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

Physical Address:
Wyoming Hall, Room 249
University of Wyoming
Laramie, WY 82071

Phone: (307) 766-6651
Fax: (307) 766-3785

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FINAL REPORT

BELLE FOURCHE RIVER WATERSHED STUDY

BASIN WIDE WATERSHED MANAGEMENT PLAN

Topical Report RSI-2501

prepared for

Wyoming Water Development Commission
6920 Yellowtail Road
Cheyenne, Wyoming 82002

March 2015

RESPEC

FINAL REPORT

BELLE FOURCHE RIVER WATERSHED STUDY

BASIN WIDE WATERSHED MANAGEMENT PLAN

Topical Report RSI-2501

by

RESPEC
P.O. Box 725
Rapid City, South Dakota 57709

and

Anderson Consulting Engineers, Inc.
375 Horsetooth Road, Building #5
Fort Collins, Colorado 80525

prepared for

Wyoming Water Development Commission
6920 Yellowtail Road
Cheyenne, Wyoming 82002

March 2015

I hereby certify that this report was prepared by us or under our direct supervision and that we are duly licensed Professional Geologists and Engineers under the laws of the State of Wyoming.

Crystal M. Hocking, P.G.

Cory S. Foreman, P.E.

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1.0 INTRODUCTION

1.1 INTRODUCTION

In 2012, the Crook County Natural Resources District (CCNRD), Campbell County Conservation District (CCCD), and Crook County Irrigation District (CCID) requested that the Wyoming Water Development Commission (WWDC) conduct a comprehensive study of the Belle Fourche River Watershed and its water resources. The local sponsors requested that the Level I watershed study evaluate watershed function; assess wetland and riparian conditions; develop geomorphic classifications; and identify resource concerns and water development opportunities on irrigated lands, rangelands, wetlands, and streams. In 2013, the WWDC approved funding for the watershed study and then contracted with RESPEC and its subconsultant, Anderson Consulting Engineers, Inc. (ACE), to provide technical and professional services for the Belle Fourche River Watershed Study, Level I, in June 2013.

1.2 OVERVIEW

The Belle Fourche River Watershed Study, Level I, is a comprehensive evaluation and an initial inventory of the water and land resources within the study area. This Level I watershed study provides important information that the CCNRD, CCCD, and CCID (the study's local sponsors) and the WWDC (the study's sponsor), could use in developing water resources and implementing conservation practices that address water and land resource concerns within the study area. This watershed study includes in-depth descriptions about needed water development projects that could provide economic, ecological, and social benefits to the state of Wyoming and its citizens.

Because of the size and variability of the study area for the Belle Fourche River Watershed, as shown in Figure 1.1, the final reports for the watershed were separated into this basin-wide summary report and a final report was completed for each of the three subareas or subbasins. The terms "watershed" and "study area" are used interchangeably throughout this study and associated reports. The "subarea" and "subbasin" terms are also used interchangeably in these reports. This basin-wide summary report was completed for the study area and includes data and information regarding the overall study area along with inclusion of all three of the subbasin reports and watershed management plan and rehabilitation components. Throughout these reports, mention will be made where more specific information can be found within the subbasin reports or the basin-wide summary report where appropriate.

These reports, accompanied by the "digital library" and Geographic Information System (GIS) geodatabase, are intended to provide the results of the Belle Fourche River Watershed Study, Level I. This effort included reviewing previous work contained in numerous databases,

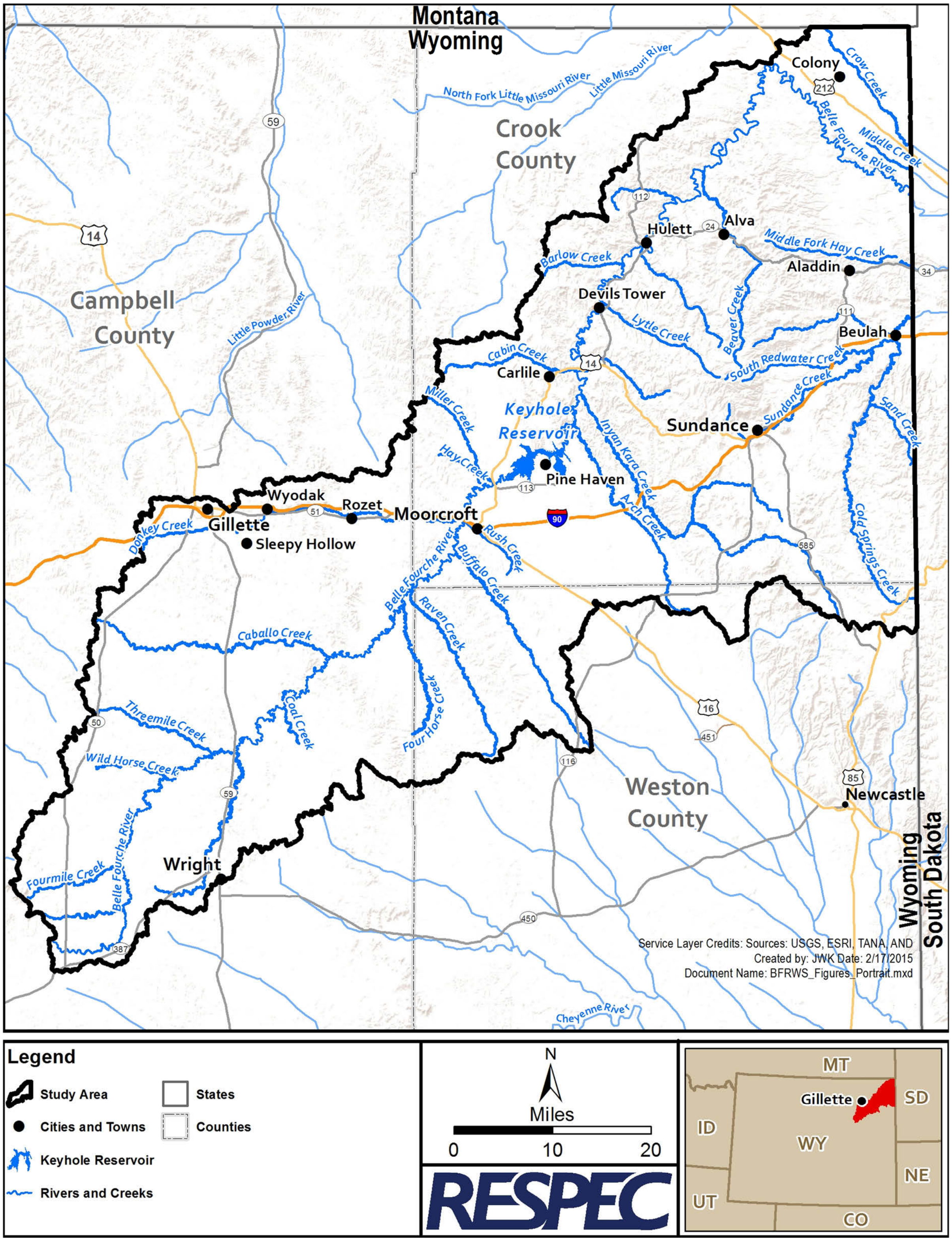

Figure 1.1. Study Area for the Belle Fourche River Watershed Study, Level I.

studies, and reports regarding the natural resources within the study area. Additionally, the information that was reviewed and determined to be relevant to the study's purpose was compiled into the digital library and GIS geodatabase. Information in the digital library was combined with the data collected during the inventory effort and used to generate proposed conceptual alternatives outlined in Chapter 4.0 of this report, titled *Belle Fourche River Watershed Management and Rehabilitation Plan*.

1.2.1 What Is a Watershed Study?

A watershed is defined in the Merriam-Webster Dictionary as "a region or area bounded peripherally by a divide and draining ultimately to a particular watercourse or body of water" [Merriam-Webster, 2013]. The *Operating Criteria of the Wyoming Water Development Program*, [WWDC, 2011a] describes watershed studies as the following:

> *These studies provide a detailed evaluation of an individual watershed. The studies may identify water development and system rehabilitation projects as well as address erosion control, flood control or other non-water development related environmental issues. Watershed improvement studies are an integral part of the Small Water Project Program, which has its own specific criteria. The studies may identify projects that may be eligible for the New Development, Rehabilitation, or Dam and Reservoir Programs.*

The *Operating Criteria of the Wyoming Water Development Program* describes Level I watershed studies as preliminary analyses and comparison of development alternatives, although the designation of a Level I watershed study is also used for master plans, watershed improvement studies, and other water planning studies [WWDC, 2011a]. However, a watershed study was best explained in an article titled, "Conservation and Watershed Studies. What's the Connection?" that appeared in the WWDC's *Water Planning News* Fall 2009 newsletter [WWDC, 2009a].

> *Today, conservation by watershed is an old concept with new horizons. Watersheds have long been recognized in the western United States for their significant natural resources and the interrelationships found contained in land areas connected by stream systems. These relationships were recognized by John Wesley Powell from his early expeditions of the west and resulted in proposed conservation, low density open grazing, irrigation systems and state boundaries based on watershed areas.*
>
> *The conservation concept developed over time to coalesce in the early 1930's with the formation of special districts whose boundaries were often based on watersheds. At that time the relationship between stream systems and landscape function was recognized. This relationship was broadened to embrace watershed condition and quality and its response to human influences. This further provided some understanding of the historic land use effect on watershed condition and*

how management and restoration needs to be based on local landscape characteristics.

Today, these relationships are embraced by the Wyoming Water Development Commission and Office through a watershed study program. On behalf of a local community sponsor, a watershed study can provide a comprehensive evaluation, analysis and description of the resources associated with a watershed and the watershed's water development opportunities. It is best stated that information related to the physical sciences is incorporated into a biological system.

There are three prominent issues that are important considerations in a watershed information review and study. The first is surface water storage. Surface water storage is often of significant interest to a watershed community in order to address seasonal and/or annual shortages of water supply, augment late season stream flow to benefit riparian habitat and wildlife, address flood impacts, enhance recreation opportunities, improve water quality and steam channel stability.

Second is the evaluation of irrigation infrastructure and development of information necessary to guide its rehabilitation. Of interest to local water users are ways to improve water delivery and on-farm irrigation efficiencies often timed to address annual or seasonal shortages of water supply or irrigation water delivery issues.

Third is the enhancement of upland water resources and distribution for livestock and wildlife that allows grazing management adjustments for range resource improvement. Benefits to the watershed, through plant community invigoration, reduction of erosion and stream channel stabilization, can be achieved from water development projects being strategically implemented over the watershed. Other issues and opportunities such as making beneficial use of produced water and removal of high water demand invasive species can also be important.

A watershed study, providing management and rehabilitation plans for water storage, irrigation systems and upland water development, can help empower a community to proactively enhance their watershed. Conservation by watershed can be an effective holistic approach to embracing the natural resource challenges and opportunities facing a community. A watershed study can provide the information to meet those challenges.

1.2.2 Study Area—Basin Wide

The study area for the Belle Fourche River Watershed encompasses the drainage area for the Belle Fourche River beginning at the headwaters of the river approximately 18 miles southwest of Wright, Wyoming, and flowing generally northeast where it crosses the Wyoming–South Dakota border approximately 10 miles northeast of Aladdin, Wyoming, as shown in Figure 1.1.

The Belle Fourche River Watershed is located in the upper portion of the Belle Fourche drainage. The entire Upper Belle Fourche drainage and portions of the Lower Belle Fourche and Redwater drainages within Wyoming define the study area. The study area includes the land draining to the Belle Fourche River and tributaries within Wyoming covering approximately 3,883 square miles (2,485,020 acres) in northeast Wyoming. The watershed is situated within Campbell County and Crook County with a small portion in Weston County and includes the cities, towns, and communities of Aladdin, Alva, Beulah, Carlile, Colony, Devils Tower, Gillette, Hulett, Moorcroft, Pine Haven, Rozet, Sleepy Hollow, Sundance, Wright, and Wyodak.

1.2.3 Study Area—Subbasins

In addition to the study area for the Belle Fourche River Watershed described in the previous section, three subbasins were identified based on the U.S. Geological Survey (USGS) 10th order "hydrologic units" classification which has an assigned Hydrologic Unit Code (HUC). The study area contains 15 watersheds (HUC-10) and are listed in Table 1.1. Reports for the following three subbasins within the study area were completed as part of this study:

- Belle Fourche River Watershed – Subbasin above Keyhole Reservoir
- Belle Fourche River Watershed – Subbasin below Keyhole Reservoir
- Belle Fourche River Watershed – Redwater Subbasin.

These three subbasins are illustrated in Figure 1.2 and are described in the following sections.

