lateral channel migration and downstream meander progression.

Figure 4.4-5. Aerial imagery (August 2011) depicting channel avulsions resulting in multi-threaded channel morphology.

Several projects were not fully evaluated that primarily focused on the downcutting of small tributaries or historically ephemeral channels due to the spilling (or return flows from) irrigation water conveyance systems. At certain locations on various canal systems, excess wastewater is spilled down steep ephemeral channels in a way that results in high levels of erosion and downcutting to bedrock or clay sediment layers. Examples of these sites are the Sand Draw and Coon Creek spills off the Elk-Lovell Canal and the tailwater of the Sidon Canal into an ephemeral channel. These headcuts have input excessive amounts of sediment into the Lower Shoshone River watershed. Most of them have headcut down to a hard layer but still contribute sediment due to induced bank and channel erosion, exacerbating the sediment issues within the overall system.

Extensive restoration and enhancement strategies have been developed and reviewed in the fluvial geomorphologic literature. Implementation of various restoration efforts would involve the reconstruction of a specific channel form that would be in morphologic equilibrium with hydrologic and sediment inputs. Such comprehensive efforts require comprehensive survey, modeling, and design work at the reach scale, and should be conducted by practitioners with extensive experience in river restoration science. A less comprehensive approach to river restoration is to implement isolated treatments to improve and stabilize impaired conditions. However, such treatments should be designed in the context of existing channel form, the likely scenario of channel evolution, and the potential future equilibrium channel morphology. Numerous treatment strategies exist to stabilize stream channels, but all treatment types are not universally appropriate for application within all channel forms. Tables 4.4-2 and 4.4-3 describe the relative appropriateness of instream treatments based upon morphologic channel type (Rosgen 1996). Photographic examples of various instream treatments are included in Photos 14 to 18.

Table 4.4-2. Applicability of instream restoration and stabilization treatments by Rosgen channel type.

Channel Type	Gravel Traps, V shaped	Gravel Traps, Log	Cross Vane	W-Weir	Root Wad Bank Stabilization	J-Hook, Hybrid Vanes	Toe Wood
B1	Excellent	Excellent	Good	Good	n/a	n/a	n/a
B2	Good	Good	n/a	n/a	n/a	n/a	n/a
B3	Poor	Poor	Excellent	Excellen	Excellent	Excellent	Excellent
B4	Poor	Poor	Excellent	Excellen	Excellent	Excellent	Excellent
B5	Poor	Poor	Good	Excellen	Excellent	Good	Excellent
B6	Poor	Poor	Good	Good	Excellent	Excellent	Excellent
C1	Good	Good	Good	Good	Excellent	Good	Excellent
C2	Excellent	Excellent	n/a	n/a	Excellent	Good	Excellent
C3	n/a	n/a	Excellent	Excellen	Excellent	Excellent	Excellent
C4	Poor	Poor	Excellent	Good	Excellent	Excellent	Excellent
C5	Poor	Poor	Good	Fair	Excellent	Good	Excellent
C6	Poor	Poor	Good	Good	Excellent	Good	Excellent
D3	Poor	Poor	Poor	Poor	Fair	Fair	Good
D4	n/a	Poor	Poor	Poor	Fair	Fair	Good
D5	Poor	Poor	Poor	Poor	Fair	Fair	Good
D6	Poor	Poor	Poor	Poor	Fair	Fair	Good
E3	Fair	Fair	Good	n/a	Good	Good	Fair
E4	n/a	n/a	Good	n/a	Good	Good	Fair
E5	Poor	Poor	Good	n/a	Good	Good	Fair
E6	Poor	Poor	Good	n/a	Good	Good	Fair
F1	Poor	Poor	n/a	n/a	n/a	n/a	n/a
F2	Fair	Fair	n/a	n/a	n/a	n/a	n/a
F3	Fair	Fair	Good	Fair	Good	Good	Fair
F4	n/a	n/a	Good	Fair	Good	Good	Fair
F5	Poor	Poor	Good	Fair	Good	Good	Fair
F6	Poor	Poor	Good	Fair	Good	Good	Fair
G1	n/a	n/a	n/a	n/a	n/a	n/a	n/a
G2	n/a	n/a	n/a	n/a	n/a	n/a	n/a
G3	Poor	Poor	Good	Poor	Good	Fair	Poor
G4	Poor	Poor	Good	Poor	Good	Fair	Poor
G5	Poor	Poor	Good	Poor	Good	Fair	Poor
G6	Poor	Poor	Good	Poor	Good	Fair	Poor

Table 4.4-3. Applicability of instream restoration and stabilization treatments by Rosgen channel type.

Channel Type	Low Stage Check Dam	Medium Stage Check Dam	Boulder Placement	Single Wing Deflector	Double Wing Deflector	Channel Constrictor	Bank Cover
B1	Poor	Poor	Poor	Poor	Poor	Poor	Excellent
B2	Excellent	Excellent	n/a	Excellent	Excellent	Excellent	Excellent
B3	Excellent	Good	Excellent	Excellent	Excellent	Excellent	Excellent
B4	Excellent	Good	Excellent	Excellent	Excellent	Excellent	Excellent
B5	Good	Fair	Fair	Good	Good	Good	Excellent
B6	Good	Fair	Fair	Good	Good	Good	Excellent
C1	Poor	Poor	Poor	Poor	Poor	Poor	Excellent
C2	Good	Fair	n/a	Good	Good	Good	Good
C3	Good	Fair	Good	Good	Good	Good	Good
C4	Fair	Poor	Poor	Fair	Fair	Fair	Good
C5	Fair	Poor	Poor	Poor	Poor	Poor	Fair
C6	Fair	Poor	Poor	Poor	Poor	Fair	Good
D3	Poor	Poor	Poor	Fair	Fair	Fair	Poor
D4	Poor	Poor	Poor	Fair	Fair	Fair	Poor
D5	Poor	Poor	Poor	Fair	Fair	Fair	Poor
D6	Poor	Poor	Poor	Fair	Fair	Fair	Poor
E3	n/a	Poor	Poor	Poor	Fair	n/a	n/a
E4	n/a	Poor	Poor	Poor	Fair	n/a	n/a
E5	n/a	Poor	Poor	Poor	Fair	n/a	n/a
E6	n/a	Poor	Poor	Poor	Fair	n/a	n/a
F1	Poor	Poor	Poor	Fair	Poor	Poor	Fair
F2	Fair	Poor	n/a	Fair	Fair	Fair	Fair
F3	Fair	Poor	Fair	Good	Good	Fair	Fair
F4	Fair	Poor	Poor	Good	Fair	Fair	Fair
F5	Fair	Poor	Poor	Fair	Fair	Fair	Fair
F6	Fair	Poor	Fair	Fair	Fair	Fair	Fair
G1	n/a	n/a	Poor	n/a	n/a	n/a	Poor
G2	n/a	n/a	n/a	n/a	n/a	n/a	Poor
G3	Fair	Poor	Poor	Poor	Fair	n/a	Poor
G4	Fair	Poor	Poor	Poor	Fair	n/a	Poor
G5	Fair	Poor	Poor	Poor	Fair	n/a	Poor
G6	Fair	Poor	Poor	Poor	Fair	n/a	Poor

Photo 14. Instream treatment example: W-weir.

Photo 15. Instream treatment example: rock cross vanes.

Photo 16. Instream treatment example: rock J-hook vane.

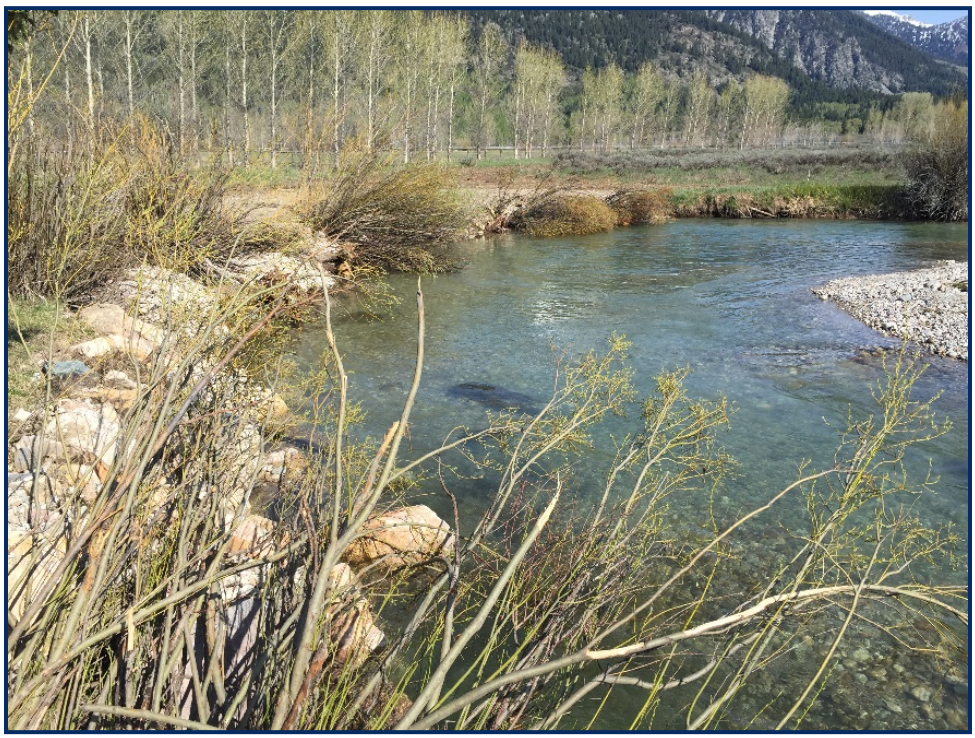


Photo 17. Instream treatment example: root wad revetment and bank cover.

Photo 18. Instream treatment example: root wad revetment and rock barb.

4.4.1 Diversion Improvement Projects

The Big Fork Diversion on the Shoshone River provides water for irrigation and wetland maintenance on the Yellowtail WHMA. The diversion supplies irrigation water for a total of 800 acres, water for eight (8) constructed wetlands that are filled and maintained annually, and sub irrigation of the Shoshone River north bank riparian area.

Due to high sediment loads with frequent mid-channel and lateral bar formation, the Shoshone River is subject to lateral and vertical instability at the diversion location. These instabilities, along with ice jams and high spring flows, have resulted in the need for frequent maintenance efforts to maintain the functionality of the diversion. Maintenance activities incur regular costs that water users must cover, and maintenance activities are often associated with channel manipulation and site disturbance that effect riverine and riparian conditions. A conceptual design plan to improve the diversion while reducing maintenance requirements represents a typical approach that could be applied at diversions located throughout the basin in order to benefit water users and the river system.

The conceptual design plan for the Big Fork Diversion includes modifications to the feeder channel inlet, incorporation of a roughened rock ramp to function as a grade control, incorporation of a constructed floodplain bench to improve sediment transport in the vicinity of the diversion, and incorporation of bioengineered bank stabilization treatments in targeted areas (Figure 4.4.1-1).

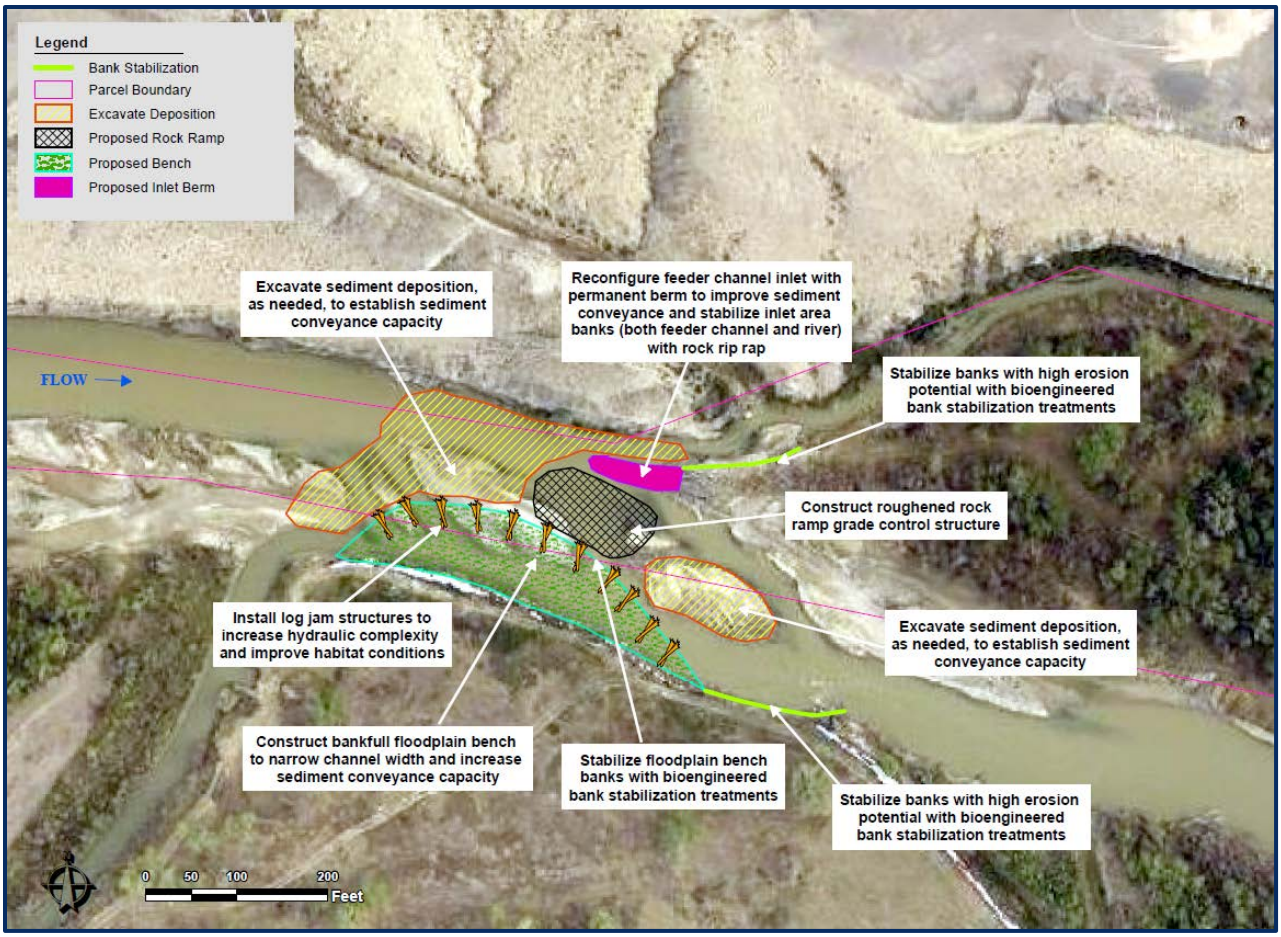


Figure 4.4.1-1. Aerial imagery depicting conceptual design for the Big Fork Diversion on the Lower Shoshone River.

The rock ramp treatment is comprised of a roughened channel bed that is stabilized by large immobile boulders. The ramp incorporates a low flow channel designed for biological benefit, including low flow fish passage, and a high flow channel designed to withstand the design flood flow. Boulders are incorporated into the rock ramp to promote vertical channel stability while increasing instream complexity and improving habitat quality. Due to the highly dynamic characteristics of the Lower Shoshone River, the boulders are considered deformable and may adjust over time, but are still anticipated to maintain their primary function of providing vertical channel stability and sufficient hydraulic head on the diversion intake. This function precludes the need for regular maintenance associated with the construction of temporary push-up dams or coffer dams in order to deliver water to the diversion.

A bankfull floodplain bench treatment is incorporated within the conceptual design to narrow the mainstem river channel width to improve sediment transport capacity and reduce the propensity for sediment deposition proximate to the diversion. This method of channel narrowing reduces maintenance requirements associated with the removal of deposited gravel proximate to the diversion.

The Big Fork Diversion conceptual design example represents an approach to diversion improvements that could be applied in the basin. The combination of maintaining head on the diversion with a roughened rock ramp while also narrowing the channel through installation of a floodplain bench maintains diversion functionality, improves sediment transport, and reduces the need for regular maintenance activities that are costly to water users and disruptive to the riverine system. A photographic example of a recently completed project that utilized this approach to diversion improvement is included below (Photo 19).

Photo 19. Photograph depicting recently completed diversion improvement project that utilized a roughened rock ramp adjacent to a diversion inlet in the Big Lost River.

4.5 Wetland Development and Enhancement Opportunities

Wetland creation and enhancement could enhance wildlife habitat and improve water quality in the watershed. Strategically located wetlands could filter irrigation return water prior to entering a waterway or provide additional filtering capacity for overbank flows when installed on the active floodplain. Table 4.5-1 contains the one identified wetland enhancement potential project.

Table 4.5-1. Wetland development and enhancement potential projects.

Project Number	Project Name	Project Type	Development Type
55	Wetland Enhancement	SWPP-environmental	Rehab

Wetland creation and enhancement activities in the watershed have historically been concentrated in and around Yellowtail Wildlife Habitat Management Area. Wetland creation in the Yellowtail WHMA has primarily been associated with pond and marsh construction and associated hydrologic

modifications for waterfowl habitat. Enhancement of existing wetlands has primarily occurred via control of invasive species (e.g., Russian olive, salt cedar, etc.). Wetland creation and enhancement further up in the watershed could enhance wildlife habitat in those areas and improve water quality in the system.

Constructed wetlands could be utilized in strategic locations to filter irrigation return water prior to entering waterways. If necessary, these wetlands could be designed with a sediment trap forebay that would allow sediment to settle out and allow easy equipment access for sediment clean-out. The constructed wetlands would also serve as wildlife habitat and allow irrigation return water to infiltrate and recharge the local aquifer. Wetlands could also be constructed along Study Area waterways to provide additional sediment and nutrient filtering capacity, stabilize streambanks, and enhance fish and wildlife habitat.

Wetland enhancement activities should continue to be focused on invasive species (e.g., Russian olive) control. Funding for these treatments is available through the NRCS and other sources. Additional wetland enhancement opportunities include diversifying habitat through hydrologic manipulations, mechanical interventions (e.g., creating pockets of shallow open water), or planting native willows and other native wetland and riparian shrubs.

4.6 Hydroelectric Power Generation Opportunities

Hydropower is generally sourced from reservoir outlets or run of the river situations (including canals) where natural drop in the channel allows generation with a relatively short penstock. Hydropower benefits are very limited for most of the small reservoirs present and identified in this study. New off channel reservoirs in the larger draws and supplied by irrigation canals are often favored sites especially if year-round flow through the canal to the site can be established. Sites where the canal sits elevated offer hydro potential (without a reservoir) by dropping the water to a lower elevation. Unfortunately, this drop also reduces the ability to use the water for irrigation at elevations above the hydro plant. Locations such as siphons can produce power however the water will be unable to rise back to the outlet of the siphon and must be used at lower elevations.

In the case of the Deaver Canal and Lovell Canal there are potential sites where the canal is elevated and hydro potential exists. In numerous places the canal is 50-feet above the valley floor and could accommodate a Kaplan unit. A Kaplan unit is capable of operating at low heads in the 10-to-100-foot range as opposed to Francis, Pelton or other higher head units. The Kaplan runner also offers larger water passageways that can better handle debris. A full Kaplan can manipulate both its wicket gates and the pitch of the runner blades. A half Kaplan has fixed runner blades. If the canal flows are relatively constant blade pitch and be fixed and a fixed blade runner will have a lower cost. The wicket gates control the flow of water through the runner and maintain head on the penstock. Under either full or half Kaplan the wicket gates are used.

The power potential of a 50-foot drop is on the order of 480 hp or 360kW for every 100 cfs of flow. If the canal could supply this 100 cfs flow in addition to the irrigation demands, the site could produce about $345.00 per day or $126,000 per year (based on $0.05 per kWh and 80% service factor) for every 100 cfs of flow delivered to the turbine.

Capital cost is the primary hurdle for any hydropower project. For budgetary purposes costs run about $5 million per MW. A 0.36 MW unit would cost about $1.8 million or about $157,000 per year based on 6% for 20 years. When the Operation and Maintenance (O&M) costs area accounted for the feasibility is further diminished.

In 2002 the WWDO conducted the Elk-Lovell Hydropower Study Level II, identified several specific sites and associated generation potential and cost. The site with the greatest power production is the combined Pumpkin Center/Brown Cascade Drops. The May-Highline site had the least power production potential. The following sizes, production and costs in Table 4.6.1 were taken from the earlier 2002 study. The cost per kWh column of the table shows that in terms of dollar cost, the Pumpkin Center Drop has the best potential. Inflation of manufacturing costs over the past 18 years indicate the Pumpkin center cost will be in the range of $2.3 million dollars in 2021 based on 3% inflation. The recent acceleration of inflation and supply chain constraints would likely drive this cost even higher. Even at $2.3 million, the 20-year debt service on the plant would be in the range of $200,500 per year at 6%. Power sales on the other hand would be in the range of $114,800 per year at $0.05 per kWh. At this time, the cost benefit ratio for the Pumpkin Center Drop is 0.57 and not feasible based on the estimated cost and assumed financing conditions.

When one considers that a hydro unit will require regular maintenance visits and maintenance effort it is apparent the sites are not feasible from a financial perspective.

Table 4.6-1. Power Potential of Selected Sites.

Name	Unit size (kW)	Unit Production (kWh)	Cost Per kWh	Annual Income at $0.05/kWh
Pumpkin Center Drop	460	2,296,000	0.57	$114,800
Brown Cascade	190	935,000	1.23	$46,750
May Highline	120	553,000	1.70	$27,650

4.7 Range and Grazing Management Opportunities

Range and grazing management opportunities in the watershed are primarily associated with upland water developments, mineral block placement, and invasive species management. Numerous upland water developments were observed in the watershed, most of which were comprised of earthen dams and ponds. These features not only serve as a source of water for livestock and wildlife but in many cases also function as sediment basins that catch silt-laden runoff from the surrounding landscape and prevent it from entering natural waterways. Many of these facilities have silted in or the dams have been breached and are in need of maintenance.

New or restored upland water developments could be utilized along with mineral block placement and exclusion fencing to protect valuable riparian, wetland, and aquatic resources, while facilitating better distribution of livestock and encouraging grazing of under-utilized areas. Functional upland water developments will reduce livestock pressure on natural riparian areas, which will reduce

streambank erosion from trampling and hoof shear and reduce sedimentation in associated waterways. Livestock often concentrate in riparian areas, especially in the fall when the riparian vegetation is the last remaining palatable vegetation on the range. Grazing in the riparian areas during the fall is especially detrimental and can prove fatal for native willow and cottonwood saplings. An added benefit of reducing livestock pressure on riparian areas via upland water developments, mineral block placement, and fencing is a reduction of pressure on regenerating willows and cottonwoods.

Invasive species management can be utilized to reclaim pastureland from aggressive species such as Russian olive and increase productivity. The NRCS and other funding agencies have technical and financial assistance available to assist with invasive species control on the watershed.

4.8 Invasive Species Management Opportunities

The watershed could benefit from invasive species management with a concerted focus along the waterways. Both Park and Big Horn County Weed and Pest Districts are actively managing invasive weeds in the Study Area and provide technical and financial assistance to private landowners. Russian olive (*Elaeagnus angustifolia*) and salt cedar (*Tamarix* spp.) are the primary woody species targeted for management in the Study Area. Both weed and pest districts provide cost-share for treating these species. Russian olive has several competitive advantages over the native cottonwood trees (*Populus* spp.) and has taken over many riparian zones in the Study Area. The riparian zone along the Lower Shoshone River is currently dominated by Russian olive, with patches of salt cedar interspersed (Photo 20). This invasion of these species is exacerbated by the altered hydrologic regime of the river. Dam operations and irrigation diversion have modified the hydrograph to the extent that that river no longer has a natural cycle of flooding which limits the natural recruitment of native willows and cottonwoods. If left unchecked, Russian olive and salt cedar form dense monocultures that outcompete native vegetation, encroach on pastureland, reduce wildlife habitat values, and limit human access. The weed and pest districts, NRCS, WGFD, and others have targeted the control of Russian olive and salt cedar over the last couple decades. WGFD alone has treated more than 2,000 acres of Russian olive and salt cedar on the Yellowtail WHMA.

Photo 20. Riparian zone on the Lower Shoshone River dominated by invasive Russian olive trees.

In addition to the woody species, priority herbaceous species for the Big Horn County Weed and Pest District currently include diffuse knapweed (*Centaurea diffusa*), spotted knapweed (*Centaurea stoebe*), houndstongue (*Cynoglossum officinale*), black henbane (*Hyoscyamus niger*), oxeye daisy (*Leucanthemum vulgare*), perennial pepperweed (*Lepidium latifolium*), purple loosestrife (*Lythrum salicaria*), yellow toadflax (*Linaria vulgaris*), and leafy spurge (*Euphorbia esula*). Russian knapweed (*Rhaponticum repens*), Canada thistle (*Cirsium arvense*), and whitetop (*Lepidium draba*). The Big Horn County Weed and Pest District currently provides a 100% cost-share program for treatment of these 9 priority invasive species. Additional cost-share programs are available for the treatment of Russian olive, salt cedar, Russian knapweed (*Rhaponticum repens*), Canada thistle (*Cirsium arvense*), and whitetop (*Lepidium draba*).

5.0 PERMITTING

This section presents information on the regulatory issues for the types of projects that have been identified in this report for the purpose of characterizing the potential environmental permitting issues. Permitting can become a complex, lengthy, and expensive process. The Study Area contains lands administered by the BLM, BOR, NPS, DOD, State, and private individuals. Depending on the location and type of project, permitting may be as simple as a water rights application or as complicated as a full Environmental Impact Statement (EIS). The National Environmental Policy Act (NEPA) applies to any federal action, and compliance is the responsibility of the lead federal agency. Other federal environmental regulations are regulated by the following federal agencies: EPA, BLM, USFS, USACE, and/or the USFWS and may apply to the potential projects described in this plan. The state of Wyoming agencies that may have approval requirements may include

DEQ, SEO, and the Board of Land Commissioners through the Office of State Lands and Investments. The following sub-sections detail various permitting requirements.

5.1 NEPA Compliance and Documentation

NEPA requires federal agencies to assess the possible environmental consequences of projects they propose to undertake, fund, or approve. NEPA applies to any of the proposed actions for which the project site is located on federal land, federal funds may be used, and/or when formal federal agency actions are necessary for the project to move forward. One of the primary intentions of the NEPA process is to avoid, minimize, and mitigate adverse environmental consequences of federal actions. NEPA requires analysis and documentation of potential adverse and beneficial effects of a proposed action and alternatives and mandates an open public involvement process.

The majority of land in the Study Area is owned by the federal government, specifically the BLM which owns over 54% of land. The second largest group of ownership within the Study Area is private owners representing almost 30% of land. Map 31 illustrates land ownership across the Study Area. For potential projects identified in this report it is likely that BLM would be the lead federal agency charged with ensuring compliance with NEPA and related environmental studies, depending on the location of the project. The USACE would likely be the lead federal agency on private lands where wetlands may be affected. The level of NEPA documentation needed for projects would be determined on a project-specific basis.

5.1.1 Bureau of Land Management

NEPA evaluations and processes for projects that may be proposed where BLM is the lead federal agency will be performed by BLM staff or qualified, independent third-party experts responsible to BLM. These experts may include specialists from other federal and/or state agencies working under Memorandums of Understanding, or other appropriate arrangements. All BLM-led NEPA-related processes and studies are administered by the lead BLM district staff (Cody Field Office), with assistance from BLM state office staff.

5.1.2 Other State/Federal Agencies

Depending on the project, it is possible that another state or federal agency may lead the NEPA process. All of the relevant state and federal land management agencies have management plans developed from NEPA-compliant processes where appropriate. These plans will guide the agencies' NEPA processes for any applicable proposed projects or improvements.

5.2 Permitting/Clearances/Approvals

Environmental resources are protected by a variety of state and federal regulations such as the Clean Water Act (CWA) and the Endangered Species Act (ESA). The permits, clearances, and approvals required will depend on the specific nature and location of each project.

5.2.1 USACE Section 404 Permit

The U.S. Army Corps of Engineers (USACE or Corps) has regulatory authority under Section 404 of the CWA to regulate the discharge of dredged or fill material into the wetlands or waters of the

U.S. The purpose of these laws is to restore and maintain the chemical, physical and biological integrity of waters of the U.S. This would include diversion structures, levees, riprap, bank stabilization, channel crossing structures, dams, and development fill. There are three kinds of permits issued by the Corps. They are 1) Individual Permit, 2) Nationwide Permit and 3) Regional General Permit.

Any project that has the potential to affect wetlands or waters in the Study Area will need to address Section 404 permitting issues. Small Projects with minor impacts will qualify for general permits (Nationwide Permit or Regional General Permit), while larger projects with greater impacts will need individual permits.

Most projects will require an application package containing a report detailing all aspects of the proposed project including efforts to avoid, minimize, and mitigate impacts. Prior to submitting an application, the Applicant should address the proposed project's purpose and need and any other alternatives considered and the reasons for their elimination. The applicant must address wetland impacts, usually requiring a formal wetland delineation, and also be prepared to discuss the potential impacts of any new structures and the impacts on current flow patterns in the designated water source.

Section 404 permit application forms can be found here:

https://www.usace.army.mil/Missions/Civil-Works/Regulatory-Program-and-Permits/Obtain-a-Permit/

5.2.2 Endangered Species Act

On new projects that are funded, authorized, carried out by federal agencies, or on federal land, the applicant is required to consult with the USFWS under Section 7 of the Endangered Species Act to make certain that the project is not likely to jeopardize the continued existence of endangered or threatened or threatened species or destroy or adversely modify critical habitat. The lead agency will prepare a biological assessment to determine project effects on threatened and endangered plant and animal species listed or proposed for listing under the Endangered Species Act. The USFWS will then issue an opinion on whether federal actions are likely to jeopardize the continued existence of a threatened or endangered species, or adversely modify critical habitat. The USFWS must approve the preparation of a biological assessment to comply with the Endangered Species Act in order to render its decision. If the USFWS determines that the proposed project could adversely impact a protected species, mitigation measures or changes to the project scope, location and methods will be required.

The Fish and Wildlife Coordination Act requires federal agencies involved in actions that will result in the control or structural modification of any natural stream or body of water for any purpose to take action to protect the fish and wildlife resources which may be affected by the action. It requires federal agencies or applicants to first consult with state and federal wildlife agencies to prevent,

mitigate, and compensate for project caused losses of wildlife resources, as well as to enhance those resources.

5.3 County Floodplain Permitting

Big Horn County Land Planning requires a Floodplain Development Permit for any proposed development occurring within a designated floodplain. Project may include: bridge or culvert, irrigation structure, habitat enhancement, stream bank or channel stabilization or restoration. Within the Lower Shoshone River Watershed and areas around Lovell, the Shoshone River and several main tributaries have been mapped as approximate Zone A floodplains by the Federal Emergency Management Agency (FEMA). These floodplains were determined by approximate methods instead of using a detailed hydrologic and hydraulic model study to set floodplain extents and baseflood elevations (BFEs). Typically, a project in a Zone A floodplain has to maintain any BFE rise to less than a foot, however Big Horn County requires the project to calculate a rise to be less than 0.5 feet. This analysis is typically performed with an existing condition and proposed condition hydraulic models or other hydraulic conveyance calculation methods. A rise in a concern if the waterway is being restricted or fill is placed within the mapped floodplain. At the time of writing, the permit application fee is $300, plus additional costs to develop and submit necessary materials for the permit application.

5.4 Mitigation

Mitigation could be required at any of the identified reservoir projects or other potential projects described in Sections 4 and 5 to address impacts to wetlands, fish and wildlife resources, sensitive or ESA-listed species, and cultural resources.

5.4.1 Wetlands

If wetland impacts associated with any future projects (determined during the Section 404 permitting process) are above the threshold (typically 0.1 acres) set by the USACE, detailed compensatory mitigation plans to replace lost wetland functions will need to be prepared and approved. The ratio of wetland replacement mitigation would be determined during the permitting process. Any required mitigation plans will follow guidance provided by the 10 April 2008 “Compensatory Mitigation for Losses of Aquatic Resources; Final Rule” in 33 CFR Parts 325 and 332 and 40 CFR Part 230, which requires compensatory mitigation plans to contain 14 elements as outlined in Part 332 Section 332.4.

5.4.2 Sensitive and ESA-Listed Species

Per NEPA and ESA requirements, surveys for sensitive or ESA-listed species would be required prior to constructing projects that are funded, authorized, carried out by federal agencies, or on federal land. If any sensitive species are found, and impacts to these species cannot be avoided, mitigation measures would be required. Mitigation of potential raptor and big game impacts would generally involve stoppage of certain construction activities during sensitive time periods and avoidance of direct disturbance of the subject species. Impacts to crucial big game habitat will

likely have more significant mitigation requirements. If any threatened and endangered species were encountered at a given site, special studies would be required to determine if appropriate mitigation could be implemented. Coordination with other agencies will be conducted by the lead federal agency, not the applicant.

5.4.3 Sage-Grouse

In 2008, the State of Wyoming adopted a regulatory mechanism (Greater Sage-Grouse Core Area Protection Strategy) to provide increased protection for greater sage-grouse and restrict habitat alterations within designated sage-grouse core population areas. The policy has been updated several times, most recently in 2019 (Wyoming Executive Order 2019-3). A map of the sage-grouse Core Population Areas within the state is presented in Figure 5.4.3-1. The Core Area Protection Strategy focuses on avoidance, minimization, and mitigation of anthropogenic disturbances to sage-grouse habitat. Mitigation is reserved for those circumstances where avoidance and minimization are either inadequate or impossible. In instances where sage-grouse habitat is impacted, impacts must be offset through compensatory mitigation.

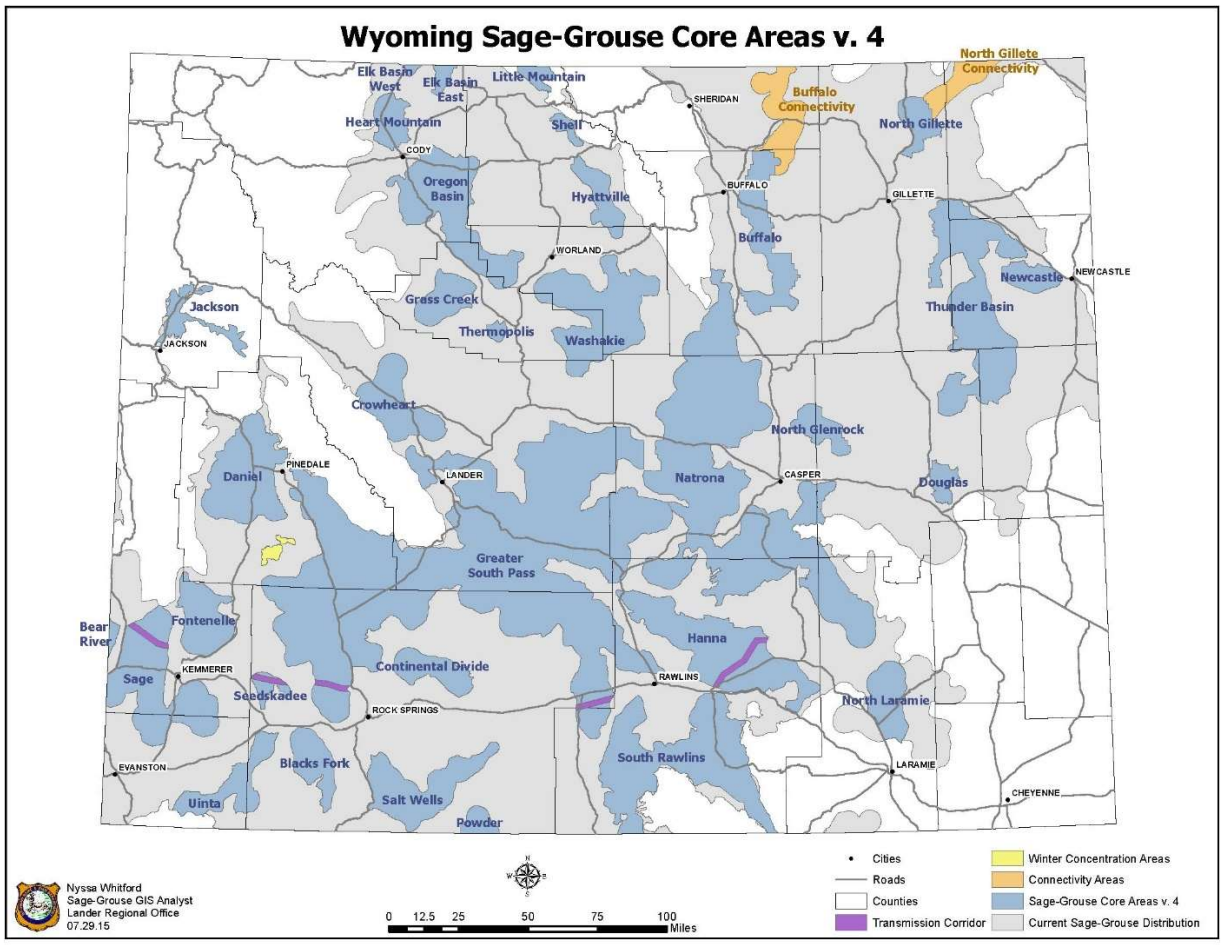


Figure 5.4.3-1. Map depicting greater sage-grouse core areas in the State of Wyoming.

The Core Area Protection Strategy includes a Compensatory Mitigation Framework that outlines mitigation requirements and mechanisms for sage-grouse habitat impacts in both core and non-core population areas. Compensatory mitigation for sage-grouse habitat impacts, or "debits," may be accomplished via "conservation credits" or "restoration credits". Conservation credits are created by removing or limiting a threat to sage-grouse or their habitat for the full duration of the impact or in perpetuity. Restoration credits are created by converting disturbed or low quality habitat to suitable sage-grouse habitat. Mitigation requirements are calculated based upon location, functionality, indirect impacts, and size of both the debits and credits. Mitigation for individual projects is most commonly achieved via purchase of mitigation credits from an approved sage-grouse habitat mitigation bank.

5.4.4 Fisheries

Impacts to fishery resources may require mitigation depending on project location and scale of impacts. Impacts to fisheries are evaluated by the lead federal agency. Impacts related to reservoir projects could potentially be mitigated through minimum reservoir release requirements and creation of a minimum pool for aquatic habitat. Fish passage on main-stem sites will likely be required. Fish screening on major intakes or diversions to canals or off-channel storage sites may be required.

5.4.5 Cultural Resources

Section 106 of the National Historic Preservation Act requires Federal agencies to analyze the effects of any *undertaking* (as defined in 36 CFR 800.16) on historic resources. The lead federal agency will conduct cultural and historic resource investigations to identify and document any such resources that will be impacted. This would include a class I (literature search) survey, a class II (reconnaissance inventory) survey, and if needed, a class III (intensive inventory) survey. If cultural resource impacts are unavoidable, a mitigation plan for cultural resources will be developed culminating in a Memorandum of Agreement (MOA) between the Wyoming SHPO and the lead federal agency with concurrence by the project sponsor, and possibly affected Native American tribes. The agreement would require approval from the Advisory Council on Historic Preservation.

6.0 ECONOMIC ANALYSIS AND PROJECT FUNDING

6.1 Overview

Multiple funding sources exist to assist with the cost of project implementation. Selection of the proper program(s) can result in a significant portion of the cost being covered by complimentary sources.

This section briefly describes some of the programs available and provides details regarding where more information can be obtained regarding these programs. In general, most of the future watershed improvement projects can reasonably expect to tap into the funding sources identified here within.

An investigation of federal, state and local funding sources was conducted to identify potential opportunities for watershed improvement projects.

The following documents provide extensive information pertaining to project funding opportunities for projects investigated within this Level I study:

- **Water Management & Conservation Assistance Programs Directory, Fourth Edition** (WWDC May 2009). This directory provides information on several local, state, and federal programs with potential project funding. This directory was last updated in 2009 and many of the contacts are out of date, but it still provides valuable information. Available online at: http://wwdc.state.wy.us/wconsprog/WtrMgntConsDirectory.html
- **Catalog of Federal Funding Sources for Watershed Protection.** This EPA website provides information pertaining to numerous funding sources including grants, loans, and cost sharing programs which are applicable to watershed projects. The document is available online at: https://www.epa.gov/nps/funding-resources-watershed-protection-and-restoration
- **Habitat Extension Bulletin No. 50 - Fisheries and Wildlife Habitat Cost Share Programs and Grants (Wyoming Game & Fish Department, August 2007)** The Wyoming came & Fish department has developed this informative bulletin pertaining to financial assistance programs available for fisheries and wildlife habitat projects. Available online at: https://wgfd.wyo.gov/Habitat/Habitat-Information/Habitat-Extension-Bulletins

As government programs frequently change according to the available budgets of the funding agencies the grants, loans, and cost share opportunities presented herein are subject to change. It is recommended that additional inquires be made if interested parties wish to pursue the opportunities presented in this section.

Significant competition for funding associated with many of the opportunities presented is frequently encountered by applicants. To increase the potential for success in obtaining funding from other sources, applicants may wish to have other funds available to leverage against these opportunities. By showing the financial commitment to projects, funding agencies may look more favorably to fund specific projects that have a higher likelihood of timely implementation. Contacts for key local groups who can provide current information on funding sources relevant to watershed projects include:

- Bureau of Land Management/Cody Field Office (307-578-5900)
- NRCS - Powell Field Office (307-754-9301)
- Powell Clarks Fork Conservation District (307-272-6678)
- Shoshone Conservation District (307-548-7422)
- Wyoming Water Development Office (307-777-7626)

6.2 Local Agencies

6.2.1 Shoshone Conservation District

Shoshone Conservation District serves as the local liaison between local landowners and resource users and state and federal government agencies. In addition to their many other roles and responsibilities, this district can also provide funding assistance as follows:

- In-kind technical assistance as local resources, capacity, and expertise allow.
- Administration of programs, projects, and grants on behalf of recipients of state and federal natural resources program funding.
- Assistance in development of leveraged, partnered programs and projects.
- Assistance in preparation of grant applications.

6.2.2 Big Horn County Weed and Pest District

Wyoming Weed and Pest Districts provide financial and in-kind support to landowners and other agencies/entities including, but not necessarily limited to:

- Cost-share in the control of noxious weeds.
- Assistance in the identification of noxious weeds and other undesirable plants.
- Organization and/or participation in local meetings, seminars, and field trips to educate local landowners and agencies on the problems and potential solutions for weed and other undesirable plant control, and
- Facilitating weed control work-days attended by a broad base of stakeholders.

6.3 State Agencies

6.3.1 Wyoming Department of Environmental Quality

The Wyoming Department of Environmental Quality (WDEQ) provides funding for implementation of best management practices (BMPs) to address non-point sources of pollution under Section 319 of the Clean Water Act. Section 319 grant funding requires a non-federal (i.e., local) match of 40 percent from the applicant with cap of $400,000. These matching funds may be provided by landowners, a conservation district, other quasigovernmental entities (e.g., watershed improvement district, irrigation district, etc.), and/or nonprofit organizations (e.g., Trout Unlimited, Ducks Unlimited, and the Rocky Mountain Elk Foundation). Applications (proposals) conforming to a specified format are required. The proposal describes in some details the issues to be addressed and the proposed methods/BMPs to be implemented, as well as providing all other information required to evaluate the proposed project and matching fund entity(ies). These proposals are normally due in August or September of each year.

Projects located within watersheds of streams on the 303d list are eligible for the 319 -Incremental Funds, which has historically been a larger amount. Projects located within watersheds which are not listed on the 303d list are only eligible for 319-base funds.

See http://deq.wyoming.gov/wqd/water-quality-assessment/resources/reports/) for the latest Water Quality Assessment and Impaired Waters List (2020).

Periodically, DEQ conducts workshops on how to apply for 319 and 205j funds. Contact the Water Quality Division for dates and locations (307-777-7781).

6.3.2 Wyoming Game and Fish Department

Wyoming Game & Fish Department funding assistance can best be summarized by the following:

'The Wyoming game and Fish Department may offer technical and funding assistance to help landowners, conservation groups, institutions, land managers, government agencies, industry and non- profit organizations develop and/or maintain water sources for fish and wildlife. Assistance may also be provided for protecting and improving riparian areas/wetlands, restoring streams, and upgrading fish passage or diversion screens. (WWDC, 2015)

A Summary of WGFD funding options is available in the Water Management & Conservation Assistance Program Directory: (http://wwdc.state.wy.us/wconsprog/2014-WMCAPDirectory.pdf)

Current programs offered by the Wyoming Game & Fish Department include Riparian Habitat Improvement Grant, Water Development/Maintenance Habitat Project Grant, Upland Development Grant, Fish Wyoming, and Wyoming Sage Grouse Conservation Fund. These programs are described below.

6.3.2a Habitat Trust Fund

Funds can be used for acquisition, maintenance, or improvement of wildlife habitat; or for the promotion of human understanding and enjoyment of the fish and wildlife resource (habitat or information & education projects). All proposals must have a Department sponsor and be entered into a Department proposal database by early January or early August annually. No cost share is required but is strongly recommended. Approximately $600,000 to $1,200,000 is allocated annually to projects across Wyoming.

6.3.2b Fish Passage Grants

Funds can be used for creating or improving upstream or downstream passage of all life stages of fish in Wyoming waterways and for screening diversions. Examples include developing fishways or fish ladders, assisting with the replacement of traditional push-up diversion dams with more fish-friendly options, and installing various screening technologies to keep fish from becoming entrained into irrigation ditches. All proposals must have a Department sponsor and be entered into a Department proposal database by early January annually. Approximately $25,000 to $90,000 is allocated annually to projects across Wyoming.

6.3.2c Wyoming Sage Grouse Conservation Fund

WGFD administers the Wyoming Sage-Grouse Conservation Fund (WSGCF). Available online at: http://gf.state.wy.us

The WSGCF is a special fund established by the Wyoming State Legislature to support the efforts of Local Sage-Grouse Working Groups (LWGS). The WSGCF funding is intended to promote conservation of sage grouse populations and habitat (sagebrush ecosystems), including socio-economic and human use of the habitat.

Requests for WSGCF funding must be made on a Project Proposal Form.

Funding is normally given to projects with matching funds, established partnerships, multi-species benefits, management relevance and consistency with the local sage-grouse conservation plan, highest wildlife impact, appropriate budgets, landscape scale, and a legacy of benefits. Evaluation criteria include: consistency with the local plan, likelihood of project success, project readiness and availability of matching funds, multiple species benefits, significance at local/state/regional level, duration of benefits, and adequacy of funding. Application may be made at any time but should be made by February 1 to receive first round consideration. Funds awarded must be expended between July 1 of the year received and September 30 of the second year after award. The funds are normally distributed as reimbursable grants (i.e., payments are made for expenses incurred and not "up-front"). Requests for funding of habitat improvement projects, including water developments, must include a livestock grazing management plan. A Project Close-out Report must also be submitted upon completion to allow tracking of expenditures and tracking of results.

6.3.3 Wyoming Office of State Lands and Investments

As the administrative advisory arm of the Board of Land Commissioners and State Loan and Investment Board, the Office of State Lands and Investments (OSLI) administers Regular Farm Loans and Small Water Development Project Loans that are applicable to potential projects identified in Section 4. The Wyoming Office of State Lands and Investments funding options are summarized at https://lands.wyo.gov/grants-loans/loans.

6.3.3a Regular Farm Loans

These loans are made for a wide range of agricultural purposes, including as most applicable to the potential projects identified in Section 4, purchasing, constructing or installing equipment and/or improvements necessary to maintain or improve the earning capacity of the farming operation. Eligible applicants include individuals whose primary residence is in Wyoming and legal entities with a majority of the ownership meeting the individual residency requirements. Single loans or combinations of loans cannot exceed an outstanding principal balance of $800,000. Loan rates are 8% for loans up to 50 percent of the appraised value of the security land and improvements and 9% for loans between 50 and 60 percent of the security. The term of a given loan is limited to 30 years.

6.3.3b Small Water Development Project Loans

These loans are authorized for projects for development and use of water upon agricultural lands for agricultural purposes. These projects may convert dry land into irrigated land or lead to more efficient use of water and/or increased crop or forage production. Eligible recipients may include court approved water districts, agencies of state and local government, persons, corporations, associations, and other legal entities recognized under state law. Individual loans up to $150,000 may be made. Interest is currently set at 4% to 6% percent and the maximum term of loan is 40 years.

6.3.4 Wyoming Water Development Commission

The mission of the Wyoming Water Development Commission (WWDC), as defined in the enabling legislation, is to:

"provide, through the commission, procedures and policies for the planning, selection, financing, construction, acquisition and operation of projects and facilities for the conservation, storage, distribution and use of water, necessary in the public interest to develop and preserve Wyoming's water and related land resources, The program shall encourage development of water facilities for irrigation,..for abatement of pollution, for preservation and development of fish and wildlife resources...and shall help make available the waters of the state for all beneficial uses..," (W.S. 41-2-112(a)).

Key aspects of the Wyoming Water Development Program and the Small Water Project Program administered by WWDC are described in the following subsections.

6.3.4a Wyoming Water Development Program

The main Wyoming Water Development Program encompasses new development, dams and reservoirs, rehabilitation, water resources planning, and master planning. Of most relevance to the Lower Shoshone River Watershed in terms of implementing alternative projects are the New Development, Rehabilitation Programs and Dams and Reservoirs Program described below. This information is drawn from the August 13, 2021 Operating Criteria of the Wyoming Water Development Program available at:

https://wwdc.state.wy.us/opcrit/WWDPopCriteria.html

It is very important to ensure that the most current information on funding is reviewed prior to making an application as WWDC's policies and procedures can and do change over time in response to legislative direction and/or Commission action. Review of information available at the above website and contact with the staff of the WWDC (307-777-7626) is recommended prior to beginning the application process.

Water Resource Planning

The Wyoming Water Development Commission serves as the water development planning agency for the State of Wyoming. In this capacity, the WWDC can provide assistance for Basin Wide Plans, Watershed Studies and Master Plans. These two types of plans are further described below:

Basin Wide Plans - The program serves to develop basin wide plans for each of the state's major drainage basins.

Watershed Studies - The program serves to provide technical information that describe and evaluate the watershed's existing conditions. Studies also identify projects that improve or maintain watershed functions and are eligible for funding from WWDC and other sources.

Master Plans -The program provides a service to municipalities, districts and other entities to assist in the preparation of planning documents which serve as master plans for future water supply systems and improvements. The plans serve as a framework for the entities to establish project priorities and to perform the financial planning necessary to meet those priorities. These plans can assist entities in preparing the reports necessary to achieve federal funding assistance for water development and other water related projects.

Groundwater Grant Program

The primary purpose of the program is to inventory the available groundwater resources in the state. The program also serves to assist communities in developing efficient water supplies. Municipalities and special districts that purvey drinking water are eligible to receive up to $400,000 in grant funds if 25% of the total project costs will be paid by local matching funds.

New Development Program

This program provides technical assistance and funding to develop waters of the state that are unused and/or un-appropriated at present. It deals with a wide range of projects, including some that are relevant to the Lower Shoshone River Watershed .

Rehabilitation Program

The Rehabilitation Program addresses the improvement of water projects completed and in use for at least fifteen years in order to assist in keeping existing water supplies effective and viable for the future. Relative to the Lower Shoshone River watershed, the Rehabilitation Program can improve existing agricultural facilities and conveyance systems to ensure safety, decrease O&M costs, and increase the efficiency of agricultural water use. The types of projects supported relevant to this watershed are essentially the same as listed above for the New Development Program.

Note that on-farm improvements (e.g., gated pipe, side rolls, center pivots and related facilities and/or equipment such as pumps, power lines) are excluded from WWDC funding under both the New Development and Rehabilitation Programs.

Dam and Reservoir Program

Proposed new dams with storage capacity of 2,000 acre feet or more and proposed expansions of existing dams of 1,000 acre-feet or more qualify for the Dam and Reservoir program. Legislative approval must be granted prior to allocating funds to a particular purpose or project. Dams and reservoirs typically provide opportunities for many potential uses. While water supply shall be emphasized in the development of reservoir operating plans, recreation, environmental enhancement, flood control, erosion control and hydropower uses should be explored as secondary purposes.

Key Criteria and Procedures

An application for funding under either the New Development or Rehabilitation Programs must meet the following key criteria most applicable to potential projects as identified in Chapter 3 of the Operating Criteria.

- “The project sponsor shall be a public entity that can legally receive state funds, incur debt, generate revenues to repay state loan, hold title and grant a minimum of a parity position mortgage on the existing water system and improvements or provide other adequate security for the anticipated state construction loan."
- The proposed project must serve fifteen or more municipal/domestic water taps or 1,000 or more water righted acres of irrigated cropland.

Important procedures, deadlines and requirements for applications to the New Development and Rehabilitation Programs include but are not necessarily limited to the following:

- A fee of $1,000 must be submitted with initial project applications; the fee does not apply to projects advanced to the next level of study or to construction within the last 5 years.
- A reimbursement fee will be required based on the number of taps and irrigated acres. The reimbursement amount is $1,000 for projects with less than 2,000 taps and 9,000 irrigated acres, $2,000 for larger projects with less than 9,000 taps and 20,000 irrigated acres, and $3,000 for projects with more than that.
- A certified resolution passed by the governing body of the sponsoring entity must accompany an application for a Level II study or Level III construction. This requirement may be deferred if the applicant is in the process of forming a public entity.
- A public entity must be in place before a Level II study or Level III construction can commence, with certain exceptions discussed below.
- The due date for new Level I and II planning study applications is March 1 of each year; the due date for Level III construction project applications is September 1 of each year. Level III applications that have not advanced from a previous WWDC Level I or II study have a due date of June 1.

Financial Plan

The current standard terms of the Wyoming Water Development Program financial plan for Level III projects are summarized as follows:

- Sixty-seven (67) percent grant to thirty-three (33) percent loan mix. It is possible to reach a maximum of 75% grant in circumstances of severe financial hardship. In such cases, the project sponsor would need to make a presentation to the Commission documenting their case.
- Minimum four (4) percent loan interest rate (current rate is 4 percent, but legislature may increase rate).
- Maximum 50-year term of loans; term shall not exceed economic life of project,
- Payment of loan interest and principal may be deferred up to 5 years after substantial completion at WWDC's discretion under special circumstances.

The Commission will evaluate whether or not a project will be funded for Level III construction following review of the results of Level II studies. If the Commission determines that the project should not advance due to high repayment costs (as determined by an analysis of the sponsor's ability-to-pay and after other funding sources have been considered), the sponsor has the option of making a formal presentation to WWDC relative to the sponsor's ability and willingness to pay. This presentation must address the need for the project, the direct and indirect benefits of the project, and any other information the sponsor feels is relevant to the Commission's final decision.

The WWDC may waive the requirement that the project sponsor be a public entity under the following exceptions:

1. The WWDC may accept applications for Level I studies from applicants that are not public entities. This will allow the applicant to know if there is a viable project prior to becoming a public entity. However, the applicant must be a public entity before applying for a Level II study. Under these circumstances, the Level I process will have a two-year

duration with the study being completed the first year and the sponsor forming a public entity the second year.

2. The WWDC may accept applications related to the construction of dams and reservoirs from applicants that are not public entities. As the evaluations of the feasibility of new dams are complex, this will allow the applicant to know if the proposed reservoir is feasible prior to becoming a public entity. However, the applicant must be a public entity before applying for Level II, Phase III funding.

The Wyoming State Legislative Services Office maintains current district formation information principally found in the Wyoming State Statutes, Title 22, Chapter 29 – Special District Elections Act.

6.3.4b Small Water Project Program

The purpose and objects of the SWPP are described on the WWDC website:

"The purpose of the Wyoming Water Development Commission (WWDC) Small Water Project Program (SWPP) is to participate with land management agencies and sponsoring entities in providing incentives for improving watershed condition and function."

"Activities should improve watershed condition and function and provide benefit for wildlife, livestock and the environment. Projects may provide improved water quality, riparian habitat, habitat for fish and wildlife and address environmental concerns by providing water supplies to support plant and animal species or serve to improve natural resource conditions."

The Small Water Project Program (SWPP) is intended to be compatible with the conventional WWDC program described above. WWDC's maximum financial contribution is a 50% match up to thirty-five thousand dollars for the SWPP. SWPP funding is a "one-time" grant so that ongoing operation and maintenance costs are not included. Loans are not available under SWPP.

Eligibility

The kinds of projects eligible for SWPP funding include, but are not necessarily limited to:

- Small reservoirs and stock watering ponds (up to 20 feet high and 20 acre-feet capacity)
- Wells
- Pipelines and conveyance facilities
- Irrigation
- Spring developments
- Solar platforms
- Windmills
- Wetland developments
- Environmental-streambank stability or erosion protection
- Rural community fire suppression systems
- Recreational projects

All SWPP projects must have a public benefit and improve watershed condition and function. Benefits may include, but are not necessarily limited to:

- Improved water quality
- Habitat and water for fish and wildlife
- Improved riparian habitat
- Increased recreational opportunities.

These projects may address environmental concerns by providing water supplies to support plant and animal species and serve as instruments to improve rangeland conditions.

Funding can only be provided to eligible public entities including, but not necessarily limited to, conservation districts, watershed improvement districts, water conservancy districts, and irrigation districts. Many of the projects discussed in the management plan are eligible for funding under the SWPP. However, there are many projects that are not eligible or have one or more components that are not eligible for SWPP funding. Each project that is not eligible or have an item(s) that are not eligible are denoted as such on the project description and cost estimates. The projects that are not recommended for funding are listed below (Pavlica 2021).

1. Cleaning or reshaping an earthen ditch: This is considered maintenance and is therefore not eligible for project funding.
2. Flumes and Measurement Devices: These expenses are the responsibility of the permit holder and not eligible expenses in the program.
3. On Farm Projects: These projects often have a difficult time providing the necessary public benefit documentation required by the legislation.
4. Drinking Water Projects: Projects of this type do not comport with the original intent of the program and therefore are not eligible.
5. Fencing: Fencing is only eligible as it is used to protect the infrastructure that is installed by the program. Program funds shall not be used to fence off riparian areas or wetland habitats.
6. Distribution Systems for Rural Community Fire Suppression: The installation of water distribution lines for the purposes of Rural Community Fire Suppression are not eligible for funding. Eligible projects must focus on supply, storage, and/or transmission.
7. Rehabilitation of a structure that has already been rehabilitated once. Program criteria limit projects to a one-time construction of a new project, a single rehabilitation of an existing project, or eligible subsequent appropriations provided the total grant doesn't exceed $35,000.
8. Completed Projects: Program criteria prohibit the use of funds for the purposes of refinancing projects that have already been completed.
9. Sponsor budgets: Program criteria prohibit funds being used to augment operating budgets. Therefore, sponsors may not send invoices for employee time unless those employees are Licensed Professional Engineers or Geologists whose time was directly used to prepare Small Water Project deliverables.
10. Maintenance: Program criteria prohibit the use of funds for the purposes of maintenance.
11. Personal Items used to complete the project: Items like tools, fuel, generators, and extended warranties that were purchased through the course of the project are not eligible for reimbursement.

Application, Evaluation and Administration

Details of the application and evaluation process and program administrative procedures are provided in the SWPP Operating Criteria available online at and Guidance document available online at the following locations:

https://wwdc.state.wy.us/small_water_projects/SWPPopCriteria.html

https://wwdc.state.wy.us/small_water_projects/SmallWaterProjectsProgramGuidanceDocument.html

Some key aspects of the process and procedures applicable to the potential projects identified in Section 4 include the following:

1. Project Eligibility. Eligible projects will improve watershed condition and function and provide multiple benefits. Projects are defined according to 11 specific project types. On farm projects and project expenses are not eligible.

2. Project Readiness. Project sponsors may apply to seek shovel ready status in order to receive a shovel ready funding priority. This step is not required.

3. Applications shall be received by November 15 of each calendar year. Applications Meeting criteria requirements will be considered during the regularly scheduled WWDC meeting in March. Project applications will be evaluated based on the project description, project location, project partners, project priorities, project readiness, and limited funding analysis.

4. Approved project applications will require a signed Project Agreement between the project sponsor, the State of Wyoming, and the sponsoring district.

6.3.5 Wyoming Wildlife and Natural Resource Trust

The Wyoming Wildlife and Natural Resource Trust (WWNRT) was formed by the state legislature in 2005 to preserve and enhance Wyoming's wildlife and natural resources. Projects funded by WWNRT must provide a public benefit such as continued agricultural production to maintain open space and healthy ecosystems, enhancements to water quality, and maintenance or enhancement of wildlife habitat.

Wildlife and Natural Resource Trust funding is available for a wide variety of projects throughout the state, including natural resource programs of other agencies. Some examples include the following:

- Projects that improve or maintain existing terrestrial habitat necessary to maintain optimum wildlife populations may include grassland restoration, changes in management, prescribed fire, or treatment of invasive plants.
- Preservation of open space by purchase or acquisition of development rights contractual obligations, or other means of maintaining open space.
- Improvement and maintenance of aquatic habitats, including wetland creation or enhancement, stream restoration, water management or other methods.

- Acquisition of terrestrial or aquatic habitat when existing habitat is determined crucial / critical, or is present in minimum amounts, and acquisition presents the necessary factor in attaining or preserving desired wildlife or fish population levels.
- Mitigation of impacts detrimental to wildlife habitat, the environment and the multiple use of renewable natural resources, or mitigation of conflicts and reduction of potential for disease transmission between wildlife and domestic livestock.

Allowable projects under this program that are potentially relevant to this watershed management plan study include:

- Improvement and maintenance of existing aquatic habitat necessary to maintain optimum fish populations.
- Conservation, maintenance, protection and development of wildlife resources, the environment, and Wyoming's natural resource heritage.
- Participation in water enhancement projects to benefit aquatic habitat for fish populations and allow for other watershed enhancements that benefit wildlife.

Funding is by grant with no matching funds required. Non-profit and governmental organizations (including watershed improvement districts, conservation districts, etc.) are eligible for funding by WWNRT- Projects will be funded in July and January. Applications may be filed any time, but must be filed within 90 days of the next funding cycle to receive consideration in that cycle.

6.4 Federal Agencies

6.4.1 Bureau of Land Management

6.4.1a BLM's Riparian Habitat Management Program

This program offers the opportunity to coordinate with outside interests on riparian improvement projects. The goal of BLM's riparian-wetland management is to maintain, restore, improve, protect, and expand these areas so they are in proper functioning condition for their productivity, biological diversity, and sustainability. The overall objective is to achieve an advanced ecological status, except where resource management objectives, including proper functioning condition, would require an earlier successional stage. The goal includes aggressive riparian-wetland information, inventory, training, and research programs as well as improving the partnerships and cooperative management processes.

Partnerships have been available for riparian improvement projects and for research into riparian issues. Funding is available on an annual basis subject to budget allocations from Congress. All submitted cooperative projects compete for the funds available in the riparian program. For information on the riparian habitat program within BLM, please contact (307) 367-5300.

6.4.1b Range Improvement Planning and Development

This program is a cooperative effort not only with the livestock operator but also with other outside interests including the various environmental/conservation groups. Water development, whether it be for better livestock distribution or improved wetland habitats for wildlife, is key to healthy

rangelands and biodiversity. Before actual range improvement development occurs, an approved management plan must be in place. These plans outline a management strategy for an area and identify the type of range improvements needed to accommodate that management. Examples of these plans are Coordinated Resource Plans, Allotment Management Plans, and Wildlife Habitat Management Plans.

All rangeland improvement projects on lands administered by the Bureau of Land Management require the execution of a Permit. Although there are a couple of methods for authorizing range improvements on the public lands, Cooperative Agreement for Range improvements form 4120-6 is the most commonly used method. This applies equally to range improvement projects involving water such as reservoirs, pits, springs, and wells including any associated pipelines for distribution. The major funding source for the Bureau of Land Management's share comes from the range improvement fund which is generated from the grazing fees collected. There, also is a limited amount of funding from the general rangeland management appropriations. If the cooperator is a livestock operator; their contributions come generally in the form of labor. There are times they also provide some of the material costs as well. Contributions from the conservation/environmental interests is monetary and often come in the form of grants, they also contribute labor on occasion. For information on the range improvement program within BLM, please contact (307) 367-5300.

6.4.1c BLM's Watershed and Water Quality Improvement

Under this program, efforts are undertaken in a cooperative approach with the State of Wyoming, Conservation Districts, livestock operators and various conservation groups. Wyoming's BLM is partnering in the implementation of several Section 319 watershed plans state-wide.

It is anticipated that as the Wyoming Department of Environmental Quality (WDEQ) continues the inventory of waters of the State and the identification of impaired and/or threatened water bodies, BLM will be partnering with the WDEQ to improve water quality in water bodies on Public Lands. In the course of developing watershed plans or TMDL's for these watersheds, BLM will be routinely involved in watershed health assessments, planning, project implementation and Best Management Practice (BMP) monitoring.

Now, and in the future, the goals of cooperative watershed projects will typically be the restoration and maintenance of healthy watershed function. These goals will typically be accomplished through approved BMP's, e.g., prescribed burns, vegetation treatments, in-stream structures, to enhance vegetation cover, control accelerated soil erosion, increase water infiltration and enhance stream flows and water quality.

6.4.2 Bureau of Reclamation WaterSMART

The Bureau of Reclamation (BOR) administers the WaterSMART Grants Program. This program provides funding on a competitive basis for projects focused on water conservation, efficiency and water marketing. Preference is given to projects that can be completed within 24 months that will help to prevent crises over water in areas identified as "hot spots" where potential for conflict is judged to be moderately to highly likely by 2025. There is a 50/50 cost sharing for the grants up to $300,000 through a small projects fund and up to $1,000,000 from the large projects fund.

6.4.2a Water and Energy Efficiency Grants

WaterSMART Water and energy efficiency grants are focused on water use efficiency, increased hydropower production, reduced water conflicts, and reliable water supplies in the western U.S. These grants are generally large-scale water development projects.

6.4.2b Water Marketing Strategy Grants

WaterSMART water marketing strategy grants provides assistance to states, tribes, and local governments to establish or expand water markets or water marketing activities. These grants do not fund on-the-ground water efficiency projects.

6.4.2c Small-Scale Water Efficiency Projects

WaterSMART small-scale water efficiency grants focus on water efficiency projects that are relatively limited in scope. Example eligible projects include flow measurement installation, automation of water delivery systems, or canal lining to address seepage. The small-scale water efficiency grants are the most likely source of funding from the WaterSMART program for many of the projects included in this watershed development and rehabilitation plan.

6.4.2d Environmental Water Resources Projects

WaterSMART environmental water resources grants are focused on projects that provide environmental benefits and have been developed through a collaborative process and established strategy for increased water resource reliability. This is a new category of WaterSMART grants beginning to 2021. Eligible projects will result in quantifiable water efficiency improvements and ecological benefits. Example projects include infrastructure improvements to mitigate drought-related impacts, watershed management, or water resources restoration projects providing ecological benefit. The environmental water resources grant program may be a source of funding for irrigation projects that can demonstrate drought mitigation and ecological benefits.

6.4.3 Environmental Protection Agency

The Healthy Watershed Grants Program administered by the Environmental Protection Agency (EPA) "*…is designed to encourage successful community-based approaches and management techniques to protect and restore the nation's watersheds. The Targeted Watersheds Grant program is a competitive grant program based on the fundamental principles of environmental improvement: collaboration, new technologies, market incentives, and results-oriented strategies. The Targeted Watersheds Grant Program focuses on multi-faceted plans for protecting and restoring water resources that are developed using partnership efforts of diverse stakeholders. Targeted Watersheds Implementation Grants are focused on individual watershed organizations. Successful watershed organizations are chosen because they best demonstrated the ability to achieve on-the-ground, measurable environmental results relatively quickly, having already completed the necessary watershed assessments and developed a technically sound watershed plan. Each of the watershed organizations exhibits strong partnerships with a wide variety of support; creative, socio-economic approaches to water restoration and protection; and explicit monitoring and environmentally-based performance measures.*" as described in the following program website: http://water.epa.gov/hwp.

6.4.4 Farm Service Agency

The Farm Service Agency (FSA) administers two potential programs that may be applicable to some of the alternative projects identified in Section 4. Technical assistance for the FSA programs is provided by NRCS. Each of these two programs is briefly discussed below.

6.4.4a Conservation Reserve Program (CRP-C)-Continuous

From the USDA Farm Service Agency; "*Conservation Reserve Program (CRP) is a land conservation program that helps agricultural producers safeguard environmentally sensitive land. CRP participants plant long-term, resource-conserving covers to improve the quality of water, control soil erosion, and enhance wildlife habitat. In return, FSA provides participants with rental payments and cost-share assistance.*"

"*Environmentally desirable land devoted to certain conservation practices may be enrolled in CRP at any time under continuous sign-up. Offers are automatically accepted provided the land and producer meet certain eligibility requirements. Continuous sign-up contracts are 10 to 15 years in duration.*"

Land in the Lower Shoshone River Watershed would qualify for this program under marginal pastureland.

6.4.4b Emergency Conservation Program (ECP)

This program provides emergency funding and technical assistance for implementing emergency livestock watering conservation measures during periods of severe drought and rehabilitating farmland damaged during natural disasters. Cost share assistance up to 75 percent of the cost to implement the emergency measure(s) is available.

The damage from the natural disaster or severe drought must create new conservation problems that if not dealt with would:

- Further damage the land
- Significantly affect the land's productive capacity
- Represent damage from a natural disaster unusual for the area (an exception to this is damage from wind erosion)
- Be too costly to repair without Federal assistance in order to return the land to agricultural production

6.4.5 Fish and Wildlife Service

Technical and financial assistance are available to private landowners, profit or nonprofit entities, public agencies, and public-private partnerships under several programs addressing the management, conservation, restoration or enhancement of wildlife and aquatic habitat (including riparian areas, streams, wetlands and grasslands). These programs include:

6.4.5a Partners for Wildlife Habitat

This program provides technical and financial assistance directly to private landowners through voluntary cooperative agreements called Wildlife Extension Agreements (WEA). The program targets habitats that are in need of management, restoration or enhancement such as riparian areas,

streams, wetlands and grasslands. Under these Wildlife Extension Agreements, private landowners agree to maintain the restoration projects as specified in the agreement but otherwise retain full control of the land.

6.4.5b North American Wetlands Conservation Act Grant Program

This grant program promotes long-term conservation of wetlands ecosystems and the waterfowl, migratory birds, fish and wildlife that depend upon such habitat. Conservation actions supported are acquisition, enhancement and restoration of wetlands and wetlands associated habitat. This program encourages voluntary, public-private partnerships. Public or private, profit or non-profit entities or individuals establishing public-private sector partnerships are eligible. Cost-share partners must at least match grant funds 50/50 with non-federal monies. *Small Grants may not exceed $75,000.*

6.4.5c Cooperative Endangered Species Conservation Fund

This program is available to states that have a cooperative agreement with the Secretary of Interior. The intent is to provide Federal assistance to any state to assist in the development of programs for the conservation of endangered and threatened species. Potential programs include animal, plant and habitat surveys, research, planning, management, land acquisition, protection, and public education. Single states may receive up to 75% of program costs.

6.4.6 Natural Resources Conservation Service

The Natural Resources Conservation Service (NRCS) administers a number of funding and technical assistance programs applicable to many of the alternative projects identified in Section 4. These programs are briefly described below and summarized in Table 6.6-1.

6.4.6a Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) is a voluntary program available to agricultural producers that provides technical assistance, cost sharing and incentive payments for projects and practices that improve water quality, enhance grazing lands, and/or increase water conservation.

Non-federal landowners (including American Indian tribes) that engage in livestock operations or agricultural production are eligible for funding. Eligible land includes cropland, rangeland, pasture, forestland, and other farm and ranch lands. Eligibility also requires that the applicant develop an EQIP plan of operations that becomes the basis of the cost-sharing agreement between NRCS and the participant.

EQIP provides payments up to 75 percent of the incurred costs and income foregone of certain conservation practices and activities. In most cases a 25 percent nonfederal match is required. Farmers and ranchers may elect to use a certified Technical Service Provider (TSP) for technical assistance needed for certain eligible activities and services. Participants may not receive, directly or indirectly, payments that, in the aggregate, exceed $450,000 for all program contracts entered during any six-year period.

Detailed information about the Wyoming EQIP program is available at the following website:

http://www.nrcs.usda.gov/wps/portal/nrcs/main/wy/programs/financial/eqip/

6.4.6b Other NRCS Programs

Other programs administered through NRCS that may be relevant to certain alternative projects discussed in Section 4 include, but are not necessarily limited to the following:

Emergency Watershed Protection (EWP)

From the NRCS website: *"The purpose of the Emergency Watershed Protection Program (EWP) was established by Congress to respond to emergencies created by natural disasters. The EWP Program is designed to help people and conserve natural resources by relieving imminent hazards to life and property caused by floods, fires, drought, windstorms, and other natural occurrences. The U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) administers the EWP Program; EWP-Recovery, and EWP–Floodplain Easement (FPE)."* Public and private landowners are eligible but must be represented by a legal subdivision of the State. The program provides up to 75% of project costs.

Agricultural Management Assistance Program (AMA)

AMA helps agricultural producers use conservation to manage risk and solve natural resource issues through natural resources conservation. Producers receive conservation technical and financial assistance to construct or improve water management or irrigation structures, plant trees for windbreaks or, in order to improve water quality and mitigate risk, diversify their operation and conservation practices including soil erosion control, integrated pest management or transition to organic farming.

Persons or legal entities cannot receive more than $50,000 in AMA program payments per fiscal year.

Conservation Stewardship Program (CSP)

CSP helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resources concerns.

Eligible lands include private and Tribal agricultural lands, cropland, grassland, pastureland, rangeland and nonindustrial private forest land.
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/financial/

6.4.7 US Army Corps of Engineers

The Army Corps of Engineers has civil responsibilities for flood damage reduction, hydroelectric power generation and navigational improvement as well as other water and land resource problems and needs including environmental preservation and enhancement, ecosystem management and comprehensive flood plain management. The Corps is responsible for a worldwide military construction program, an extensive environmental program and a broad national civil works program.

The Corps of Engineers is authorized to provide technical assistance to local communities, States and federally recognized Indian Tribes in support of their efforts to alleviate flooding impacts, reduce erosion and otherwise plan for the wise and prudent use of the nation's water and related land resources. They also have authority to construct certain water resources related projects and respond to water resource needs. These programs have limited application for the types of upland water projects but could find application for bank stabilization or should a larger reservoir type project be considered. The programs are as follows:

6.4.7a Planning Assistance to States

This program provides for assistance in preparation of plans for the development, utilization and conservation of water and related land resources. The Corps provide technical planning assistance in all areas related to water resources development such as bank stabilization, sedimentation, water conservation, ecosystem and watershed planning and water quality. Assistance is limited to $2,000,000 per state and studies are cost-shared on a 50-50 basis with a non-federal sponsor such as a state, public entity or an Indian Tribe.

6.4.7b Flood Plain Management Services

This program provides technical services and planning guidance for support and promotion of effective flood plain management. Flood and flood plain data are developed and interpreted with assistance and guidance provided in the form of "Special Studies" on all aspects of flood plain management planning. All services are provided free of charge to local, regional, state or non-federal public agencies. Federal agencies and private entities have to cover 100% of costs.

6.4.7c Flood Damage Reduction Projects

This program provides structural and non-structural projects to reduce damages caused by flooding and focuses on solving local flood problems in urban areas, towns and villages. The Corps works with the project sponsor to define the flood problem, evaluate solutions, select a plan, develop the design and construct a project. A feasibility study is conducted to identify potential projects with the first $100,000 of the cost Federal. Any cost above this amount is cost-shared 50-50 with the sponsor in the form of cash and in-kind services. Maximum federal share for planning, design and construction is $10,000,000.

6.4.7d Project Modification for Improvement of Environment

The purpose of this program is to modify structures of civil works projects previously constructed by USACE for the purpose of improving environmental quality, especially fish and wildlife values. For most projects it first must be demonstrated that the construction or operation of the project has degraded the quality of the environment. Design and implementation is 75% federal and 25% non-federal.

6.4.7e Aquatic Ecosystem Restoration

This effort is for restoration of historic habitat conditions to benefit fish and wildlife resources. This is primarily to provide structural or operational changes to improve the environment such river

channel reconnection, wetland creation or improving water quality. Conditions are similar to the Project Modification program with sponsor cost share being 35%.

6.4.7f Regulatory Authority/Responsibility

The Corps of Engineers has regulatory authority under the Clean Water Act and the River and Harbor Act. The purpose of these laws is to restore and maintain the chemical, physical and biological integrity of waters of the United States. Section 404 of the Clean Water Act authorizes the Corps to regulate the discharge of dredged or fill material into waters. This would include dams and dikes, levees, riprap, bank stabilization and development fill. There are three kinds of permits issued by the Corps. They are individual, nationwide and Regional General Permits.

6.4.8 USDA Forest Service

A number of Federal laws direct or authorize watershed management on National Forest Service lands. Some of these laws provide broad authority while others deal more narrowly with specific watershed management activities.

The objectives of the Forest Service watershed management program are to protect and enhance soil productivity, water quality, water quantity and timing of water flows and to maintain favorable conditions of stream flow and continuous production of resources from National Forest System watersheds.

It is the policy of the Forest Service to implement watershed management activities on National Forest System lands in accordance with general objectives of multiple use and the specific objectives in the forest land management plans for the area involved. It is also the intent to design management activities of other resources to minimize short term impacts on soil and water resources and to maintain or enhance long term productivity, water quality and water quantity.

The Clean Water Action Plan provides broad water quality direction for the Forest Service. Specific direction for water quality is contained in the Land and Resource Management Plan for each National Forest. The forests in Wyoming are in the process of completing the Inland West Water Reconnaissance which will provide a classification of watersheds and stream reach conditions. Forest Service water quality programs are coordinated with Wyoming Department of Environmental Quality and other appropriate agencies. The Forest Service also has a water rights program that is coordinated with the Wyoming State Engineer.

The Forest Service, in conjunction with other federal, state and local agencies, provides watershed management and condition training. T-WALK and Proper Functioning Condition surveys are field methods used to assess stream reach and other water body conditions.

6.4.9 Rural Utilities Service

The United States Department of Agriculture, Rural Development's utilities program is authorized to provide financial assistance for water and waste disposal facilities in rural areas and towns of up to 10,000 people. This program is intended for Non-profit corporations and public bodies such as municipalities, counties, and special purpose districts and authorities.

Funding may be obtained through Rural Development only when the applicant is unable to secure funding from other sources at reasonable rates and terms. The applicant must have legal capacity to borrow and repay loans, to pledge security for loans and to operate and maintain the facilities. The applicant must be financially sound and able to manage the facility effectively as well as have a financially sound facility based upon taxes, assessments, revenues, fees or other satisfactory sources of income to pay costs of operating, debt service and reserve. Grants are also available and are used to supplement loans to reduce debt service where necessary to achieve reasonable user rates. Assistance is also available on how to assemble information concerning engineering, financing and management of proposed improvements.

Loans and grants may be used to construct, repair, improve, expand or modify rural water supplies and distribution facilities such as reservoirs, pipelines, wells and pumping stations, waste collection, pumping, treatment or other disposal facilities. This assistance may also be used to acquire a water supply or water right or finance facilities in conjunction with funds from other agencies or those provided by the applicant. These funds can be used to pay legal and engineering fees connected with the development of a facility or pay other costs related to development including rights-of-way or easements and relocation of roads or utilities. Loan terms are a maximum of 40 years, State statute, or the useful life, whichever is less with interest rates based on current market yields for municipal obligations.

USDA Rural Development also guarantees loans to eligible commercial lenders to improve, develop, or finance water or waste disposal facilities in rural areas. This guarantees a warrant to protect the lender and may cover up to 90% of the principal advanced. The guarantee fee is 1% of the loan amount multiplied by the percent of the guarantee. Interest rates will be negotiated between the lender and the borrower.

6.5 Non-Profit and Other Organizations

6.5.1 Ducks Unlimited

Ducks Unlimited, Inc. (DU) is a potential funding source for wetlands and waterfowl restoration projects. Direct grant funding is limited but in-kind assistance may be available from the local chapter of DU. Additional information on DU's funding programs and opportunities is available in the Water Management & Conservation Assistance Program Directory referenced previously.

6.5.2 National Fish and Wildlife Foundation

The National Fish and Wildlife Foundation (NFWF) is a private, non-profit, tax exempt organization chartered by Congress in 1984 to sustain, restore and enhance the Nation's fish, wildlife, plants and habitats. NFWF provides grant funding on a competitive basis through their Keystone Initiative Gants and Special Grant Program. Some of the grants/programs that may be applicable to potential projects in the Lower Shoshone River Watershed include, but are not limited to the following:

6.5.2a Pulling Together Initiative

Provides support on a competitive basis for the formation of local Weed Management Area (WMA) partnerships that engage federal resource agencies, state and local governments, private

landowners, and other interested parties in developing long-term weed management projects within the scope of an integrated pest management strategy; minimum 1:1 non-federal match is required.

Funding priorities for this program include:

- Projects that focus on a particular well-defined Weed Management Area, such as a watershed, ecosystem, landscape, or county
- Projects supported by private landowners, state and local governments, and the regional/state offices of federal agencies
- Projects with a Steering Committee composed of local cooperators who are committed to working together to manage invasive and noxious plants across their jurisdictional boundaries
- Long-term weed management plans which are based on an integrated pest management approach using the principles of ecosystem management
- Inclusion of a public outreach and education component, as appropriate

6.5.2b Bring Back the Natives Grant Program

This funding source can be used to restore damaged or degraded riverine habitats and their native aquatic species provided by BLM, Bureau of Reclamation, FWS, Forest Service, and NFWF; minimum 1:1 nonfederal match required. Yellowstone cutthroat trout are one the targeted species.

6.5.2c Five-Star Restoration Program

This program provides modest financial assistance on a competitive basis to support community-based wetland, riparian, and coastal habitat restoration projects that build diverse partnerships and foster local natural resource stewardship through education, outreach and training activities; grants requested must be $20,000 to $50,000.

Information about all of these and other NFWF grants/programs is available at their website:

http://nfwf.org/

6.5.3 Trout Unlimited

The Wyoming Council of Trout Unlimited provides funding and volunteer labor for a variety of Stream and watershed projects such as erosion control and fish habitat structures, willow and other riparian plantings and stream protection fencing. Embrace-A-Stream grants are available for up to $10,000 per project on a 1:1 matching basis. Partnerships are encouraged and can include local conservation districts and state and federal agencies. The grant application is prepared in coordination with the local TU Chapter and submitted by the Chapter. Objectives are to protect, restore, reconnect, and sustain habitat for the conservation of trout. Additional instructions and application can be found at the following website:

http://www.tu.org/conservation/watershed-restoration-home-rivers-initiative/embrace-a-stream

6.6 Funding Summary

The following Table 6.6-1 summarizes the potential funding sources discussed above with contact information, where available. The SWPP and WaterSMART programs were identified as the most likely sources of funding for the majority of the projects included in this watershed management,

development, and rehabilitation plan. SWPP funding eligibility is identified for each of the individual project components listed in Appendix B. WaterSMART funding is focused on water conservation in the western U.S.; and therefore, potentially applicable for many irrigation system improvement projects. Other potential sources of funding for irrigation projects to focus on include the NRCS grant programs such as Agricultural Management Assistance fund (AMA), and the Environmental Quality Incentives Program (EQIP).

Table 6.6-1. Funding Sources

Agency/Entity	Program Name	Project Type	Web Address	Telephone
Local				
Shoshone Conservation District		Technical assistance, state and federal grant partnering, grant applications	www.facebook.com/pages/category/Government-Organization/Shoshone-Conservation-District-103081609763312/	307-548-7422
Big Horn County Weed and Pest		Technical assistance and cost share in the control of noxious and invasive weeds	www.bighorncountywy.gov/departments/weed-pest	307-765-2855
State				
Wyoming Department of Environmental Quality	Watershed Protection Program	Implementation of BMP's	deq.wyoming.gov/wqd/watershed-protection/	307-777-7937
Wyoming Game and Fish Department	Habitat Trust Fund	Habitat acquisition, maintenance or improvements	wgfd.wyo.gov/	307-777-4600
	Fish Passage Grants	Creating and improving passage		
	Wyoming Sage Grouse Conservation Fund	Protection and enhancement of sage grouse habitat		
	Regular Farm Loans	Improvements related to improving farm earning capacity	lands.wyo.gov/	307-777-7331

Wyoming Office of State Lands and Investments	Small Water Development Project Loans	Water development for agriculture		
Wyoming Water Development Commission - Wyoming Water Development Program	Water Resource Planning	Basin wide plans and master planning of water resource development	wwdc.state.wy.us/	307-777-7626
	Groundwater Grant Program	Ground water inventory and development		
	New Development Program	Storage, supply, watershed and recreation projects		
	Rehabilitation Program	Rehab of old (>15yrs) water source and conveyance systems		
	Dam and Reservoir Program	New dams and expansion of existing dams		
Wyoming Water Development Commission - Small Water Project Program		Watershed condition and function, upland water, small reservoirs, wells, pipelines, springs, solar, windmills, and wetlands	wwdc.state.wy.us/small_water_projects/small_water_project.html	307-777-7626
Wyoming Wildlife and Natural Resource Trust Fund		Preservation of open space, ecosystem health, water quality, wildlife habitat	wwnrt.wyo.gov/	307-777-8024
Federal				
	Riparian Habitat Management Program	Wetland function and health	www.blm.gov/wyoming	307-775-6256
	Range Improvement Planning and Development	Rangeland health, watershed BMP's		

Bureau of Land Management	Watershed and Water Quality Improvement			
Bureau of Reclamation	WaterSMART	Water and Energy Efficiency	www.usbr.gov/watersmart/	303-445-2839
		Water Marketing Strategy	www.usbr.gov/watersmart/	303-445-2906
		Small-Scale Water Efficiency	www.usbr.gov/watersmart/	303-445-2764
		Environmental Water Resources	www.usbr.gov/watersmart/	303-445-2839
Environmental Protection Agency	Watershed Grants Program	Watershed restoration	www.epa.gov/nps/funding-resources-watershed-protection-and-restoration	307-777-6733
Farm Service Agency	Conservation Reserve Program (CRP-C)-Continuous	Marginal pastureland qualifies; watershed restoration riparian buffers, shelter belts, erosion control	www.fsa.usda.gov/state-offices/Wyoming/index	307-261-5231
	Emergency Conservation Program (ECP)	Emergency watering, disaster rehabilitation		
Fish and Wildlife Service	Partners for Wildlife	Riparian, wetland, and grassland	www.fws.gov/wyominges/	307-722-2374
	North American Wetlands Conservation Act Grant Program	Wetlands conservation		
	Cooperative Endangered Species Conservation Fund	Habitat surveys, planning, management, land acquisition, public education		
	Environmental Quality Incentives Program (EQIP)	Water quality, land enhancement, water conservation	www.nrcs.usda.gov/wps/portal/nrcs/main/wy/pro	307-765-2483

Natural Resources Conservation Service	Emergency Watershed Protection	Watershed protection related to natural disasters	grams/financial/eqip/	
	Agricultural Management Assistance (AMA) Program	Use conservation to manage risk		
	Conservation Stewardship Program	Maintain exiting conservation systems		
US Army Corps of Engineers	Planning Assistance to States	Planning for conservation of water and land resources, sediment control, watershed planning, water quality	www.nwo.usac.army.mil/Missions/Regulatory-Program/Wyoming/	307-722-2300
	Flood Plain Management Services	Flood plain guidance and special studies		
	Flood Damage Reduction Projects	Flood control in developed areas such as towns or villages		
	Project Modification for Improvement of Environment	Water resource structure modifications for fish and wildlife benefit		
	Aquatic Ecosystem Restoration	Water resource development modifications for fish habitat enhancement		
	Water Resources Projects	Large projects >$10 million; levees; channels, flood plains		
USDA Forest Service	Watershed Management Program	Soil productivity, water quality, water quantity	www.fs.fed.us/	303-275-5350
USDA Rural Utilities Service	Rural Utilities Program	Water and wastewater in rural communities	www.rd.usda.gov/wy	307-233-6710
Private				

Ducks Unlimited		Wetlands and waterfowl restoration projects	www.ducks.org/wyoming/	901-758-3825
National Fish and Wildlife Foundation	Pulling Together Initiative	Weed and invasives management	www.nfwf.org/	Denver Office: 303-222-6482
	Bring Back the Natives Grant Program	Restoration of riverine habitats and native aquatic species		
	Five-Star Restoration Program	Wetlands and riparian habitat restoration		
Trout Unlimited		Erosion control, habitat restoration, fish passage, habitat enhancements	www.wyomingtu.org/	307-421-3288

7.0 CONCLUSIONS AND RECOMMENDATIONS

This section provides the conclusions and recommendations of this Level I watershed study. The conclusions and recommendations pertain to the watershed improvements presented in the Watershed Management, Development, and Rehabilitation Plan (Section 4) and incorporate interpretations from the economic and permitting analyses (Sections 5 and 6).

This Level I watershed study provides an inventory and description of the Lower Shoshone River watershed (Section 3). The study evaluated historic and current conditions and impairments with a focus on identifying opportunities for water resource improvement projects to maintain, enhance, or restore watershed functions. A primary goal of this project was to identify potential projects, or activities that support sustainable water use for current and future generations. Specific project recommendations are described in Section 4 and summarized below.

- **Irrigation and Drainage System Improvements and Rehabilitation:** The irrigation improvement opportunities focus on increasing irrigation coverage on fallow areas, more efficient use of the watershed's water resources, and reduce sediment impacts generated with over application of water to fields and canals. A common discussion with landowners and stakeholders was the need for more efficient irrigation to reduce the need to spill excess water from canals, reduce saturation of erosive soils, reduce salination of soils caused by over application and evaporation of flooded crops and pastures, and eliminate the need to drain fields and reduce development of stagnant waters which increase mosquito and other pests. In many instances, the producers could easily convert the irrigation systems from flood irrigation (e.g. gated pipe) to a low head sprinkler system (e.g. center pivot), but the capital costs for the conversion were typically beyond the economic means of the producers. A watershed wide effort should be developed to improve the economic viability to introduce these conversions that allows the producers to improve their production and reduce impacts

to the watershed. In summary, specific recommendations include converting dirt ditches to gated pipe, pipelines, diversion structures, drainage improvements, canal lining, and irrigation system (e.g., pivot sprinklers) improvements to increase efficiency. A total of 48 potential irrigation and drainage systems improvement and rehabilitation projects were identified ranging in estimated cost from $10,528 to $2,875,848.