1.2.3.1 Subbasin Above Keyhole Reservoir

The Belle Fourche River Watershed – Subbasin above Keyhole Reservoir encompasses the drainage area for the Belle Fourche River beginning at the headwaters of the Belle Fourche River approximately 18 miles southwest of Wright, Wyoming, and flowing generally northeast where it enters Keyhole Reservoir, which is located on the Belle Fourche River approximately 6 miles northeast of Moorcroft, Wyoming. The Subbasin above Keyhole Reservoir includes all of the land draining to the Belle Fourche River and tributaries covering approximately 1,948 square miles or 1,246,950 acres in northeast Wyoming. This subbasin is the largest of the three subbasins and encompasses over 50 percent of the study area. The subbasin is mainly situated in Campbell County with smaller portions in Crook and Weston Counties. The Subbasin above Keyhole Reservoir includes the cities, towns, and communities of Gillette, Moorcroft, Pine Haven, Rozet, Sleepy Hollow, Wright, and Wyodak.

1.2.3.2 Subbasin Below Keyhole Reservoir

The Belle Fourche River Watershed – Subbasin below Keyhole Reservoir encompasses the drainage area for the Belle Fourche River beginning at the outlet of Keyhole Reservoir where it flows generally northeast to the Wyoming–South Dakota state line approximately 10 miles northeast of Aladdin, Wyoming. The Subbasin below Keyhole Reservoir includes all of the land draining to the Belle Fourche River and tributaries covering approximately 1,406 square miles or 900,050 acres in northeast Wyoming and encompasses approximately 36 percent of the study area. The subbasin is mainly situated in Crook County with smaller portions in Weston County, including the cities, towns, and communities of Alva, Carlile, Colony, Devils Tower, and Hulett.

Table 1.1. Watersheds (10th Order Hydrologic Unit Codes) by Subbasins in the Belle Fourche River Watershed Study Area

Hydrologic Unit Code	Watershed (HUC-10) Name	Study Subbasin	Acres	Square Miles
1012020101	Mud Spring Creek-Belle Fourche River	Above Keyhole Reservoir	225,640	352.6
1012020103	Caballo Creek	Above Keyhole Reservoir	166,640	260.4
1012020106	Donkey Creek	Above Keyhole Reservoir	163,250	255.1
1012020102	Hay Creek-Belle Fourche River	Above Keyhole Reservoir	180,190	281.5
1012020104	Buffalo Creek-Belle Fourche River	Above Keyhole Reservoir	299,180	467.5
1012020105	Wind Creek-Belle Fourche River	Above Keyhole Reservoir	212,050	331.3
Subtotal			**1,246,950**	**1,948.4**
1012020203	Owl Creek	Below Keyhole Reservoir	22,910	35.8
1012020201	Upper Belle Fourche River	Below Keyhole Reservoir	202,650	316.1
1012020202	Middle Belle Fourche River	Below Keyhole Reservoir	43,470	67.9
1012020107	Arch Creek-Belle Fourche River	Below Keyhole Reservoir	216,390	338.1
1012020108	Inyan Kara Creek	Below Keyhole Reservoir	215,330	336.5
1012020109	Blacktail Creek-Belle Fourche River	Below Keyhole Reservoir	199,300	311.4
Subtotal			**900,050**	**1,406.3**
1012020301	Upper Redwater Creek	Redwater	124,050	193.8
1012020304	Lower Redwater Creek	Redwater	53,790	84.0
1012020302	Sand Creek	Redwater	160,180	250.3
Subtotal			**338,020**	**528.2**
Total			**2,485,020**	**3,882.8**

1.2.3.3 Redwater Subbasin

The Belle Fourche River Watershed – Redwater Subbasin encompasses the Wyoming portion of the drainage area for Redwater Creek, including Cold Springs Creek, Sand Creek, and Sundance Creek. Also included in the Redwater Subbasin are the streams that drain portions of Wyoming, but do not converge with Redwater Creek within Wyoming. The Redwater Subbasin includes all of the land draining to Redwater Creek and tributaries covering approximately 528 square miles or 338,020 acres in northeast Wyoming. The Redwater Subbasin is the smallest of the three subbasins and encompassed less than 14 percent of the study area. The subbasin is mainly situated in Crook County with a small portion in Weston County, and includes the cities, towns, and communities of Aladdin, Beulah, and Sundance, Wyoming.

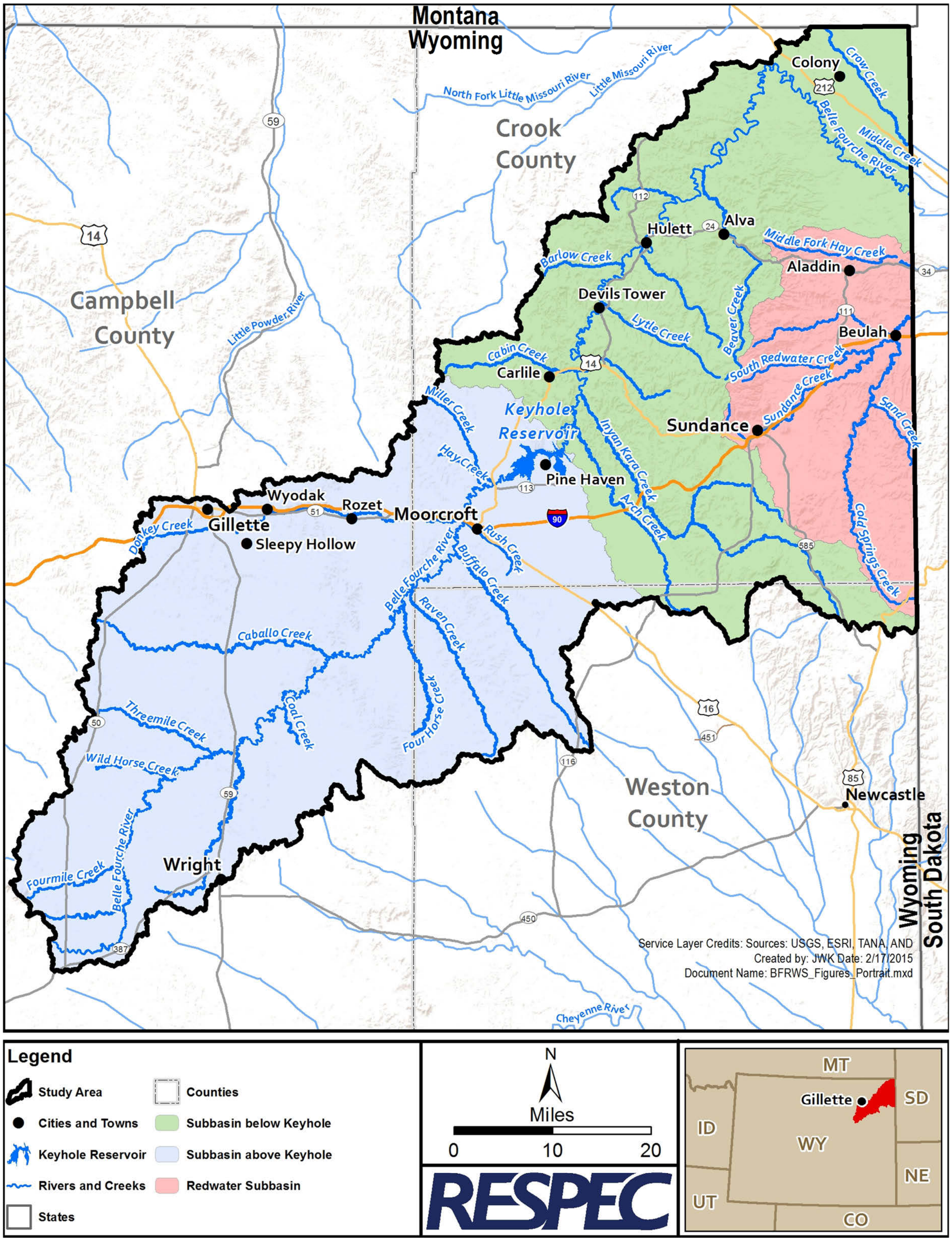

Figure 1.2. Belle Fourche River Watershed and Distinct Subbasins Within the Study Area.

1.3 STUDY ISSUES AND UNDERSTANDING

This Level I watershed study provides a comprehensive description and preliminary analysis of the Belle Fourche River Watershed and concludes with the Watershed Management and Rehabilitation Plan, which is included in Chapter 4.0 of this report. The plan outlines proposed alternatives that address water and land resource issues and concerns. The expectation of the local sponsors (CCNRD, CCCD, and CCID) and the WWDC was to identify water development opportunities within the study area. In developing the Watershed Management and Rehabilitation Plan, the consultant worked with the local sponsors, the WWDO and several study participants to address the following key issues within the watershed:

- Surface water availability and storage
- Irrigation system assessment and improvements
- Rangeland and grazing assessment and improvements
- Wetland and riparian area restoration and channel stability
- Invasive and noxious weed management.

1.4 PURPOSE AND SCOPE

The primary purpose of this Level I study was to combine all of the available, relevant data and information with the study-generated inventory data into a GIS geodatabase and digital library. In addition, a comprehensive watershed management and rehabilitation plan was to be developed that outlined the potential water development opportunities and watershed improvement alternatives. To accomplish this effort, the following objectives were completed:

- Foster communication among residents and landowners, local sponsors, and the WWDC.
- Solicit public participation in the watershed study.
- Perform a geomorphic classification of the major tributaries in the study area to identify impaired reaches and improvement options to restore channel stability.
- Assess existing irrigation systems and generate rehabilitation alternatives for the irrigators participating in the study.
- Evaluate existing surface water features, storage requirements, and potential opportunities to improve water availability for livestock and wildlife.
- Prepare a watershed management and rehabilitation plan that includes problem areas and proposes improvement alternatives within the watershed.
- Identify permits, easements, and clearances necessary for plan implementation.
- Estimate costs for proposed improvement alternatives and potential projects.
- Complete an economic analysis and identify potential sources of funding.

2.0 PROJECT MEETINGS

2.1 INTRODUCTION

Public involvement and landowner participation were an important element of the Belle Fourche River Watershed Study effort because of the amount and complexity of the water and land issues and concerns within the study area. Therefore, considerable emphasis and time was placed on this aspect of the study. The public involvement effort began in 2012 with the CCNRD, CCCD, CCID, and the WWDO coordinating activities for submitting a Watershed Study Level I application in 2012. RESPEC and ACE were awarded the contract in June 2013 and began gathering background information and preparing for planned scoping meetings.

2.2 SCOPING MEETINGS, OPEN HOUSES, AND LANDOWNER MEETINGS

2.2.1 Scoping Meetings, Landowner Open Houses, and Project Meetings

Scoping meetings, landowner open houses, landowner meetings, and on-site field visits were coordinated and conducted by RESPEC and ACE staff in cooperation with the CCNRD, CCCD, CCID, WWDO, and Natural Resources Conservation Service (NRCS). Table 2.1 lists the meetings conducted during the watershed study. Scoping meetings typically included formal presentations by RESPEC staff. The objectives of the scoping meetings included the following:

- Discuss the purpose, existing data, and available information for the watershed study
- Obtain input and opinions from residents and landowners about the study area
- Identify concerns and answer questions about the area's water and land resources
- Request participation in the study effort and coordinate inventory activities
- Present initial results and preliminary findings from the watershed study.

During the September 2013 scoping meetings in Gillette, Hulett, and Sundance, Wyoming, RESPEC representatives made presentations, summarized work, and outlined tasks. Draft maps generated with available GIS data were presented to inform attendees of the study's progress. Questions were answered during the meetings but most discussions occurred between the attendees and local sponsors and partners representatives after each of the scoping meetings. Landowner open houses were held in Sundance on February 28, and October 16, 2014; in Moorcroft on April 16, 2014; and in Gillette on April 17 and October 15, 2014. During the open houses, landowners discussed their concerns and potential projects with the consultant and representatives from CCNRD, CCCD, CCID, WWDO, or NRCS.