- **Water Storage Opportunities:** The water storage improvement opportunities focus on improving upland water storage for winter or off season grazing support for cattle and other livestock and settling ponds to remove sediment prior to flowing downstream to irrigation infrastructure. Existing upland BLM reservoirs were suggested for rehabilitation, but no specific project was ever identified. There appears to be numerous relic reservoirs on the upland BLM land south of Lovell that could be rehabilitated to collect and store seasonal runoff to be applied during the drier times of the year or to support grazing leases on the public land. Specific recommendations include piping existing water rights to uplands for winter watering and rehabilitation of existing reservoirs. No large-scale reservoir projects were identified by project stakeholders. Many stakeholders discussed that the existing Buffalo Bill reservoir has sufficient storage capacity to provide their irrigation needs. A total of 4 potential water storage projects were identified ranging in cost from $82,159 to $874,076.
- **Livestock/Wildlife Upland Water Development Opportunities:**
  The upland water storage improvement opportunities focus on projects discussed above. A total of 5 potential upland water development projects were identified ranging in cost from $33,101 to $614,829.
- **Stream Channel Restoration:**
  The stream channel restoration opportunities focus on stabilizing several highly erodible banks, reducing sediment input, protecting important irrigation infrastructure and production areas, and improving shading and habitat for fish and aquatic species. Specific recommendations include installing non-erodible toe protection, bio-engineered bank protection, and creation of a bankfull bench to improve floodplain function and reduce near bank shear stress. A total of 4 potential channel stabilization projects were identified ranging in cost from $36,308 to $332,904.
- **Wetland Development and Enhancement:**
  One potential wetland project was identified. The focus of the wetland development and enhancement opportunity is on installing cattle crossing on an existing wetland to reduce routine impacts and pocket excavation to improve deeper water habitat for waterfowl and other species. Specific recommendations include removal of monoculture cattails through excavation to produce pocket water habitat to create diversified hemi-marsh habitat. The estimated cost of for the potential wetland project is $34,000.
- **Hydroelectric Power Generation:**
  Hydropower benefits are very limited for most of the small reservoirs present and identified in this study. Sites where a canal sits elevated offer hydro potential (without a reservoir) by

dropping the water to a lower elevation. Unfortunately, this drop also reduces the ability to use the water for irrigation at elevations above the hydro plant. Locations such as siphons can produce power however the water will be unable to rise back to the outlet of the siphon and must be used at lower elevations. In the case of the Deaver Canal and Lovell Canal there are potential sites where the canal is elevated and hydro potential exists. Capital cost is the primary hurdle for any hydropower project. For budgetary purposes costs run about $5million per MW. A 0.36 MW unit, which is the anticipated size of a project in one of the canals, would cost about $1.8 million or about $ 157,000 per year based on 6% for 20 years. The power production based on 10 months or 300 days of annual operation would be about 2,073 MWh equivalent to $103,650 per year at $0.05 per kWh. When O&M costs are accounted for the feasibility is further diminished. No projects were further developed for this study due to the high capital cost and minimal economic feasibility.

- **Range and Grazing Management:** Range and grazing management opportunities in the watershed include the development or rehabilitation of upland water developments, fencing, mineral block placement, and invasive species management. Water developments and invasive species management are discussed in dedicated sections of the report. Mineral block placement and fencing are management tools that can be utilized to encourage grazing in underutilized areas and reduce livestock pressure on sensitive riparian zones.
- **Invasive species:** Invasive species management opportunities are concentrated in the riparian corridors and primarily involve the control of Russian olive and salt cedar. If left unchecked, Russian olive and salt cedar form dense monocultures that outcompete native vegetation, encroach on pastureland, reduce wildlife habitat values, and limit human access. In addition to the woody species, there are a number of herbaceous weeds (e.g., Canada thistle, Russian knapweed, whitetop, etc.) that have been identified as treatment priorities in the watershed. Both Park and Big Horn County Weed and Pest Districts offer technical and financial assistance for treating these species.

8.0 REFERENCES

BRS Engineering. 2003. Irrigation Diversion Operation and Description Memoranda. Wyoming State Water Plan.

Case, J.C., Arneson, C.S., and Hallberg, L.L., 1998, Preliminary 1:500,000-scale digital surficial geology map of Wyoming: Wyoming State Geological Survey, Geologic Hazards Section Digital Map 98-1 (HDSM 98-1), scale 1:500,000

Clausen, E. 2012. Shoshone River-Greybull River Drainage Divide Area Landforms Origins in the Wyoming Bighorn Basin, USA. Retrieved from geomorphologyresearch.com on August 9, 2021.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. USDI Fish and Wildlife Service, Wash. DC. 131pp.

Dey, P. D., T. A. Annear, S. Yekel, R. McKnight 2003. Winter flow recommendations for the Shoshone River below Buffalo Bill Dam. Wyoming. Wyoming Game and Fish Department Administrative Report, Cheyenne.

Engineering Associates. 2002. Deaver Irrigation Rehabilitation Project Levell II Study. Prepared for the Wyoming Water Development Commission.

Engineering Associates. 2009. Willwood Irrigation District Rehabilitation and GIS Level II Study. Prepared for the Wyoming Water Development Commission.

Greenwood Mapping, Inc. 2007. Framework Water Plan, Irrigated Lands and Water Rights Technical Memorandum.

Hamerlinck, J.D., and Arneson, C.S., editors, 1998, Wyoming ground water vulnerability assessment handbook, Volume 1 – Background, model development, and aquifer sensitivity analysis: Laramie, University of Wyoming, Spatial Data and Visualization Center Publication SDVC 98-01-1.

Inberg-Miller Engineers. 1994. Sidon Canal Rehabilitation Project Level II Project Report. Prepared for the Wyoming Water Development Commission.

Isaak, D.J.; Wenger, S.J.; Peterson, E.E.; Ver Hoef, J.M.; Hostetler, S.W.; Luce, C.H.; Dunham, J.B.; Kershner, J.L.; Roper, B.B.; Nagel, D.E.; Chandler, G.L.; Wollrab, S.P.; Parkes, S.L.; Horan, D.L. 2016. NorWeST modeled summer stream temperature scenarios for the western U.S. Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2016-0033.

James Gores and Associates. 1990. Globe Canal Investigations Level II Final Report. Prepared for the Wyoming Water Development Commission.

Leopold, L.B. and J.P. Miller. 1954. A Postglacial Chronology for Some Alluvial Valleys in Wyoming. Geological Survey Water-Supply Paper 1261. United States Government Printing Office.

Libra, R., D. Doremus, and C. Goodwin. 1981. Volume II-A Occurrence and Characteristics of Ground Water in the Bighorn Basin, Wyoming. Water Resources Research Institute, University of Wyoming.

Lovell Hydropower Study Level II Final Report. (2003). A&H Consulting, Inc.

Lowham, H.W. 2009. Estimating streamflow from concurrent discharge measurements. Prepared for Wyoming Water Development Commission.

Merit Energy Company. 2020. Wyoming Pollutant Discharge Elimination System (WYPES) Permit Renewal Application Submittal.

Mackin, J.H. 1937. Erosional history of the Big Horn Basin, Wyoming. GSA Bulletin (1937) 48 (6): 813–894.

McElroy, B. 2017. Report on Potential to Flush Shoshone River Channel of Fine Sediment Deposited after October 2016 Evacuation from Willwood Dam. Sedimentary Petrology Laboratory, Department of Geology & Geophysics, University of Wyoming.

Miller, 2003. Peak-Flow Characteristics of Wyoming Streams. U.S. Geological Survey, Water-Resources Investigations Report 03-4107.

Miselis, D.V, Wesche, T.A., and Lowham, H.W., 1999, Development of hydrologic models for estimating streamflow characteristics of Wyoming's mountainous basins: Laramie, Wyoming, Project Completion Report submitted to the University of Wyoming Research Office.

Mitsch, W. J. and J. G. Gosselink. 1986. Wetlands. New York, Van Nostrand Reinhold. 539 pp.

MWH. 2010. Task 3C – Industrial and Mining Water Use Technical Memorandum. Prepared for the Wyoming Water Development Commission.

NatureServe Explorer. 2014. Western Great Plains Riparian Ecological System. https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.722725/Western_Great_Plains_Riparian. Accessed August 10, 2021.

Nicholoff, S. H. 2003. Wyoming Bird Conservation Plan, Version 2.0. Wyoming Partners In Flight. Wyoming Game and Fish Department, Lander.

https://wgfd.wyo.gov/Wildlife-in-Wyoming/More-Wildlife/Nongame-Birds/Bird-Conservation-Plan

NRCS (Natural Resources Conservation Service), 2007, Part 654 Stream Restoration Design, National Engineering Handbook, United States Department of Agriculture.

NRCS. 2011. Conservation Benefits of Rangeland Practices: Assessment, Recommendations, and Knowledge Gaps, D. D. Briske (ed.), Allen Press, Inc., Lawrence, KS.

NRCS. 2021a. Ecological site R032XY144WY Saline Upland (SU) 5-9" Big Horn Basin Precipitation Zone.

NRCS. 2021b. Ecological site R032XY150WY Sandy (Sy) 5-9" Big Horn Basin Precipitation Zone.

NRCS. 2021c. Ecological site R032XY154WY Shale (Sh) 5-9" Big Horn Basin Precipitation Zone.

NRCS. 2021d. Ecological site R032XY138WY Saline Lowland (SL) 5-9" Big Horn Basin Precipitation Zone.

Pavlica, J. 2021. Small Water Projects Program Guidance Document. Wyoming Water Development Office, Cheyenne, Wyoming.

Plafcan, Maria, Cassidy, E.W., and Smalley, M.L., 1993, Water resources of Big Horn County, Wyoming, with a section on Water-right administration, by R.G. Stockdale: U.S. Geological Survey Water-Resources Investigations Report 93-4021, 142 p., 2 pl.

Rosgen, D.L., 1994. A Stream Classification System. Catena, 22 169199. Elsevier Science, Amsterdam

Rosgen, D.L. 1996. Applied River Morphology. Pagosa Springs, CO ; Wildland Hydrology Books.

Rosgen, D.L. 2006. A Watershed Assessment for River Stability and Sediment Supply. Wildland Hydrology Books, Fort Collins, CO.

Rosgen, D.L. 2012. Valley Types, draft manuscript, Wildland Hydrology Books, Fort Collins, COSage (Sage Civil Engineering). 2015. Willwood Irrigation District, Master Plan Update Level I Study. Prepared for the Wyoming Water Development Commission.

Sage (Sage Civil Engineering). 2016. Deaver Irrigation District, Master Plan Update Level I Study. Prepared for the Wyoming Water Development Commission.

Sage (Sage Civil Engineering). 2017. Lovell Irrigation District, Master Plan Level I Study. Prepared for the Wyoming Water Development Commission.

Sawyer, H., M. Hayes, B. Rudd, and M.J. Kauffman. 2014. The Red Desert to Hoback mule deer migration assessment. U. Wyoming, Wyoming Migration Initiative, Laramie.

Shoshone Municipal Pipeline Website (www.shoshonemunicipalpipeline.org/index.html)

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at https://websoilsurvey.nrcs.usda.gov/.

State of Wyoming. 2019. State of Wyoming Executive Department Executive Order 2019-3 Greater Sage-Grouse Core Area Protection. 58pp. Available online at:

https://wgfd.wyo.gov/WGFD/media/content/PDF/Habitat/Sage%20Grouse/Governor-Gordon-Greater-Sage-Grouse-EO-2019-3_August-21-2019_Final-Signed_2.pdf

Sutherland, W.M. 2014. Wyoming Bentonite Summary Report. September 2014. Wyoming State Geological Survey.

Swenson, F. A., and Swenson, H. A., 1957, Geology and groundwater, Heart Mountain and Chapman Bench Divisions, Shoshone Irrigation Project, Wyoming: U.S. Geol. Survey Water-Supply Paper 1418, 55 p.

Taboga, K.G., and J.E. Stafford. 2016. Wyoming State Geological Survey Statewide Groundwater Recharge Study. Wyoming State Geological Survey. Open File Report 2016-8. Laramie, Wyoming.

Taucher, P. T.T. Bartos, K.E. Clarey, S.A. Quillinan, L.L. Hallberg, M.L. Clark, M. Thompson, N. Gribb, B. Worman, and T. Gracias. 2012. Wind/Bighorn River Basin Water Plan Update Groundwater Study Level I (2008-2011). Laramie, Wyoming.

Tiner, R.W. 1997. NWI Maps: What They Tell Us. National Wetlands Newsletter. Volume 19. No. 2. Environmental Law Institute. Washington, DC. 6pp.

Town of Cowley Water Master Plan http://library.wrds.uwyo.edu/wwdcrept/Cowley/Town_of_Cowley-Master_Plan_Study_Level_I-Executive_Summary-2016.pdf)

Town of Cowley Water Master Plan Study Final Report. (2016) Morrison Maierle

Town of Deaver Level I Master Plan Final Report. (2001) TREC

USBR (U.S. Bureau of Reclamation). 2010 Bighorn Lake Sediment Management Plan Final Report. completed by the Omaha District Corps of Engineers, Hydrologic Engineering Branch, Sedimentation and Channel Stabilization Section for the Bureau of Reclamation, Great Plains Region, Montana Area Office. Work was performed under Interagency Agreement No. 07AA602252.

USFS (U.S. Forest Service). 2015. Western U.S. Stream Flow Metrics. Rocky Mountain Research Station Air, Water, & Aquatic Environments Program. Available online at: http://www.fs.fed.us/rm/boise/AWAE/projects/modeled_stream_flow_metrics.shtml

Waterstreet, D. 2021. Presentation: Managing Sediment at Willwood Dam to Protect Downstream Fisheries, June 21, 2021. Wyoming Department of Environmental Quality Water Quality Division, Watershed Protection Section. Available online at:

https://westernstateswater.org/wp-content/uploads/2021/01/Waterstreet_Willwood-Dam-on-the-Shoshone-River-061721.pdf

WDAC (Willwood Dam Advisory Committee). 2017. Willwood Dam Advisory Committee and Working Groups Terms of Reference. June 27, 2017.

WDEQ (Wyoming Department of Environmental Quality). 2020. Wyoming's 2020 Integrated 305(b) and 303(d) Report. Water Quality Division – Watershed Protection Program. Cheyenne, WY.

WDEQ. 2021. Wyoming Surface Water Classification List. Cheyenne, WY.

Wenck (Wenck Associates, Inc. and Western EcoSystems Technology, Inc.). 2019. Agricultural, Municipal, Domestic, and Industrial Water Use Index Technical Memo. Prepared for the Wyoming Water Development Commission.

WGFD (Wyoming Game and Fish Department). 2017. State Wildlife Action Plan 2017 (SWAP), Cheyenne, WY.

WGFD. 2017. Shoshone River Basin Management Plan (BMP), Cheyenne, WY.

WGFD. 2020. Statewide Habitat Plan 2020 (SHP), Cheyenne, WY. 44pp.

WGFD. 2021. Statewide Habitat Plan 2020 Priority Areas. ArcGIS Story Map. Available online at:

https://wgfd.maps.arcgis.com/apps/MapSeries/index.html?appid=4f325cb8a9b247df8753fd37919b727e

WGFD. "Conserving Wildlife - Serving People." Wyoming Game and Fish Department – Yellowtail. Available online at:

http://wgfd.wyo.gov/Public-Access/WHMA/WHMA/Yellowtail.

WOGCC (Wyoming Oil and Gas Conservation Commission). 2020. Wyoming Oil and Gas Conservation Commission 2020 County Production Report. Available online at: http://pipeline.wyo.gov/legacywogcce.cfm

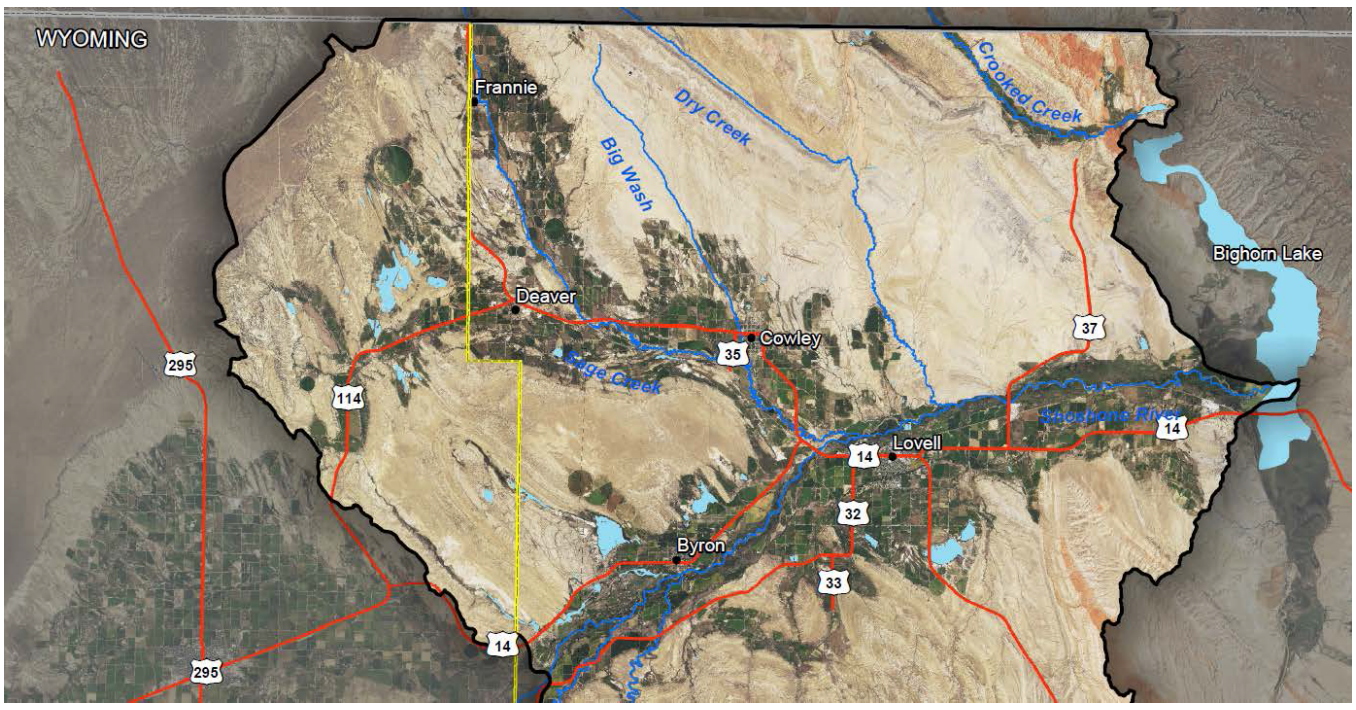
WWDC. 2018. Public Water System Survey Report. Available online at

wwdc.state.wy.us

WWG 3 (Willwood Working Group #3). 2021. Working Together to Protect the Shoshone River. ESRI Story Map available online at: https://wdeq.maps.arcgis.com/apps/Cascade/index.html?appid=ed288248983c467b9365852bd32f01c1

WWG 3 (Willwood Working Group #3). 2021a. Sediment Watershed Plan for the Shoshone River from Buffalo Bill Reservoir to Willwood Dam. ESRI Story Map available online at: https://wacd.maps.arcgis.com/apps/Shortlist/index.html?appid=69c4ca45589e46d6b7a348e23c65e58e

LOWER SHOSHONE RIVER LEVEL I WATERSHED STUDY
APPENDIX A



MARCH 11 2022

PREPARED FOR:
WYOMING WATER DEVELOPMENT COMMISSION
SHOSHONE CONSERVATION DISTRICT

PREPARED BY:
BIOTA RESEARCH AND CONSULTING, INC.

IN ASSOCIATION WITH:
SUNRISE ENGINEERING, INC.

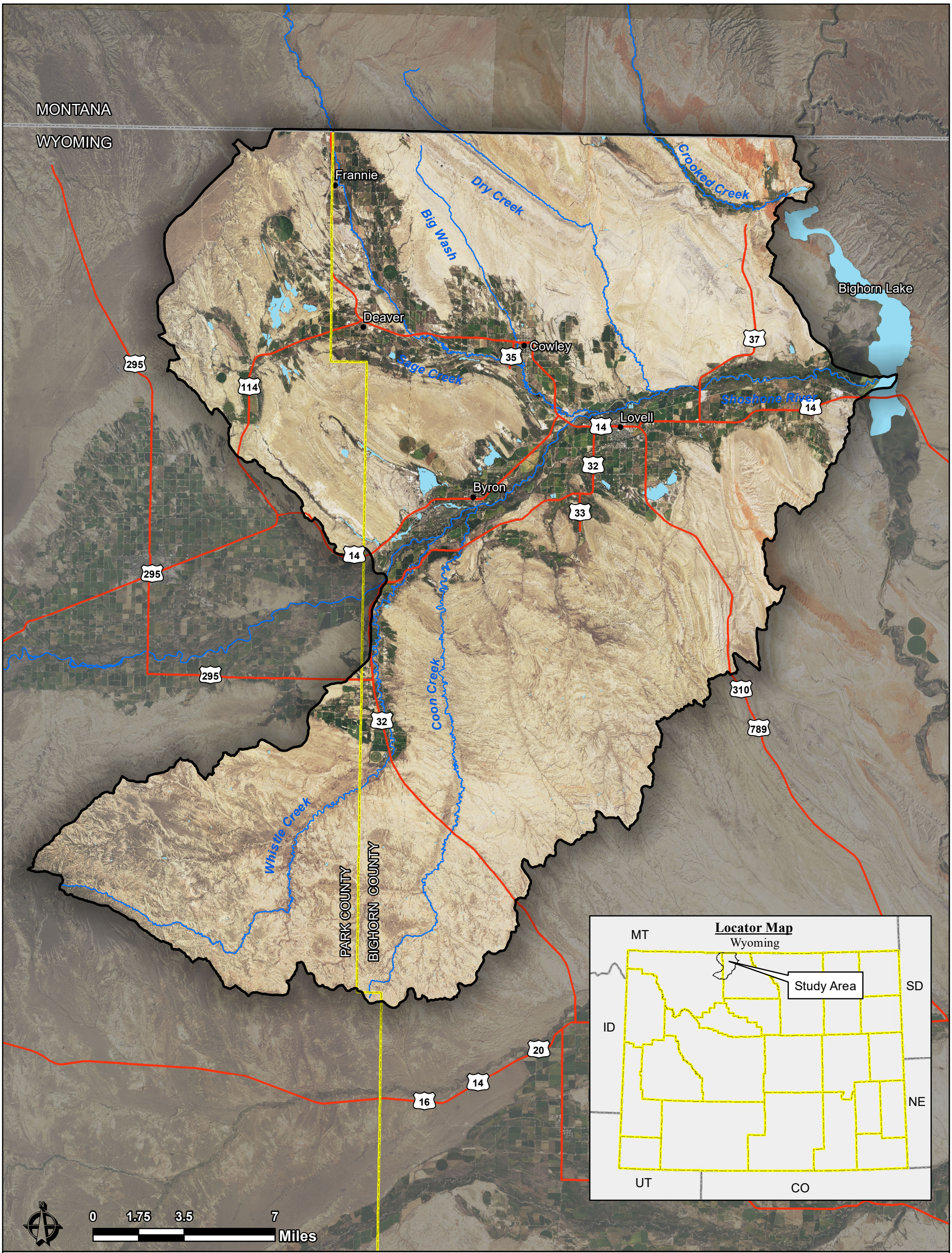
Appendix A - Lower Shoshone River Level I Watershed Study

WWDC Contract Number 05SC0298344

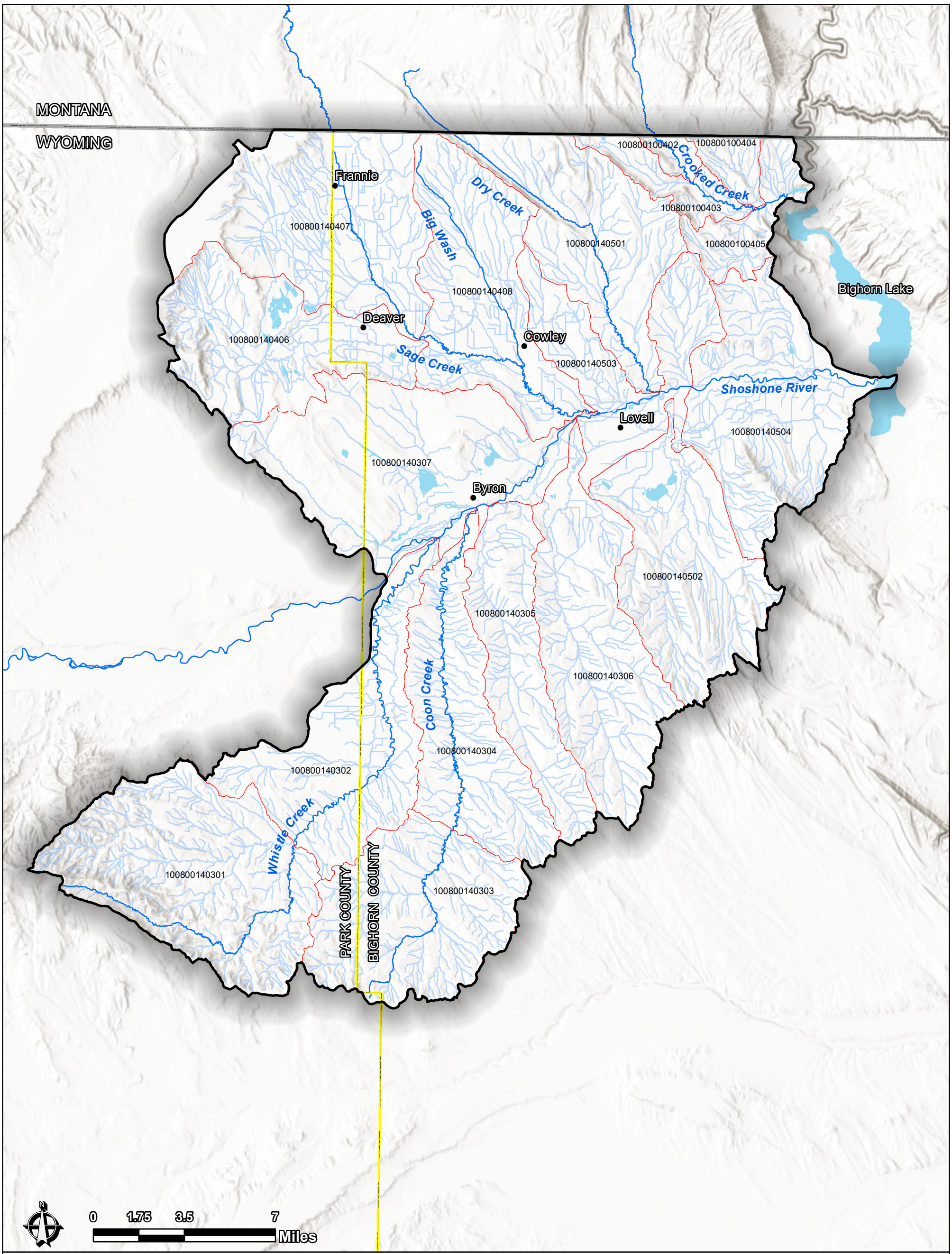
MARCH 11, 2022

List of Maps

Map 1 Watershed Location and Study Area
Map 2 Hydrology
Map 3 Stream Gauging Stations
Map 4 Climate Predictions
Map 5 Geomorphic Rosgen Type Stream Channel Classification
Map 6 Geomorphic Valley Type Stream Channel Classification
Map 7 Principal Aquifers
Map 8 U.S. Geological Survey (USGS) Mapped Springs
Map 9 Wyoming State Engineer's Office (SEO) Permitted Wells
Map 10 Watershed Topography
Map 11 STATSGO2 Soils U.S. General Mapping (legend on separate page)
Map 12 Surficial Geology (legend on separate page)
Map 13 Geological Hazards
Map 14 Bedrock Geology
Map 15 Average Annual Parameter-elevation Regressions on Independent Slopes Model (PRISM) Precipitation 1981-2010
Map 16 Habitat Priority Areas 2020 Wyoming Game and Fish Department (WGFD) Statewide Habitat
Map 17 Plan Wyoming Game and Fish Department (WGFD) Trout Stream Class
Map 18 In-stream Structures
Map 19 Greater Sage-Grouse Core Population Areas
Map 20 National Land Cover Database (NLCD) Land Cover (legend and focus area on separate pages)
Map 21 Landfire Land Cover Classification (legend on separate page)
Map 22 Northwest Gap Analysis Program (GAP) Land Cover (focus area and legend on separate pages)
Map 23 National Wetlands Inventory (NWI) Mapped Wetlands (focus area on separate page)
Map 24 Irrigated Lands
Map 25 Water Systems
Map 26 Agricultural Crops National Agricultural Statistics Service (NASS) (legend on separate page)
Map 27 Water Basins
Map 28 Functional Water Basins
Map 29 Non-Functional Water Basins
Map 30 Ecological Sites (legend on separate page)
Map 31 Land Ownership
Map 32 Transportation and Communication Infrastructure
Map 33 Wyoming Pollutant Discharge Elimination System (WYPDES) Permits
Map 34 Oil and Gas Resources
Map 35 Mines and Minerals
Map 36 Grazing Allotments
Map 37 Cultural Resources Per-Section
Map 38 National Register of Historic Places (NRHP)
Map 39 Potential Projects

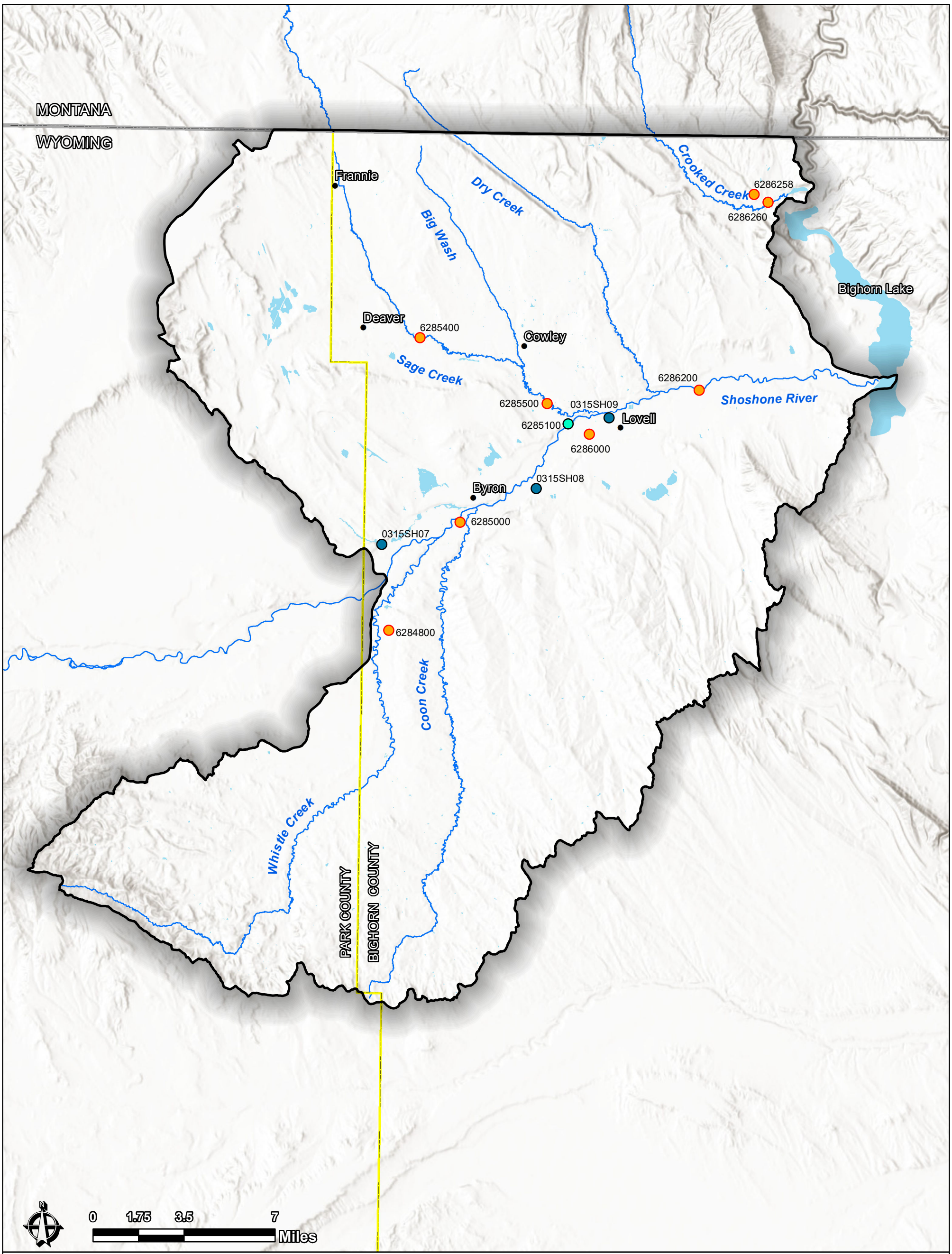


MAP 1	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: 2019 NAIP IMAGERY	**WATERSHED LOCATION AND STUDY AREA** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
County Boundary
Major Waterbody
Major Watercourse
HUC12 Boundary with 12-Digit Code
NHD Flowline Mapping

MAP 2	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI World Hillshade	**HYDROLOGY** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota

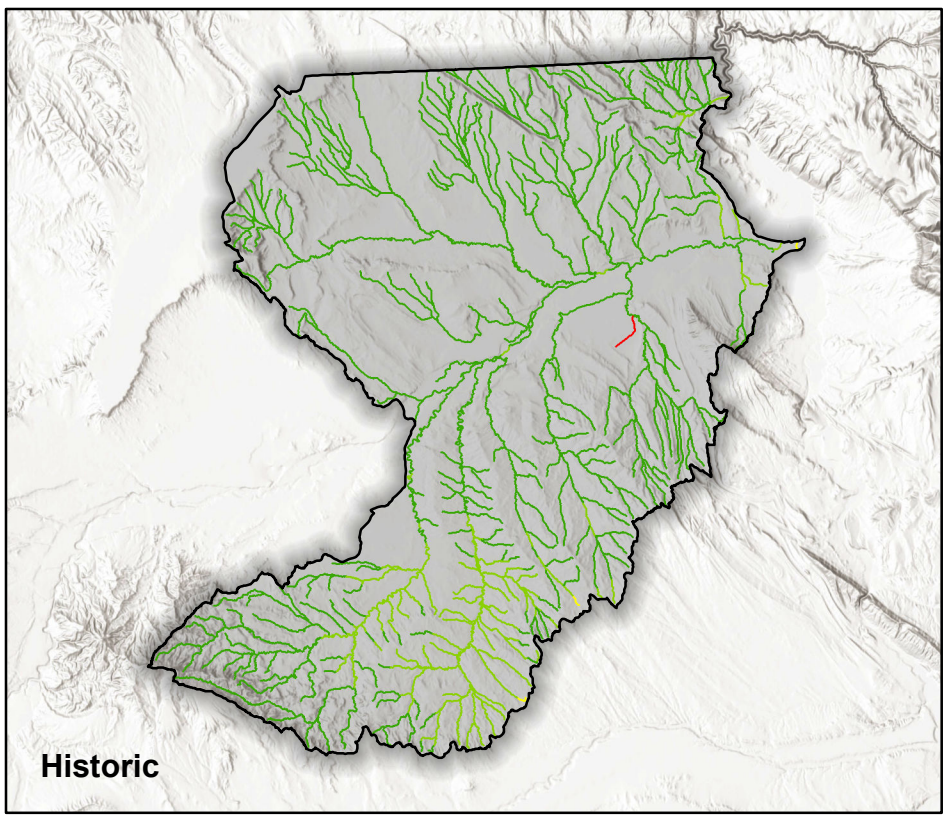


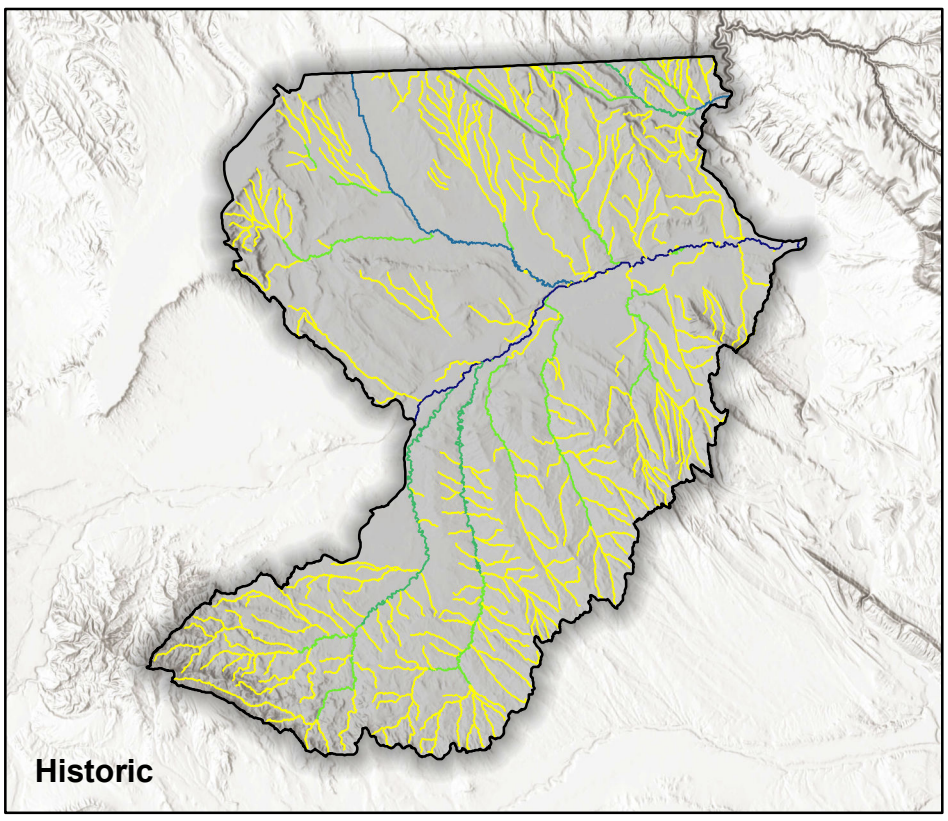
Lower Shoshone Watershed Study Area
State Boundary
County Boundary
Major Waterbody
Major Watercourse

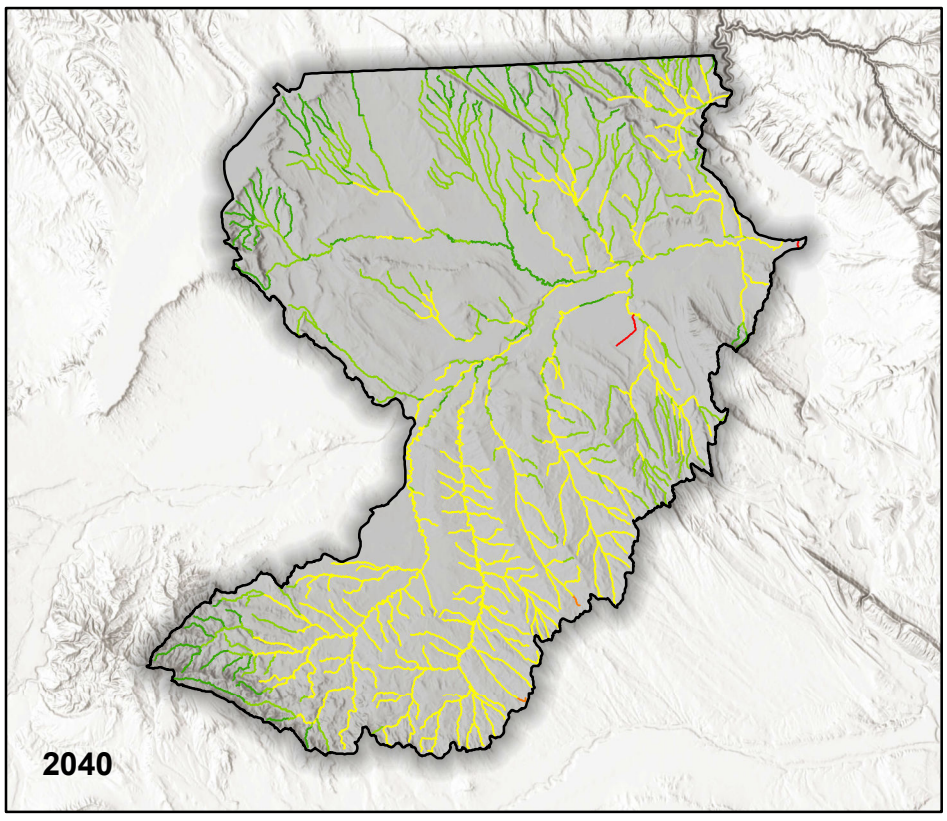
Stream Gauging Stations

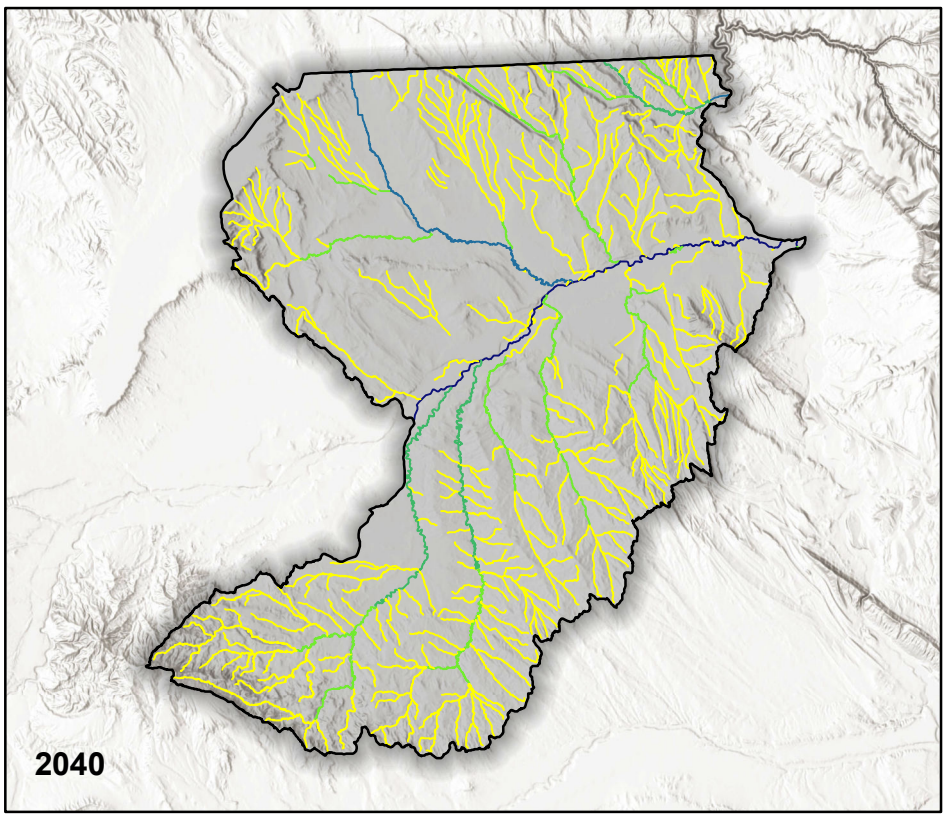
SEO - Active
USGS/SEO - Active
USGS - Inactive

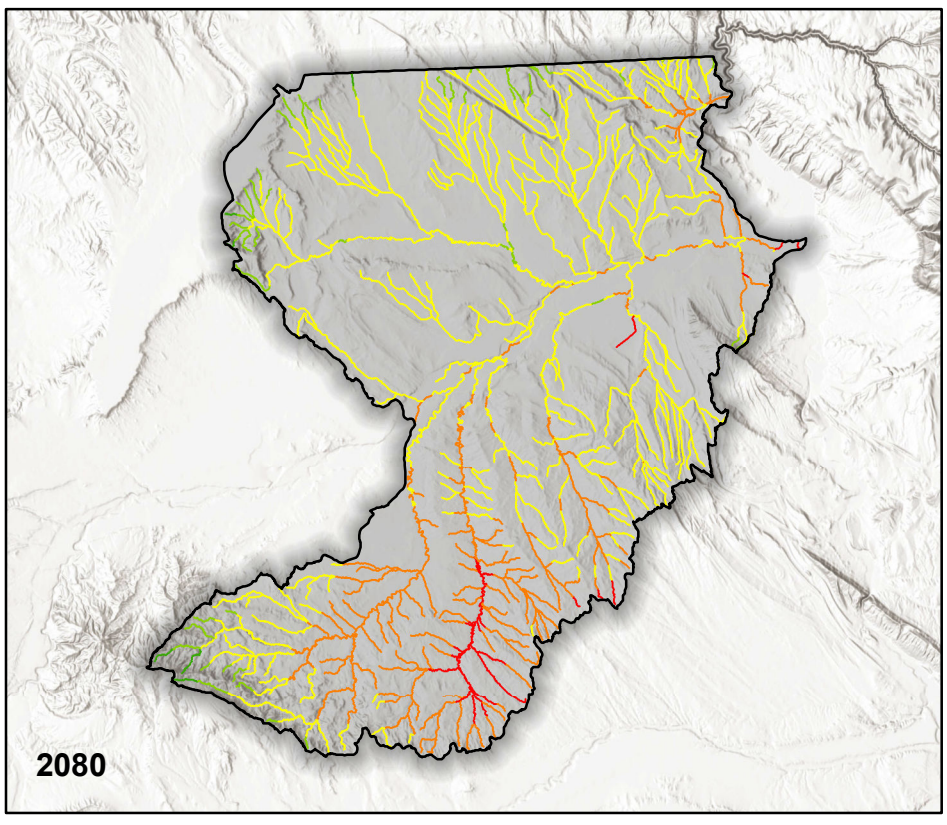
MAP 3	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI World Hillshade	**STREAM GAUGING STATIONS** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota

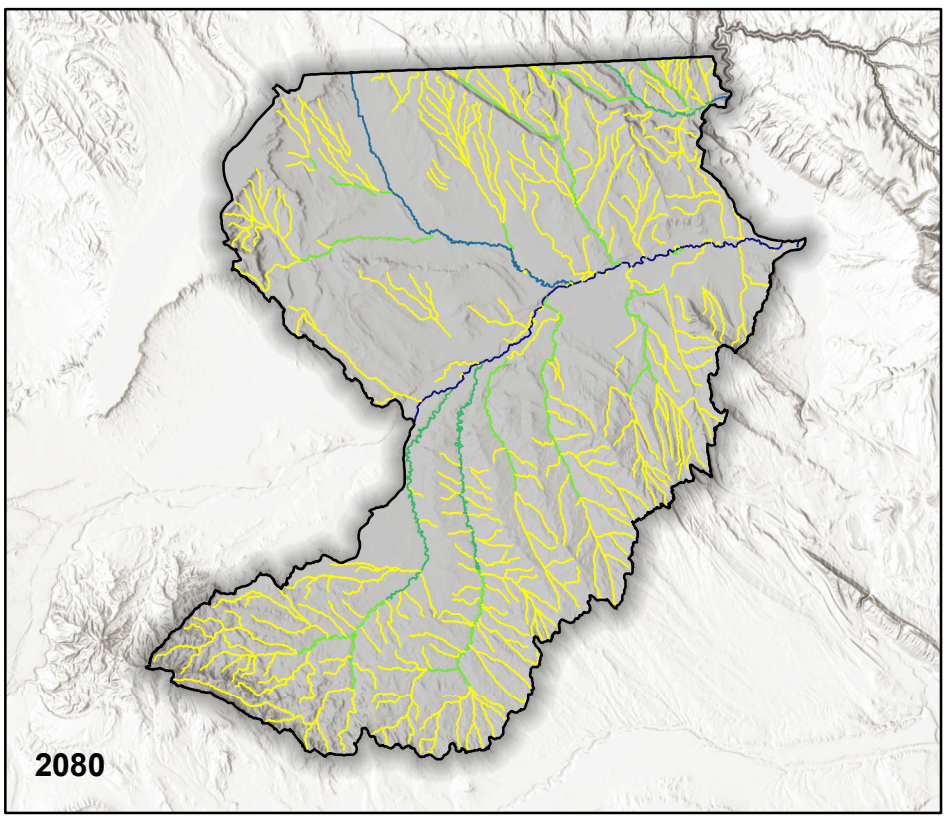












Mean August Water Temperature (F)

- 61 to 63
- 63 to 64
- 64 to 66
- 66 to 67
- 67 to 74

Lower Shoshone Watershed Project Area

0 2.25 4.5 9 13.5 18 Miles

Mean Summer (June 1 to Sept. 30) Flow (cfs)

- 0 to 1
- 1 to 5
- 5 to 10
- 10 to 40
- 40 to 3124

MAP 4

PROJECT: 05SC0298344

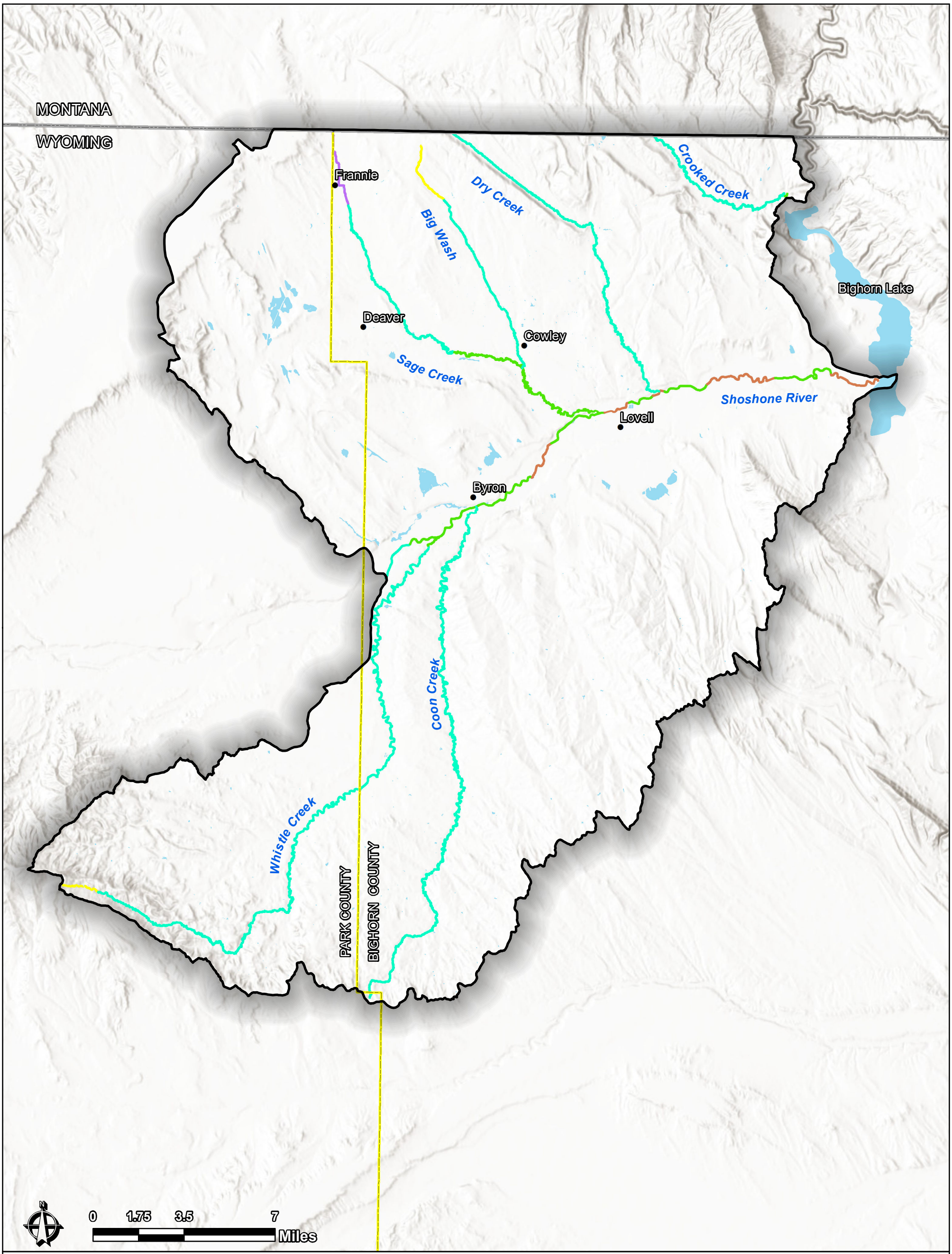
DATE: O1/10/2022

SCALE: 1 inch = 3.5 Miles
UNITS: Miles
BASEMAP: ESRI World Hillshade

CLIMATE PREDICTIONS

Lower Shoshone Level 1 Watershed Study
Park and Bighorn County, Wyoming

research & consulting inc.
Biota

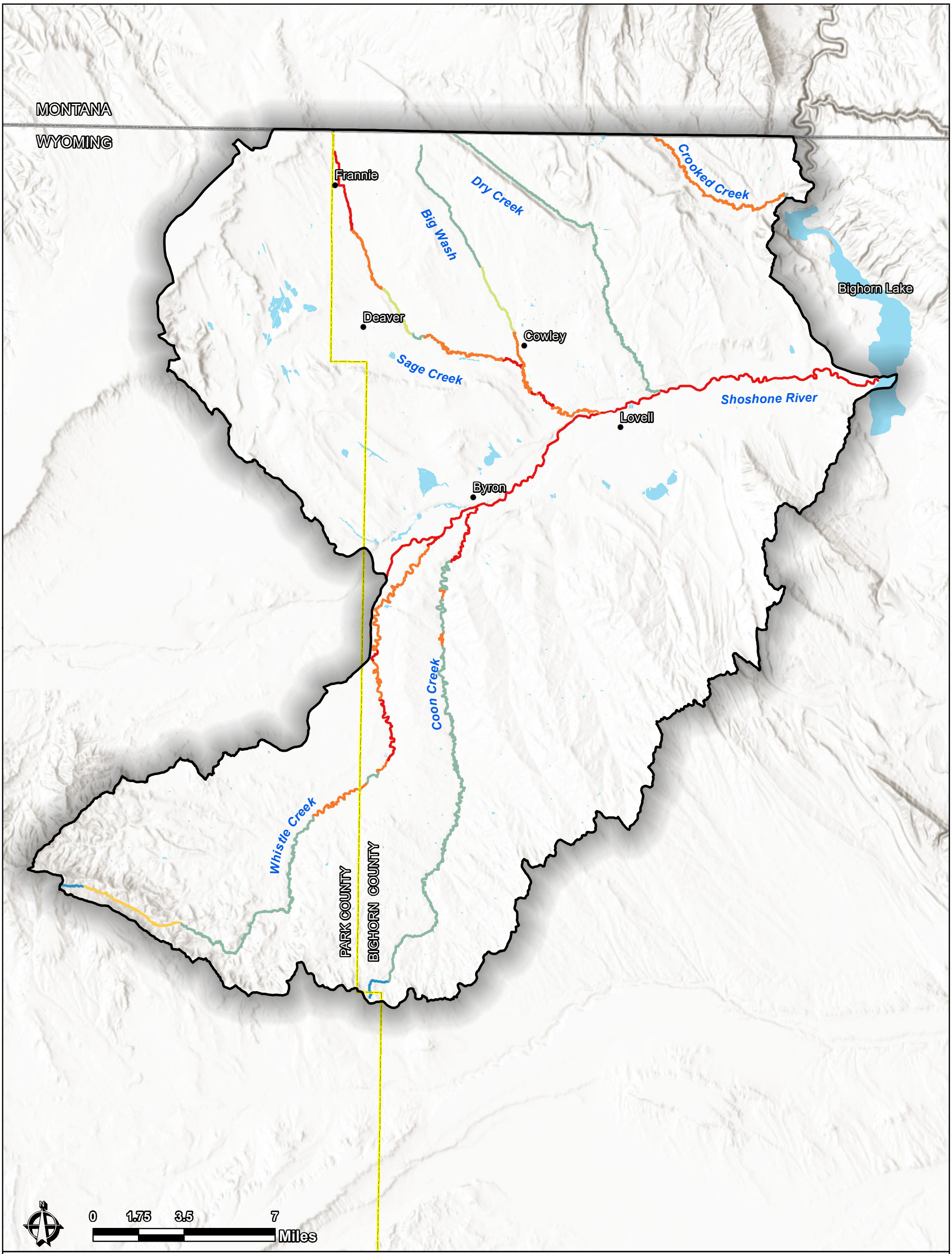


Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody

RosgenType

A
B
C
D
E

MAP 5	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI WORLD HILLSHADE	**GEOMORPHIC ROSGEN TYPE STREAM CHANNEL CLASSIFICATION** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota

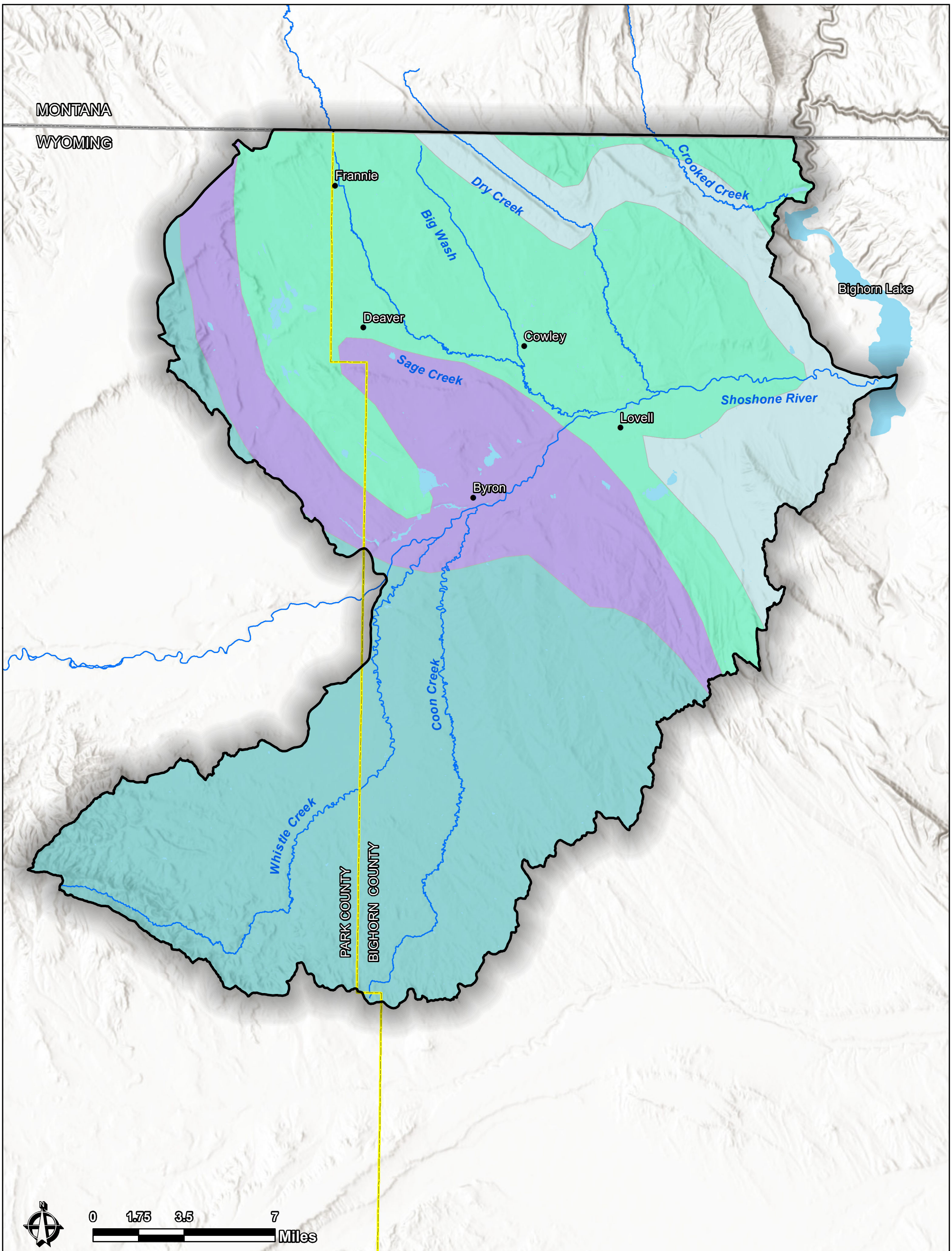


Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody

ValleyType

- I
- II
- IV
- VII
- VIIIa
- VIIIb

MAP 6	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI WORLD HILLSHADE	**GEOMORPHIC VALLEY TYPE STREAM CHANNEL CLASSIFICATION** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse
Upper Cretaceous Aquifers
Lower Cretaceous Aquifers
Lower Tertiary Aquifers
Unnamed Rock Aquifers

MAP 7

PROJECT: 05SC0298344

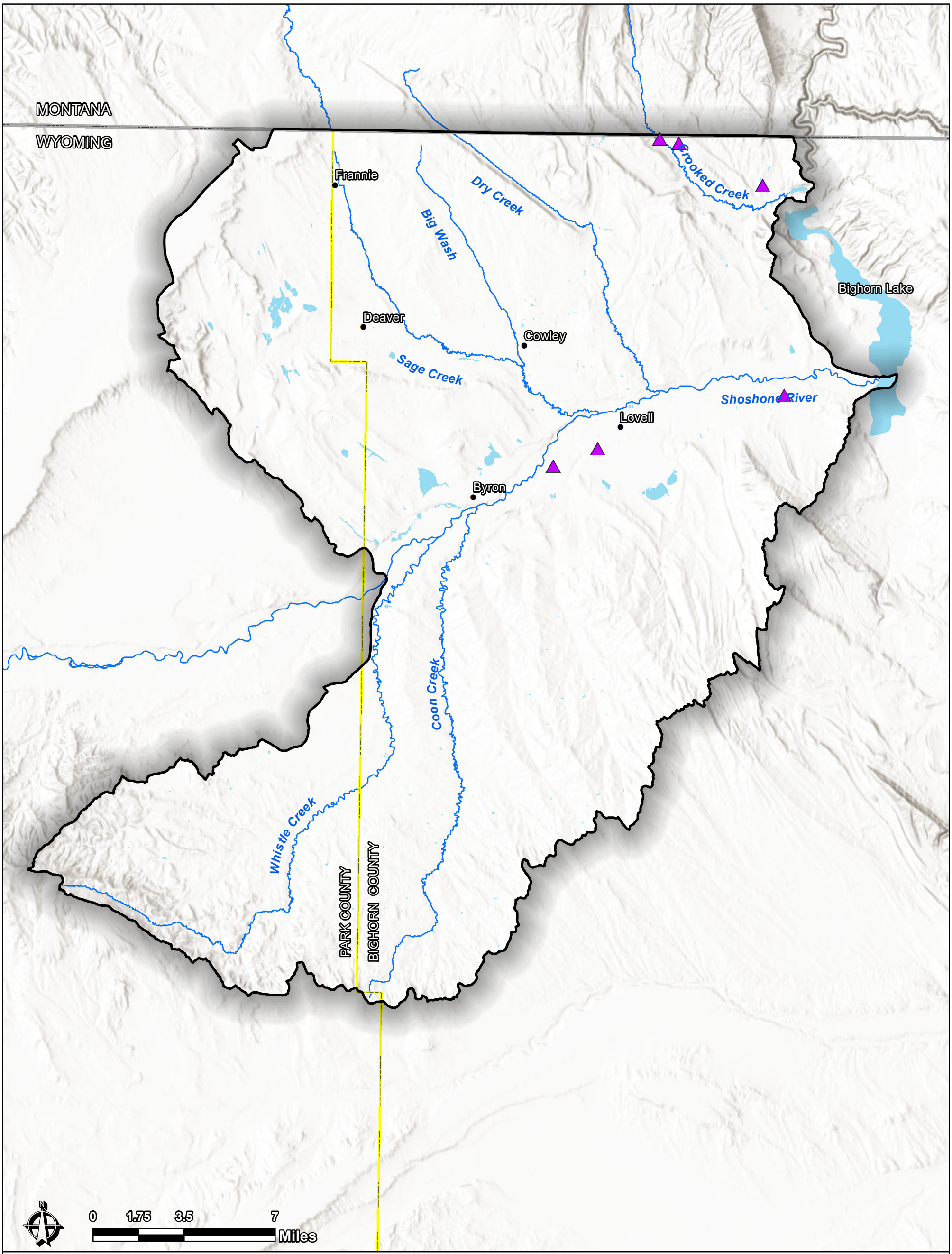
DATE: O1/10/2022

SCALE: 1 inch = 3.5 Miles
UNITS: Miles
BASEMAP: ESRI WORLD HILLSHADE

PRINCIPAL AQUIFERS

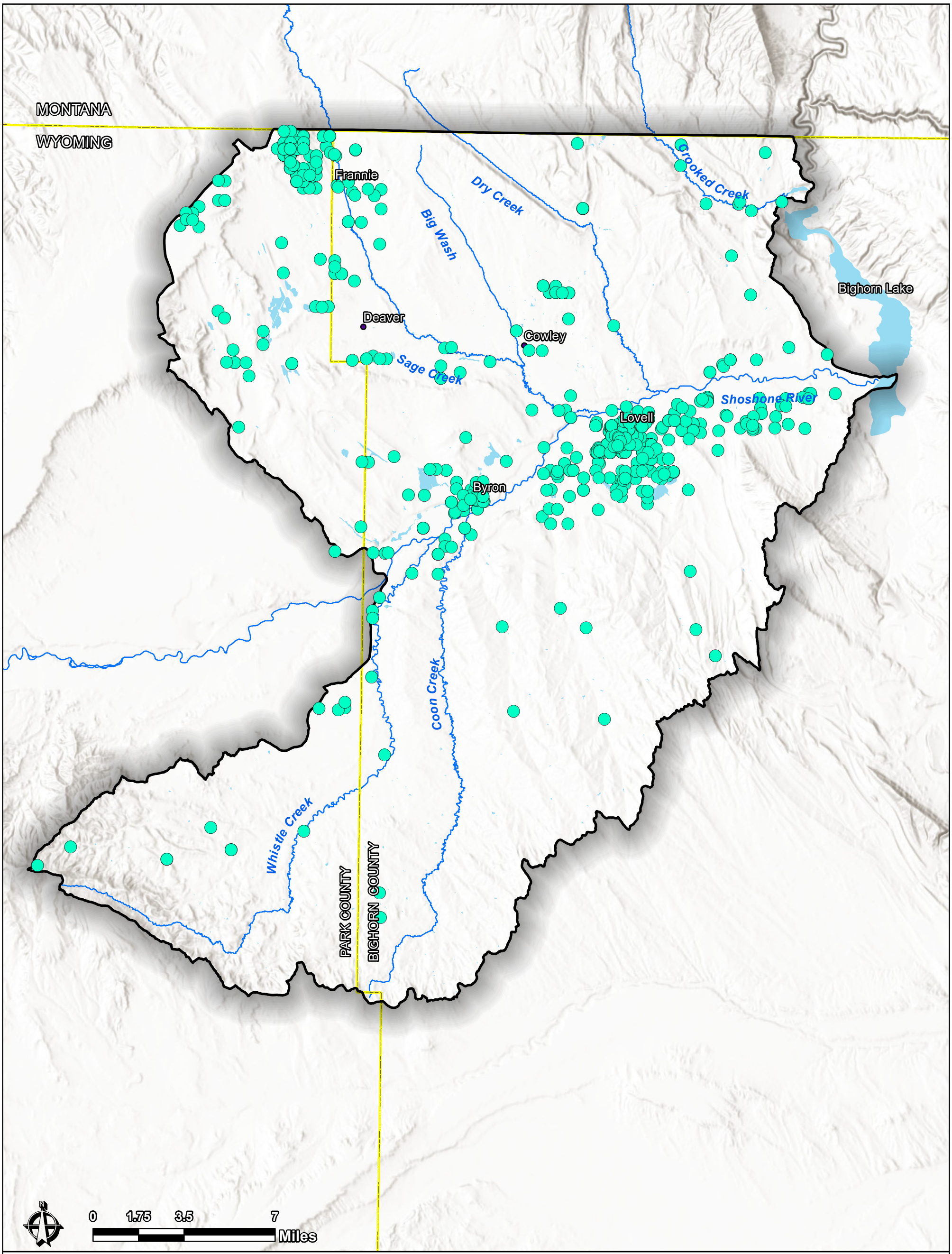
Lower Shoshone Level 1 Watershed Study
Park and Bighorn County, Wyoming

research & consulting inc.
Biota



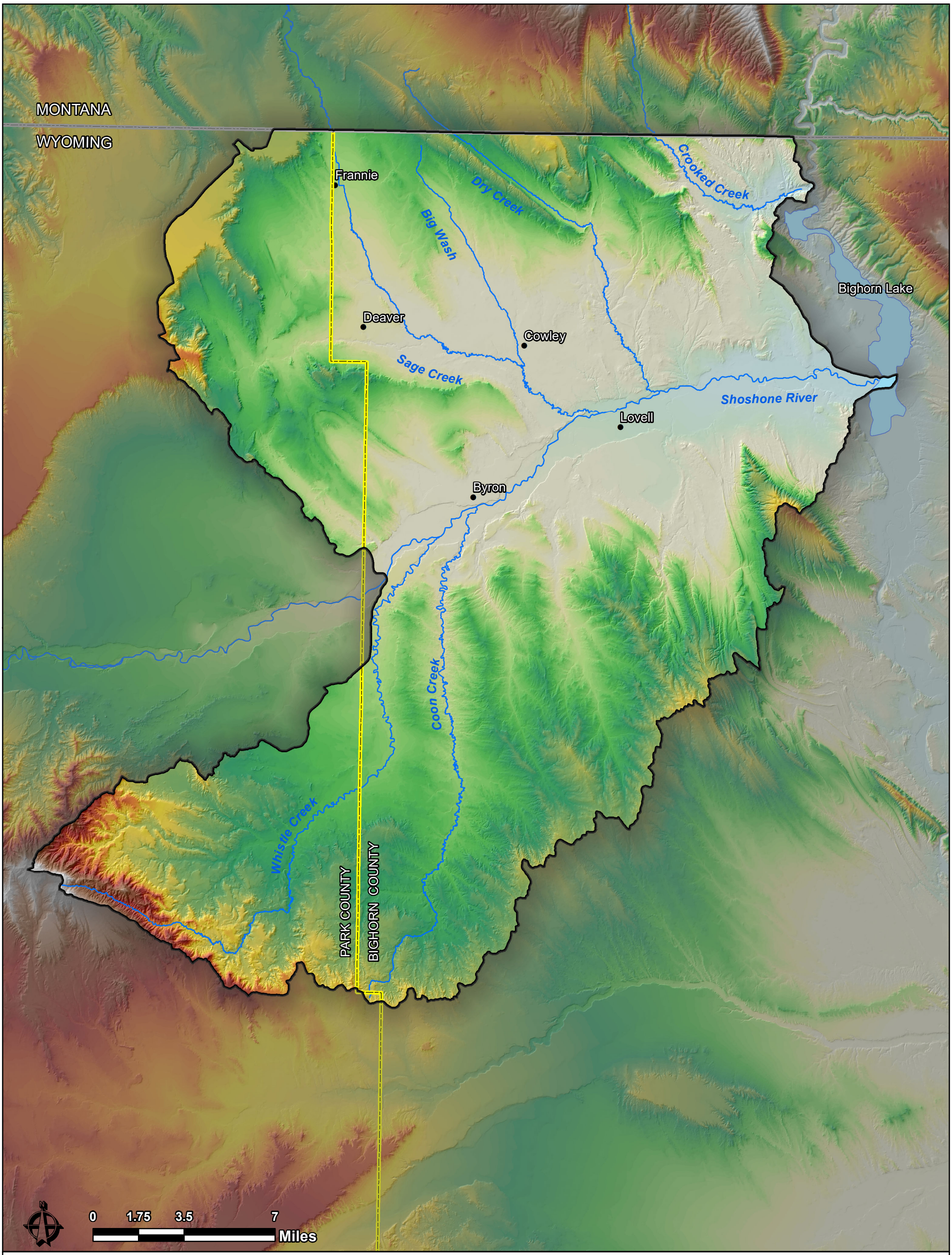
Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Water Body
Major River/ Creek
Inactive Spring

MAP 8	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI World Hillshade	**USGS MAPPED SPRINGS** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse
SEO Permitted Wells

MAP 9	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI World Hillshade	**SEO PERMITTED WELLS** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



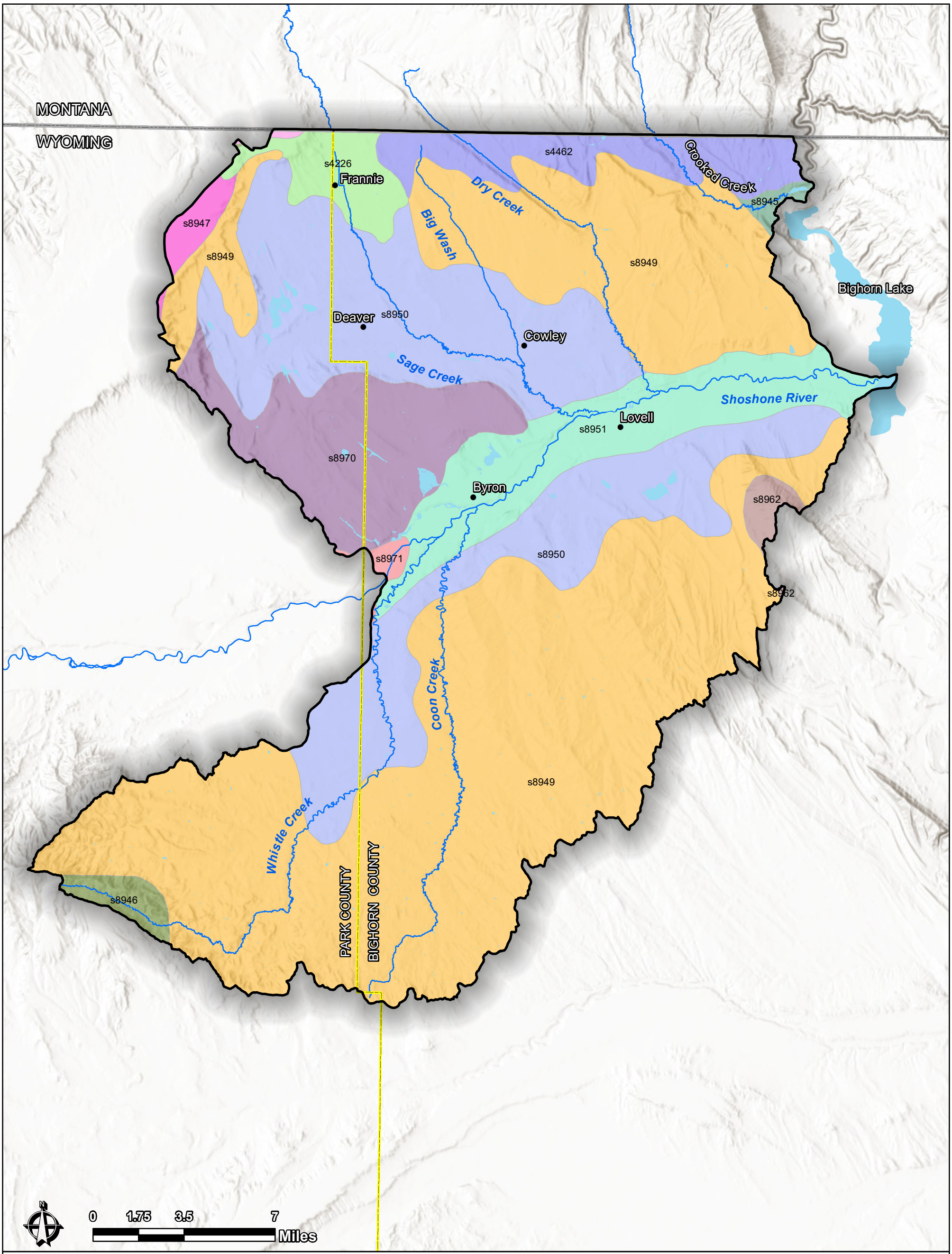
Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse

Ground Elevation (feet)

High : 2562.11

Low : 1103.5

MAP 10	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: DEM Hillshade	**WATERSHED TOPOGRAPHY** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse

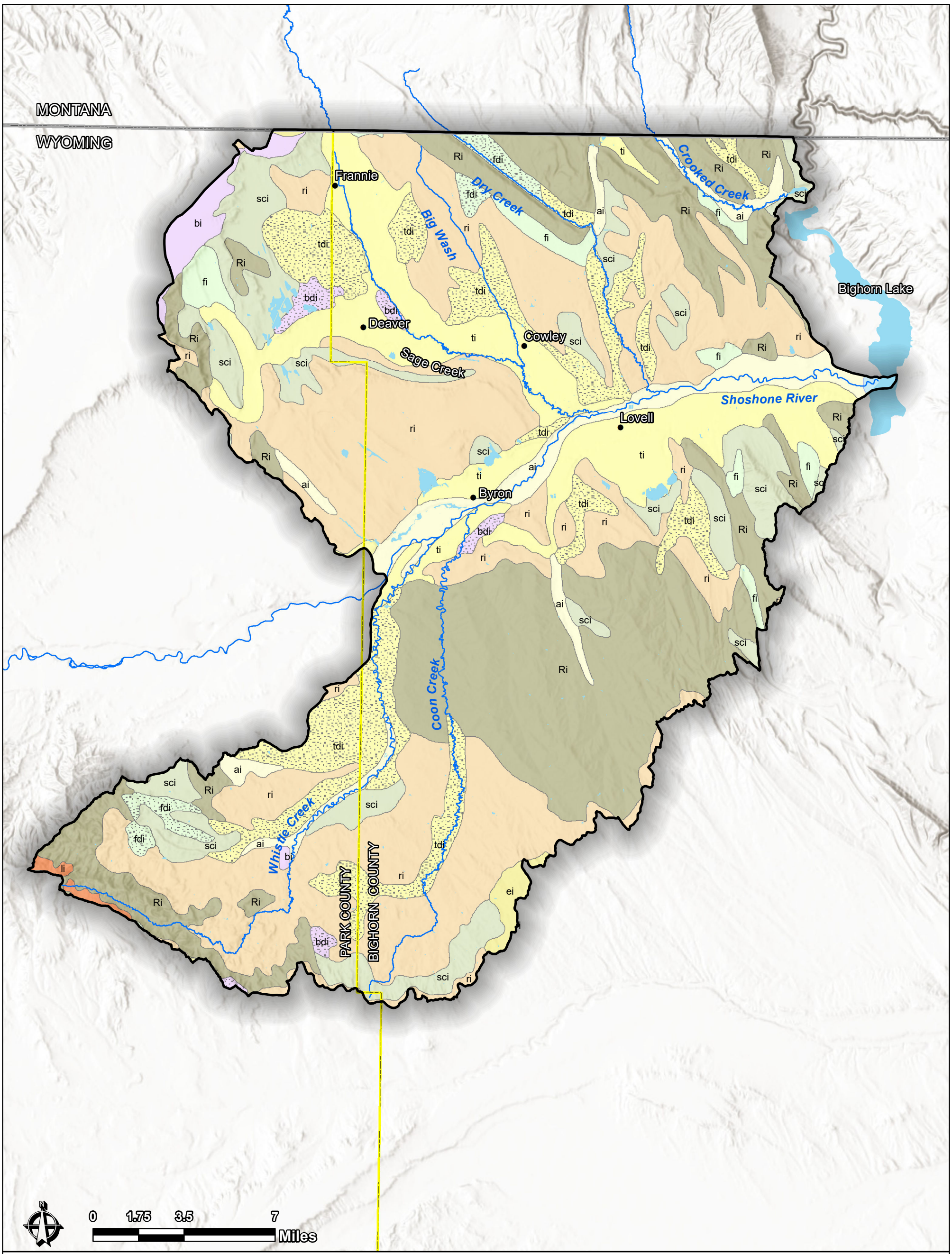
*Soils Legend continued on the next page

MAP 11	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI World Hillshade	**STATSGO2 SOILS** **U.S. GENERAL MAPPING** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota

STATSGO2 Soils - U.S, GENERAL MAPPING
Map Unit Symbol - Description

- s8962 - Spearfish-Rekop-Neville-Gystrum
- s4226 - Stormitt-Nihill-Neville-Harvey family-Bowbac
- s4462 - Travessilla family-Rock outcrop-Midway
- s8946 - Travson-Shingle-Rock outcrop-Midway-Keyner-Hiland-Bowbac
- s4187 - Vonalee-Kishona-Haverdad-Forkwood
- s8947 - Vonalee-Kishona-Haverdad-Forkwood
- s8369 - Water
- s8945 - Welring-Travson-Spearfish-Shavano-Rock outcrop-Midway-Clifterson
- s8970 - Worland-Rock outcrop-Oceanet-Apron
- s8971 - Youngston-Sharland-Garland
- s8950 - Youngston-Uffens-Stutzman-Lostwells-Apron
- s8951 - Youngston-Willwood-Sharland-Preatorson-Lostwells-Garland-Apron
- s8949 - Youngston-Worland-Persayo-Oceanet-Greybull

MAP 11b	PROJECT: 05SC0298344 DATE: O1/10/2022	**STATSGO2 SOILS LEGEND** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse

*Surficial Geology Legend continued on the next page

MAP 12	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI World Hillshade	**SURFICIAL GEOLOGY** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota

Surficial Geology Unit

River valley deposits

- ai - Alluvium with scattered terrace, slope wash, eolian, residuum, grus, and glacial deposits
- ti - Terrace deposits mixed with scattered alluvium, residuum, eolian, slope wash, and outwash deposits
- tdi - Dissected terrace deposits mixing with alluvium, residuum, eolian, and slope wash deposits
- fi - Alluvial fan and gradational fan deposits mixed with scattered slope wash, residuum and eolian deposits
- fdi - Dissected alluvial fan and gradational fan deposits mixed with scattered residuum and slope wash deposits

Bedrock/ Residuum/ Mined

- ri - Residuum mixed with alluvium, eolian, slope wash, and grus deposits, and/or bedrock outcrops
- Ri - Bedrock and glaciated bedrock, including hotspring deposits and volcanic necks; mixed with scattered shallow eolian, grus, slope wash, colluvium, residuum, glacial, and alluvium deposits

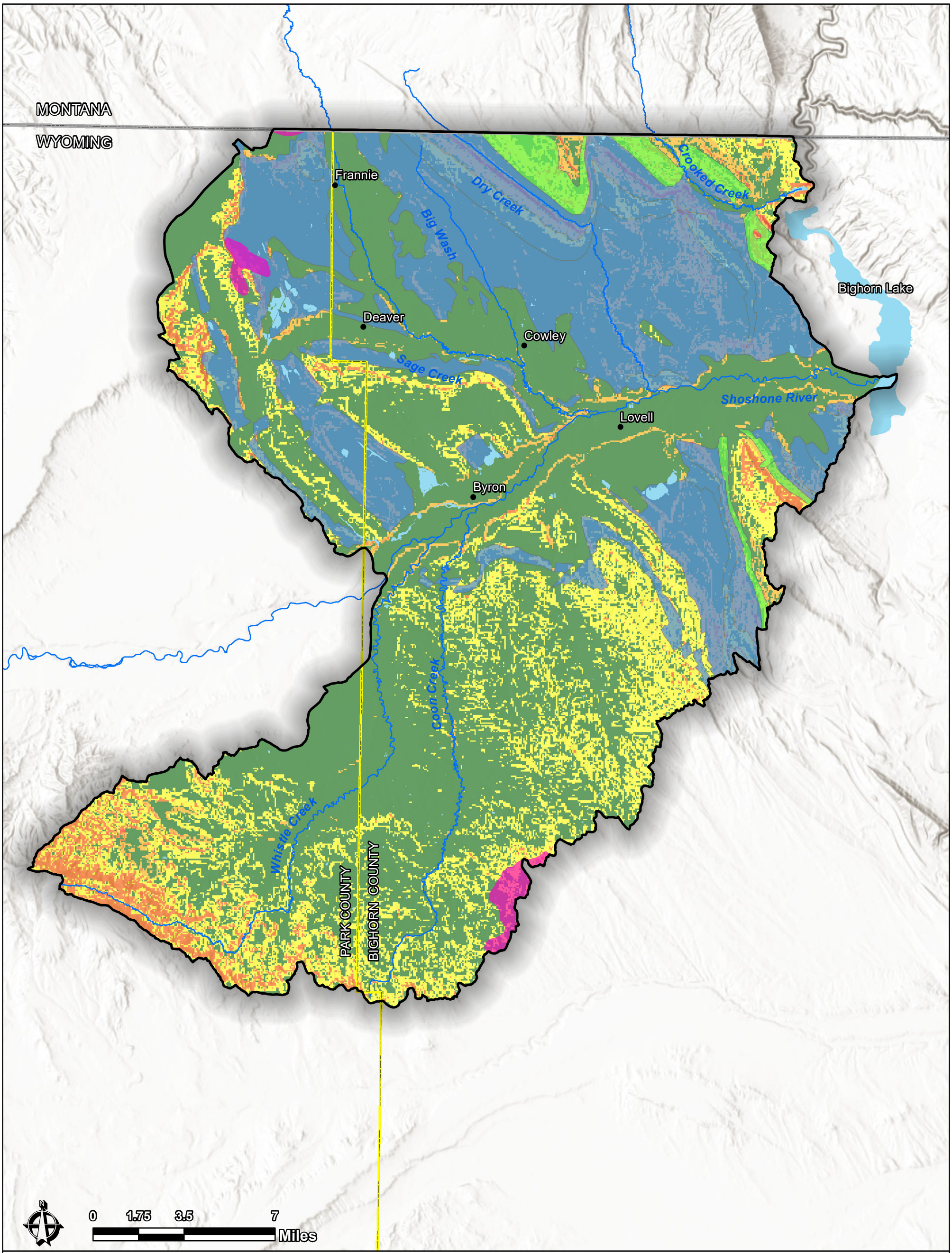
Upland Deposits

- ei - Eolian deposits mixed with scattered residuum, alluvium, and slope wash deposits
- sci - Slope wash and colluvium mixed with scattered slope wash, residuum, grus, glacial, periglacial, alluvium, and eolian deposits, and /or bed rock outcrops
- bdi - Dissected bench deposits, with scattered residuum, slope wash, landslide, and eolian deposits
- bi - Bench deposits, including eolian, slope wash, outwash, and bench and/ or mesa

Other Deposits/ Features

- li - Landslide deposits mixed with scattered residuum and slope wash deposits, Tertiary landslides, and bedrock outcrops; landslides too small and numerious to show separetly
- Lake

MAP 12b	PROJECT: 05SC0298344 DATE: O1/10/2022	**SURFICIAL GEOLOGY LEGEND** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
County Boundary
Major Waterbody
Major Watercourse

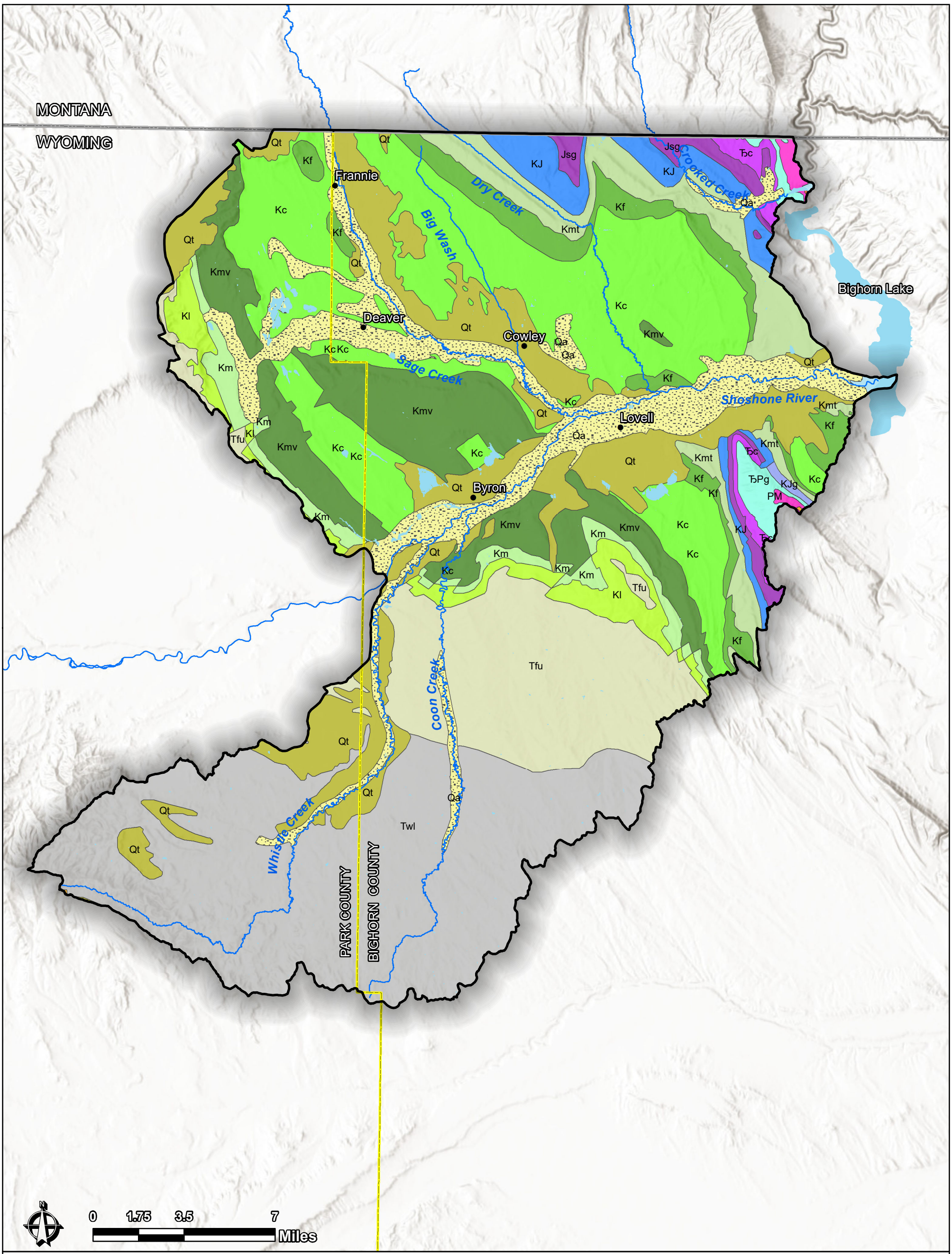
Windblown Deposits
Locally susceptible, low hazard
Regionally susceptible, moderate hazard

Landslide Susceptibility

High : 10

Low : 0

MAP 13	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI World Hillshade	**GEOLOGICAL HAZARDS** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area

State Boundary

County Boundary

Major Waterbody

Major Watercourse

*Bedrock Geology Legend continued on the next page

MAP 14	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI World Hillshade	**BEDROCK GEOLOGY** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota

Bedrock Geology

Water

Quaternary

Qa | Alluvium and colluvium

Qt | Gravel, pediment, and fan deposits

Triassic

Ꞧc | Chugwater Formation (N, NE), or Chugwater Group or Formation (S)

Triassic - Permian

ꞦPg | Goose Egg Formation

Cretaceous

Kc | Cody Shale

Kf | Frontier Formation

Kl | Lance Formation

Km | Meeteetse Formation

Kmv | Mesaverde Formation (N) or Mesaverde Group (S)

Kmt | Mowry and Thermopolis Shales

Cretaceous - Jurassic

KJ | Cloverly and Morrison Formations (N, S) or Cloverly Formation (Hartville uplift), or Inyan Kara Group (Black Hills), and Morrison Formation (NE)

KJg | Cloverly, Morrison, Sundance, and Gypsum Spring Formations

Mississippian - Devonian

MD | Madison Limestone or Group, and Darby Formation, or Madison Group, and Three Forks and Jefferson Formations

Mississippian

Mm | Madison Group (TB), Madison Limestone or Group (N), or Madison Limestone (S)

Permian - Mississippian

PM | Tensleep Sandstone and Amsden Formation

Jurassic

Jsg | Sundance and Gypsum Spring Formations

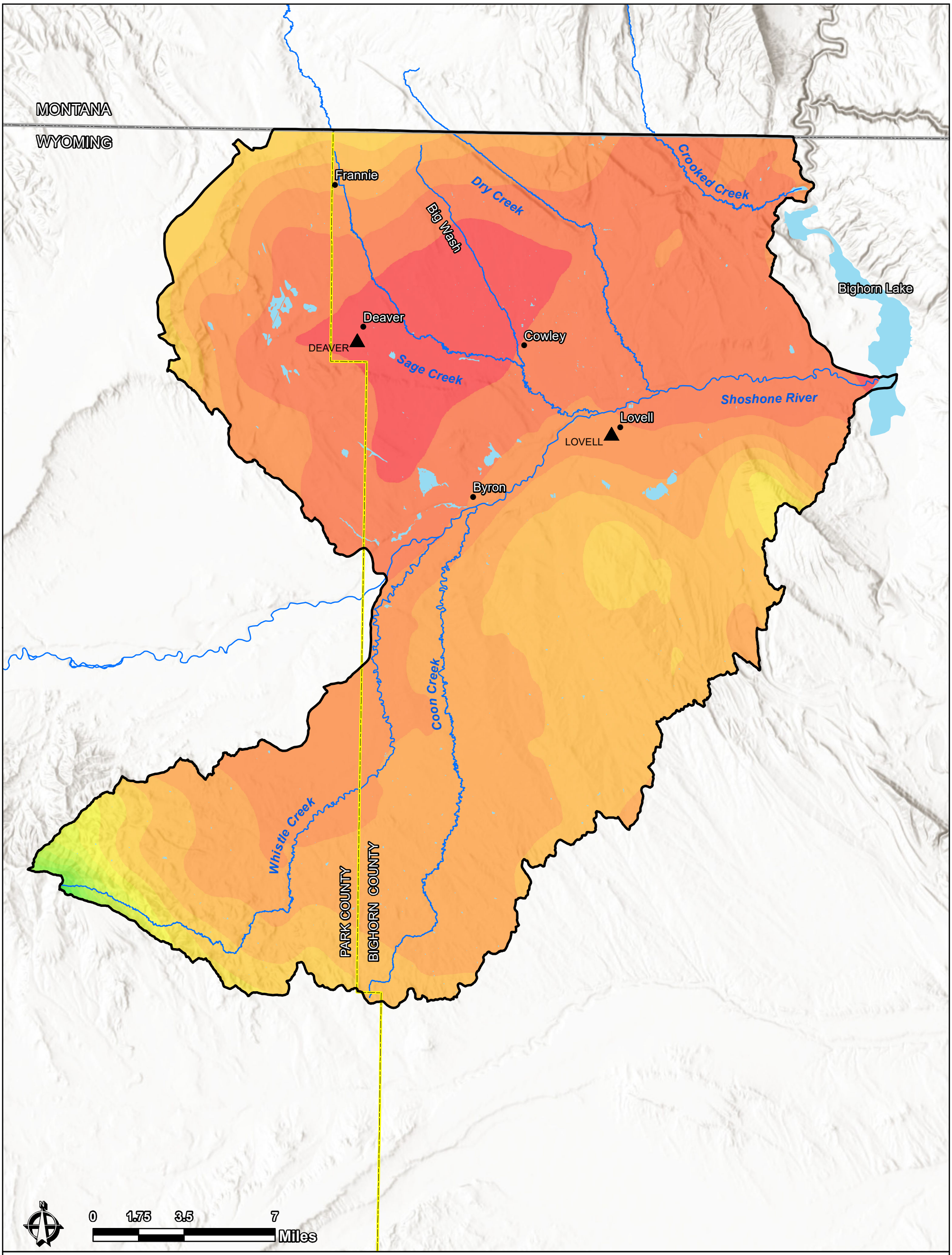
Paleocene

Tfu | Fort Union Formation

Eocene

Twl | Willwood Formation

MAP 14b	PROJECT: 05SC0298344 DATE: O1/10/2022	**BEDROCK GEOLOGY LEGEND** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
County Boundary
Major Waterbody
Major Watercourse

Inches of Precipitation

5.5 - 6	7.5 - 8	9.5 - 10	11.5 - 12
6 - 6.5	8 - 8.5	10 - 10.5	12 - 12.5
6.5 - 7	8.5 - 9	10.5 - 11	12.5 - 13
7 - 7.5	9 - 9.5	11 - 11.5	Weather Station

MAP 15

PROJECT: 05SC0298344

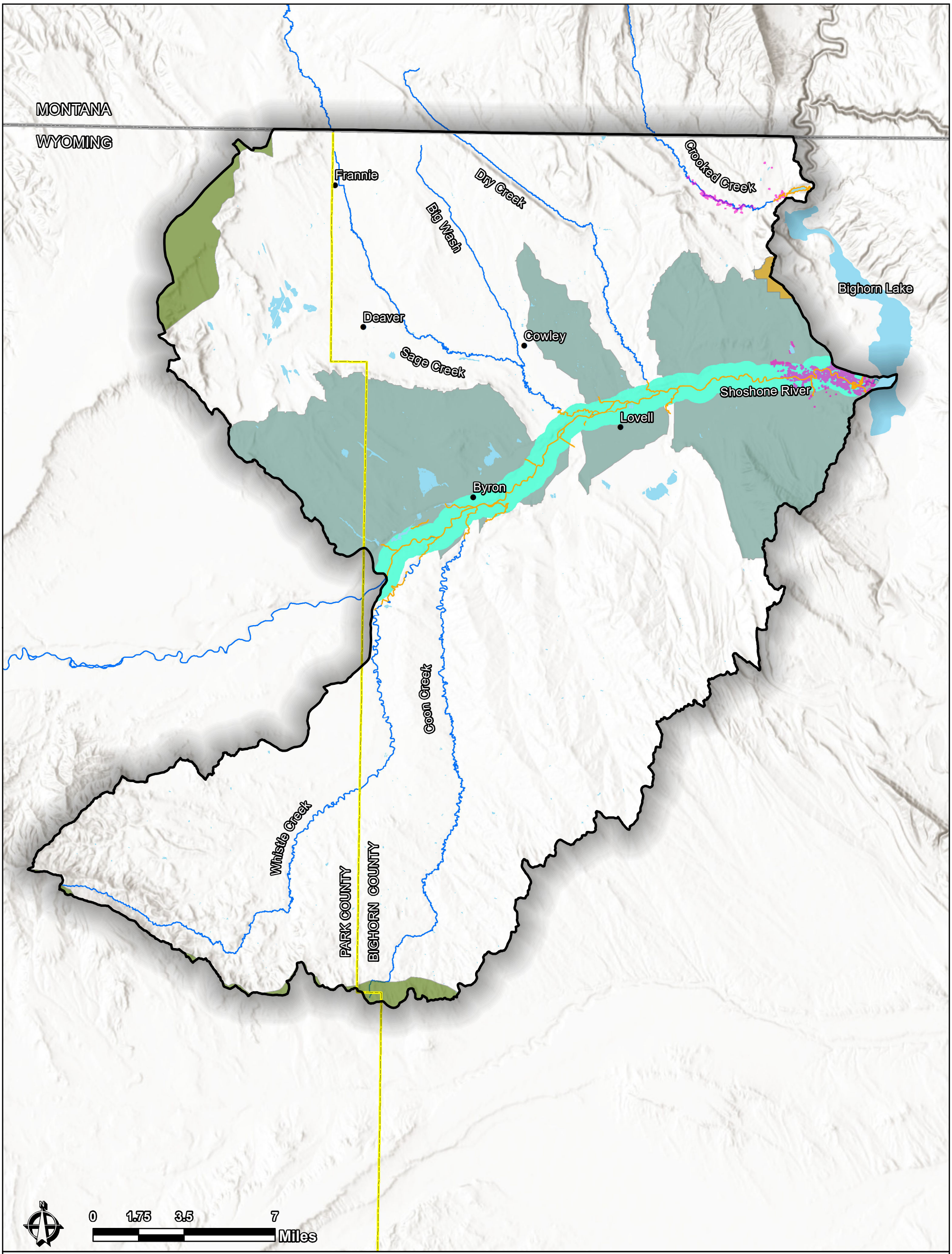
DATE: O1/10/2022

SCALE: 1 inch = 3.5 Miles
UNITS: Miles
BASEMAP: ESRI World Hillshade

AVERAGE ANNUAL (PRISM) PRECIPITATION 1981-2010

Lower Shoshone Level 1 Watershed Study
Park and Bighorn County, Wyoming

research & consulting inc.
Biota



Lower Shoshone Watershed Study Area
State Boundary
County Boundary
Major Waterbody
Major Watercourse

Aquatic Crucial Habitat
SWAP Aquatic Conservation Area
Riparian

Aquatic Connectivity Habitat
Fish Passage

Terrestrial Crucial Habitat
Bighorn Mountains Riparian and Aspen Communities
Statewide Sage Grouse Core

MAP 16

PROJECT: 05SC0298344

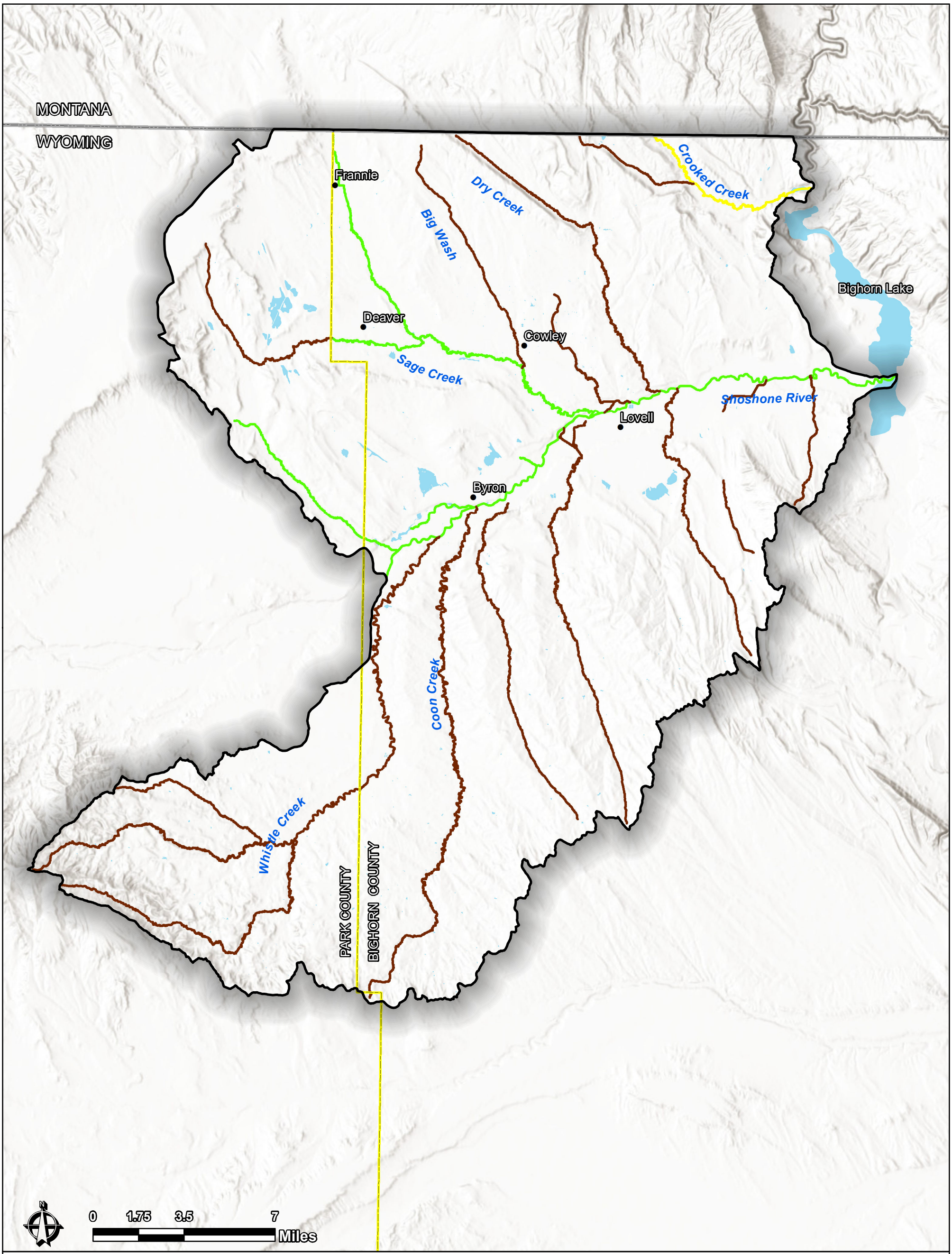
DATE: O1/10/2022

SCALE: 1 inch = 3.5 Miles
UNITS: Miles
BASEMAP: ESRI World Hillshade

HABITAT PRIORITY AREAS
2020 WGFD STATEWIDE HABITAT PLAN

Lower Shoshone Level 1 Watershed Study
Park and Bighorn County, Wyoming

research & consulting inc.
Biota

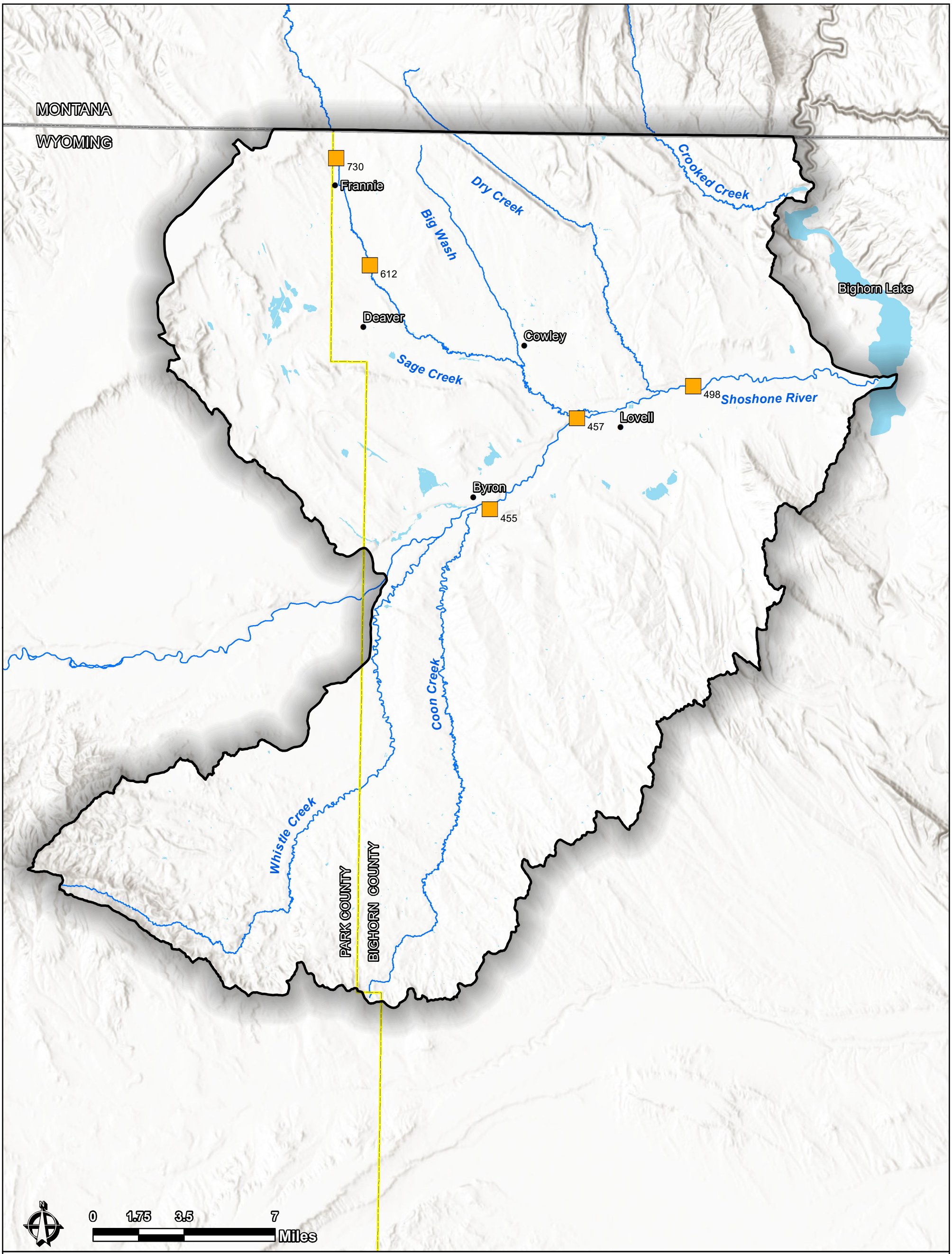


Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody

Trout Stream Classifications

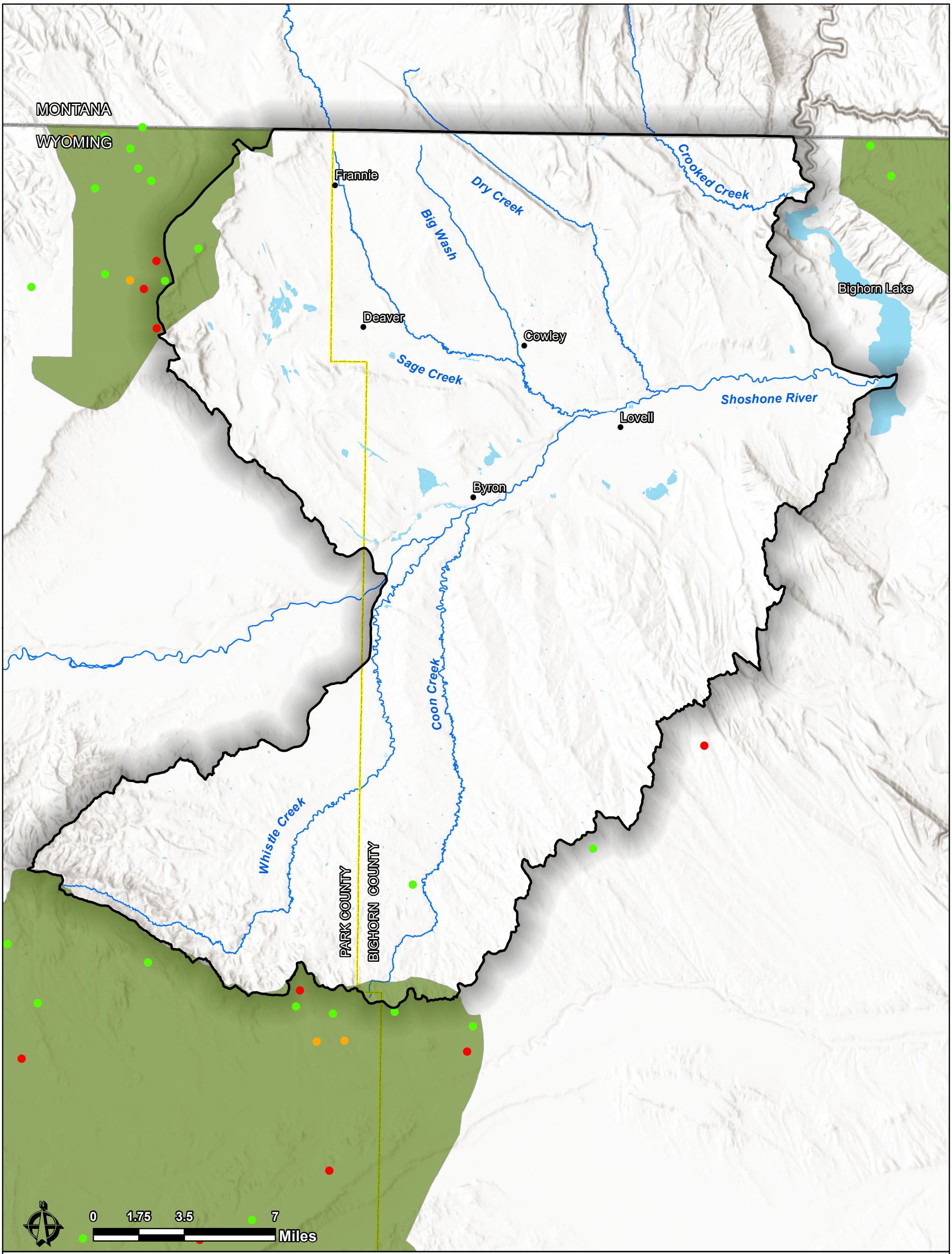
clear
green
yellow

MAP 17	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI World Hillshade	**WGFD TROUT STREAM CLASS** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse
In-stream structures mapped by WGFD

MAP 18	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI WORLD HILLSHADE	**IN-STREAM STRUCTURES** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



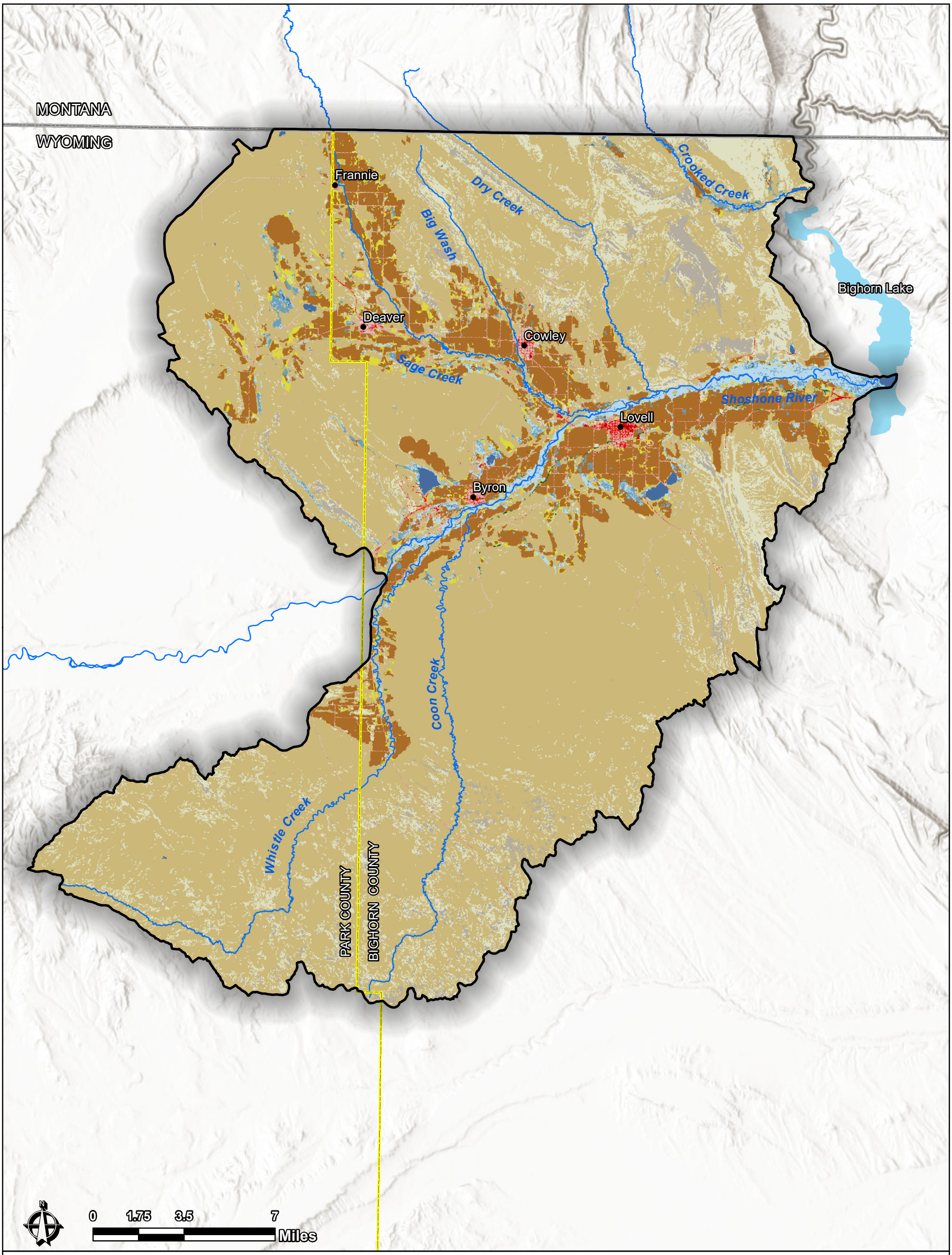
Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse

Greater Sage-Grouse Core Population Areas

Sage-Grouse Lek (WGFD 2020 Survey)

- Occupied
- Undetermined
- Unoccupied

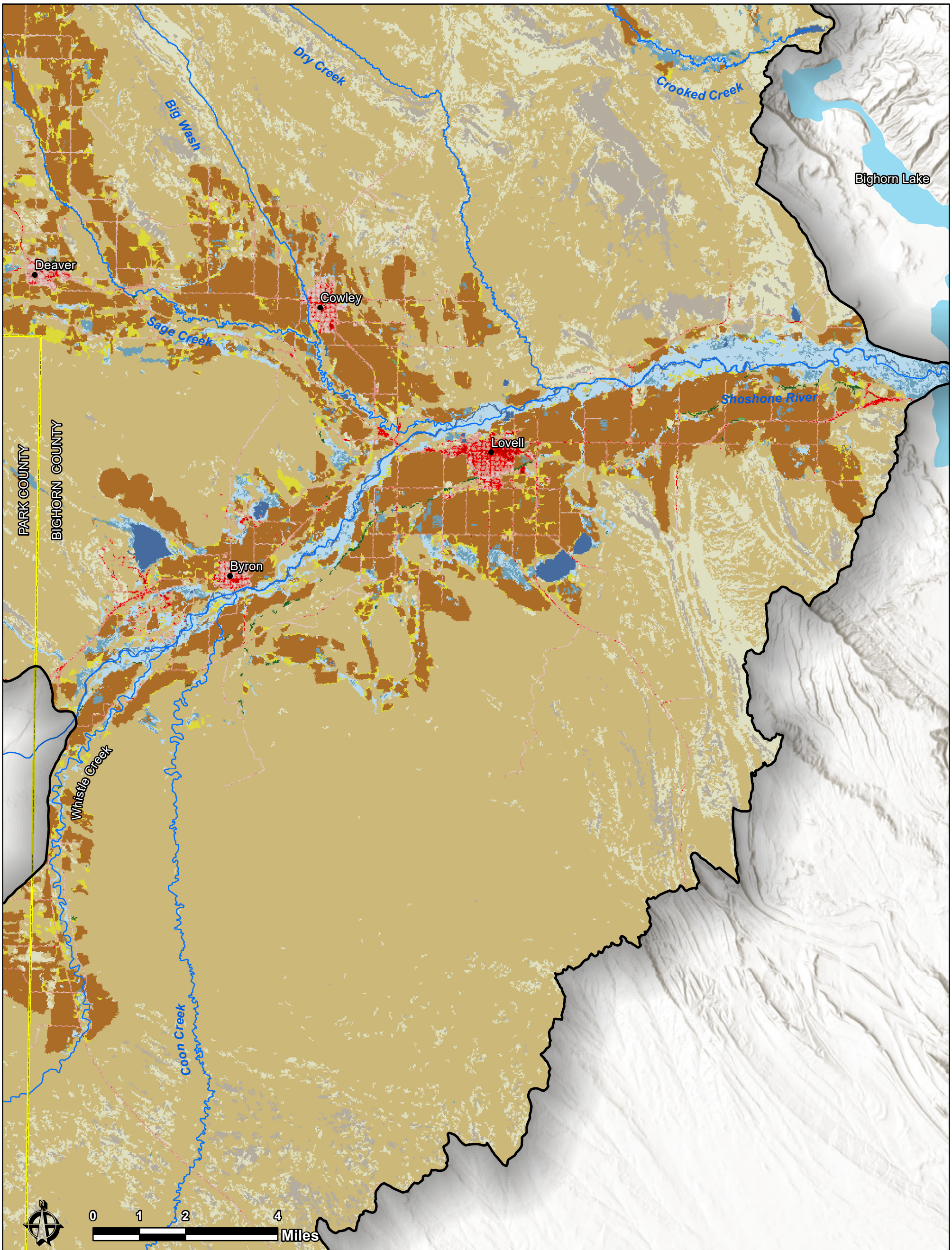
MAP 19	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI World Hillshade	**GREATER SAGE-GROUSE CORE POPULATION AREAS** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse

*NLCD LAND COVER Legend continued on the next page

MAP 20	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI World Hillshade	**NLCD LAND COVER** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse

*NLCD LAND COVER Legend continued on the next page

MAP 20b

PROJECT: 05SC0298344

DATE: O1/10/2022

SCALE: 1 inch = 1 Mile
UNITS: Miles
BASEMAP: ESRI Wrold Hillshade

NLCD LAND COVER

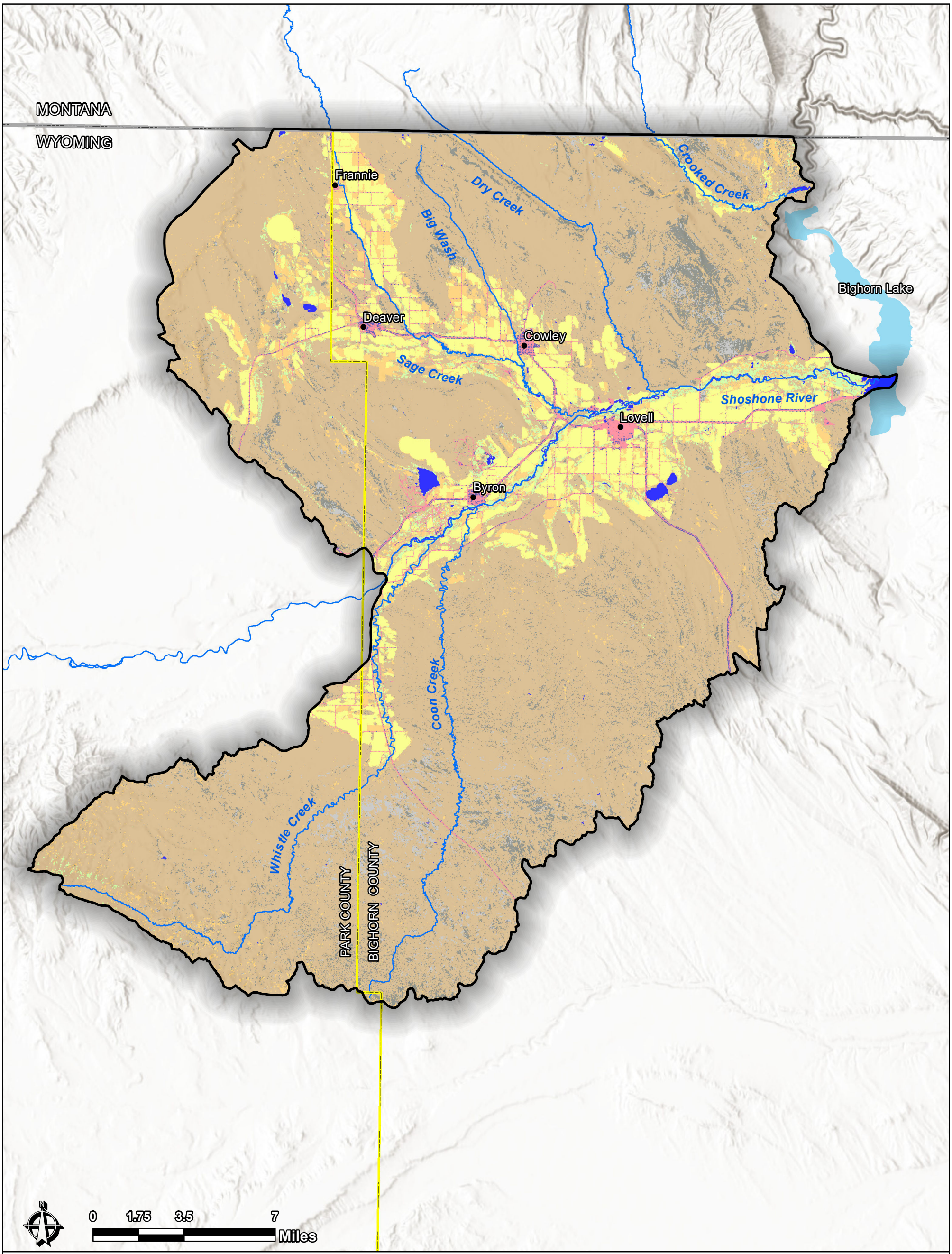
Lower Shoshone Level 1 Watershed Study
Park and Bighorn County, Wyoming

research & consulting inc.
Biota

NLCD Land Cover

- Woody Wetlands
- Shrub/Scrub
- Open Water
- Mixed Forest
- Herbaceuous
- Hay/Pasture
- Evergreen Forest
- Emergent Herbaceuous Wetlands
- Developed, Open Space
- Developed, Medium Intensity
- Developed, Low Intensity
- Developed, High Intensity
- Deciduous Forest
- Cultivated Crops
- Barren Land

MAP 20c	PROJECT: 05SC0298344 DATE: O1/10/2022	**NLCD LAND COVER LEGEND** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
County Boundary
Major Waterbody
Major Watercourse

Herbaceous Cover
Shrubland
Sparse Vegetation
Barren
Quarries-Strip Mines-Gravel Pits-Well and Wind Pads

Cropland
Open tree canopy
Developed
Developed Upland
Open Water

MAP 21

PROJECT: 05SC0298344

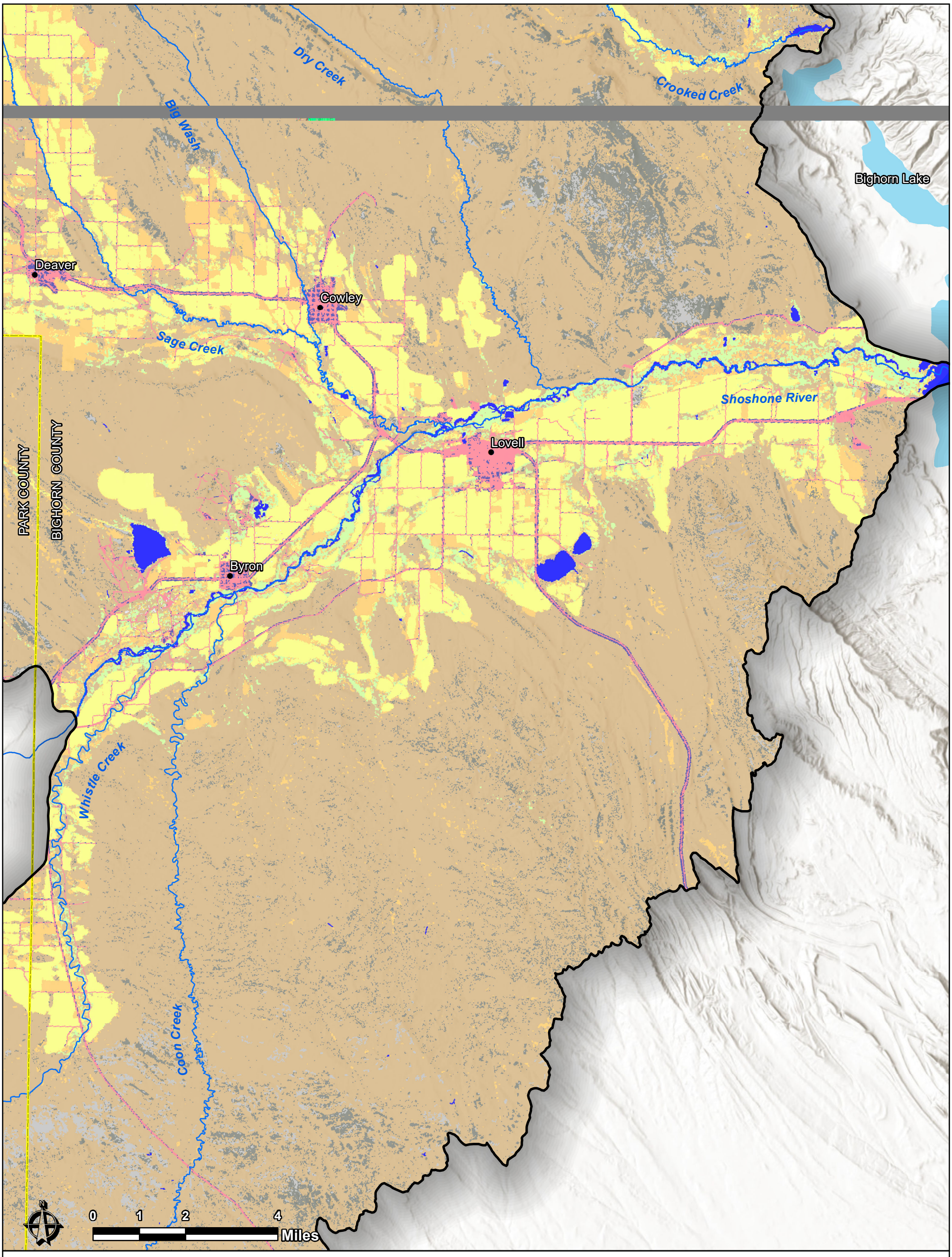
DATE: O1/10/2022

SCALE: 1 inch = 3.5 Miles
UNITS: Miles
BASEMAP: ESRI World Hillshade

LANDFIRE LAND COVER CLASSIFICATION

Lower Shoshone Level 1 Watershed Study
Park and Bighorn County, Wyoming

research & consulting inc.
Biota



Lower Shoshone Watershed Study Area
State Boundary
County Boundary
Major Waterbody
Major Watercourse

Herbaceous Cover
Shrubland
Sparse Vegetation
Barren
Quarries-Strip Mines-Gravel Pits-Well and Wind Pads

Cropland
Open tree canopy
Developed
Developed Upland
Open Water

MAP 21b

PROJECT: 05SC0298344

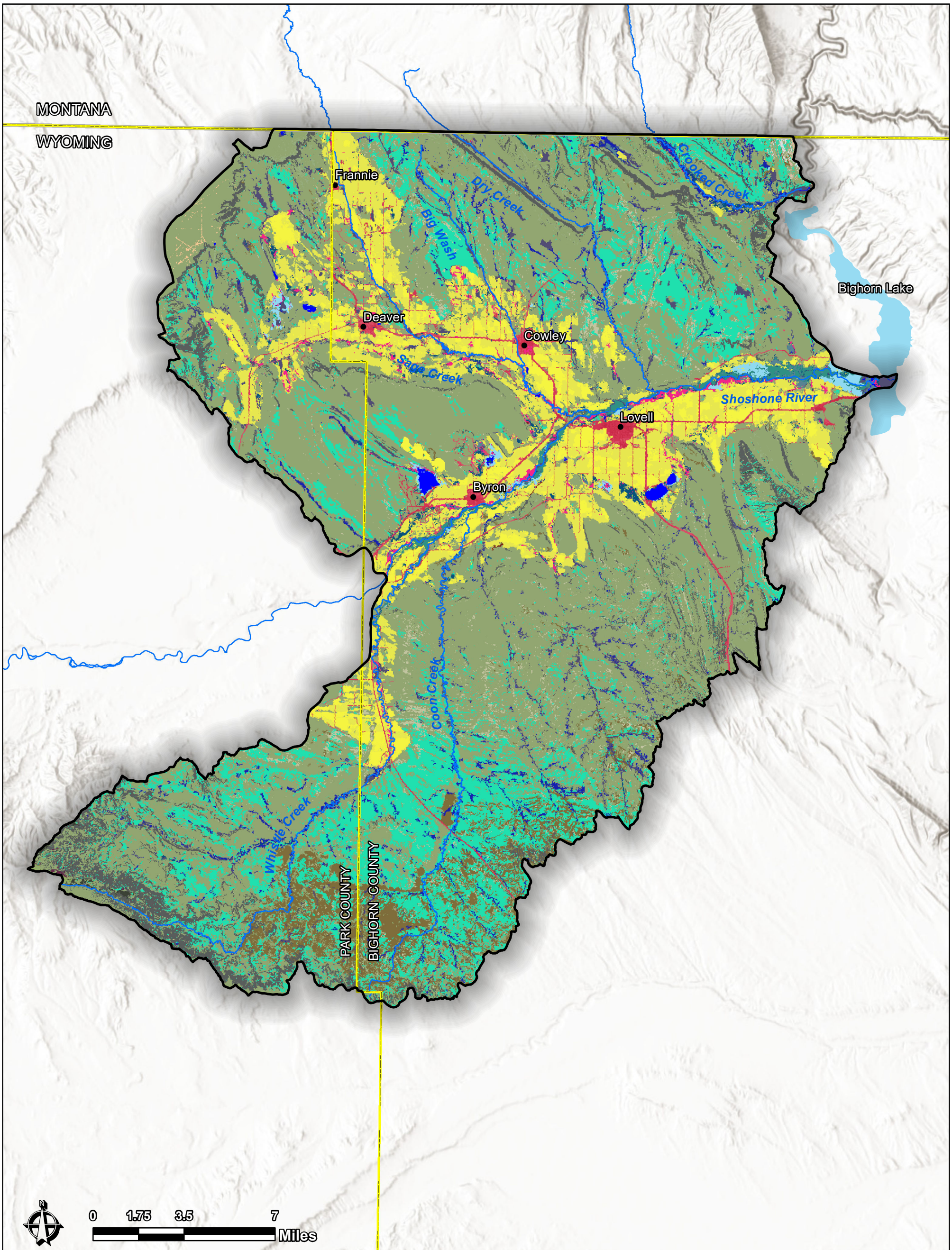
DATE: O1/10/2022

SCALE: 1 inch = 1 Mile
UNITS: Miles
BASEMAP: ESRI World Hillshade

LANDFIRE LAND COVER CLASSIFICATION

Lower Shoshone Level 1 Watershed Study
Park and Bighorn County, Wyoming

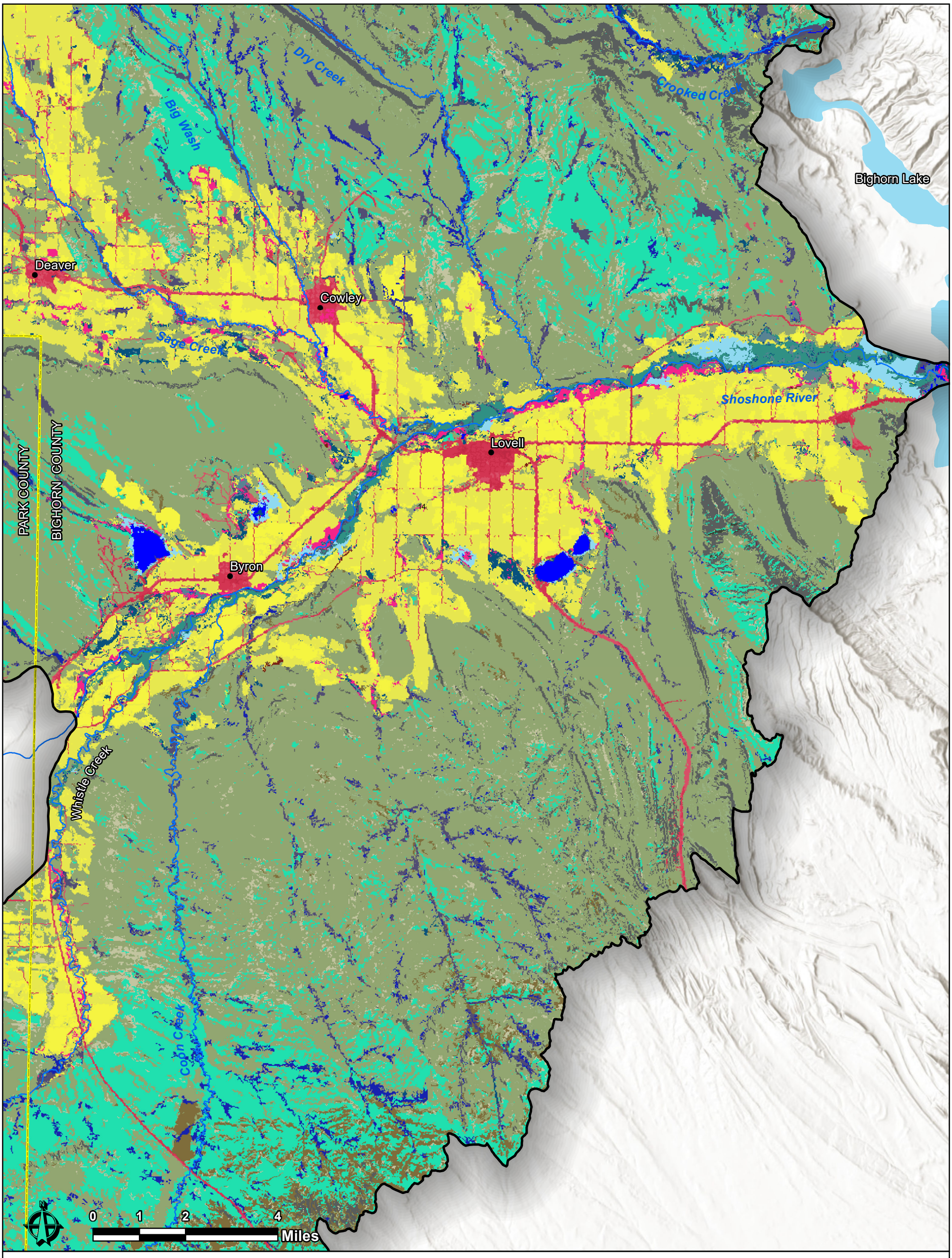
research & consulting inc.
Biota



Lower Shoshone Watershed Study Area
State Boundary
County Boundary
Major Waterbody
Major Watercourse

*NWGAP Legend continued on the next page

MAP 22	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI World Hillshade	**NWGAP LAND COVER** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
County Boundary
Major Waterbody
Major Watercourse

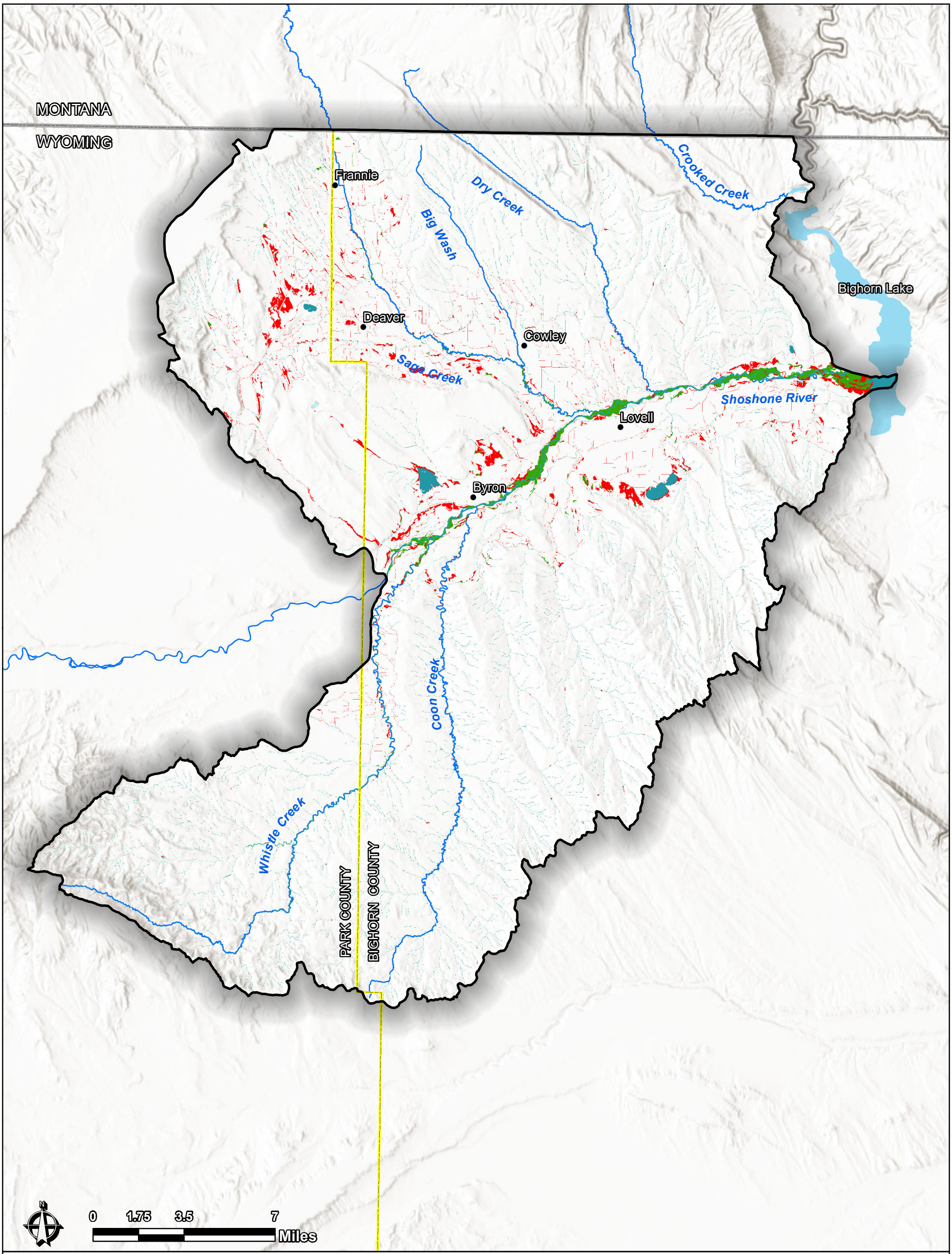
*NWGAP Legend continued on the next page

MAP 22b	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 1 Mile UNITS: Miles BASEMAP: ESRI World Hillshade	**NWGAP LAND COVER CLASSIFICATION** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota

NWGAP LAND COVER LEGEND

- Wyoming Basins Dwarf Sagebrush Shrubland and Steppe
- Western Great Plains Shortgrass Prairie
- Western Great Plains Saline Depression Wetland
- Western Great Plains Riparian Woodland and Shrubland
- Western Great Plains Open Freshwater Depression Wetland
- Western Great Plains Floodplain
- Western Great Plains Closed Depression Wetland
- Western Great Plains Cliff and Outcrop
- Western Great Plains Badland
- Southern Rocky Mountain Ponderosa Pine Woodland
- Rocky Mountain Foothill Limber Pine-Juniper Woodland
- Rocky Mountain Cliff, Canyon and Massive Bedrock
- Pasture/Hay
- Open Water
- Northwestern Great Plains Mixedgrass Prairie
- Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland
- Northern Rocky Mountain Foothill Conifer Wooded Steppe
- Introduced Riparian and Wetland Vegetation
- Inter-Mountain Basins Shale Badland
- Inter-Mountain Basins Montane Sagebrush Steppe
- Inter-Mountain Basins Mixed Salt Desert Scrub
- Inter-Mountain Basins Mat Saltbush Shrubland
- Inter-Mountain Basins Greasewood Flat
- Inter-Mountain Basins Cliff and Canyon
- Inter-Mountain Basins Big Sagebrush Steppe
- Inter-Mountain Basins Big Sagebrush Shrubland
- Developed, Open Space
- Developed, Medium Intensity
- Developed, Low Intensity
- Developed, High Intensity
- Cultivated Cropland

MAP 22c	PROJECT: 05SC0298344 DATE: O1/10/2022	**NWGAP LAND COVER LEGEND** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse

NWI Wetlands

Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Lake
Riverine

*NWI Wetlands Legend continued on the next page

MAP 23

PROJECT: 05SC0298344

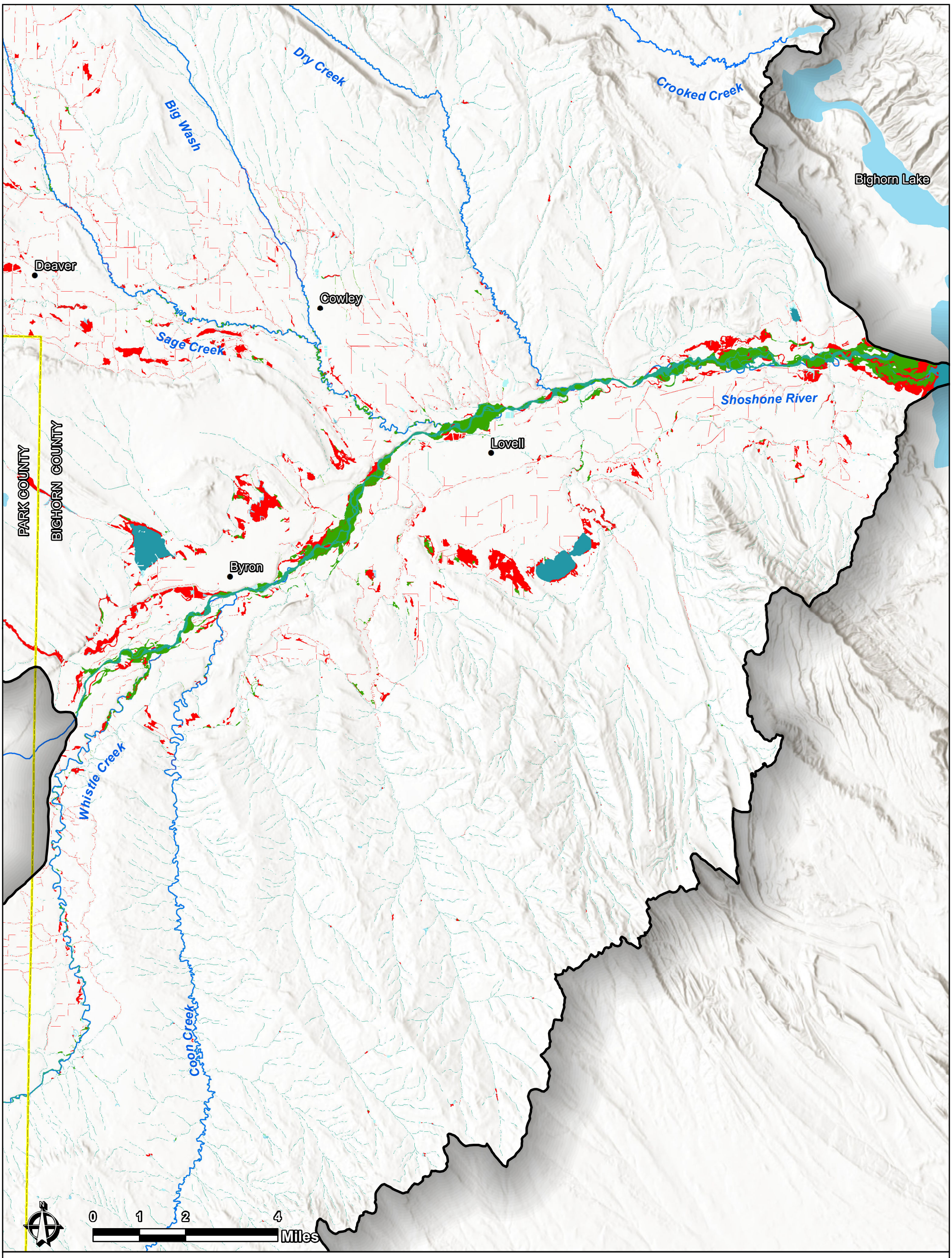
DATE: O1/10/2022

SCALE: 1 inch = 3.5 Miles
UNITS: Miles
BASEMAP: ESRI World Imagery

NWI MAPPED WETLANDS

Lower Shoshone Level 1 Watershed Study
Park and Bighorn County, Wyoming

research & consulting inc.
Biota

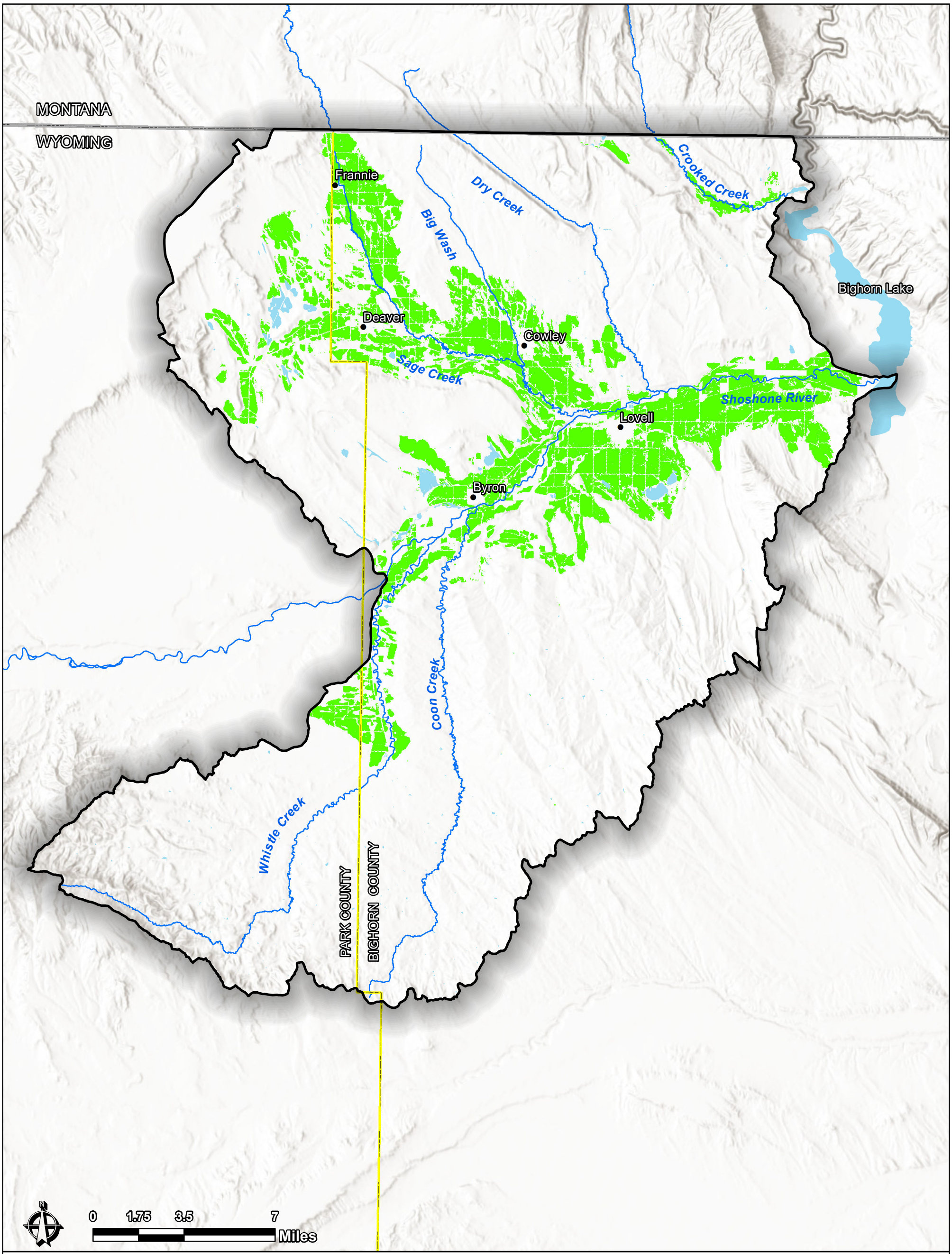


Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse

NWI Wetlands

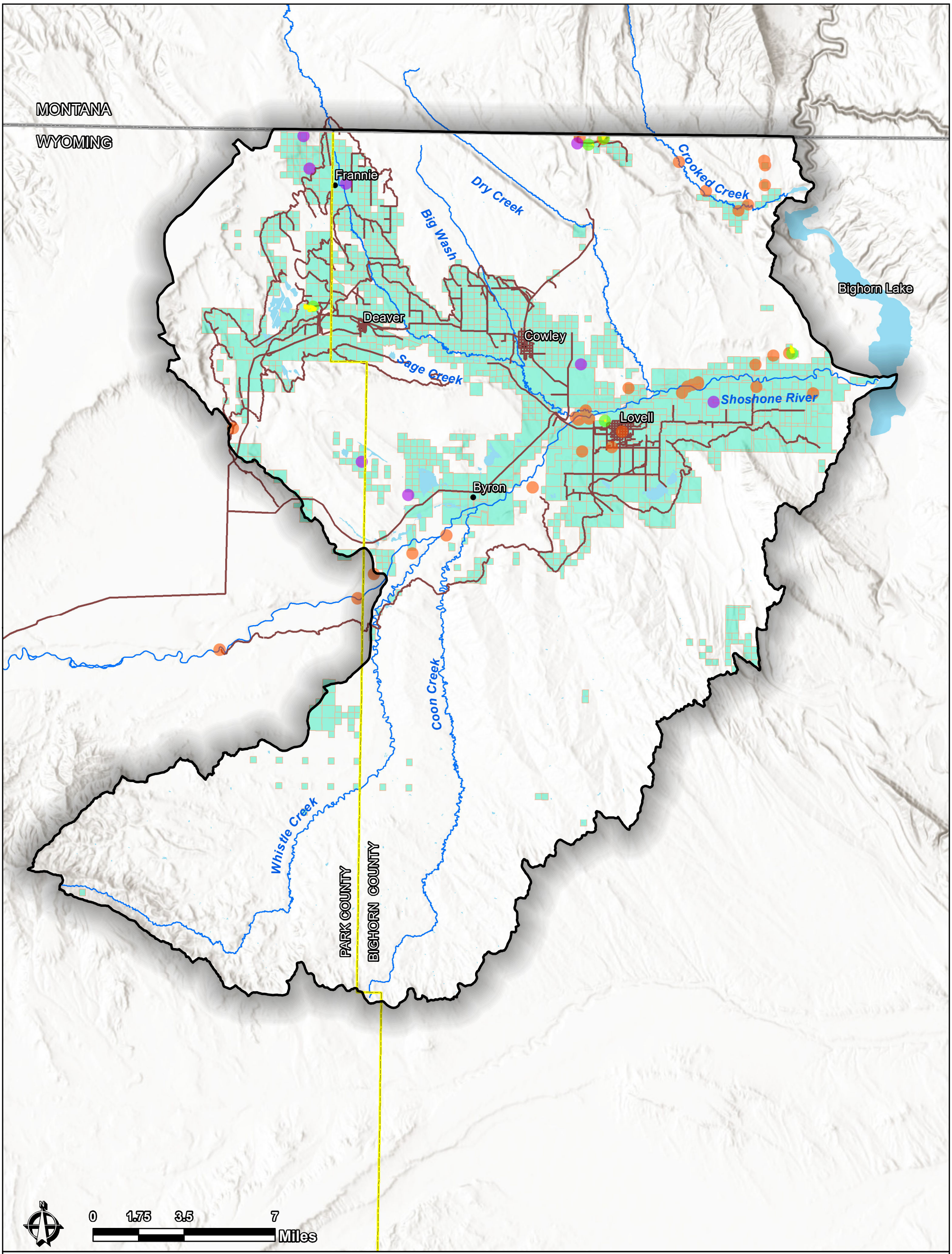
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Lake
Riverine

MAP 23b	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 1 Mile UNITS: Miles BASEMAP: ESRI World Hillshade	**NWI MAPPED WETLANDS** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
County Boundary
Major Waterbody
Major Watercourse
WWDC Irrigated Lands Layer

MAP 24	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI World Hillshade	**IRRIGATED LANDS** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse
Reservoirs
Places of Use
Conveyance Systems
Points of Diversion - Ground Water
Points of Diversion - Surface Water
Points of Diversion - Reservoirs

MAP 25

PROJECT: 05SC0298344

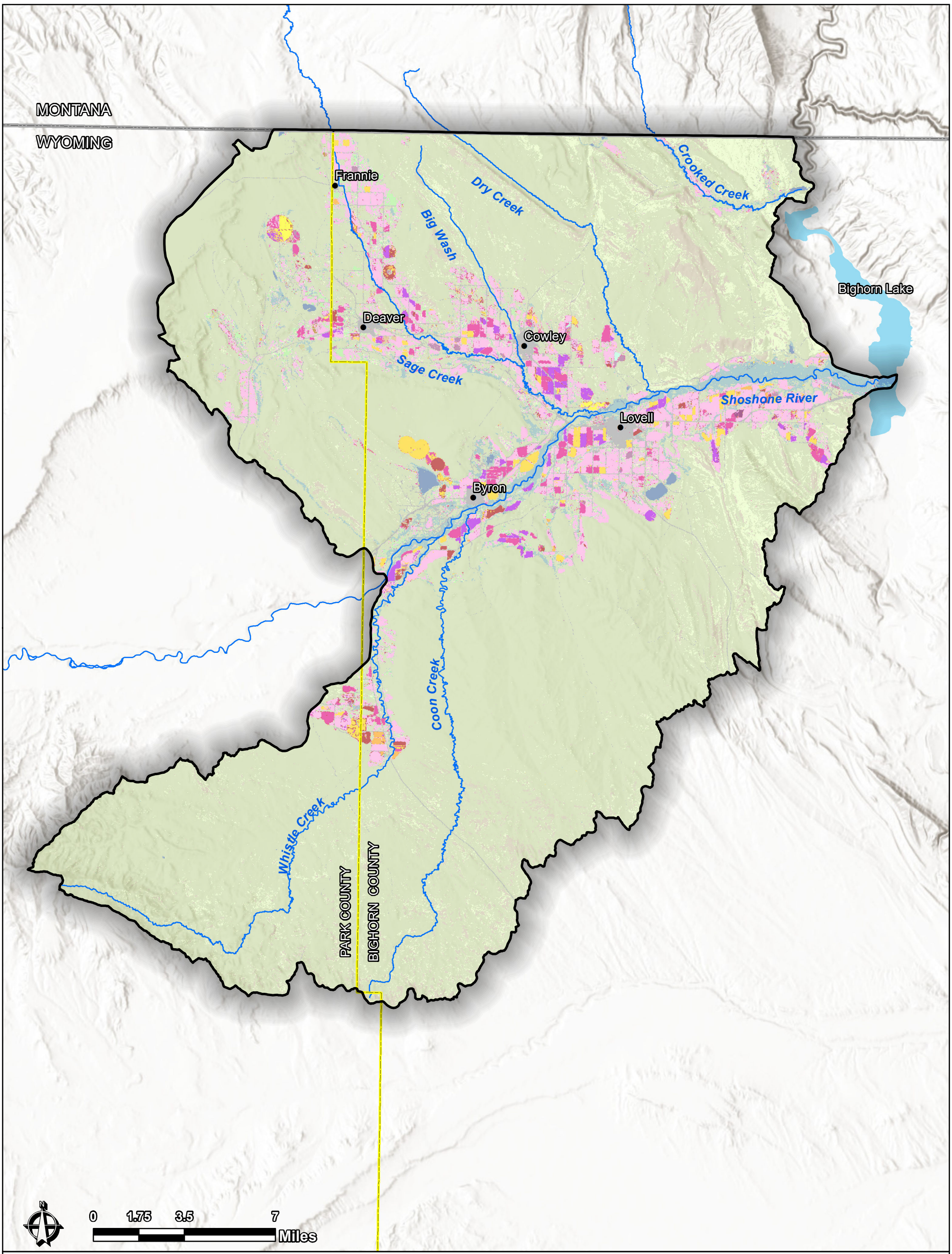
DATE: O1/10/2022

SCALE: 1 inch = 3.5 Miles
UNITS: Miles
BASEMAP: ESRI WORLD HILLSHADE

WATER SYSTEMS

Lower Shoshone Level 1 Watershed Study
Park and Bighorn County, Wyoming

research & consulting inc.
Biota



Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse

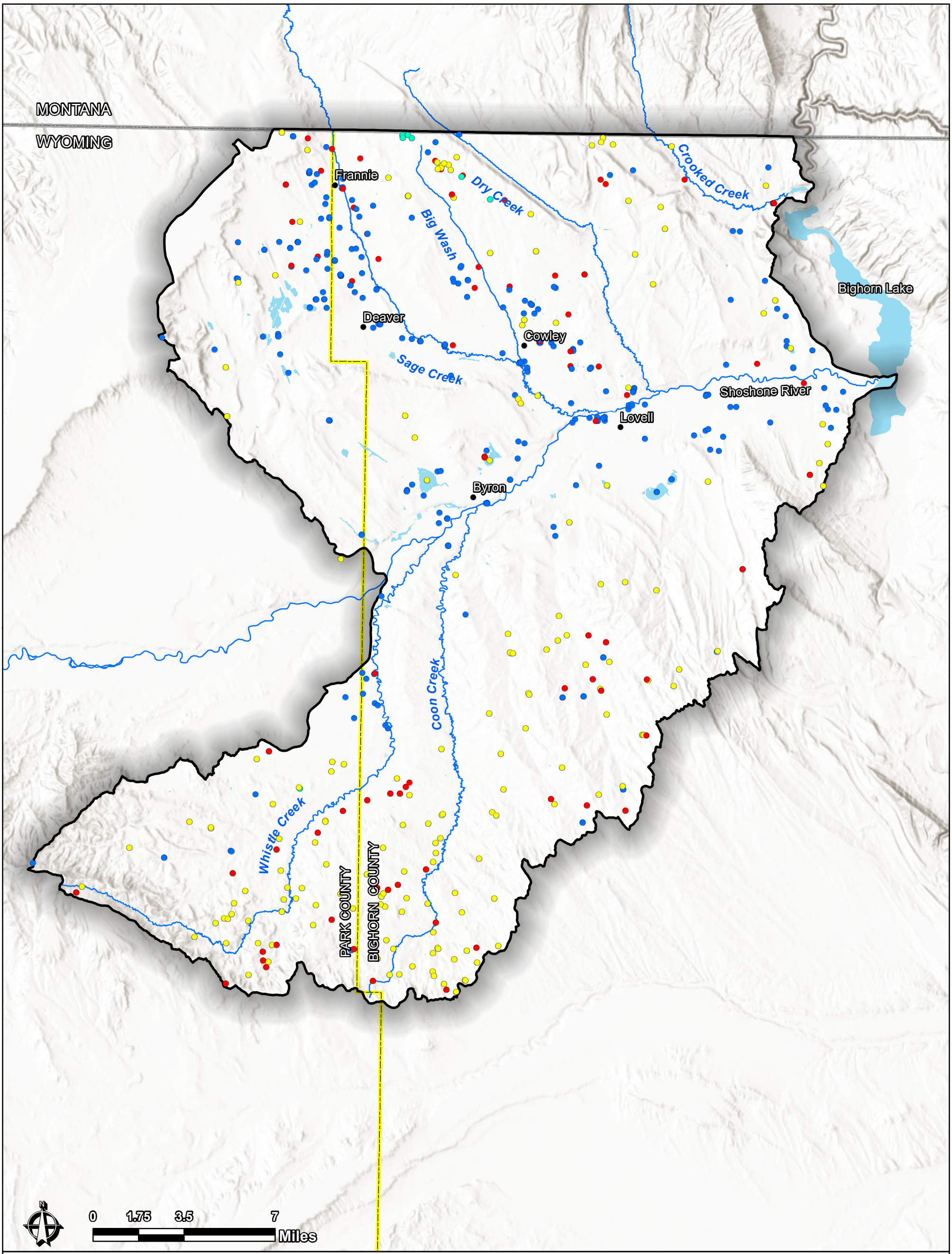
*Agricultural Crops Legend continued on the next page

MAP 26	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI WORLD HILLSHADE	**AGRICULTURAL CROPS NASS** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota

Agricultural Crops

- Alfalfa
- Background
- Barley
- Barren
- Corn
- Deciduous Forest
- Developed/High Intensity
- Developed/Low Intensity
- Developed/Med Intensity
- Developed/Open Space
- Dry Beans
- Evergreen Forest
- Fallow/Idle Cropland
- Grassland/Pasture
- Herbaceous Wetlands
- Millet
- Mixed Forest
- Oats
- Open Water
- Other Crops
- Other Hay/Non Alfalfa
- Safflower
- Shrubland
- Sod/Grass Seed
- Sorghum
- Spring Wheat
- Sugarbeets
- Sunflower
- Triticale
- Winter Wheat
- Woody Wetlands

MAP 26b	PROJECT: 05SC0298344 DATE: O1/10/2022	**AGRICULTURAL CROPS LEGEND** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse

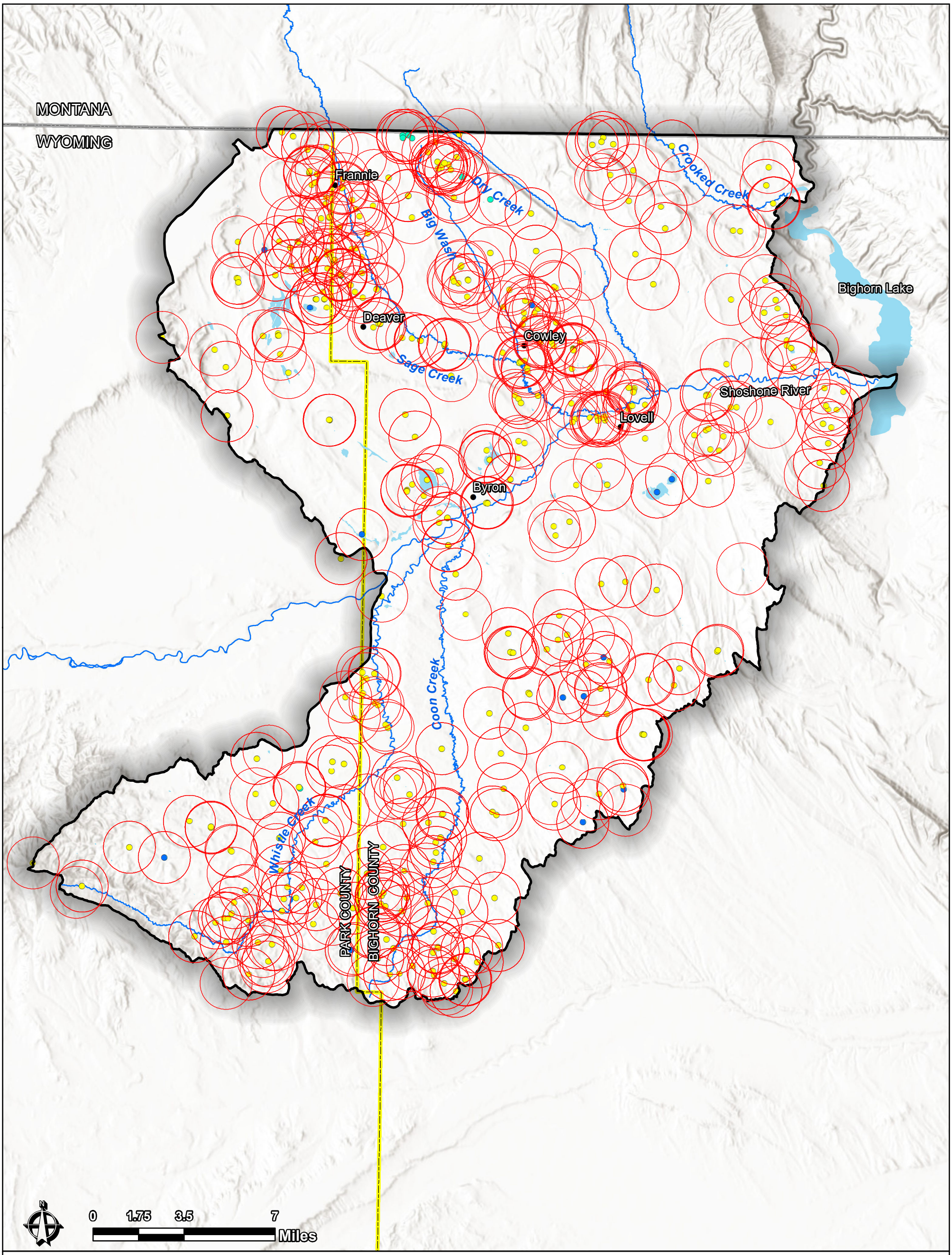
Functional Water Basins

- Named Lakes and Reservoirs
- Functional Stock Tanks and Reservoirs
- Ponds

Non-Functional Water Basins

- Non Functional Stock Tanks and Reservoirs

MAP 27	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI WORLD HILLSHADE	**WATER BASINS** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse
Named Lakes and Reservoirs
Functional Stock Tanks and Reservoirs
Ponds
1-mile Buffer

Map 28

PROJECT: 05SC0298344

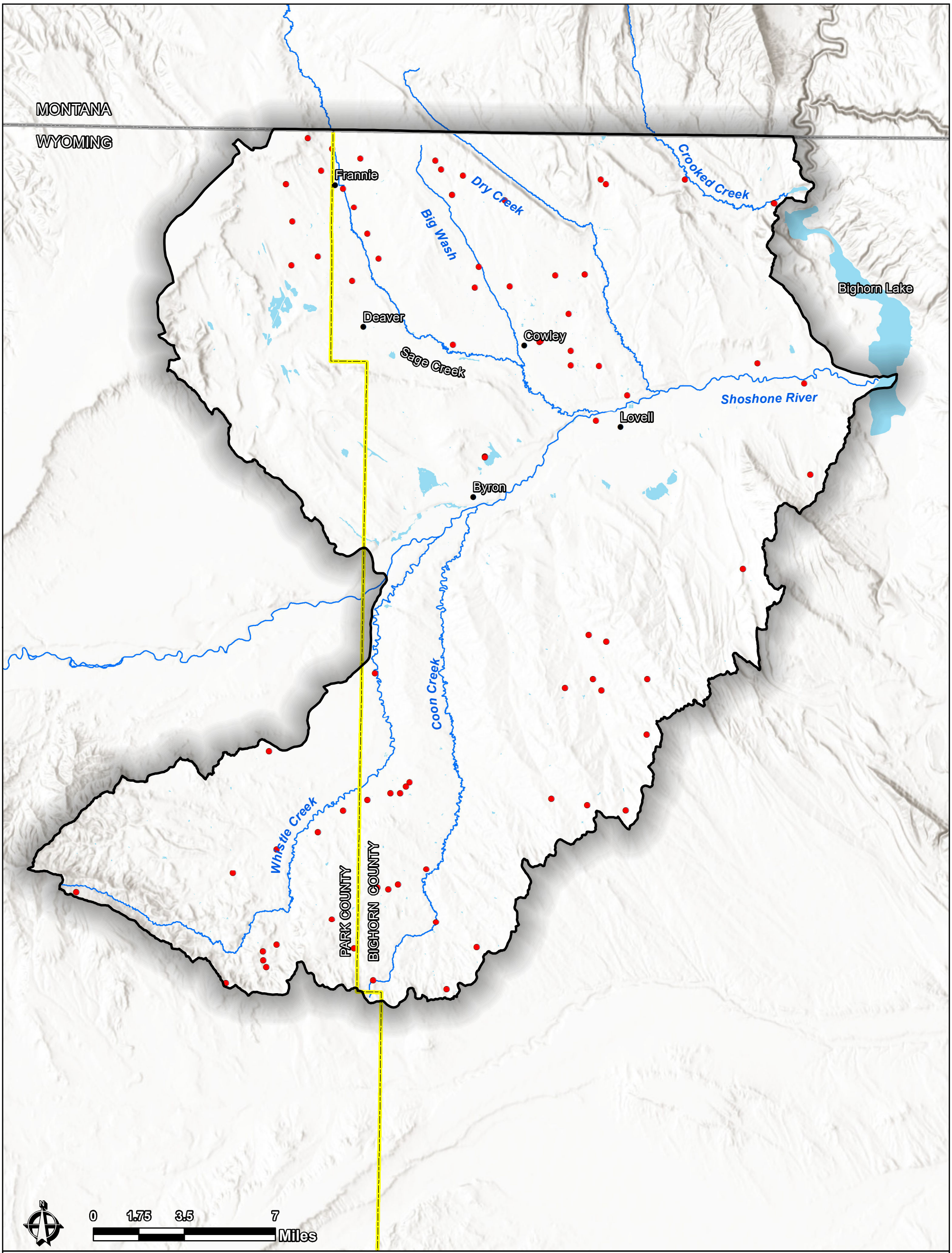
DATE: O1/10/2022

SCALE: 1 inch = 3.5 Miles
UNITS: Miles
BASEMAP: ESRI WORLD HILLSHADE

FUNCTIONAL WATER BASINS

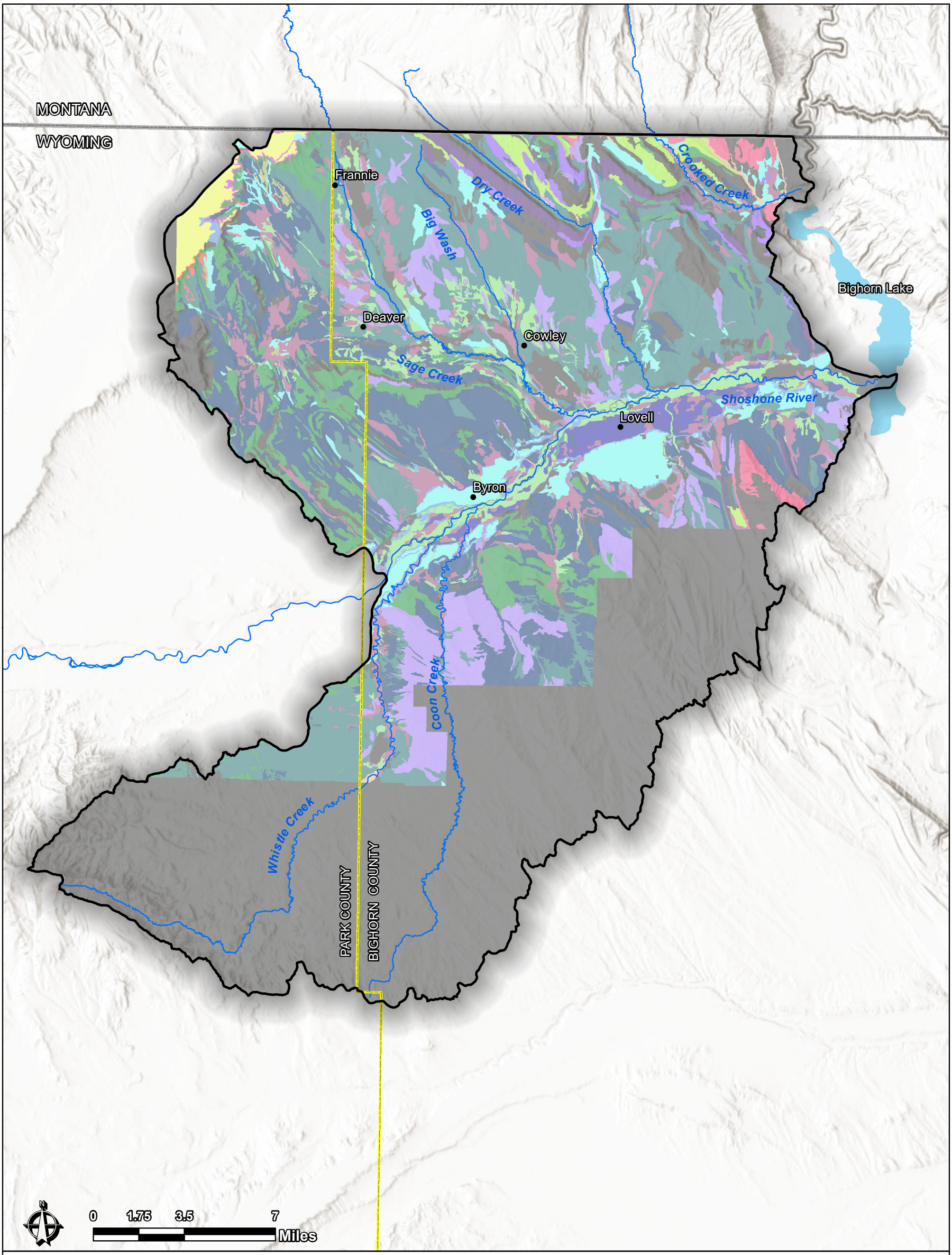
Lower Shoshone Level 1 Watershed Study
Park and Bighorn County, Wyoming

research & consulting inc.
Biota



Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse
Non Functional Stock Tanks and Reservoirs

MAP 29	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI WORLD HILLSHADE	**NON-FUNCTIONAL WATER BASINS** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
County Boundary
Major Waterbody
Major Watercourse

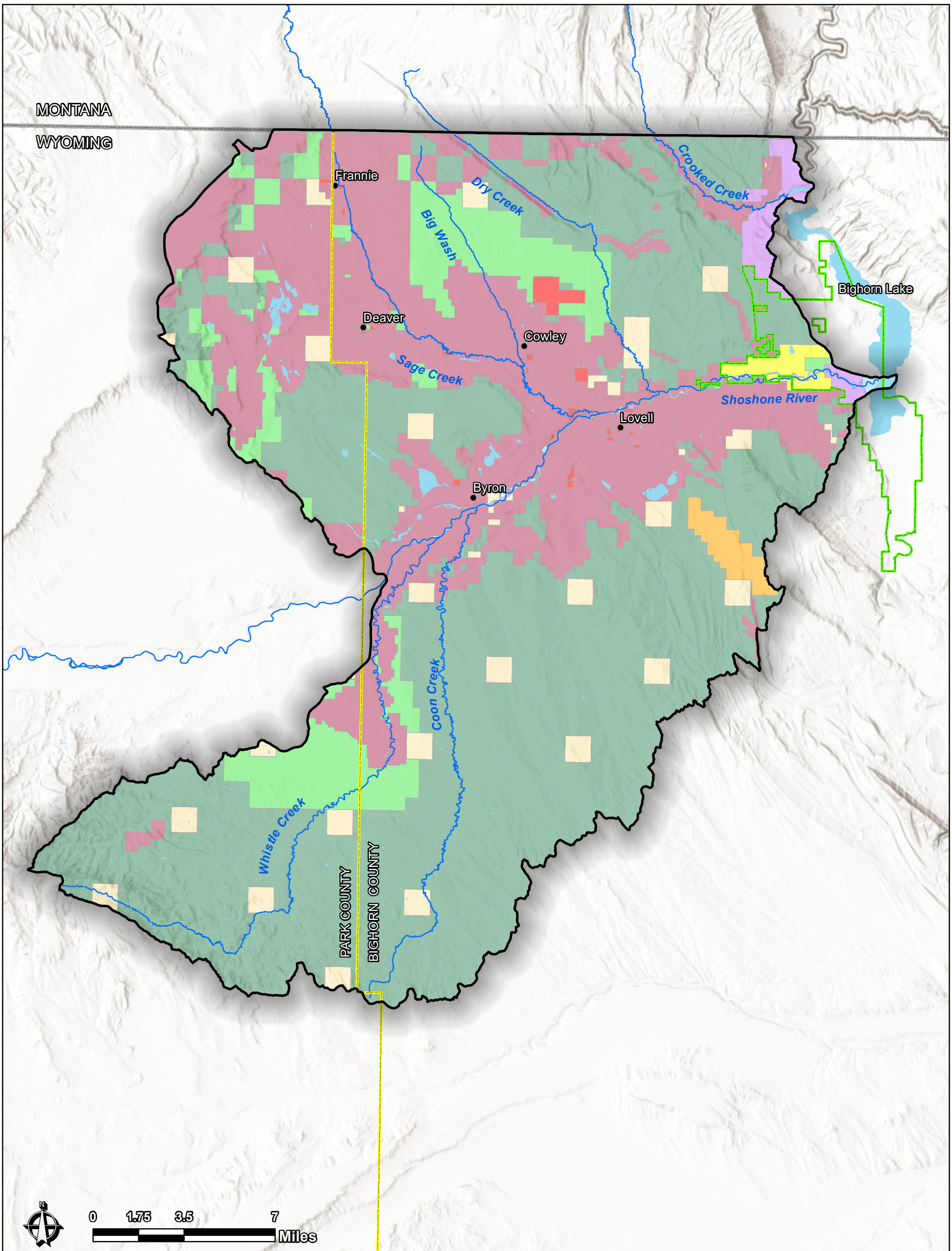
*Ecological Site Legend continued on the next page

MAP 30	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI World Hillshade	**ECOLOGICAL SITES** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota

ECOLOGICAL SITE DESCRIPTIONS LEGEND

- No Data Available
- Clayey (Cy) 5-9" Big Horn Basin Precipitation Zone
- Coarse Upland (CU) 10-14" East Precipitation Zone
- Coarse Upland (CU) 5-9" Big Horn Basin Precipitation Zone
- Gravelly (Gr) 5-9" Big Horn Basin Precipitation Zone
- Loamy (Ly) 10-14" East Precipitation Zone
- Loamy (Ly) 5-9" Big Horn Basin Precipitation Zone
- Loamy Calcareous Big Horn Basin Mesic, 7-12" Big Horn Basin Precipitation Zone
- Lowland (LL) 5-9" Big Horn Basin Precipitation Zone
- Saline Lowland (SL) 5-9" Big Horn Basin Precipitation Zone
- Saline Lowland (SL) 10-14" East Precipitation Zone
- Saline Subirrigated (SS) 5-9" Big Horn Basin Precipitation Zone
- Saline Upland (SU) 5-9" Big Horn Basin Precipitation Zone
- Sandy (Sy) 10-14" East Precipitation Zone
- Sandy (Sy) 5-9" Big Horn Basin Precipitation Zone
- Shale (Sh) 5-9" Big Horn Basin Precipitation Zone
- Shallow Clayey (SwCy) 5-9" Big Horn Basin Precipitation Zone
- Shallow Loamy (SwLy) 10-14" East Precipitation Zone
- Shallow Loamy (SwLy) 5-9" Big Horn Basin Precipitation Zone
- Shallow Sandy (SwSy) 5-9" Big Horn Basin Precipitation Zone
- Shallow To Gravel 5-9" Mesic Big Horn Basin Precipitation Zone
- Very Shallow (VS) 10-14" East Precipitation Zone
- Very Shallow (VS) 5-9" Big Horn Basin Precipitation Zone
- Wetland (WL) 5-9" Big Horn Basin Precipitation Zone