Table 2.1. Scoping, Landowner, Study, and Coordination Meetings (Page 1 of 2)

Number	Date	Type	Location
1	07/02/13	Local Sponsor Meeting	CCNRD Sundance Office
2	07/10/13	Local Sponsor Meeting	CCCD Gillette Office
3	07/18/13	Coordination Meeting	Campbell County GIS Gillette Office
4	07/30/13	Coordination Meeting	CCNRD, CCCD, CCID Conference Call
5	09/09/13	Coordination Meeting	CCNRD Sundance Office
6	09/16/13	Coordination Meeting	CCCD Gillette Office
7	09/16/13	Scoping Meeting	Campbell County Rec Center Gillette
8	09/17/13	Project Update/Status	Wyoming Association of Conservation Districts (WACD) Area I Meeting Wright
9	09/18/13	Scoping Meeting	Hulett Civic Center
10	09/19/13	Scoping Meeting	Sundance State Bank
11	10/16/13	Landowner Meeting	Canfield Ranch
12	01/09/14	Project Update/Status	Hulett Community Center
13	01/23/14	Landowner Meeting	Ellsbury Ranch
14	02/11/14	Landowner Meeting	CCNRD Sundance Office
15	02/28/14	Landowner Open House	Sundance State Bank
16	03/03/14	Project Update/Status	CCNRD Sundance Office
17	03/04/14	Landowner Meeting	RESPEC Spearfish Office
18	03/10/14	Local Sponsor Meeting	CCCD Gillette Office
19	03/10/14	Local Sponsor Meeting	CCID Hulett Community Center
20	04/07/14	Local Sponsor Meeting	CCCD/CCNRD Joint Meeting Moorcroft
21	04/16/14	Landowner Open House	Moorcroft Fire Department
22	04/17/14	Landowner Open House	Gillette Fire Department
23	04/18/14	Landowner Meeting	Keyhole Ranch
24	04/21/14	Landowner Meeting	Turgeon Ranch
25	04/22/14	Landowner Meeting	McNally Ranch
26	04/22/14	Landowner Meeting	Bush Ranch
27	04/22/14	Landowner Meeting	Yake Property
28	04/22/14	Landowner Meeting	Brown Property
29	04/23/14	Landowner Meeting	Erland Ranch
30	04/23/14	Landowner Meeting	Habeck Ranch
31	04/24/14	Landowner Meeting	Bishop Ranch
32	04/25/14	Coordination Meeting	CCNRD Sundance Office
33	04/25/14	Landowner Meeting	Driskill Ranch
34	04/25/14	Coordination Meeting	City of Sundance Office

Table 2.1. Scoping, Landowner, Study, and Coordination Meetings (Page 2 of 2)

Number	Date	Type	Location
35	05/20/14	Landowner Meeting	Shipwheel Ranch
36	05/20/14	Coordination Meeting	CCNRD Sundance Office
37	06/17/14	Landowner Meeting	McNally Ranch
38	07/10/14	Landowner Meeting	Williams Ranch
39	07/10/14	Landowner Meeting	Nieman 77 Ranch
40	07/10/14	Landowner Meeting	Ellsbury Ranch
41	07/22/14	Landowner Meeting	Keyhole Ranch
42	07/24/14	Coordination Meeting	CCNRD Sundance Office
43	08/20/14	Local Sponsor Meeting	CCCD Gillette Office
44	08/22/14	Landowner Meeting	Six T Nine Ranch
45	08/29/14	Landowner Meeting	Rourke Ranch
46	08/29/14	Landowner Meeting	Pearson Ranch
47	09/03/14	Landowner Meeting	Six T Nine Ranch
48	09/05/14	Landowner Meeting	Ellsbury Ranch
49	09/18/14	Landowner Meeting	RESPEC Spearfish Office
50	09/19/14	Landowner Meeting	CCCD Gillette Office
51	09/22/14	Landowner Meeting	Schlabach Ranch
52	09/22/14	Coordination Meeting	U.S. Forest Service (USFS) Bear Lodge Ranger District Office
53	10/03/14	Landowner Meeting	Keyhole Ranch
54	10/03/14	Landowner Meeting	Ellsbury Ranch
55	10/03/14	Coordination Meeting	CCNRD Sundance Office
56	10/10/14	Landowner Meeting	Empire Ranch
57	10/10/14	Landowner Meeting	Graham Ranch
58	10/13/14	Landowner Meeting	Ondriezek Ranch
59	10/15/14	Landowner Open House	CCCD Gillette Office
60	10/16/14	Landowner Open House	CCNRD Sundance Office
61	10/23/14	Landowner Meeting	Jensen Ranch
62	10/24/14	Landowner Meeting	Downey Ranch
63	10/24/14	Landowner Meeting	Altaffer Ranch
64	10/25/14	Landowner Meeting	Warbonnet Ranch
65	10/25/14	Landowner Meeting	Driskill Ranch
66	10/31/14	Landowner Meeting	Mule Shoe Ranch

RESPEC staff presented draft maps, explained initial findings, and described potential alternatives. Draft maps were generated using GIS data to update attendees of available information and data analysis progress. Similar to previous meetings, questions were answered throughout the open houses during informal discussions with landowners. In addition to the scoping meetings and landowner open houses, the CCID held its annual meeting at the Hulett Community Center on March 10, 2014, and invited representatives from RESPEC to present preliminary information and discuss potential alternatives for improving water storage and irrigation water delivery within the study area.

2.2.2 Landowner Meetings and Field Visits

During and following scoping meetings and landowner open houses, landowners interested in participating in the watershed study typically contacted the consultant, CCNRD, CCCD, or NRCS staff. Individual meetings with landowners were then scheduled at landowners' residences and properties where discussions focused on land and water resource concerns and issues specific to the landowner. Usually, the landowner gave a tour of the property to the consultant and was often accompanied by a representative from the CCNRD, CCCD, or NRCS. During these property visits, initial planning and conceptual project designs were discussed for upland livestock/wildlife and irrigation water improvements.

Field inventory efforts were often conducted in coordination with planned scoping meetings, landowner open houses, CCNRD and CCCD board meetings, and landowner visits. Field activities focused on irrigation inventory, upland livestock/wildlife water opportunities, riparian and stream channel conditions, dam and reservoir assessment, and hydrologic investigations. Throughout the watershed study, local ranchers, irrigators, and residents who invited the study team to visit their properties and discuss issues and concerns demonstrated extensive knowledge and valuable insight about the watershed. Because of the willingness of landowners to share information, insight, and direction, the study team was able to incorporate this knowledge and experience into the study and provide a more effective evaluation of the watershed.

3.0 WATERSHED DESCRIPTION AND INVENTORY

3.1 INTRODUCTION AND PURPOSE

A substantial amount of information exists about the land and water resources within the Belle Fourche River Watershed. The objective of the watershed description and inventory task was to gather, review, and compile data and findings in existing databases, studies, and reports regarding the resources within the study area into a digital library and GIS storage system. This material was then used to describe, characterize, and summarize key features; identify problems or issues; and outline water development opportunities and improvement alternatives within the watershed.

This description and inventory chapter covers many of the study area's natural resources including history, land use, land ownership, transportation, irrigation, energy, climate, hydrology, geology, soils, and vegetation. Brief reviews of the current conditions of natural resources in the area are also included. Specifically, the soil, vegetative, hydrologic, agricultural, urban, and wildlife data were mapped, analyzed, and summarized. In addition to the mapped features of the watershed, summary data tables are included for several watershed attributes.

3.2 DATA COLLECTION AND MANAGEMENT

3.2.1 Collection of Existing Information

A significant amount of data, plans, and reports regarding the land and water resources were collected as part of the study. Much of this information is obtainable from local, state, and federal personnel and websites. During this study, representatives of private, local, state, and federal organizations were contacted in person, by telephone, and by email to request available data and information and to verify the datasets downloaded from websites. The list below includes many of the organizations that were contacted:

- Campbell County Conservation District (CCCD)
- Crook County Natural Resource District (CCNRD)
- City of Gillette
- City of Sundance
- Campbell County
- Crook County
- Weston County

- The Nature Conservancy
- Wyoming Water Development Commission (WWDC)
- Wyoming Department of Environmental Quality (WDEQ)
- Wyoming State Engineer's Office (SEO)
- Wyoming Department of Transportation (WYDOT)
- Wyoming Game and Fish Department (WGFD)
- Wyoming State Geological Survey (WSGS)
- Wyoming Geographic Information Science Center (WyGISC)
- Wyoming Oil and Gas Conservation Commission (WOGCC)
- Wyoming Office of State Lands and Investments (OSLI)
    - Wyoming State Board of Land Commissioners (SBLC)
    - Wyoming State Loan and Investment Board (SLIB)
- Wyoming Wildlife and Natural Resources Trust (WWNRT)
- U.S. Department of Agriculture (USDA)
    - Farm Service Agency (FSA)
    - Forest Service (USFS)
    - Natural Resource Conservation Service (NRCS)
- U.S. Environmental Protection Agency (EPA)
- U.S. Department of the Interior (USDI)
    - U.S. Bureau of Reclamation (USBR)
    - U.S. Geological Survey (USGS)
    - National Park Service (NPS)
    - Bureau of Land Management (BLM)
    - U.S. Fish and Wildlife Service (USFWS).

3.2.2 Geographic Information System

The data collected for this study was compiled into a GIS using ESRI's ArcGIS 10.2. This format allows the data to be visualized, analyzed, compared, and evaluated to interpret and understand many resource attributes. GIS helps with integrating the spatial and tabular data in conjunction with linking spreadsheets, reference documents, photographs, and field data and allows for centralized storage. As part of the GIS, an ESRI ArcMap document ("mxd" file extension) was created for sponsors and other ArcGIS software users.

The data in the study's GIS is stored in an easily accessible file structure that uses a geodatabase format with feature datasets and feature classes to represent geometric locations and attributes for geographic features represented by points, lines, and polygons. Additional attributes are stored in dBase tables which can be joined to feature classes. All feature classes are in the North American Datum (NAD) of 1983 Universal Transverse Mercator (UTM) Zone 13 North coordinate system that can be measured in several latitude and longitude geographic coordinates including decimal degrees.

The spatial data gathered during the study were obtained from Campbell County, Crook County, Weston County, SEO, WDEQ, WyGISC, NPS, BLM, USGS, NRCS, WGFD, USFS, and others. In addition, spatial data were collected and developed in association with landowners and participants. Table 3.1 lists the datasets, maps, and imagery included in the study's GIS. The GIS can also be used for future planning efforts, such as completing permits, environmental assessments, program applications, and project mapping. Because the datasets are updated periodically, future users are encouraged to obtain the latest datasets from the original sources.

3.2.3 Digital Library

The study's digital library includes reference documents, maps, figures, spreadsheets, and images collected and produced during the study. The digital library contains a list of all available documents that can be viewed by clicking the links, searching for keywords, or browsing the library.

3.3 STUDY AREA

The study area for the Belle Fourche River Watershed encompasses the drainage area for the Belle Fourche River beginning at the headwaters of the river approximately 18 miles southwest of Wright, Wyoming, and flowing generally northeast where it crosses the Wyoming–South Dakota state line approximately 10 miles northeast of Aladdin, Wyoming, as shown in Figure 1.1. The study area covers approximately 3,883 square miles or 2,485,020 acres and includes the land draining to the Belle Fourche River and tributaries in northeast Wyoming. The study area is located within Crook County (56 percent), Campbell County (34 percent), and Weston County (10 percent). The cities, towns, and communities of Aladdin, Alva, Beulah, Carlile, Colony, Devils Tower, Gillette, Hulett, Moorcroft, Pine Haven, Rozet, Sleepy Hollow, Sundance, Wright, and Wyodak are located within the watershed.

The watershed is approximately 90 miles north-south and 90 miles east-west. The study area is bounded as follows: on the north by the Upper Little Missouri drainage and the northwest by the Little Powder drainage; on the west by the Upper Powder drainage and on the southwest by the Antelope drainage; on the south by the Upper Cheyenne drainage and on the southeast by the Beaver drainage; and on the east by the Wyoming–South Dakota state line.

The Belle Fourche River and its major tributaries—Four Horse Creek, Inyan Kara Creek, Jim Creek, Redwater Creek, and South Redwater Creek—are in the study area. Approximately

Table 3.1. Feature Datasets and Classes Contained in the Study's Geographic Information System (Page 1 of 3)

Feature Dataset	Feature Class	Feature Dataset	Feature Class
Basin_Plan	opportunities_05	Habitat	AquaticCrucial_hp09
BFR_Upland_Sources	LW_Existing_Sources		AquaticEnhancement_hp09
	LW_Proposed_Projects		CombCrucial_hp09
	LW_Proposed_Projects_ Locations		CombEnhancement_hp09
	Viable_Springs_Ponds_ Reservoirs		CriticalStreamCorridors
	Viable_Wells		TerrestrialCrucial_hp09
	Viable_Wells_Buffer		TerrestrialEnhancement_ hp09
Boundaries	Conservation_Districts_WY		WGFD_Streams_Blue
	Project	Hydrologic_ Units	WBD_HUC10
	Project_Keyhole_DS		WBD_HUC10_Project
	Project_Keyhole_US		WBD_HUC12
	Project_Red		WBD_HUC6
Climate	AveMaxTemp_1981_2010		WBD_HUC8
	AveMinTemp_1981_2010	Hydrography	BFRWS_Rosgen
	AvePrecip_1981_2010		CONUS_BF
	AvePrecip1971_2000		CONUS_wet_poly
	COOP_Stations		HistoricallyProposedReservoirs
	precip_a_wy		ImpairedLakes2012_draft
	Weather_Stations		ImpairedStreams2012_draft
Cultural	Cultural_Sites		NEMjrRsvr_dd27
	historic_pt_NPS		NEStkRes_dd27
	Monuments_and_Markers		NEStkResPmts_dd27
	Pioneer_Trails		NHDFlowlines
Ecology	Eco_Site_Precip_Zone		NHDWaterbodies
	ecoregions		NWI

Table 3.1. Feature Datasets and Classes Contained in the Study's Geographic Information System (Page 2 of 3)

Feature Dataset	Feature Class	Feature Dataset	Feature Class
Energy	Pipelines	Hydrography	OSU_Surface_Management
	Power_Generation		PotentialDamReservoir
	powerlines_WUS_CAN_sgca		Reservoirs
	WindProjects		Spring_Seep
Geology	Active_Coal_Permits		Springs_BLM
	Active_NonCoal_Permits		streams_other
	Bedrock_Geology		USGS_gages
	Faults		WetlandComplexes2010
	Landslides		Wetlands
	PowderRiverBasin		WWDC_Transducers_Gage
	Surface_Geology	Other	WYPDES
Irrigated_Land	Irrigated_Land	Parcels	Campbell_Parcels_7_13
	POD		CrookCoParcel2013
	SEO_Irrigation_Districts		WestonCoParcel_2013
Land_Management	acec_blm	Wells	SEOWeIIs
	Agriculture_Grazing_ Allotments		UIC
	allotments_blm		WDEQCIass_I_V
	BLM_Allotments_WY	Wildlife	ant05mb
	BLM_AMBU		ant08mr
	blm_right_of_way		ant12cr
	blm_right_of_way_closed		antl2hh
	rneg_cra_based		ant12pa
	rngreg_ecoreg_based		ant12sr
	State_Fed_Ownership_Clip		elk05mb
	Surface_FedMin_Clip_2014		elk08mr
	Surface_Lands		elk12cr
	surface_ownership		elk12hh
	WY_BLM_Field_Office_ Boundaries		elk12pa

Table 3.1. Feature Datasets and Classes Contained in the Study's Geographic Information System (Page 3 of 3)

Feature Dataset	Feature Class	Feature Dataset	Feature Class
Oil_Gas Soils Transportation	Oil_Gas_areal_fields	Wildlife	elk12sr
	Oil_Gas_Pipelines		mdr05mb
	Oil_Gas_point_fields		mdr08mr
	Oil_Gas_Wells		mdr12cr
	AWC		mdr12hh
	ESD_FINAL		mdr12pa
	HSG		mdr12sr
	Hydric_Soils		mln12hm
	k_rockfree		sagegrouse_coreareas_v3
	k_WS		sagegrouse_develop_habitat
	mlra_a_wy		sagegrouse_habitat
	MUN		sagegrouse_Ieks_2012
	PMN		sagegrouse_Ieks_Iam_2012
	Soil_Surface_Texture		wtd05mb
	soilmu_a_wy011		wtd06mr
	soilmu_a_wy045		wtd12cr
	soilmu_a_wy605		wtd12hh
	soilmu_a_wy705		wtd12sr
	Soils_WY_250k		WYSagegrouse_currentdistribution
	SSURGO_DL_MapUnits		elev_ft
	STATSGO_MUN		elev_m
	t_domcond		Hillshade
	tWA		NationalVegetationClassification
	WEG		NLCD_2001
	WEI		NLCD_2006
	Major_Highways		Slope
	railroads		WY_Landcover_GAP_ Analysis1

11,110 stream miles are located within the watershed with 2,180 stream miles classified as perennial. Additionally, the study area contains several tributaries that do not flow into the Belle Fourche River in Wyoming, but rather, flow through South Dakota first before converging with the Belle Fourche River. These tributaries include Crow Creek, Ghost Creek, Gummit Canyon Creek, Hay Creek, Headland Draw, Middle Creek, Owl Creek, Redwater Creek, and Ruben Creek.

3.4 LAND USES AND ACTIVITIES

3.4.1 History of the Study Area

Northeastern Wyoming was once covered by a prehistoric ocean dating back 110 million years to the Cretaceous Period. Millions of years later, the water receded, and just 13,000 years ago the first people arrived. Evidence from more than 1,000 years ago suggests the presence of aboriginal people well before Europeans began to settle in the area. The first groups of people were the Plains Indian tribes that followed bison throughout the land. The tribes were unbothered until white settlers began passing through on fur-trading ventures bound for the west coast in the early 1800s. In the 1840s, 1850s, and 1860s, westbound settlers and miners in search of gold flooded the Oregon, California, and Mormon Trails that crossed areas of present-day central Wyoming.

Northeastern Wyoming remained in tribal control the longest of any part of the territory. To keep it that way, Cheyenne and Lakota Indian tribes began to attack white settlers and travelers in the 1860s. The Treaty of Fort Laramie in 1868 set aside the area east of Dakota Territory and south of Montana, including much of the Black Hills and the Powder River Basin, as hunting grounds for the tribes. The Indian tribes were aware of gold in the area but kept it a secret from the white settlers in hopes of preserving their lands and way of life. Despite the agreement to keep white people out of the Black Hills, rumors of gold began to spread in the early 1870s. In 1874, the government sent a military expedition to the Black Hills under the leadership of Lieutenant Colonel George A. Custer. After exploration, Custer reported back that there really was gold in the Black Hills. The word of gold sparked the Black Hills gold rush which, once again, pressured the tribes to sell their homelands.

In 1875, government officials met with Lakota Sioux chiefs in an attempt to purchase the Black Hills. The Indians declined saying that the land was holy ground and they refused to sell. In early 1876, the government ordered the tribes to leave the Powder River Basin and the Black Hills. The tribes continued to refuse, which led to the 1876 and 1877 campaign against the Sioux including the fights on the Rosebud (1876), Custer's defeat on the Little Bighorn (1876), and the attack on Dull Knife's village of Cheyenne on the Red Fork of Powder River (1876). The war concluded with Indian surrender in 1877, which forced the Indians to reservation lands outside the area [Wyoming State Historical Society, 2014].

3.4.1.1 Cattle, Sheep, and Farming

Early cattle drives from Texas to Montana during the late 1860s passed through northeast Wyoming. With the end of Indian threats and the start to white settlement, cattle ranches began to spring up in the late 1870s. Businessmen from the east and from Britain shipped in cattle and hired cowboys to care for the stock. Soon, ranchers began to grow their own hay for cattle feed. By the 1890s, many ranchers were taking advantage of the wet soils and cheap irrigation found along the bottomlands of the small tributary streams. In 1891, the Chicago, Burlington, and Quincy Railroad reached Gillette and Moorcroft and created a more convenient shipping point for cattle ranchers in the area. Before that time, herds had to be trailed hundreds of miles to be shipped to market. Moorcroft soon became a shipping hub for cattle and was the largest cattle-shipping point in the country.

Because of the high costs involved with establishing cattle herds, sheep followed the cattle industry to the area. By the turn of the last century, sheep significantly outnumbered cattle in Wyoming. As the ranching and farming market expanded, wet and fertile lands along the tributaries were already settled. It became apparent that irrigation and water storage was needed to farm and ranch more acres. Small reservoirs were developed for local irrigation. Over time, ranching and agriculture became successful in many parts of northeastern Wyoming. Early-day farmers cultivated wheat, oats, rye, corn, garden vegetables, and small fruits for profit [Wyoming State Historical Society, 2014].

3.4.1.2 Coal

The discovery and extraction of coal in northeastern Wyoming began in the 1870s in the area around the current-day city of Aladdin. Originally, coal was transported more than 50 miles by wagon to the gold smelters in Lead and Deadwood in the Dakota Territory. In 1895, the Black Hills Coal Company was founded and began mining coal. Soon, the company needed a more efficient way to ship the coal. In 1898, the Black Hills Coal Company built the Wyoming and Missouri River Railroad to haul coal from the Aladdin area 18 miles to the east to the main Chicago and Northwestern Railroad line in Belle Fourche, South Dakota. The new line also connected the mines to gold smelters in Lead and Deadwood, South Dakota.

During the same time, coal extraction began around the Gillette area. Underground mines were established as early as 1909. In 1923, the Wyodak Company began developing large surface operations east of Gillette. For many years, Wyodak was the largest surface coal mine (area) in the world. Wyodak, purchased by the Black Hills Corporation in 1956, is considered to be the oldest, continually operated coal mine in the United States.

Northeast Wyoming's coal is low in sulfur compared to coal mined in the eastern United States. The Clean Air Act was amended in 1990 to require electric utilities to reduce sulfur emissions from their coal-fired power plants. Since then, northeast Wyoming's coal has been a highly desirable piece of the national market [Wyoming State Historical Society, 2014].

3.4.1.3 Oil and Bentonite

Oil was first discovered in northeastern Wyoming in the 1890s. The demand for crude oil during World War I raised interest and created a profitable industry. As demand for oil increased, so did the interest in bentonite, fine clay that was used primarily in oil drilling. After World War I, falling demand for oil slowed the industry, and falling agriculture prices hit area farmers and ranchers hard. Industrial workers left the area to look for the next opportunity, which left nearby towns quiet and empty with little sustainable industry.

Bentonite was the first industry to break the slump. Demand for bentonite increased as more uses were found, including cement and plaster, cosmetics, insecticides, herbicides, and textiles. As World War II approached, oil and bentonite demands increased along with agricultural prices. Workers from Arizona and New Mexico came to the area to work in the mines, ranches, and farms [Wyoming State Historical Society, 2014].

3.4.2 Land Ownership

The study area covers approximately 3,883 square miles or 2,485,020 acres in northeastern Wyoming. According to the BLM's 2014 surface management status dataset, private land within the watershed encompasses approximately 2,045,900 acres (82.3 percent) of the watershed, 260,050 acres (10.5 percent of parcels) are managed by federal agencies, and 170,520 acres (6.9 percent of parcels) are owned by the state of Wyoming. The USFS manages 187,940 acres (72.3 percent) and the BLM manages 67,380 acres (25.9 percent) of the federal lands within the watershed. The USBR, NPS, and USACE manage 2,390 acres (0.9 percent), 1,340 acres (0.5 percent), and 1,000 acres (0.4 percent) of the remaining federal lands, respectively.

The distribution of generalized categories of surface land ownership and management by type within each county is shown in Table 3.2. Because of the scale of the land management spatial data, the estimated acres and corresponding percentages have been rounded up to the nearest square mile. In addition to the land ownership and management, the BLM's 2014 surface management data and county parcel data from Campbell, Crook, and Weston Counties were collected and included in the study's GIS. Figure 3.1 displays the ownership and management categories within the study area.

3.4.3 Transportation and Energy Infrastructure

Transportation within the study area is centered along Interstate 90, which runs east and west throughout the entire watershed. From west to east, Interstate 90 runs through Gillette, Moorcroft, Sundance, and finally Beulah before entering South Dakota. Several large highways run through the study area, including U.S Highway 212 in the northeast corner of the watershed; U.S. Highway 14 running east-west through the watershed; and U.S. Highway 16 running from the south, through the middle of the study area, and to the west. State highways are located throughout the study area with various other local roads and unimproved trails.

Table 3.2. Land Ownership by County Within the Study Area

County	Federal		Private		State		Water/Other		Total	
	Sq. Mi.	%	Sq. Mi.	%	Sq. Mi.	%	Sq. Mi.	%	Sq. Mi.	%
Campbell	46	3.5	1,192	90.2	82	6.2	1	0.1	1,321	34.0
Crook	311	14.2	1,703	77.9	159	7.3	12	0.5	2,185	56.3
Weston	50	13.3	301	79.8	26	6.9	–	–	377	9.7
Total	407	10.5	3,196	82.3	267	6.9	13	0.3	**3,883**	**100.0**

Sq. Mi. = square miles

The Burlington Northern Santa Fe (BNSF) Railway has two major railroad lines. One railroad runs east-west from Upton to Gillette, and the other runs north-south through the western portion of the watershed. These lines meet up between Wyodak and Rozet along Interstate 90. The Chicago and North Western Railway operates a major railroad line in the northeast portion of the watershed near Colony, Wyoming, running southeast along U.S. Highway 212 into South Dakota. Major roads and railroads in the study area are shown on Figure 3.2.

All six coal facilities and one natural gas facility are located around Wyodak, which is approximately 2 miles east of Gillette. One natural gas facility and both wind facilities are located in the southwestern edge of the watershed. Two coal facilities and two natural gas facilities can be found near, but outside, the study area as well. Power transmission lines run throughout the study area, although the majority of transmission lines are in the western portion. Power generation and power transmission lines in and near the study area are shown on Figure 3.3. The study area contains numerous pipelines that are mainly used for crude oil and natural gas as well as fuel products, as shown on Figure 3.4. These maps of the energy and power lines that go across the study area are general estimates of the locations and alignment.

3.4.4 Irrigation

Irrigation within the study area is primarily agricultural use. Based on the evaluation of the irrigated acreage provided by the WWDO, approximately 22,330 acres of irrigated lands comprises 0.9 percent of the study area as shown in Figure 3.5. Of the 22,330 irrigated acres, approximately 16,090 acres (72.1 percent) of the irrigated parcels are in Crook County, 4,090 acres (18.3 percent) in Campbell County, and the remaining 2,140 acres (9.6 percent) of irrigated parcels are in Weston County.