MAP 30b	PROJECT: 05SC0298344 DATE: O1/10/2022	**ECOLOGICAL SITES LEGEND** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse

Ownership

Bureau of Land Management - 54.1%
Bureau of Reclamation - 8.6%
Department of Defense - 0.8%
Local Government - 0.5%
Yellowtail WHMA
Private - 29.8%
State - 3.8%
Wyoming Game & Fish - 0.67%
National Park Service
(Big Horn Canyon National Recreation Area) - 1.2%

Map 31

PROJECT: 05SC0298344

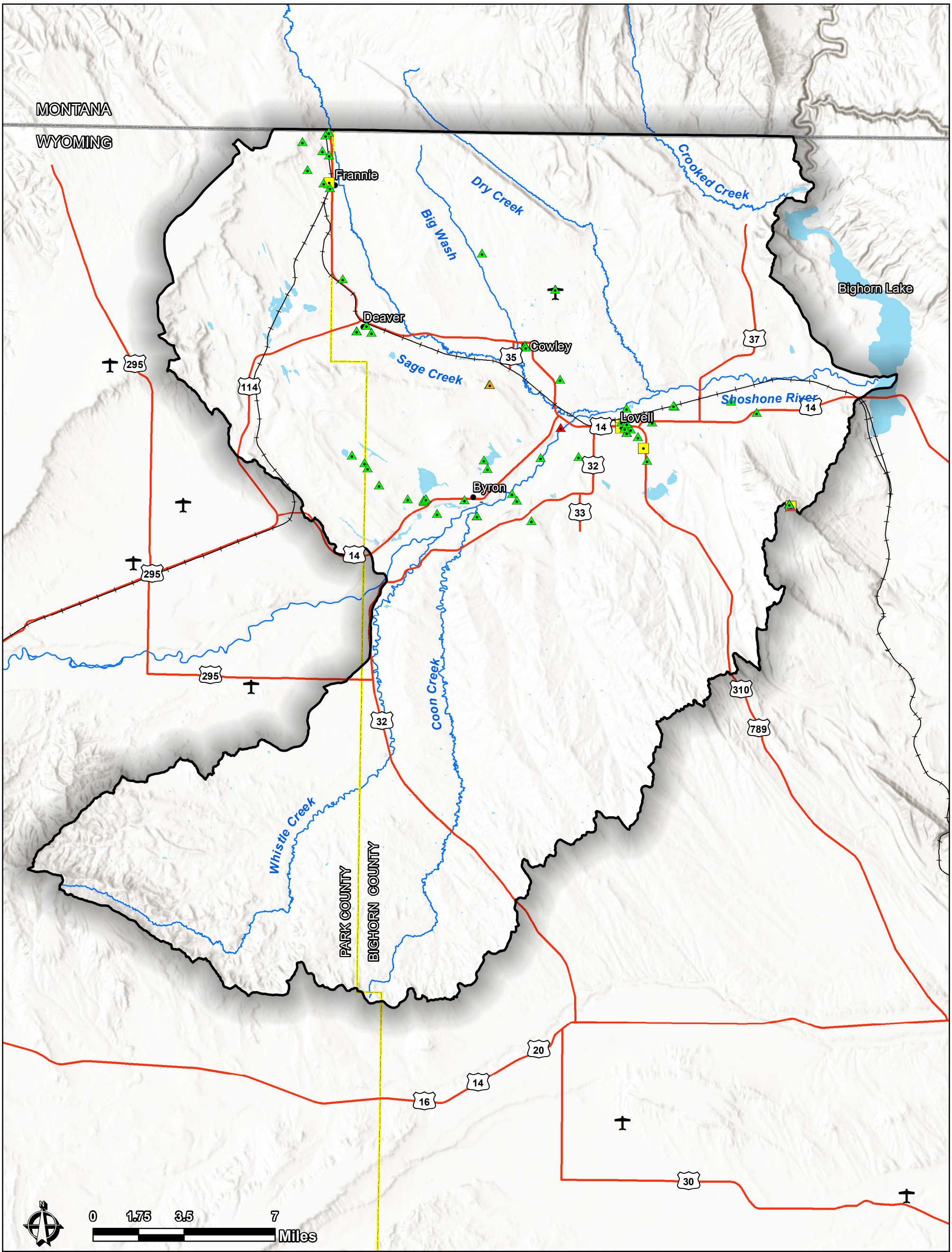
DATE: O1/10/2022

SCALE: 1 inch = 3.5 Miles
UNITS: Miles
BASEMAP: ESRI World Hillshade

LAND OWNERSHIP

Lower Shoshone Level 1 Watershed Study
Park and Bighorn County, Wyoming

research & consulting inc.
Biota



Lower Shoshone Watershed Study Area
State Boundary
County Boundary
Major Waterbody
Major Watercourse
Railroads
Major Road
Structure - Antenna Structure
Structure - Private Land Mobile Radio
Structure - FM Radio
Structure - Cell
Structure - Microwave
Airports

MAP 32

PROJECT: 05SC0298344

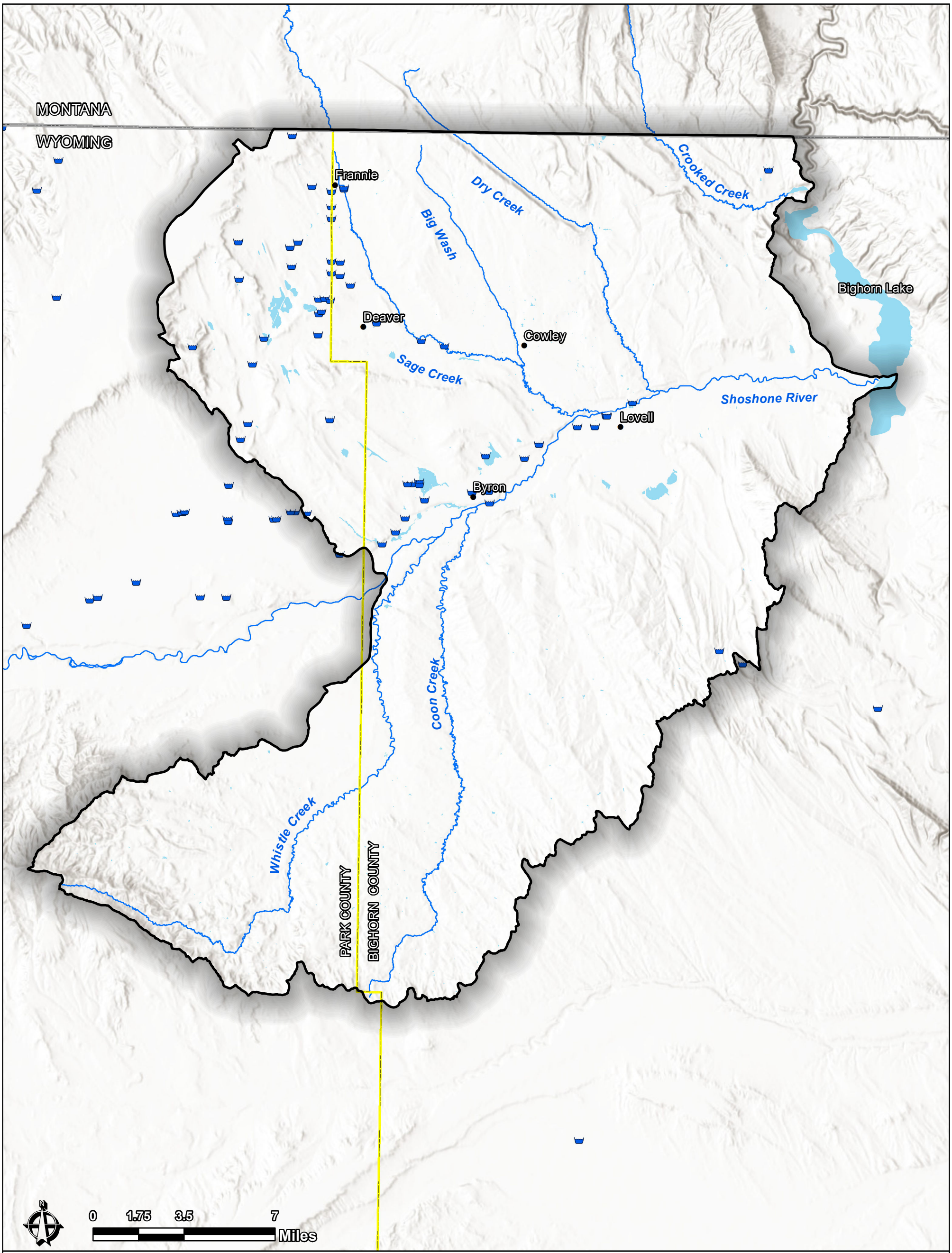
DATE: O1/10/2022

SCALE: 1 inch = 3.5 Miles
UNITS: Miles
BASEMAP: ESRI World Hillshade

TRANSPORTATION AND COMMUNICATION INFRASTRUCTURE

Lower Shoshone Level 1 Watershed Study
Park and Bighorn County, Wyoming

research & consulting inc.
Biota



Lower Shoshone Watershed Study Area
State Boundary
County Boundary
Major Waterbody
Major Watercourse
WYPDES Permits

MAP 33

PROJECT: 05SC0298344

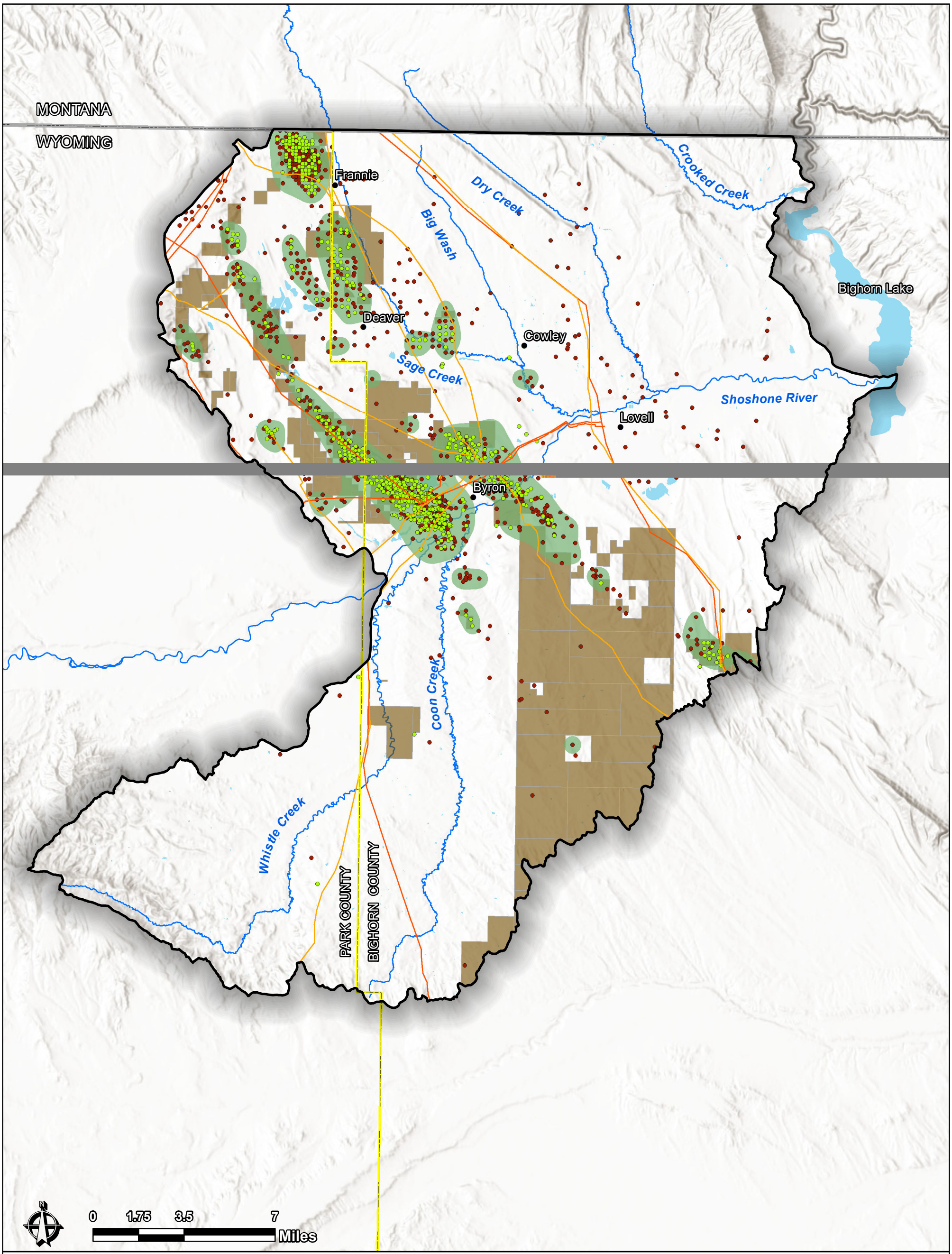
DATE: O1/10/2022

SCALE: 1 inch = 3.5 Miles
UNITS: Miles
BASEMAP: ESRI World Hillshade

WYDPDES PERMITS

Lower Shoshone Level 1 Watershed Study
Park and Bighorn County, Wyoming

research & consulting inc.
Biota

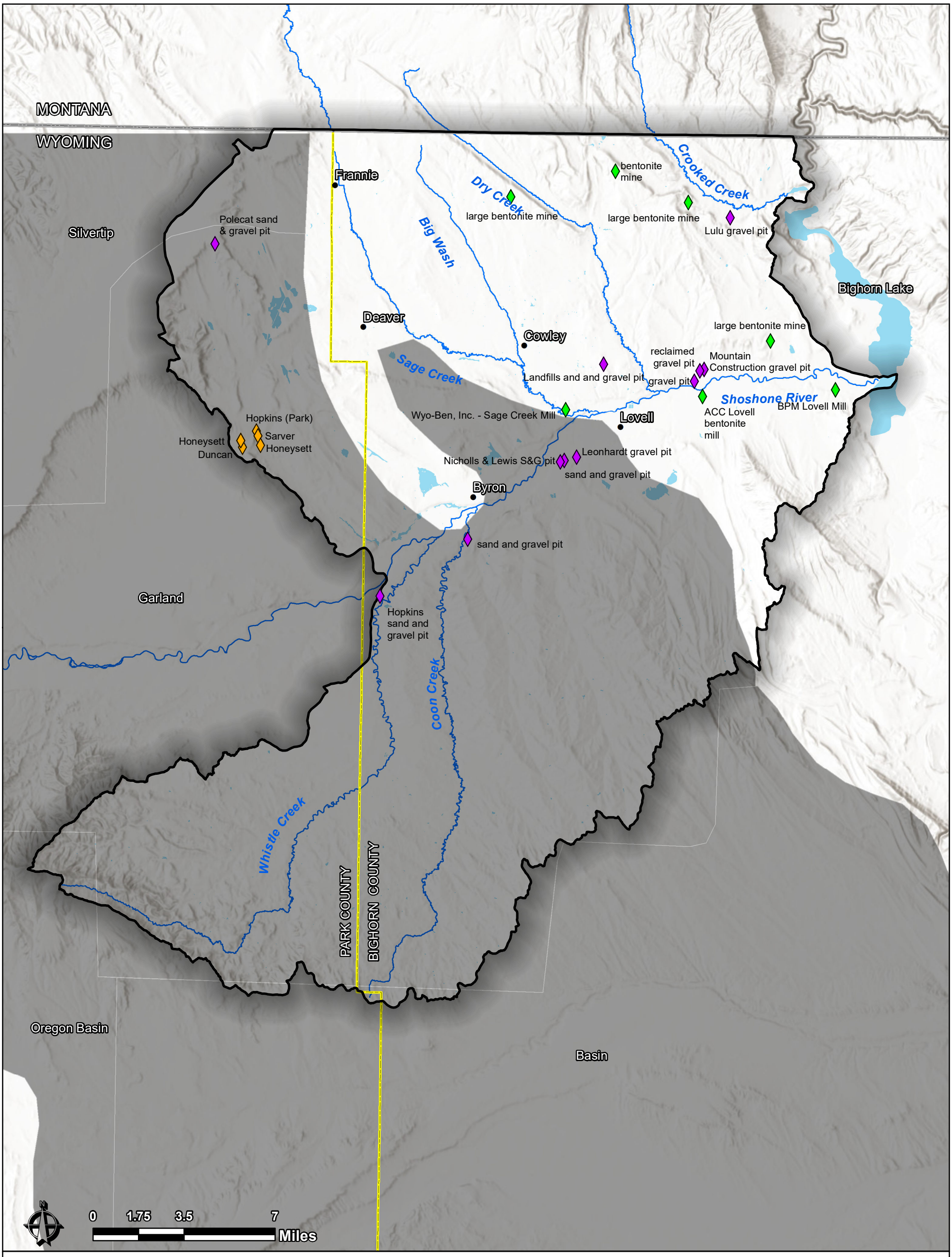


Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse
Oil and Gas Fields
BLM Active Oil and Gas Lease
Wells
Plugged/ Abandoned Wells

Pipelines

Crude Oil
Natural Gas

MAP 34	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI World Hillshade	**OIL AND GAS RESOURCES** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
County Boundary
Major Waterbody
Major Watercourse

Mines

Bentonite
Coal
Unconsolidated gravel, sand, cobbles, & silt
Coal Field

MAP 35

PROJECT: 05SC0298344

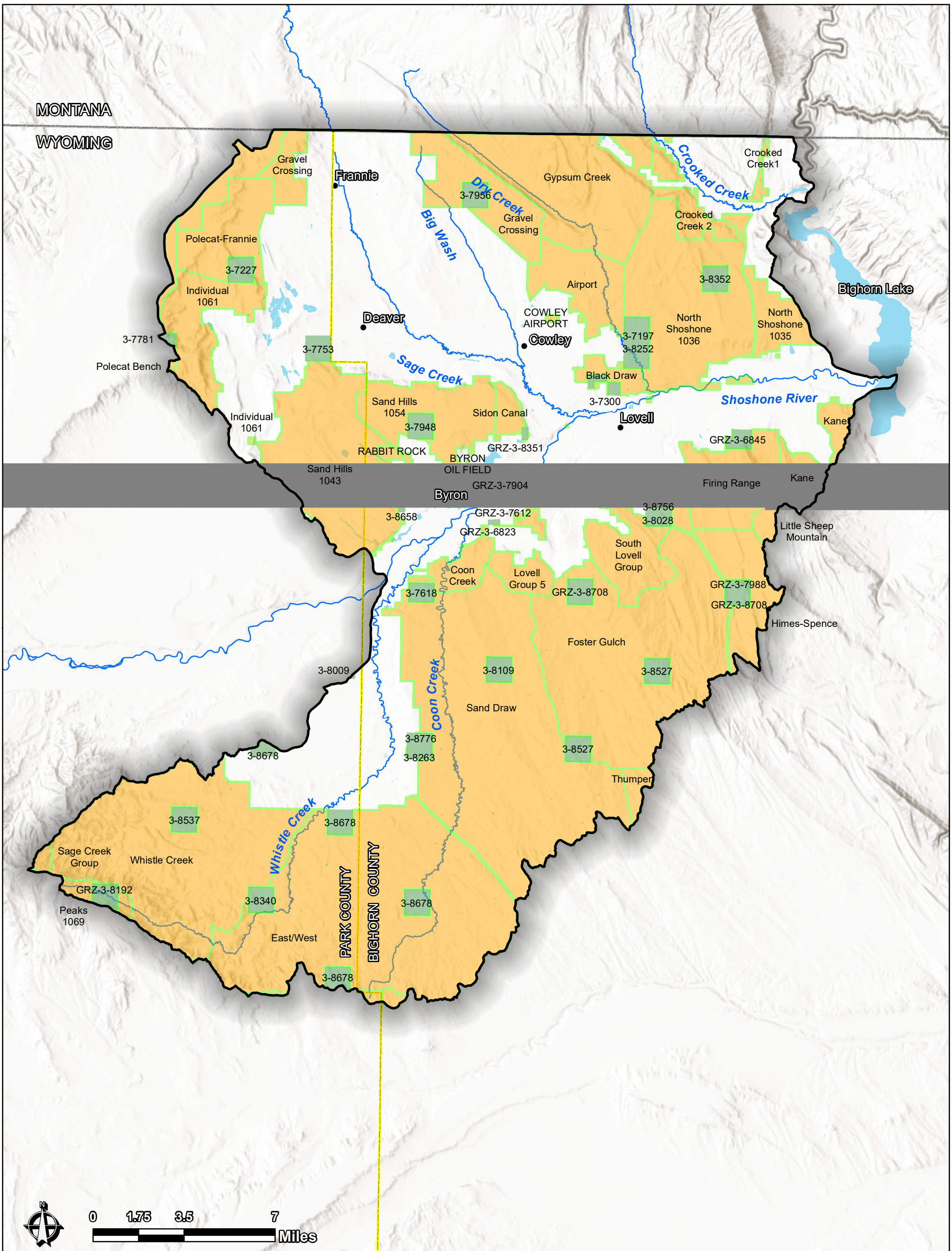
DATE: O1/10/2022

SCALE: 1 inch = 3.5 Miles
UNITS: Miles
BASEMAP: ESRI WORLD HILLSHADE

MINES AND MINERALS

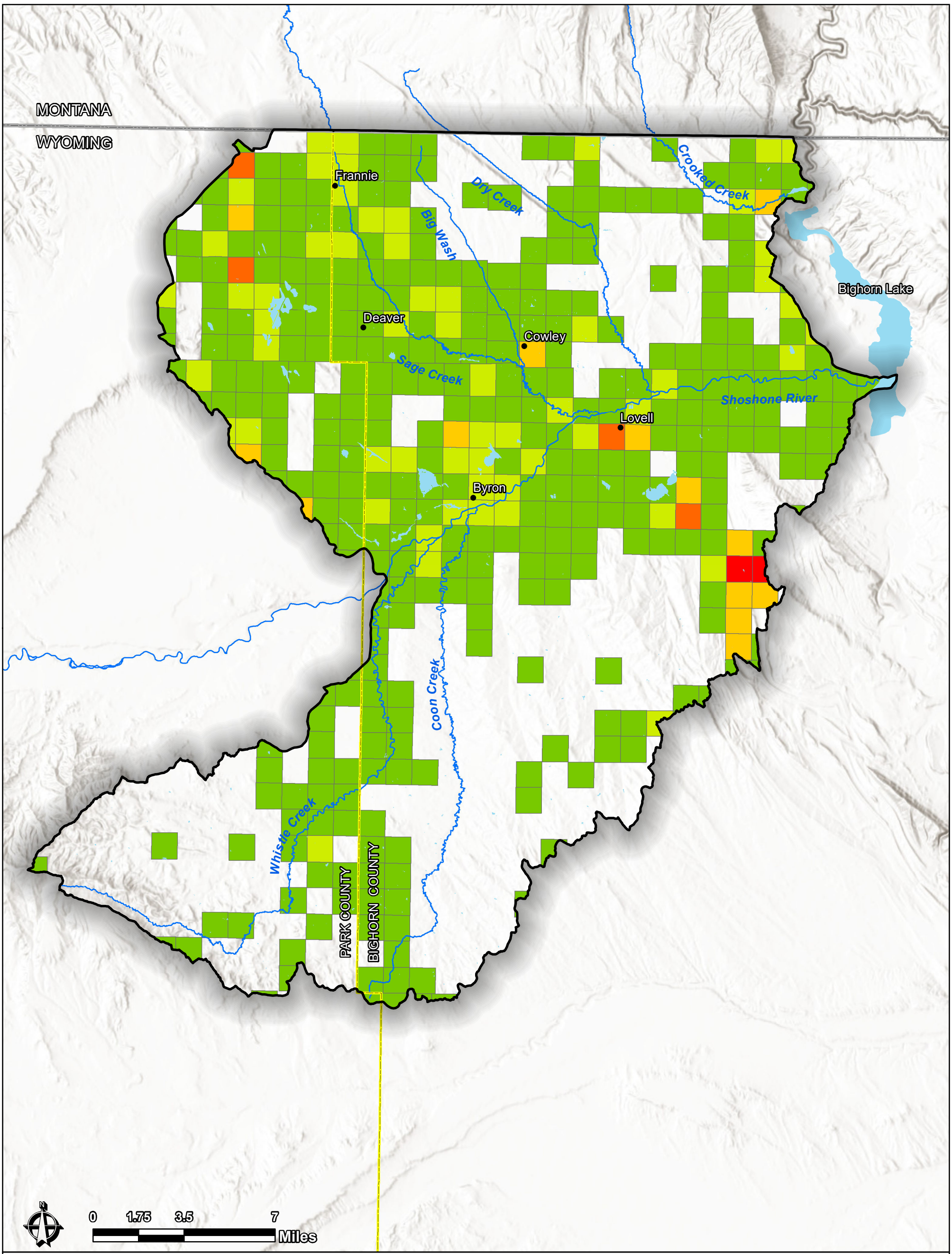
Lower Shoshone Level 1 Watershed Study
Park and Bighorn County, Wyoming

research & consulting inc.
Biota



Lower Shoshone Watershed Study Area
State Boundary
County Boundary
Major Waterbody
Major Watercourse
BLM National Grazing Allotment
State Grazing Allotment

MAP 36	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI World Hillshade	**GRAZING ALLOTMENTS** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
County Boundary
Major Waterbody
Major Watercourse

Resource Count of Number of Cultural Sites Eligable for inclusion on the National Register of Historical Places

1 - 4
5 - 9
10 - 14
15 - 20
21 - 33

MAP 37

PROJECT: 05SC0298344

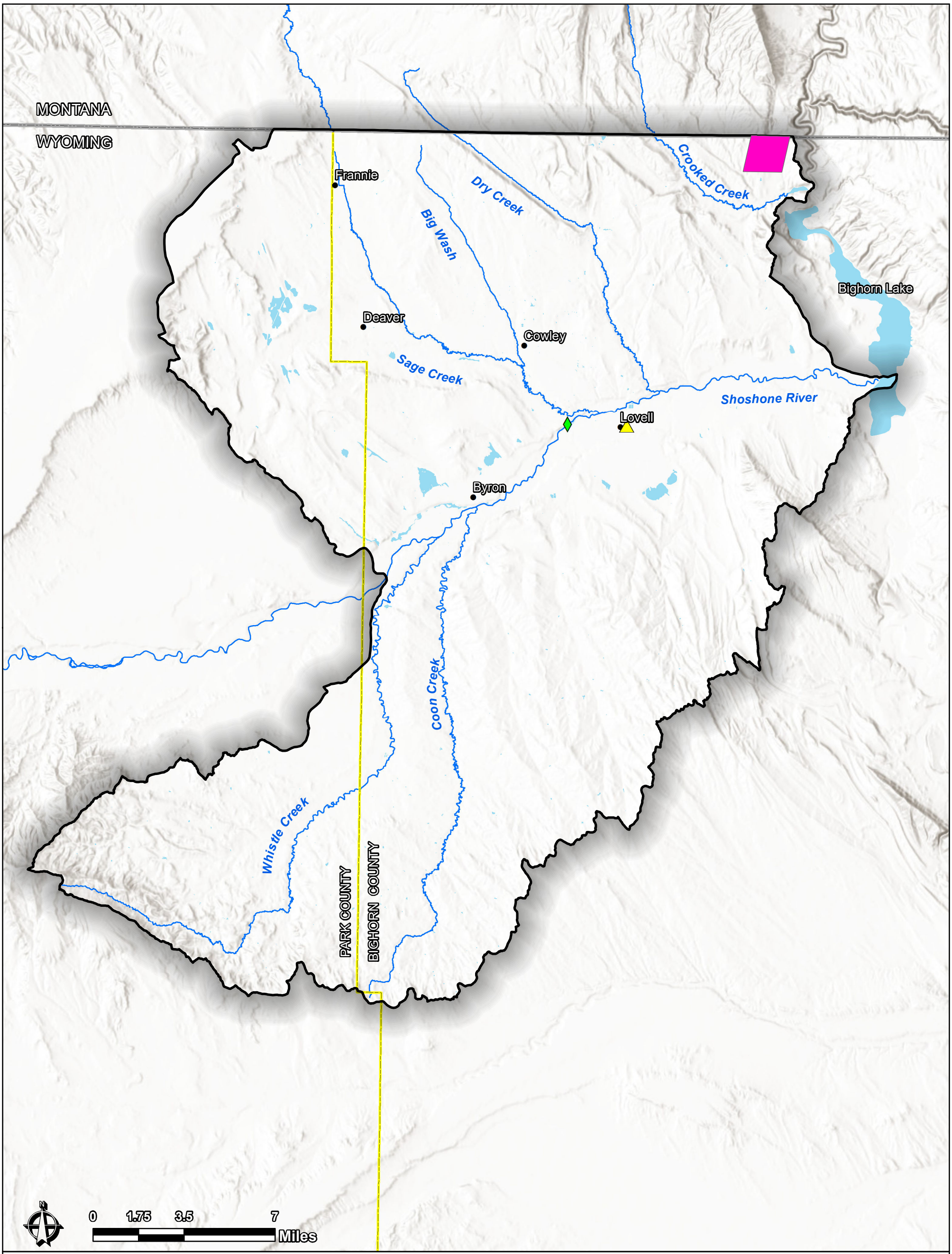
DATE: O1/10/2022

SCALE: 1 inch = 3.5 Miles
UNITS: Miles
BASEMAP: ESRI World Hillshade

CULTURAL RESOURCES PER-SECTION

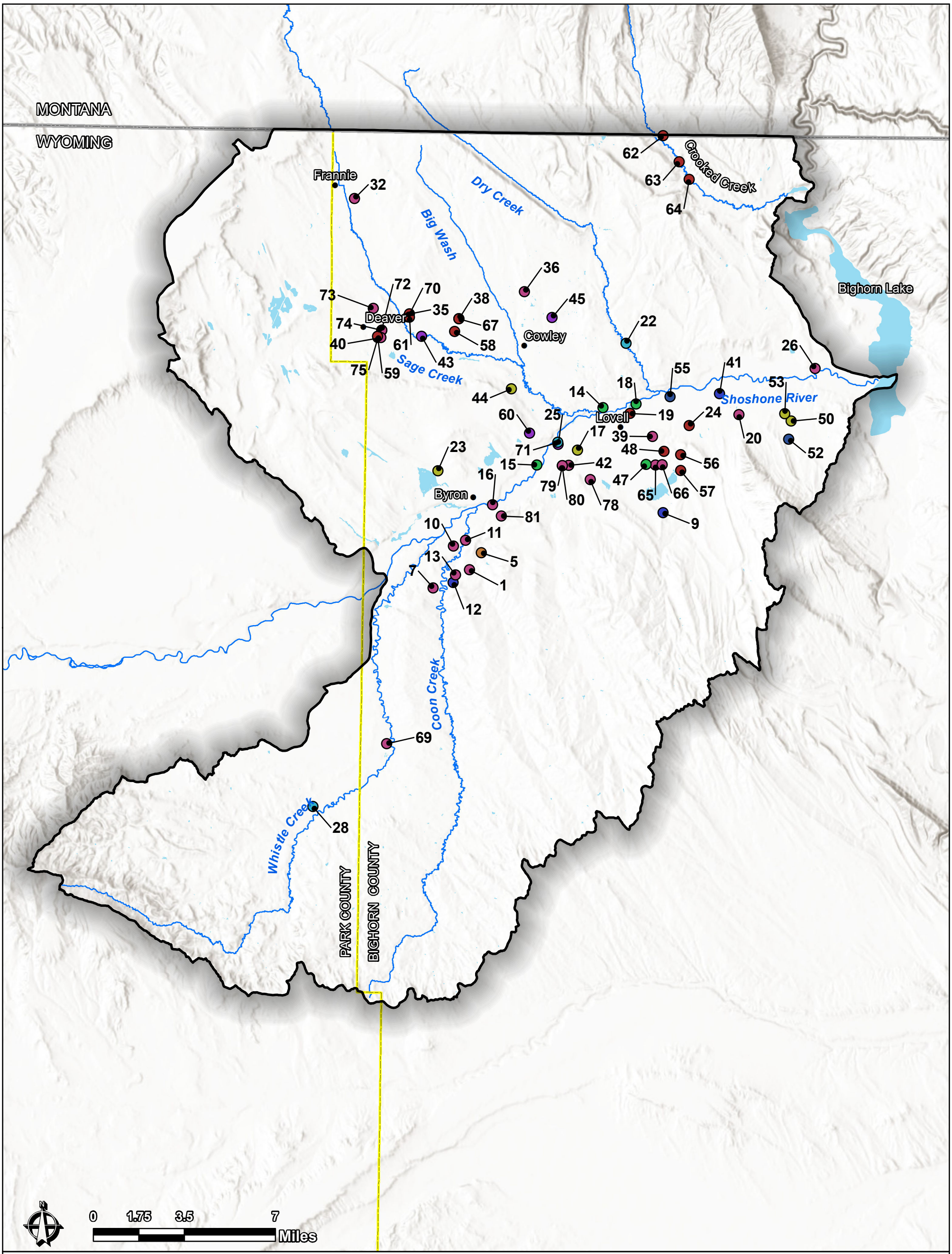
Lower Shoshone Level 1 Watershed Study
Park and Bighorn County, Wyoming

research & consulting inc.
Biota



Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Waterbody
Major Watercourse
Bad Pass Trail
Hyart Theater
EJZ Bridge

MAP 38	PROJECT: 05SC0298344 DATE: O1/10/2022 SCALE: 1 inch = 3.5 Miles UNITS: Miles BASEMAP: ESRI WORLD HILLSHADE	**NATIONAL REGISTER OF HISTORIC PLACES** **Lower Shoshone Level 1 Watershed Study** **Park and Bighorn County, Wyoming**	research & consulting inc. Biota



Lower Shoshone Watershed Study Area
State Boundary
Counties
Major Water Body
Major River/ Creek

Potential Project Opportunities

- Dam-reservoir
- Ditch-canal
- Pipe conversion
- SWPP-channel stabilization
- SWPP-environmental
- SWPP-irrigation
- SWPP-spring development
- SWPP-well
- Other

MAP 39

PROJECT: 05SC0298344

DATE: O1/10/2022

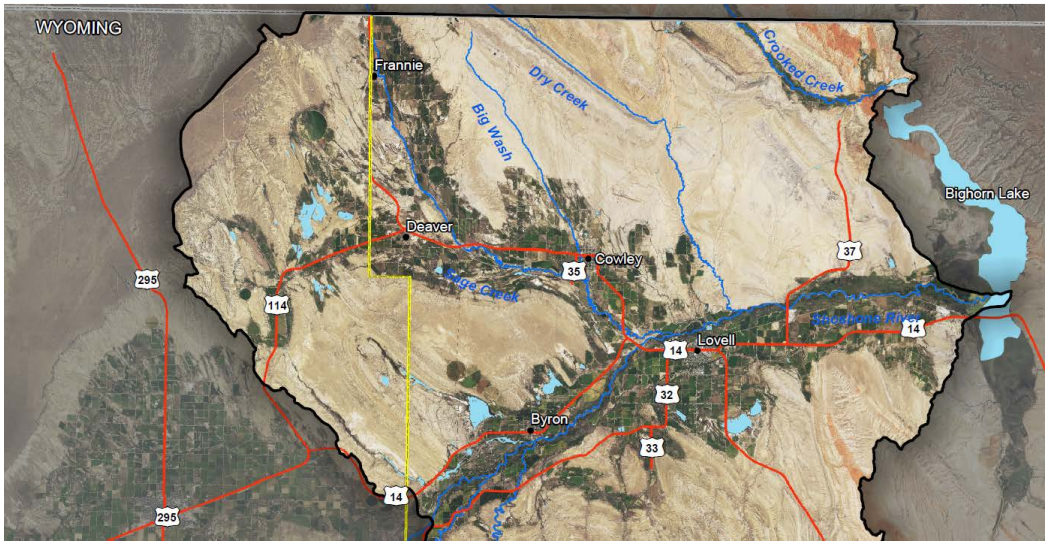
SCALE: 1 inch = 3.5 Miles
UNITS: Miles
BASEMAP: ESRI WORLD HILLSHADE

POTENTIAL PROJECTS

Lower Shoshone Level 1 Watershed Study
Park and Bighorn County, Wyoming

research & consulting inc.
Biota

LOWER SHOSHONE RIVER LEVEL I WATERSHED STUDY
FINAL REPORT - APPENDIX B



MARCH 11, 2022

PREPARED FOR:
WYOMING WATER DEVELOPMENT COMMISSION
SHOSHONE CONSERVATION DISTRICT

PREPARED BY:
BIOTA RESEARCH AND CONSULTING, INC.

IN ASSOCIATION WITH:
SUNRISE ENGINEERING, INC.

LOWER SHOHONE RIVER LEVEL I WATERSHED STUDY

APPENDIX B (PROJECT INFORMATION)

Contents:

Project Prioritization Methods

Project Prioritization Matrix

Individual Project (ID# 1-81) Design Information

Lower Shoshone Level I Watershed Study Project Prioritization Methods

Required Water Rights (Low/Med/High)
Low - none; SEO permit approved or not required
Medium - routine water rights permitting required with SEO
High - significant SEO permitting effort

Feasibility (Low/Med/High)
Takes into account the following factors
- implementation difficulty
- land ownership
- overall scale of project

SWPP Eligible (Yes/No/Partial)
Yes - all project components are SWPP eligible
No - no project components are SWPP eligible
Partial - some project components are SWPP eligible

Benefit/Cost (Low/Med/High)
Takes into account the following factors
- public benefit
- water resource benefits
- ancillary benefits
- number of beneficiaries
- relative project cost

Project Information							Required Water Rights		Feasibility		SWPP Eligible		Benefit/Cost		Total Score
Rank	ID	ProjectName	OwnerName	PrjType	DevelopmentType	Account	Low/Med/High	Score	Low/Med/High	Score	Yes/No/Partial	Score	Low/Med/High	Score	
1	17	Diversion Canal Erosion	Walker, Jim	Ditch-canal	Rehab	Account II	Low	3	High	3	Yes	5	High	3	14
1	9	BLM Solar Pump	Beck, Tim	SWPP-well	Rehab	Account II	Low	3	High	3	Yes	5	High	3	14
1	23	Sidon Canal Reuse Water Project	Rageth, Brent	Ditch-canal	New supply and rehab	Account II	Low	3	High	3	Yes	5	High	3	14
1	45	Storage Settling Pond	Blackburn, Ken	Dam-reservoir	New	Account I	Low	3	High	3	Yes	5	High	3	14
1	58	Lateral Sidon to South Neighbors	Ellis, Spencer and Casey	Pipe conversion	Rehab	Account II	Low	3	High	3	Yes	5	High	3	14
1	59	Lateral Sidon to Lower Field at Wormington	Ellis, Spencer and Casey	Pipe conversion	Rehab	Account II	Low	3	High	3	Yes	5	High	3	14
1	81	Eagle Rock Transmission Pipe	Hopkin, Fred	SWPP-irrigation	Rehab	Account II	Low	3	High	3	Yes	5	High	3	14
1	53	Bury lateral and Replace parallel ditches	Schilthuis, Kevin	Ditch-canal	Rehab	Account II	Low	3	High	3	Yes	5	High	3	14
1	77	Burying Lateral on end of Deaver Irrigation Canal - Probably not pursue	Ellis, Spencer and Casey	Pipe conversion	Rehab	Account II	Low	3	High	3	Yes	5	High	3	14
2	18	Streambank Erosion and Drain Protection	Bischoff, Dave	SWPP-channel stabilization	Rehab	Account II	Low	3	High	3	Yes	5	Medium	2	13
2	16	Globe Canal Headgate and Diversion	Walker, Jim	SWPP-irrigation	Rehab	Account II	Low	3	High	3	Yes	5	Medium	2	13
2	41	Solar Pump Water Cattle	Brad Tippetts	SWPP-well	New	Account II	Low	3	High	3	Yes	5	Medium	2	13
2[1]	19	Moss Ranch Ditch Rehab	Bischoff, Dave	Pipe conversion	Rehab	Account II	Low	3	High	3	Yes	5	Medium	2	13
2	35	Pipeline to Control Seepage	Wambeke, Paul	Pipe conversion	Rehab	Account II	Low	3	High	3	Yes	5	Medium	2	13
2	50	Line or Pipe Hunt Canal	Schilthuis, Kevin	Ditch-canal	Rehab	Account II	Low	3	Medium	2	Yes	5	High	3	13
2	60	Building of Reservoir on Marchants Coulee	Ellis, Spencer and Casey	Dam-reservoir	New	Account I	Low	3	High	3	Yes	5	Medium	2	13
2	24	Bubbler and Pipe	Tippetts, Rand	Pipe conversion	Rehab	Account II	Low	3	High	3	Yes	5	Medium	2	13
3	14	Shoshone River Bank Stabilization Lower Site	Hessenthaler, David	SWPP-channel stabilization	New	Account I	Low	3	Medium	2	Yes	5	Medium	2	12
3	15	Shoshone River Bank Stabilization Upper Site	Hessenthaler, David	SWPP-channel stabilization	New	Account I	Low	3	Medium	2	Yes	5	Medium	2	12
3	47	Sand Draw Erosion Control	Leithead, Vance	SWPP-channel stabilization	New	Account I	Low	3	Medium	2	Yes	5	Medium	2	12
3	55	Wetland Enhancement	Bischoff, Beth	SWPP-environmental	Rehab	Account I	Low	3	High	3	Partial	3	High	3	12
3	12	Solar well	Beck, Tim	SWPP-well	New	Account I	Medium	2	High	3	Yes	5	Medium	2	12
3	73	Estes Corner 40	Wambeke, Angie	SWPP-irrigation	Rehab	Account II	Low	3	Medium	2	Yes	5	Medium	2	12
3	74	Estes Home Place	Wambeke, Angie	SWPP-irrigation	New	Account I	Low	3	Medium	2	Yes	5	Medium	2	12
3	56	Convert Ditch to Gated Pipe	Price, Chris	Pipe conversion	Rehab	Account II	Low	3	High	3	Partial	3	High	3	12
3	57	Convert Ditch to Gated Pipe	Price, Chris	Pipe conversion	Rehab	Account II	Low	3	High	3	Partial	3	High	3	12
3	5	Seep Development	Beck, Tim	SWPP-spring development	New	Account I	High	1	High	3	Yes	5	High	3	12
3	13	Wetland development	Beck, Tim	SWPP-irrigation	New	Account I	Medium	2	Medium	2	Yes	5	High	3	12
3	40	Chris Wambeke Short Rows	Wambeke, Christopher	SWPP-irrigation	Rehab	Account II	Low	3	Medium	2	Yes	5	Medium	2	12
4	25	Reservoir	Traylor, Reba	Dam-reservoir	New	Account I	High	1	High	3	Yes	5	Medium	2	11
4	68	Headcut Erosion Control	Bischoff, Beth	SWPP-channel stabilization	Rehab	Account II	Low	3	Medium	2	Yes	5	Low	1	11
4	78	Lateral Pipeline from Lovell Canal Bench lateral to North side of road	Ellis, Spencer and Casey	SWPP-irrigation	New	Account I	Low	3	Medium	2	Yes	5	Low	1	11
4	28	Whistle Creek Livestock Pipe	Flitner, Greg	Other	New	Account I	Medium	2	Medium	2	Yes	5	Medium	2	11

[1] Suggested projects with no design due to a lack of information despite multiple attempts to contact the proposer, it was determined to be infeasible, or removed by the proposer.
n/a: Not ranked due to a lack of information. No designs developed.

Project Information							Required Water Rights		Feasibility		SWPP Eligible		Benefit/Cost		Total Score
Rank	ID	ProjectName	OwnerName	PrjType	DevelopmentType	Account	Low/Med/High	Score	Low/Med/High	Score	Yes/No/Partial	Score	Low/Med/High	Score	
4	26	Pipe Irrigation Improvements North of House	Zook, Doug	SWPP-irrigation	Rehab	Account II	Low	3	High	3	Partial	3	Medium	2	11
4	39	Water Use Improvement Project	Anders, Warren	SWPP-irrigation	Rehab	Account II	Low	3	High	3	Partial	3	Medium	2	11
4	62	Ditch to Pipe	Tillet, John	Pipe conversion	Rehab	Account II	Medium	2	High	3	Partial	3	High	3	11
4	69	Bury Drains for Center Pivot	Flitner, Greg	SWPP-irrigation	Rehab	Account I	Low	3	High	3	Partial	3	Medium	2	11
4	70	Sprinkler System	Wambeke, Paul	SWPP-irrigation	Rehab	Account II	Low	3	High	3	Partial	3	Medium	2	11
4	76	Levi Miller Gated Pipe Project - Same as Bill Miller #37	Miller, Levi	Pipe conversion	Rehab	Account II	Low	3	High	3	Partial	3	Medium	2	11
4	7	Coon Creek Headgate	Beck, Tim	SWPP-irrigation	New supply and rehab	ccount I and	Low	3	High	3	Partial	3	Medium	2	11
4	10	Pasture near gravel pit	Beck, Tim	SWPP-irrigation	New	Account I	Low	3	Medium	2	Partial	3	High	3	11
4	11	Gravel pit pivot	Beck, Tim	SWPP-irrigation	New	Account I	Medium	2	High	3	Partial	3	High	3	11
4	20	Buried Pipeline into Surface Irrigation	Bischoff, Dave	SWPP-irrigation	Rehab	Account II	Low	3	High	3	Partial	3	Medium	2	11
4	32	Irrigation Water Improvement	Merrill, Keri	SWPP-irrigation	Rehab	Account II	Low	3	High	3	Partial	3	Medium	2	11
4	67	Irrigation Improvements	Schwope, Michelle	Pipe conversion	Rehab	Account II	Low	3	High	3	Partial	3	Medium	2	11
4	37	Convert Ditch to Gated Pipe	Miller, Bill	Pipe conversion	Rehab	Account II	Low	3	High	3	Partial	3	Medium	2	11
4	42	Despain Gated Pipe	Blain, Zachary	SWPP-irrigation	Rehab	Account II	Low	3	High	3	Partial	3	Medium	2	11
4	82	Sidon Canal Tailwater Headcut	Crosby, Casey	Ditch-canal	Rehab	Account II	Low	3	Low	1	Yes	5	Medium	2	11
5	72	Estes 80	Wambeke, Angie	SWPP-irrigation	Rehab	Account II	Low	3	Medium	2	Partial	3	Medium	2	10
5	80	Continue Pipeline Through Moncur Lateral Stopped Short	Blain, Zachary	SWPP-irrigation	New	Account I	Low	3	Medium	2	Partial	3	Medium	2	10
5	43	Sage Creek Settling Dam	Blackburn, Ken	Dam-reservoir	New	Account I	Medium	2	Low	1	Yes	5	Medium	2	10
5	48	Ditch Piping	Leithead, Vance	Pipe conversion	Rehab	Account II	Low	3	Medium	2	Partial	3	Medium	2	10
5	44	Sidon Diversion Lateral	Blackburn, Ken	Ditch-canal	New	Account I	Medium	2	Medium	2	Yes	5	Low	1	10
5[1]	3	Sand Draw	Beck, Tim	SWPP-channel stabilization	Rehab	Account II	Low	3	Low	1	Yes	5	Low	1	10
5	63	Ditch to Pipe	Tillet, John	Pipe conversion	Rehab	Account II	Medium	2	High	3	Partial	3	Medium	2	10
5	64	Ditch to Pipe	Tillet, John	Pipe conversion	Rehab	Account II	Medium	2	High	3	Partial	3	Medium	2	10
5	75	Wambeke Home Place	Wambeke, Angie	SWPP-irrigation	Rehab	Account II	Low	3	Medium	2	Partial	3	Medium	2	10
5	1	Dike Ditch	Beck, Tim	SWPP-irrigation	Rehab	Account II	Low	3	Medium	2	Partial	3	Medium	2	10
6	22	Dry Creek Cow Watering	Crosby, Casey	Other	New	Account I	High	1	Medium	2	Yes	5	Low	1	9
6[1]	2	BLM Reservoirs	Beck, Tim	Dam-reservoir	Rehab	Account II	High	1	Medium	2	Yes	5	Low	1	9
7	79	Gated Pipe Extension	Blain, Zachary	SWPP-irrigation	New	Account I	Low	3	High	3	No	#N/A	Medium	2	#N/A
7[1]	21	Dam Waste Water and 100 Acre Pivot - Not Pursue	Crosby, Casey	SWPP-irrigation	New	Account I	High	1	Medium	2	Partial	3	Medium	2	8
7	36	Pivot Feasibility	Miller, Bill	SWPP-irrigation	Rehab	Account II	Low	3	High	3	No	#N/A	Medium	2	#N/A
7	52	Rainfall Runoff Analysis for East Lovell Catchment	Schilthuis, Kevin	SWPP-environmental	New	Account I	Low	3	High	3	No	#N/A	Medium	2	#N/A
7	65	Center Pivot	Beddes	SWPP-irrigation	Rehab	Account II	Low	3	High	3	No	#N/A	Medium	2	#N/A
7	66	Center Pivot see 65	Beddes	SWPP-irrigation	Rehab	Account II	Low	3	High	3	No	#N/A	Medium	2	#N/A
8	71	Island Access	Traylor, Reba	Other	New	Account I	Low	3	High	3	No	#N/A	Low	1	#N/A
8[1]	8	Coon Creek Bridge	Beck, Tim	SWPP-channel stabilization	Rehab	Account II	Low	3	High	3	No	#N/A	Low	1	#N/A
8	38	Irrigation Improvements	Schwope, Michelle	SWPP-irrigation	Rehab	Account II	Low	3	High	3	No	#N/A	Low	1	#N/A

[1] Suggested projects with no design due to a lack of information despite multiple attempts to contact the proposer, it was determined to be infeasible, or removed by the proposer.
n/a: Not ranked due to a lack of information. No designs developed.

Project Information							Required Water Rights		Feasibility		SWPP Eligible		Benefit/Cost		Total Score
Rank	ID	ProjectName	OwnerName	PrjType	DevelopmentType	Account	Low/Med/High	Score	Low/Med/High	Score	Yes/No/Partial	Score	Low/Med/High	Score	
9	51	Sprinklers/Gated pipe for East Lovell Canal	Schilthuis, Kevin	SWPP-irrigation	Rehab	Account II	Low	3	Low	1	No	#N/A	Medium	2	#N/A
9	54	Improve Open Drain and Line Antiquated Clay Tile Drain	Schilthuis, Kevin	SWPP-irrigation	Rehab	Account II	Low	3	Low	1	No	#N/A	Medium	2	#N/A
10[1]	4	Sand Draw Siphon Turbine	Beck, Tim	Other	New	Account I	Low	3	Low	1	No	#N/A	Low	1	#N/A
10[1]	6	Coon Creek Siphon Turbine	Beck, Tim	Other	New	Account I	Low	3	Low	1	No	#N/A	Low	1	#N/A
10	49	Remove Flood Irrigation	Schilthuis, Kevin	SWPP-irrigation	Rehab	Account II	Low	3	Low	1	No	#N/A	Low	1	#N/A
n/a	27	Headgate and Pipe	Undem, Joel	unknown	unknown	unknown									
n/a	29	Pivots	Guccion, Lynn	SWPP-irrigation	Rehab	Account II									
n/a	30	No Name	Haskell, Bart	unknown	unknown	unknown									
n/a	31	No Name	Rael, David	unknown	unknown	unknown									
n/a	33	No Name	Crosby, Chris	unknown	unknown	unknown									
n/a	34	New Land Irrigation	Tillett, Hip	SWPP-irrigation	New	Account I									

[1] Suggested projects with no design due to a lack of information despite multiple attempts to contact the proposer, it was determined to be infeasible, or removed by the proposer.
n/a: Not ranked due to a lack of information. No designs developed.

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

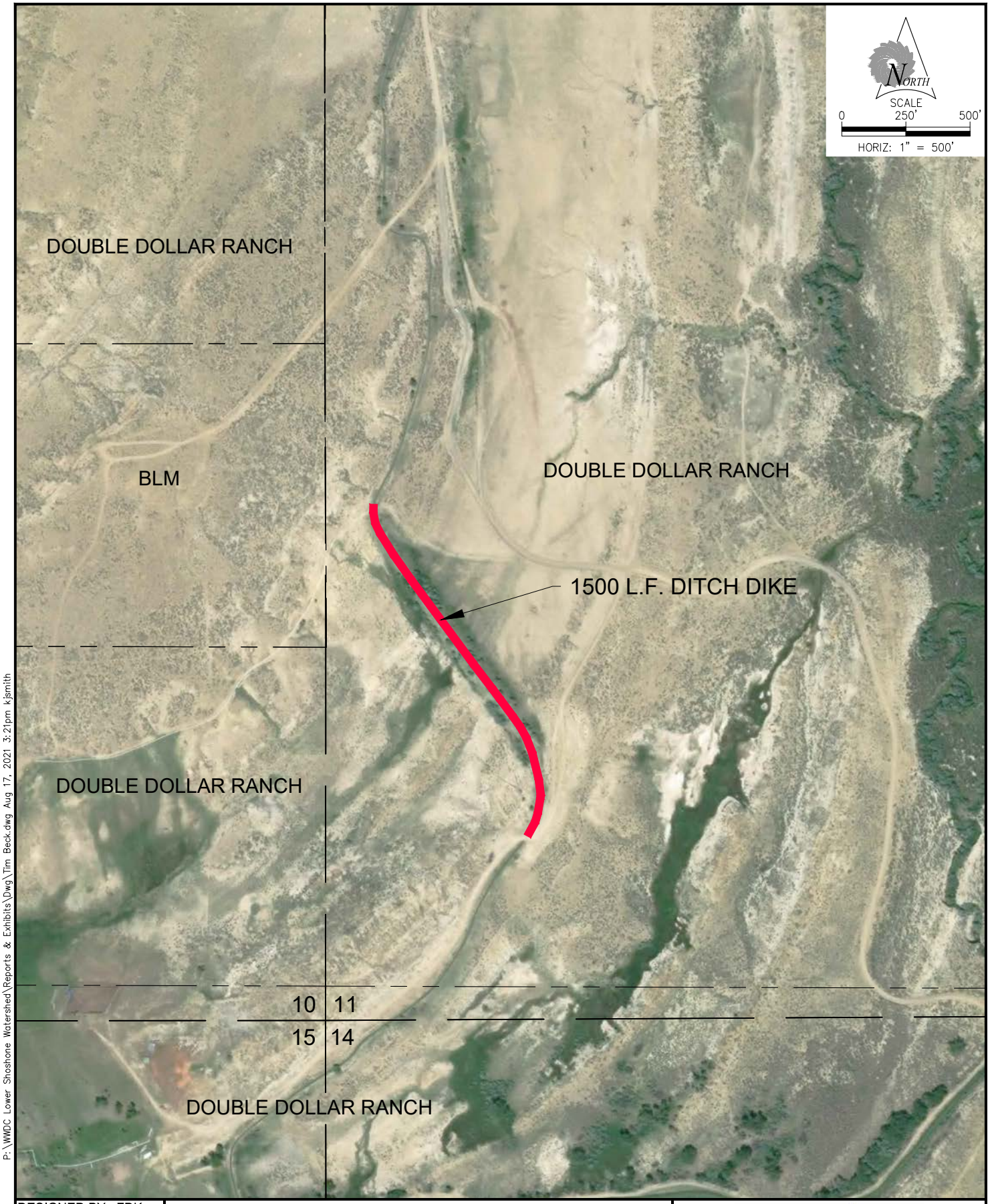
Project ID #:	1	
Owner/Operator:	**Beck, Tim**	
Site Name:		
Type Of Project:	Dike to Ditch	
Land Jurisdiction:	Private	
Location:	44.756521N	-108.509429W

Project Description

Statement of Purpose and Need: Native dirt irrigation ditch within a constructed dike, seeps.
Proposed Project: Convert to pipe and center pivot. The center pivot portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable
State Engineers Office: No Permitting
Wyoming Office of State Lands: None
Wyoming Department of Environmental Quality: Not applicable
Bureau of Land Management: None
Other Landowners: Double Dollar Ranch



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Tim Beck.dwg Aug 17, 2021 3:21pm kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#1 TIM BECK (DIKE DITCH)
LOCATED IN SECTION 11 T55N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 1
Owner/Operator: **Beck, Tim**
Site Name:
Type Of Project: Dike to Ditch

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$4,500.00	$4,500
2	Traffic Control	1	L.S.	$0.00	$0
3	Grade and Smooth Pipe Route	1,500	L.F.	$2.00	$3,000
4	Furnish and install 18" Pipe	1,500	L.F.	$24.00	$36,000
5	Headgate Wall	5	Cu. Yd.	$500.00	$2,500
6	Centerpivot Pump *	1	L.S.	$10,000.00	$10,000
7	Centerpivot Electrical *	1	L.S.	$5,000.00	$5,000
8	Center Pivot *	1	L.S.	$38,000.00	$38,000
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$99,000**

INCIDENTAL PROJECT COSTS

Construction Permits	$500
Performance Bond	$1,000
Insurance	$500
15% O&P	$14,850
Subtotal 1	**$16,850**
Subtotal 2	**$115,850**
Construction Engineering @ 10% of Subtotal #2	$11,585
Subtotal 3	**$127,435**
Contingency @ 15% of Subtotal #3	$19,115
Total Construction Cost	**$146,550**
Preparation of Final Designs and Specifications	$11,724
Permitting @ 5% of Project Cost	$7,328
Legal @ 4% of Project Cost	$5,862
Environmental Study	Fill In
Total Project Cost	**$171,464**

SITE PHOTOS:

Project ID #:	5
Owner/Operator:	**Beck, Tim**
Site Name:	Coon Creek Seep
Type Of Project:	Seep Development
Land Jurisdiction:	Private
Location:	44.76623N -108.50035W

Project Description

Statement of Purpose and Need: Existing seep to the east of Sand Draw siphon. Flow is approximately 20" wide x 10" deep at 3-4 fps (half of the flow in winter).
Proposed Project: Install solar pump with pipe and trough system to water cattle in the winter. Include hardened ford crossing for cattle and enclosure fencing to keep cattle out of the spring collection area.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

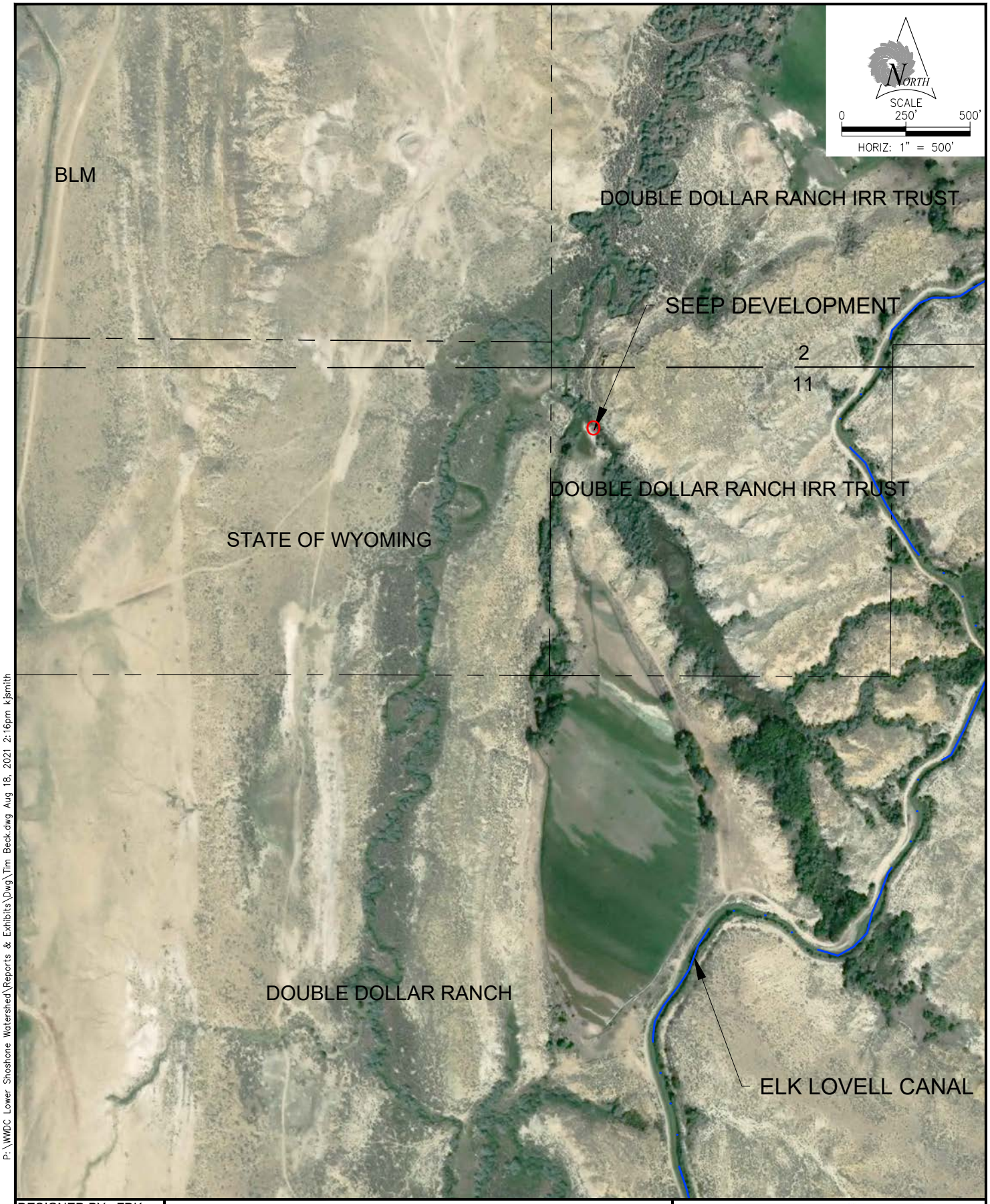
State Engineers Office: No Permitting

Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Landowners: Double Dollar Ranch



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Tim Beck.dwg Aug 18, 2021 2:16pm kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
#5 TIM BECK (SEEP DEVELOPMENT)
LOCATED IN SECTION 11 T55N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	5
Owner/Operator:	**Beck, Tim**
Site Name:	Coon Creek Seep
Type Of Project:	Seep Development

ITEMIZED COST ESTIMATE

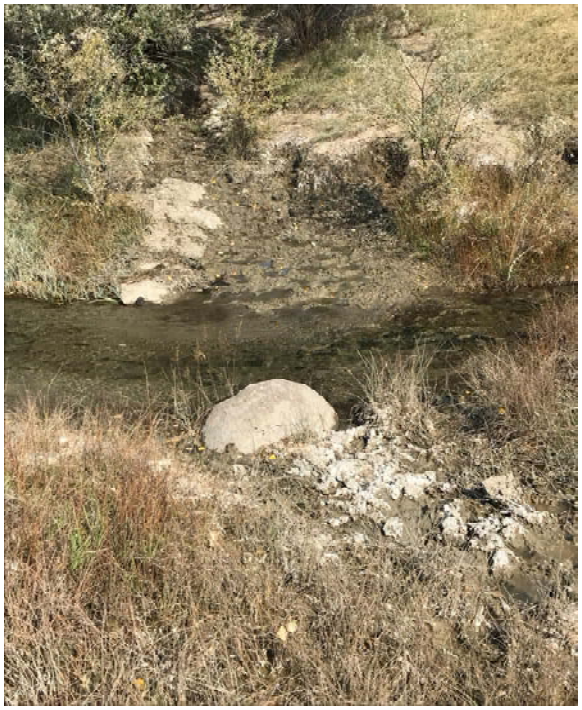
CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$5,000.00	$5,000
2	Pump System	1	LS	$11,000.00	$11,000
3	400 W Solar Panel, Mounts and Pole	1	L.S.	$2,500.00	$2,500
4	Charge Controller and Inverter	1	L.S.	$600.00	$600
5	Storage Tank (5000 gallons)	5,000	Gal.	$2.00	$10,000
6	Water Trough and Float Controller	1	Each	$2,200.00	$2,200
7	2" HDPE Pipe and Fittings	50	LF	$6.00	$300
8	Road Base	5	Yd.	$40.00	$200
9	Cattle Crossing	1	Each	$1,500.00	$1,500
10	Protection Fencing	100	L.F.	$10.00	$1,000
				Total Construction Cost	**$34,300**

INCIDENTAL PROJECT COSTS

Construction Permits	$200
Performance Bond	$400
Insurance	$200
15% O&P	$5,145
Subtotal 1	**$5,945**
Subtotal 2	**$40,245**
Construction Engineering @ 10% of Subtotal #2	$4,025
Subtotal 3	**$44,270**
Contingency @ 15% of Subtotal #3	$6,640
Total Construction Cost	**$50,910**
Preparation of Final Designs and Specifications	$4,073
Permitting @ 5% of Project Cost	$2,545
Legal @ 4% of Project Cost	$2,036
Environmental Study	Fill In
Total Project Cost	**$59,565**

SITE PHOTOS:



Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	7
Owner/Operator:	**Beck, Tim**
Site Name:	West of Coon Creek
Type Of Project:	Headgate Restoration and Pipe and Solar Pivot
Land Jurisdiction:	Private
Location:	44.74612N -108.53770W

Project Description

Statement of Purpose and Need: Irrigate 65 acres west of Coon Creek.
Proposed Project: The proposed project will include work on existing headgate (16" Waterman gate buried by silt) and piping to connect to a solar pivot. Piping will cross two draws and may require air release valve. The center pivot portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

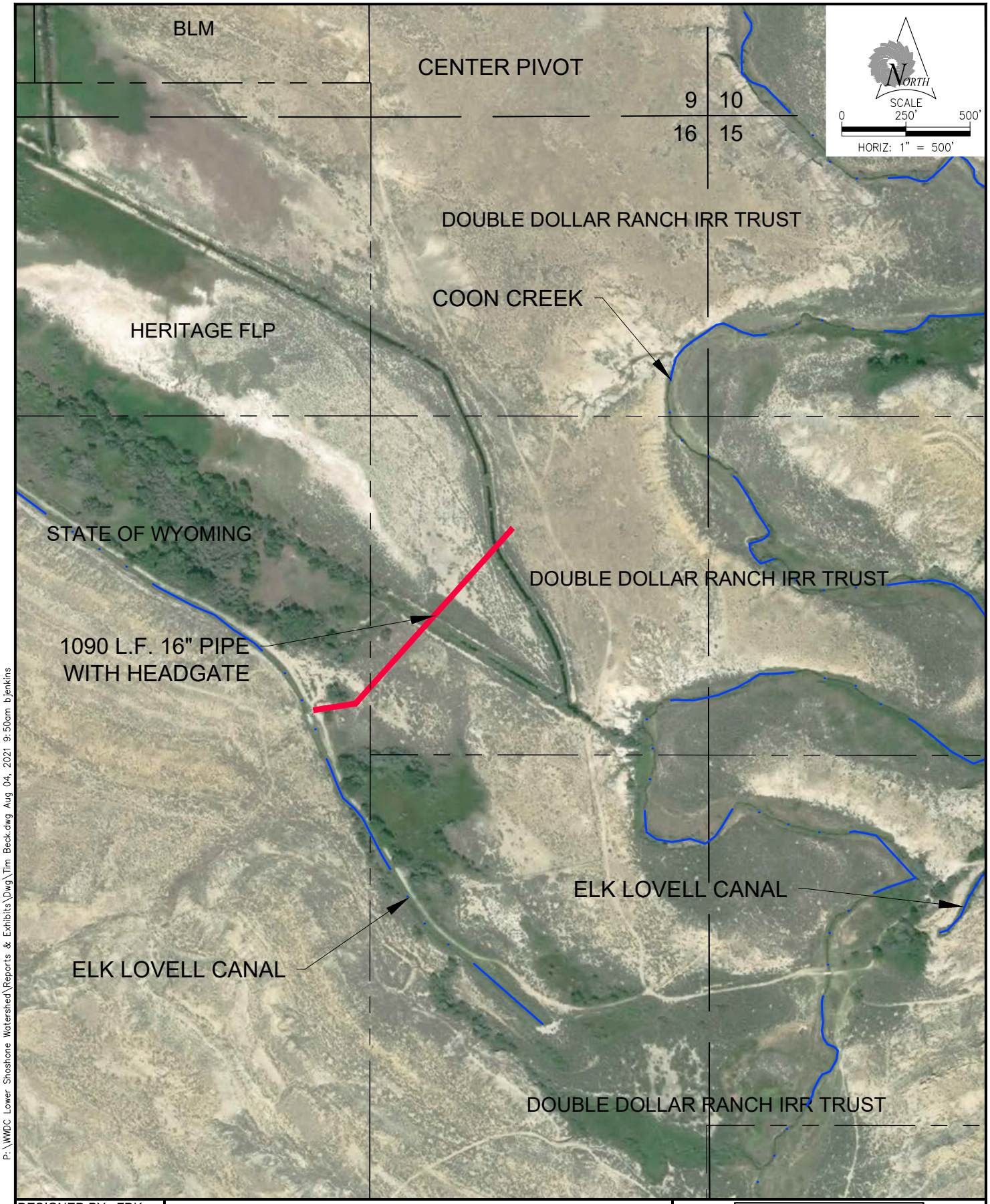
Wyoming Office of State Lands: Headgate on State lands.

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Landowners: Double Dollar Ranch

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Tim Beck.dwg Aug 04, 2021 9:50am bjenkins

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
#7 TIM BECK (HEADGATE AND PIPE LATERAL)
LOCATED IN SECTION 16 T55N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE
ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 7
Owner/Operator: **Beck, Tim**
Site Name: Coon Creek
Type Of Project: Headgate Restoration and Pipe and Solar Pivot

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	Restore Head Gate	1	L.S.	$1,000.00	$1,000
4	Furnish and Install 16" Transfer Pipe	1,100	L.F.	$18.00	$19,800
5	Air Release valve	1	Each	$1,500.00	$1,500
6	Center Pivot Pump *	1	Each	$10,000.00	$10,000
7	Center Pivot Electrical *	1	Each	$5,000.00	$5,000
8	Center Pivot *	1	Each	$38,000.00	$38,000
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$77,300**

INCIDENTAL PROJECT COSTS

Construction Permits	$400
Performance Bond	$800
Insurance	$400
15% O&P	$11,595
Subtotal 1	**$13,195**
Subtotal 2	**$90,495**
Construction Engineering @ 10% of Subtotal #2	$9,050
Subtotal 3	**$99,545**
Contingency @ 15% of Subtotal #3	$14,932
Total Construction Cost	**$114,476**
Preparation of Final Designs and Specifications	$9,158
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$123,634**

SITE PHOTOS: Coon Creek

Potential pipe path

Existing headgate

Headgate just upstream from canal drop

Project ID #:	9
Owner/Operator:	**Beck, Tim**
Site Name:	
Type Of Project:	Weir for Existing Solar Pump
Land Jurisdiction:	Private/ BLM
Location:	44.49644N -108.35111W

Project Description

Statement of Purpose and Need: Existing solar pump near BLM land by the lake. The current system has resulted in 2 ruined impellers. System needs a way to settle the sand so it doesn't enter the pump. The pump pushes water for approximately 3 miles.
Proposed Project: Install a 5' by 5' concrete weir box system to settle existing sand before entering pump.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable
State Engineers Office: No Permitting
Wyoming Office of State Lands: Not applicable
Wyoming Department of Environmental Quality: Not applicable
Bureau of Land Management: Pipe on BLM Lands, potential Section 7 consultation due to federal lands.
Other Landowners: Adjacent Landowners on Canal

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 9
Owner/Operator: **Beck, Tim**
Site Name:
Type Of Project: Weir for Existing Solar Pump

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

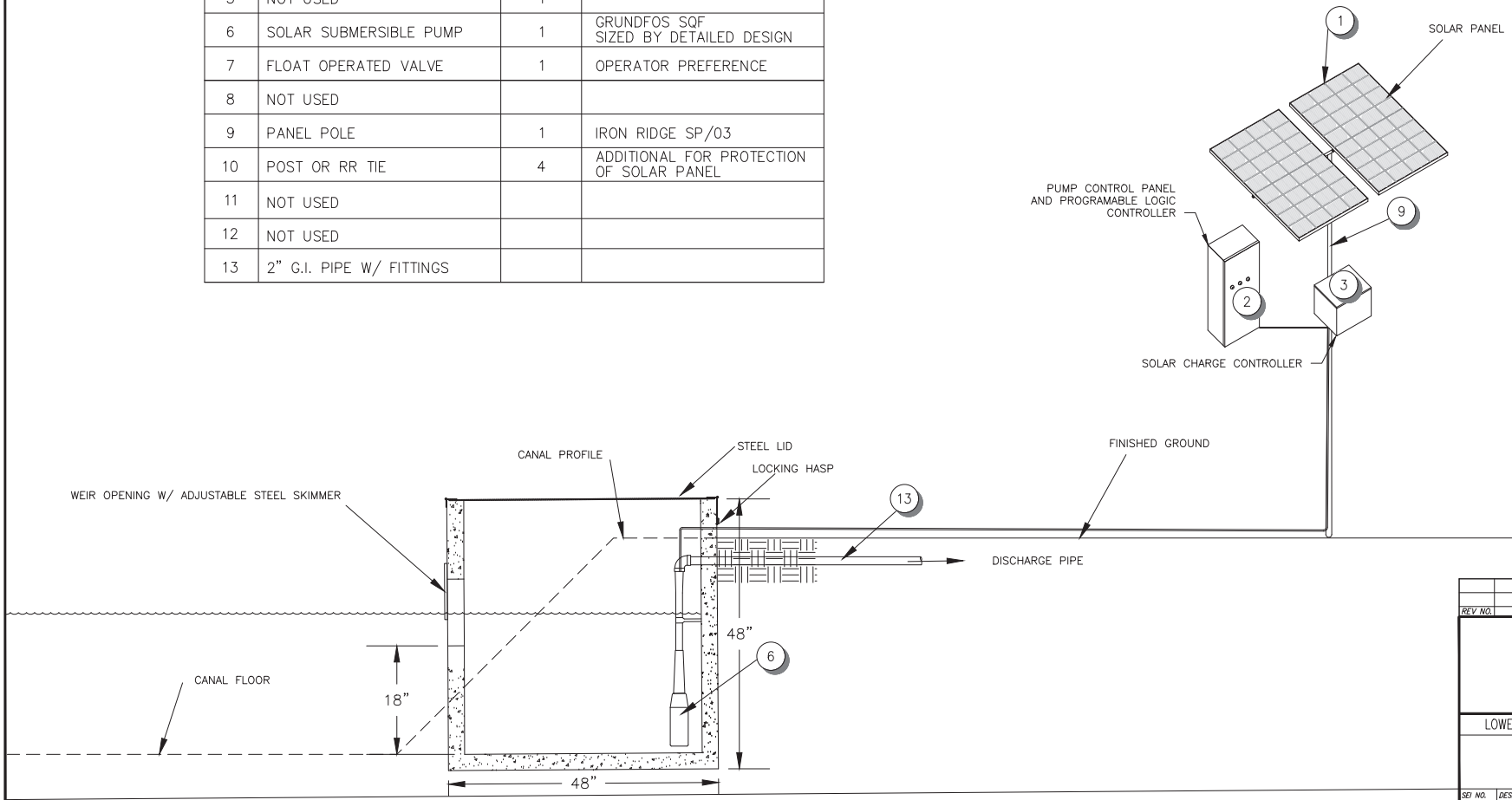
Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$750.00	$750
2	Traffic Control	1	L.S.	$0.00	$0
3	5 by 5' concrete weir box	3	Cu, Yd,.	$500.00	$1,500
4	Skimmer plate	1	Each	$250.00	$250
5	Pump System	1	LS	$11,000.00	$11,000
6	400 W Solar Panel, Mounts and Pole	1	L.S.	$2,500.00	$2,500
7	Charge Controller and Inverter	1	L.S.	$600.00	$600
8	Excavation and Earthwork	5	Cu, Yd,.	$500.00	$2,500
				Total Construction Cost	**$19,100**

INCIDENTAL PROJECT COSTS

Construction Permits	$100
Performance Bond	$200
Insurance	$100
15% O&P	$2,865
Subtotal 1	**$3,265**
Subtotal 2	**$22,365**
Construction Engineering @ 10% of Subtotal #2	$2,237
Subtotal 3	**$24,602**
Contingency @ 15% of Subtotal #3	$3,690
Total Construction Cost	**$28,292**
Preparation of Final Designs and Specifications	$2,263
Permitting @ 5% of Project Cost	$1,415
Legal @ 4% of Project Cost	$1,132
Environmental Study	Fill In
Total Project Cost	**$33,101**

EQUIPMENT SCHEDULE

NO.	DESCRIPTION	SIZE/#	REMARKS
1	SOLAR PANEL		SIZED BY PUMP DEMAND
2	PUMP PANEL CONTROL	1	W/PLC
3	SOLAR CHARGE CONTROLLER	1	BY PANEL MANUFACTURER
5	NOT USED	1	
6	SOLAR SUBMERSIBLE PUMP	1	GRUNDFOS SQF SIZED BY DETAILED DESIGN
7	FLOAT OPERATED VALVE	1	OPERATOR PREFERENCE
8	NOT USED		
9	PANEL POLE	1	IRON RIDGE SP/03
10	POST OR RR TIE	4	ADDITIONAL FOR PROTECTION OF SOLAR PANEL
11	NOT USED		
12	NOT USED		
13	2" G.I. PIPE W/ FITTINGS		



REV NO.	COMMENT	DATE

SUNRISE ENGINEERING
47 EAST 4TH AVENUE
AFTON, WYOMING 83110
TEL 307.885.8500 - FAX 307.885.8501
www.sunrise-eng.com

LOWER SHOSHONE WATERSHED STUDY

WEIR AND PUMP

DETAILS

SEI NO.	DESIGNED	DRAWN	CHECKED	SHEET NO.	
07484	FDK	KJS	XXX	1 of 1	D1

P:\WWDC Lower Shoshone Watershed\Dwg C3D\Sheets\Solar pump in weir.dwg Aug 19, 2021 2:30pm kjsmith

Project ID #:	10
Owner/Operator:	**Beck, Tim**
Site Name:	Coon Creek
Type Of Project:	Sprinkler System
Land Jurisdiction:	Private
Location:	44.76966N -108.52225W

Project Description

Statement of Purpose and Need: Irrigate floodplain area west of Coon Creek. Potential of flooding from Coon Creek needs to be addressed.
Proposed Project: An existing water source exists on Coon Creek but downstream end of the parcel (approx 20 acres). The proposed project will include diversion, pump, pipeline and sprinkler. The center pivot portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

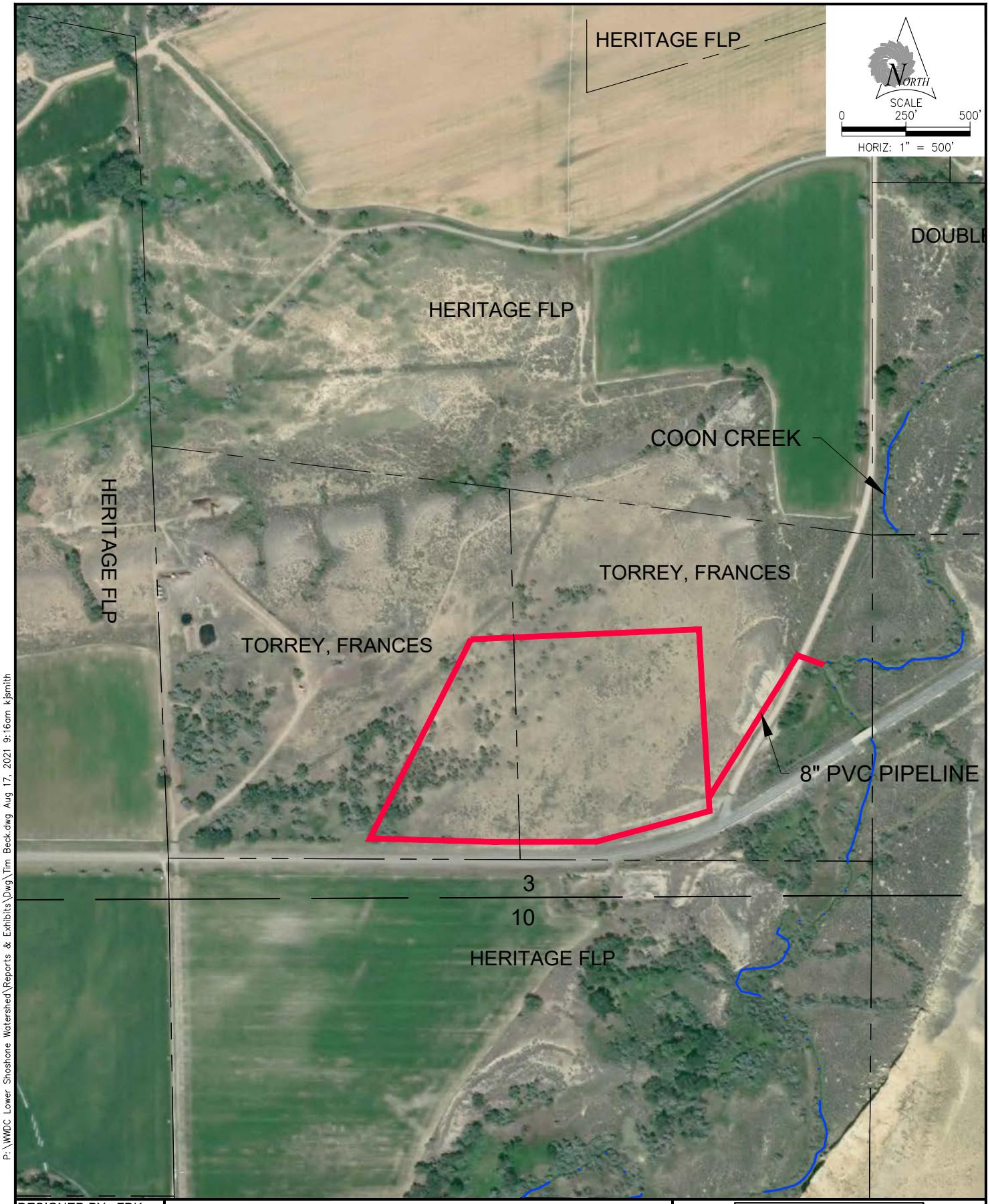
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Landowners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Tim Beck.dwg Aug 17, 2021 9:16am kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED LEVEL 1 STUDY

#10 TIM BECK (FLOOD MITIGATION)
LOCATED IN SECTION 3 T55N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	10
Owner/Operator:	**Beck, Tim**
Site Name:	Coon Creek
Type Of Project:	Sprinkler System

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	8-inch PVC SDR 18 Pipe	680	L.F.	$26.00	$17,680
4	Center Pivot Pump *	1	L.S.	$10,000.00	$10,000
5	Center Pivot Electrical *	1	L.S.	$5,000.00	$5,000
6	Center Pivot *	1	L.S.	$38,000.00	$38,000
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$72,680**

INCIDENTAL PROJECT COSTS

Construction Permits	$400
Performance Bond	$800
Insurance	$400
15% O&P	$10,902
Subtotal 1	**$12,502**
Subtotal 2	**$85,182**
Construction Engineering @ 10% of Subtotal #2	$8,518
Subtotal 3	**$93,700**
Contingency @ 15% of Subtotal #3	$14,055
Total Construction Cost	**$107,755**
Preparation of Final Designs and Specifications	$8,620
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$116,376**

SITE PHOTOS: Coon Creek

Project ID #:	11	
Owner/Operator:	**Beck, Tim**	
Site Name:	Coon Creek	
Type Of Project:	Pivot	
Land Jurisdiction:	Private	
Location:	44.77288N	-108.51300W

Project Description

Statement of Purpose and Need: Existing gravel pit to be reclaimed. Following the reclamation install pivot irrigation system east of Coon Creek.
Proposed Project: The proposed project includes a solar powered pivot sprinkler system using water from Coon Creek located on the west border of site. The center pivot portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

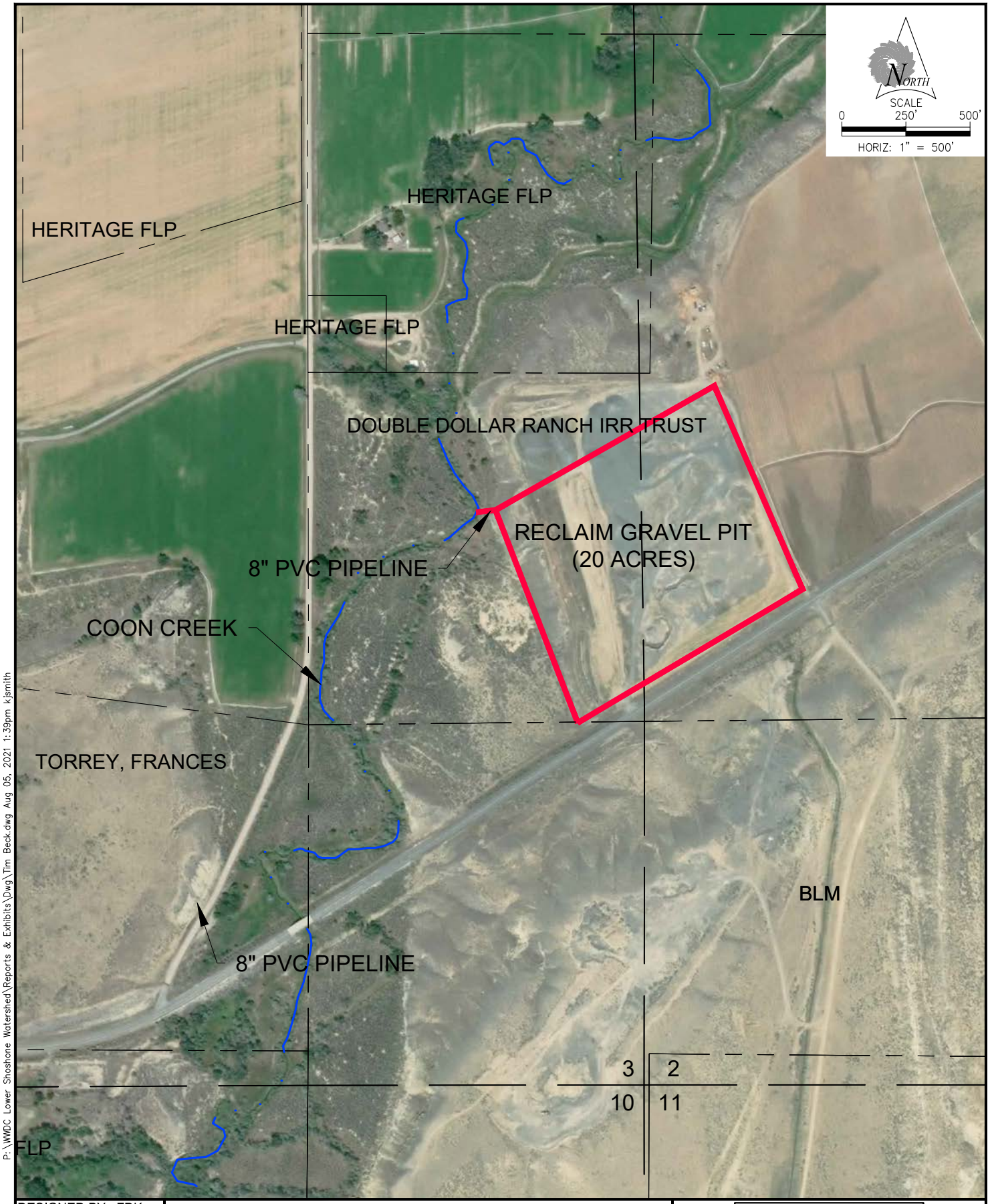
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: A small part of the proposed irrigated acres partially lies on BLM and will require BLM approval. Potential Section 7 consultation due to federal lands.

Other Landowners: Double Dollar Ranch

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Tim Beck.dwg Aug 05, 2021 1:39pm kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED LEVEL 1 STUDY

#11 TIM BECK (RECLAIM PIT SOLAR PIVOT)
LOCATED IN SECTIONS 2,3 T55N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	11
Owner/Operator:	**Beck, Tim**
Site Name:	Coon Creek
Type Of Project:	Pivot

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	8-inch PVC SDR 18 Pipe	110	L.F.	$26.00	$2,860
4	Center Pivot Pump *	1	L.S.	$10,000.00	$10,000.00
5	Center Pivot Electrical *	1	L.S.	$5,000.00	$5,000.00
6	Center Pivot *	1	L.S.	$38,000.00	$38,000.00
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$57,860**

INCIDENTAL PROJECT COSTS

Construction Permits	$300
Performance Bond	$600
Insurance	$300
15% O&P	$8,679
Subtotal 1	**$9,879**
Subtotal 2	**$67,739**
Construction Engineering @ 10% of Subtotal #2	$6,774
Subtotal 3	**$74,513**
Contingency @ 15% of Subtotal #3	$11,177
Total Construction Cost	**$85,690**
Preparation of Final Designs and Specifications	$6,855
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$92,545**

Project ID #:	12
Owner/Operator:	**Beck, Tim**
Site Name:	Multiple Sites
Type Of Project:	Solar Well
Land Jurisdiction:	Private
Location:	

Project Description

Statement of Purpose and Need: Some pasture areas could benefit from a ground water source after the canals are drained.
Proposed Project: The proposed project is a solar powered well producing about 2 gpm to be stored in a 5,000 gallon tank connected to a trough.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: Well Permit

Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Depending on project location it could involve BLM lands and require BLM approval. Potential Section 7 consultation due to federal lands.

Other Landowners: Double Dollar Ranch

Other Concerns

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	12
Owner/Operator:	**Beck, Tim**
Site Name:	Multiple Sites
Type Of Project:	Solar Well

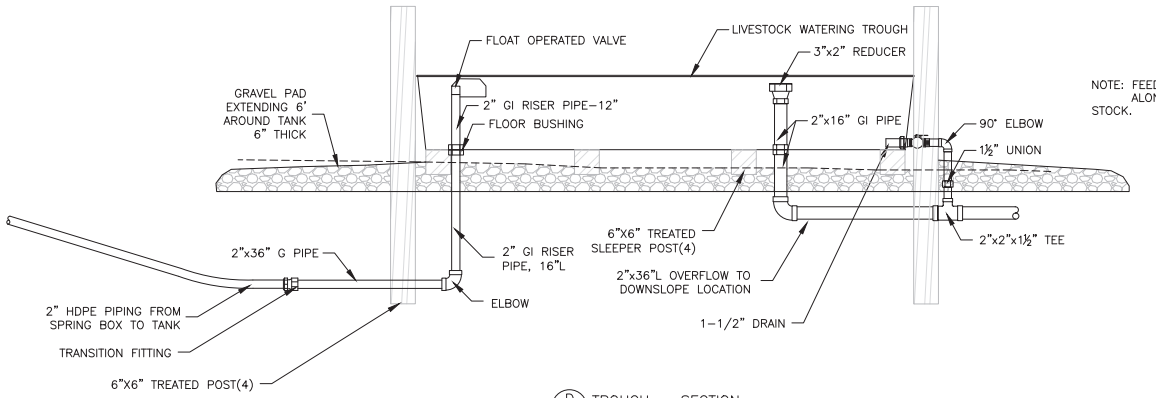
ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$5,000.00	$5,000
2	New 100' Well	100	LF	$110.00	$11,000
3	Pump Test	12	Hours	$260.00	$3,120
4	Pump System	1	LS	$11,000.00	$11,000
5	400 W Solar Panel, Mounts and Pole	1	L.S.	$2,500.00	$2,500
6	Charge Controller and Inverter	1	L.S.	$600.00	$600
7	Storage Tank (5000 gallons)	5,000	Gal.	$2.00	$10,000
8	Water Trough and Float Controller	1	Each	$2,200.00	$2,200
9	2" HDPE Pipe and Fittings	50	LF	$6.00	$300
10	Road Base	5	Yd.	$40.00	$200
				Total Construction Cost	**$45,920**

INCIDENTAL PROJECT COSTS

Construction Permits	$300
Performance Bond	$500
Insurance	$300
15% O&P	$6,888
Subtotal 1	**$7,988**
Subtotal 2	**$53,908**
Construction Engineering @ 10% of Subtotal #2	$5,391
Subtotal 3	**$59,299**
Contingency @ 15% of Subtotal #3	$8,895
Total Construction Cost	**$68,194**
Preparation of Final Designs and Specifications	$5,455
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$73,649**

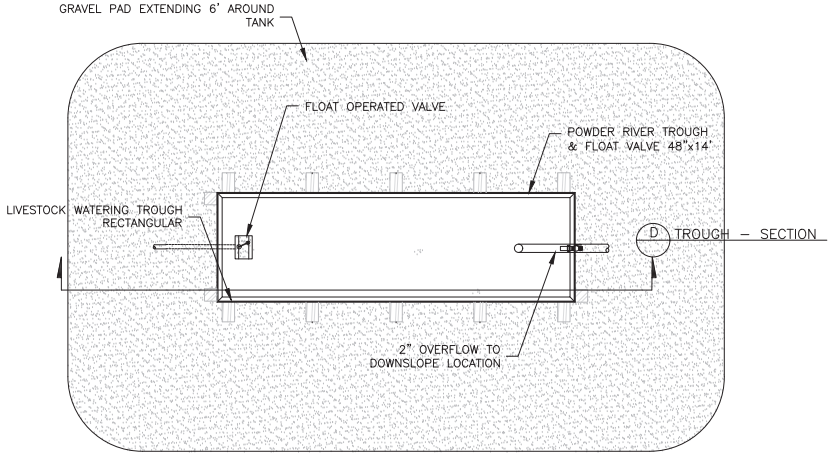


D TROUGH – SECTION

NOTE: FEEDER PANELS ON EACH SIDE OR LONGITUDINAL POLES ALONG CENTER ARE RECOMMENDED TO PREVENT ENTRY BY STOCK.

Trough Miscellaneous Fittings

	Fitting Name	Size	Number	Comments
	Floor Bushing with F.I.P Threaded outlet	2"	1	May also install through wall
	Wall Bushing with F.I.P Threaded outlet	1-1/2"	1	
	Compression Coupling IPS PE x F.I.P.	2"	1	
	90 deg ell	2"	2	
	90 deg ell	1-1/2"	1	
	Pipe Nipple	36"L x 2"	2	
	Pipe Nipple	12"L x 2"	1	
	Pipe Nipple	16"L x 2"	3	
	Pipe Nipple	2"L x 1-1/2"	2	
	Pipe Nipple	8"L x 1-1/2"	2	
	Tee G.I.	2"x2" x1-1/2"	1	
	Reducer	3" x 2"	1	Overflow inlet
	Pipe Union	1-1/2"	1	On Drain Pipe
	Ball Valve	1-1/2"	1	
	Float Operated Valve			Provided by Trough Supplier
	RR Tie	8'	9	



D TROUGH – PLAN VIEW

REV NO.	COMMENT	DATE

SUNRISE ENGINEERING
47 EAST 4TH AVENUE
AFTON, WYOMING 83110
TEL 307.885.8500 - FAX 307.885.8501
www.sunrise-eng.com

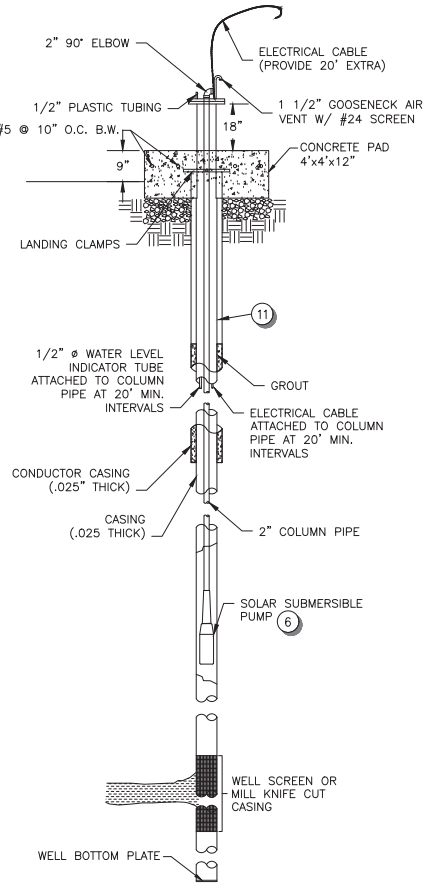
LOWER SHOSHONE WATERSHED STUDY

TYPICAL SPRING DEVELOPMENT

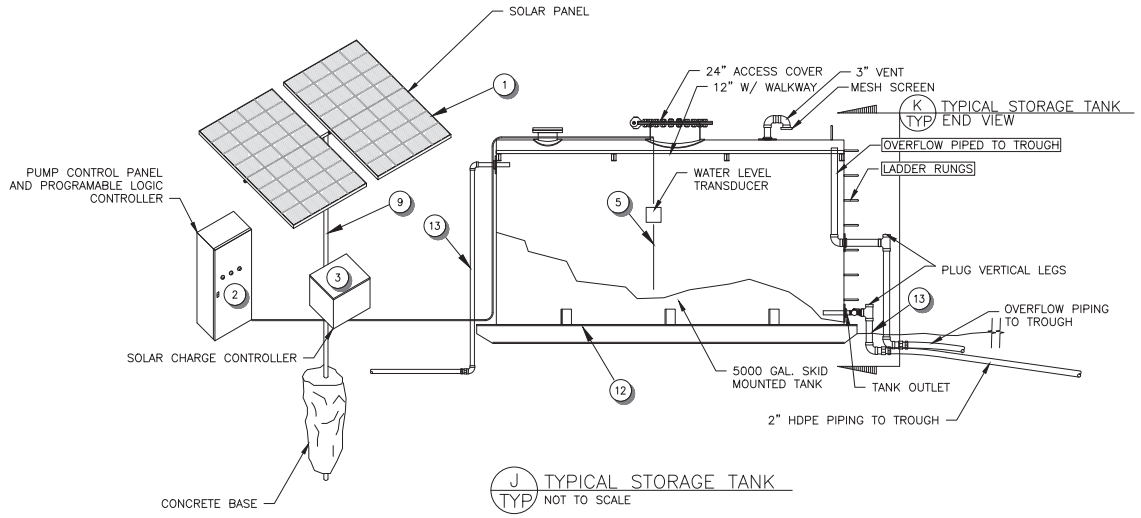
DETAILS

SEI NO.	DESIGNED	DRAWN	CHECKED	SHEET NO.	
07484	FDK	KJS	XXX	1 of 2	D1

P:\WWDC Lower Shoshone Watershed\Dwg C3D\Sheets\Typical Spring development.dwg Aug 17, 2021 11:48am kjsmith



H TYP TYPICAL WELL
NOT TO SCALE

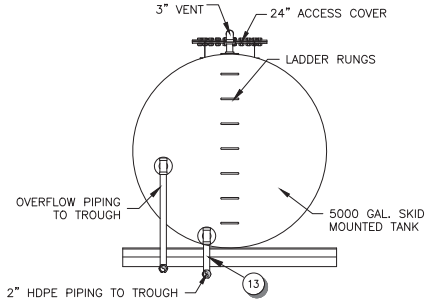


K TYP TYPICAL STORAGE TANK
END VIEW

J TYP TYPICAL STORAGE TANK
NOT TO SCALE

EQUIPMENT SCHEDULE

NO.	DESCRIPTION	SIZE/#	REMARKS
1	SOLAR PANEL		SIZED BY PUMP DEMAND
2	PUMP PANEL CONTROL	1	W/PLC
3	SOLAR CHARGE CONTROLLER	1	BY PANEL MANUFACTURER
4	TROUGH RDF		600 GALLON
5	LEVEL SENSOR	1	W6400 BY GLOBAL WATER
6	SOLAR SUBMERSIBLE PUMP	1	GRUNDFOS SQF SIZED BY DETAILED DESIGN
7	FLOAT OPERATED VALVE	1	OPERATOR PREFERENCE
8	NOT USED		
9	PANEL POLE	1	IRON RIDGE SP/03
10	POST OR RR TIE	4	ADDITIONAL FOR PROTECTION OF SOLAR PANEL
11	COMPLETED WELL	1	
12	STORAGE TANK	1	5000 GALLON SKID MOUNTED
13	2" G.I. PIPE W/ FITTINGS		
14	NOT USED		
15	3" G.I. PIPE W/ FITTINGS		
	OPTIONAL		
	24V STORAGE BATTERIES		FOR LATE SEASONS, EVENING AND MORNINGS



K TYP TYPICAL STORAGE TANK
END VIEW

REV NO.	COMMENT	DATE

SUNRISE ENGINEERING
47 EAST 4TH AVENUE
AFTON, WYOMING 83110
TEL 307.885.8500 - FAX 307.885.8501
www.sunrise-eng.com

LOWER SHOSHONE WATERSHED STUDY

TYPICAL WELL DEVELOPMENT

DETAILS

SEI NO.	DESIGNED	DRAWN	CHECKED	SHEET NO.	
07484	FDK	KJS	XXX	2 of 2	D2

P:\WWDC Lower Shoshone Watershed\Dwg C3D\Sheets\Typical Well development.dwg Aug 17, 2021 10:03am kjsmith

Project ID #:	13
Owner/Operator:	**Beck, Tim**
Site Name:	
Type Of Project:	Sump or Well, Solar Pump, Pipeline and Trough
Land Jurisdiction:	Private/ BLM
Location:	44.753980N -108.520983W

Project Description

Statement of Purpose and Need: This location holds significant seepage and is generally saturated creating unsuitable footing for cattle and surface deposition of salts.
Proposed Project: Install a sump or well with solar pump to collect water and pump it to a trough located on higher ground. Fence the site to keep cattle out to protect installed components.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

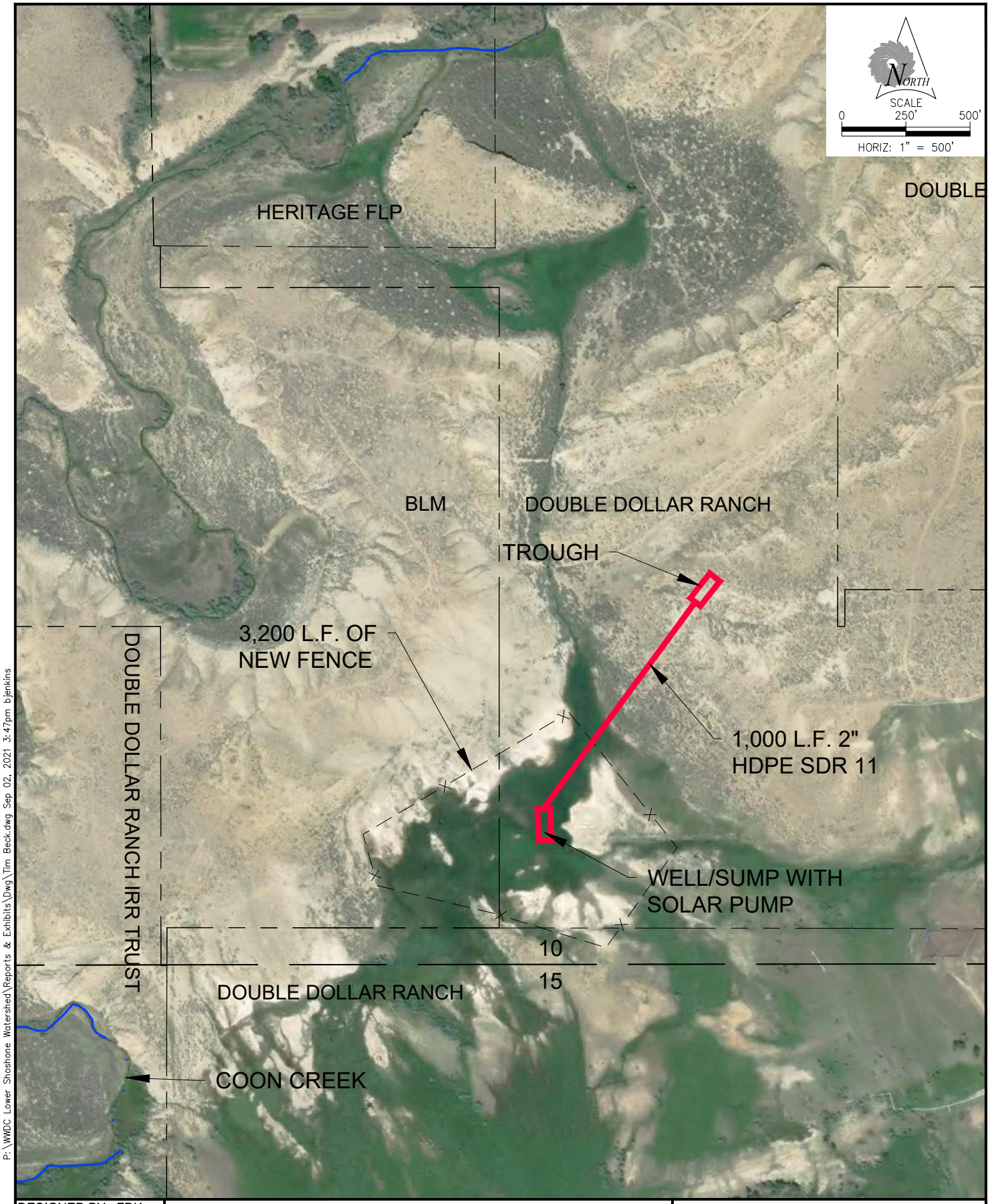
State Engineers Office: No Permitting

Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Fencing may fall on BLM lands depending on the extent of fencing. Potential Section 7 consultation due to federal lands.

Other Landowners: Adjacent landowners on canal



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Tim Beck.dwg Sep 02, 2021 3:47pm bjenkins

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED LEVEL 1 STUDY

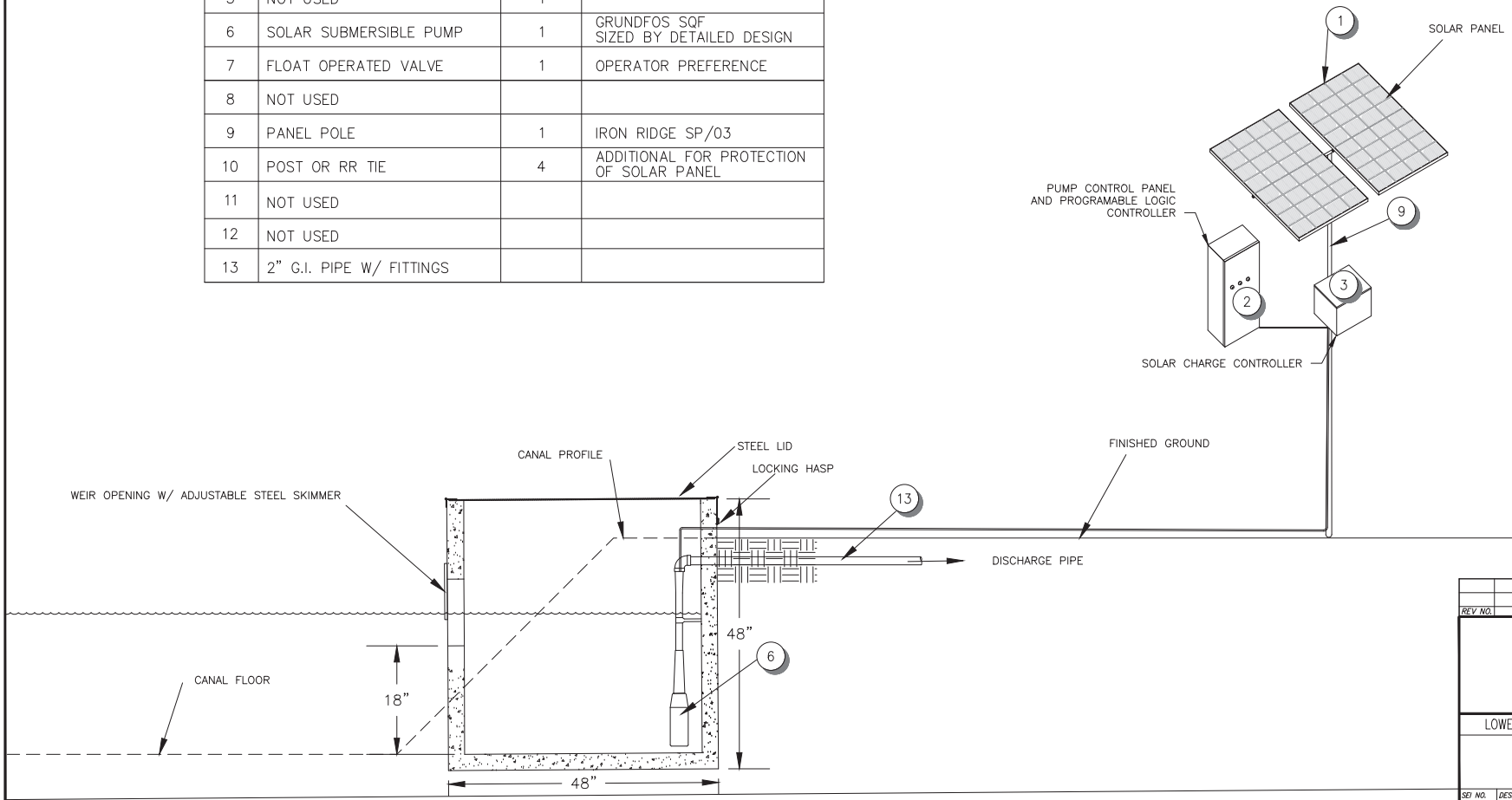
#13 TIM BECK (WETLAND DEVELOPMENT)
LOCATED IN SECTION 10 T55N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

EQUIPMENT SCHEDULE

NO.	DESCRIPTION	SIZE/#	REMARKS
1	SOLAR PANEL		SIZED BY PUMP DEMAND
2	PUMP PANEL CONTROL	1	W/PLC
3	SOLAR CHARGE CONTROLLER	1	BY PANEL MANUFACTURER
5	NOT USED	1	
6	SOLAR SUBMERSIBLE PUMP	1	GRUNDFOS SQF SIZED BY DETAILED DESIGN
7	FLOAT OPERATED VALVE	1	OPERATOR PREFERENCE
8	NOT USED		
9	PANEL POLE	1	IRON RIDGE SP/03
10	POST OR RR TIE	4	ADDITIONAL FOR PROTECTION OF SOLAR PANEL
11	NOT USED		
12	NOT USED		
13	2" G.I. PIPE W/ FITTINGS		



REV NO.	COMMENT	DATE

SUNRISE ENGINEERING
47 EAST 4TH AVENUE
AFTON, WYOMING 83110
TEL 307.885.8500 - FAX 307.885.8501
www.sunrise-eng.com

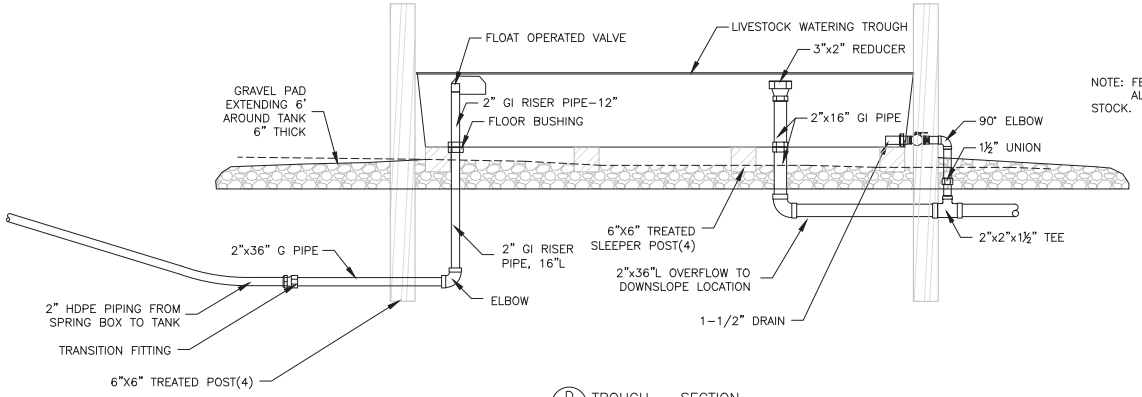
LOWER SHOSHONE WATERSHED STUDY

WEIR AND PUMP

DETAILS

SEI NO.	DESIGNED	DRAWN	CHECKED	SHEET NO.	
07484	FDK	KJS	XXX	1 of 1	D1

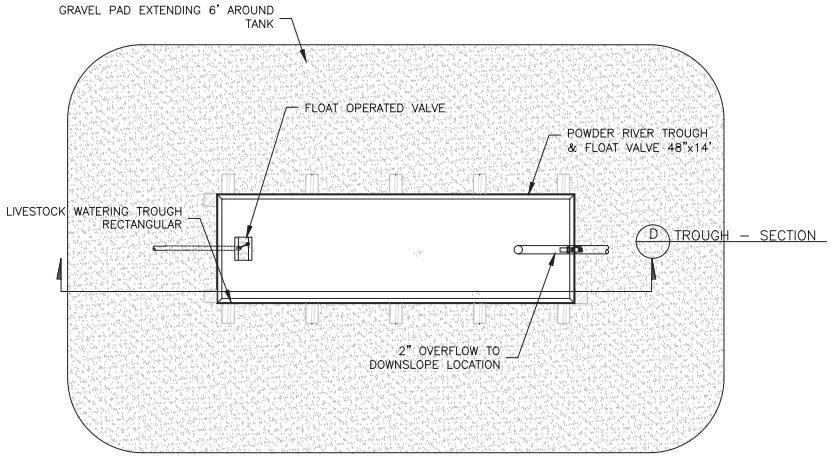
P:\WWDC Lower Shoshone Watershed\Dwg C3D\Sheets\Solar pump in weir.dwg Aug 19, 2021 2:30pm kjsmith



NOTE: FEEDER PANELS ON EACH SIDE OR LONGITUDINAL POLES ALONG CENTER ARE RECOMMENDED TO PREVENT ENTRY BY STOCK.

D TROUGH – SECTION

Trough Miscellaneous Fittings			
Fitting Name	Size	Number	Comments
Floor Bushing with F.I.P Threaded outlet	2"	1	May also install through wall
Wall Bushing with F.I.P Threaded outlet	1-1/2"	1	
Compression Coupling IPS PE x F.I.P.	2"	1	
90 deg ell	2"	2	
90 deg ell	1-1/2"	1	
Pipe Nipple	36"L x 2"	2	
Pipe Nipple	12"L x 2"	1	
Pipe Nipple	16"L x 2"	3	
Pipe Nipple	2"L x 1-1/2"	2	
Pipe Nipple	8"L x 1-1/2"	2	
Tee G.I.	2"x2" x1-1/2"	1	
Reducer	3" x 2"	1	Overflow inlet
Pipe Union	1-1/2"	1	On Drain Pipe
Ball Valve	1-1/2"	1	
Float Operated Valve			Provided by Trough Supplier
RR Tie	8'	9	



D TROUGH – PLAN VIEW

REV NO.	COMMENT	DATE

SUNRISE ENGINEERING
47 EAST 4TH AVENUE
AFTON, WYOMING 83110
TEL 307.885.8500 · FAX 307.885.8501
www.sunrise-eng.com

LOWER SHOSHONE WATERSHED STUDY

TYPICAL TROUGH DETAILS

SEI NO.	DESIGNED	DRAWN	CHECKED	SHEET NO.	
07484	FDK	KJS	XXX	2 of 2	D2

C:\Users\dkemington\appdata\local\temp\AcPublish_20320\Typical Spring development.dwg Sep 02, 2021 2:40pm dkemington

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 13
Owner/Operator: **Tim Beck**
Site Name:
Type Of Project: Sump or Well, Solar Pump, Pipeline and Trough

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,500.00	$2,500
2	Traffic Control	1	L.S.	$0.00	$0
3	5' by 5' concrete collection box	3	Cu, Yd,.	$500.00	$1,500
4	Collection Pipe and Rock Trench	40	L.F.	$50.00	$2,000
5	Pump System	1	LS	$8,000.00	$8,000
6	400 W Solar Panel, Mounts and Pole	1	L.S.	$2,500.00	$2,500
7	Charge Controller and Inverter	1	L.S.	$600.00	$600
8	1.5" HDPE Pipe	1,000	L.F.	$15.00	$15,000
9	Trough and Float Valve	1	Each	$2,200.00	$2,200
10	Protection Fencing	100	L.F.	$10.00	$1,000
				Total Construction Cost	**$35,300**

INCIDENTAL PROJECT COSTS

Construction Permits	$200
Performance Bond	$400
Insurance	$200
15% O&P	$5,295
Subtotal 1	**$6,095**
Subtotal 2	**$41,395**
Construction Engineering @ 10% of Subtotal #2	$4,140
Subtotal 3	**$45,535**
Contingency @ 15% of Subtotal #3	$6,830
Total Construction Cost	**$52,365**
Preparation of Final Designs and Specifications	$4,189
Permitting @ 5% of Project Cost	$2,618
Legal @ 4% of Project Cost	$2,095
Environmental Study	Fill In
Total Project Cost	**$61,267**

SITE PHOTOS:

Project ID #:	14
Owner/Operator:	**Hessenthaler, David**
Site Name:	Lower Site
Type Of Project:	Bank Stabilization
Land Jurisdiction:	Private
Location:	

Project Description

Statement of Purpose and Need: Stabilize approximately 1,150 feet of actively eroding bank to reduce sediment input into Shoshone River and preserve existing land in operation.
Proposed Project: The proposed project is a bioengineered bank treatment of total length 1,155 feet including bank sloping, armored rock toe, and riparian cutting plantings.

Permitting Requirements

Big Horn County: Floodplain Development Permit

State Engineers Office: Not applicable

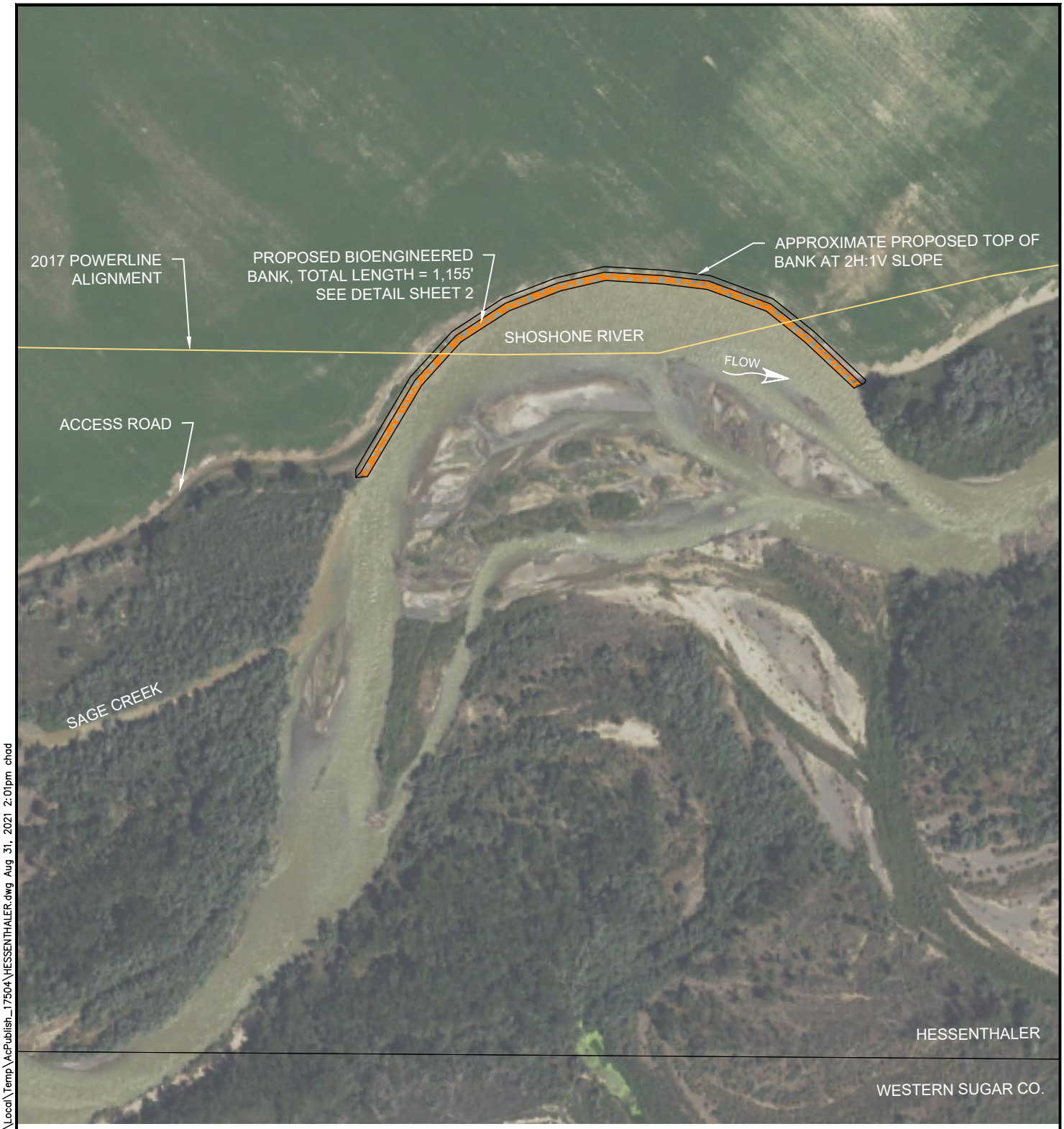
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: 401 Water Quality Certification

Bureau of Land Management: Not applicable

Army Corps of Engineers: 404 permit

Other Concerns



0' 125' 250' 500'

N

C:\Users\chad\AppData\Local\Temp\AcPublish_17504\HESSENTHALER.dwg Aug 31, 2021 2:01pm chad

DESIGNED BY: CB
DRAWN BY: CB
CHECKED BY: RC
DATE: 8/26/2021
REV:
SHEET: 1

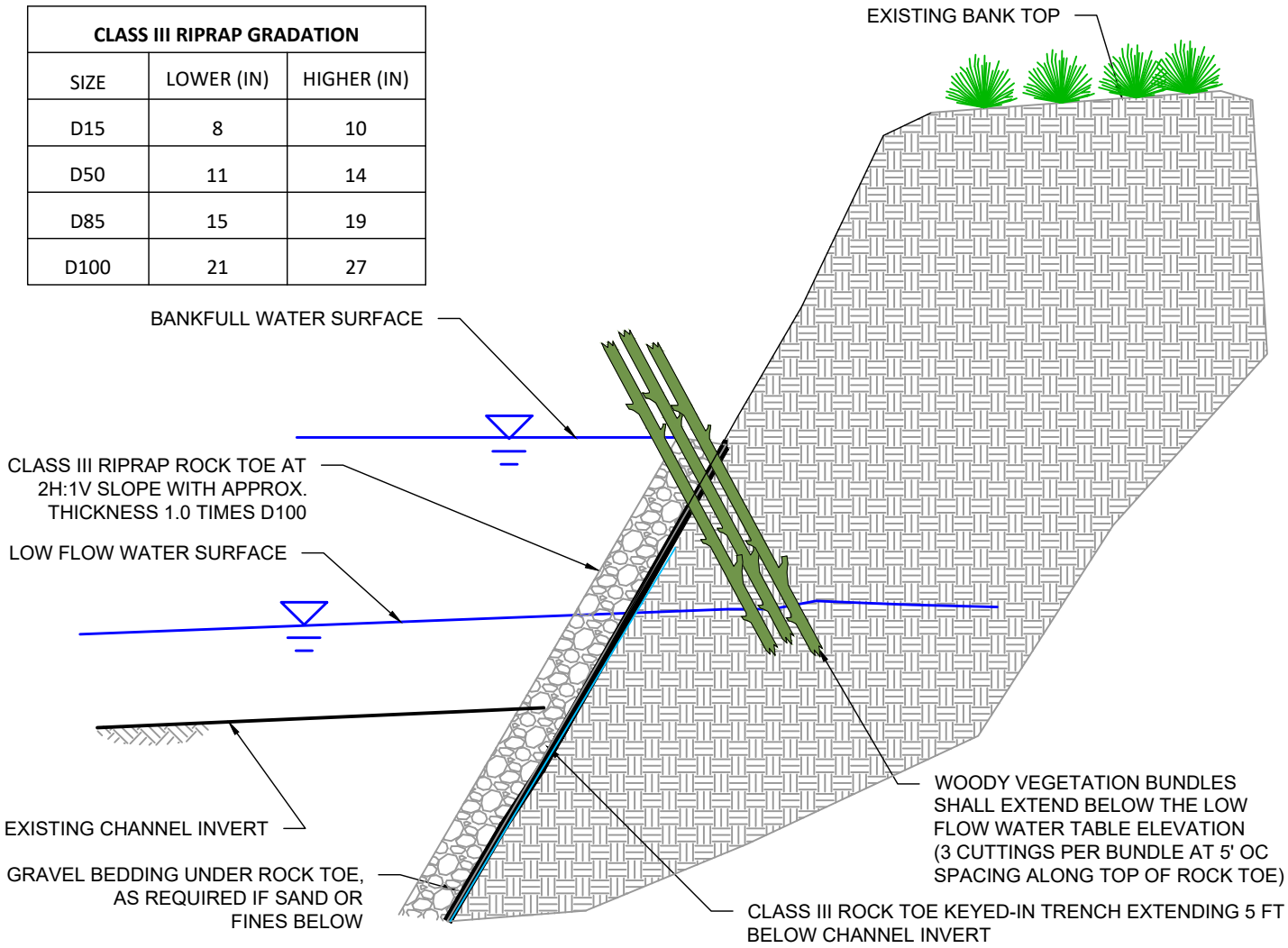
WWDC- LOWER SHOSHONE WATERSHED LEVEL 1 STUDY

DAVID HESSENTHALER (RIVER BANK STABILIZATION LOWER SITE)
LOCATED IN SECTION 10 T56N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

CLASS III RIPRAP GRADATION		
SIZE	LOWER (IN)	HIGHER (IN)
D15	8	10
D50	11	14
D85	15	19
D100	21	27



ROCK TOE - SECTION VIEW

NTS

ROCK TOE CONSTRUCTION NOTES:

1. INSTALL TEMPORARY COFFERDAM TO ISOLATE WORK AREA, IF NECESSARY. COFFERDAM METHOD TO BE PROPOSED BY THE CONTRACTOR AND APPROVED BY THE OWNER.
2. CONSTRUCT THE ROCK TOE AND BIOENGINEERING BANK STABILIZATION TREATMENTS ALONG SHOSHONE RIVER.
3. THE BANK AND ROCK TOE SHOULD HAVE A SLOPE OF 2H:1V STARTING AT THE EXISTING TOE AND SLOPING UPWARDS.
4. TOE ROCK SHALL BE HARD, DURABLE, SUB-ROUNDED TO ANGULAR IN SHAPE, RESISTANT TO WEATHERING TO WATER AND ICE ACTION; FREE OF EXCESS AMOUNTS OF THIN FLAT, AND ELONGATED PIECES, FREE FROM OVERBURDEN, SPOIL, SHALE, STRUCTURAL DEFECTS, AND ORGANIC MATERIAL. THE SMALLER STONE SHALL BE UNIFORMLY DISTRIBUTED THROUGHOUT THE WORK. THE ROCK SHALL BE MANIPULATED BY HAND OR MACHINE METHODS SUFFICIENTLY TO SECURE A UNIFORM SURFACE AND MASS STABILITY. ROCK SHALL BE SOURCED FROM LOCALLY AVAILABLE COARSE MATERIAL.
5. STRUCTURE SHALL BE KEYED-IN A TRENCH EXTENDING BELOW THE SCOUR DEPTH.
6. ADD GRAVEL BEDDING FOR SETTING ROCK, AS NEEDED.
7. PLACE GRAVEL FILTER BEHIND ROCK TOE, IF NECESSARY, BETWEEN RIPRAP AND NATIVE MATERIAL. FILTER SHALL BE SPREAD IMMEDIATELY AHEAD OF THE ROCK PLACEMENT.
8. PLACEMENT OF ROCK RIPRAP SHALL START AT THE TOE OF THE SLOPE AND PROCEED UP THE SLOPE. THE RIPRAP SHALL BE PLACED SUCH THAT DAMAGE TO THE FILTER LAYER DOES NOT OCCUR. FILTER DISPLACED OR OTHERWISE DAMAGED DURING PLACEMENT SHALL BE REPLACED.
9. CONTINUE BANK FACE SLOPING AS SHOWN IN THE PLAN.
10. PLACE LOCALLY SOURCED RIPARIAN DORMANT HARDWOOD VEGETATION BUNDLES ALONG THE ROCK TOE AND BANK FACE USING A STANDARD LIVE STAKE INSTALLATION PROCEDURE .
11. FINAL CONFIGURATION OF ROCK TOE STRUCTURE SHALL BE AS DIRECTED IN FIELD.

C:\Users\chad\AppData\Local\Temp\AcPublish_22644\HESSENTHALER.dwg Aug 26, 2021 3:49pm chad

DESIGNED BY: CB
DRAWN BY: CB
CHECKED BY: RC
DATE: 8/26/2021
REV:
SHEET: 2

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
DAVID HESSENTHALER (RIVER BANK STABILIZATION DETAIL)
LOCATED IN SECTION 10 T56N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	14
Owner/Operator:	**Hessenthaler, David**
Site Name:	Lower Site
Type Of Project:	Bank Stabilization

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$5,000.00	$5,000
2	Bank Sloping	1,069	C.Y.	$12.00	$12,833
3	Toe Rock Purchase, Delivery & Install	1,925	C.Y.	$80.00	$154,000
4	Cutting Collect & Install (3 per 5' bank)	693	Each	$2.00	$1,386
5	Water Management	1	L.S.	$5,000.00	$5,000
				Total Construction Cost	**$178,219**

INCIDENTAL PROJECT COSTS

Construction Permits	$900
Performance Bond	$1,800
Insurance	$900
15% O&P	$26,733
Subtotal 1	**$30,333**
Subtotal 2	**$208,552**
Construction Engineering @ 10% of Subtotal #2	$20,855
Subtotal 3	**$229,407**
Contingency @ 15% of Subtotal #3	$34,411
Total Construction Cost	**$263,819**
Preparation of Final Designs and Specifications	$21,105
Permitting @ 3% of Project Cost	$7,915
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$292,839**

SITE PHOTOS: Lower Site

Project ID #:	15
Owner/Operator:	**Hessenthaler, David**
Site Name:	Upper Site
Type Of Project:	Bank Stabilization
Land Jurisdiction:	Private
Location:	

Project Description

Statement of Purpose and Need: Stabilize approximately 475 feet of actively eroding bank to reduce sediment input into Shoshone River and preserve existing land in operation.
Proposed Project: The proposed project is a bioengineered bank treatment of total length 475 feet including bank sloping, armored rock toe, and riparian cutting plantings.

Permitting Requirements

Big Horn County: Floodplain Development Permit

State Engineers Office: Not applicable

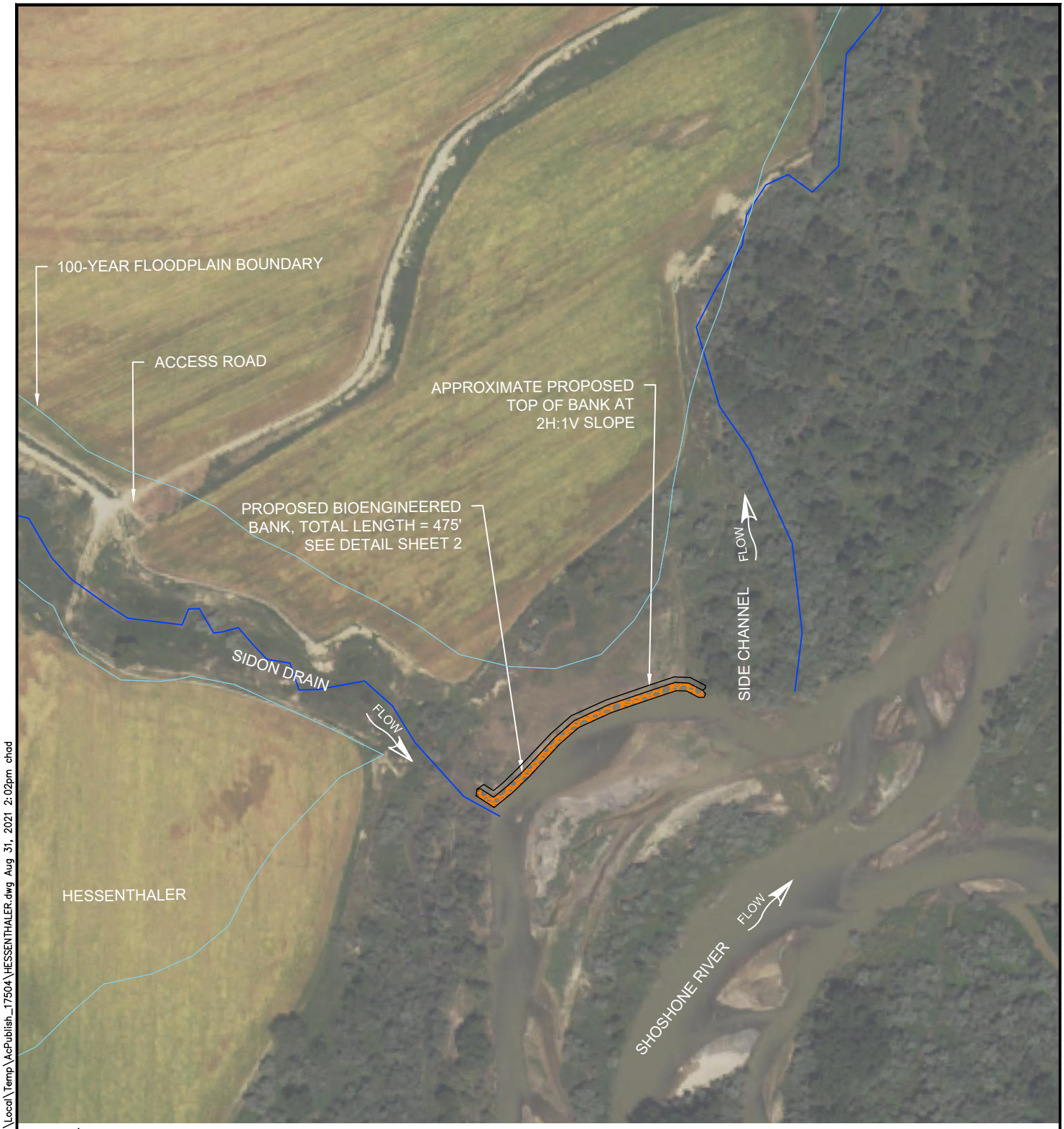
Wyoming Office of State Lands: Not applicable

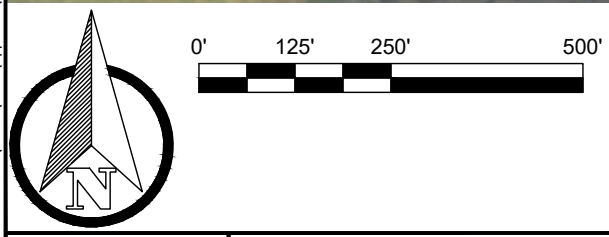
Wyoming Department of Environmental Quality: 401 Water Quality Certification

Bureau of Land Management: Not applicable

Army Corps of Engineers: 404 permit

Other Concerns





C:\Users\chad\AppData\Local\Temp\AcPublish_17504\HESSENTHALER.dwg Aug 31, 2021 2:02pm chad

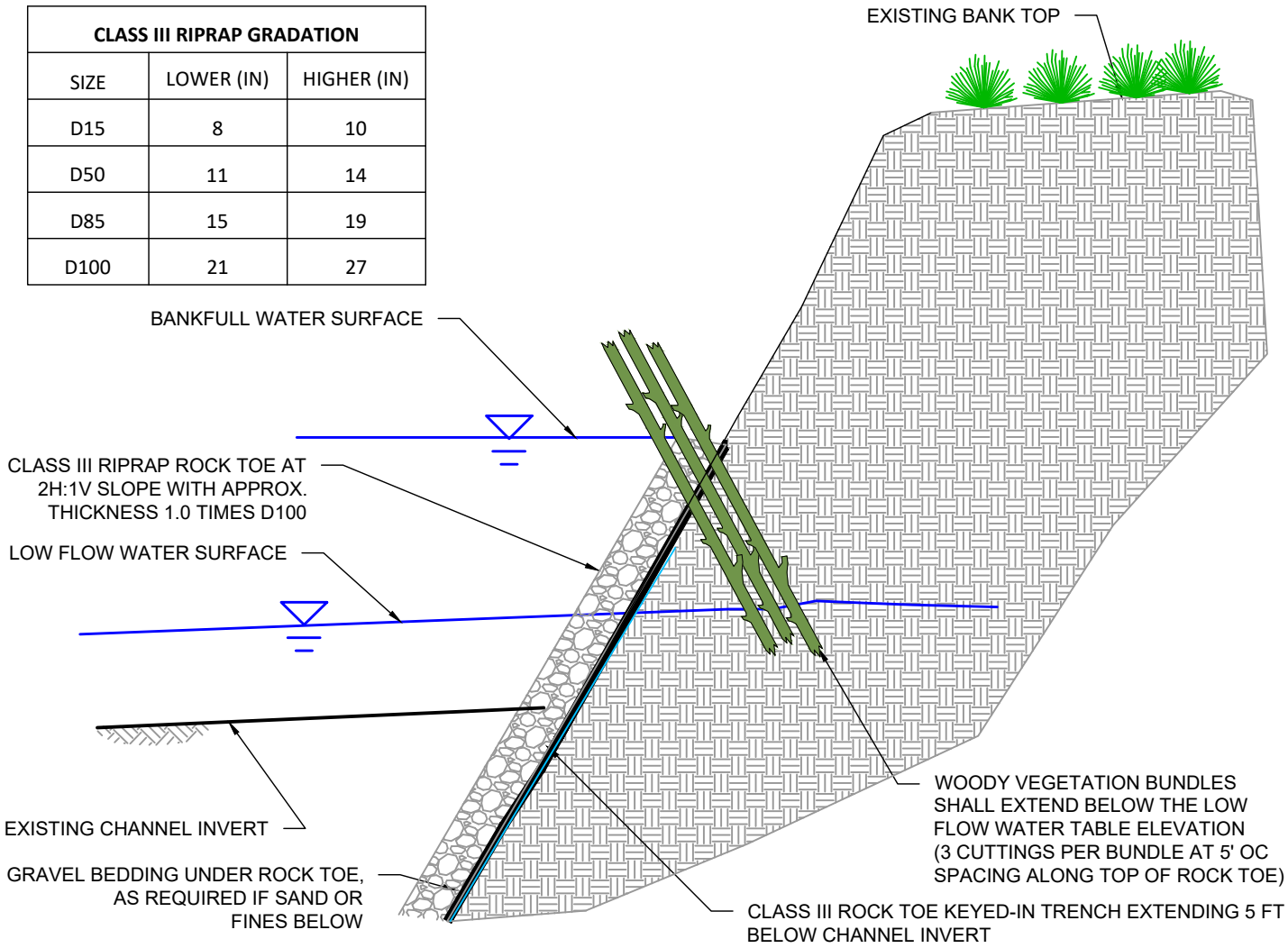
DESIGNED BY: CB
DRAWN BY: CB
CHECKED BY: RC
DATE: 8/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED LEVEL 1 STUDY

DAVID HESSENTHALER (RIVER BANK STABILIZATION UPPER SITE)
LOCATED IN SECTION 19 T56N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

CLASS III RIPRAP GRADATION		
SIZE	LOWER (IN)	HIGHER (IN)
D15	8	10
D50	11	14
D85	15	19
D100	21	27



ROCK TOE - SECTION VIEW

NTS

ROCK TOE CONSTRUCTION NOTES:

1. INSTALL TEMPORARY COFFERDAM TO ISOLATE WORK AREA, IF NECESSARY. COFFERDAM METHOD TO BE PROPOSED BY THE CONTRACTOR AND APPROVED BY THE OWNER.
2. CONSTRUCT THE ROCK TOE AND BIOENGINEERING BANK STABILIZATION TREATMENTS ALONG SHOSHONE RIVER.
3. THE BANK AND ROCK TOE SHOULD HAVE A SLOPE OF 2H:1V STARTING AT THE EXISTING TOE AND SLOPING UPWARDS.
4. TOE ROCK SHALL BE HARD, DURABLE, SUB-ROUNDED TO ANGULAR IN SHAPE, RESISTANT TO WEATHERING TO WATER AND ICE ACTION; FREE OF EXCESS AMOUNTS OF THIN FLAT, AND ELONGATED PIECES, FREE FROM OVERBURDEN, SPOIL, SHALE, STRUCTURAL DEFECTS, AND ORGANIC MATERIAL. THE SMALLER STONE SHALL BE UNIFORMLY DISTRIBUTED THROUGHOUT THE WORK. THE ROCK SHALL BE MANIPULATED BY HAND OR MACHINE METHODS SUFFICIENTLY TO SECURE A UNIFORM SURFACE AND MASS STABILITY. ROCK SHALL BE SOURCED FROM LOCALLY AVAILABLE COARSE MATERIAL.
5. STRUCTURE SHALL BE KEYED-IN A TRENCH EXTENDING BELOW THE SCOUR DEPTH.
6. ADD GRAVEL BEDDING FOR SETTING ROCK, AS NEEDED.
7. PLACE GRAVEL FILTER BEHIND ROCK TOE, IF NECESSARY, BETWEEN RIPRAP AND NATIVE MATERIAL. FILTER SHALL BE SPREAD IMMEDIATELY AHEAD OF THE ROCK PLACEMENT.
8. PLACEMENT OF ROCK RIPRAP SHALL START AT THE TOE OF THE SLOPE AND PROCEED UP THE SLOPE. THE RIPRAP SHALL BE PLACED SUCH THAT DAMAGE TO THE FILTER LAYER DOES NOT OCCUR. FILTER DISPLACED OR OTHERWISE DAMAGED DURING PLACEMENT SHALL BE REPLACED.
9. CONTINUE BANK FACE SLOPING AS SHOWN IN THE PLAN.
10. PLACE LOCALLY SOURCED RIPARIAN DORMANT HARDWOOD VEGETATION BUNDLES ALONG THE ROCK TOE AND BANK FACE USING A STANDARD LIVE STAKE INSTALLATION PROCEDURE .
11. FINAL CONFIGURATION OF ROCK TOE STRUCTURE SHALL BE AS DIRECTED IN FIELD.

C:\Users\chad\AppData\Local\Temp\AcPublish_22644\HESSENTHALER.dwg Aug 26, 2021 3:49pm chad

DESIGNED BY: CB
DRAWN BY: CB
CHECKED BY: RC
DATE: 8/26/2021
REV:
SHEET: 2

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
DAVID HESSENTHALER (RIVER BANK STABILIZATION DETAIL)
LOCATED IN SECTION 10 T56N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	15
Owner/Operator:	**Hessenthaler, David**
Site Name:	Upper Site
Type Of Project:	Bank Stabilization

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$5,000.00	$5,000
2	Bank Sloping	660	C.Y.	$12.00	$7,917
3	Toe Rock Purchase, Delivery & Install	1,100	C.Y.	$80.00	$87,963
4	Cutting Collect & Install (3 per 5' bank)	285	Each	$2.00	$570
5	Water Management	1	L.S.	$3,000.00	$3,000
				Total Construction Cost	**$104,450**

INCIDENTAL PROJECT COSTS

Construction Permits	$600
Performance Bond	$1,100
Insurance	$600
15% O&P	$15,667
Subtotal 1	**$17,967**
Subtotal 2	**$122,417**
Construction Engineering @ 10% of Subtotal #2	$12,242
Subtotal 3	**$134,659**
Contingency @ 15% of Subtotal #3	$20,199
Total Construction Cost	**$154,858**
Preparation of Final Designs and Specifications	$12,389
Permitting @ 3% of Project Cost	$4,646
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$171,892**

SITE PHOTOS: Upper Site

Project ID #:	16
Owner/Operator:	**Walker, Jim**
Site Name:	Glove Canal Headgate
Type Of Project:	Diversion Structure
Land Jurisdiction:	Private
Location:	

Project Description

Statement of Purpose and Need: Replace seasonal push up diversion with permanent boulder structure to provide necessary head into existing Globe Canal headgate.
Proposed Project: The proposed project is a boulder j-hook weir and bank armoring. J-hook weir consists of approximately 60 4' boulders and 230' of bank protection to resist flanking around the existing concrete headgate wall.

Permitting Requirements

Big Horn County: Floodplain Development Permit

State Engineers Office: Not applicable

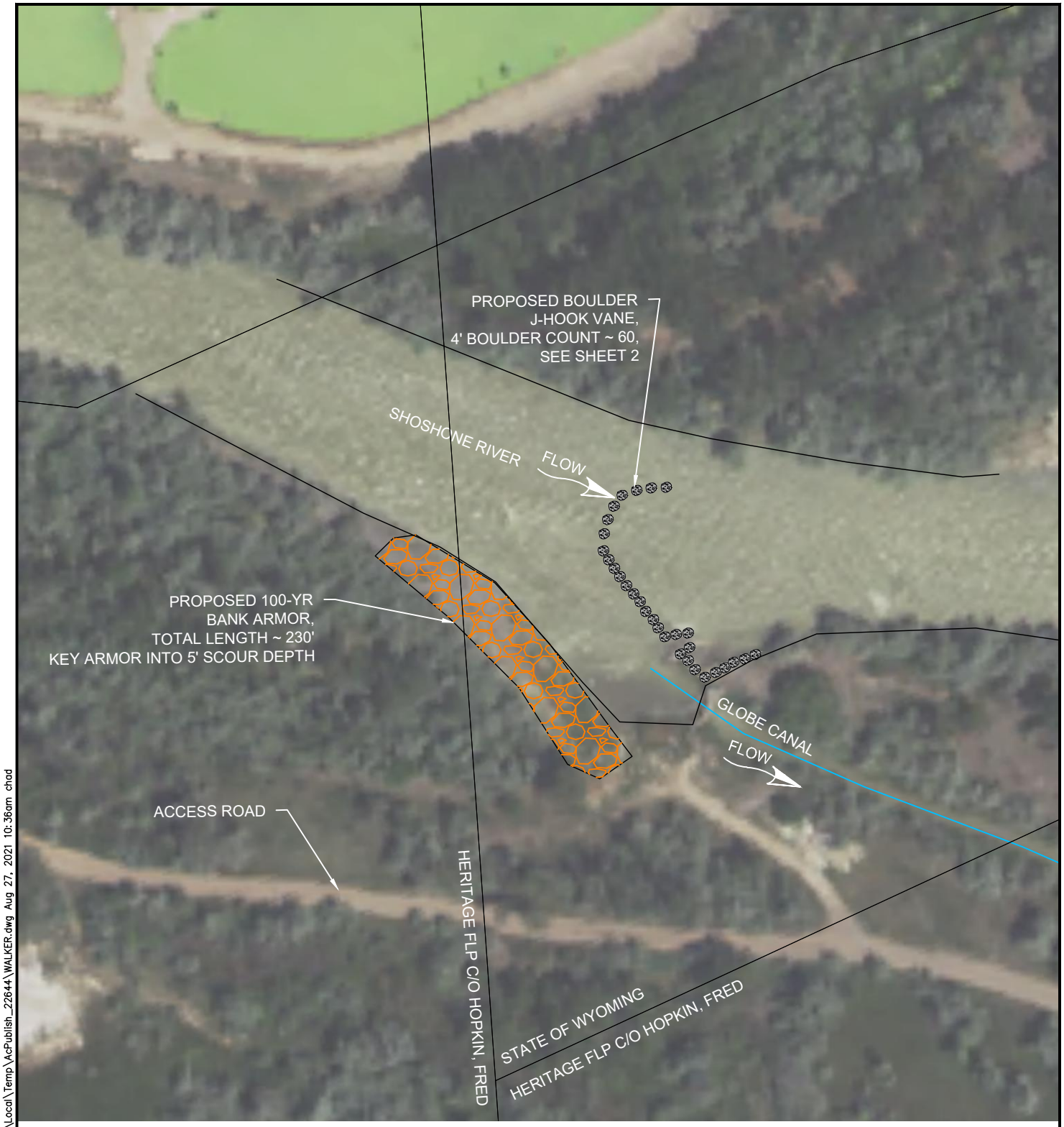
Wyoming Office of State Lands: Not applicable

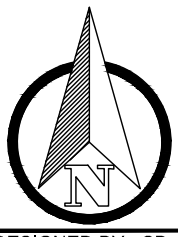
Wyoming Department of Environmental Quality: 401 Water Quality Certification

Bureau of Land Management: Not applicable

Army Corps of Engineers: 404 permit

Other Concerns





0' 50' 100' 200'

C:\Users\chad\AppData\Local\Temp\AcPublish_22644\WALKER.dwg Aug 27, 2021 10:36am chad

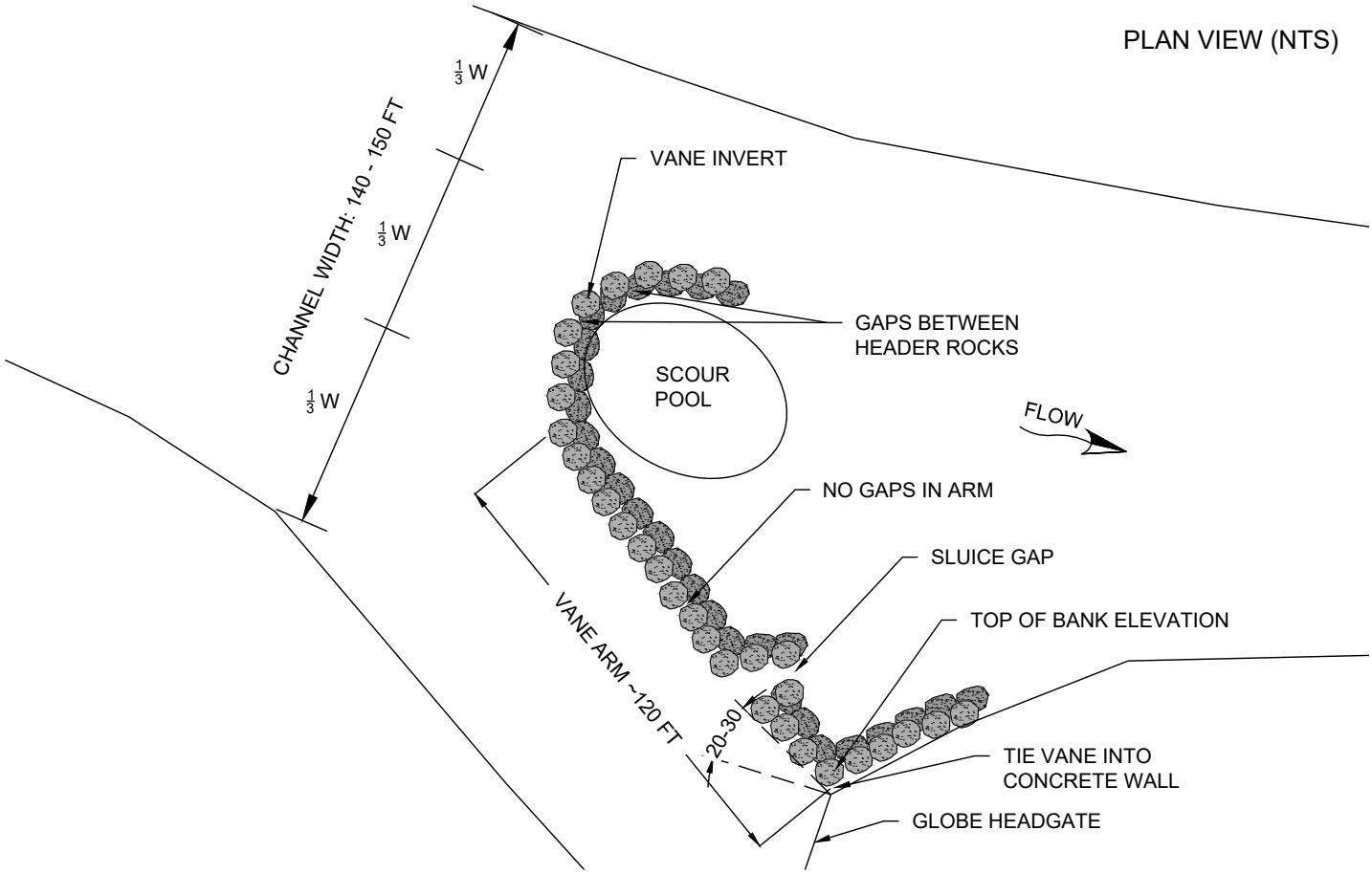
DESIGNED BY: CB
DRAWN BY: CB
CHECKED BY: RC
DATE: 8/01/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

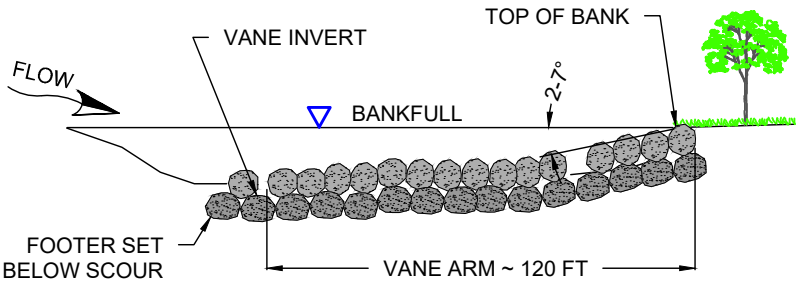
JIM WALKER - GLOBE CANAL (GLOBE CANAL HEADGATE & DIVERSION)
LOCATED IN SECTION 38 T56N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

PLAN VIEW (NTS)



PROFILE VIEW (NTS)



J-HOOK VANE SPECIFICATIONS	
PARAMETER	**SPECIFICATION**
VANE INVERT ELEVATION	0.0 - 0.8 FT ABOVE GRADE
TOP ELEVATION	AT OR ABOVE BANKFULL
VANE ARM LENGTH	120 FT
DEPARTURE ANGLE	20 - 30 DEGREES
ARM SLOPE	2 - 7%
GAPS IN VANE INVERT	0.5 FT
VANE INVERT WIDTH	45 FT
FOOTER ROCK DIAMETER	~ 4 FT

C:\Users\chad\AppData\Local\Temp\AcPublish_22644\J-HOOK DETAIL.dwg Aug 27, 2021 10:34am chad

DESIGNED BY: CB
DRAWN BY: CB
CHECKED BY: RC
DATE: 8/27/2021
REV:
SHEET: 2

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
JIM WALKER - GLOBE CANAL (GLOBE CANAL HEADGATE & DIVERSION)
LOCATED IN SECTION 38 T56N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	16
Owner/Operator:	**Walker, Jim**
Site Name:	Glove Canal Headgate
Type Of Project:	Diversion Structure

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$5,000.00	$5,000
2	J-Hook Construction	1	L.S.	$20,000.00	$20,000
3	Boulder Purchase, Delivery	142	C.Y.	$80.00	$11,378
4	Bank Armor Rock Purchase, Delivery & Install	532	C.Y.	$80.00	$42,593
5	Water Management	1	L.S.	$10,000.00	$10,000
				Total Construction Cost	**$88,970**

INCIDENTAL PROJECT COSTS

Construction Permits	$500
Performance Bond	$900
Insurance	$500
15% O&P	$13,346
Subtotal 1	**$15,246**
Subtotal 2	**$104,216**
Construction Engineering @ 10% of Subtotal #2	$10,422
Subtotal 3	**$114,638**
Contingency @ 15% of Subtotal #3	$17,196
Total Construction Cost	**$131,833**
Preparation of Final Designs and Specifications	$10,547
Permitting @ 7% of Project Cost	$9,228
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$151,608**

SITE PHOTOS: Glove Canal Headgate

Project ID #:	17
Owner/Operator:	**Walker, Jim**
Site Name:	Diversion Canal Erosion
Type Of Project:	Bank Stabilization
Land Jurisdiction:	Private
Location:	

Project Description

Statement of Purpose and Need: Stabilize approximately 650 feet of actively eroding bank to reduce sediment input into Shoshone River and protect existing Globe Canal.
Proposed Project: The proposed project is a bioengineered bank treatment of total length 650 feet including bank full bench to build out from canal, armored rock toe, and riparian cutting plantings.

Permitting Requirements

Big Horn County: Floodplain Development Permit

State Engineers Office: Not applicable

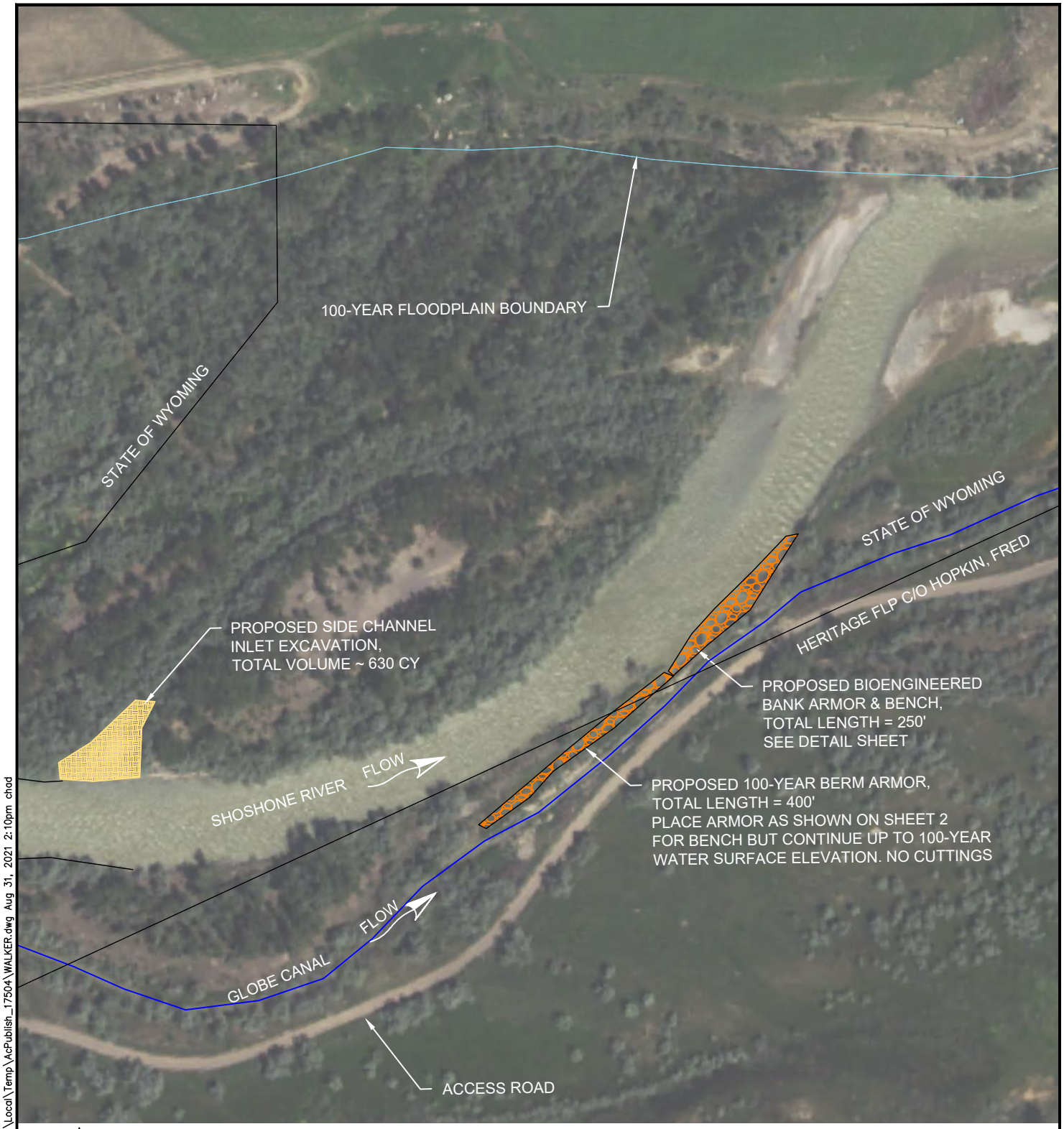
Wyoming Office of State Lands: Not applicable

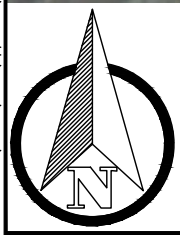
Wyoming Department of Environmental Quality: 401 Water Quality Certification

Bureau of Land Management: Not applicable

Army Corps of Engineers: 404 permit

Other Concerns





0' 100' 200' 400'

C:\Users\chad\AppData\Local\Temp\AcPublish_17504\WALKER.dwg Aug 31, 2021 2:10pm chad

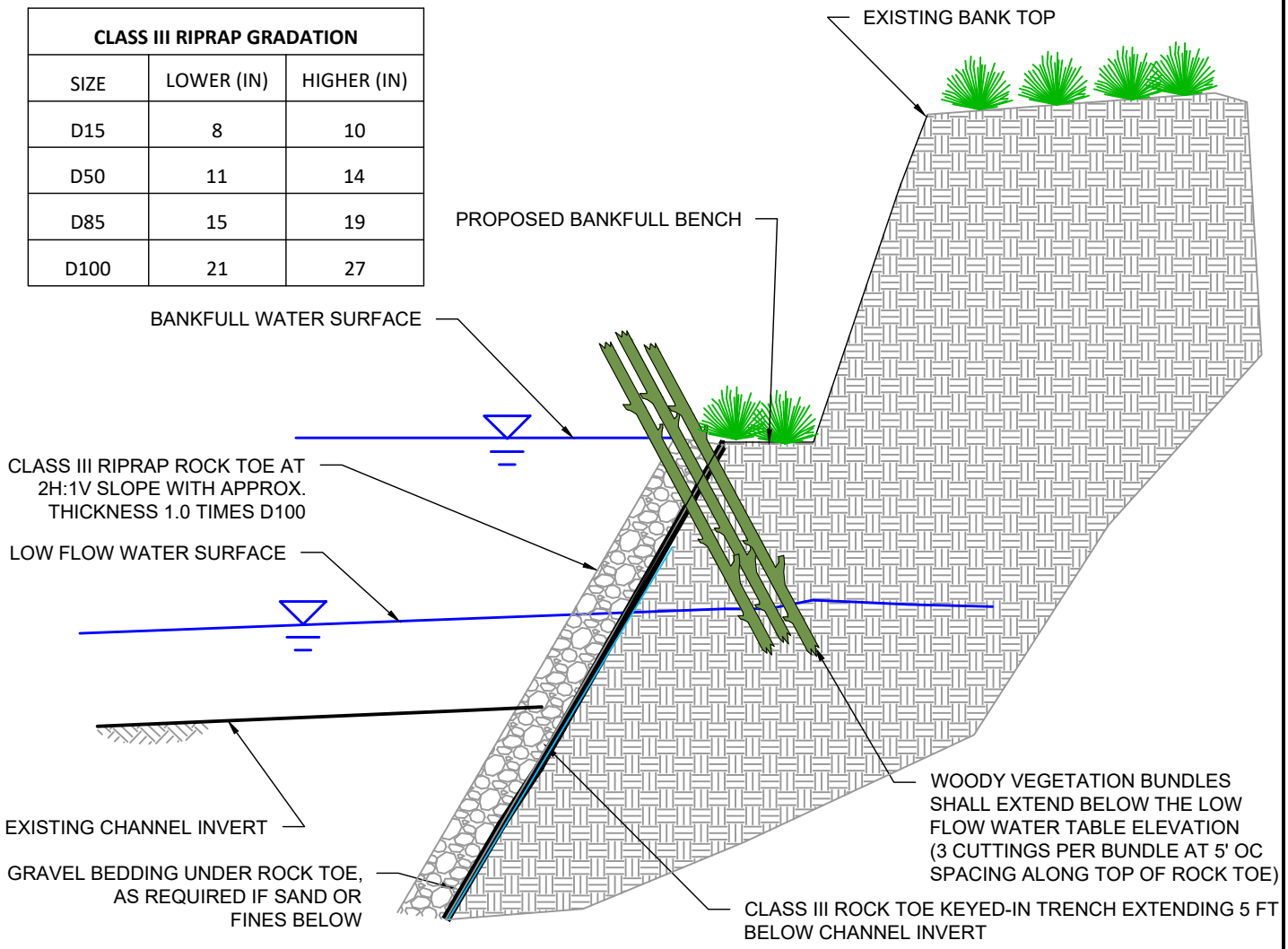
DESIGNED BY: CB
DRAWN BY: CB
CHECKED BY: RC
DATE: 8/27/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

JIM WALKER - GLOBE CANAL (DIVERSION CANAL EROSION)
LOCATED IN SECTION 38 T56N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

CLASS III RIPRAP GRADATION		
SIZE	LOWER (IN)	HIGHER (IN)
D15	8	10
D50	11	14
D85	15	19
D100	21	27



ROCK TOE - SECTION VIEW

NTS

ROCK TOE CONSTRUCTION NOTES:

1. INSTALL TEMPORARY COFFERDAM TO ISOLATE WORK AREA, IF NECESSARY. COFFERDAM METHOD TO BE PROPOSED BY THE CONTRACTOR AND APPROVED BY THE OWNER.
2. CONSTRUCT THE ROCK TOE AND BIOENGINEERING BANK STABILIZATION TREATMENTS ALONG SHOSHONE RIVER.
3. THE ROCK TOE SHOULD HAVE A SLOPE OF 2H:1V STARTING AT THE BANKFULL BENCH AND SLOPING DOWN.
4. TOE ROCK SHALL BE HARD, DURABLE, SUB-ROUNDED TO ANGULAR IN SHAPE, RESISTANT TO WEATHERING TO WATER AND ICE ACTION; FREE OF EXCESS AMOUNTS OF THIN FLAT, AND ELONGATED PIECES, FREE FROM OVERBURDEN, SPOIL, SHALE, STRUCTURAL DEFECTS, AND ORGANIC MATERIAL. THE SMALLER STONE SHALL BE UNIFORMLY DISTRIBUTED THROUGHOUT THE WORK. THE ROCK SHALL BE MANIPULATED BY HAND OR MACHINE METHODS SUFFICIENTLY TO SECURE A UNIFORM SURFACE AND MASS STABILITY. ROCK SHALL BE SOURCED FROM LOCALLY AVAILABLE COARSE MATERIAL.
5. STRUCTURE SHALL BE KEYED-IN A TRENCH EXTENDING BELOW THE SCOUR DEPTH.
6. ADD GRAVEL BEDDING FOR SETTING ROCK, AS NEEDED.
7. PLACE GRAVEL FILTER BEHIND ROCK TOE, IF NECESSARY, BETWEEN RIPRAP AND NATIVE MATERIAL. FILTER SHALL BE SPREAD IMMEDIATELY AHEAD OF THE ROCK PLACEMENT.
8. PLACEMENT OF ROCK RIPRAP SHALL START AT THE TOE OF THE SLOPE AND PROCEED UP THE SLOPE. THE RIPRAP SHALL BE PLACED SUCH THAT DAMAGE TO THE FILTER LAYER DOES NOT OCCUR. FILTER DISPLACED OR OTHERWISE DAMAGED DURING PLACEMENT SHALL BE REPLACED.
9. CONTINUE BANKFUL BENCH CONSTRUCTION AS SHOWN IN THE PLAN TO PROVIDE OFFSET FROM EXISTING DRAIN.
10. PLACE LOCALLY SOURCED RIPARIAN DORMANT HARDWOOD VEGETATION BUNDLES ALONG THE ROCK TOE AND BANK FACE USING A STANDARD LIVE STAKE INSTALLATION PROCEDURE .
11. FINAL CONFIGURATION OF ROCK TOE AND BENCH STRUCTURE SHALL BE AS DIRECTED IN FIELD.

C:\Users\chad\AppData\Local\Temp\AcPublish_22644\WALKER.dwg Aug 27, 2021 10:44am chad

DESIGNED BY: CB
DRAWN BY: CB
CHECKED BY: RC
DATE: 8/27/2021
REV:
SHEET: 2

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
JIM WALKER - GLOBE CANAL (DIVERSION CANAL EROSION)
LOCATED IN SECTION 38 T56N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	17
Owner/Operator:	**Walker, Jim**
Site Name:	Diversion Canal Erosion
Type Of Project:	Bank Stabilization

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$5,000.00	$5,000
2	Bench Construction	1,269	C.Y.	$12.00	$15,222
3	Toe Rock Purchase, Delivery & Install	417	C.Y.	$80.00	$33,333
4	Cutting Collect & Install (3 per 5' bank)	150	Each	$2.00	$300
5	Berm Armor Rock Purchase, Delivery & Install	926	C.Y.	$80.00	$74,074
6	Side Channel Inlet Excavation	630	C.Y.	$12.00	$7,560
7	Water Management	1	L.S.	$5,000.00	$5,000
				Total Construction Cost	**$140,490**

INCIDENTAL PROJECT COSTS

Construction Permits	$800
Performance Bond	$1,500
Insurance	$800
15% O&P	$21,073
Subtotal 1	**$24,173**
Subtotal 2	**$164,663**
Construction Engineering @ 10% of Subtotal #2	$16,466
Subtotal 3	**$181,129**
Contingency @ 15% of Subtotal #3	$27,169
Total Construction Cost	**$208,299**
Preparation of Final Designs and Specifications	$16,664
Permitting @ 3% of Project Cost	$6,249
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$231,212**

SITE PHOTOS: Diversion Canal Erosion

Project ID #:	18
Owner/Operator:	**Bischoff, Dave**
Site Name:	Drain Protection
Type Of Project:	Bank Stabilization
Land Jurisdiction:	Private
Location:	

Project Description

Statement of Purpose and Need: Stabilize approximately 1000 feet of actively eroding bank to reduce sediment input into Shoshone River and preserve existing drain.
Proposed Project: The proposed project is a bioengineered bank treatment of total length 1000 feet including bank full bench to build out from drain, armored rock toe, and riparian cutting plantings.

Permitting Requirements

Big Horn County: Floodplain Development Permit

State Engineers Office: Not applicable

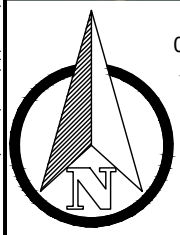
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: 401 Water Quality Certification

Bureau of Land Management: Not applicable

Army Corps of Engineers: 404 permit

Other Concerns



0' 125' 250' 500'

C:\Users\chad\AppData\Local\Temp\AcPublish_17504\BISCHOFF-DAVE.dwg Aug 31, 2021 1:56pm chad

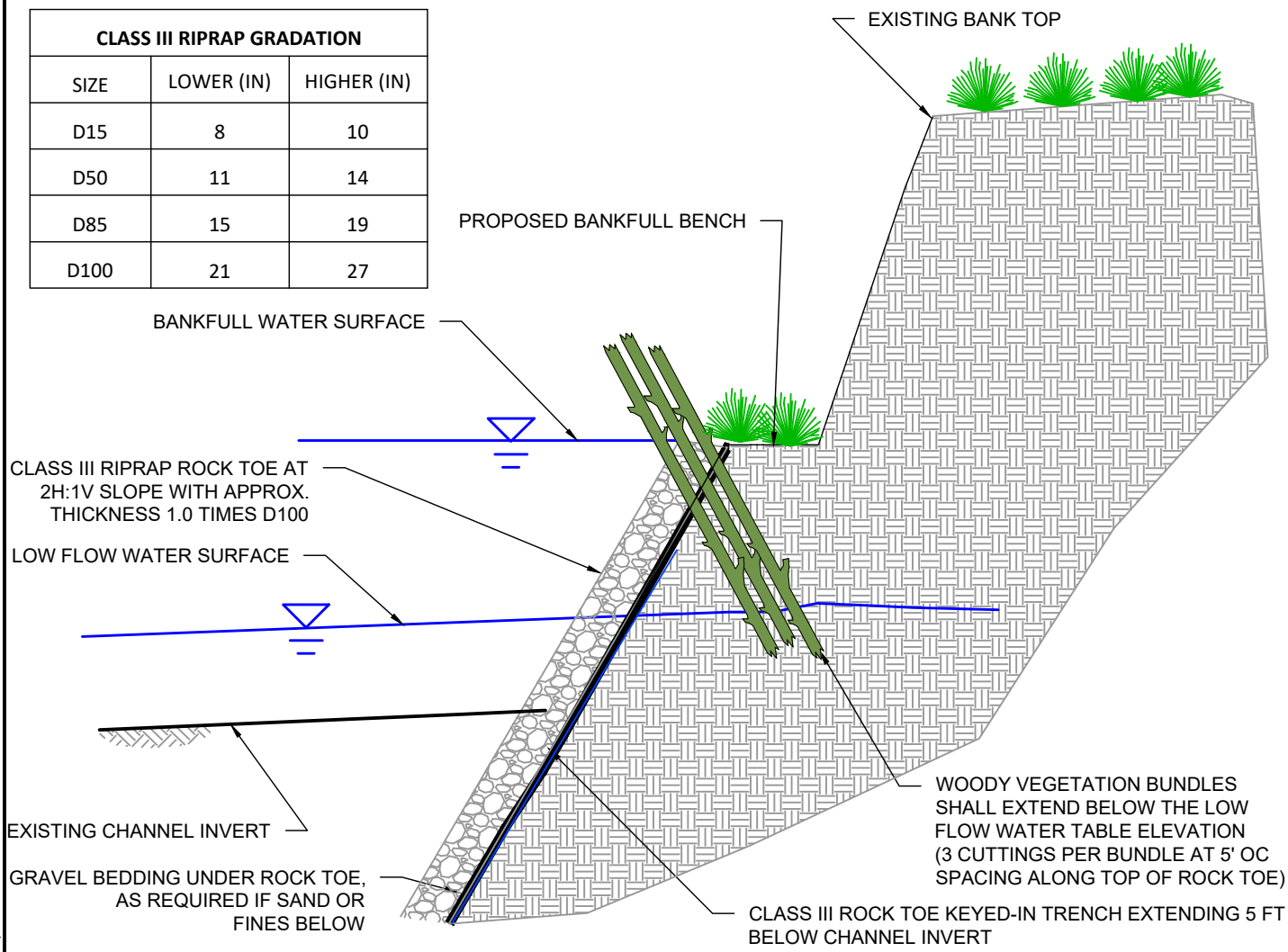
DESIGNED BY: CB
DRAWN BY: CB
CHECKED BY: RC
DATE: 8/262021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

DAVE BISCHOFF (STREAMBANK EROSION & DRAIN PROTECTION)
LOCATED IN SECTION 11 T56N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

CLASS III RIPRAP GRADATION		
SIZE	LOWER (IN)	HIGHER (IN)
D15	8	10
D50	11	14
D85	15	19
D100	21	27



ROCK TOE - SECTION VIEW

NTS

ROCK TOE CONSTRUCTION NOTES:

1. INSTALL TEMPORARY COFFERDAM TO ISOLATE WORK AREA, IF NECESSARY. COFFERDAM METHOD TO BE PROPOSED BY THE CONTRACTOR AND APPROVED BY THE OWNER.
2. CONSTRUCT THE ROCK TOE AND BIOENGINEERING BANK STABILIZATION TREATMENTS ALONG SHOSHONE RIVER.
3. THE ROCK TOE SHOULD HAVE A SLOPE OF 2H:1V STARTING AT THE BANKFULL BENCH AND SLOPING DOWN.
4. TOE ROCK SHALL BE HARD, DURABLE, SUB-ROUNDED TO ANGULAR IN SHAPE, RESISTANT TO WEATHERING TO WATER AND ICE ACTION; FREE OF EXCESS AMOUNTS OF THIN FLAT, AND ELONGATED PIECES, FREE FROM OVERBURDEN, SPOIL, SHALE, STRUCTURAL DEFECTS, AND ORGANIC MATERIAL. THE SMALLER STONE SHALL BE UNIFORMLY DISTRIBUTED THROUGHOUT THE WORK. THE ROCK SHALL BE MANIPULATED BY HAND OR MACHINE METHODS SUFFICIENTLY TO SECURE A UNIFORM SURFACE AND MASS STABILITY. ROCK SHALL BE SOURCED FROM LOCALLY AVAILABLE COARSE MATERIAL.
5. STRUCTURE SHALL BE KEYED-IN A TRENCH EXTENDING BELOW THE SCOUR DEPTH.
6. ADD GRAVEL BEDDING FOR SETTING ROCK, AS NEEDED.
7. PLACE GRAVEL FILTER BEHIND ROCK TOE, IF NECESSARY, BETWEEN RIPRAP AND NATIVE MATERIAL. FILTER SHALL BE SPREAD IMMEDIATELY AHEAD OF THE ROCK PLACEMENT.
8. PLACEMENT OF ROCK RIPRAP SHALL START AT THE TOE OF THE SLOPE AND PROCEED UP THE SLOPE. THE RIPRAP SHALL BE PLACED SUCH THAT DAMAGE TO THE FILTER LAYER DOES NOT OCCUR. FILTER DISPLACED OR OTHERWISE DAMAGED DURING PLACEMENT SHALL BE REPLACED.
9. CONTINUE BANKFUL BENCH CONSTRUCTION AS SHOWN IN THE PLAN TO PROVIDE OFFSET FROM EXISTING DRAIN.
10. PLACE LOCALLY SOURCED RIPARIAN DORMANT HARDWOOD VEGETATION BUNDLES ALONG THE ROCK TOE AND BANK FACE USING A STANDARD LIVE STAKE INSTALLATION PROCEDURE .
11. FINAL CONFIGURATION OF ROCK TOE AND BENCH STRUCTURE SHALL BE AS DIRECTED IN FIELD.