Approximately 4,800 acres (21.5 percent) of the irrigated lands in the study area are within the CCID along the Belle Fourche River below Keyhole Reservoir. The remaining 17,530 acres (78.5 percent) of the irrigated lands in the study area are located outside of the CCID and

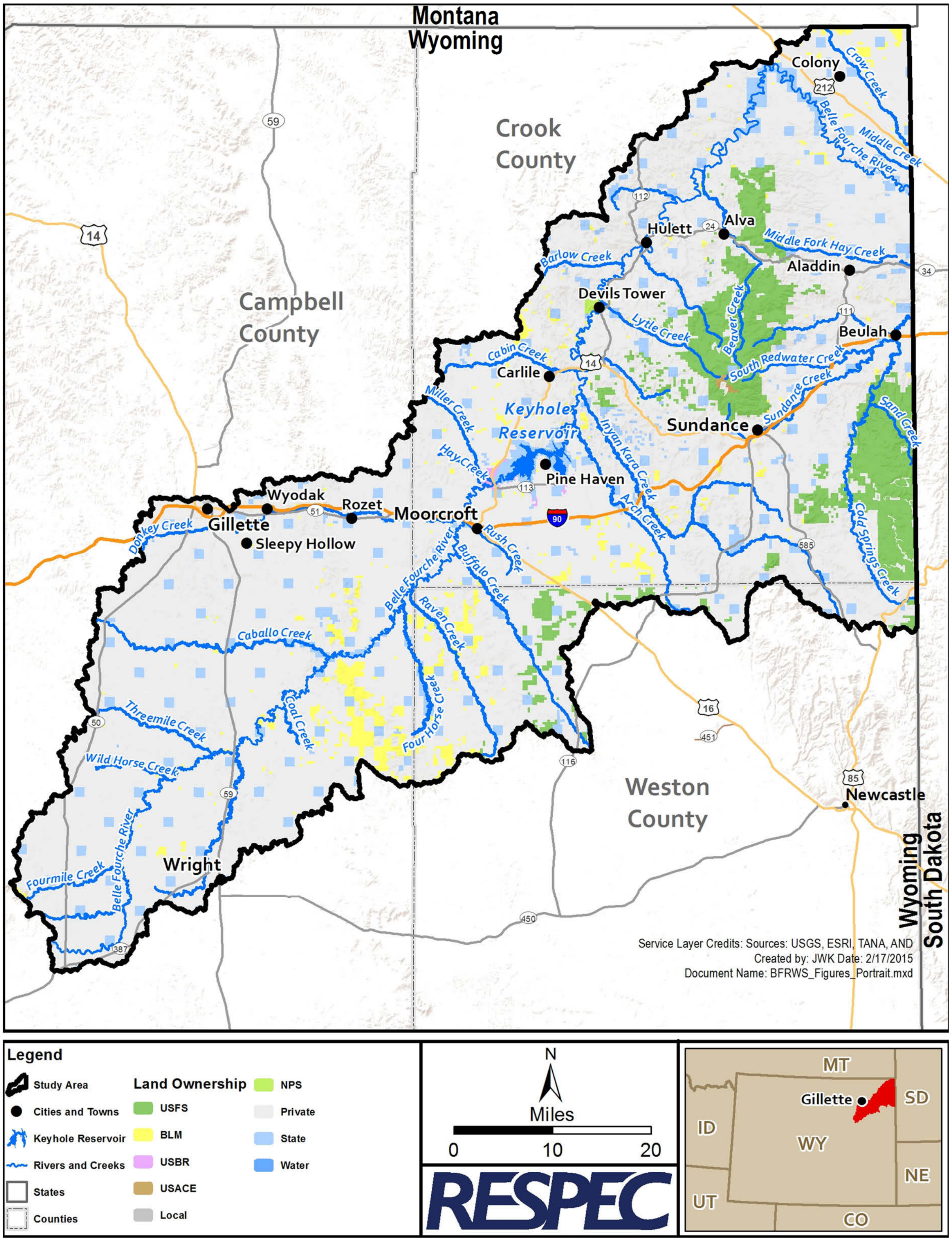

Figure 3.1. Categories of Land Ownership Within the Study Area.

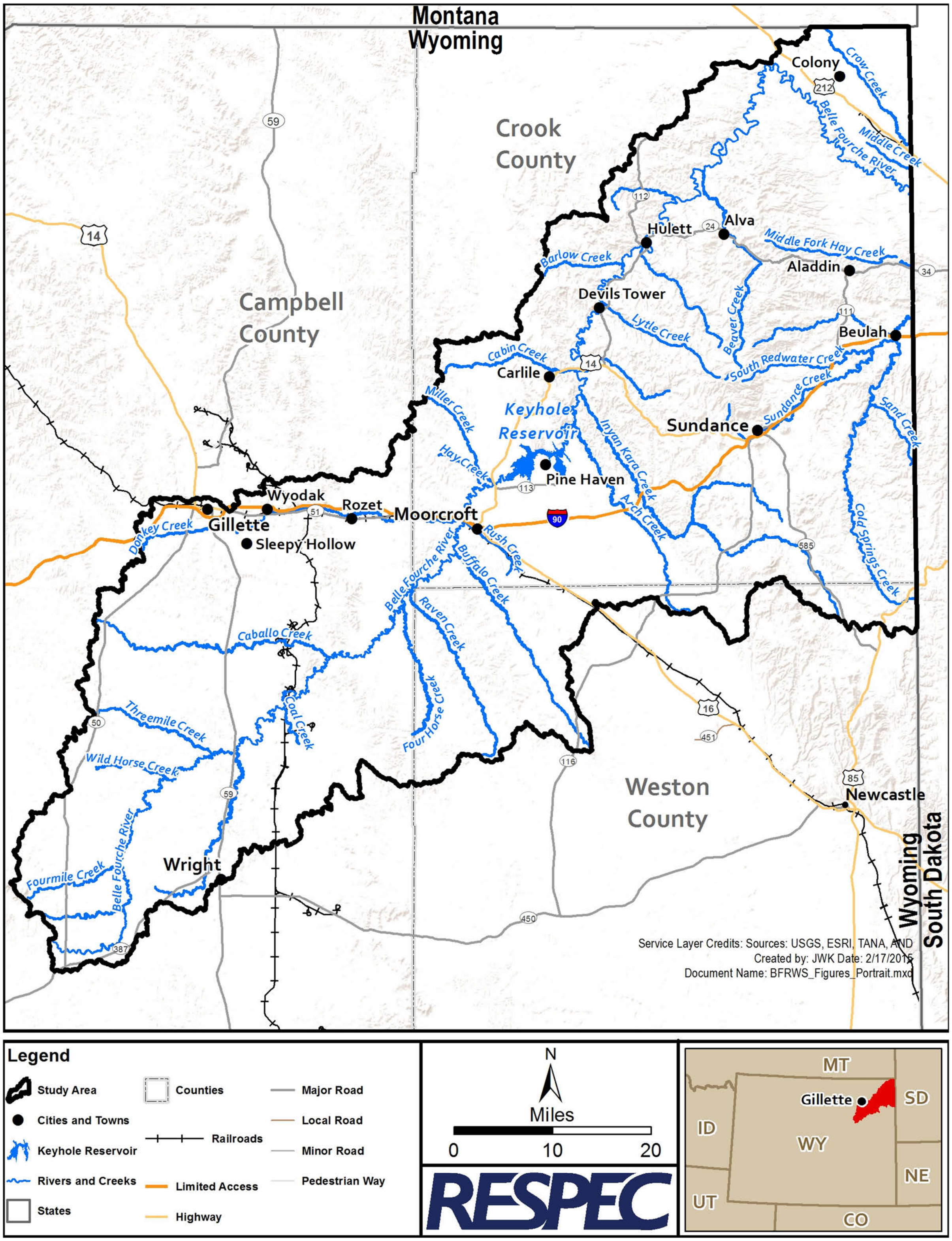

Figure 3.2. Infrastructure Features in the Study Area.

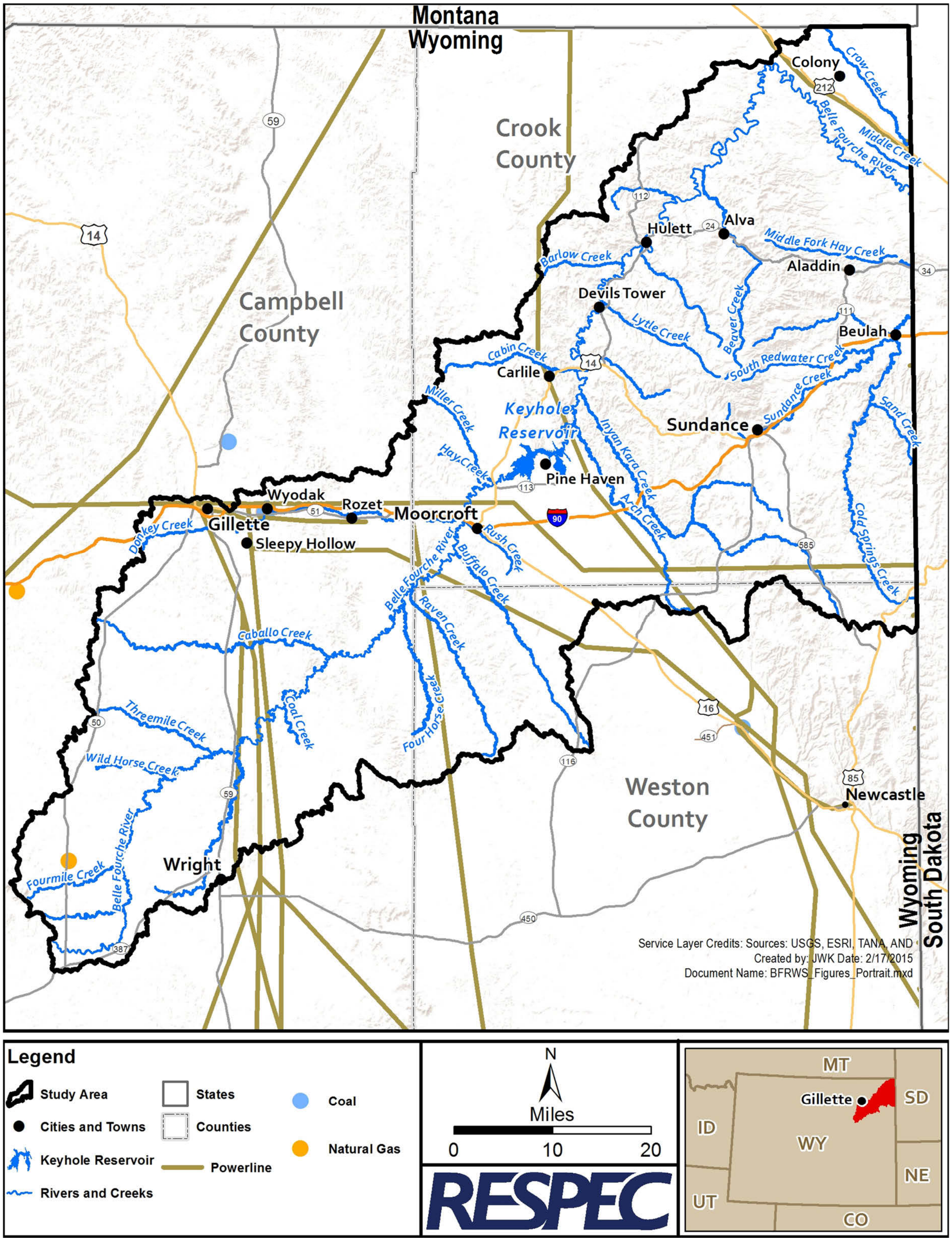

Figure 3.3. Power Generation and Transmission Lines Within the Study Area.