C:\Users\chad\AppData\Local\Temp\AcPublish_17504\BISCHOFF-DAVE.dwg Aug 31, 2021 1:56pm chad

DESIGNED BY: CB
DRAWN BY: CB
CHECKED BY: RC
DATE: 8/262021
REV:
SHEET: 2

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

DAVE BISCHOFF (STREAMBANK EROSION & DRAIN PROTECTION)
LOCATED IN SECTION 11 T56N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	18
Owner/Operator:	**Bischoff, Dave**
Site Name:	Drain Protection
Type Of Project:	Bank Stabilization

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$5,000.00	$5,000
2	Bench Construction	4,824	C.Y.	$12.00	$57,889
3	Toe Rock Purchase, Delivery & Install	1,667	C.Y.	$80.00	$133,333
4	Cutting Collect & Install (3 per 5' bank)	600	Each	$2.00	$1,200
5	Water Management	1	L.S.	$5,000.00	$5,000
				Total Construction Cost	**$202,422**

INCIDENTAL PROJECT COSTS

Construction Permits	$1,100
Performance Bond	$2,100
Insurance	$1,100
15% O&P	$30,363
Subtotal 1	**$34,663**
Subtotal 2	**$237,086**
Construction Engineering @ 10% of Subtotal #2	$23,709
Subtotal 3	**$260,794**
Contingency @ 15% of Subtotal #3	$39,119
Total Construction Cost	**$299,913**
Preparation of Final Designs and Specifications	$23,993
Permitting @ 3% of Project Cost	$8,997
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$332,904**

SITE PHOTOS: Drain Protection

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	20	
Owner/Operator:	**Bischoff, Dave**	
Site Name:		
Type Of Project:	Canal to Pipe	
Land Jurisdiction:	Private	
Location:	44.84481N	-108.30045W

Project Description

Statement of Purpose and Need: Currently an open dirt irrigation ditch which feeds cropland and is prone to erosion.
Proposed Project: The proposed project will replace the existing soil ditch with buried pipe which will tie into gated surface irrigation system reducing erosion.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Land Owners: None

Other Concerns

P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Bischoff.dwg Aug 17, 2021 11:58am kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
#20 DAVE BISCHOFF (BURIED LATERAL)
LOCATED IN SECTION 9, T56N R95W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	20
Owner/Operator:	**Bischoff, Dave**
Site Name:	Bischoff Ranch
Type Of Project:	Canal to Pipe

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$4,500.00	$4,500
2	Traffic Control	1	L.S.	$0.00	$0
3	Furnish and Install 10" Buried Pipe	1,800	L.F.	$20.00	$36,000
5	Concrete (Diversion Structure)	5	Cu.Yd.	$500.00	$2,500
6	Waterman Headgate	1	Each	$3,000.00	$3,000
7	Tie to Existing Gated Surface Irrigation	1	Each	$1,500.00	$1,500
				Total Construction Cost	**$47,500**

INCIDENTAL PROJECT COSTS

Construction Permits	$300
Performance Bond	$500
Insurance	$300
15% O&P	$7,125
Subtotal 1	**$8,225**
Subtotal 2	**$55,725**
Construction Engineering @ 10% of Subtotal #2	$5,573
Subtotal 3	**$61,298**
Contingency @ 15% of Subtotal #3	$9,195
Total Construction Cost	**$70,492**
Preparation of Final Designs and Specifications	$5,639
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$76,131**

SITE PHOTOS: Bischoff Ranch

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	22
Owner/Operator:	**Crosby, Casey**
Site Name:	Dry Creek Cow Watering
Type Of Project:	Upland Water
Land Jurisdiction:	Private/ State
Location:	44.88389N -108.38958W

Project Description

Statement of Purpose and Need: Project will provide water from Dry Creek across State and Federal lands to four watering troughs. Creek has potential of flash floods so pump placement out of the flood zone is important. **Proposed Project:** The proposed project will create a diversion into a cistern with a solar pump. The pump will feed the pipeline which provides water to four watering troughs.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: Point of Diversion

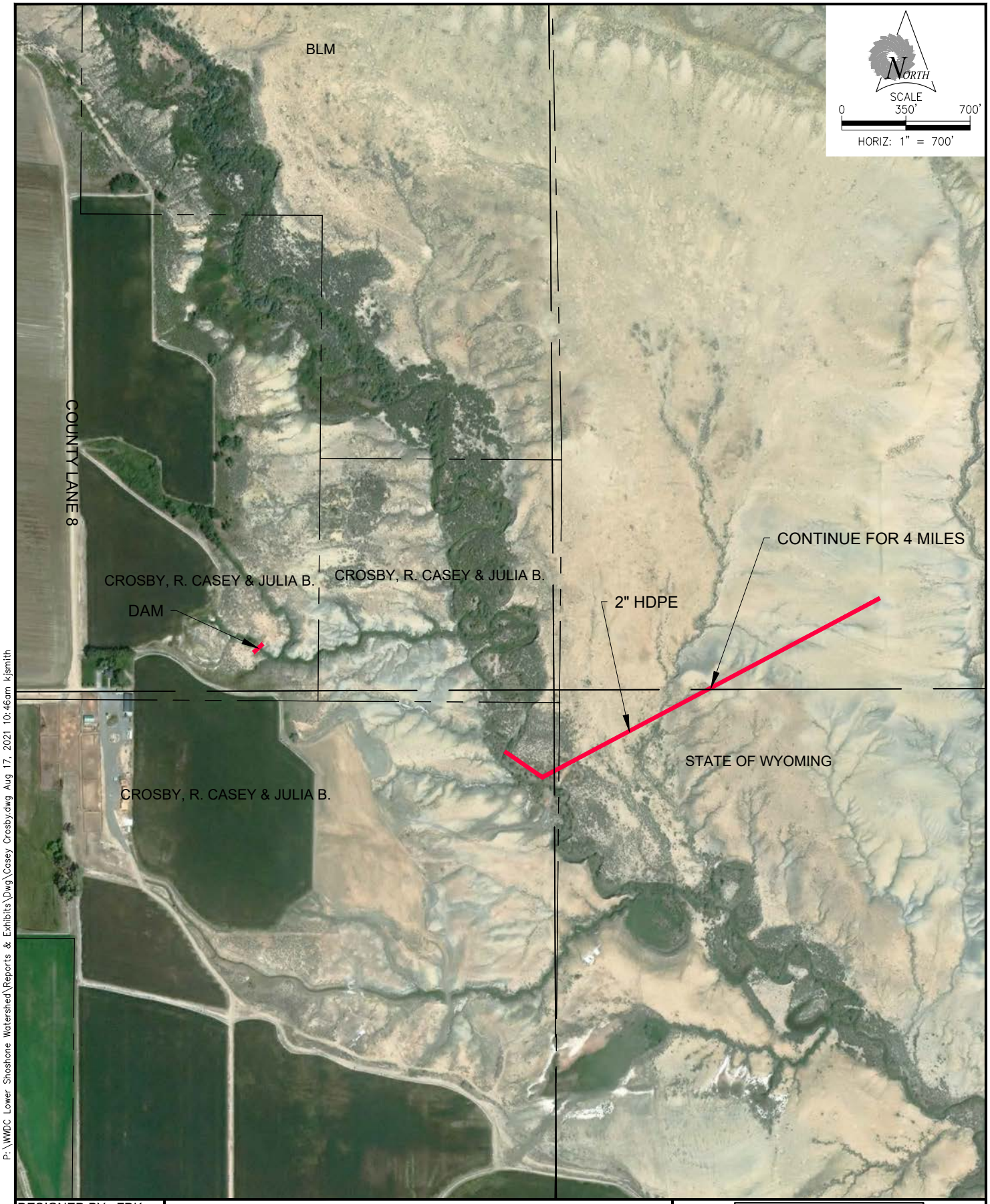
Wyoming Office of State Lands: Crosses State lands

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Yes, pipeline and troughs may exist on BLM land. Potential Section 7 consultation due to federal lands

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Casey Crosby.dwg Aug 17, 2021 10:46am kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#21 & #22 CASEY CROSBY (PIPE LATERAL & DAM)
LOCATED IN SECTION 29 T57N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 22
Owner/Operator: **Casey, Crosby**
Site Name: Dry Creek Cow Watering
Type Of Project: Upland Water

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$4,500.00	$4,500
2	Traffic Control	1	L.S.	$0.00	$0
3	Grade and Smooth Pipe Route	20,000	L.F.	$1.00	$20,000
4	Furnish and Install 2" HDPE Buried Pipe	20,000	L.F.	$7.00	$140,000
5	Concrete (Diversion Structure)	5	Cu.Yd.	$500.00	$2,500
6	Waterman Headgate	1	Each	$3,000.00	$3,000
7					
8	Solar Pump	1	L.S.	$3,000.00	$3,000.00
9	Solar Panels, Brackets, and Poles	1	L.S.	$1,500.00	$1,500.00
10	Control Panel	1	L.S.	$600.00	$600.00
11	Water Trough and Float Controller	4	Each	$2,200.00	$8,800
				Total Construction Cost	**$183,900**

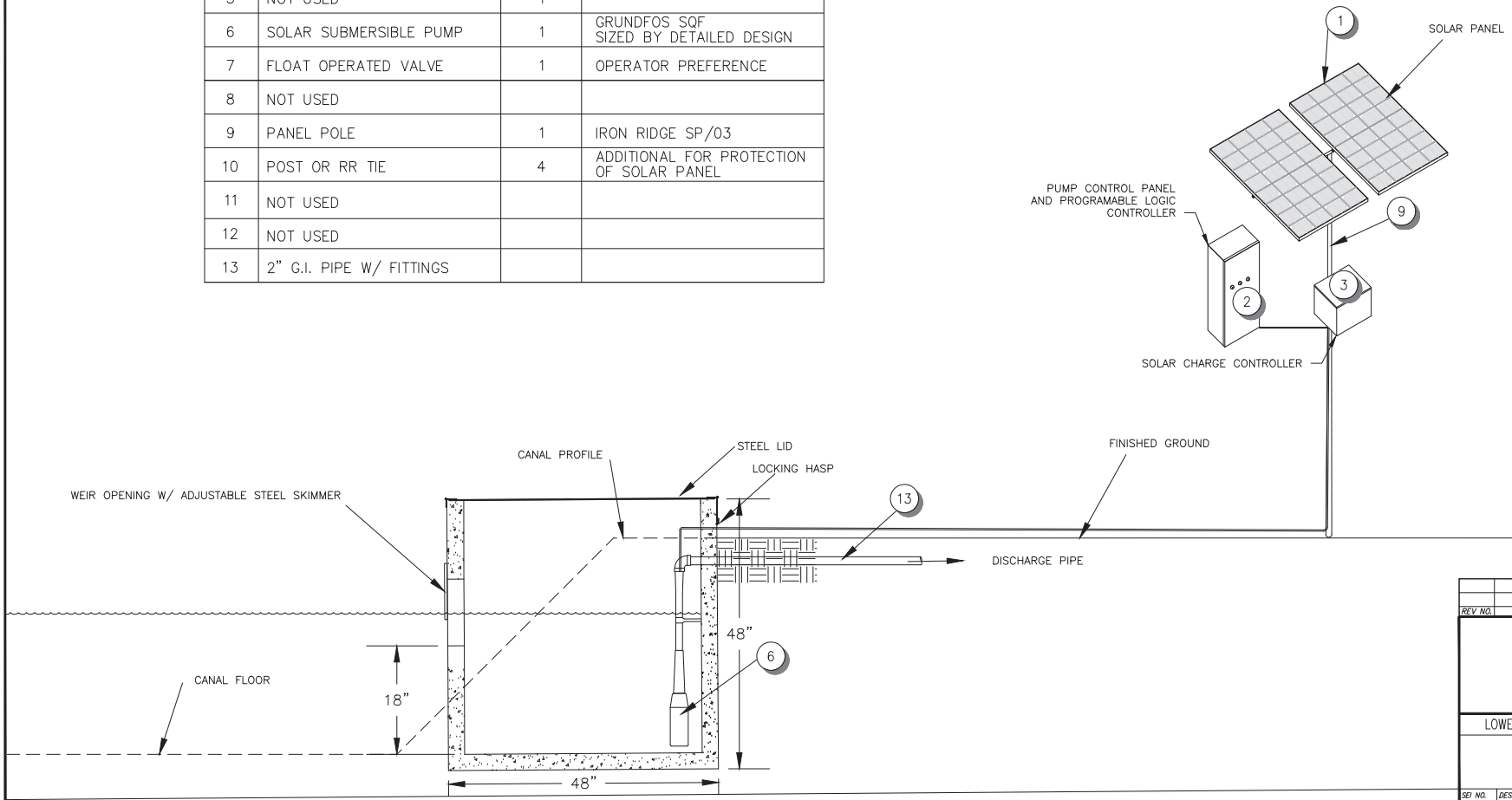
INCIDENTAL PROJECT COSTS

Construction Permits	$1,000
Performance Bond	$1,900
Insurance	$1,000
15% O&P	$27,585
Subtotal 1	**$31,485**
Subtotal 2	**$215,385**
Construction Engineering @ 10% of Subtotal #2	$21,539
Subtotal 3	**$236,924**
Contingency @ 15% of Subtotal #3	$35,539
Total Construction Cost	**$272,462**
Preparation of Final Designs and Specifications	$21,797
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$294,259**

SITE PHOTOS: Dry Creek Cow Watering

EQUIPMENT SCHEDULE

NO.	DESCRIPTION	SIZE/#	REMARKS
1	SOLAR PANEL		SIZED BY PUMP DEMAND
2	PUMP PANEL CONTROL	1	W/PLC
3	SOLAR CHARGE CONTROLLER	1	BY PANEL MANUFACTURER
5	NOT USED	1	
6	SOLAR SUBMERSIBLE PUMP	1	GRUNDFOS SQF SIZED BY DETAILED DESIGN
7	FLOAT OPERATED VALVE	1	OPERATOR PREFERENCE
8	NOT USED		
9	PANEL POLE	1	IRON RIDGE SP/03
10	POST OR RR TIE	4	ADDITIONAL FOR PROTECTION OF SOLAR PANEL
11	NOT USED		
12	NOT USED		
13	2" G.I. PIPE W/ FITTINGS		



REV NO.	COMMENT	DATE

SUNRISE ENGINEERING
47 EAST 4TH AVENUE
AFTON, WYOMING 83110
TEL 307.885.8500 - FAX 307.885.8501
www.sunrise-eng.com

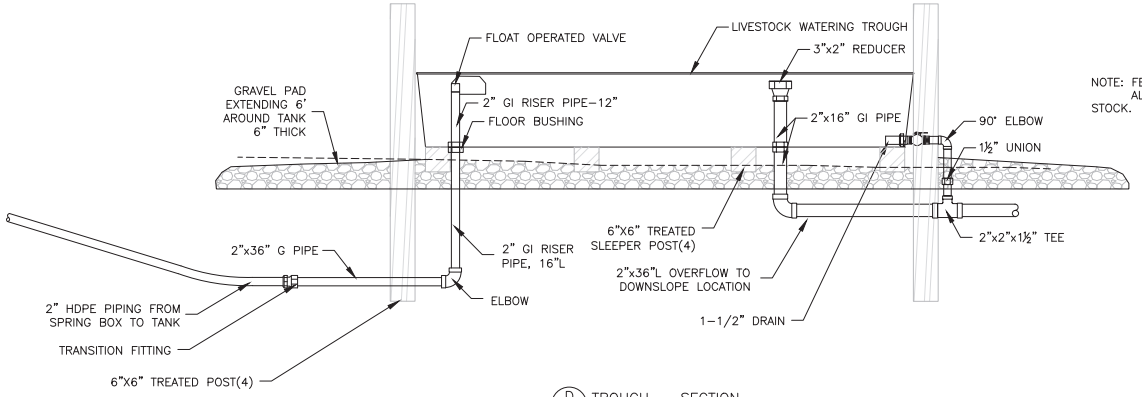
LOWER SHOSHONE WATERSHED STUDY

WEIR AND PUMP

DETAILS

SEI NO.	DESIGNED	DRAWN	CHECKED	SHEET NO.	
07484	FDK	KJS	XXX	1 of 1	D1

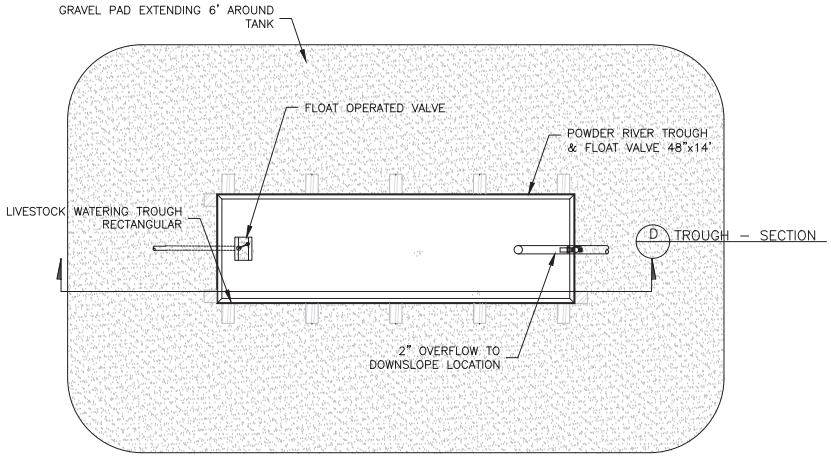
P:\WWDC Lower Shoshone Watershed\Dwg C3D\Sheets\Solar pump in weir.dwg Aug 19, 2021 2:30pm kjsmith



NOTE: FEEDER PANELS ON EACH SIDE OR LONGITUDINAL POLES ALONG CENTER ARE RECOMMENDED TO PREVENT ENTRY BY STOCK.

D TROUGH – SECTION

Trough Miscellaneous Fittings			
Fitting Name	Size	Number	Comments
Floor Bushing with F.I.P Threaded outlet	2"	1	May also install through wall
Wall Bushing with F.I.P Threaded outlet	1-1/2"	1	
Compression Coupling IPS PE x F.I.P.	2"	1	
90 deg ell	2"	2	
90 deg ell	1-1/2"	1	
Pipe Nipple	36"L x 2"	2	
Pipe Nipple	12"L x 2"	1	
Pipe Nipple	16"L x 2"	3	
Pipe Nipple	2"L x 1-1/2"	2	
Pipe Nipple	8"L x 1-1/2"	2	
Tee G.I.	2"x2" x1-1/2"	1	
Reducer	3" x 2"	1	Overflow inlet
Pipe Union	1-1/2"	1	On Drain Pipe
Ball Valve	1-1/2"	1	
Float Operated Valve			Provided by Trough Supplier
RR Tie	8'	9	



D TROUGH – PLAN VIEW

REV NO.	COMMENT	DATE

SUNRISE ENGINEERING
47 EAST 4TH AVENUE
AFTON, WYOMING 83110
TEL 307.885.8500 · FAX 307.885.8501
www.sunrise-eng.com

LOWER SHOSHONE WATERSHED STUDY

TYPICAL TROUGH DETAILS

SEI NO.	DESIGNED	DRAWN	CHECKED	SHEET NO.	
07484	FDK	KJS	XXX	2 of 2	D2

C:\Users\dkemington\appdata\local\temp\AcPublish_20320\Typical Spring development.dwg Sep 02, 2021 2:40pm dkemington

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	23
Owner/Operator:	**Rageth, Brent**
Site Name:	Sidon Canal Reuse Water Project
Type Of Project:	Water Collection
Land Jurisdiction:	Private
Location:	48.81149N -108.53541W

Project Description

Statement of Purpose and Need: Project will provide additional drain tiles to collect ponding water in the field into a sump.
Proposed Project: The proposed project will install two additional drain tiles 1200 feet long by 3 feet deep gravel, with 6 inch diameter corrugated pipe. The drain tiles will collect water into a concrete manhole. The water will be pumped from the manhole into the Sidon Canal.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: Filed as ground water permit as additional supply. Will need map of downstream use areas.

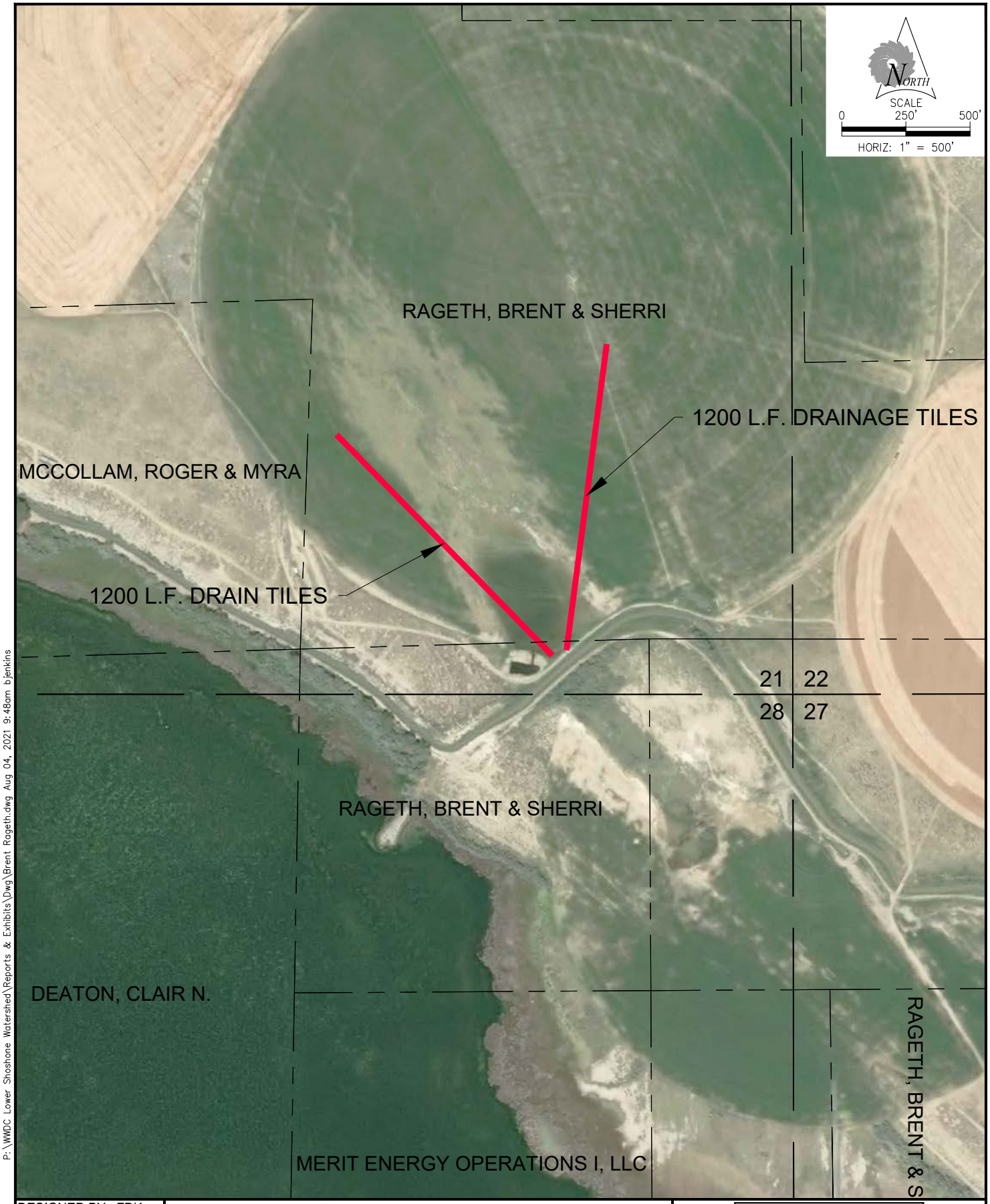
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Brent Rageth.dwg Aug 04, 2021 9:48am bjenkins

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
#23 BRENT RAGETH (DRAINAGE TILES)
LOCATED IN SECTION 21 T56N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	23
Owner/Operator:	**Rageth, Brent**
Site Name:	Sidon Canal Reuse Water Project
Type Of Project:	Water Collection

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$4,800.00	$4,800
2	Traffic Control	1	L.S.	$0.00	$0
3	Furnish & Install 6" Corrugated Drain Pipe	2,400	L.F.	$25.00	$60,000
4	Drain Rock	540	Cu.Yd.	$35.00	$18,900
5	Manhole	1	Each	$4,500.00	$4,500
6	5 HP Pump and Piping	1	Each	$4,500.00	$4,500
7	Control Panel & Level Controls	1	L.S.	$1,200.00	$1,200
				Total Construction Cost	**$93,900**

INCIDENTAL PROJECT COSTS

Construction Permits	$500
Performance Bond	$1,000
Insurance	$500
15% O&P	$14,085
Subtotal 1	**$16,085**
Subtotal 2	**$109,985**
Construction Engineering @ 10% of Subtotal #2	$10,999
Subtotal 3	**$120,984**
Contingency @ 15% of Subtotal #3	$18,148
Total Construction Cost	**$139,131**
Preparation of Final Designs and Specifications	$11,130
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$150,262**

SITE PHOTOS: Sidon Canal Reuse Water Project

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	24	
Owner/Operator:	**Tippets, Rand**	
Site Name:		
Type Of Project:	Bubbler and Pipe	
Land Jurisdiction:	Private	
Location:	44.83848N	-108.33933W

Project Description

Statement of Purpose and Need: Replace existing canal system with pipe system.
Proposed Project: Bury approximately 320' of 15" PIP and install a bubbler with a screen and 2 headgates. One to go straight through to approximately 1440' of 15" PIP. The other to a fitting to connect gated irrigation pipe. Raise headgate 1' to be higher in Globe Canal. Tie headgate into 15" pipe to the field corner and bubbler location.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

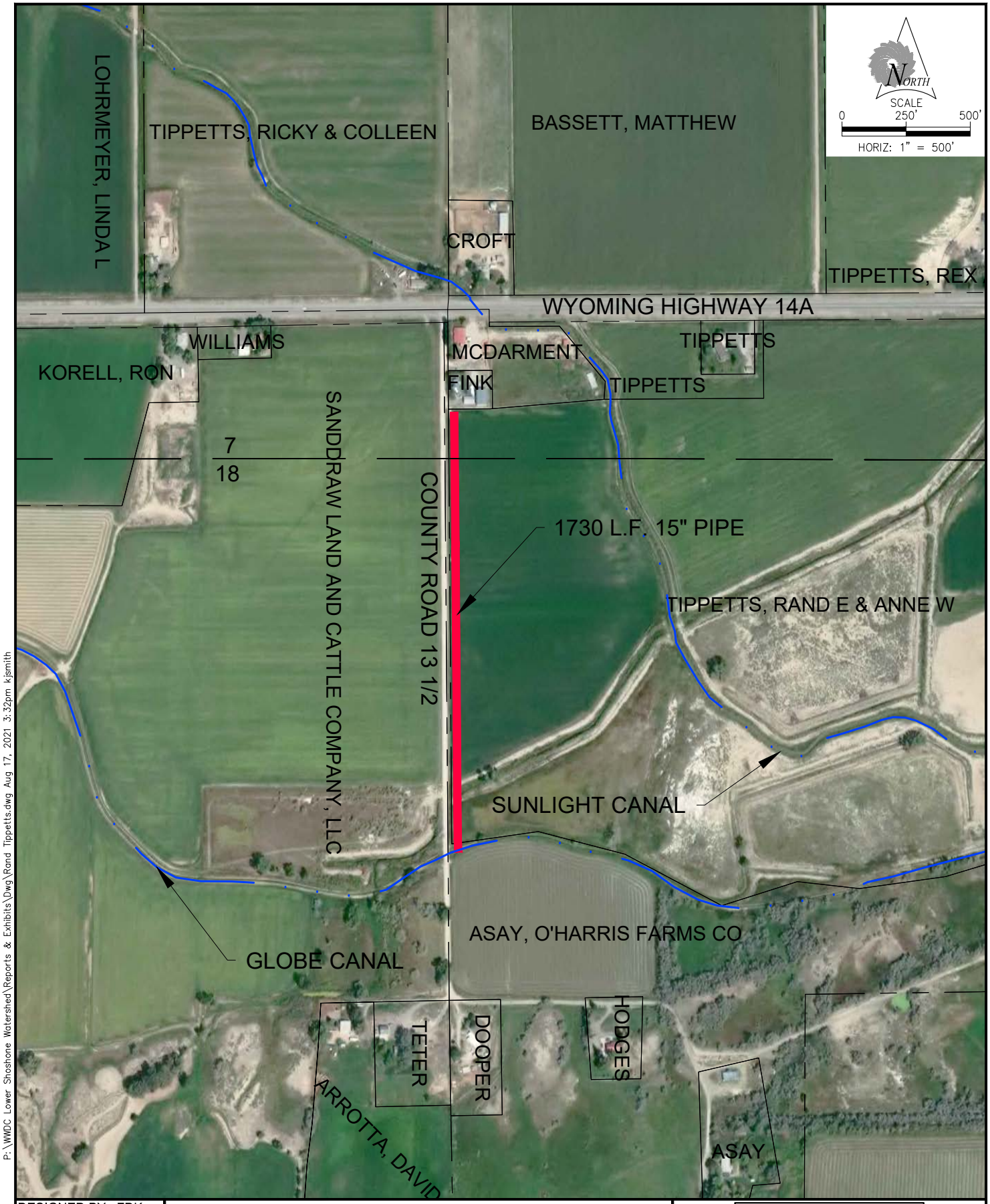
State Engineers Office: No Permitting

Wyoming Office of State Lands: Not applicable.

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Land owners: None



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Rand Tippetts.dwg Aug 17, 2021 3:32pm kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 8/10/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#24 RAND TIPPETTS (BUBBLER GATED PIPE)
LOCATED IN SECTION 7, 18 T56N R95W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 24
Owner/Operator: **Tippetts, Rand**
Site Name:
Type Of Project: Bubbler and Pipe

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	Grade and Smooth Pipe Route	1,730	L.F.	$1.00	$1,730
4	Furnish and Install 15" PIP	1,730	L.F.	$28.00	$48,440
5	Intake Valve	1	L.S.	$700.00	$700
6	Vehicle Crossovers	1	Each	$500.00	$500
7	Install and Raise Headgates	12	Cu.Yd.	$500.00	$6,000
8	Furnish and Install Bubbler	2	Each	$1,400.00	$2,800
9	Trash Rack	1	Each	$500.00	$500
10	Concrete Box for Bubbler	2	Each	$500.00	$1,000
				Total Construction Cost	**$63,670**

INCIDENTAL PROJECT COSTS

Construction Permits	$400
Performance Bond	$700
Insurance	$400
15% O&P	$9,551
Subtotal 1	**$11,051**
Subtotal 2	**$74,721**
Construction Engineering @ 10% of Subtotal #2	$7,472
Subtotal 3	**$82,193**
Contingency @ 15% of Subtotal #3	$12,329
Total Construction Cost	**$94,521**
Preparation of Final Designs and Specifications	$7,562
Permitting @ 5% of Project Cost	$4,726
Legal @ 4% of Project Cost	$3,781
Environmental Study	Fill In
Total Project Cost	**$110,590**

SITE PHOTOS:

Existing headgate

Existing ditch

Existing ditch

Project ID #:	25
Owner/Operator:	**Traylor, Reba**
Site Name:	Reservoir
Type Of Project:	Reservoir
Land Jurisdiction:	Private
Location:	

Project Description

Statement of Purpose and Need: Excavate seasonal reservoir for winter watering of livestock and floodplain mitigation.
Proposed Project: The proposed project is a 0.6 acre surface and 2.1 acre-feet volume reservoir. Water use would require a SW-2 application to change some of existing irrigation water right to reservoir to be used for filling the reservoir. The reservoir is located within the Shoshone River floodplain so a floodplain development permit would be necessary as well.

Permitting Requirements

Big Horn County: Floodplain Development Permit

State Engineers Office: Water Right Application

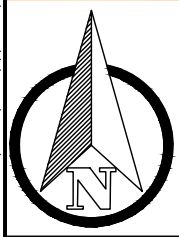
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Not applicable

Army Corps of Engineers: Not applicable

Other Concerns



0' 75' 150' 300'

C:\Users\chad\AppData\Local\Temp\AcPublish_17104\TRAYLOR_Pond.dwg Dec 13, 2021 10:18am chad

DESIGNED BY: CB
DRAWN BY: CB
CHECKED BY: RC
DATE: 9/01/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

REBA TRAYLOR (WINTER WATERING RESERVOIR)
LOCATED IN SECTION 17 T56N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	25
Owner/Operator:	**Traylor, Reba**
Site Name:	Reservoir
Type Of Project:	Reservoir

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$5,000.00	$5,000
2	Pond Excavation	3,444	C.Y.	$12.00	$41,333
3	Furnish and Install Knife Gate Valve	1	Ea	$600.00	$600
4	Remove, Grade and Smooth Abandoned Pipe Route	392	L.F.	$5.00	$1,960
5	Outlet Rip-Rap Splash Pad	2	C.Y.	$125.00	$250
				Total Construction Cost	**$49,143**

INCIDENTAL PROJECT COSTS

Construction Permits	$300
Performance Bond	$500
Insurance	$300
15% O&P	$7,372
Subtotal 1	**$8,472**
Subtotal 2	**$57,615**
Construction Engineering @ 10% of Subtotal #2	
Subtotal 3	**$57,615**
Contingency @ 15% of Subtotal #3	$8,642
Total Construction Cost	**$66,257**
Preparation of Final Designs and Specifications	$6,626
Permitting @ 7% of Project Cost	$4,638
Water Right Change @ 7% of Project Cost	$4,638
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$82,159**

SITE PHOTOS: Reservoir

Project ID #:	26
Owner/Operator:	**Zook, Doug**
Site Name:	Improvements North of House
Type Of Project:	Ditch to Pipe
Land Jurisdiction:	Private
Location:	44.87100N -108.24113W

Project Description

Statement of Purpose and Need: Project will convert ditch to gated and transmission piping thus reducing erosion.
Proposed Project: The proposed project will provide gated and transmission piping to two existing fields previously served by a ditch. The proposed piping will connect to an existing pipe which carries water under the roadway southeast of the house. The gated pipe portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

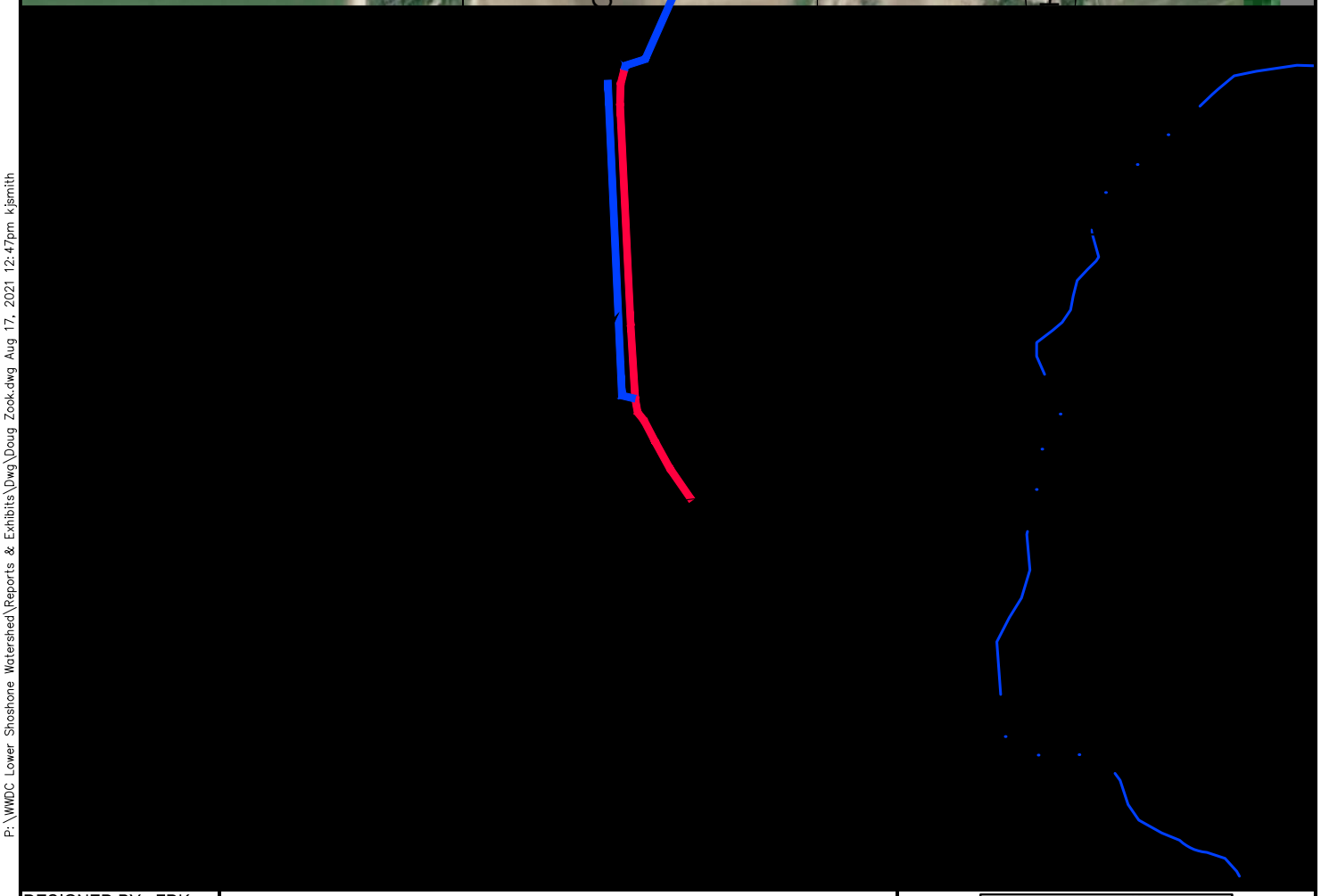
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Doug Zook.dwg Aug 17, 2021 12:47pm kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#26 DOUG ZOOK (BURIED LATERAL & REPLACE DITCHES)
LOCATED IN SECTION 1 & 12, T56N R95W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 26
Owner/Operator: **Zook, Doug**
Site Name: Improvements North of House
Type Of Project: Canal to Pipe

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$4,500.00	$4,500
2	Traffic Control	1	L.S.	$0.00	$0
3	Connect to Existing Pipe	1	Each	$1,500.00	$1,500
4	Furnish and Install 12" Gated Pipe *	2,190	L.F.	$8.00	$17,520
5	Furnish and Install 12" Transfer Pipe	1,310	L.F.	$10.00	$13,100
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$36,620**

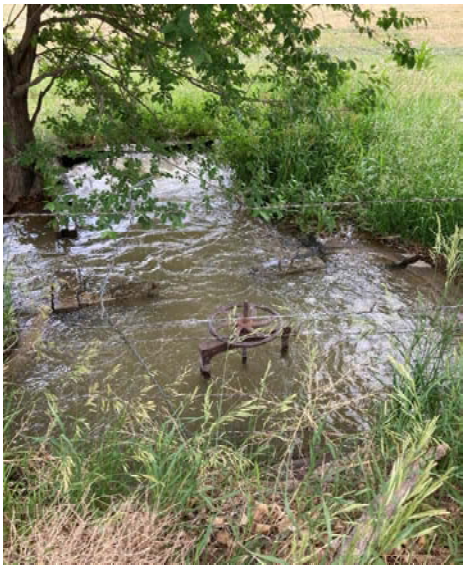
INCIDENTAL PROJECT COSTS

Construction Permits	$200
Performance Bond	$400
Insurance	$200
15% O&P	$5,493
Subtotal 1	**$6,293**
Subtotal 2	**$42,913**
Construction Engineering @ 10% of Subtotal #2	$4,291
Subtotal 3	**$47,204**
Contingency @ 15% of Subtotal #3	$7,081
Total Construction Cost	**$54,285**
Preparation of Final Designs and Specifications	$4,343
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$58,628**

SITE PHOTOS: Improvements North of House

Existing ditch

Existing ditch



Existing headgate

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	28
Owner/Operator:	**Flitner, Greg**
Site Name:	Whistle Creek
Type Of Project:	Water Tanks and Piping
Land Jurisdiction:	Private & BLM
Location:	44.62344N -108.62894W

Project Description

Statement of Purpose and Need: Establish a more reliable source of stock water to an area that is highly susceptible to drought conditions and allow to distribute livestock more efficiently. This is a project for a stock water pipeline that would be very beneficial for livestock as well as the highly concentrated wild horse population. The BLM sounds like they are in favor of it as well.
Proposed Project: The proposed project will include 10.25 miles of pipeline to feed 6 watering tanks.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

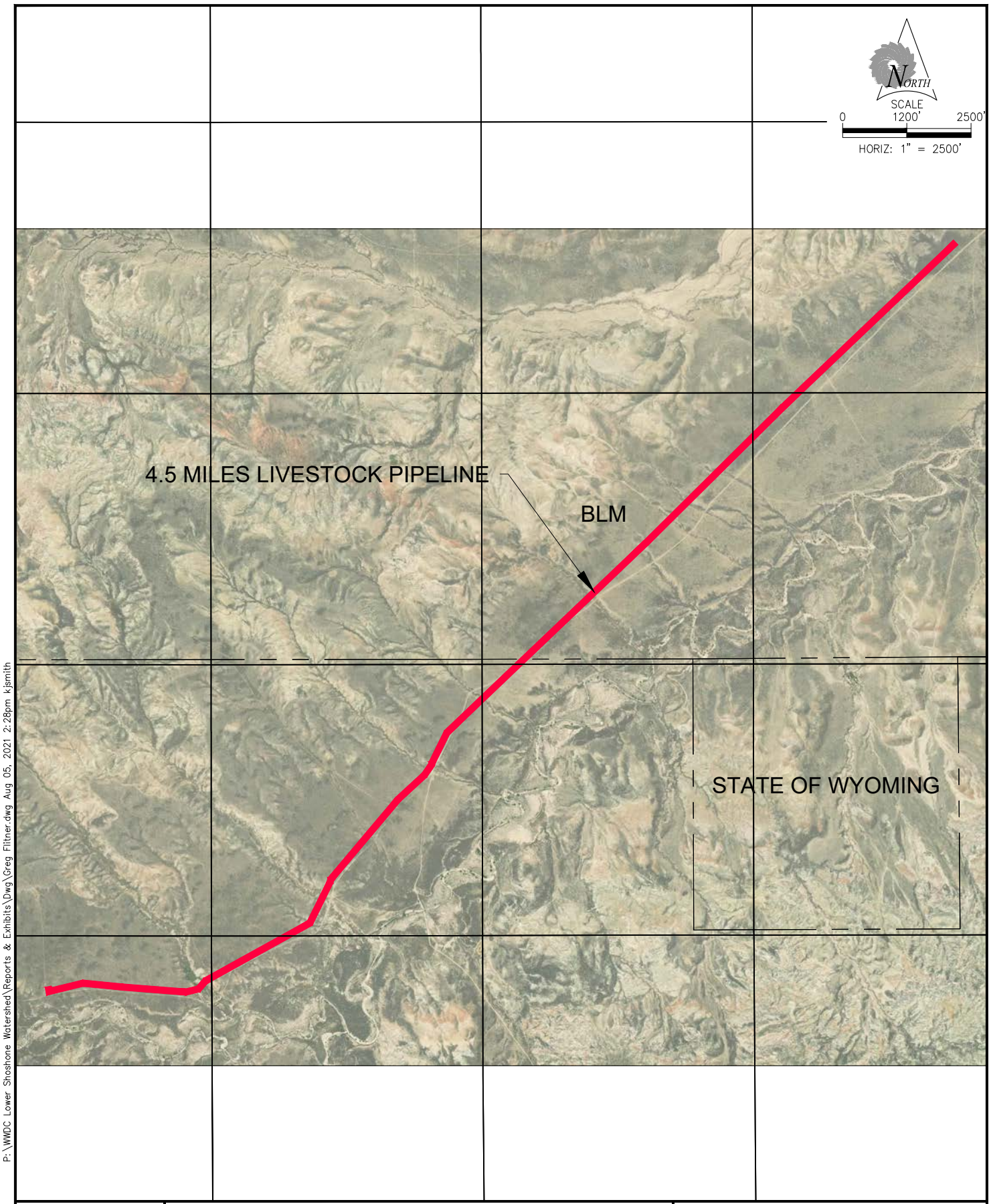
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: The proposed pipe will cross portions of BLM lands and will require BLM approval. Potential Section 7 consultation due to federal lands.

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Greg Flitner.dwg Aug 05, 2021 2:28pm kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
#28 GREG FLITNER (LIVESTOCK PIPELINE)
LOCATED IN SECTION 3 & 4 T53N R98W
LOCATED IN SECTION 24, 25, 26, 34, & 35 T54N R98W
PARK COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	28
Owner/Operator:	**Flitner, Greg**
Site Name:	Whistle Creek
Type Of Project:	Water Tanks and Piping

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	Furnish and Install 2" HDPE Pipe	54,000	L.F.	$6.00	$324,000
4	Pump System	1	LS	$11,000.00	$11,000
5	400 W Solar Panel, Mounts and Pole	1	L.S.	$2,500.00	$2,500
6	Charge Controller and Inverter	1	L.S.	$600.00	$600
7	Storage Tank (5000 gallons)	6	Each	$5,000.00	$30,000
8	Water Trough and Float Controller	6	Each	$2,200.00	$13,200
9	Road Base	30	Cu. Yd.	$40.00	$1,200
				Total Construction Cost	**$384,500**

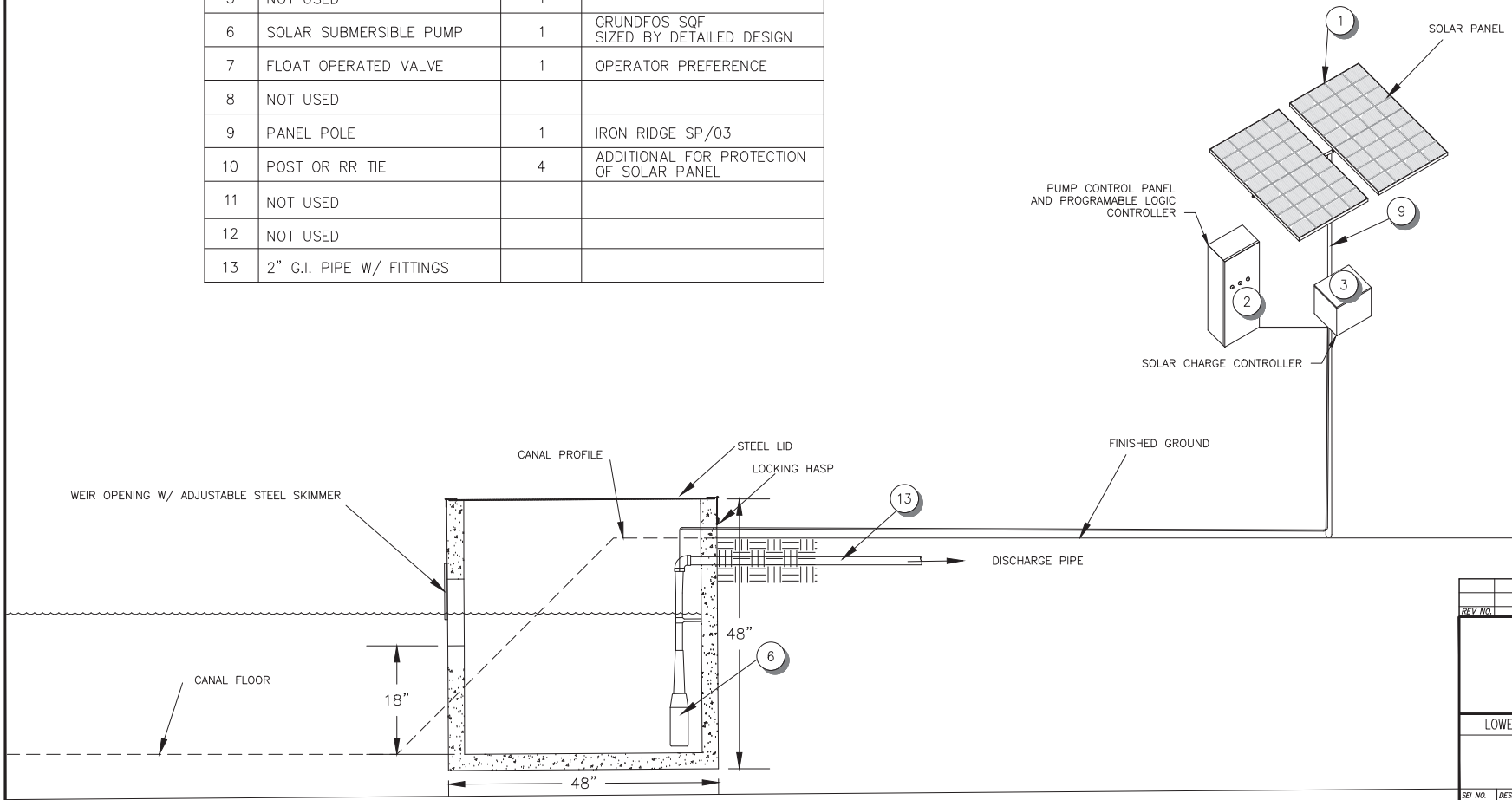
INCIDENTAL PROJECT COSTS

Construction Permits	$2,000
Performance Bond	$3,900
Insurance	$2,000
15% O&P	$57,675
Subtotal 1	**$65,575**
Subtotal 2	**$450,075**
Construction Engineering @ 10% of Subtotal #2	$45,008
Subtotal 3	**$495,083**
Contingency @ 15% of Subtotal #3	$74,262
Total Construction Cost	**$569,345**
Preparation of Final Designs and Specifications	$45,548
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$614,892**

SITE PHOTOS: Whistle Creek

EQUIPMENT SCHEDULE

NO.	DESCRIPTION	SIZE/#	REMARKS
1	SOLAR PANEL		SIZED BY PUMP DEMAND
2	PUMP PANEL CONTROL	1	W/PLC
3	SOLAR CHARGE CONTROLLER	1	BY PANEL MANUFACTURER
5	NOT USED	1	
6	SOLAR SUBMERSIBLE PUMP	1	GRUNDFOS SQF SIZED BY DETAILED DESIGN
7	FLOAT OPERATED VALVE	1	OPERATOR PREFERENCE
8	NOT USED		
9	PANEL POLE	1	IRON RIDGE SP/03
10	POST OR RR TIE	4	ADDITIONAL FOR PROTECTION OF SOLAR PANEL
11	NOT USED		
12	NOT USED		
13	2" G.I. PIPE W/ FITTINGS		



REV NO.	COMMENT	DATE

SUNRISE ENGINEERING
47 EAST 4TH AVENUE
AFTON, WYOMING 83110
TEL 307.885.8500 - FAX 307.885.8501
www.sunrise-eng.com

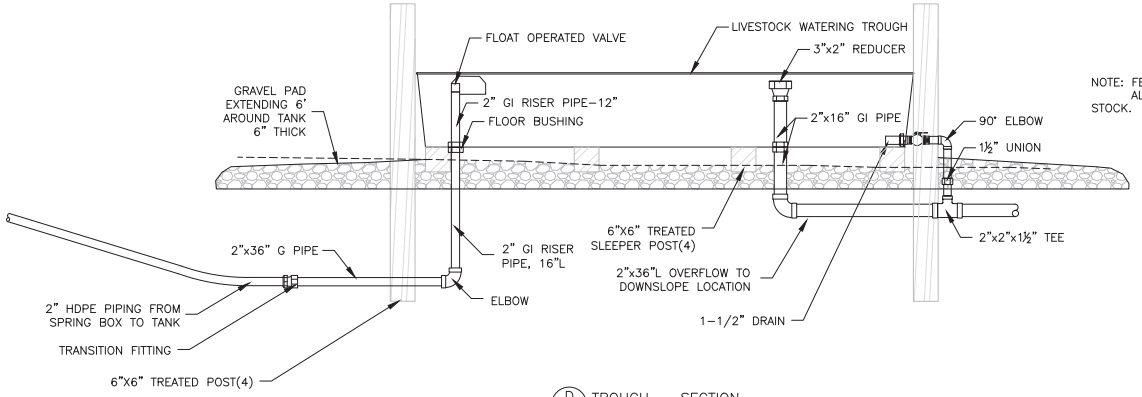
LOWER SHOSHONE WATERSHED STUDY

WEIR AND PUMP

DETAILS

SEI NO.	DESIGNED	DRAWN	CHECKED	SHEET NO.	
07484	FDK	KJS	XXX	1 of 1	D1

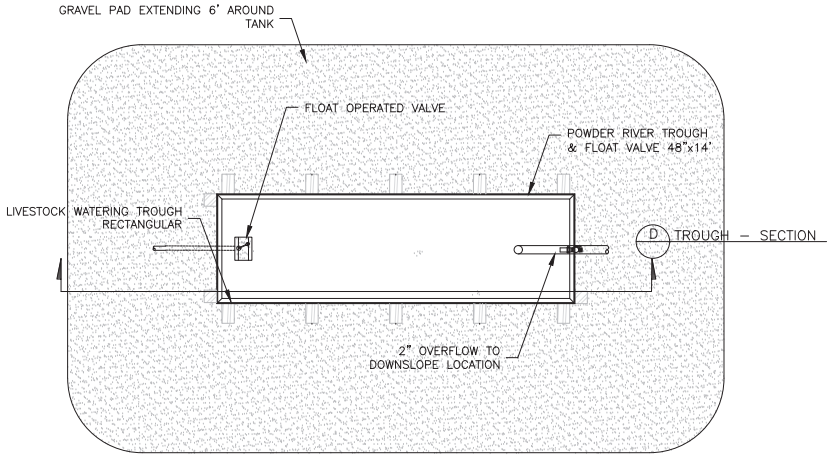
P:\WWDC Lower Shoshone Watershed\Dwg C3D\Sheets\Solar pump in weir.dwg Aug 19, 2021 2:30pm kjsmith



NOTE: FEEDER PANELS ON EACH SIDE OR LONGITUDINAL POLES ALONG CENTER ARE RECOMMENDED TO PREVENT ENTRY BY STOCK.

D TROUGH – SECTION

Trough Miscellaneous Fittings			
Fitting Name	Size	Number	Comments
Floor Bushing with F.I.P Threaded outlet	2"	1	May also install through wall
Wall Bushing with F.I.P Threaded outlet	1-1/2"	1	
Compression Coupling IPS PE x F.I.P.	2"	1	
90 deg ell	2"	2	
90 deg ell	1-1/2"	1	
Pipe Nipple	36"L x 2"	2	
Pipe Nipple	12"L x 2"	1	
Pipe Nipple	16"L x 2"	3	
Pipe Nipple	2"L x 1-1/2"	2	
Pipe Nipple	8"L x 1-1/2"	2	
Tee G.I.	2"x2" x1-1/2"	1	
Reducer	3" x 2"	1	Overflow inlet
Pipe Union	1-1/2"	1	On Drain Pipe
Ball Valve	1-1/2"	1	
Float Operated Valve			Provided by Trough Supplier
RR Tie	8'	9	



D TROUGH – PLAN VIEW

REV NO.	COMMENT	DATE

SUNRISE ENGINEERING
47 EAST 4TH AVENUE
AFTON, WYOMING 83110
TEL 307.885.8500 · FAX 307.885.8501
www.sunrise-eng.com

LOWER SHOSHONE WATERSHED STUDY

TYPICAL TROUGH DETAILS

SEI NO.	DESIGNED	DRAWN	CHECKED	SHEET NO.	
07484	FDK	KJS	XXX	2 of 2	D2

C:\Users\dkemington\appdata\local\temp\AcPublish_20320\Typical Spring development.dwg Sep 02, 2021 2:40pm dkemington

Project ID #:	32
Owner/Operator:	**Merril, Keri**
Site Name:	
Type Of Project:	Irrigation Improvements
Land Jurisdiction:	Private
Location:	44.96223N -108.60396W

Project Description

Statement of Purpose and Need: Current irrigation system takes a long time to irrigate and wastes water heavily. Old pipe and the inability to close the pipe system cause the irrigation system to have very low pressure and ditches create heavy water loss.
Proposed Project: Replace existing pipe with gated pipe, convert existing ditches to gated pipe. The gated pipe portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

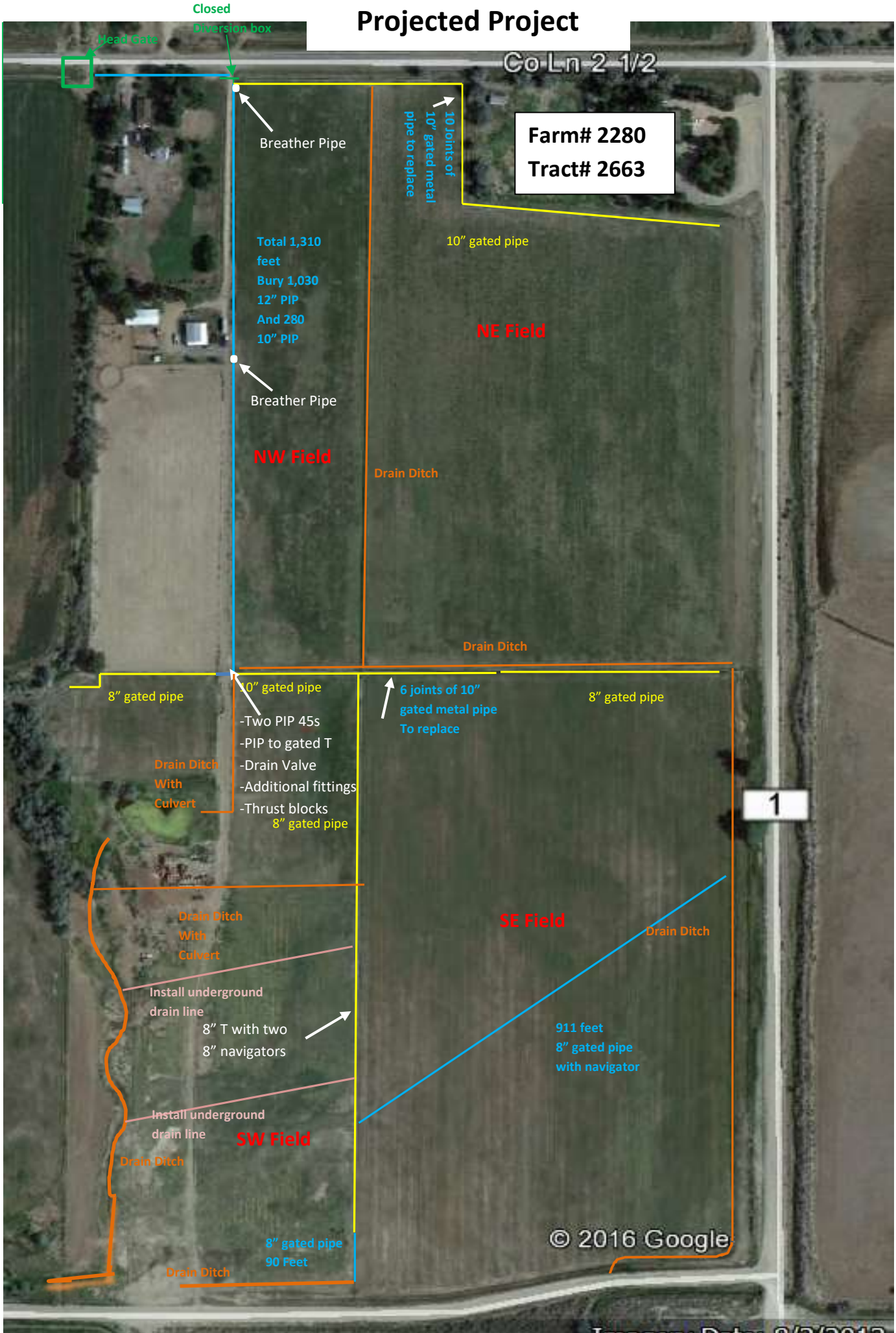
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Land owners: None

Projected Project



Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 32
Owner/Operator: **Merril, Keri**
Site Name:
Type Of Project: Irrigation Improvements

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$750.00	$750
2	Traffic Control	1	L.S.	$0.00	$0
3	Headgate	5	Cu, Yd,.	$500.00	$2,500
4	Install Drain Pipe	640	L.F.	$16.00	$10,240
5	Install 8" Gated Pipe *	2,390	L.F.	$16.00	$38,240
6	Install 10" Gated Pipe *	1,620	L.F.	$17.00	$27,540
7	Install 12" PIP Pipe	1,300	L.F.	$19.00	$24,700
8	install Drain Ditch	650	L.F.	$21.00	$13,650
9	Install Breather Pipe	2	L.F.	$150.00	$300
10	8" Navigators	2	Each	$2,500.00	$5,000
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$122,920**

INCIDENTAL PROJECT COSTS

Construction Permits	$700
Performance Bond	$1,300
Insurance	$700
15% O&P	$18,438
Subtotal 1	**$21,138**
Subtotal 2	**$144,058**
Construction Engineering @ 10% of Subtotal #2	$14,406
Subtotal 3	**$158,464**
Contingency @ 15% of Subtotal #3	$23,770
Total Construction Cost	**$182,233**
Preparation of Final Designs and Specifications	$14,579
Permitting @ 5% of Project Cost	$9,112
Legal @ 4% of Project Cost	$7,289
Environmental Study	Fill In
Total Project Cost	**$213,213**

SITE PHOTOS:

Project ID #:	35	
Owner/Operator:	**Wambeke, Paul**	
Site Name:		
Type Of Project:	Ditch to Pipeline	
Land Jurisdiction:	Private	
Location:	44.89858N	-108.55942W

Project Description

Statement of Purpose and Need: Project will convert ditch to 15-inch pipe thus reducing seepage.
Proposed Project: The proposed project will replace an existing concrete ditch with pipe. The proposed piping will connect to an existing headgate.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

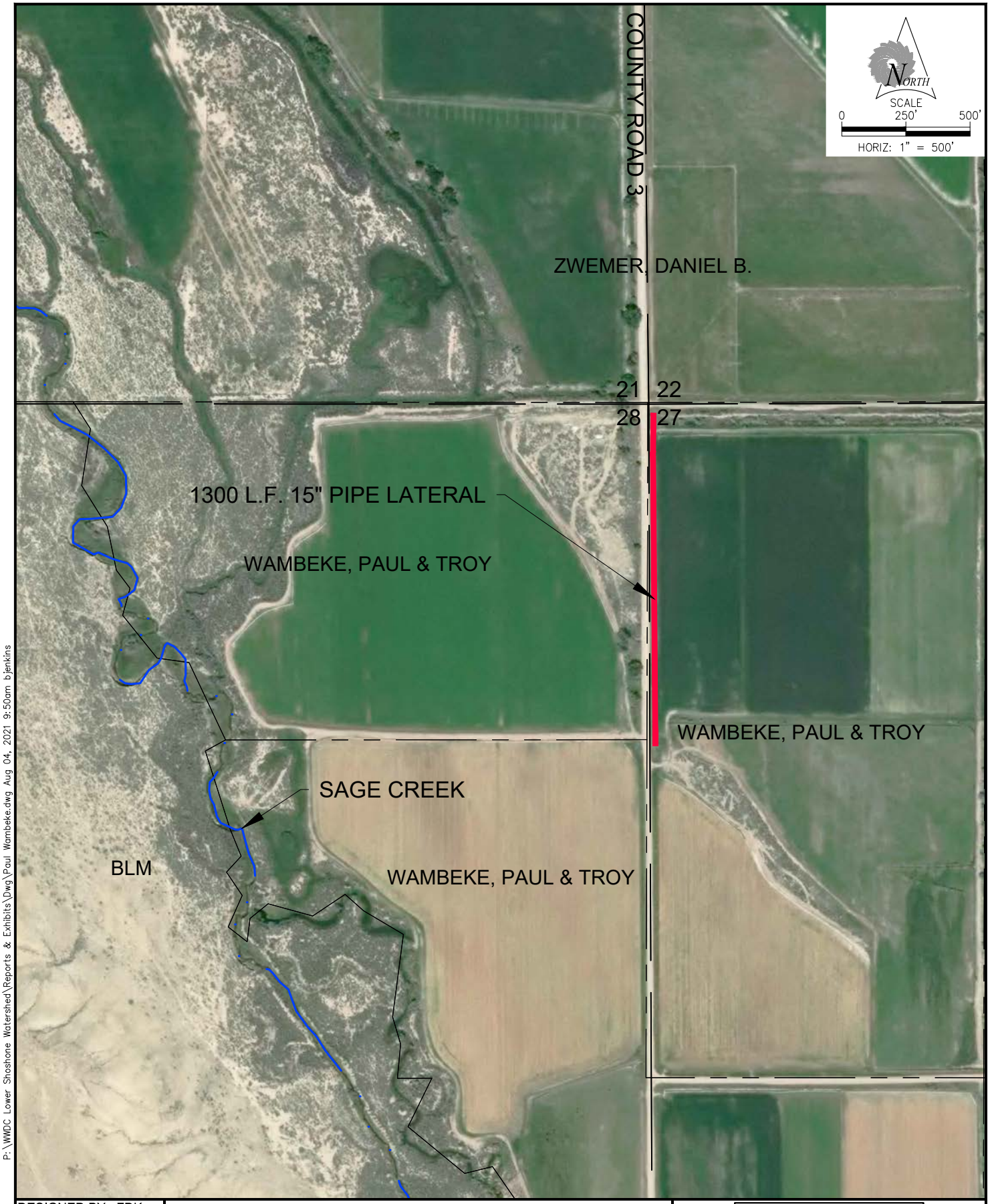
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Paul Wambeke.dwg Aug 04, 2021 9:50am bjenkins

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED LEVEL 1 STUDY

#35 PAUL WAMBEKE (PIPE LATERAL)
LOCATED IN SECTION 27 T57N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 35
Owner/Operator: **Wambeke, Paul**
Site Name:
Type Of Project: Ditch to Pipeline

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$1,000.00	$1,000
2	Traffic Control	1	L.S.	$0.00	$0
3	Connect to Existing Headgate	1	Each	$1,500.00	$1,500
4	Intake Valve	1	L.S.	$700.00	$700
5	Furnish and Install 15" Pipe	1,300	L.F.	$25.00	$32,500
6	Turnout Valve	2	Each	$1,500.00	$3,000
7	Remove and Dispose of Existing Concrete	1,300	L.F.	$8.00	$10,400
				Total Construction Cost	**$49,100**

INCIDENTAL PROJECT COSTS

Construction Permits	$300
Performance Bond	$500
Insurance	$300
15% O&P	$7,365
Subtotal 1	**$8,465**
Subtotal 2	**$57,565**
Construction Engineering @ 10% of Subtotal #2	$5,757
Subtotal 3	**$63,322**
Contingency @ 15% of Subtotal #3	$9,498
Total Construction Cost	**$72,820**
Preparation of Final Designs and Specifications	$5,826
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$78,645**

SITE PHOTOS:

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	36	
Owner/Operator:	**Miller, Bill**	
Site Name:		
Type Of Project:	Pivot	
Land Jurisdiction:	Private	
Location:	44.91060N	-108.47534W

Project Description

Statement of Purpose and Need: Provide pivot irrigation to farm
Proposed Project: The proposed project will include installing pump station, pipe to pivot, pivot sprinklers, pump at canal on north end of parcel. Also, install 12" gated pipe and settling ponds. The center pivot and gated pipe portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Not applicable

Other Land Owners: None

Other Concerns

P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Bill Miller.dwg Aug 23, 2021 2:32pm bjenkins

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
#36 BILL MILLER (CENTER PIVOT)
LOCATED IN SECTION 19,20 T57N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 36
Owner/Operator: **Miller, Bill**
Site Name:
Type Of Project: Pivot

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	12" Gated Water Line to Pivot *	1,810	L.F.	$12.00	$21,720
4	Pump at Canal	1	Each	$10,000.00	$10,000
5	Settling Ponds	5	Cu. Yd	$500.00	$2,500
6	Pivot Sprinkler *	2	Each	$38,000.00	$76,000
7	Pivot Electrical *	1	Each	$5,000.00	$5,000
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$117,220**

INCIDENTAL PROJECT COSTS

Construction Permits	$600
Performance Bond	$1,200
Insurance	$600
15% O&P	$17,583
Subtotal 1	**$19,983**
Subtotal 2	**$137,203**
Construction Engineering @ 10% of Subtotal #2	$13,720
Subtotal 3	**$150,923**
Contingency @ 15% of Subtotal #3	$22,638
Total Construction Cost	**$173,562**
Preparation of Final Designs and Specifications	$13,885
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$187,447**

SITE PHOTOS:

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	37	
Owner/Operator:	**Miller, Bill**	
Site Name:		
Type Of Project:	Ditch to Pipeline	
Land Jurisdiction:	Private	
Location:	44.89445N	-108.46931W

Statement of Purpose and Need: Convert ditch to gated piping thus reducing seepage.
Proposed Project: The proposed project will replace an existing concrete ditch with a gated pipe. The gated pipe portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

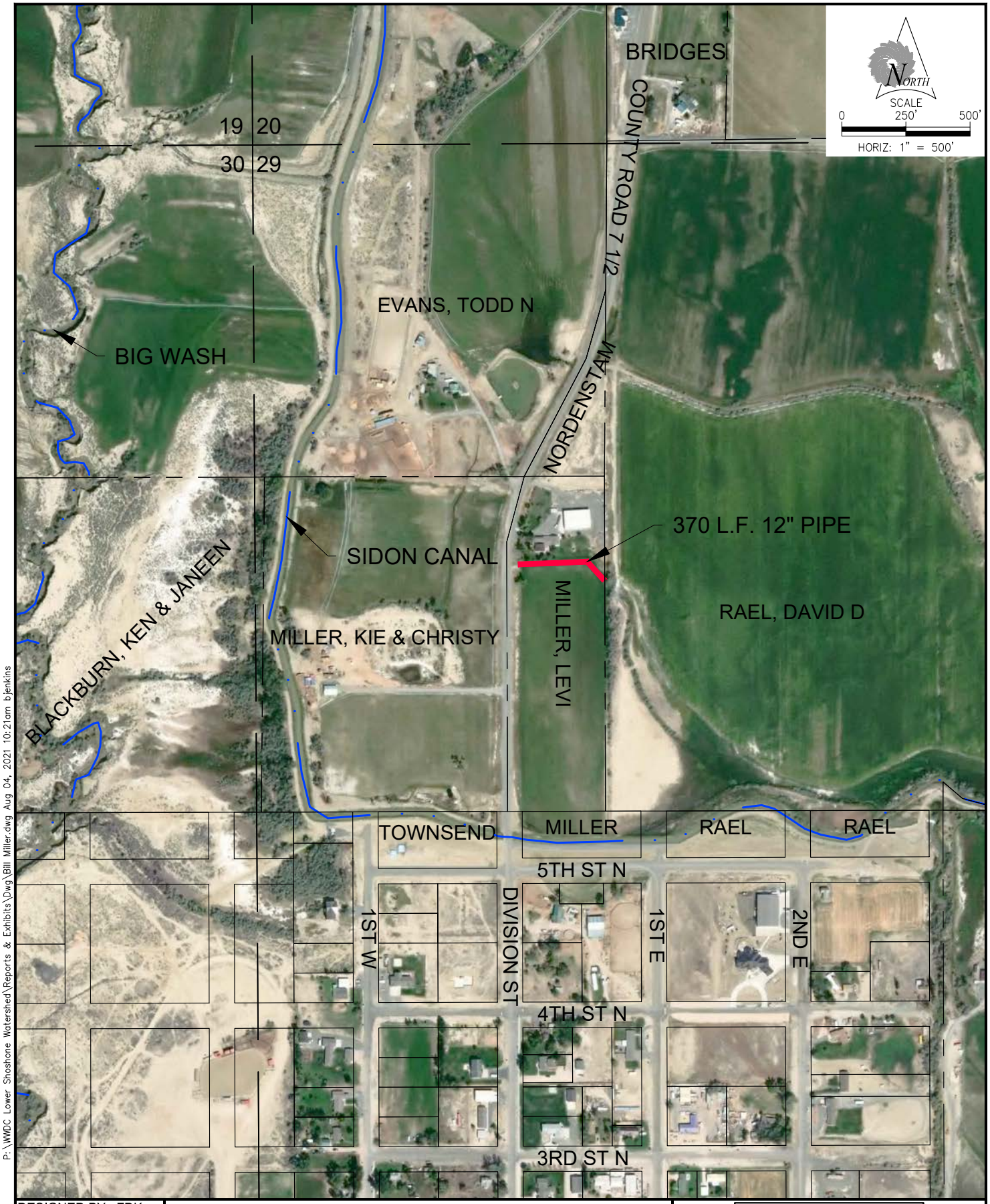
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Bill Miller.dwg Aug 04, 2021 10:21am bjenkins

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#37 BILL MILLER (GATED PIPE LATERAL)
LOCATED IN SECTION 29 T57N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 37
Owner/Operator: **Miller, Bill**
Site Name:
Type Of Project: Ditch to Pipeline

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$500.00	$500
2	Traffic Control	1	L.S.	$0.00	$0
3	Install New Headgate	1	Each	$2,500.00	$2,500
4	Furnish and Install 12" Gated Pipe *	370	L.F.	$8.00	$2,960
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$5,960**

INCIDENTAL PROJECT COSTS

Construction Permits	$100
Performance Bond	$100
Insurance	$100
15% O&P	$894
Subtotal 1	**$1,194**
Subtotal 2	**$7,154**
Construction Engineering @ 10% of Subtotal #2	$715
Subtotal 3	**$7,869**
Contingency @ 15% of Subtotal #3	$1,180
Total Construction Cost	**$9,050**
Preparation of Final Designs and Specifications	$724
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$9,774**

SITE PHOTOS:

Project ID #:	38
Owner/Operator:	**Schwope, Michelle**
Site Name:	
Type Of Project:	Irrigation Improvements
Land Jurisdiction:	Private
Location:	44.89617N 108.52065W

Project Description

Statement of Purpose and Need: Provide pivot irrigation on 40 acres to replace existing gated pipe and ditch irrigation.
Proposed Project: The proposed project will include installing center pivot including source and piping. The center pivot portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

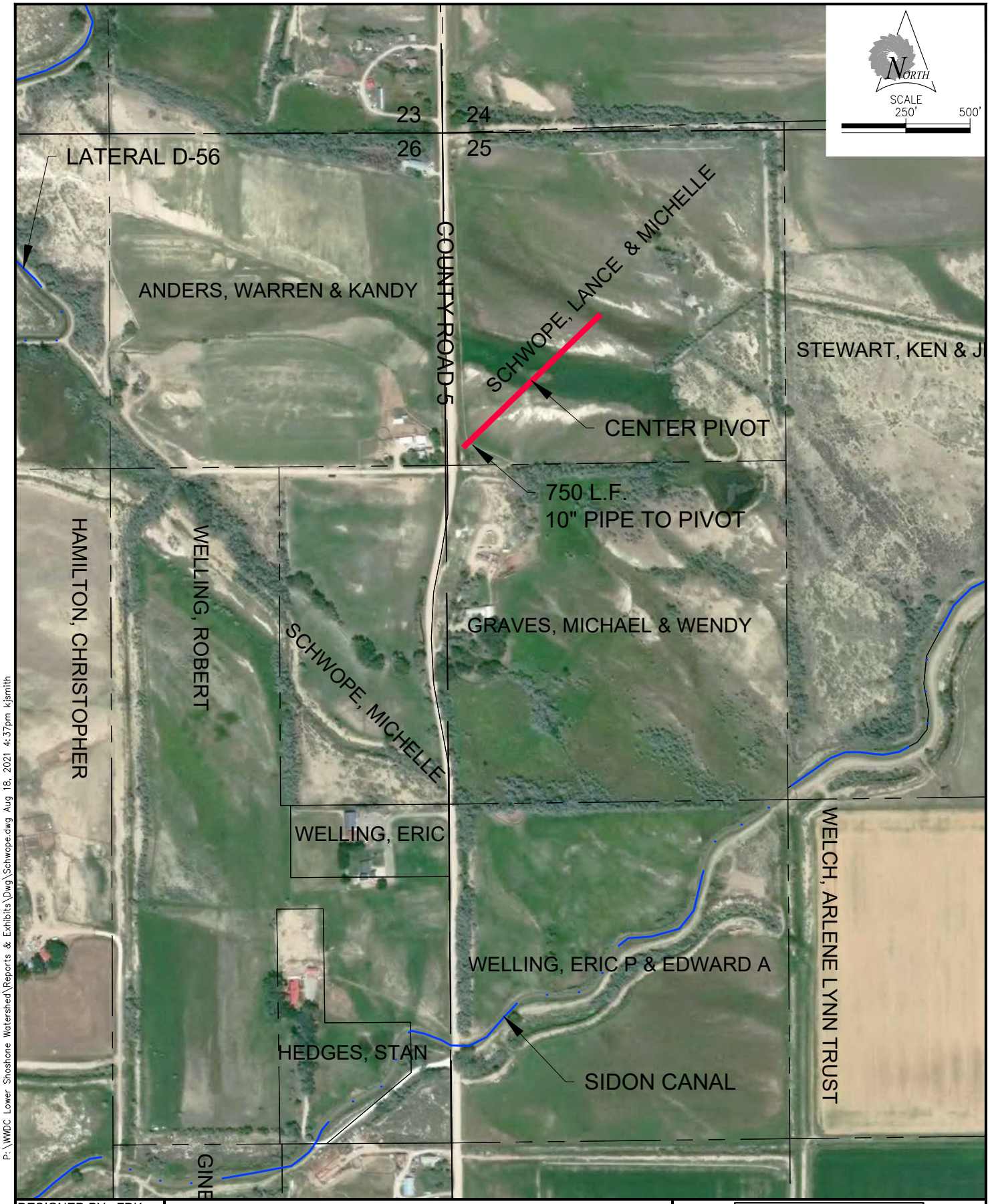
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Schwope.dwg Aug 18, 2021 4:37pm kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#38 MICHELLE SCHWOPE (CENTER PIVOT)
LOCATED IN SECTION 25 T57N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 38
Owner/Operator: **Schwope, Michelle**
Site Name:
Type Of Project: Pivot

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	10" Water Line to Pivot *	750	L.F.	$7.00	$5,250
4	Pump at Canal *	1	Each	$10,000.00	$10,000
5	Pivot Sprinkler *	2	Each	$38,000.00	$76,000
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$93,250**

INCIDENTAL PROJECT COSTS

Construction Permits	$500
Performance Bond	$1,000
Insurance	$500
15% O&P	$13,988
Subtotal 1	**$15,988**
Subtotal 2	**$109,238**
Construction Engineering @ 10% of Subtotal #2	$10,924
Subtotal 3	**$120,161**
Contingency @ 15% of Subtotal #3	$18,024
Total Construction Cost	**$138,185**
Preparation of Final Designs and Specifications	$11,055
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$149,240**

SITE PHOTOS:

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	39	
Owner/Operator:	**Warren, Anders**	
Site Name:		
Type Of Project:	Ditch to Center Pivot	
Land Jurisdiction:	Private	
Location:	44.83221N	-108.36779W

Project Description

Statement of Purpose and Need: Outdated irrigation ditch wastes water and leeches nutrients
Proposed Project: Replace ditch with gated pipe and install two center pivot lines. The center pivot and gated pipe portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable
State Engineers Office: No Permitting
Wyoming Office of State Lands: Not applicable
Wyoming Department of Environmental Quality: Not applicable
Bureau of Land Management: None
Other Land owners: None

P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Warren Anders.dwg Oct 12, 2021 9:13am bjenkins

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#39 WARREN ANDERS (HEADGATE, PIPE LATERAL & PIVOT)
LOCATED IN SECTIONS 13, 14, 23, 24 T56N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	40
Owner/Operator:	**Wambeke, Christopher**
Site Name:	
Type Of Project:	Change Irrigation Source
Land Jurisdiction:	Private
Location:	44.88501N -108.58155W

Project Description

Statement of Purpose and Need: Change source of irrigation water. Water Currently runs through our property and we share the water. Prefer to have water come from the head gate on their place so we can change the way we water our field. To be done in conjunction with Project 75

Proposed Project: The proposed project will change source of an irrigation ditch.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

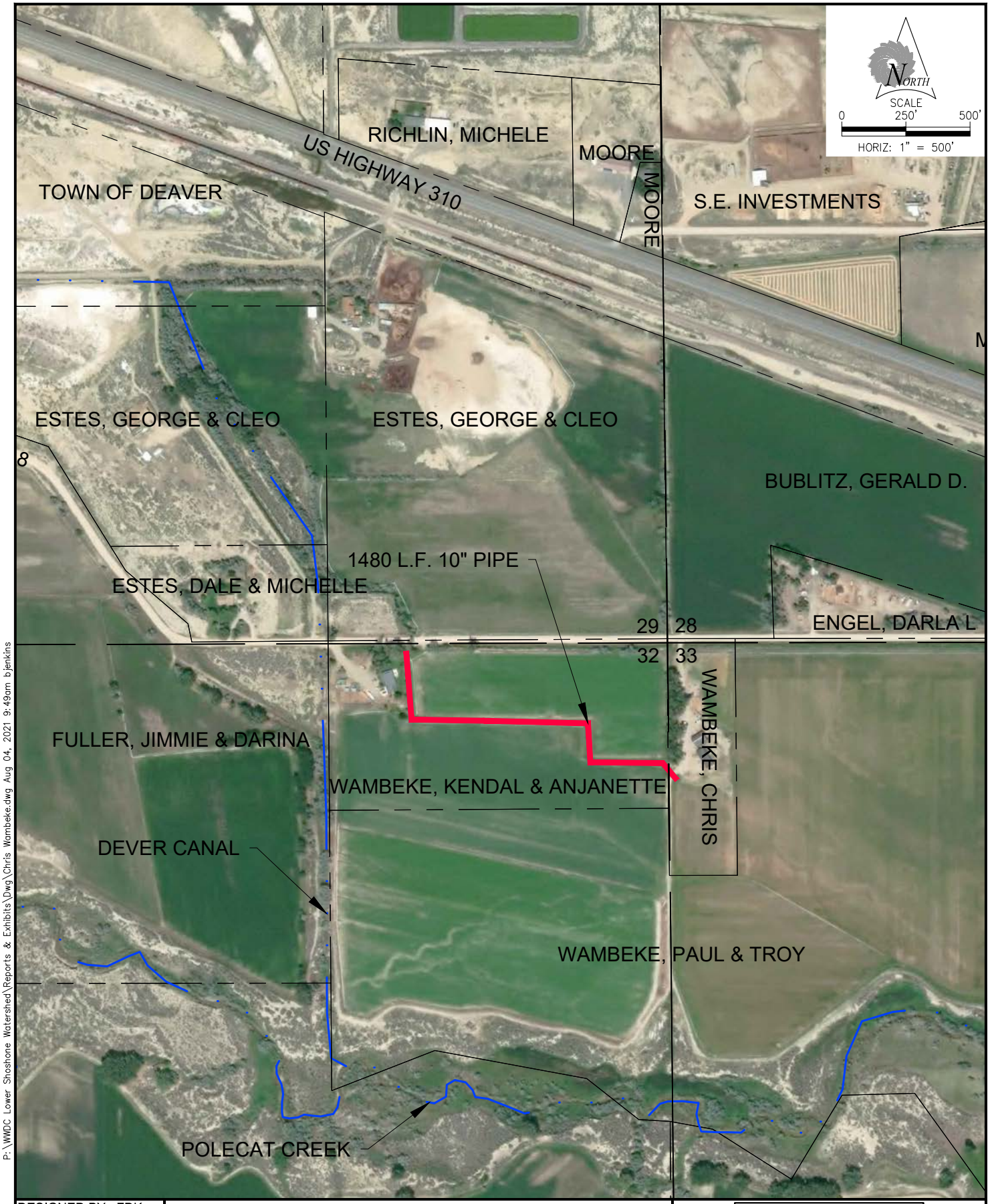
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Chris Wambeke.dwg Aug 04, 2021 9:49am bjenkins

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#40 CHRIS WAMBEKE (PIPE LATERAL)
LOCATED IN SECTION 32 T57N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 40
Owner/Operator: **Wambeke, Christopher**
Site Name:
Type Of Project: Change Irrigation Source

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$500.00	$500
2	Traffic Control	1	L.S.	$0.00	$0
3	Install New Headgate	1	Each	$2,500.00	$2,500
4	Furnish and Install 10" Pipe	1,480	L.F.	$8.00	$11,840
				Total Construction Cost	**$14,840**

INCIDENTAL PROJECT COSTS

Construction Permits	$100
Performance Bond	$200
Insurance	$100
15% O&P	$2,226
Subtotal 1	**$2,626**
Subtotal 2	**$17,466**
Construction Engineering @ 10% of Subtotal #2	$1,747
Subtotal 3	**$19,213**
Contingency @ 15% of Subtotal #3	$2,882
Total Construction Cost	**$22,094**
Preparation of Final Designs and Specifications	$1,768
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$23,862**

SITE PHOTOS:

Project ID #:	41
Owner/Operator:	**Tippetts, Brad**
Site Name:	
Type Of Project:	Solar Pump
Land Jurisdiction:	Private
Location:	

Project Description

Statement of Purpose and Need: Portable or stationary solar pump for winter water for cattle grazing in fields.
Proposed Project: Pump 7-8' of suction head out of existing drains into a trough with outflow back to the drain.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: Well Permit

Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Land Owners: None

Other Concerns

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 41
Owner/Operator: **Tippetts, Brad**
Site Name:
Type Of Project: Solar Pump

ITEMIZED COST ESTIMATE

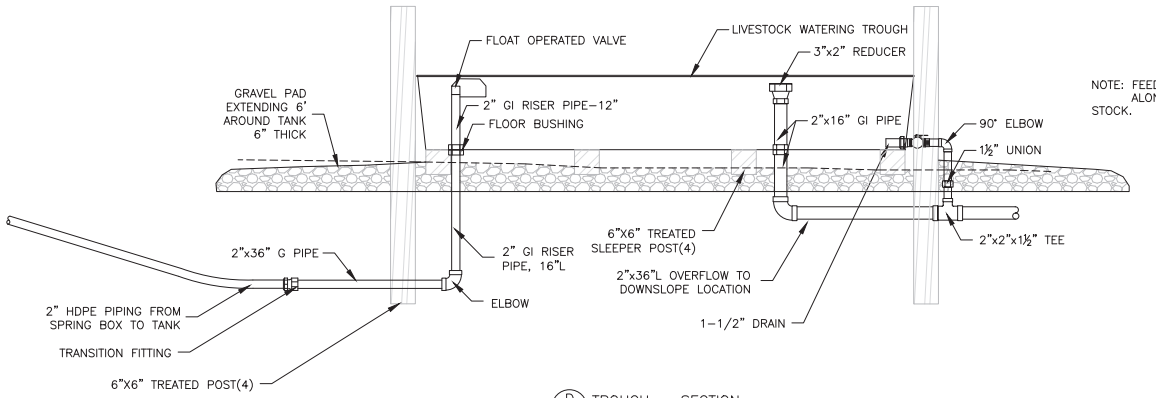
CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$5,000.00	$5,000
2	Pump System	1	LS	$11,000.00	$11,000
3	400 W Solar Panel, Mounts and Pole	1	L.S.	$2,500.00	$2,500
4	Charge Controller and Inverter	1	L.S.	$600.00	$600
5	Storage Tank (5000 gallons)	5,000	Gal.	$2.00	$10,000
6	Water Trough and Float Controller	1	Each	$2,200.00	$2,200
7	2" HDPE Pipe and Fittings	50	LF	$6.00	$300
8	Road Base	5	Yd.	$40.00	$200
				Total Construction Cost	**$31,800**

INCIDENTAL PROJECT COSTS

Construction Permits	$200
Performance Bond	$400
Insurance	$200
15% O&P	$4,770
Subtotal 1	**$5,570**
Subtotal 2	**$37,370**
Construction Engineering @ 10% of Subtotal #2	$3,737
Subtotal 3	**$41,107**
Contingency @ 15% of Subtotal #3	$6,166
Total Construction Cost	**$47,273**
Preparation of Final Designs and Specifications	$3,782
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$51,055**

SITE PHOTOS:

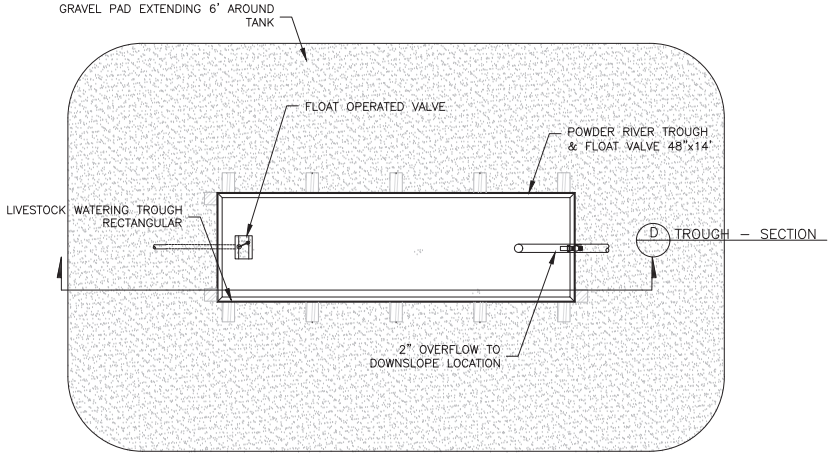


D TROUGH – SECTION

NOTE: FEEDER PANELS ON EACH SIDE OR LONGITUDINAL POLES ALONG CENTER ARE RECOMMENDED TO PREVENT ENTRY BY STOCK.

Trough Miscellaneous Fittings

	Fitting Name	Size	Number	Comments
	Floor Bushing with F.I.P Threaded outlet	2"	1	May also install through wall
	Wall Bushing with F.I.P Threaded outlet	1-1/2"	1	
	Compression Coupling IPS PE x F.I.P.	2"	1	
	90 deg ell	2"	2	
	90 deg ell	1-1/2"	1	
	Pipe Nipple	36"L x 2"	2	
	Pipe Nipple	12"L x 2"	1	
	Pipe Nipple	16"L x 2"	3	
	Pipe Nipple	2"L x 1-1/2"	2	
	Pipe Nipple	8"L x 1-1/2"	2	
	Tee G.I.	2"x2" x1-1/2"	1	
	Reducer	3" x 2"	1	Overflow inlet
	Pipe Union	1-1/2"	1	On Drain Pipe
	Ball Valve	1-1/2"	1	
	Float Operated Valve			Provided by Trough Supplier
	RR Tie	8'	9	



D TROUGH – PLAN VIEW

REV NO.	COMMENT	DATE

SUNRISE ENGINEERING
47 EAST 4TH AVENUE
AFTON, WYOMING 83110
TEL 307.885.8500 - FAX 307.885.8501
www.sunrise-eng.com

LOWER SHOSHONE WATERSHED STUDY

TYPICAL SPRING DEVELOPMENT

DETAILS

SEI NO.	DESIGNED	DRAWN	CHECKED	SHEET NO.	
07484	FDK	KJS	XXX	1 of 2	D1

P:\WWDC Lower Shoshone Watershed\Dwg C3D\Sheets\Typical Spring development.dwg Aug 17, 2021 11:48am kjsmith

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	42	
Owner/Operator:	**Blain, Zachary**	
Site Name:	Despain Gated Pipe	
Type Of Project:	Ditch to Pipe	
Land Jurisdiction:	Private	
Location:	44.81416N	-108.43257W

Project Description

Statement of Purpose and Need: Add gated pipe to water east end of field more efficiently. Currently rows are long so it takes a long time for water to travel the entire length. Transmission from Moncour lateral. Pasture is 35-40 acres with concrete ditch along county road.