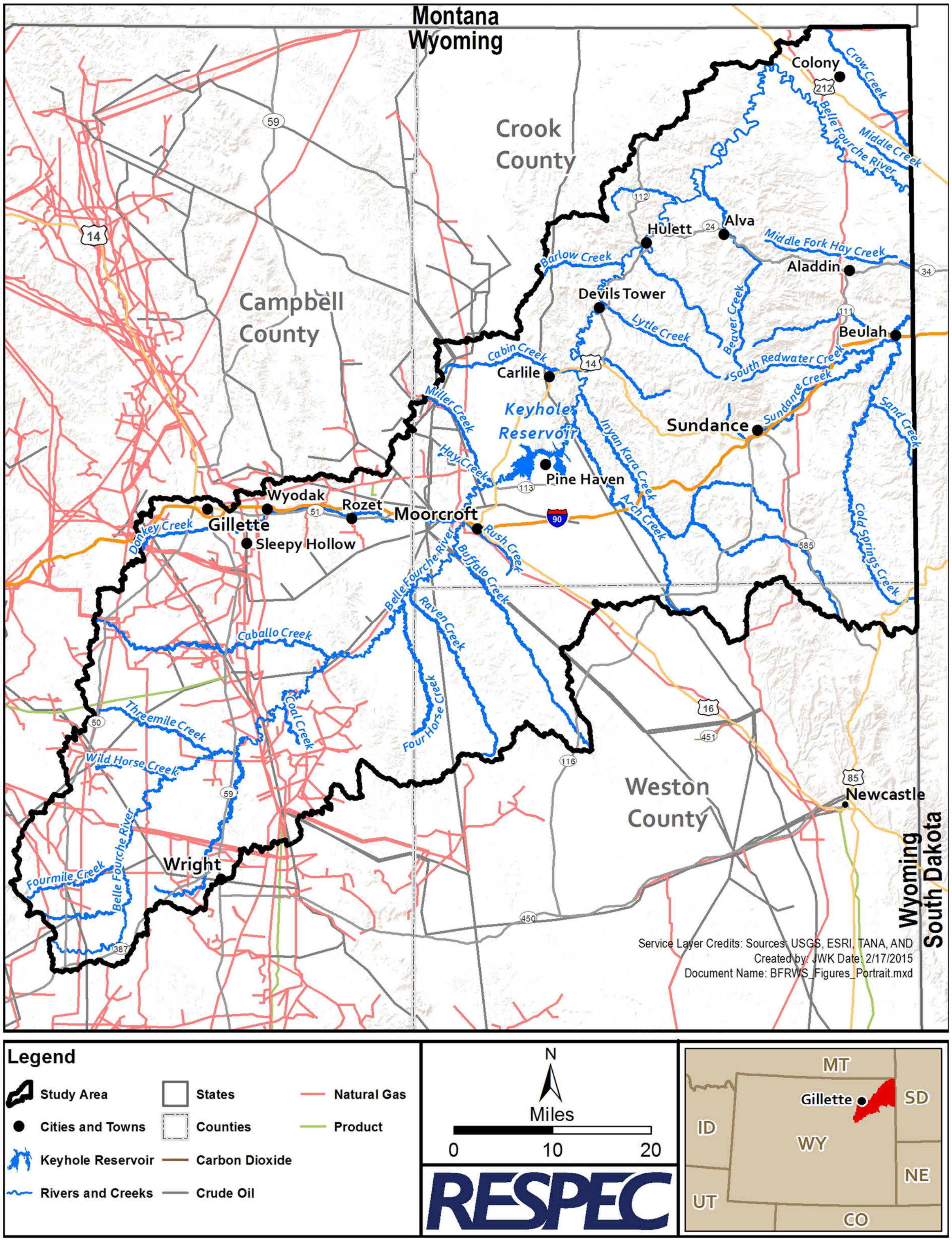

Figure 3.4. Pipelines Within the Study Area.

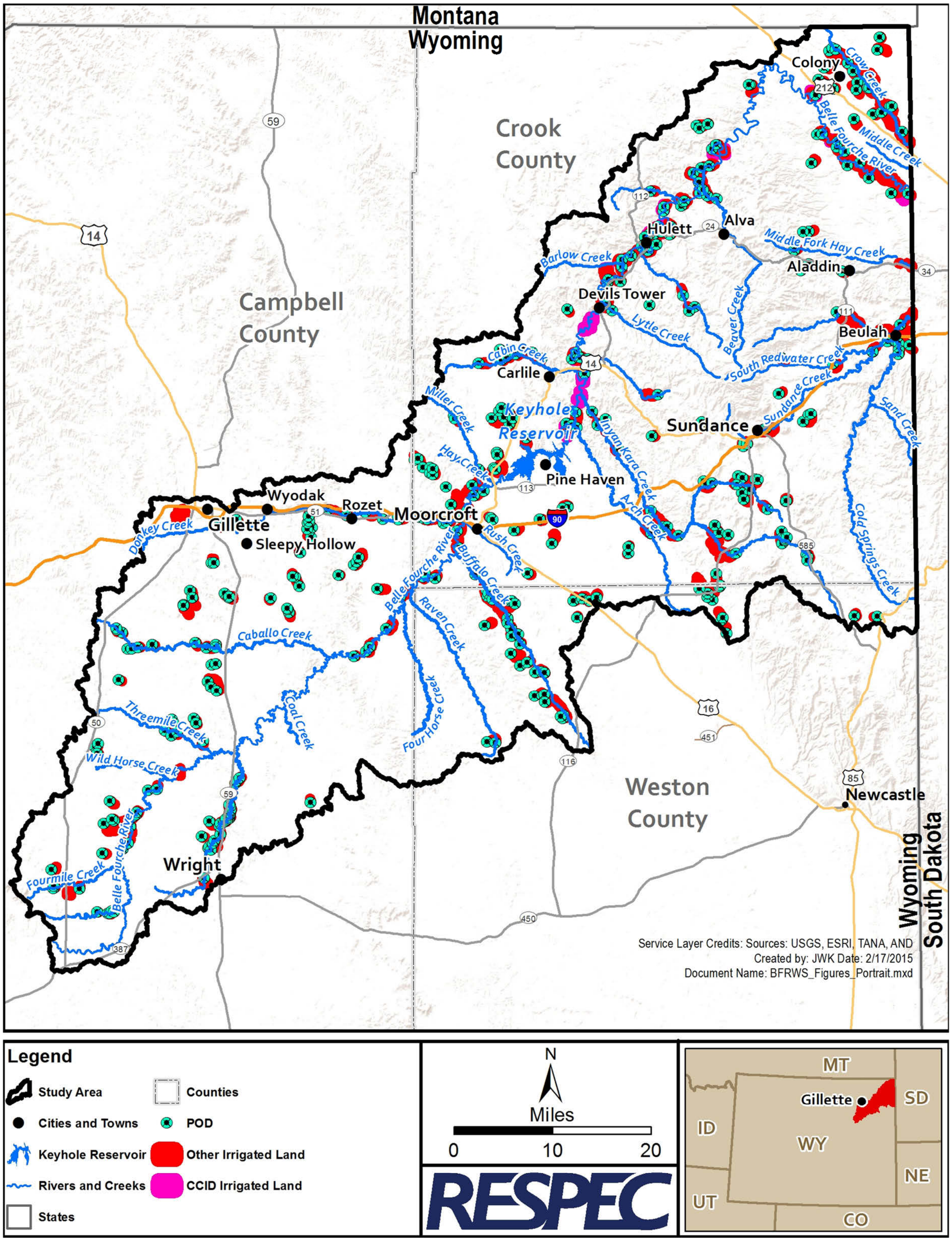

Figure 3.5. Irrigated Lands in the Belle Fourche River Watershed.

located along numerous streams, including Belle Fourche River, Donkey Creek, Inyan Kara Creek, Hay Creek, Redwater Creek, Crow Creek, and Beaver Creek. The irrigated acres located within the study area are listed by subwatershed (HUC10) in Table 3.3. The crops primarily grown on irrigated lands within the study area include alfalfa, hay, small grains such as oats and barley, and corn [HKM Engineering Inc. et al., 2002].

Table 3.3. Irrigated Lands by Subwatershed (HUC10) Within the Study Area

Watershed (HUC10)	Estimated Area (acres)	Total Irrigated Acres (%)	Within the CCID
Arch Creek-Belle Fourche River	1,374	6.1	Yes
Blacktail Creek-Belle Fourche River	2,759	12.4	Yes
Buffalo Creek-Belle Fourche River	1,852	8.3	
Caballo Creek	750	3.4	
Donkey Creek	1,231	5.5	
Hay Creek-Belle Fourche River	483	2.2	
Inyan Kara Creek	2,395	10.7	
Lower Redwater Creek	144	0.6	
Middle Belle Fourche River	3,077	13.8	
Mud Spring Creek-Belle Fourche River	1,174	5.3	
Owl Creek	351	1.6	
Sand Creek	438	1.9	
Upper Belle Fourche River	2,584	11.6	Yes
Upper Redwater Creek	1,987	8.9	
Wind Creek-Belle Fourche River	1,726	7.7	
Total Estimated Acres	**22,325**	**100.0**	

3.4.4.1 Crook County Irrigation District

The CCID is comprised of approximately 4,450 acres located along the Belle Fourche River between Keyhole Reservoir and the Wyoming–South Dakota state line. Keyhole Reservoir is the only significant irrigation water storage facility in northeast Wyoming. It can store up to 185,800 acre-feet of irrigation water, of which 90 percent is controlled by South Dakota irrigators. Approximately 18,000 acre-feet of Keyhole's storage is owned by CCID, which uses the water to supplement direct-flow rights along the Belle Fourche River [HKM Engineering Inc. et al., 2002].

The CCID contract for 9.7 percent of the storage space in Keyhole Reservoir became effective on January 1, 1985. The remaining 0.3 percent of Wyoming's 10 percent storage space in Keyhole Reservoir was originally contracted to Shattuck Hills (Pine Haven, Wyoming). The Shattuck Hills contract has now been transferred to the Keyhole Country Club Golf Course. The present Wyoming storage space (10 percent) in Keyhole Reservoir is 18,208 acre-feet. Full development acres for the CCID are approximately 4,800 acres, and the CCID is presently actively irrigating about 2,000 acres. Approximately 18,000 acre-feet of Keyhole's storage is contracted to the CCID whose lands are along the Belle Fourche River below Keyhole Reservoir.

3.4.4.2 Murray Ditch

One of the major diversions in the study area is the Murray Ditch, which conveys water from Redwater Creek in Sections 20 and 29 of Township 53 North, Range 60 West in Crook County north of Beulah. The Murray Ditch is also known as the Jan Moeller or Redwater Ditch and is incorrectly labeled Miller Ditch on the National Hydrography Dataset (NHD). The Murray Ditch headgate diverts from the main stem of Redwater Creek, approximately 1.2 miles from the South Dakota border; however, the headgate is approximately 2.3 miles from the South Dakota border along the Murray Ditch [HKM Engineering Inc. et al., 2002]. The Murray Ditch is an open ditch with direct-flow water rights adjudicated in Wyoming as listed in Table 3.4.

Table 3.4. Direct-Flow Water Rights Adjudicated in Wyoming in the Murray Ditch [HKM Engineering Inc. et al., 2002]

Permit	Priority Date	Permitted Use[(a)]	Area (acres)	Flow (cfs)[(b)]	Cumulative Flow (cfs)[(b)]
Territorial	11/01/1881	D, I	95.47	1.36	1.36
Territorial	10/01/1882	I	88.89	1.27	2.63
306E	01/21/1898	I	40.00	0.57	3.20
5520E	11/20/1950	I	64.62	0.92	4.12

(a) D = domestic; I = irrigation
(b) cfs = cubic feet per second.

3.4.5 Grazing

Livestock grazing and ranching has occurred within the study area for more than 130 years, often in combination with other land uses, including timber production, mining, oil and gas production, wildlife habitat, and recreation. Livestock operations are almost all beef cattle ranches with cow-calf enterprises involving some yearling, backgrounding, and replacement heifer components. These grazed rangelands and forestlands provide the foundation for the area's communities, which commonly manage their ranching operations' livestock, timber, pasture and hay forage, mineral and energy, wildlife, and water resources, in conjunction with hunting and other recreational uses.

3.4.5.1 Range and Forestlands

Approximately 2.4 million acres of rangeland and forestlands are within the watershed and covers more than 96 percent of the study area. Rangeland acres were approximated by using the shrub/scrub and grassland hebaceous vegetative cover types, and the forestland acres were approximated by using the deciduous/evergreen vegetative cover types from the National Land Cover Dataset (NLCD). The NLCD is a 16-category land cover classification method that is applied across the United States using Landsat imagery.

Nearly 1.97 million acres of rangelands are within the watershed and covers approximately 79 percent of the study area. Private land encompasses approximately 1,723,220 acres (87.5 percent) of the rangelands within the study area. The state of Wyoming manages 145,600 acres (7.4 percent), the BLM manages approximately 60,390 acres (3.1 percent) and the USFS manages approximately 32,130 acres (1.6 percent) of the rangelands within the study area as shown in Table 3.5. The remaining 7,340 acres (0.4 percent) of rangelands are managed by the other agencies, including the USBR, NPS, and local agencies.

Table 3.5. Rangelands by Ownership/Management Within the Study Area

Land Ownership or Management	Rangeland Acres	Total Rangeland Acres (%)
Private	1,723,220	87.5
State of Wyoming	145,600	7.4
BLM	60,390	3.1
USFS	32,130	1.6
Other (USBR, NPS, Local)	7,340	0.4
Total	**1,968,680**	**100.0**

In addition to the rangelands in the watershed, forestlands cover approximately 432,740 acres (17.4 percent) within the study area. Private land encompasses approximately 249,580 acres (57.7 percent) of the forestlands within the study area. The USFS manages approximately 155,560 acres (35.9 percent) of the forestlands and the state of Wyoming owns 20,130 acres (4.7 percent) within the watershed. The remaining 7,470 acres (1.7 percent) of the forestlands in the study area are managed by the BLM, NPS, USACE, USBR, and local agencies, as shown in Table 3.6.

3.4.5.2 Federal Grazing Allotments

Grazing on an estimated 94,860 acres of federal rangelands within the watershed is primarily administered by the BLM. The BLM has 159 grazing allotments that encompass approximately 309,100 acres. These BLM allotments are comprised of significant amounts of private and state lands typically managed under an Allotment Management Plan (AMP) and are sometimes situated in neighboring watersheds but extend into the study area. The BLM Buffalo Field Office administers 87 percent of the BLM allotments, the BLM Newcastle Field Office administers 12 percent of the allotments, and the BLM South Dakota Field Office administers 1 percent of the allotments, which are illustrated in Figure 3.6 and summarized in Table 3.7. The BLM allotments are administered by the BLM's Buffalo and Newcastle Field Offices under the respective Record of Decisions and approved 2001 Buffalo RMP and the 2000 Newcastle RMP. Currently, the Buffalo Field Office is revising the existing Buffalo RMP [BLM, 2000; 2001; 2003].

Table 3.6. Forestlands by Ownership/Management Within the Study Area

Land Ownership or Management	Forestland Acres	Total Forestland Acres (%)
Private	249,580	57.7
USFS	155,560	35.9
State of Wyoming	20,130	4.7
Other (BLM, NPS, USACE, USBR, Local)	7,470	1.7
Total	**432,740**	**100.0**

Grazing management on BLM land is conducted in accordance with the Federal Land Policy and Management Act of 1976 and the Taylor Grazing Act of 1934. Policies and procedures for managing grazing on BLM lands are outlined in the BLM's regulations, which were revised in 1995 to sustain or improve rangeland health. Grazing activities on BLM lands in the state of Wyoming must meet the requirements specified in *Standards for Healthy Rangelands and Guidelines for Livestock Grazing Management for the Public Lands* [Bureau of Land Management, 1997]. More information about the BLM's grazing management standards and guidelines can be found online (*http://www.blm.gov/wy/st/en/programs/grazing.html)*. The BLM's grazing management guidelines that are pertinent for this watershed study include the following summaries:

- Support infiltration, maintain soil moisture, stabilize soils, and provide sufficient water to maintain system function and soil permeability.
- Restore, maintain, or improve riparian plant communities to sustain adequate residual plant cover for sediment capture and groundwater recharge.
- Implement riparian improvements to maintain or enhance stream channel morphology.

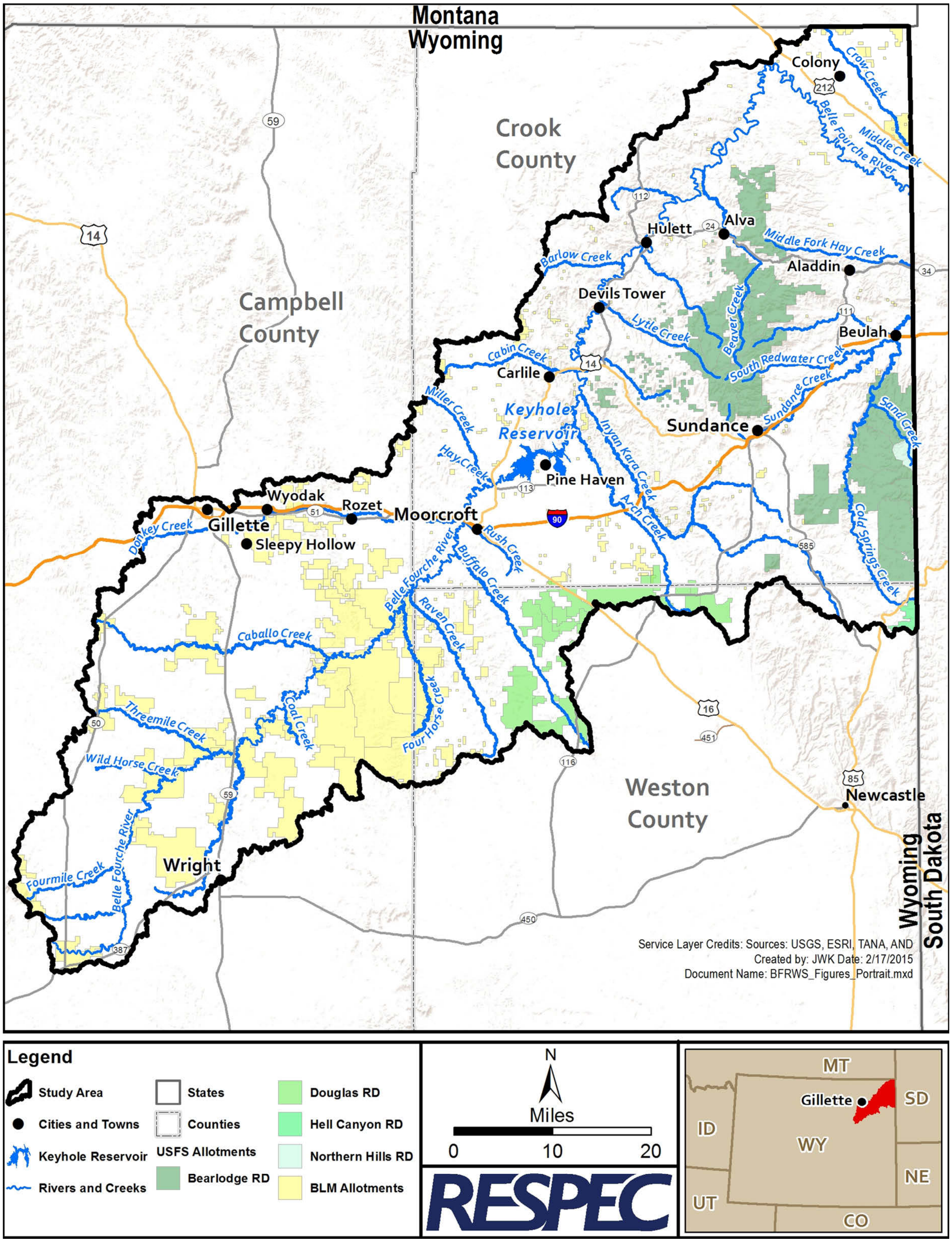

Figure 3.6. Federal Grazing Allotments in the Study Area.

Table 3.7. Bureau of Land Management Allotment Summary for the Study Area (Page 1 of 3)

Allotment Number	Allotment Name	Area (acres)	Allotment Number	Allotment Name	Area (acres)
Buffalo Field Office			**Buffalo Field Office**		
2242	Four Horse Creek	6,435	12080	Dry Creek Ranch Inc.	13,858
2243	Brower Draw	8,950	12082	Wild Horse Creek (Bar 76)	13,159
2248	Coon Track Creek	3,620	12091	West Timber Creek	2,465
2249	Osborn	3,661	12095	Neil Butte	7,353
2256	Pinette Draw	7,930	12103	Threemile Creek Reservoir	2,381
2258	Cabin Canyon	15,739	12149	Coal Creek	3,355
2263	Rozet	872	12150	Yellowhammer	6,101
2272	Sand Rock/Hoe Creek	804	12158	Jiggs Reservoir	912
2280	South Middle Butte	0	12208	Caballo Draw	2,344
2292	Simpson, John H.	2,464	12209	Belle Fourche TR	16,663
2306	Gardner Lake	204	12231	Hilight	7,076
2309	Mary Straatsma Est	1,968	22021	Bishop	34,611
2319	Rattlesnake Creek	2,368	22027	Cordero Allotment	2,833
2320	Jeffers Draw	2,794	22106	Wagonhammer	997
2321	Stuart, James R.	168	22107	Fortin Draw	688
2325	Linch (Iberlin)	5,629	22123	Lone Tree	19
2329	Rochelle Hills	1,398	22126	Four Horse	13,561
2330	Reel	3,082	22130	Cottonwood Creek E.	94
2331	Winter Draw	3,938	22210	Bone Pile Creek	12,081
2349	Three Mile Creek	15,233	22590	S. Wyodak	7,041
2366	Antelope Draw	1,348	**Newcastle Field Office**		
2367	Mud Spring Creek	2,011	694	Brakes	81
2381	Wagensen Don Et Al	1,151	745	Cabin Creek II	87
2452	S. Gillette Forty	494	753	Right Creek II	40
2468	Chalk Hills	3,106	4045	Rifle Pit Road	40
12023	Lawver	17,144	4050	Crazy Creek	82
12036	Willow Creek (T Chair)	2,083	4055	South Redwater Creek	150
12049	Camblin	3,128	4058	Pipeline	1,214
12069	Cook	2,255	4059	The Brakes	39

Table 3.7. Bureau of Land Management Allotment Summary for the Study Area (Page 2 of 3)

Allotment Number	Allotment Name	Area (acres)	Allotment Number	Allotment Name	Area (acres)
Newcastle Field Office			Newcastle Field Office		
4060	Little Creek	118	4184	Rock Hill	124
4065	Buck Creek S13	164	4186	Four Corners	86
4070	Dry Creek III	38	4194	Soap Creek	202
4078	Left Creek	686	4196	Horse Creek	84
4079	Pine Ridge I	538	4197	Berger Creek	291
4082	Heinbaugh Creek II	7	4203	East Creek	82
4083	Brush Creek II	40	4205	Government Draw	326
4100	Cabin Creek I	114	4206	Sugarloaf Mountain	39
4106	Inyan Kara Creek	282	4208	Boggy Creek II	126
4108	Keyhole Lake	78	4211	Branaman Mountain	85
4110	Black Gulch	194	4214	Gumbo Creek III	239
4113	Deep Draw I	244	4218	Crow Creek I	2,172
4117	Sage Creek II	41	4220	Red Canyon II	147
4125	Right Creek I	283	4223	Four Horse Creek	242
4138	Miller Creek	80	4224	Barlow Creek	77
4139	Storm Hill	117	4226	Kaiser Divide	83
4141	Cold Springs Creek	53	4228	Deep Draw II	1,342
4142	Gladson Creek	26	4230	Terhune	76
4143	Deer Creek	257	4242	Raven Creek S33	632
4144	Beaver/Inyan Kara	41	4246	Raven Creek III	1,020
4147	Dry Creek I	80	4251	Barnard Creek	194
4149	Jack	351	4252	Lipe Canyon II	40
4154	Strawberry Hill	6	4256	Stockade Beaver Creek	22
4162	W Bacon Creek	115	4259	Hoffman Creek	41
4164	Pine Ridge II	1,138	4263	Dry Creek S4+5	205
4166	Schoolhouse	153	4265	Cedar Hill I	779
4169	The Basin	156	4270	Well	42
4173	Deep Creek	340	4275	Coal Draw	1,194
4178	Cedar Ridge	81	4285	Cundy Creek	40

Table 3.7. Bureau of Land Management Allotment Summary for the Study Area (Page 3 of 3)

Allotment Number	Allotment Name	Area (acres)	Allotment Number	Allotment Name	Area (acres)
Newcastle Field Office			**Newcastle Field Office**		
4291	Hayworth Draw	325	4367	Chicago Creek	158
4298	Rocky Ford Creek	248	4375	Basin Reservoir No. 1	42
4299	Lime Buttes	412	4376	Cabin Creek IV	81
4304	Trail Creek	3,215	4377	Basin Reservoir	326
4306	Ronning Draw	1,151	4378	Brosa Draw	718
4308	Mcque Draw	38	4379	Cyclone Canyon	84
4310	Duling	80	4383	Cottonwood Creek II	83
4315	Humboldt Creek	232	4384	Antelope Draw	121
4317	Pine Creek Spring	76	4393	Green Mountain I	41
4320	Arnold Creek	80	4395	Cedar Hill II	83
4322	Quail Spring	44	4404	Wind Creek	282
4326	Hospital Gulch	162	4407	Hay Creek II	40
4332	Cabin Creek III	39	4410	Dark Canyon	194
4335	Ponderosa	39	4413	Red Canyon I	124
4343	Vore Draw	123	14009	Raven Creek I	1,357
4344	Newman Divide	40	14010	Raven Creek II	444
4349	Benton Creek	39	14016	Freda Creek	966
4350	Green Mountain II	41	14017	Houston Creek	327
4351	Buck Draw	3,773	14018	Pine Ridge III	1,918
4353	Edith Creek	499	14025	Lipe Canyon I	230
4357	Raven Wyoming	1,015	**South Dakota Field Office**		
4358	Eggie Creek	44	1801	Daley Creek	4,299
4366	Moore Canyon	39			

- Develop springs, seeps, reservoirs, wells, or other water development projects in a manner that protects watershed ecological and hydrological functions.
- Implement range improvements away from riparian areas to avoid conflicts in achieving or maintaining riparian function.
- Adopt management practices and implement range improvements that protect vegetative cover and thereby maintain, restore, or enhance water quality.

In addition to the BLM allotments within the watershed, the USFS administers 26 grazing allotments that encompass approximately 54,210 rangeland acres consisting of private, state, and federal lands within the study area. The USFS Douglas Ranger District administers these grazing allotments under the respective Record of Decisions and the 2002 Thunder Basin National Grassland Land RMP [USFS, 2009]. These USFS allotments are also shown in Figure 3.6 and summarized in Table 3.8.