Project Description: Run gated pipe 10-12" along center to water east half. Headgate and pipe at fence, gated pipe on east side of powerline. The gated pipe portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

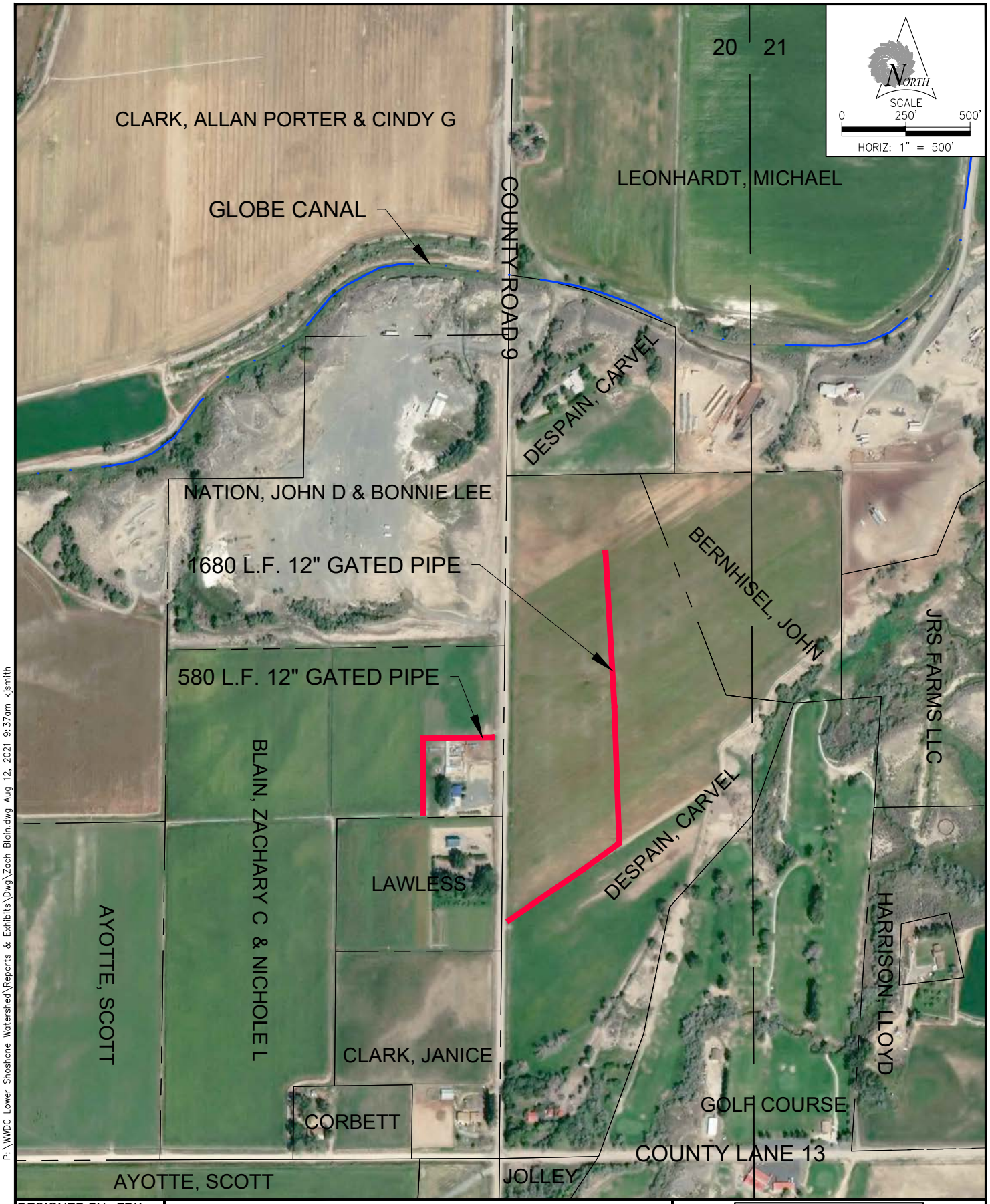
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Zach Blain.dwg Aug 12, 2021 9:37am kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#42 & #79 ZACH BLAIN (BURIED LATERAL & REPLACE DITCHES)
LOCATED IN SECTION 20 T56N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	42
Owner/Operator:	**Zachery, Blain**
Site Name:	Despain Gated Pipe
Type Of Project:	Ditch to Pipe

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$750.00	$750
2	Traffic Control	1	L.S.	$0.00	$0
3	Headgate	5	Cu. Yd.	$500.00	$2,500
4	Furnish and Install 12" Gated Pipe *	1,680	L.F.	$18.00	$30,240
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$33,490**

INCIDENTAL PROJECT COSTS

Construction Permits	$200
Performance Bond	$400
Insurance	$200
15% O&P	$5,024
Subtotal 1	**$5,824**
Subtotal 2	**$39,314**
Construction Engineering @ 10% of Subtotal #2	$3,931
Subtotal 3	**$43,245**
Contingency @ 15% of Subtotal #3	$6,487
Total Construction Cost	**$49,732**
Preparation of Final Designs and Specifications	$3,979
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$53,710**

SITE PHOTOS: Despain Gated Pipe

Project ID #:	43
Owner/Operator:	**Blackburn, Ken**
Site Name:	Sage Creek
Type Of Project:	Reservoir
Land Jurisdiction:	BLM
Location:	44.886067N -108.549793W

Project Description

Statement of Purpose and Need: The Sidon Canal crosses under Sage Creek at this location midway between Deaver and Cowley. During peak flow Sage Creek has created significant bank cuts with walls up to 30 + feet high. Large block type slabs of the bank have been observed collapsing into the creek as the banks are under cut. A dam in this vicinity could be used to reduce peak flows downstream in Sage Creek and reduce the severe bank erosion occurring downstream. Stored water could also be diverted into the Sidon Canal reducing the required flows in the Sidon upstream of this location thereby reducing erosion and sediment in the canal. The project will eliminate significant sediment finding its way to Bighorn Lake.
Proposed Project: The proposed project will construct a medium size dam (35 feet tall x 350 feet long) across Sage Creek downstream of the canal crossing on private ground. The basin will intercept flows in Sage Creek and create conditions conducive to sedimentation when the canal is diverted into and out of the pool area. The inundated pool area will be about 20 acres of private ground.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: Permitting of the dam will be required as well as any diversions or changes in points of diversions. In addition the method of reservoir operations will be a point of interest.

Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Land Owners: The project will impact 20+ acres of private ground. Purchase of the pool area will likely be required.

Other Concerns

Soil Types - The type of soils around the permitter of the proposed project should be reviewed for stability in a constant submerged state.

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	43
Owner/Operator:	**Blackburn, Ken**
Site Name:	Sage Creek
Type Of Project:	Reservoir

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$50,000.00	$50,000
2	Traffic Control	1	L.S.	$2,000.00	$2,000
3	Clearing and Grubbing Footprint of Dam and Pool Area	30	Acres	$1,000.00	$30,000
4	Excavation of Core Trench	1,500	C.Y.	$12.00	$18,000
5	Install 60" Low Level Outlet Pipe	200.0	L.F.	$400.00	$80,000
6	Low Level Valve	1.0	L.S.	$30,000.00	$30,000
7	Core Placement	5,800	C.Y.	$25.00	$145,000
8	Canal Inlet Structure to Reservoir	1	L.S.	$30,000.00	$30,000
9	Reservoir Outlet to Canal	1	L.S.	$40,000.00	$40,000
10	Mis Rip Rap	200	C.Y.	$80.00	$16,000
				Total Construction Cost	**$441,000**

INCIDENTAL PROJECT COSTS

Construction Permits	$2,300
Performance Bond	$4,500
Insurance	$2,300
15% O&P	$66,150
Subtotal 1	**$75,250**
Subtotal 2	**$516,250**
Construction Engineering @ 10% of Subtotal #2	$51,625
Subtotal 3	**$567,875**
Contingency @ 15% of Subtotal #3	$85,181
Total Construction Cost	**$653,056**
Preparation of Final Designs and Specifications	$52,245
Permitting @ 5% of Project Cost	$32,653
Legal @ 4% of Project Cost	$26,122
Land Purchase	$70,000
Environmental Study	$40,000
Total Project Cost	**$874,076**

Project ID #:	44
Owner/Operator:	**Blackburn, Ken**
Site Name:	
Type Of Project:	Piped Diversion Lateral (From Sidon Canal)
Land Jurisdiction:	Private
Location:	44.85764N -108.47888W

Project Description

Statement of Purpose and Need: The Sidon Canal experiences significant erosion and losses due to the volume of water that must circumvent the basin in which the Town of Cowley is located. Much of this water is then delivered to fields on the east side of Sage Creek south of Cowley. By eliminating this volume of water that circumvents the Sage Creek Basin, bank maintenance, excess seepage and lower breach risk this project will improve reliability and improve water efficiency and reduce maintenance efforts.
Proposed Project: The proposed project will install a 10,260 foot 30" piped lateral to deliver flow to approximately 2,000 acres south of Cowley before the water must circumvent the basin.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

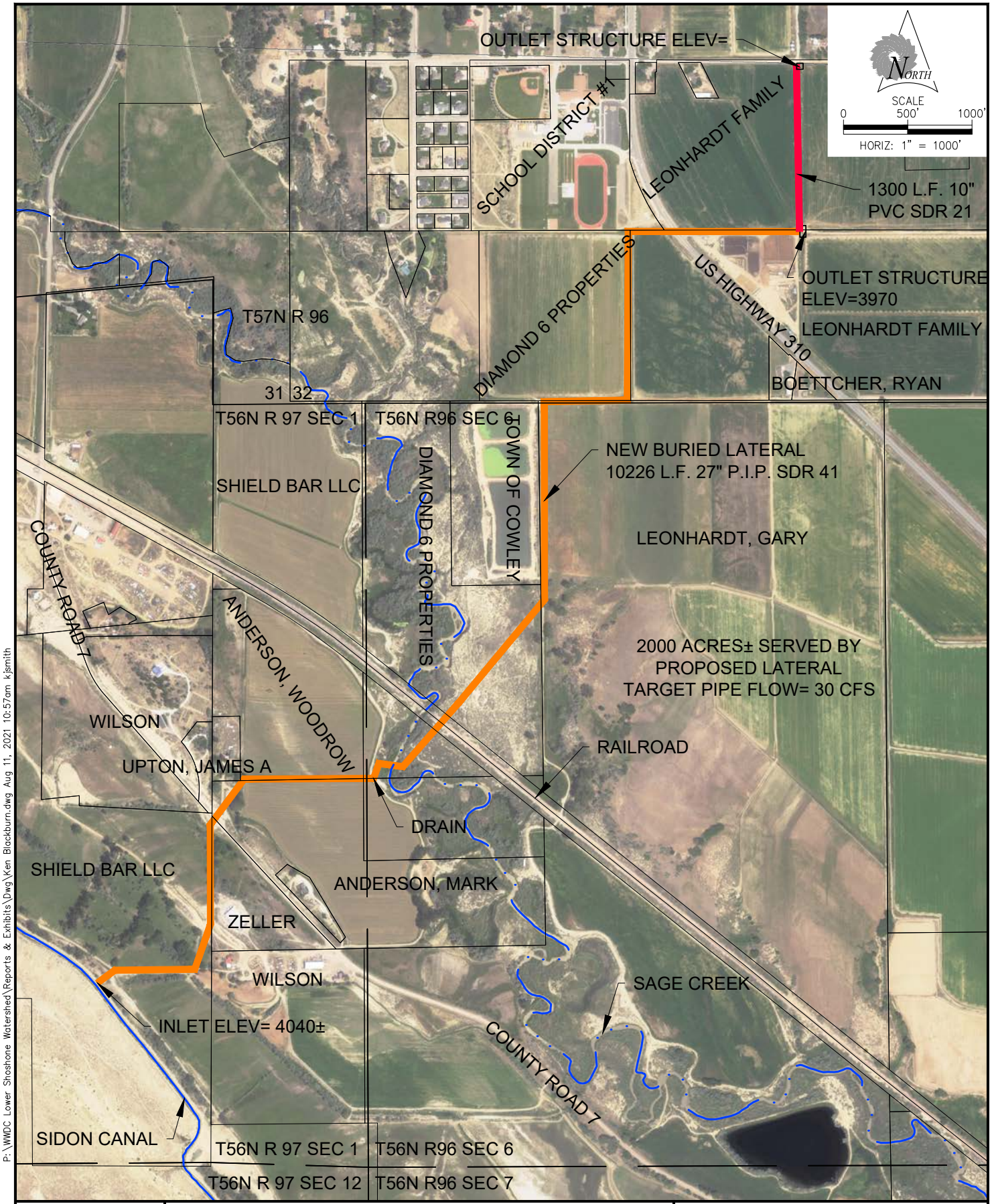
State Engineers Office:

Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Not applicable

Other Land Owners: Project crosses several other landowners and will require easement acquisition and agreement on intermediate delivery points. In addition, the project crosses county roads and runs in County Rights of Way and will require permitting by the County.



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Ken Blackburn.dwg Aug 11, 2021 10:57am kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 10/15/2020
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

44 KEN BLACKBURN (BURIED LATERAL)
LOCATED IN SECTION 32, T57N R96W,
SECTION 6, T56N R96, SECTION 1, T56N R97
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 44
Owner/Operator: **Blackburn, Ken**
Site Name: 0
Type Of Project: Piped Diversion Lateral (From Sidon Canal)

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$85,000.00	$85,000
2	Traffic Control	1	L.S.	$25,000.00	$25,000
3	Clearing and Grubbing Alignment	1	L.S.	$1,500.00	$1,500
4	Install Main Diversion on Sidon Canal	1.0	L.S.	$25,000.00	$25,000
5	Furnish and Install 27-inch PVC P.I.P. Pipe DR 41	10,300.0	L.F.	$125.00	$1,287,500
6	Sage Creek Crossing	1.0	L.S.	$15,000.00	$15,000
7	Bore and Jack Highway 7 Crossing	50.0	L.F.	$600.00	$30,000
8	Bore and Jack Railroad Crossing	50.0	L.F.	$700.00	$35,000
9	Bore and Jack Highway 789 Crossing	100.0	L.F.	$600.00	$60,000
10	Install 15-inch PVC P.E.P. SDR 41	1,300.0	L.F.	$35.00	$45,500
11	Install 12" Drain and Valve at Sage Creek	1	L.S.	$5,500.00	$5,500
12	Furnish and Install PVC TEE and Delivery Riser	5	Each	$3,500.00	$17,500
13	Furnish and Install Knife Gate Valve	5	Each	$600.00	$3,000
14	Outlet Splitter Structure	1	L.S.	$25,000.00	$25,000
15					$0
16	Construction Permits				$8,400
17	Performance Bond				$16,700
18	Insurance				$8,400
19	15% O&P				$249,075
20					$0
21					$0
				Cost of Project Components Total (Subtotal 1)	**$1,943,075**

Construction Engineering Cost (subtotal #1 x 10%)	$194,308
Components + Construction Engineering Costs (Subtotal #2)	**$2,137,383**
Contingency (subtotal #2 x 15%)	$320,607
Construction Cost Total (subtotal #2 + Contingency)(Subtotal #3)	**$2,457,990**

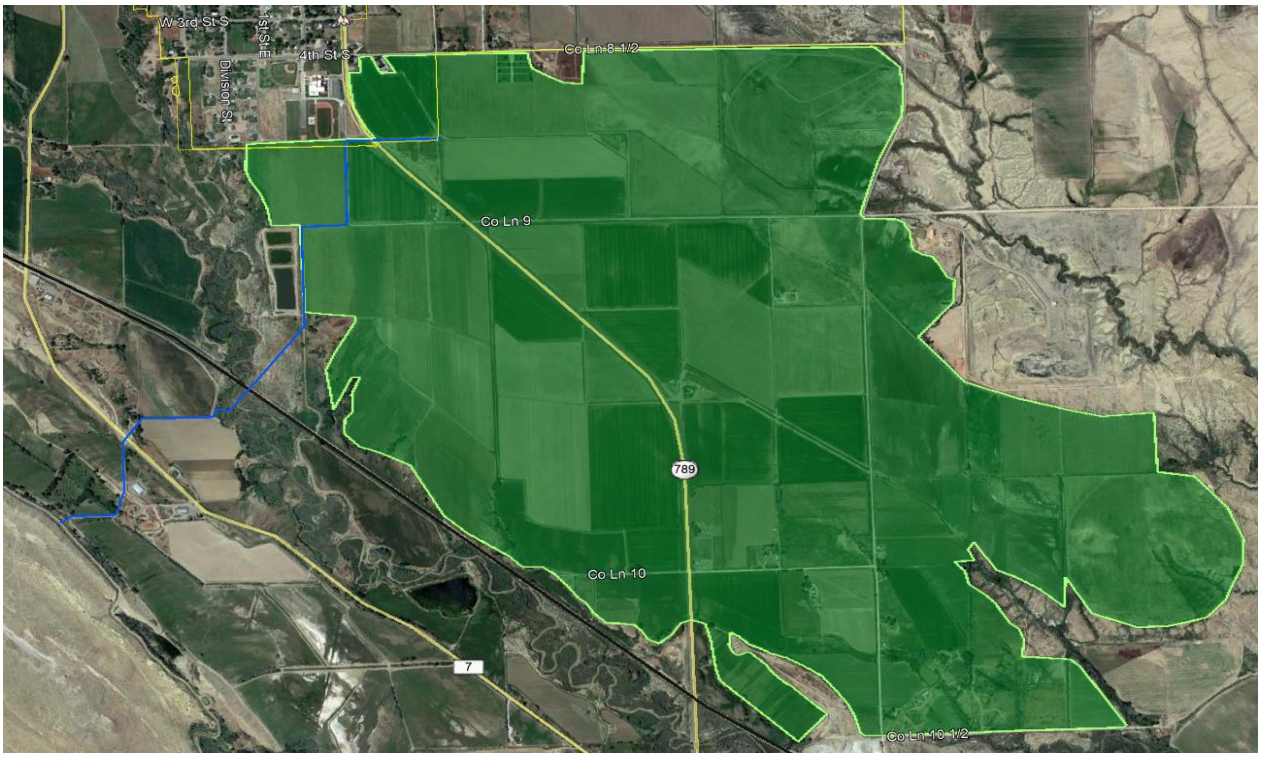
PRE-CONSTUCTION COSTS

Preparation of Final Designs and Specifications (subtotal #1 x 10%)	$194,308
Permitting @ 5% of Project Cost	$122,899
Legal @ 4% of Project Cost	$98,320
Acqusition of Access and Rights of Way	$40,000
Pre Constrution Costs Total (Subtotal #4)	**$455,527**

TOTAL WWDC ELIGIBLE PROJECT COST

Total WWDC Eligible Project Cost (subtoal #3 + subtoal #4) (Subtotal #5)	**$2,913,516**

SITE PHOTOS:



Irrigated Lands (green) and proposed pipeline (blue)

Project ID #:	45
Owner/Operator:	**Blackburn, Ken**
Site Name:	BLM
Type Of Project:	Sedimentation Basin
Land Jurisdiction:	BLM
Location:	44.897628N -108.447614W

Project Description

Statement of Purpose and Need: The Sidon Canal experiences significant erosion and bank losses due to the volume of water carried. In addition, during certain seasons the main river diversion brings in sediment. The entrained sediments settle at headgates, control structures, and the point of application on the fields creating increased maintenance efforts and adjustment of operations to accommodate sediment buildup.
Proposed Project: The proposed project will construct a small one acre sedimentation basin in a draw located on BLM lands east of Cowley. The basin will slow flow and create conditions conducive to sedimentation. Sediments collected can then be removed from this concentrated point and stockpiled on-site. The height of the embankment is estimated at seven feet and the length at 430 feet.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office:

Wyoming Office of State Lands: Not applicable

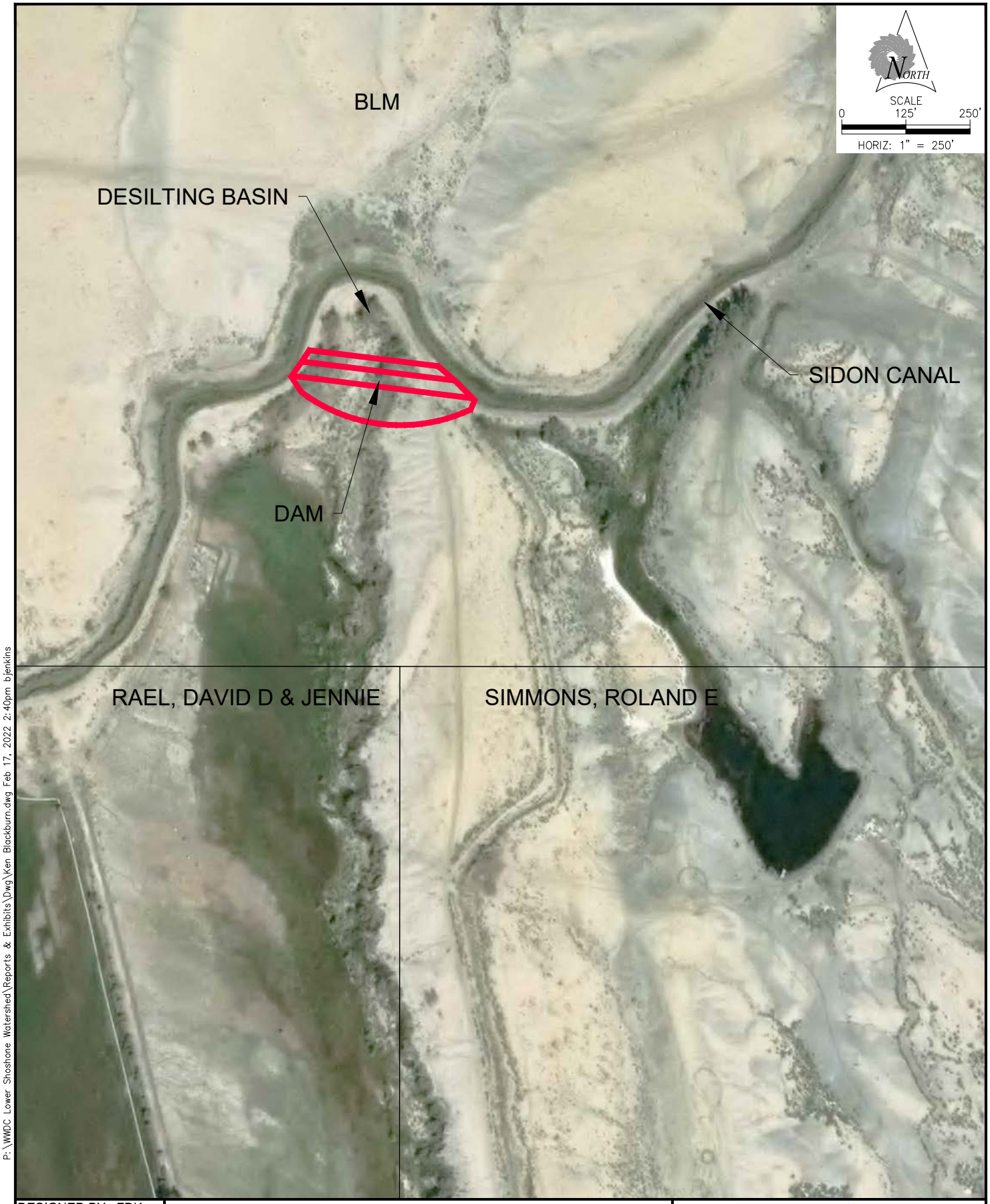
Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Full permitting authorization is required for both the pond area and the sediment stockpile area. Potential Section 7 consultation due to federal lands.

Other Land Owners: The project will not impact adjacent private ground.

Other Concerns

Soil Types - The type of soils around the permitter of the proposed project should be reviewed for stability in a constant submerged state.



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Ken Blackburn.dwg Feb 17, 2022 2:40pm bjenkins

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 2/17/2022
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
45 KEN BLACKBURN (DESILTING BASIN)
LOCATED IN SECTION 28, T57N R96W,
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	45
Owner/Operator:	**Blackburn, Ken**
Site Name:	BLM
Type Of Project:	Sedimentation Basin

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$3,500.00	$3,500
2	Traffic Control	1	L.S.	$0.00	$0
3	Clearing and Grubbing Alignment	1	L.S.	$1,500.00	$1,500
4	Embankment Construction	3,470	C.Y.	$12.00	$41,640
5	Install 10" Drain Pipe	50.0	L.F.	$20.00	$1,000
6	Install Drain Gate Valve	1.0	L.S.	$1,500.00	$1,500
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
				Total Construction Cost	**$49,140**

INCIDENTAL PROJECT COSTS

Construction Permits	$300
Performance Bond	$500
Insurance	$300
15% O&P	$7,371
Subtotal 1	**$8,471**
Subtotal 2	**$57,611**
Construction Engineering @ 10% of Subtotal #2	$5,761
Subtotal 3	**$63,372**
Contingency @ 15% of Subtotal #3	$9,506
Total Construction Cost	**$72,878**
Preparation of Final Designs and Specifications	$5,830
Permitting @ 5% of Project Cost	$3,644
Legal @ 4% of Project Cost	$2,915
Environmental Study	Fill In
Total Project Cost	**$85,267**

Project ID #:	47
Owner/Operator:	**Leithead, Vance**
Site Name:	Sand Draw Erosion Control
Type Of Project:	Bank Stability
Land Jurisdiction:	Mixed Public & Private
Location:	

Project Description

Statement of Purpose and Need: Stabilize approximately 136 feet of actively eroding bank to reduce sediment input into Sand Draw and Shoshone River and preserve existing agricultural land.
Proposed Project: The proposed project is a channel realignment and bioengineered bank treatment of total length 136 feet including channel excavation, channel backfill, bank grading, armored rock toe, and riparian cutting plantings.

Permitting Requirements

Big Horn County: Floodplain Development Permit

State Engineers Office: Not applicable

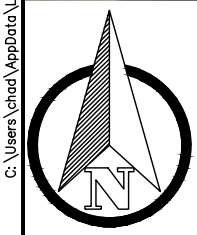
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: 401 Water Quality Certification

Bureau of Land Management: Not applicable

Army Corps of Engineers: 404 permit

Other Concerns



0' 50' 100' 200'

C:\Users\chad\AppData\Local\Temp\AcPublish_17504\LEITHEAD.dwg Aug 31, 2021 2:06pm chad

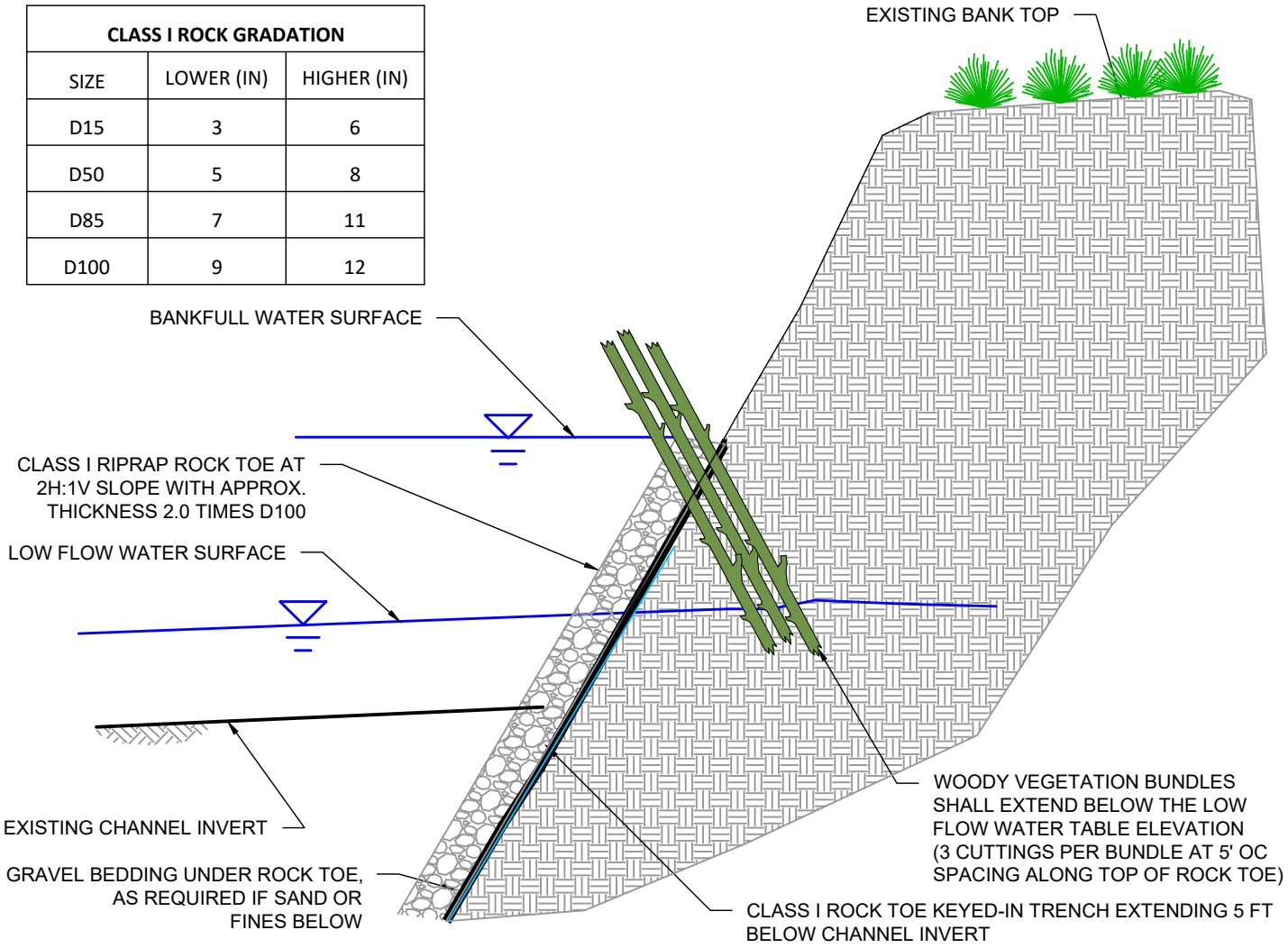
DESIGNED BY: CB
DRAWN BY: CB
CHECKED BY: RC
DATE: 8/30/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

VANCE LEITHEAD (SAND DRAW EROSION CONTROL)
LOCATED IN SECTION 24 T56N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

CLASS I ROCK GRADATION		
SIZE	LOWER (IN)	HIGHER (IN)
D15	3	6
D50	5	8
D85	7	11
D100	9	12



ROCK TOE - SECTION VIEW

NTS

ROCK TOE CONSTRUCTION NOTES:

1. INSTALL TEMPORARY COFFERDAM TO ISOLATE WORK AREA, IF NECESSARY. COFFERDAM METHOD TO BE PROPOSED BY THE CONTRACTOR AND APPROVED BY THE OWNER.
2. CONSTRUCT THE ROCK TOE AND BIOENGINEERING BANK STABILIZATION TREATMENTS ALONG SHOSHONE RIVER.
3. THE BANK AND ROCK TOE SHOULD HAVE A SLOPE OF 2H:1V STARTING AT THE EXISTING TOE AND SLOPING UPWARDS.
4. TOE ROCK SHALL BE HARD, DURABLE, SUB-ROUNDED TO ANGULAR IN SHAPE, RESISTANT TO WEATHERING TO WATER AND ICE ACTION; FREE OF EXCESS AMOUNTS OF THIN FLAT, AND ELONGATED PIECES, FREE FROM OVERBURDEN, SPOIL, SHALE, STRUCTURAL DEFECTS, AND ORGANIC MATERIAL. THE SMALLER STONE SHALL BE UNIFORMLY DISTRIBUTED THROUGHOUT THE WORK. THE ROCK SHALL BE MANIPULATED BY HAND OR MACHINE METHODS SUFFICIENTLY TO SECURE A UNIFORM SURFACE AND MASS STABILITY. ROCK SHALL BE SOURCED FROM LOCALLY AVAILABLE COARSE MATERIAL.
5. STRUCTURE SHALL BE KEYED-IN A TRENCH EXTENDING BELOW THE SCOUR DEPTH.
6. ADD GRAVEL BEDDING FOR SETTING ROCK, AS NEEDED.
7. PLACE GRAVEL FILTER BEHIND ROCK TOE, IF NECESSARY, BETWEEN RIPRAP AND NATIVE MATERIAL. FILTER SHALL BE SPREAD IMMEDIATELY AHEAD OF THE ROCK PLACEMENT.
8. PLACEMENT OF ROCK RIPRAP SHALL START AT THE TOE OF THE SLOPE AND PROCEED UP THE SLOPE. THE RIPRAP SHALL BE PLACED SUCH THAT DAMAGE TO THE FILTER LAYER DOES NOT OCCUR. FILTER DISPLACED OR OTHERWISE DAMAGED DURING PLACEMENT SHALL BE REPLACED.
9. CONTINUE BANK FACE SLOPING AS SHOWN IN THE PLAN.
10. PLACE LOCALLY SOURCED RIPARIAN DORMANT HARDWOOD VEGETATION BUNDLES ALONG THE ROCK TOE AND BANK FACE USING A STANDARD LIVE STAKE INSTALLATION PROCEDURE .
11. FINAL CONFIGURATION OF ROCK TOE STRUCTURE SHALL BE AS DIRECTED IN FIELD.

C:\Users\chad\AppData\Local\Temp\AcPublish_17504\LEITHEAD.dwg Aug 31, 2021 2:06pm chad

DESIGNED BY: CB
DRAWN BY: CB
CHECKED BY: RC
DATE: 8/30/2021
REV:
SHEET: 2

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
VANCE LEITHEAD (SAND DRAW EROSION CONTROL)
LOCATED IN SECTION 24 T56N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	47
Owner/Operator:	**Leithead, Vance**
Site Name:	Sand Draw Erosion Control
Type Of Project:	Bank Stability

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$5,000.00	$5,000
2	Channel Excavation	66	C.Y.	$12.00	$792
3	Toe Rock Purchase, Delivery & Install	121	C.Y.	$80.00	$9,671
4	Cutting Collect & Install (3 per 5' bank)	82	Each	$2.00	$163
5	Channel Backfill	113	C.Y.	$12.00	$1,356
6	Bank Grading	47	C.Y.	$12.00	$560
7	Water Management	1	L.S.	$3,000.00	$3,000
				Total Construction Cost	**$20,542**

INCIDENTAL PROJECT COSTS

Construction Permits	$200
Performance Bond	$300
Insurance	$200
15% O&P	$3,081
Subtotal 1	**$3,781**
Subtotal 2	**$24,324**
Construction Engineering @ 10% of Subtotal #2	$2,432
Subtotal 3	**$26,756**
Contingency @ 15% of Subtotal #3	$4,013
Total Construction Cost	**$30,769**
Preparation of Final Designs and Specifications	$2,462
Permitting @ 10% of Project Cost	$3,077
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$36,308**

SITE PHOTOS: Sand Draw Erosion Control

Project ID #:	48
Owner/Operator:	**Liethead, Vance**
Site Name:	County Road 12-1/2
Type Of Project:	Ditch Piping
Land Jurisdiction:	Private Ditch Easement
Location:	44.82392N -108.35879W

Project Description

Statement of Purpose and Need: This segment of ditch experiences seepage and in some areas is perched on a levee requiring significant effort to maintain. In total about 135 acres receive water from the ditch equating to a flow of about 2 cfs. By eliminating bank maintenance, excess seepage and breach risk this project will improve reliability and improve water efficiency and reduce maintenance efforts.
Proposed Project: Project will line the delivery ditch using 4,100 feet of 15-inch pipe. In addition some gated pipe will be required to service one field. The gated pipe portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office:

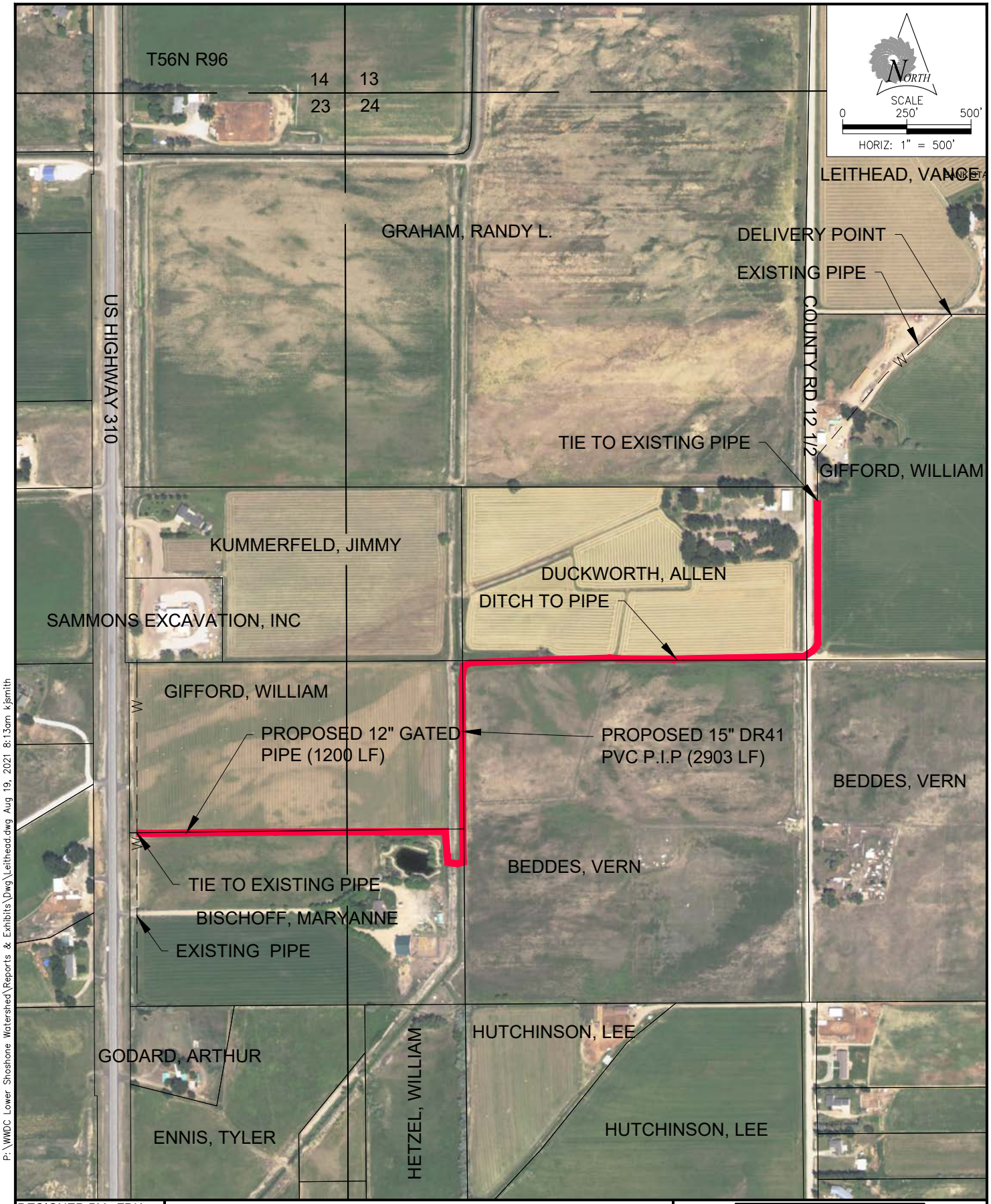
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Not applicable

Other Land Owners: Project crosses several other landowners and will require easement verification and permission and agreement on intermediate delivery points. In addition, the project crosses road 12-1/2 and will require authorization by the County.

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Leithead.dwg Aug 19, 2021 8:13am kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED LEVEL 1 STUDY

VANCE LEITHEAD (DITCH TO PIPE)
LOCATED IN SECTIONS 23 & 24 T56N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 48
Owner/Operator: **Liethead, Vance**
Site Name: County Road 12-1/2
Type Of Project: Ditch Piping

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$6,000.00	$6,000
2	Traffic Control	1	L.S.	$300.00	$300
3	Clearing and Grubbing Alignment	1	L.S.	$1,500.00	$1,500
4	Furnish and Install 15-inch PVC P.I.P. Type Pipe DR 41	2,910.0	L.F.	$22.00	$64,020
5	Furnish and Install 12-inch Transfer Pipe	30.0	L.F.	$11.00	$330
6	Furnish and Install 12-inch Gated Pipe *	1,200	L.F.	$12.00	$14,400
7	Furnish and Install 15-inch to 12-inch Adapter	1	Each	$115.00	$115
8	Furnish and Install PVC TEE and Delivery Riser	2	Each	$1,200.00	$2,400
9	Furnish and Install Knife Gate Valve	2	Each	$600.00	$1,200
10	Outlet Rip-Rap Splash Pad	1	C.Y.	$125.00	$125
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$90,390**

INCIDENTAL PROJECT COSTS

Construction Permits	$500
Performance Bond	$1,000
Insurance	$500
15% O&P	$13,559
Subtotal 1	**$15,559**
Subtotal 2	**$105,949**
Construction Engineering @ 10% of Subtotal #2	$10,595
Subtotal 3	**$116,543**
Contingency @ 15% of Subtotal #3	$17,482
Total Construction Cost	**$134,025**
Preparation of Final Designs and Specifications	$10,722
Permitting @ 5% of Project Cost	$6,701
Legal @ 4% of Project Cost	$5,361
Environmental Study	Fill In
Total Project Cost	**$156,809**

SITE PHOTOS: County Road 12-1/2

View looking west from CO RD 12 1/2 along alignment

View looking north along CO RD 12 1/2 alignment on right hand side of road

Project ID #:	50	
Owner/Operator:	**Schilthuis, Kevin**	
Site Name:	Pipe Hunt Canal	
Type Of Project:		
Land Jurisdiction:	Private	
Location:	44.84163N	-108.25946W

Project Description

Statement of Purpose and Need: Subbing from Hunt Canal is causing excessive alkalinity, salinity, sodicity in several areas, and therefore erosive soils and need for high chemical inputs to grow crops which will quickly enter the Big Horn Lake.
Proposed Project: Replace canal with 48" pipe

Permitting Requirements

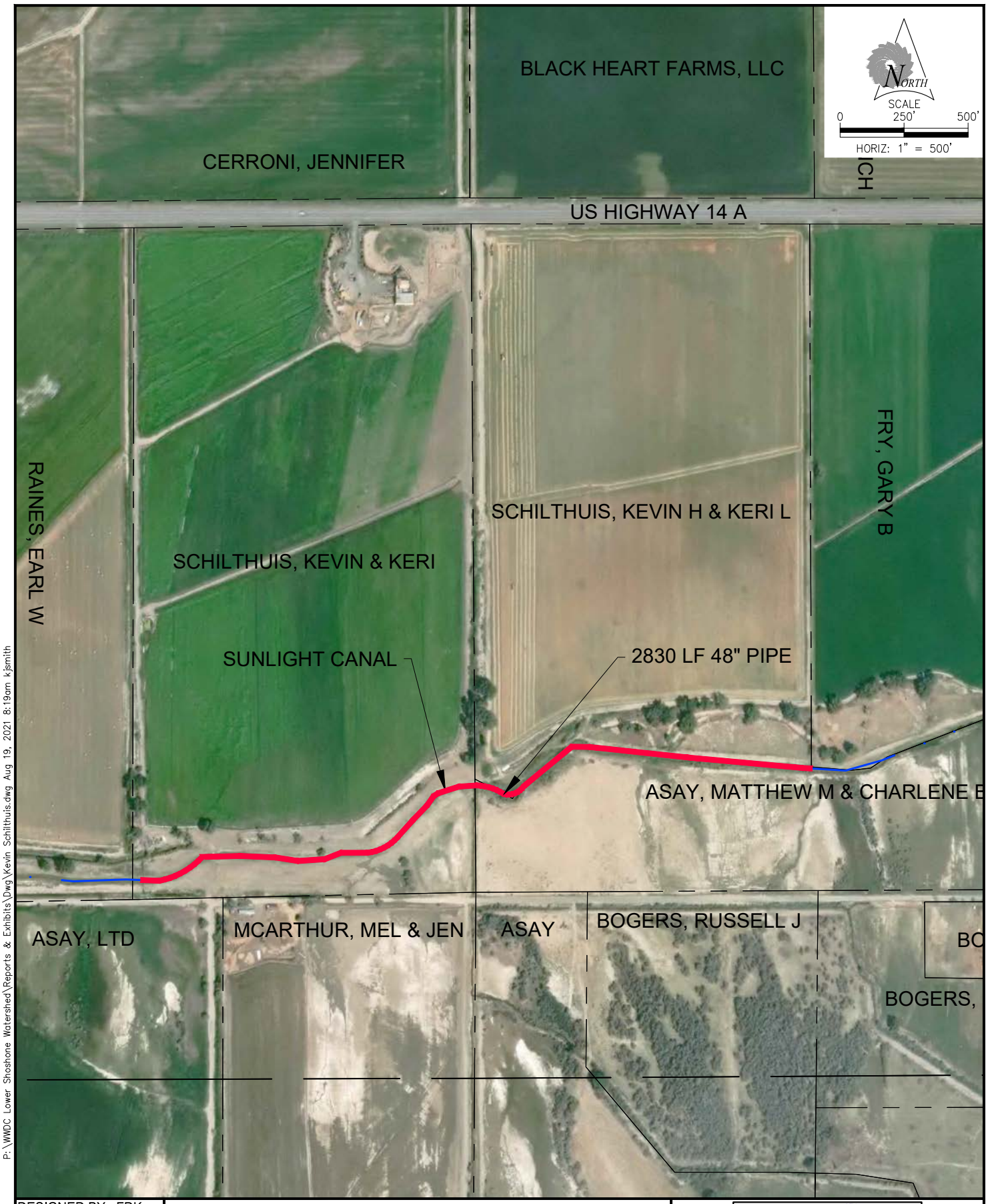
Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No permitting

Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Kevin Schilthuis.dwg Aug 19, 2021 8:19am kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED LEVEL 1 STUDY

#50 KEVIN SCHILTHUIS (LINE OF PIPE SUNLIGHT CANAL)
LOCATED IN SECTION 11, T56N R95W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 50
Owner/Operator: **Schilthuis, Kevin**
Site Name: Pipe Hunt Canal
Type Of Project: **Private**

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	Furnish and install 48" pipe	2,800	L.F.	$24.00	$67,200
4	Headgate	5	Cu.Yd.	$500.00	$2,500
5	Trash Rack	1	L.S.	$2,000.00	$2,000.00
6	Outfall Tail Wall	5	Cu.Yd.	$500.00	$2,500
				Total Construction Cost	**$76,200**

INCIDENTAL PROJECT COSTS

Construction Permits	$400
Performance Bond	$800
Insurance	$400
15% O&P	$11,430
Subtotal 1	**$13,030**
Subtotal 2	**$89,230**
Construction Engineering @ 10% of Subtotal #2	$8,923
Subtotal 3	**$98,153**
Contingency @ 15% of Subtotal #3	$14,723
Total Construction Cost	**$112,876**
Preparation of Final Designs and Specifications	$9,030
Permitting @ 5% of Project Cost	$5,644
Legal @ 4% of Project Cost	$4,515
Environmental Study	Fill In
Total Project Cost	**$132,065**

SITE PHOTOS: Pipe Hunt Canal

Project ID #:	52
Owner/Operator:	**Schilthuis, Kevin**
Site Name:	East Lovell Catchment Rainfall Runoff Analysis
Type Of Project:	Modeling
Land Jurisdiction:	Mixed Public & Private
Location:	

Project Description

Statement of Purpose and Need: Water catchment analysis for lands east of Lovell that can help community and landowners understand what opportunities are missing and what improvements might be made to mitigate the negative effects of large magnitude storms.
Proposed Project: The proposed project is a desktop study and hydrology modeling analysis for the watershed east of Lovell. A rainfall runoff analysis would be performed for several theoretical precipitation events to look at runoff and routing of storm water within the catchment. The analysis project is not eligible for SWPP funding. Please refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Big Horn County: Not applicable

State Engineers Office: Not applicable

Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Not applicable

Army Corps of Engineers: Not applicable

Other Concerns

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	52
Owner/Operator:	**Schilthuis, Kevin**
Site Name:	East Lovell Catchment Rainfall Runoff Analysis
Type Of Project:	Modeling

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Delineate catchment areas	6	Hr	$125.00	$750
2	Collect and analyze rainfall data	5	Hr	$125.00	$625
3	Develop hydrologic model (HEC-HMS)	40	Hr	$135.00	$5,400
4	Create output maps	12	Hr	$125.00	$1,500
5	Develop hydrologic report	40	Hr	$135.00	$5,400
6	Stakeholder meeting (virtual)	4	Hr	$135.00	$540
7	Report revisions to comments	10	Hr	$135.00	$1,350
				Total Construction Cost	**$15,565**

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	53	
Owner/Operator:	**Schilthuis, Kevin**	
Site Name:		
Type Of Project:	Ditch to Pipe	
Land Jursidiction:	Private	
Location:	44.84578N	-108.26460W

Project Description

Statement of Purpose and Need: Existing conveyance ditch west of property has been a cause of concern and expense. Ditch is constantly flooding onto property.
Proposed Project: The proposed project will replace the ditch with 10" transmission pipe.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

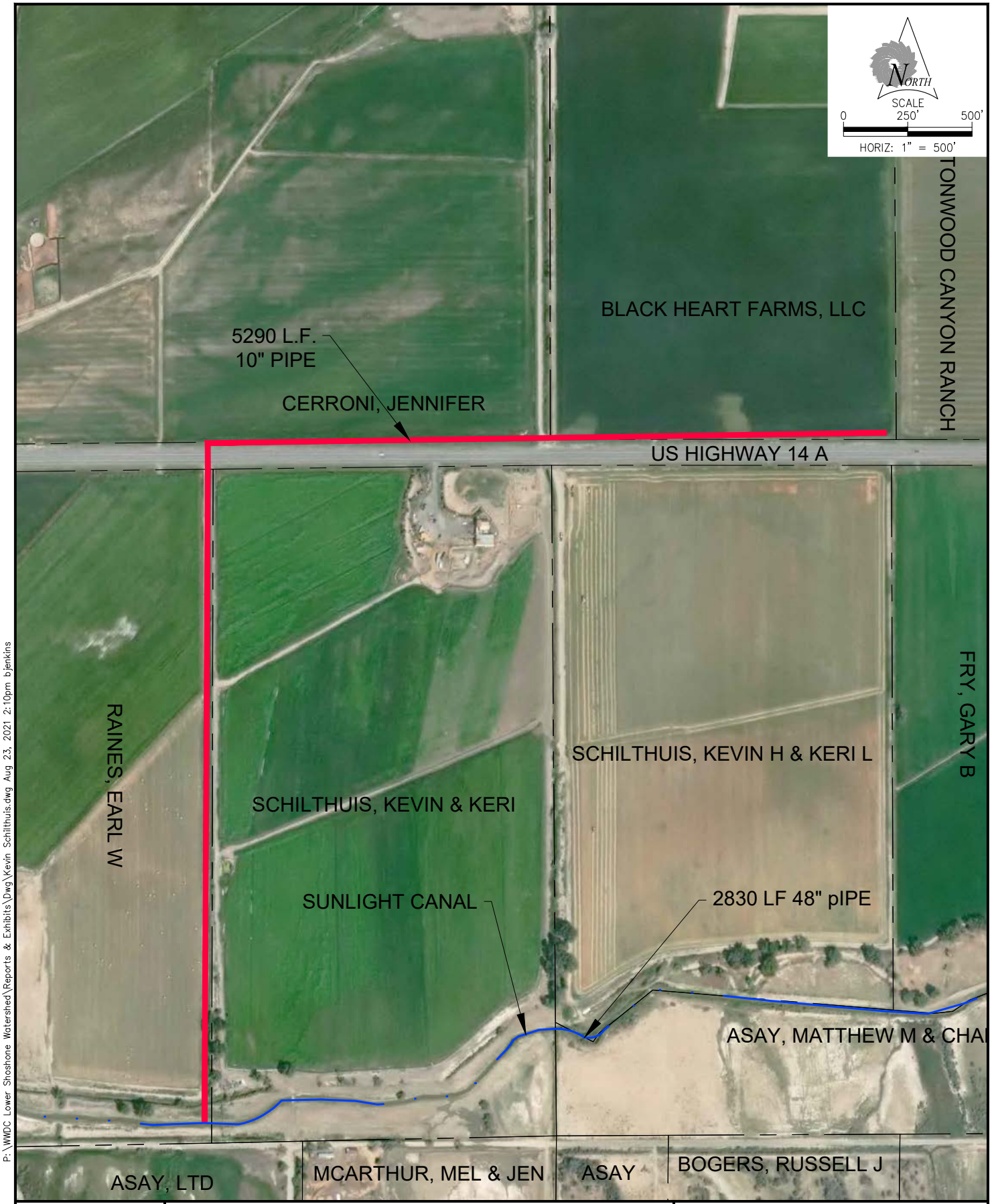
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Land Owners: The pipe crosses several landowner's property and would require agreement.

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Kevin Schilthuis.dwg Aug 23, 2021 2:10pm bjenkins

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED LEVEL 1 STUDY

#53 KEVIN SCHILTHUIS (BURIED LATERAL & REPLACE DITCHES)
LOCATED IN SECTION 11, T56N R95W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 53
Owner/Operator: **Schilthuis, Kevin**
Site Name:
Type Of Project: Ditch to Pipe

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	Furnish and install 10" Pipe	5,290	L.F.	$12.00	$63,480
4	Headgate	5	Cu.Yd.	$500.00	$2,500
5	Road Crossing	1	Each	$3,000.00	$3,000
				Total Construction Cost	**$70,980**

INCIDENTAL PROJECT COSTS

Construction Permits	$400
Performance Bond	$800
Insurance	$400
15% O&P	$10,647
Subtotal 1	**$12,247**
Subtotal 2	**$83,227**
Construction Engineering @ 10% of Subtotal #2	$8,323
Subtotal 3	**$91,550**
Contingency @ 15% of Subtotal #3	$13,732
Total Construction Cost	**$105,282**
Preparation of Final Designs and Specifications	$8,423
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$113,705**

SITE PHOTOS:

Project ID #:	55
Owner/Operator:	**Bischoff, Beth**
Site Name:	Wetland Enhancement
Type Of Project:	Wetland Enhancement
Land Jurisdiction:	Private
Location:	

Project Description

Statement of Purpose and Need: Enhance existing wetland that has had Russian Olive removed recently in the western portion of the area.
Proposed Project: The proposed project is a wetland enhancement including a cattle crossing structure to limit disturbance and reduce maintenance. The existing wetland will be enhanced by reducing the cattail monoculture with excavation. The pockets will be excavated up to 2 feet deep to create pocket water habitat to create diversified hemi-marsh habitat. The crossing structure portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Big Horn County: Floodplain Development Permit

State Engineers Office: Not applicable

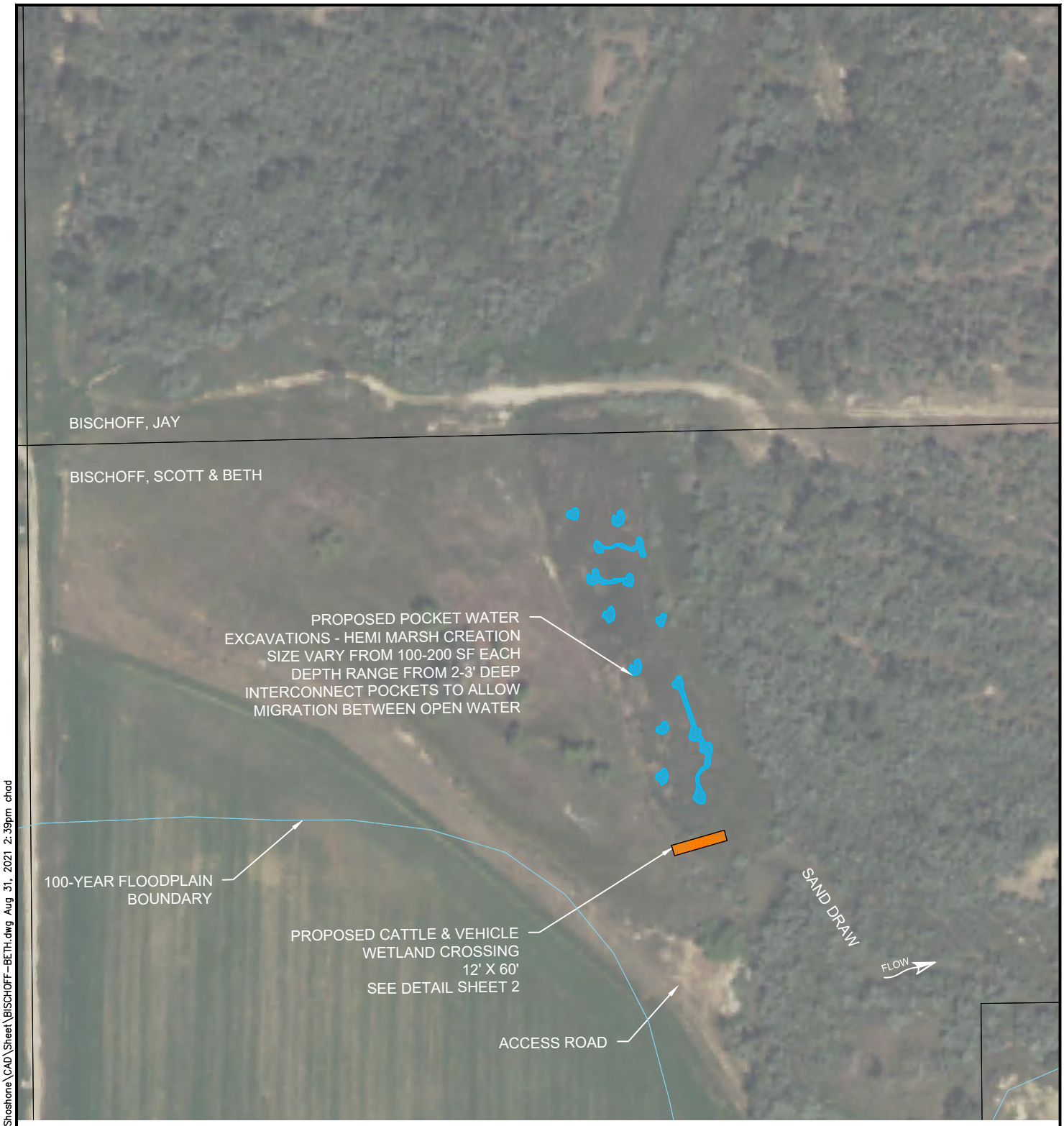
Wyoming Office of State Lands: Not applicable

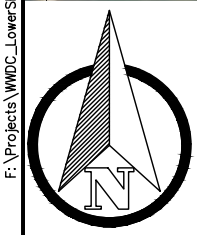
Wyoming Department of Environmental Quality: 401 Water Quality Certification

Bureau of Land Management: Not applicable

Army Corps of Engineers: 404 permit

Other Concerns





0' 75' 150' 300'

F:\Projects\WWDC_LowerShoshone\CAD\Sheet\BISCHOFF-BETH.dwg Aug 31, 2021 2:39pm chad

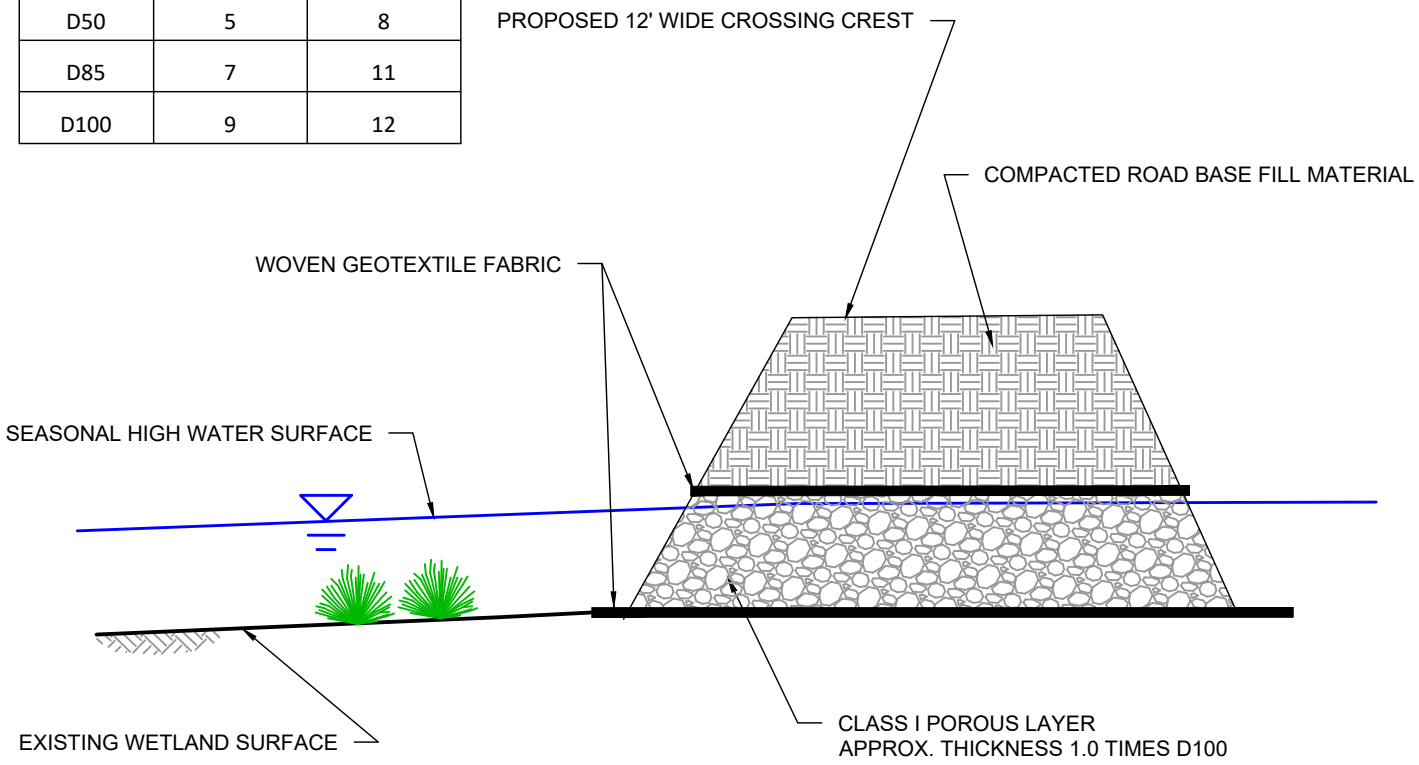
DESIGNED BY: CB
DRAWN BY: CB
CHECKED BY: RC
DATE: 8/31/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

BETH BISCHOFF (WETLAND ENHANCEMENT)
LOCATED IN SECTION 01 T56N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

CLASS I ROCK GRADATION		
SIZE	LOWER (IN)	HIGHER (IN)
D15	3	6
D50	5	8
D85	7	11
D100	9	12



WETLAND CROSSING - TYPICAL SECTION

NTS

WETLAND CROSSING CONSTRUCTION NOTES:

1. INSTALL BASED GEOTEXTILE FABRIC TO SEGREGATE POROUS ROCK MEDIA FROM UNDERLYING WETLAND SOILS.
2. PLACE CLASS I POROUS ROCK MATERIAL ON TOP OF GEOTEXTILE. FOR INCREASED SURFACE WATER, 12" OR SMALLER HDPE CULVERTS MAY BE PLACED WITH FINER MATERIAL UP TO THE HAUNCHES.
3. POROUS ROCK MATERIAL SHALL BE HARD, DURABLE, SUB-ROUNDED TO ANGULAR IN SHAPE, RESISTANT TO WEATHERING TO WATER AND ICE ACTION; FREE OF EXCESS AMOUNTS OF THIN FLAT, AND ELONGATED PIECES, FREE FROM OVERBURDEN, SPOIL, SHALE, STRUCTURAL DEFECTS, AND ORGANIC MATERIAL. THE SMALLER STONE SHALL BE UNIFORMLY DISTRIBUTED THROUGHOUT THE WORK. THE ROCK SHALL BE MANIPULATED BY HAND OR MACHINE METHODS SUFFICIENTLY TO SECURE A UNIFORM SURFACE AND MASS STABILITY. ROCK SHALL BE SOURCED FROM LOCALLY AVAILABLE COARSE MATERIAL.
4. PLACE UPPER GETOTEXTILE FABRIC BEFORE PLACING STANDARD ROAD BASE MATERIAL.
5. PLACE STANDARD ROAD BASE MATERIAL IN 12" LIFTS AND COMPACT TO FIRM AND UNYIELDING SURFACE BEFORE PLACING NEXT LIFT. PLACE LIFTS UNTIL DESIRED ROAD CREST ELEVATION IS MET.
6. FINAL CONFIGURATION OF WETLAND CROSSING STRUCTURE SHALL BE AS DIRECTED IN FIELD.

F:\Projects\WWDC_LowerShoshone\CAD\Sheet\BISCHOFF-BETH.dwg Aug 31, 2021 2:39pm chad

DESIGNED BY: CB
DRAWN BY: CB
CHECKED BY: RC
DATE: 8/31/2021
REV:
SHEET: 2

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
BETH BISCHOFF (WETLAND ENHANCEMENT)
LOCATED IN SECTION 01 T56N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	55
Owner/Operator:	**Bischoff, Beth**
Site Name:	Wetland Enhancement
Type Of Project:	Wetland Enhancement

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$5,000.00	$5,000
2	Pocket Excavations	262	C.Y.	$20.00	$5,231
3	Geotextile*	1	Ea	$1,000.00	$1,000
4	Porous Rock*	62	C.Y.	$80.00	$4,978
5	Road Base Material*	53	C.Y.	$30.00	$1,600
6	Water Management	1	L.S.	$1,000.00	$1,000
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$18,809**

INCIDENTAL PROJECT COSTS

Construction Permits	$100
Performance Bond	$200
Insurance	$100
15% O&P	$2,821
Subtotal 1	**$3,221**
Subtotal 2	**$22,031**
Construction Engineering @ 10% of Subtotal #2	$2,203
Subtotal 3	**$24,234**
Contingency @ 15% of Subtotal #3	$3,635
Total Construction Cost	**$27,869**
Preparation of Final Designs and Specifications	$4,180
Permitting @ 7% of Project Cost	$1,951
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$34,000**

SITE PHOTOS: Wetland Enhancement

Project ID #:	56
Owner/Operator:	**Price, Chris**
Site Name:	Sand Draw Land and Cattle Company
Type Of Project:	Ditch to Pipe
Land Jurisdiction:	Private and BLM
Location:	44.822227N -108.34553W

Project Description

Statement of Purpose and Need: This 2,870 foot ditch crosses private lands irrigating about 65 acres. The ditch soils are sandy and erodible and along much of its length the ditch is elevated on a levee. Seepage and erosion greatly reduce the effectiveness of the diverted irrigation water. Past attempts to use bentomat or salvaged concrete pipe sections have helped eliminate some breaches but have largely failed to reduce seepage. Breaches continue to appear in new areas.

Proposed Project: The proposed project will replace the ditch with gated pipe and sections of transfer pipe thereby eliminating the washouts and seepage. The project will conserve water presently lost to unproductive roadside locations. The gated pipe portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

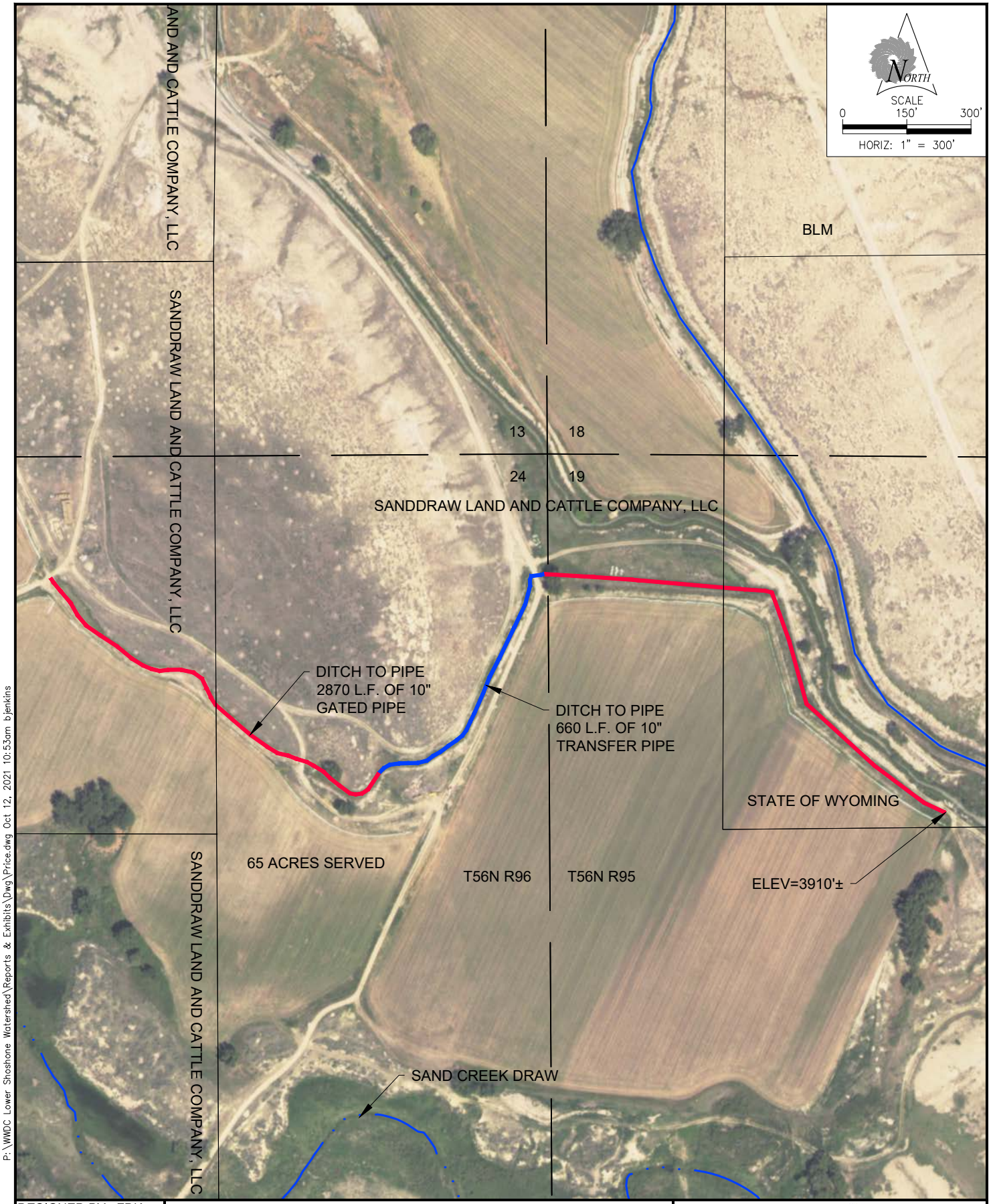
State Engineers Office: No Permitting

Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: No BLM lands involved in project.

Other Land Owners: None



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Price.dwg Oct 12, 2021 10:53am bjenkins

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED LEVEL 1 STUDY

#56 CHRIS PRICE (DITCH TO PIPE)
LOCATED IN T56N R96W, SEC 24, T56N R95W SEC 19
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	56
Owner/Operator:	**Price, Chris**
Site Name:	Sand Draw Land and Cattle Company
Type Of Project:	Ditch to Pipe

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	Grade and Smooth Pipe Route	2,870	L.F.	$3.00	$8,610
4	Furnish and Install 10" Gated Pipe*	2,270	L.F.	$8.00	$18,160
5	Furnish and install 10" Transfer Pipe	600	L.F.	$7.00	$4,200
6	Intake Valve	1	L.S.	$700.00	$700
7	Turnout Valve	1	Each	$800.00	$800
8	Vehicle Crossovers	2	Each	$500.00	$1,000
				Total Construction Cost	**$35,470**

* Item not eligible for SWPP funding

INCIDENTAL PROJECT COSTS

Construction Permits	$200
Performance Bond	$400
Insurance	$200
15% O&P	$5,321
Subtotal 1	**$6,121**
Subtotal 2	**$41,591**
Construction Engineering @ 10% of Subtotal #2	$4,159
Subtotal 3	**$45,750**
Contingency @ 15% of Subtotal #3	$6,862
Total Construction Cost	**$52,612**
Preparation of Final Designs and Specifications	$4,209
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$56,821**

SITE PHOTOS: Sand Draw Land and Cattle Company

Proposed Pipe Route (blue)

Project ID #:	57
Owner/Operator:	**Price, Chris**
Site Name:	Sand Draw Land and Cattle Company
Type Of Project:	Ditch to Pipe
Land Jurisdiction:	Private and BLM
Location:	44.813458N -108.345519 W

Project Description

Statement of Purpose and Need: This 4,155 foot ditch crosses private lands irrigating about 79 acres. The ditch soils are sandy and erodible and along much of its length the ditch is elevated on a levee. Seepage and erosion greatly reduce the effectiveness of the diverted irrigation water. Past attempts to use bentomat or salvaged concrete pipe sections have helped eliminate some breaches but have largely failed to reduce seepage. Breaches continue to appear in new areas.

Proposed Project: The proposed project will replace the ditch with gated pipe and sections of transfer pipe thereby eliminating the washouts and seepage. The project is also expected to allow the irrigation an additional 10 acres located north of the current acreage. The gated pipe portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

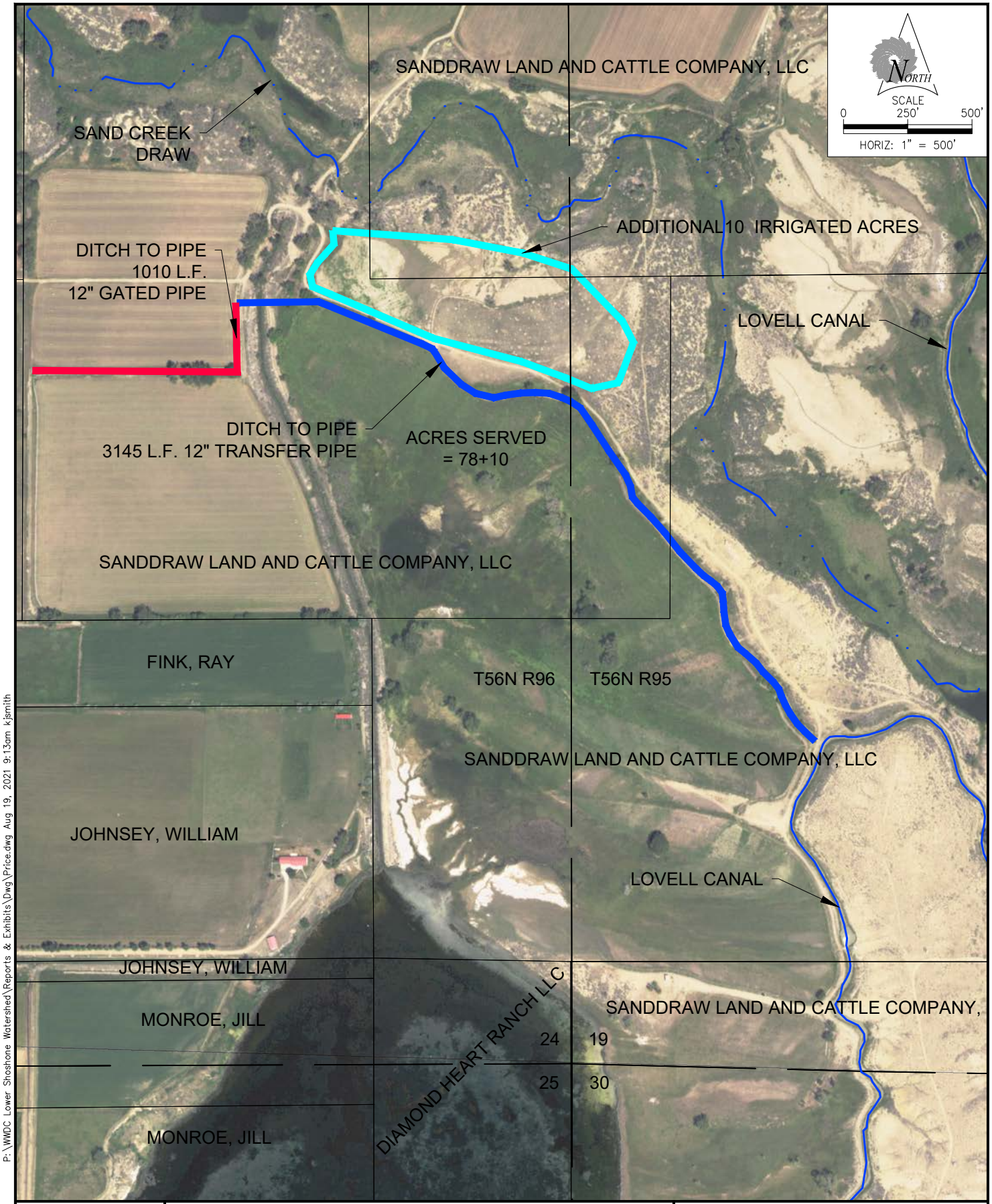
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Price.dwg Aug 19, 2021 9:13am kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

CHRIS PRICE (DITCH TO PIPE)
LOCATED IN T56N R96W, SEC 24, T56N R95W SEC 19
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 57
Owner/Operator: **Price, Chris**
Site Name: Sand Draw Land and Cattle Company
Type Of Project: Ditch to Pipe

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	Grade and Smooth Pipe Route	4,155	L.F.	$3.00	$12,465
4	Furnish and install 10" Transfer Pipe	3,145	L.F.	$8.00	$25,160
5	Furnish and install 10" Gated Pipe*	1,010	L.F.	$7.00	$7,070
6	Intake Valve	1	Each	$700.00	$700
7	Turnout valve	2	Each	$800.00	$1,600
8	Vehicle Crossovers	3	Each	$500.00	$1,500
				Total Construction Cost	**$50,495**

* Item not eligible for SWPP funding

INCIDENTAL PROJECT COSTS

Construction Permits	$300
Performance Bond	$600
Insurance	$300
15% O&P	$7,574
Subtotal 1	**$8,774**
Subtotal 2	**$59,269**
Construction Engineering @ 10% of Subtotal #2	$5,927
Subtotal 3	**$65,196**
Contingency @ 15% of Subtotal #3	$9,779
Total Construction Cost	**$74,976**
Preparation of Final Designs and Specifications	$5,998
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$80,974**

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	58	
Owner/Operator:	**Ellis, Spencer and Casey**	
Site Name:	Sidon Lateral to South Neighbors	
Type Of Project:	Ditch to Pipe	
Land Jurisdiction:	Private	
Location:	44.88903N	-108.52390 W

Project Description

Statement of Purpose and Need: Bury existing ditch that plugs with trash due to it being open. This will conserve water from overflowing into drains and/or fields.
Proposed Project: The proposed project will replace the ditch with 10" transfer pipe.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

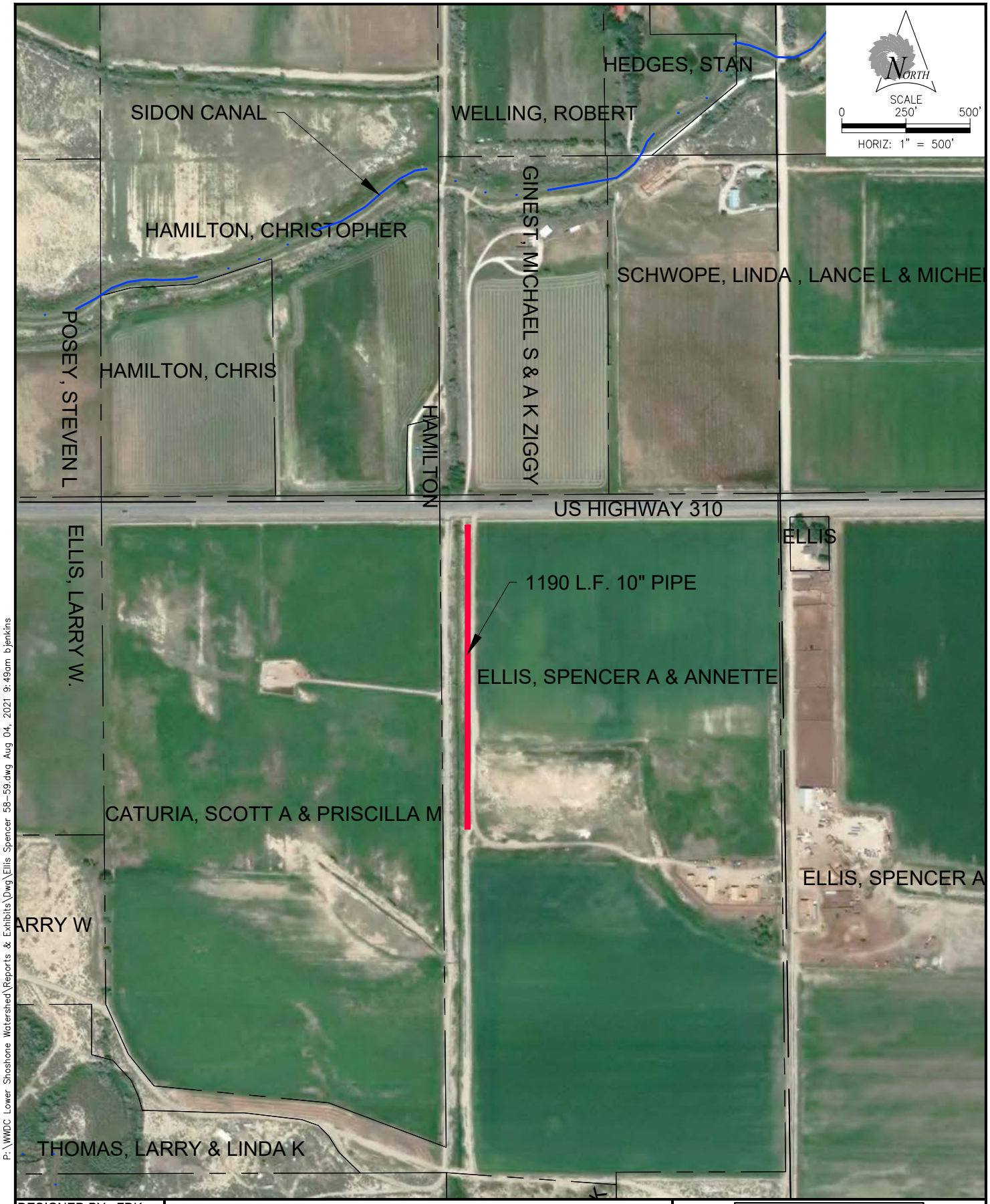
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Ellis Spencer 58-59.dwg Aug 04, 2021 9:49am bjenkins

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#58 SPENCER ELLIS (PIPE LATERAL)
LOCATED IN SECTION 35 T57N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	58
Owner/Operator:	**Ellis, Spencer and Casey**
Site Name:	Sidon Lateral to South Neighbors
Type Of Project:	Ditch to Pipe

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$300.00	$300
2	Traffic Control	1	L.S.	$0.00	$0
3	Furnish and install 10" Transfer Pipe	1,190	L.F.	$7.00	$8,330
4	Headgate	5	Cu.Yd.	$500.00	$2,500
				Total Construction Cost	**$11,130**

INCIDENTAL PROJECT COSTS

Construction Permits	$100
Performance Bond	$200
Insurance	$100
15% O&P	$1,670
Subtotal 1	**$2,070**
Subtotal 2	**$13,200**
Construction Engineering @ 10% of Subtotal #2	$1,320
Subtotal 3	**$14,519**
Contingency @ 15% of Subtotal #3	$2,178
Total Construction Cost	**$16,697**
Preparation of Final Designs and Specifications	$1,336
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$18,033**

SITE PHOTOS: Sidon Lateral to South Neighbors

Photo: Sidon lateral to neighboring parcels.

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	59
Owner/Operator:	**Ellis, Spencer and Casey**
Site Name:	Sidon Lateral to Lower Field at Wormington
Type Of Project:	Ditch to Pipe
Land Jurisdiction:	Private
Location:	44.88570N -108.58417W

Project Description

Statement of Purpose and Need: Convert a ditch to pipe along CO LN 8 beginning about 1/2 mile east of Deaver and running east parallel to the road.
Proposed Project: The proposed project will replace a ditch connecting to the Sidon Canal with 10" transfer pipe.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

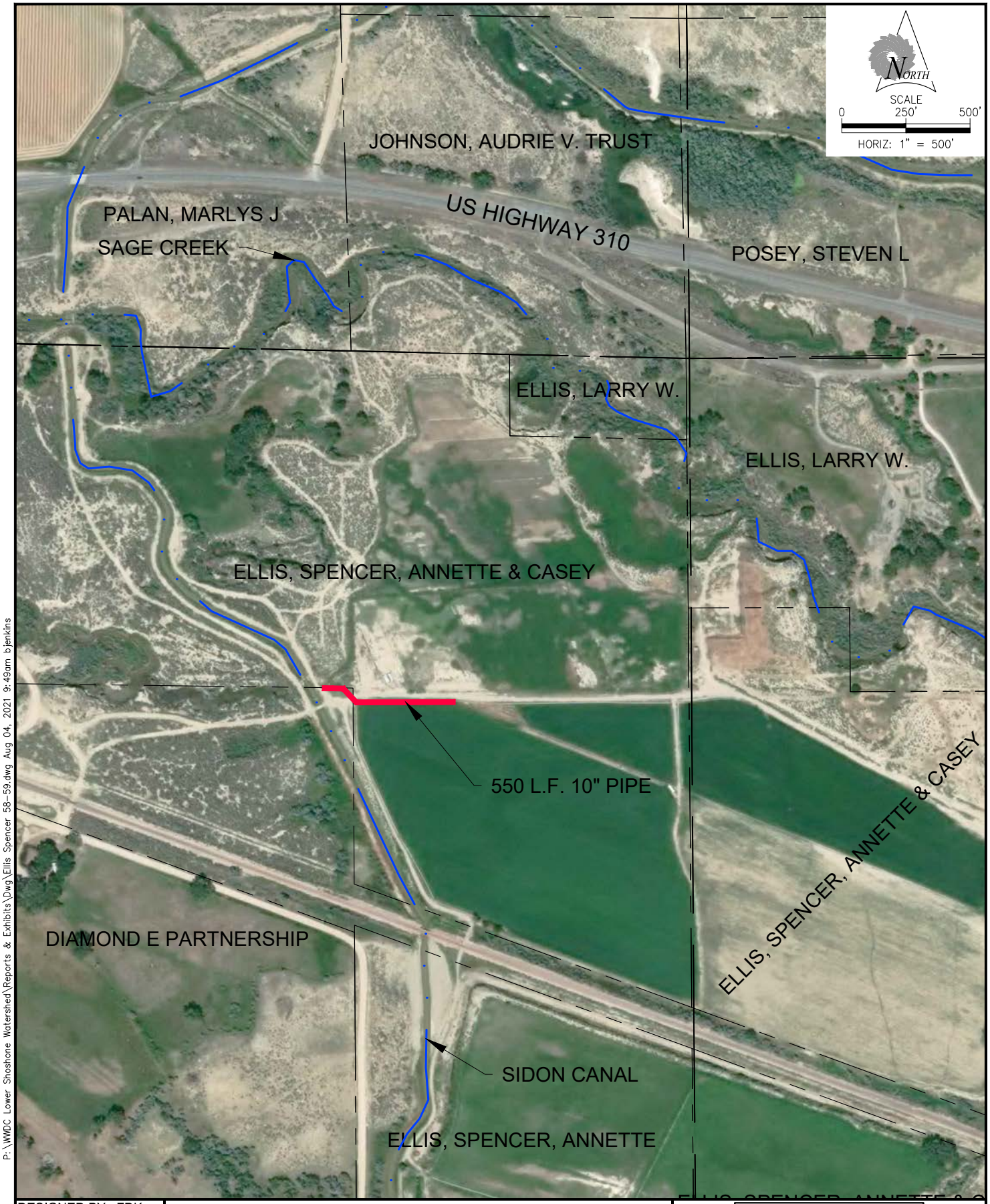
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Not applicable

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Ellis Spencer 58-59.dwg Aug 04, 2021 9:49am bjenkins

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#59 SPENCER ELLIS (PIPE LATERAL)
LOCATED IN SECTION 34 T57N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	59
Owner/Operator:	**Ellis, Spencer and Casey**
Site Name:	Sidon Lateral to Lower Field at Wormington
Type Of Project:	Ditch to Pipe

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$300.00	$300
2	Traffic Control	1	L.S.	$0.00	$0
3	Furnish and install 10" Transfer Pipe	550	L.F.	$7.00	$3,850
4	Headgate	5	Cu.Yd.	$500.00	$2,500
				Total Construction Cost	**$6,650**

INCIDENTAL PROJECT COSTS

Construction Permits	$100
Performance Bond	$100
Insurance	$100
15% O&P	$998
Subtotal 1	**$1,298**
Subtotal 2	**$7,948**
Construction Engineering @ 10% of Subtotal #2	$795
Subtotal 3	**$8,742**
Contingency @ 15% of Subtotal #3	$1,311
Total Construction Cost	**$10,054**
Preparation of Final Designs and Specifications	$804
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$10,858**

SITE PHOTOS: Sidon Lateral to Lower Field at Wormington

Project ID #:	60
Owner/Operator:	**Ellis, Spencer and Casey**
Site Name:	
Type Of Project:	Sedimentation Basin
Land Jurisdiction:	BLM
Location:	44.8330868N -108.464024W

Project Description

Statement of Purpose and Need: The Sidon Canal experiences significant erosion and bank losses due to the volume water carried. In addition during certain seasons the main river diversion brings in sediment. The entrained sediments settle at headgates, control structures and the point of application on the fields creating increased maintenance efforts and adjustment of operations to accommodate sediment buildup.
Proposed Project: The proposed project will construct a small 1 acre sedimentation basin in a draw located on BLM lands south of Cowley. The basin will slow flow and create conditions conducive to sedimentation. Sediments collected can then be removed from this concentrated point and stockpiled on-site. The creation of the basin will largely be by excavation of existing soils.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office:

Wyoming Office of State Lands: Not applicable

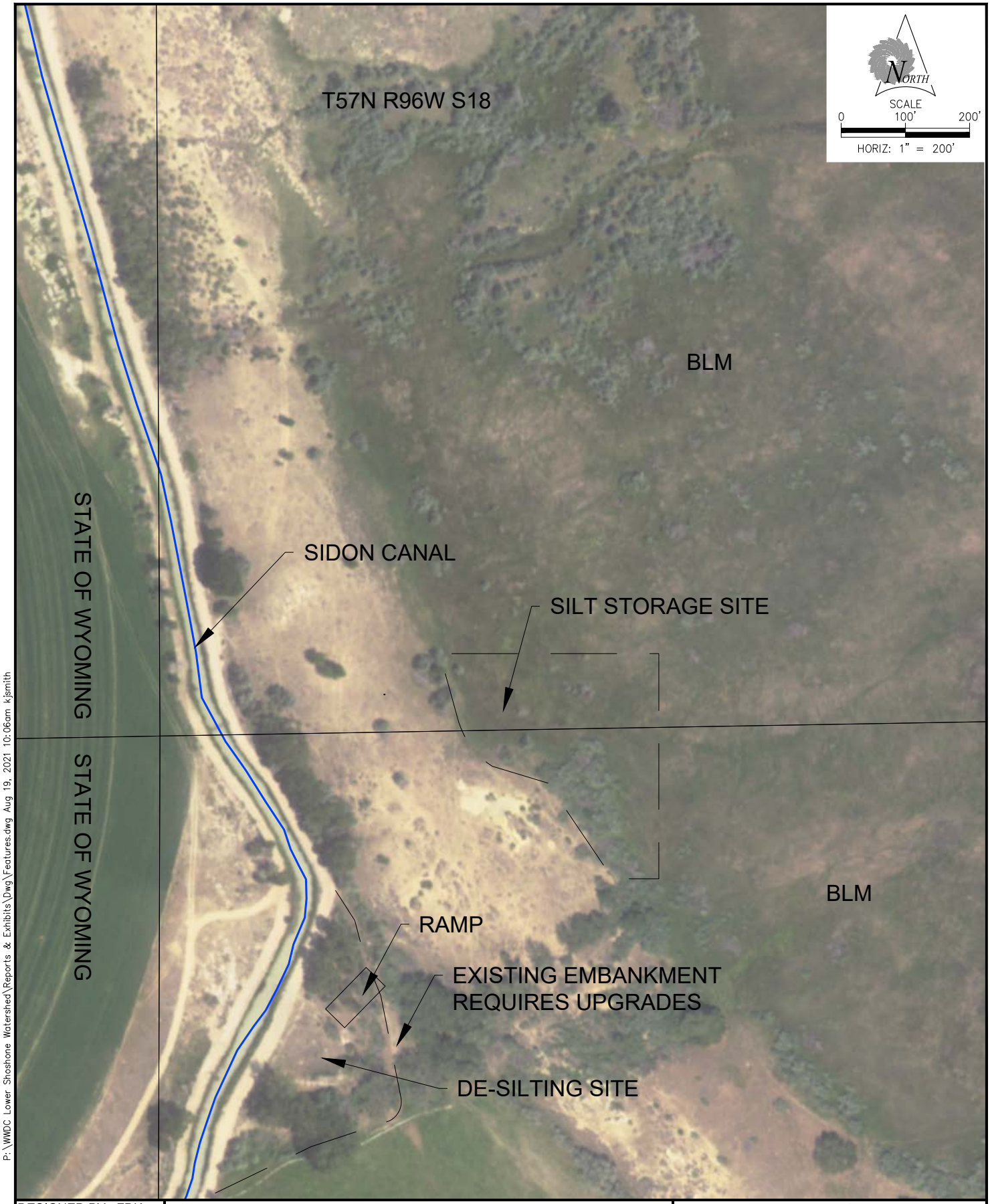
Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Full permitting authorization is required for both the pond area and the sediment stockpile area.

Other Land Owners: The project will not impact adjacent private ground.

Other Concerns

Soil Types - The type of soils around the permitter of the proposed project should be reviewed for stability in a constant submerged state.



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Features.dwg Aug 19, 2021 10:06am k.jsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 8/10/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
SIDON CANAL DE-SILTING SITE
LOCATED IN SECTION 28, T57N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	60
Owner/Operator:	**Ellis, Spencer and Casey**
Site Name:	0
Type Of Project:	Sedimentation Basin

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$4,000.00	$4,000
2	Traffic Control	1	L.S.	$0.00	$0
3	Clearing and Grubbing Alignment	1	L.S.	$1,500.00	$1,500
4	Excavation of Pool Area	8,000	C.Y.	$9.00	$72,000
5	Install 10" Drain Pipe	700.0	L.F.	$20.00	$14,000
6	Install Drain Gate Valve	1.0	L.S.	$1,500.00	$1,500
				Total Construction Cost	**$93,000**

INCIDENTAL PROJECT COSTS

Construction Permits	$500
Performance Bond	$1,000
Insurance	$500
15% O&P	$13,950
Subtotal 1	**$15,950**
Subtotal 2	**$108,950**
Construction Engineering @ 10% of Subtotal #2	$10,895
Subtotal 3	**$119,845**
Contingency @ 15% of Subtotal #3	$17,977
Total Construction Cost	**$137,822**
Preparation of Final Designs and Specifications	$11,026
Permitting @ 5% of Project Cost	$6,891
Legal @ 4% of Project Cost	$5,513
Environmental Study	Fill In
Total Project Cost	**$161,251**

Project ID #:	62
Owner/Operator:	**Tillet, John**
Site Name:	Crooked Creek
Type Of Project:	Ditch to Pipe
Land Jurisdiction:	Private and BLM
Location:	44.999717N -108.362506W

Project Description

Statement of Purpose and Need: This ditch crosses both private and BLM lands primarily irrigating private lands. The ditch soils are sandy and erodible with collapsing and widening banks that routinely washout and erode the field below the ditch.
Proposed Project: The proposed project will replace the ditch with gated pipe for 5810 L.F. thereby eliminating the washouts and the erosion of the fields below the ditch into Crooked Creek and ultimately Bighorn Lake. The gated pipe portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

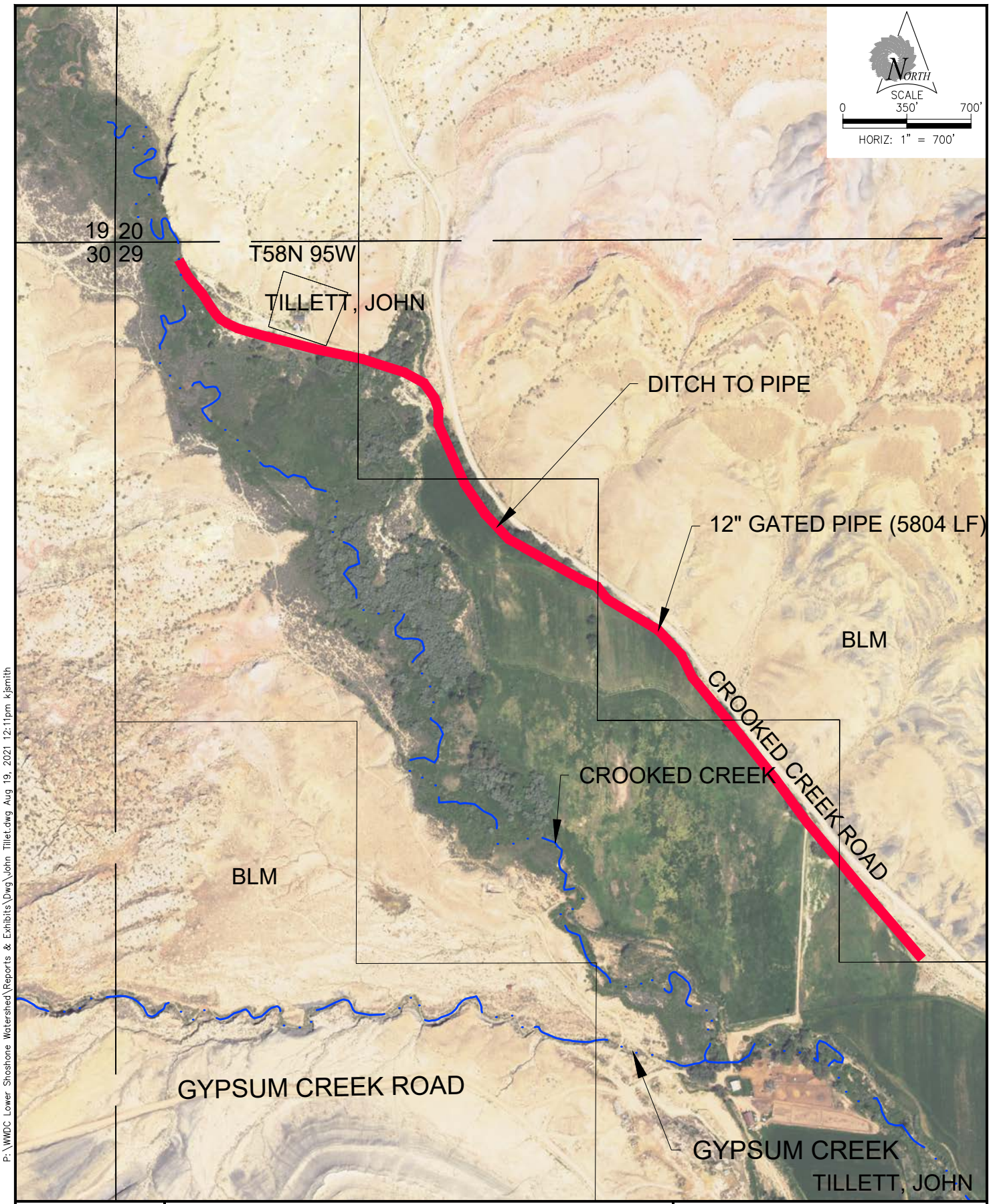
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: The proposed pipe will cross portions of BLM lands and will require BLM approval. Potential Section 7 consultation due to federal lands.

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\John Tillet.dwg Aug 19, 2021 12:11pm kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 10/15/2020
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
#62 JOHN TILLET (DITCH TO PIPE)
LOCATED IN SECTION 29 T58N R95W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	62
Owner/Operator:	**Tillet, John**
Site Name:	Crooked Creek
Type Of Project:	Ditch to Pipe

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	Grade and Smooth Pipe Route	5,810	L.F.	$3.00	$17,430
4	Furnish and Install 12" Gated Pipe*	5,810	L.F.	$8.00	$46,480
5	Furnish and install 12" Transfer Pipe	200	L.F.	$7.00	$1,400
6	Intake Valve	1	L.S.	$700.00	$700
7	Vehicle Crossovers	1	Each	$500.00	$500
8	Furnish and Install PVC TEE and Delivery Riser	2	Each	$1,200.00	$2,400
9	Furnish and Install Knife Gate Valve	2	Each	$600.00	$1,200
				Total Construction Cost	**$72,110**

* Item not eligible for SWPP funding

INCIDENTAL PROJECT COSTS

Construction Permits	$400
Performance Bond	$800
Insurance	$400
15% O&P	$10,817
Subtotal 1	**$12,417**
Subtotal 2	**$84,527**
Construction Engineering @ 10% of Subtotal #2	$8,453
Subtotal 3	**$92,979**
Contingency @ 15% of Subtotal #3	$13,947
Total Construction Cost	**$106,926**
Preparation of Final Designs and Specifications	$8,554
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$115,480**

Project ID #:	63
Owner/Operator:	**Tillet, John**
Site Name:	Crooked Creek
Type Of Project:	Ditch to Pipe
Land Jurisdiction:	Private and BLM
Location:	44.985174N -108.34978W

Project Description

Statement of Purpose and Need: This ditch crosses both private and BLM lands primarily irrigating private lands. The ditch soils are sandy and erodible with collapsing and widening banks the routinely washout and erode the field below the ditch.
Proposed Project: The proposed project will replace the ditch with gated pipe (2430 LF) thereby eliminating the washouts and the erosion of the fields below the ditch into Crooked Creek and ultimately Bighorn Lake. The gated pipe portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

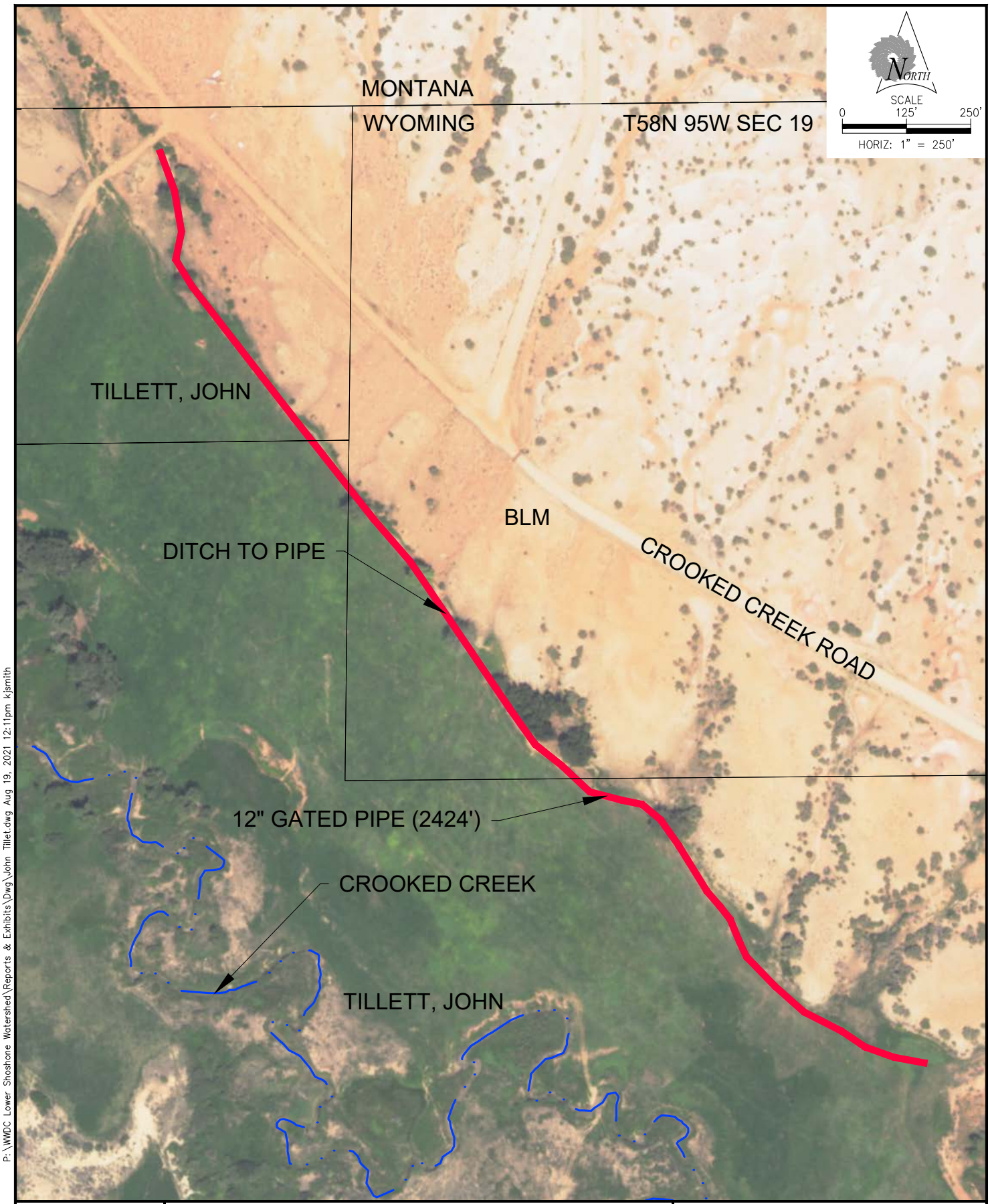
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: The proposed pipe will cross portions of BLM lands and will require BLM approval. Potential Section 7 consultation due to federal lands.

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\John Tillet.dwg Aug 19, 2021 12:11pm kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 10/15/2020
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
#63 JOHN TILLET (DITCH TO PIPE)
LOCATED IN SECTION 19, T58N R95W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	63
Owner/Operator:	**Tillet, John**
Site Name:	Crooked Creek
Type Of Project:	Ditch to Pipe

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	Grade and Smooth Pipe Route	2,430	L.F.	$1.00	$2,430
4	Furnish and Install 12" Gated Pipe*	2,430	L.F.	$8.00	$19,440
5	Furnish and install 12" Transfer Pipe	200	L.F.	$7.00	$1,400
6	Intake Valve	1	L.S.	$700.00	$700
7	Vehicle Crossovers	1	Each	$500.00	$500
8	Furnish and Install PVC TEE and Delivery Riser	2	Each	$1,200.00	$2,400
9	Furnish and Install Knife Gate Valve	2	Each	$600.00	$1,200
				Total Construction Cost	**$30,070**

* Item not eligible for SWPP funding

INCIDENTAL PROJECT COSTS

Construction Permits	$200
Performance Bond	$400
Insurance	$200
15% O&P	$4,511
Subtotal 1	**$5,311**
Subtotal 2	**$35,381**
Construction Engineering @ 10% of Subtotal #2	$3,538
Subtotal 3	**$38,919**
Contingency @ 15% of Subtotal #3	$5,838
Total Construction Cost	**$44,756**
Preparation of Final Designs and Specifications	$3,581
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$48,337**

Project ID #:	64
Owner/Operator:	**Tillet, John**
Site Name:	Crooked Creek
Type Of Project:	Ditch to Pipe
Land Jurisdiction:	Private and BLM
Location:	44.97541N -108.341594W

Project Description

Statement of Purpose and Need: This ditch crosses both private and BLM lands primarily irrigating private lands. The ditch soils are sandy and erodible with collapsing and widening banks the routinely washout and erode the field below the ditch.
Proposed Project: The proposed project will replace the ditch with gated pipe (4300 LF) and sections of transfer pipe (1730 LF) thereby eliminating the washouts and the erosion of the fields below the ditch into Crooked Creek and ultimately Bighorn Lake. The gated pipe portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: The proposed pipe will cross portions of BLM lands and will require BLM approval. Potential Section 7 consultation due to federal lands.

Other Land Owners: None

Other Concerns

P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\John Tillet.dwg Aug 19, 2021 12:11pm kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 10/15/2020
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
#64 JOHN TILLET (DITCH TO PIPE)
LOCATED IN SECTION 29 T58N R95W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	64
Owner/Operator:	**Tillet, John**
Site Name:	Crooked Creek
Type Of Project:	Ditch to Pipe

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	Grade and Smooth Pipe Route	6,030	L.F.	$1.00	$6,030
4	Furnish and Install 10" Gated Pipe*	4,300	L.F.	$8.00	$34,400
5	Furnish and install 10" Transfer Pipe	1,730	L.F.	$7.00	$12,110
6	Intake Valve	2	L.S.	$700.00	$1,400
7	Vehicle Crossovers	1	Each	$500.00	$500
8	Furnish and Install PVC TEE and Delivery Riser	2	Each	$1,200.00	$2,400
9	Furnish and Install Knife Gate Valve	2	Each	$600.00	$1,200
				Total Construction Cost	**$60,040**

* Item not eligible for SWPP funding

INCIDENTAL PROJECT COSTS

Construction Permits	$400
Performance Bond	$700
Insurance	$400
15% O&P	$9,006
Subtotal 1	**$10,506**
Subtotal 2	**$70,546**
Construction Engineering @ 10% of Subtotal #2	$7,055
Subtotal 3	**$77,601**
Contingency @ 15% of Subtotal #3	$11,640
Total Construction Cost	**$89,241**
Preparation of Final Designs and Specifications	$7,139
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$96,380**

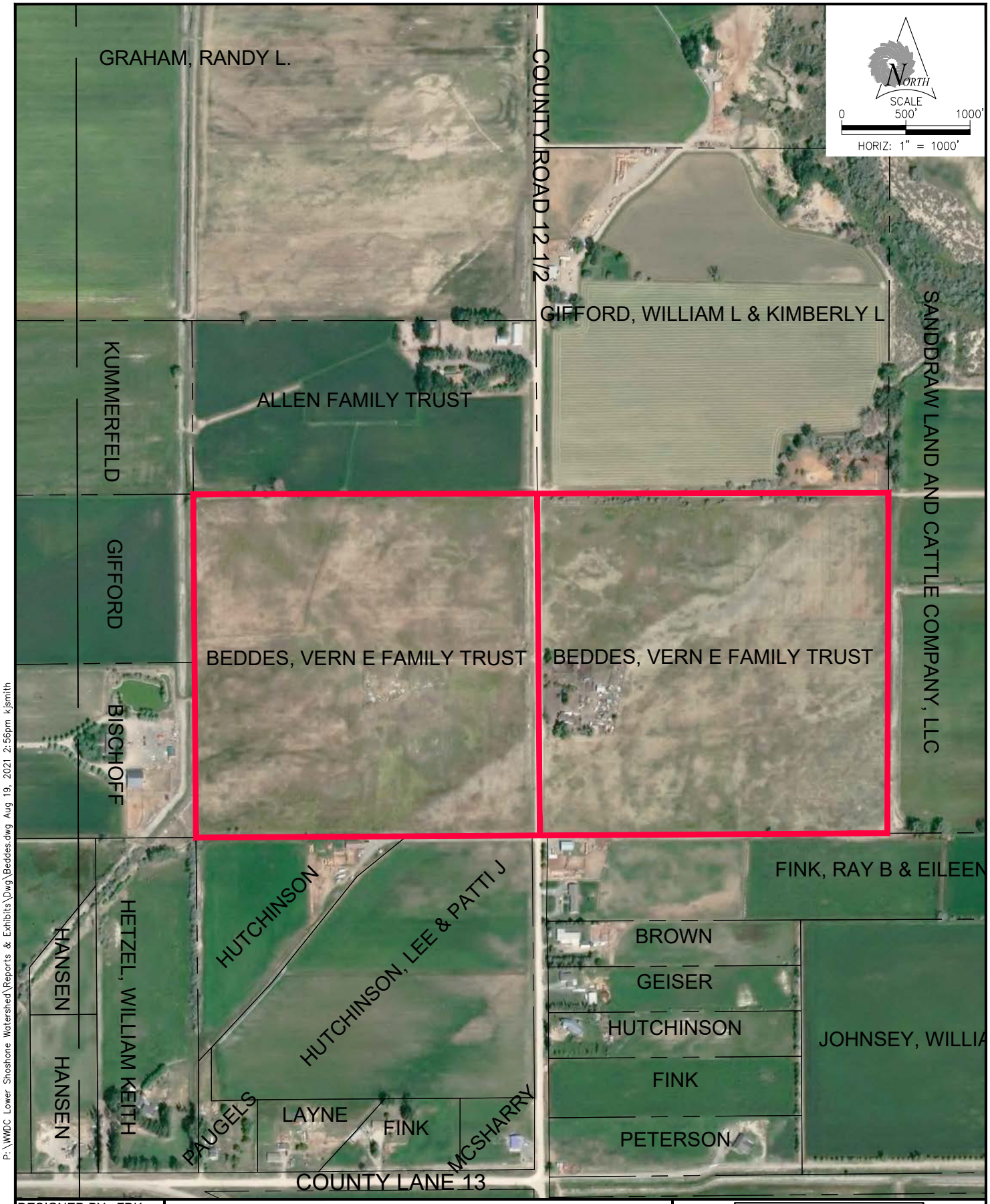
Project ID #:	65 & 66	
Owner/Operator:	**Beddes**	
Site Name:		
Type Of Project:	Pivot Irrigation	
Land Jurisdiction:	Private	
Location:	44.81637N	-108.36523W

Project Description

Statement of Purpose and Need: Beddes has not been contacted - Vance Leithead suggested these two center pivot projects each on about a 40 acre parcel.
Proposed Project: Install two 40 acre pivots. The center pivot portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable
State Engineers Office: No Permitting
Wyoming Office of State Lands: Not applicable
Wyoming Department of Environmental Quality: Not applicable
Bureau of Land Management: None
Other Land owners: None



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Beddes.dwg Aug 19, 2021 2:56pm kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 8/10/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#65 & #66 BEDDES (CENTER PIVOT)
LOCATED IN SECTION 24 T56N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 65
Owner/Operator: **Beddes**
Site Name:
Type Of Project: Pivot Irrigation

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$750.00	$750
2	Traffic Control	1	L.S.	$0.00	$0
3	Headgate	5	Cu, Yd,.	$500.00	$2,500
4	Replace ditch with 12" Gated Pipe*	1,000	L.F.	$16.00	$16,000
5	8-inch PVC SDR 18 Pipe*	500	L.F.	$26.00	$17,680
6	Center Pivot Pump*	1	L.S.	$10,000.00	$10,000
7	Center Pivot Electrical*	1	L.S.	$5,000.00	$5,000
8	Center Pivot*	1	L.S.	$38,000.00	$38,000.00
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$89,930**

INCIDENTAL PROJECT COSTS

Construction Permits	$500
Performance Bond	$900
Insurance	$500
15% O&P	$13,490
Subtotal 1	**$15,390**
Subtotal 2	**$105,320**
Construction Engineering @ 10% of Subtotal #2	$10,532
Subtotal 3	**$115,851**
Contingency @ 15% of Subtotal #3	$17,378
Total Construction Cost	**$133,229**
Preparation of Final Designs and Specifications	$10,658
Permitting @ 5% of Project Cost	$6,661
Legal @ 4% of Project Cost	$5,329
Environmental Study	Fill In
Total Project Cost	**$155,878**

Project ID #:	67
Owner/Operator:	**Schwope, Michelle**
Site Name:	Newton Pasture Ditch
Type Of Project:	Ditch to Pipe
Land Jurisdiction:	Private
Location:	44.89617 N -108.52065 W

Project Description

Statement of Purpose and Need: Existing cement lined ditch is damaged and leaks. Ditch conveys water to two additional neighbors.
Proposed Project: The proposed project will remove the ditch and replace with gated pipe. The gated pipe portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

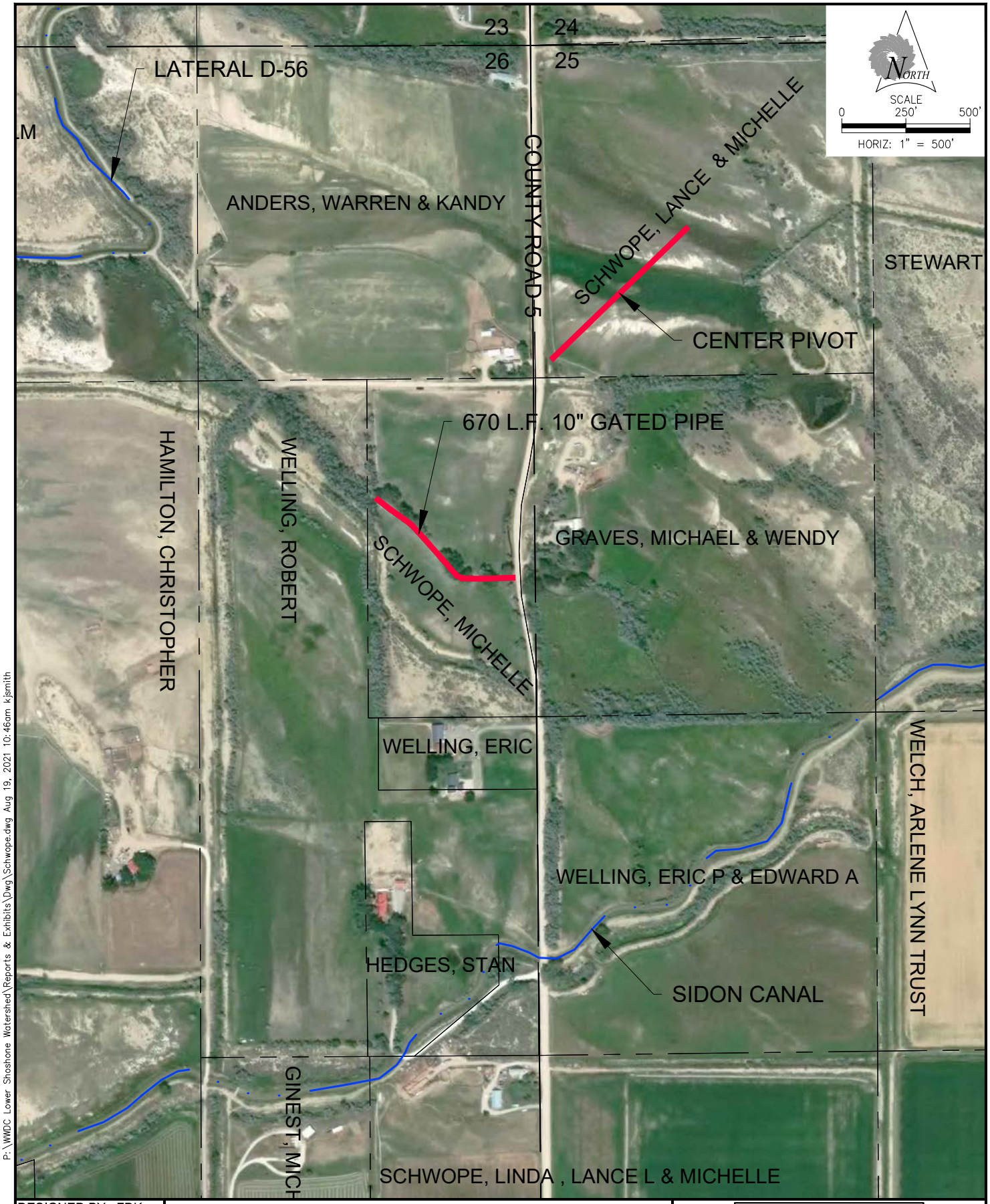
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Not applicable

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Schwope.dwg Aug 19, 2021 10:46am kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#67 MICHELLE SCHWOPE (GATED PIPE LATERAL)
LOCATED IN SECTION 26 T57N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 67
Owner/Operator: **Schwope, Michelle**
Site Name: Newton Pasture Ditch
Type Of Project: Ditch to Pipe

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$400.00	$400
2	Traffic Control	1	L.S.	$0.00	$0
3	Furnish and install 10" Gated Pipe*	670	L.F.	$8.00	$5,360
4	Headgate	5	Cu.Yd.	$500.00	$2,500
				Total Construction Cost	**$8,260**

* Item not eligible for SWPP funding

INCIDENTAL PROJECT COSTS

Construction Permits	$100
Performance Bond	$100
Insurance	$100
15% O&P	$1,239
Subtotal 1	**$1,539**
Subtotal 2	**$9,799**
Construction Engineering @ 10% of Subtotal #2	$980
Subtotal 3	**$10,779**
Contingency @ 15% of Subtotal #3	$1,617
Total Construction Cost	**$12,396**
Preparation of Final Designs and Specifications	$992
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$13,387**

SITE PHOTOS: Newton Pasture Ditch

Project ID #:	69
Owner/Operator:	**Flitner, Greg**
Site Name:	
Type Of Project:	Drains and Center Pivot
Land Jurisdiction:	Private
Location:	44.65919N -108.57219W

Project Description

Statement of Purpose and Need: Improve water use efficiency and reduce water losses from old ditch.
Proposed Project: Bury a north/south and east/west drain to install pivot for more efficient water distribution. Put in a center pivot and an underground ditch to get water to a neighbor. The center pivot portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

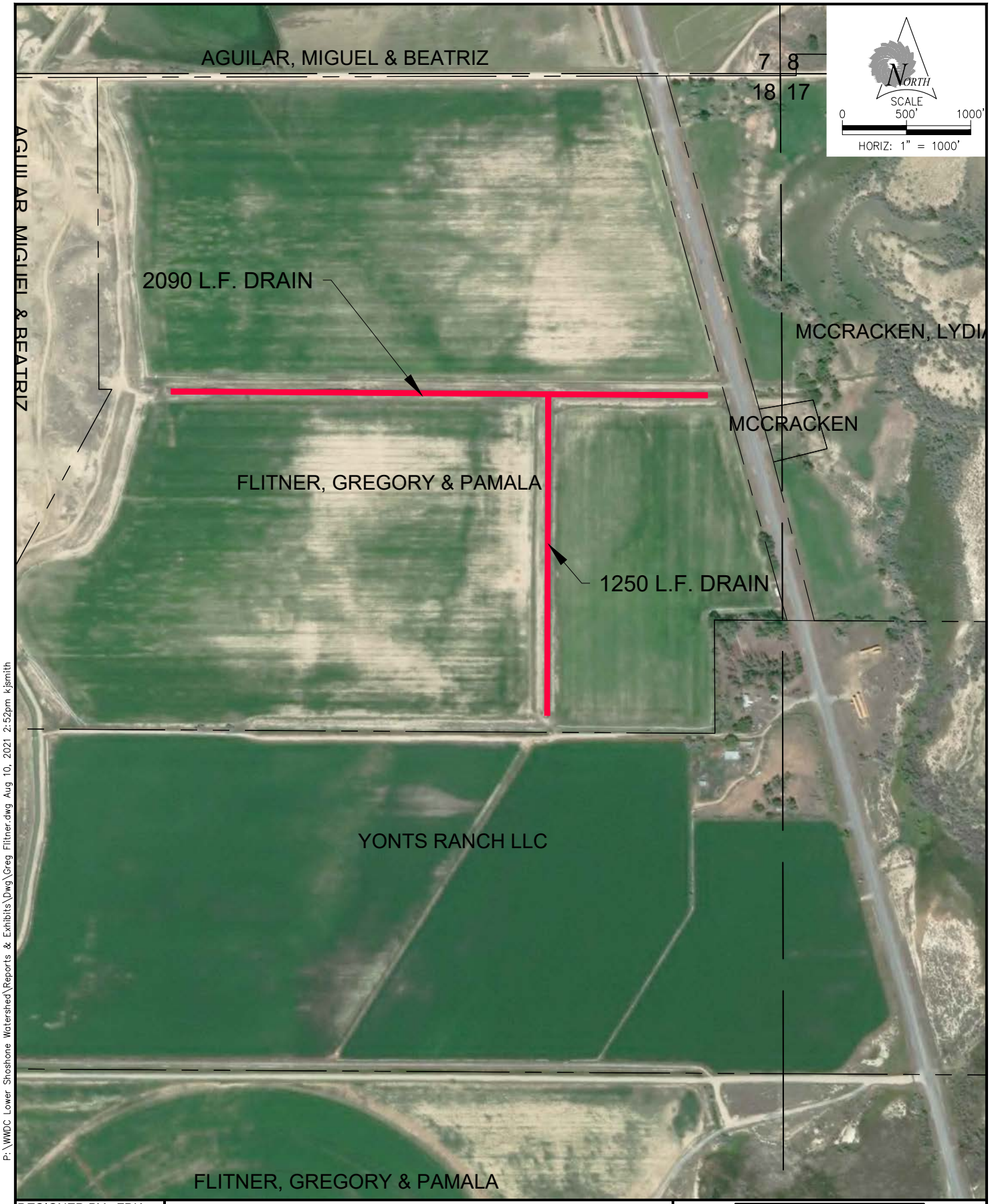
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Not applicable

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Greg Flitner.dwg Aug 10, 2021 2:52pm kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
#69 GREG FLITNER (DRAIN TILES)
LOCATED IN SECTION 18 T54N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	69
Owner/Operator:	**Flitner, Greg**
Site Name:	Flitner Fields
Type Of Project:	Drains and Center Pivot

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$750.00	$750
2	Traffic Control	1	L.S.	$0.00	$0
3	Furnish and Install Drain Pipe	3,340	L.F.	$12.00	$40,080
4	Furnish and Install Center Pivot*	1	L.S.	$38,000.00	$38,000
5	Headgate	5	Cu.Yd.	$500.00	$2,500
				Total Construction Cost	**$81,330**

* Item not eligible for SWPP funding

INCIDENTAL PROJECT COSTS

Construction Permits	$500
Performance Bond	$900
Insurance	$500
15% O&P	$12,200
Subtotal 1	**$14,100**
Subtotal 2	**$95,430**
Construction Engineering @ 10% of Subtotal #2	$9,543
Subtotal 3	**$104,972**
Contingency @ 15% of Subtotal #3	$15,746
Total Construction Cost	**$120,718**
Preparation of Final Designs and Specifications	$9,657
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$130,376**

SITE PHOTOS: Flitner Fields

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	70	
Owner/Operator:	**Wambeke, Paul**	
Site Name:		
Type Of Project:	Change Irrigation Method	
Land Jurisdiction:	Private	
Location:	44.89684N	-108.56065W

Project Description

Statement of Purpose and Need: Existing irrigation system is less than optimal with regard to efficiency. Change the method of irrigation by replacing existing bubbler system with more efficient center pivot.
Proposed Project: The proposed project will install a center pivot on about 62 acres. The center pivot portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

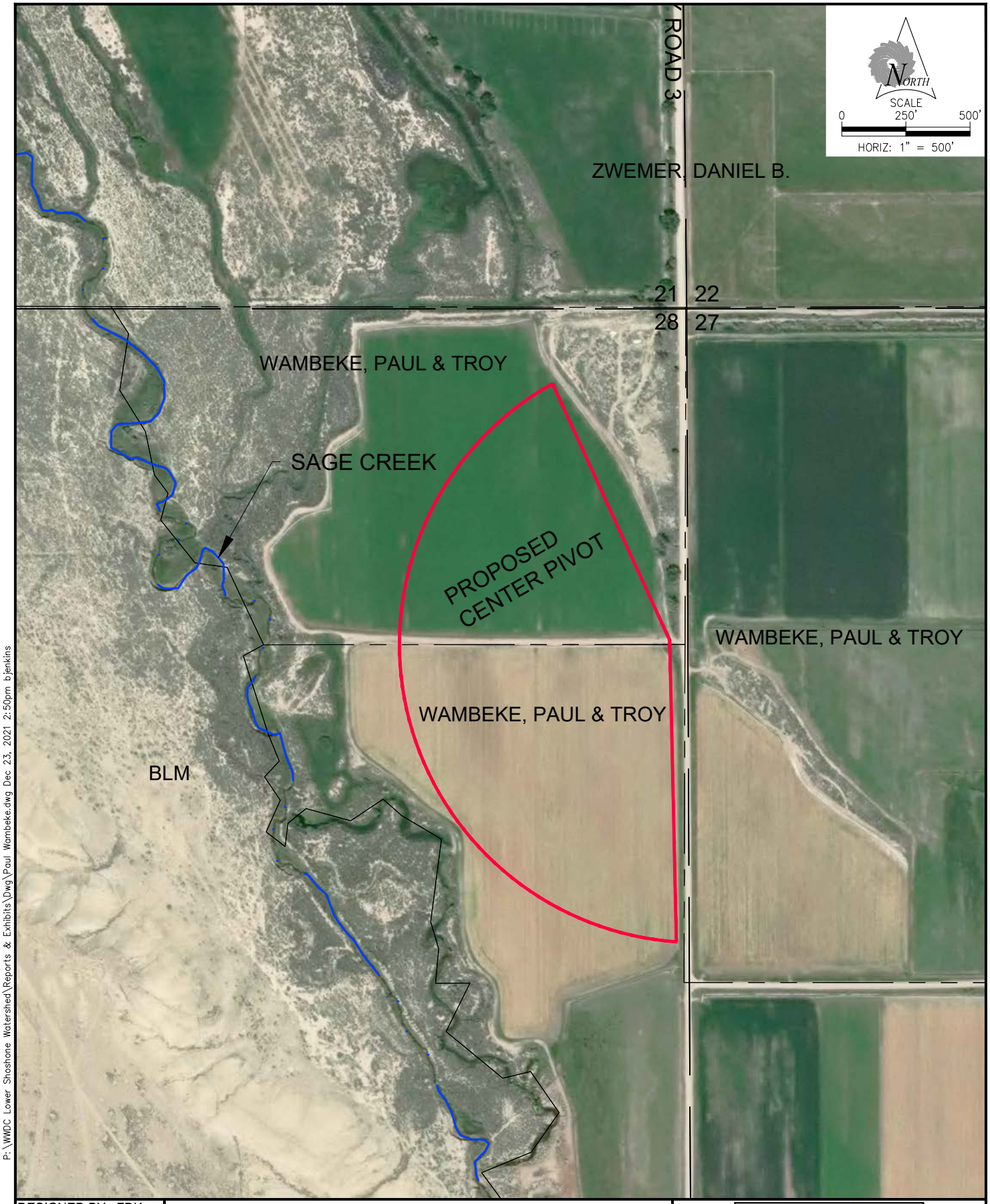
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: None

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Paul Wambeke.dwg Dec 23, 2021 2:50pm bjenkins

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#70 PAUL WAMBEKE (CENTER PIVOT)
LOCATED IN SECTION 27 T57N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 70
Owner/Operator: **Wambeke, Paul**
Site Name:
Type Of Project: Center Pivot

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$750.00	$750
2	Traffic Control	1	L.S.	$0.00	$0
3	Headgate	5	Cu, Yd,.	$500.00	$2,500
4	Install new wet well for Pump*	1	L.S.	$3,000.00	$3,000
6	Center Pivot Pump*	1	L.S.	$10,000.00	$10,000
7	Center Pivot Electrical*	1	L.S.	$6,000.00	$6,000
8	Center Pivot*	1	L.S.	$45,000.00	$45,000
				Total Construction Cost	**$67,250**

* Item not eligible for SWPP funding

INCIDENTAL PROJECT COSTS

Construction Permits	$400
Performance Bond	$700
Insurance	$400
15% O&P	$10,088
Subtotal 1	**$11,588**
Subtotal 2	**$78,838**
Construction Engineering @ 10% of Subtotal #2	$7,884
Subtotal 3	**$86,721**
Contingency @ 15% of Subtotal #3	$13,008
Total Construction Cost	**$99,729**
Preparation of Final Designs and Specifications	$7,978
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$107,708**

SITE PHOTOS:

Project ID #:	71
Owner/Operator:	**Traylor, Reba**
Site Name:	Island Access
Type Of Project:	Channel Crossing
Land Jurisdiction:	Private
Location:	

Project Description

Statement of Purpose and Need: Channel crossing to access 8 acre island in Shoshone River for purposes of livestock grazing and hunting.
Proposed Project: The proposed project is a standard NRCS channel crossing structure for hoofed animals. The crossing includes ramp grading on either side with 8" minus gravel bedding and surfacing material. This project is not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Big Horn County: Floodplain Development Permit

State Engineers Office: Not applicable

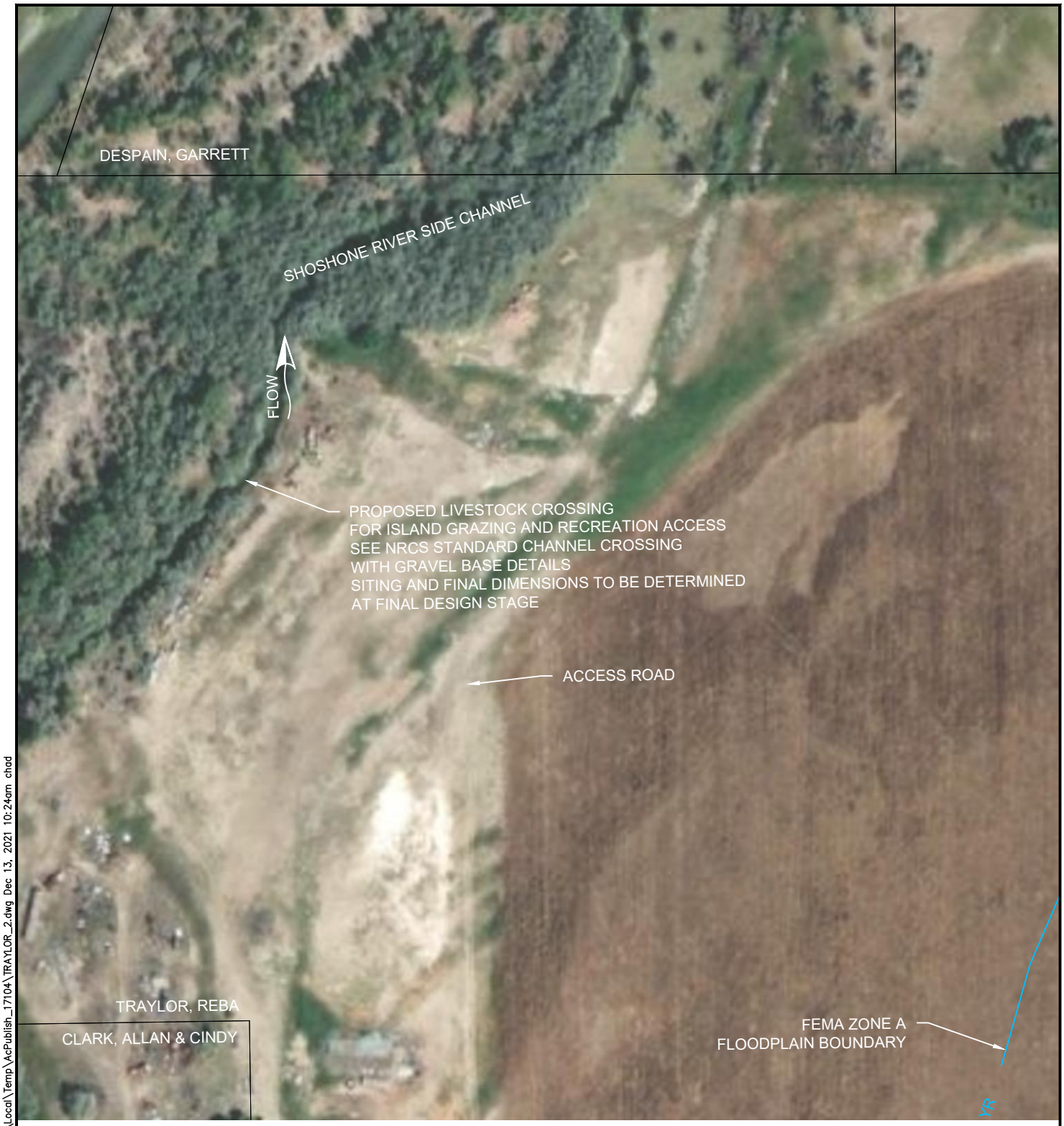
Wyoming Office of State Lands: Not applicable

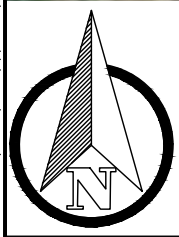
Wyoming Department of Environmental Quality: 401 Water Quality Certification

Bureau of Land Management: Not applicable

Army Corps of Engineers: 404 permit

Other Concerns





0' 75' 150' 300'

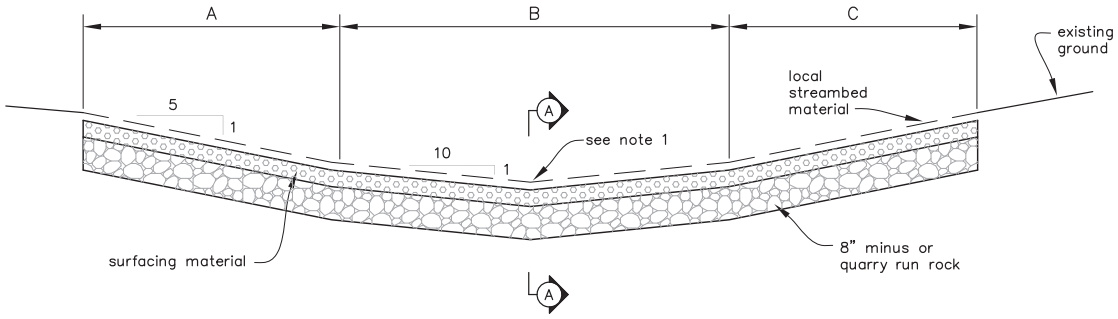
C:\Users\chad\AppData\Local\Temp\AcPublish_17104\TRAYLOR_2.dwg Dec 13, 2021 10:24am chad

DESIGNED BY: CB
DRAWN BY: CB
CHECKED BY: RC
DATE: 8/30/2021
REV:
SHEET: 1

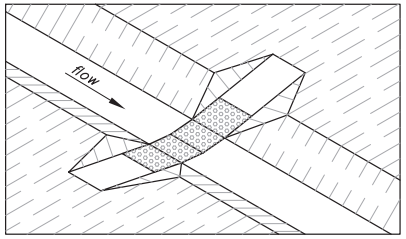
WWDC- LOWER SHOSHONE WATERSHED LEVEL 1 STUDY

REBA TRAYLOR (ISLAND ACCESS)
LOCATED IN SECTION 17 T56N R96W
BIG HORN COUNTY, WYOMING

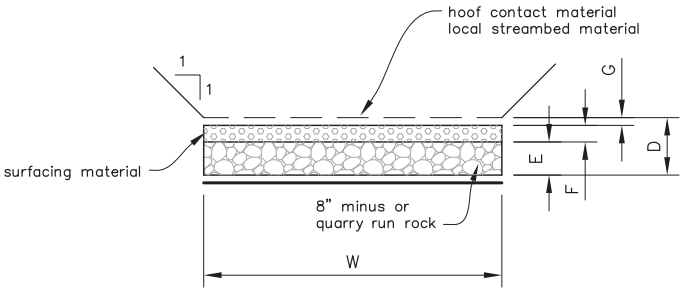
research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com



CENTERLINE PROFILE



ISOMETRIC



SECTION Ⓐ

DIMENSIONS

A = _____ (ft)

B = _____ (ft)

C = _____ (ft)

D = _____ (ft)

E = _____ (ft)

F = _____ (ft)

G = _____ (ft)

W = _____ (ft)

Station _____

CONSTRUCTION NOTES

1. Crossing surface shall be a minimum of 0.2 ft below channel invert.
2. Surfacing material shall be compacted as per method (4) of CS–15.6.
3. _____

NOTE: This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.

Drawing not to scale.

Date 8/05
Designed
Drawn
Checked
Approved
Title

CHANNEL CROSSING
GRAVEL BASE
LIVESTOCK FACILITIES

NRCS
Natural Resources Conservation Service
United States Department of Agriculture

File Name or_cattle_xing.dwg
Drawing No.
Sheet of

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	71
Owner/Operator:	**Traylor, Reba**
Site Name:	Island Access
Type Of Project:	Channel Crossing

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$5,000.00	$5,000
2	Ramp Grading*	74	C.Y.	$20.00	$1,481
3	Gravel Bedding*	24	C.Y.	$80.00	$1,956
4	Surfacing Material*	12	C.Y.	$80.00	$978
5	Replace Streambed Material*	7	C.Y.	$20.00	$140
6	Water Management*	1	L.S.	$3,000.00	$3,000
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$12,555**

INCIDENTAL PROJECT COSTS

Construction Permits	$100
Performance Bond	$200
Insurance	$100
15% O&P	$1,883
Subtotal 1	**$2,283**
Subtotal 2	**$14,838**
Construction Engineering @ 10% of Subtotal #2	$1,484
Subtotal 3	**$16,322**
Contingency @ 15% of Subtotal #3	$2,448
Total Construction Cost	**$18,770**
Preparation of Final Designs and Specifications	$2,816
Permitting @ 10% of Project Cost	$1,877
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$23,463**

SITE PHOTOS: Island Access

Project ID #:	72
Owner/Operator:	**Wambeke, Angie**
Site Name:	Estes 80
Type Of Project:	Irrigation Improvements
Land Jurisdiction:	Private
Location:	44.90127N -108.58845W

Project Description

Statement of Purpose and Need: Improve water delivery system to irrigate more efficiently. Current system consists of three pastures. One pasture has concrete ditch and tubes. One has a dirt ditch supply and the third has gated pipe.
Proposed Project: The proposed project will replace existing water system with more gated pipe and buried transmission line for a pivot system. The center pivot and gated pipe portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

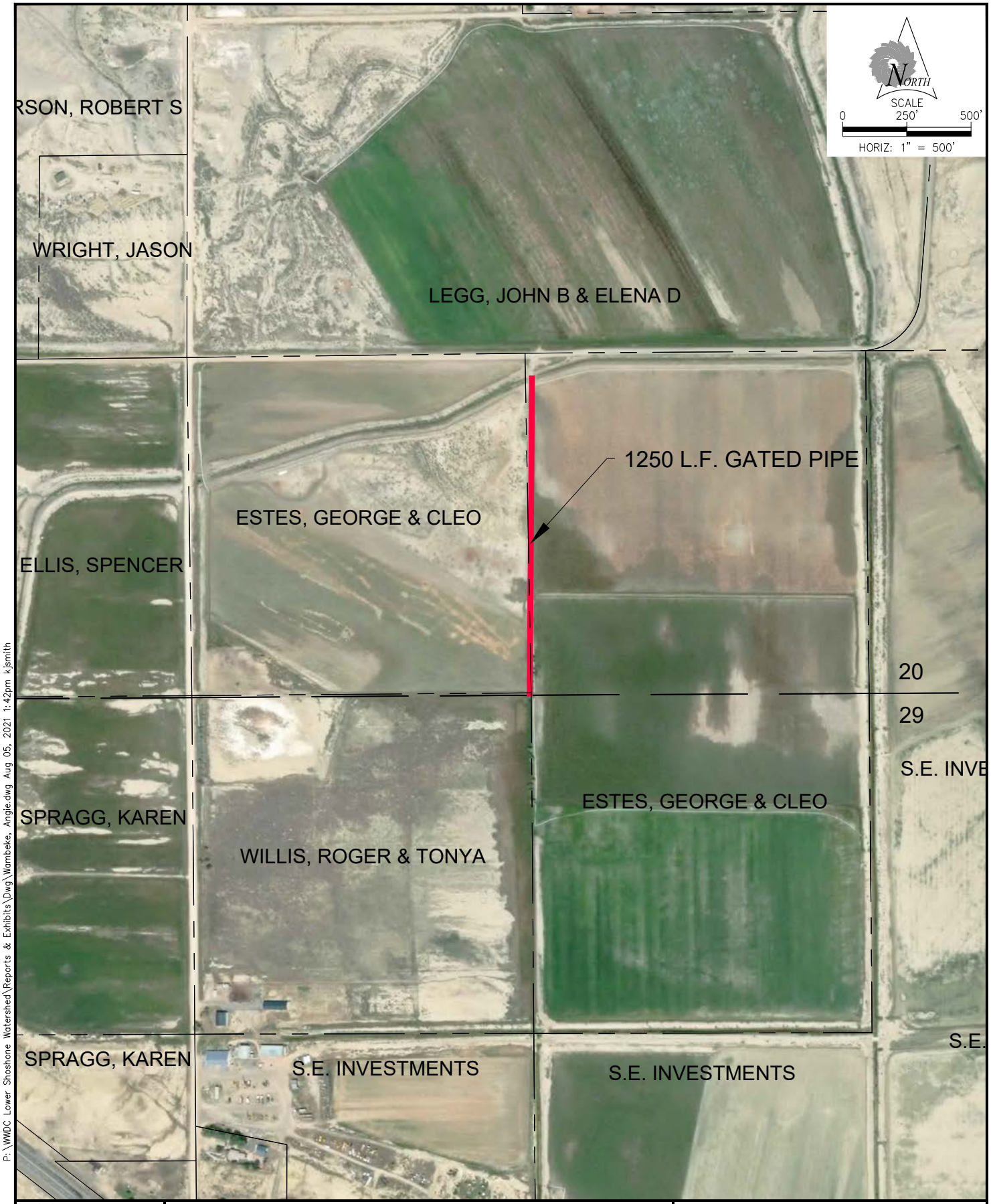
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Not applicable

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Wambeke, Angie.dwg Aug 05, 2021 1:42pm kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
#72 ANGIE WAMBEKE (GATED PIPE)
LOCATED IN SECTION 20 T57N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	72
Owner/Operator:	**Wambeke, Angie**
Site Name:	Estes 80
Type Of Project:	Irrigation Improvements

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	12" Water Line to Pivot	500	L.F.	$12.00	$6,000
5	12" Gated Pipe*	1,250	L.F.	$12.00	$15,000
6	Pivot Sprinkler*	1	Each	$38,000.00	$38,000
				Total Construction Cost	**$61,000**

* Item not eligible for SWPP funding

INCIDENTAL PROJECT COSTS

Construction Permits	$400
Performance Bond	$700
Insurance	$400
15% O&P	$9,150
Subtotal 1	**$10,650**
Subtotal 2	**$71,650**
Construction Engineering @ 10% of Subtotal #2	$7,165
Subtotal 3	**$78,815**
Contingency @ 15% of Subtotal #3	$11,822
Total Construction Cost	**$90,637**
Preparation of Final Designs and Specifications	$7,251
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$97,888**

SITE PHOTOS: Estes 80

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	73	
Owner/Operator:	**Wambeke, Angie**	
Site Name:	Estes Corner 40	
Type Of Project:	Improve Drains	
Land Jurisdiction:	Private	
Location:	44.90131N	-108.88233W

Project Description

Statement of Purpose and Need: Improve drainage across field and on bottom of field to more efficiently move water to a different shared drain.
Proposed Project: The proposed project will bury the existing drain ditch across field and improve drainage on bottom of field.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

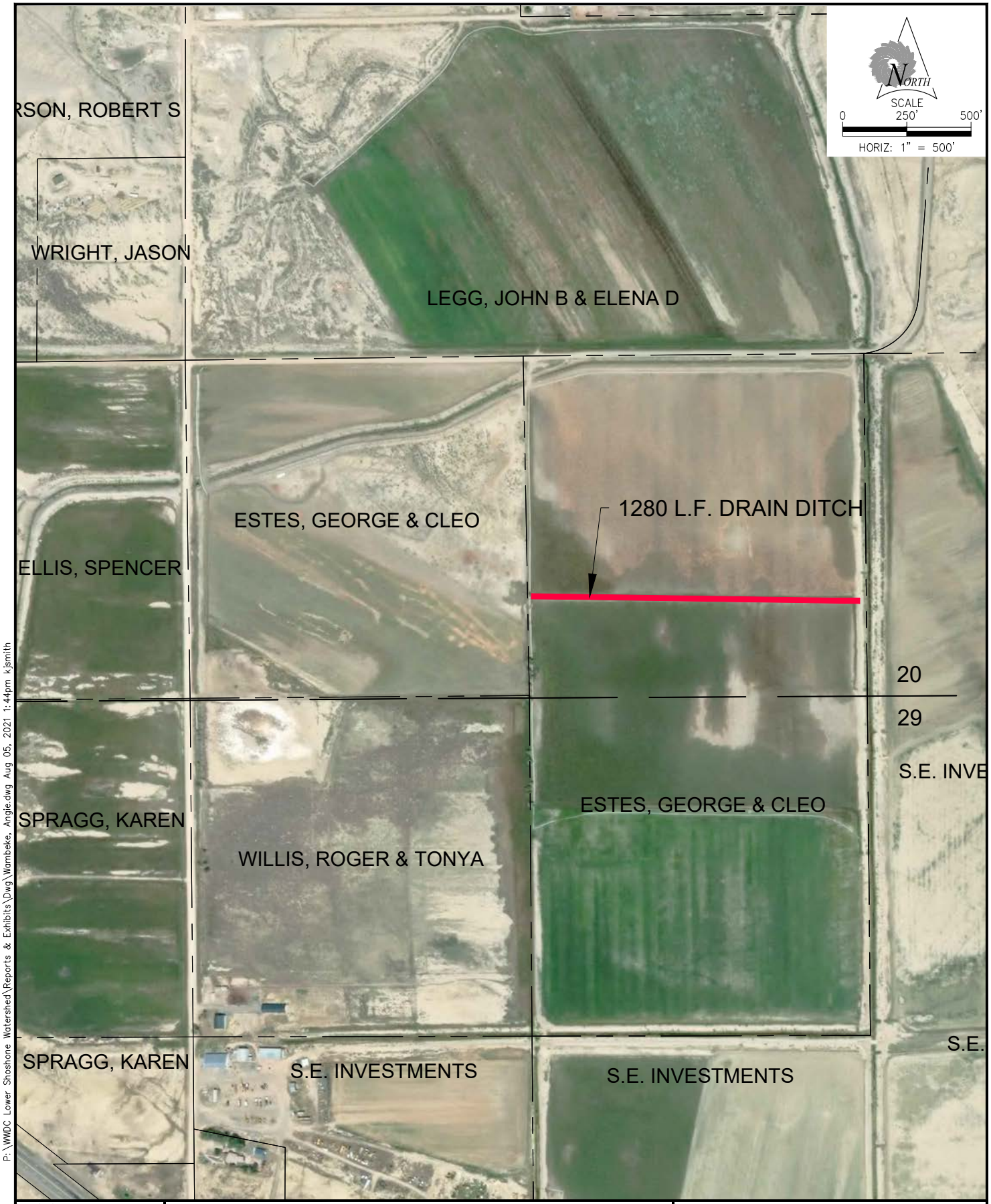
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Not applicable

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Wambeke, Angie.dwg Aug 05, 2021 1:44pm kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#73 ANGIE WAMBEKE (DRAIN DITCH,CENTER PIVOT)
LOCATED IN SECTION 20 T57N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	73
Owner/Operator:	**Wambeke, Angie**
Site Name:	Estes Corner 40
Type Of Project:	Improve Drains

ITEMIZED COST ESTIMATE

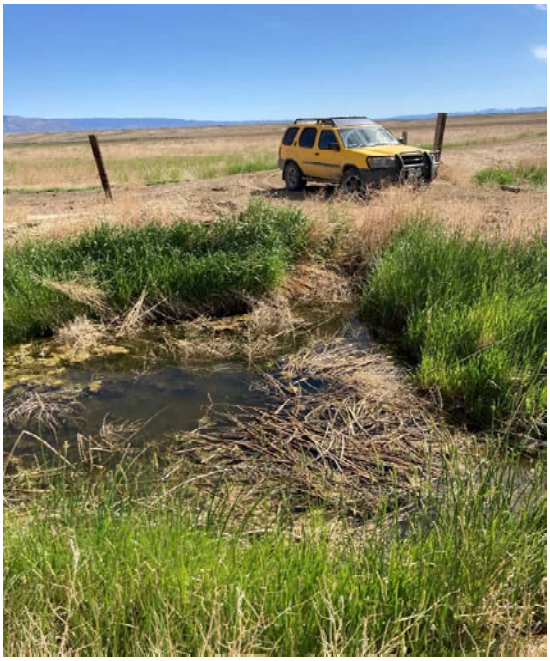
CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	Bury Existing Drain 6"	1,280	L.F.	$16.00	$20,480
				Total Construction Cost	**$22,480**

INCIDENTAL PROJECT COSTS

Construction Permits	$200
Performance Bond	$300
Insurance	$200
15% O&P	$3,372
Subtotal 1	**$4,072**
Subtotal 2	**$26,552**
Construction Engineering @ 10% of Subtotal #2	$2,655
Subtotal 3	**$29,207**
Contingency @ 15% of Subtotal #3	$4,381
Total Construction Cost	**$33,588**
Preparation of Final Designs and Specifications	$2,687
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$36,275**

SITE PHOTOS: Estes Corner 40



Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	74	
Owner/Operator:	**Wambeke, Angie**	
Site Name:	Estes Home Place	
Type Of Project:	Improve Drainage	
Land Jurisdiction:	Private	
Location:	44.88914N	-108.58095W

Project Description

Statement of Purpose and Need: Improve drainage across field to decrease salinity of soil in fields and re-establish pastures. North side has concavity because of historic manure buildup from cleaning corral. Detailed survey required to see if slope will provide increased drainage. Sprinklers could alleviate the need to flood and drain a complicated and flat topography. Lateral at Estes headgate is open ditch.
Proposed Project: The proposed project will install drains and remove an existing ditch.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Not Applicable

Other Land Owners: None

Other Concerns

P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Wambeke, Angie.dwg Aug 05, 2021 1:41pm kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#74 ANGIE WAMBEKE (DRAINS)
LOCATED IN SECTION 29 T57N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	74
Owner/Operator:	**Wambeke, Angie**
Site Name:	Estes Home Place
Type Of Project:	Improve Drainage

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	Install Drain and remove ditch	1,800	L.F.	$30.00	$54,000
				Total Construction Cost	**$56,000**

INCIDENTAL PROJECT COSTS

Construction Permits	$300
Performance Bond	$600
Insurance	$300
15% O&P	$8,400
Subtotal 1	**$9,600**
Subtotal 2	**$65,600**
Construction Engineering @ 10% of Subtotal #2	$6,560
Subtotal 3	**$72,160**
Contingency @ 15% of Subtotal #3	$10,824
Total Construction Cost	**$82,984**
Preparation of Final Designs and Specifications	$6,639
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$89,623**

SITE PHOTOS: Estes Home Place

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	75	
Owner/Operator:	**Wambeke, Angie**	
Site Name:	Home Place	
Type Of Project:	Ditch to Pipeline	
Land Jurisdiction:	Private	
Location:	44.88514N	-108.58386W

Project Description

Statement of Purpose and Need: Project will convert ditch to 15-inch pipe and recontour a field to improve irrigation flow and allow irrigation from one side rather than three.
Proposed Project: The proposed project will pipe from the ditch diversion to an existing distribution box then along the north and east sides of the house to reach the gated pipe on the north end of the field. A portion of the 30 acre field will be regraded and a new drain installed on the south side. The on-farm (regrading) portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

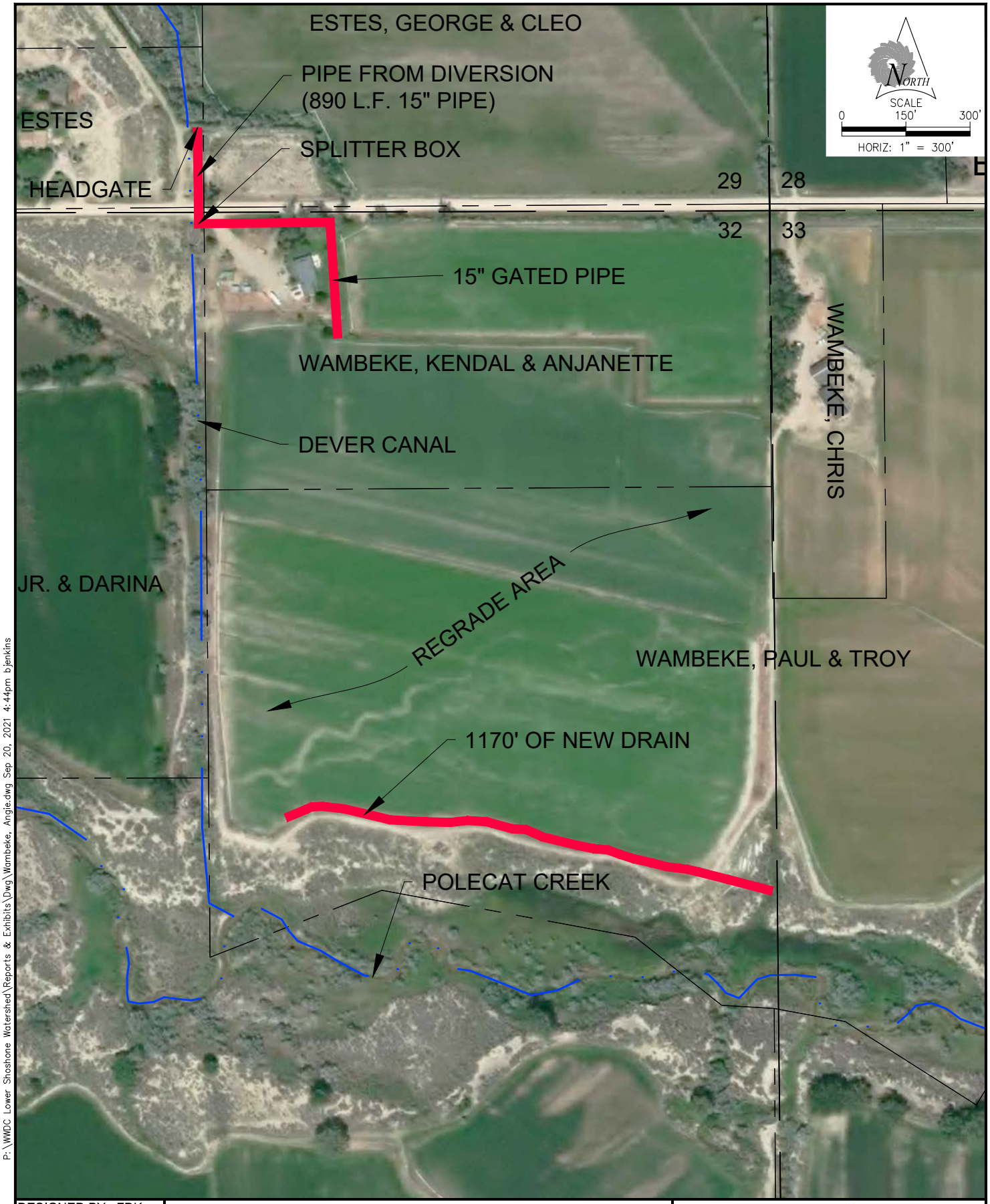
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Not applicable

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Wambeke, Angie.dwg Sep 20, 2021 4:44pm bjenkins

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
#75 ANGIE WAMBEKE (PIPE AND DRAIN)
LOCATED IN SECTION 29,& 32 T57N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota
SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	75
Owner/Operator:	**Wambeke, Angie**
Site Name:	Home Place
Type Of Project:	Ditch to Pipeline

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$1,000.00	$1,000
2	Traffic Control	1	L.S.	$200.00	$200
3	Connect to Existing Headgate	1	Each	$1,500.00	$1,500
4	Intake Valve	1	L.S.	$700.00	$700
5	Furnish and Install 15" Pipe	805	L.F.	$25.00	$20,125
6	Turnout Valve	2	Each	$1,500.00	$3,000
7	New Drainage Ditch	1,300	L.F.	$5.00	$6,500
8	Regrade Portion of Field to Facilitate Irrigation From North Side	72,000	S.Y.	$0.60	$43,200
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$76,225**

INCIDENTAL PROJECT COSTS

Construction Permits	$400
Performance Bond	$800
Insurance	$400
15% O&P	$11,434
Subtotal 1	**$13,034**
Subtotal 2	**$89,259**
Construction Engineering @ 10% of Subtotal #2	$8,926
Subtotal 3	**$98,185**
Contingency @ 15% of Subtotal #3	$14,728
Total Construction Cost	**$112,912**
Preparation of Final Designs and Specifications	$9,033
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$121,945**

SITE PHOTOS: Home Place

East side of house looking north

Mid-point distribution Box

Tie-in Headgate

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	78	
Owner/Operator:	**Ellis, Spencer and Casey**	
Site Name:	Lovell Canal Bench Lateral	
Type Of Project:	Bury Lateral	
Land Jurisdiction:	Private	
Location:	44.80774N	-108.416147W

Project Description

Statement of Purpose and Need: Convert Ditch To irrigation
Proposed Project: The proposed project will install 15" gated pipe to increase irrigated acreage. The gated pipe portions are not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

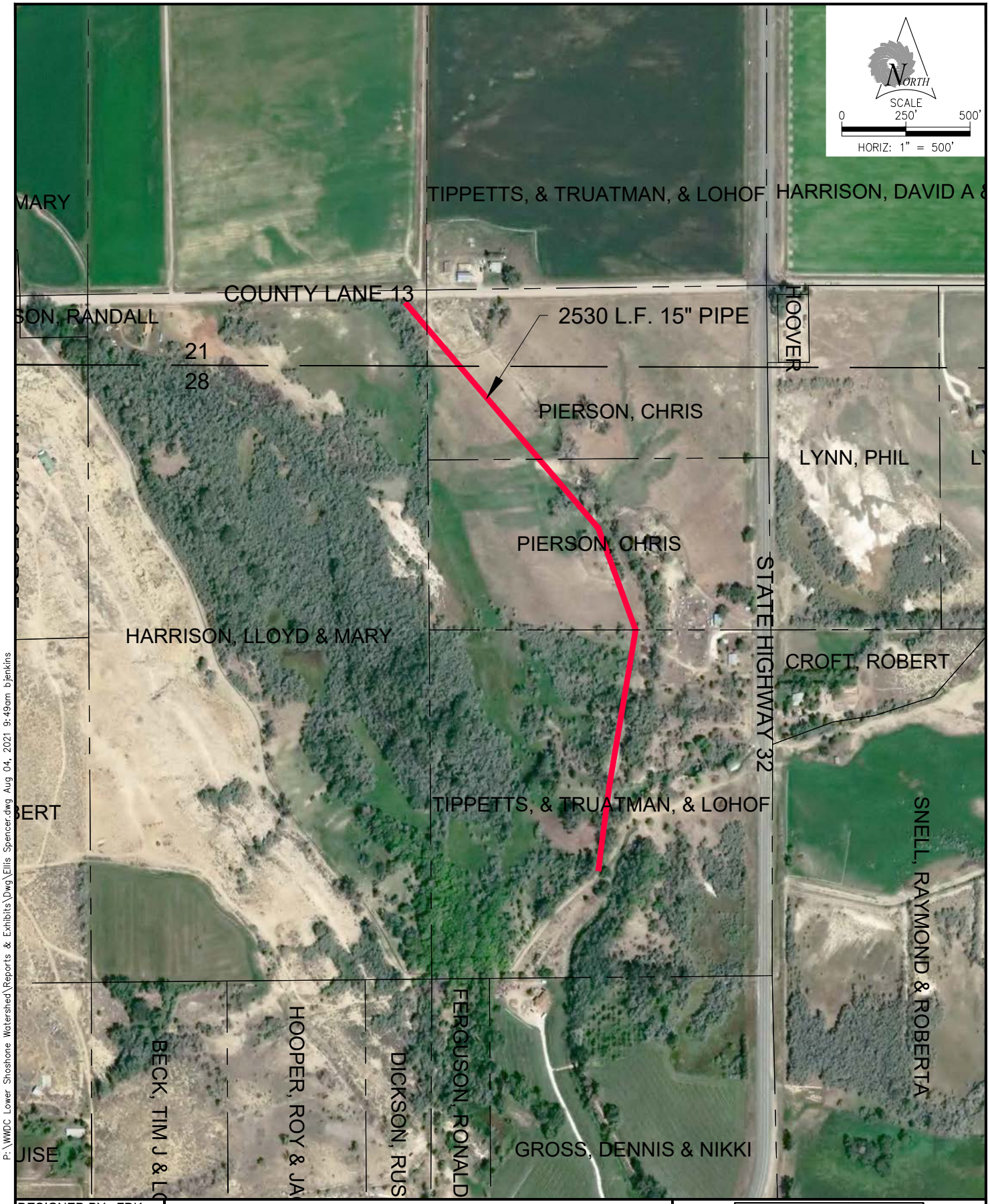
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Not Applicable

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Ellis Spencer.dwg Aug 04, 2021 9:49am bjenkins

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#78 SPENCER ELLIS (BURIED LATERAL)
LOCATED IN SECTION 21 & 28 T56N R95W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	78
Owner/Operator:	**Spencer, Ellis and Casey**
Site Name:	Lovell Canal Bench Lateral
Type Of Project:	Bury Lateral

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$750.00	$750
2	Traffic Control	1	L.S.	$0.00	$0
3	Furnish and Install 15" Gated Pipe*	1,000	L.F.	$12.00	$12,000
4	Headgate	5	Cu.Yd.	$500.00	$2,500
5	Tie into Pipe	1	Each	$250.00	$250
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$15,500**

INCIDENTAL PROJECT COSTS

Construction Permits	$100
Performance Bond	$200
Insurance	$100
15% O&P	$2,325
Subtotal 1	**$2,725**
Subtotal 2	**$18,225**
Construction Engineering @ 10% of Subtotal #2	$1,823
Subtotal 3	**$20,048**
Contingency @ 15% of Subtotal #3	$3,007
Total Construction Cost	**$23,055**
Preparation of Final Designs and Specifications	$1,844
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$24,899**

SITE PHOTOS: Lovell Canal Bench Lateral

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	79	
Owner/Operator:	**Blain, Zachery**	
Site Name:		
Type Of Project:	Extend Existing Pipe	
Land Jurisdiction:	Private	
Location:	44.81530 N	-108.43816W

Project Description

Statement of Purpose and Need: Conserve water and time by replacing existing soil ditches with pipe.
Proposed Project: The proposed project will extend an existing 12" gated pipe and connect to existing pipe. Gated pipe is not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

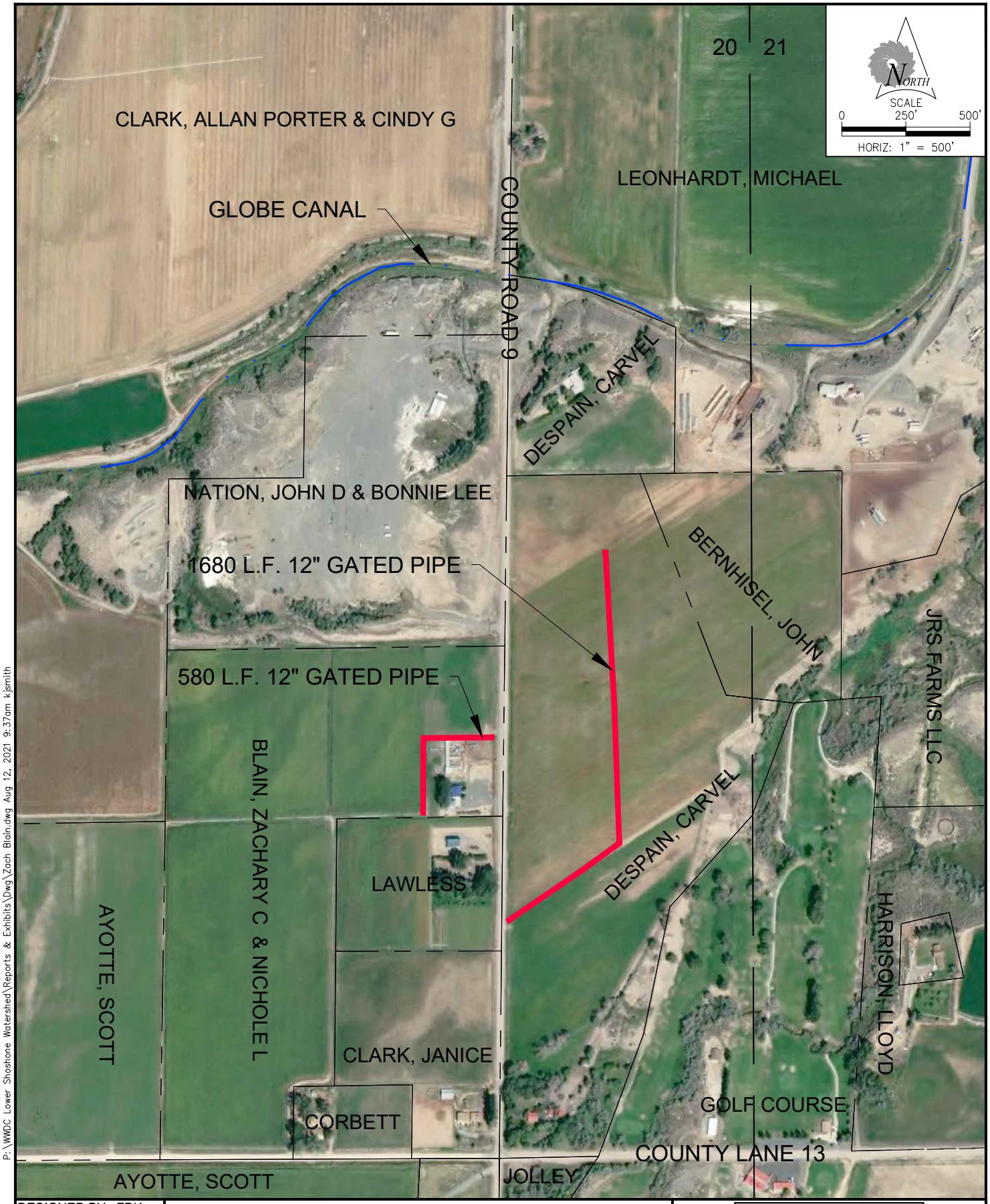
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Not applicable

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Zach Blain.dwg Aug 12, 2021 9:37am kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#42 & #79 ZACH BLAIN (BURIED LATERAL & REPLACE DITCHES)
LOCATED IN SECTION 20 T56N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 79
Owner/Operator: **Blain, Zachery**
Site Name:
Type Of Project: Pipe Extension

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$300.00	$300
2	Traffic Control	1	L.S.	$0.00	$0
4	Furnish and Install 12" Gated Pipe*	580	L.F.	$8.00	$4,640
5	Connect to Existing Pipe	1	L.S.	$1,500.00	$1,500
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$6,440**

INCIDENTAL PROJECT COSTS

Construction Permits	$100
Performance Bond	$100
Insurance	$100
15% O&P	$966
Subtotal 1	**$1,266**
Subtotal 2	**$7,706**
Construction Engineering @ 10% of Subtotal #2	$771
Subtotal 3	**$8,477**
Contingency @ 15% of Subtotal #3	$1,271
Total Construction Cost	**$9,748**
Preparation of Final Designs and Specifications	$780
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$10,528**

SITE PHOTOS:

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Project Description

Project ID #:	80
Owner/Operator:	**Blain, Zachary**
Site Name:	Moncour Lateral
Type Of Project:	Extend Current Pipeline
Land Jurisdiction:	Private
Location:	44.8153N -108.43816W

Project Description

Statement of Purpose and Need: Improve water levels for multiple users and reduce losses and erosion in existing ditches.

Proposed Project: The proposed project will install pipelines through existing splits across highway and county roads. Install flow measurement device to control canal split. The flow measurement portion is not eligible for SWPP funding. Please see the table below and refer to Section 6.3.4b for additional information on SWPP eligibility.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office: No Permitting

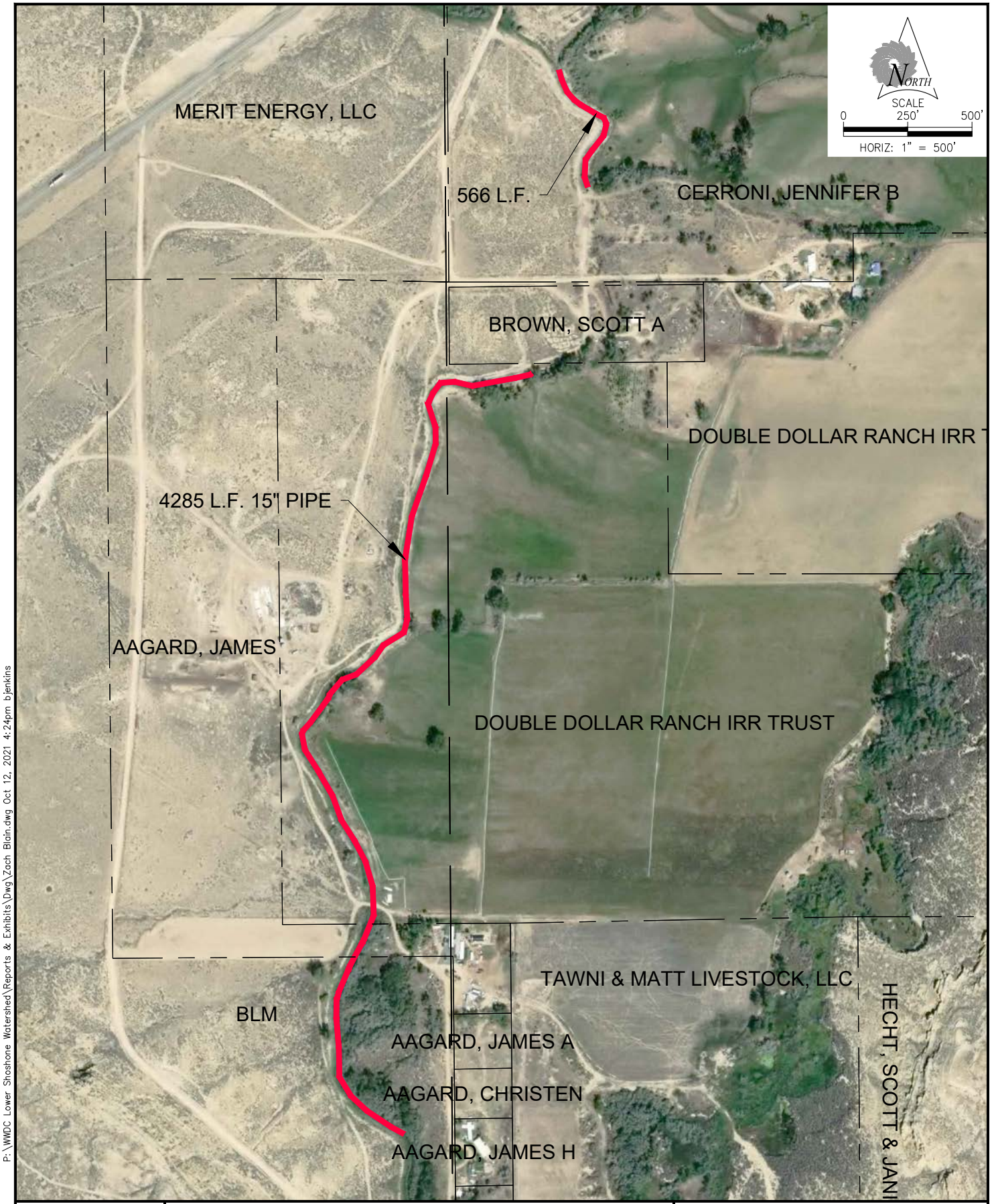
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Not applicable

Other Land Owners: None

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Zach Blain.dwg Oct 12, 2021 4:24pm bjenkins

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY
#80 ZACH BLAIN (CONTINUED BURIED LATERAL)
LOCATED IN SECTION 31 &32 T56N R96W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #:	80
Owner/Operator:	**Blain, Zachary**
Site Name:	Moncour Lateral
Type Of Project:	Extend Current Pipeline

ITEMIZED COST ESTIMATE

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$2,000.00	$2,000
2	Traffic Control	1	L.S.	$0.00	$0
3	Install 15" Pipeline	4,855	L.F.	$24.00	$116,520
4	Install Splitting Device*	1	L.S.	$2,000.00	$2,000
5	Headwall	5	Cu. Yd.	$500.00	$2,500
6	Connect to Existing pipe	1	Each	$1,500.00	$1,500
*	Item not eligible for SWPP funding			**Total Construction Cost**	**$124,520**

INCIDENTAL PROJECT COSTS

Construction Permits	$700
Performance Bond	$1,300
Insurance	$700
15% O&P	$18,678
Subtotal 1	**$21,378**
Subtotal 2	**$145,898**
Construction Engineering @ 10% of Subtotal #2	$14,590
Subtotal 3	**$160,488**
Contingency @ 15% of Subtotal #3	$24,073
Total Construction Cost	**$184,561**
Preparation of Final Designs and Specifications	$14,765
Permitting @ 5% of Project Cost	$0
Legal @ 4% of Project Cost	$0
Land Purchase	$0
Environmental Study	$0
Total Project Cost	**$199,326**

SITE PHOTOS: Moncour Lateral

Project ID #:	81
Owner/Operator:	**Hopkin, Fred**
Site Name:	Eagle Rock Transmission Pipe
Type Of Project:	Ditch Piping
Land Jurisdiction:	
Location:	44.78683N -108.49002W

Project Description

Statement of Purpose and Need: We divert water out of what is known as Sand Draw Creek to irrigate 80 acres below Eagle Rock. There was a concrete structure at the diversion point at what is known as Sokes Hole. The structure recently failed and collapsed into the creek. The water travels in an open ditch about 2,600 feet to the beginning of the field. Because of its proximity to Sand Draw and Shoshone River, it is hazardous to burn and maintain for fear of fire passing to a very vegetative area on the river.
Proposed Project: Bury the ditch in 12" PIP pipe and eliminate this troublesome ditch. In addition, reconstruct the failed concrete structure.

Permitting Requirements

Greater Sage-Grouse Core Area Protection: Not applicable

State Engineers Office:

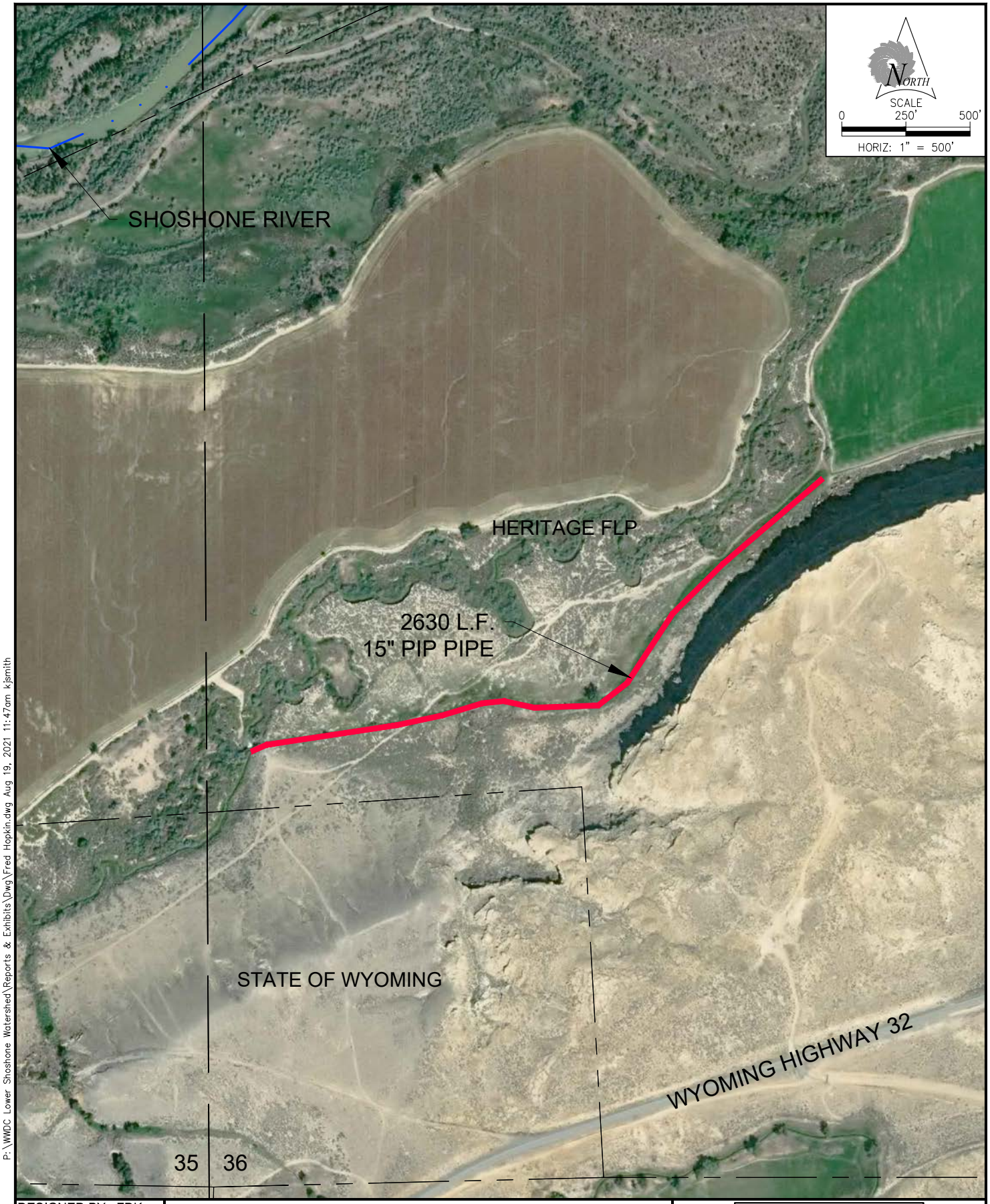
Wyoming Office of State Lands: Not applicable

Wyoming Department of Environmental Quality: Not applicable

Bureau of Land Management: Not applicable

Other Land Owners: Project crosses private lands and will require easement verification and permission and agreement.

Other Concerns



P:\WWDC Lower Shoshone Watershed\Reports & Exhibits\Dwg\Fred Hopkin.dwg Aug 19, 2021 11:47am kjsmith

DESIGNED BY: FDK
DRAWN BY: BJ
CHECKED BY: RVH
DATE: 7/26/2021
REV:
SHEET: 1

WWDC- LOWER SHOSHONE WATERSHED
LEVEL 1 STUDY

#81 FRED HOPKIN (BURIED LATERAL)
LOCATED IN SECTION 35 T56N R97W
BIG HORN COUNTY, WYOMING

research & consulting inc.
Biota

SUNRISE ENGINEERING
www.sunrise-eng.com

Lower Shoshone Watershed Study Level I

Watershed Improvement Project

Engineer's Opinion of Probable Construction Costs

Project ID #: 81
Owner/Operator: **Hopkin, Fred**
Site Name: Eagle Rock Transmission Pipe
Type Of Project: Ditch Piping

CONSTRUCTION COSTS

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	L.S.	$5,000.00	$5,000
2	Traffic Control	1	L.S.	$0.00	$0
3	Clearing and Grubbing Alignment	1	L.S.	$1,500.00	$1,500
4	Furnish and Install 15-inch PVC P.I.P. Type Pipe DR 41	2,630.0	L.F.	$22.00	$57,860
5	Reconstruct Diversion Structure Concrete	10	C.Y.	$600.00	$6,000
6	Furnish and Install Knife Gate Valve	2	Each	$600.00	$1,200
7	Outlet Rip-Rap Splash Pad	2	C.Y.	$125.00	$250
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
				Total Construction Cost	**$71,810**

INCIDENTAL PROJECT COSTS

Construction Permits	$400
Performance Bond	$800
Insurance	$400
15% O&P	$10,772
Subtotal 1	**$12,372**
Subtotal 2	**$84,182**
Construction Engineering @ 10% of Subtotal #2	$8,418
Subtotal 3	**$92,600**
Contingency @ 15% of Subtotal #3	$13,890
Total Construction Cost	**$106,490**
Preparation of Final Designs and Specifications	$8,519
Permitting @ 5% of Project Cost	$5,324
Legal @ 4% of Project Cost	$4,260
Environmental Study	Fill In
Total Project Cost	**$124,593**

SITE PHOTOS: Eagle Rock Transmission Pipe

Head of Ditch

End of ditch looking upstream

Continuation of ditch beyond project