Table 3.8. U.S. Forest Service Allotment Summary for the Thunder Basin National Grasslands Within the Study Area

Medicine Bow-Routt National Forest Ranger District	Allotment Number	Allotment Name	Area (acres)
Douglas	9356	Arledge	4,825.6
	9218	Bacon Creek	2.1
	9304	Burr	266.2
	9318	Clyde	1,522.0
	9337	Cossart	43.2
	9325	Cranston	687.4
	9338	Driskell	2,978.8
	9345	Hagerman	753.9
	9001	Kara Community	2,119.8
	9370	Materi	718.9
	9333	May	1,349.1
	9372	Mirich	3,889.0
	9375	Murray	2,565.0
	9359	Pickrel	10,620.5
	9307	Pine Ridge	9,515.9
	9388	Rankin	660.8
	9303	Reynolds	1,864.5
	9326	Saunders	19.5
	9392	Schuette	635.1
	9376	Shannon	2.3
	9373	Shepperson	6,944.4
	9371	Stellwagon	483.6
	9335	Sweet	179.0
	9324	Sweet Ranch	140.5
	9355	Watt	1,408.4
	9357	Webster	15.8

The USFS grazing allotments on rangelands within the study area are partially comprised of "Bankhead-Jones" lands. In the early 1900s, settlers homesteaded and filed land patents on 320 and 640 acres of public land under the Homestead Act of 1909 and the Stock Raising Homestead Act of 1916, respectively [USFS, 2009]. Homesteaders dry farmed and raised livestock until several years of drought in the 1930s and hard economic times during the Great Depression caused many to abandon their homesteads. As a result, the federal government began repurchasing the abandoned homesteads in the 1930s under the Bankhead-Jones Farm Tenant Act and the USFS over management of these lands in 1954 [USFS, 2009].

Additionally, approximately 161,700 acres of federal forestlands are within the watershed. The USFS administers those federal forestlands in 31 grazing allotments, which encompass approximately 179,850 acres of federal, state, and private lands within the Black Hills National Forest (BHNF). These grazing allotments are also shown in Figure 3.6 and listed in Table 3.9. The majority (96 percent) of these allotment acres are a part of the Bear Lodge Ranger District with the remaining allotments within the Hell Canyon and Northern Hills Ranger Districts. The USFS manages the allotments under their 2006 BHNF's Land and RMP or "Forest Plan" and associated amendments [USFS, 1997; 2005]. In 2010, the BHNF reauthorized domestic livestock grazing as part of the Bearlodge Range 2010 Project involving four allotments on the Bearlodge Ranger District in Crook County, Wyoming. The allotments include Addition, Beaver Creek, Divide, and Oak Creek and cover approximately 32,576 acres consisting of 23,814 acres of USFS land, 7,617 acres of private land, and 1,145 acres of state land [USFS, 2010].

3.4.5.3 State of Wyoming Lands

Most of the state lands within the watershed are leased to private landowners for grazing. These leases are issued by the Wyoming SBLC and administered by the Wyoming OSLI. State grazing and agricultural leases allow lessees to construct lease-related improvements on state land, subject to Board approval. Grazing management practices and the operation and management of installed improvements on state grazing leases are usually established and implemented by the lessee. Upon a transfer of a state grazing land lease, the new lessee reimburses the previous lessee for improvements.

3.4.5.4 Private Lands

Private land encompasses approximately 1,723,220 acres (87.5 percent) of the rangelands and approximately 249,580 acres (57.7 percent) of the forestlands within the study area. Grazing practices on private lands are established by the landowner and/or manager and often with technical assistance from the local NRCS Field Office or a range consultant. Management practices and improvements on private lands are implemented and owned by the landowner or manager. Landowners and managers who voluntarily participate in Farm Bill programs may be required to follow NRCS standards and specifications or an approved grazing plan included in a conservation plan developed for the enrolled property or applicable Farm Bill program. Private grazing lands are often managed for multiple uses, including timber production, mining, oil and gas production, wildlife habitat, and recreation.

Table 3.9. U.S. Forest Service Allotment Summary for the Black Hills National Forest Within the Study Area

Black Hills National Forest Ranger District	Allotment Number	Allotment Name	Area (acres)
Bearlodge	110	Addition	5,798.4
	103	Beaver Creek	12,785.4
	107	Blacktail	10,240.2
	126	Cole	357.3
	117	Divide	3,366.8
	104	Farrall	12,371.5
	122	Grand Canyon	11,929.6
	111	Huett Springs	2,131.5
	124	Idol	10,444.7
	116	Inyan Kara	1,547.8
	121	Lame Jones	395.6
	115	Lost Canyon	7,575.6
	118	Lytle Creek	3,107.0
	102	North Bearlodge	8,403.7
	109	Oak Creek	1,099.9
	108	Ogden	8,397.2
	120	Pheasant Draw	393.4
	105	Redwater	5,995.8
	125	Sandcreek	17,480.1
	113	Silver Creek	11,915.0
	114	Stearns Park	3,312.6
	101	Stoney Point	9,085.1
	106	Togus	5,519.5
	119	Warren Peak	8,058.7
	112	Willow Springs	11,811.6
Hell Canyon	403	Cold Creek	1.6
	406	Dry Beaver	48.5
	416	Soldier Creek	2,926.1
	417	Stovehole	6.4
Northern Hills	710	Bear Ridge	1.0
	711	Cement Ridge	3,344.9

Public land management policies directly affect the management of the private rangelands because public grazing leases and federal grazing allotments are integral components of a typical private grazing operation within the study area. Whether grazing occurs on private or public lands, a system of well-distributed, reliable water sources is a vital component to maintain or improve range conditions. A considerable amount of information regarding soils, hydrology, ecology, production, and vegetation within the study area is available. The ecological site description, which helps landowners and managers evaluate the condition of a range or forest site by comparing the current growth to what the site is capable of growing, can also be a valuable tool for landowners to use in their decision making.

3.4.5.5 Existing Water Supply

A dependable water supply is the foundation for grazing management; it is necessary to provide sufficient amounts of suitable-quality water to animals over private and public rangelands. Numerous upland water sources are currently within the study area. Many rangeland improvements and grazing management projects have developed existing water sources such as springs, wells, and perennial streams. These projects often included storage tanks, ponds, reservoirs, pumping plants, and spring developments with pipelines carrying livestock and wildlife water to remote stock tanks.

Existing water sources on properties of participating landowners and managers were mapped within the watershed study. Mapping was not completed for the majority of private lands in the watershed because many landowners or managers did not participate in the study. The mapping is not a complete account of all viable water sources but serves as a baseline for estimating livestock and wildlife water needs within the watershed. Mapping viable water sources within the watershed included the following items:

- Maps of springs were obtained from the BLM Buffalo and Newcastle Field Offices and the BHNF Bearlodge Ranger District.
- Maps of stock wells were created by using data obtained from the SEO and WWDO.
- Interviews with landowners were conducted during study meetings and field visits.
- Maps were developed and existing stock ponds and reservoirs were inventoried during landowner field visits and assessed using aerial imagery, infrared imagery, topographic maps, and hydrography datasets.

This mapping effort indicated the existence of 363 stock reservoirs, ponds, lakes, and reservoirs. Digitized locations of springs were included by using BLM, USFS, and USGS data. Although a detailed field verification of these sites was beyond the scope of this study, an initial review of the existing sources was completed. Recent high-resolution aerial imagery was examined by using the GIS data to determine the status and viability of the water features.

Existing structures containing water and showing no breaches of the dam or spillway were determined to be likely water sources. Some of the structures showed visible evidence of dam and spillway breaches and were determined to be nonfunctional. Other structures were observed to have filled with sediment and were determined to be nonfunctional, and still other structures were dry and designated as potential water sources. An example of the mapping process is shown in Figure 3.7, and the results of this mapping effort are presented in Figure 3.8. Approximately 295 of the structures appear to be viable sources, 5 structures appear to be breached, and 63 structures were dry or leaking and more work is required to determine functionality.

Several livestock/wildlife water development projects have been completed within the study area. Typically, these projects included wells, spring developments, pipelines, and stock tanks. A 1-mile buffer was delineated around the existing viable water source locations within the study area and is presented in Figure 3.9. This figure of mapping results does not include surface water sources such as perennial and intermittent streams, undeveloped springs, or breached or nonfunctional ponds and reservoirs. Additionally, the existing water supply is augmented by the Gillette Regional Water Supply Project (GRWSP). The GRWSP relies on groundwater to supply water to the city of Gillette and over 40 local water and improvement districts serving a regional population in excess of 57,000.

3.4.5.6 Ecological Site Descriptions

Rangelands are classified as ecological sites based on soils, topography, and climate that create each site's unique characteristics. An ecological site is a conceptual division of the landscape defined by the BLM, USFS, and NRCS [Caudle et al., 2013] as the following:

> *A distinctive kind of land based on recurring soil, landform, geological, and climate characteristics that differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation and in its ability to respond similarly to management actions and natural disturbances.*

Ecological sites incorporate environmental factors such as climate, soils, landform, hydrology, vegetation, and natural disturbance regimes that together define the site and its relationships between these factors and how they influence plant community composition [Caudle et al., 2013]. The characteristics differentiating ecological sites and their features are documented as an ecological site description (ESD), which includes the following:

- Data used to define the distinctive properties and characteristics of the sites
- Biotic and abiotic characteristics that differentiate the site (i.e., climate, physiographic, soil characteristics, plant communities)
- Ecological dynamics including how changes in climate, disturbance processes, and management can affect the site.

An ESD includes interpretations about the land uses that a specific ecological site can support and management alternatives for achieving objectives. ESDs are valuable tools that can be used to help landowners and managers make decisions through evaluating the condition or

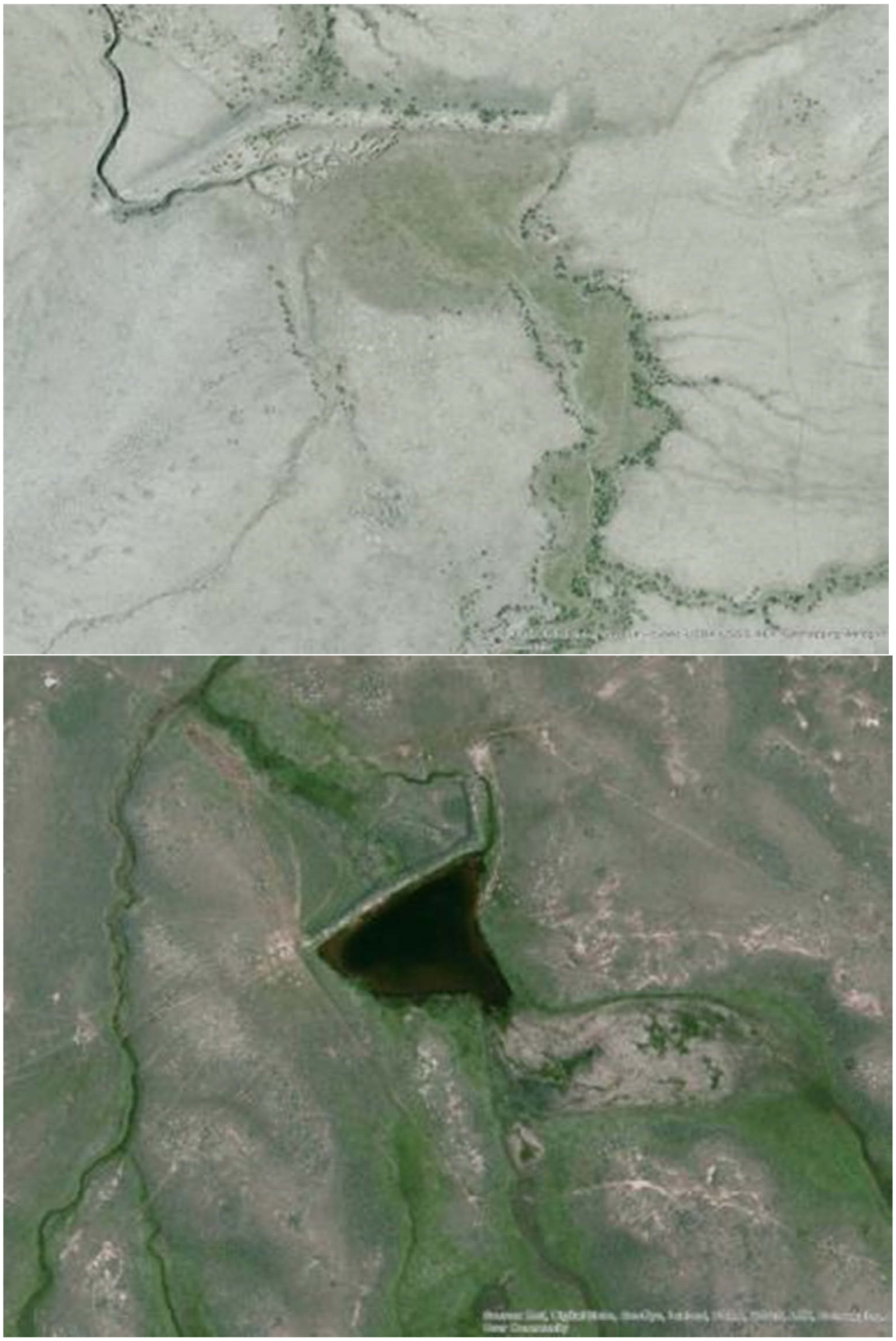

Figure 3.7. Geographic Information System Evaluation of Stock Ponds and Reservoirs Within the Study Area.

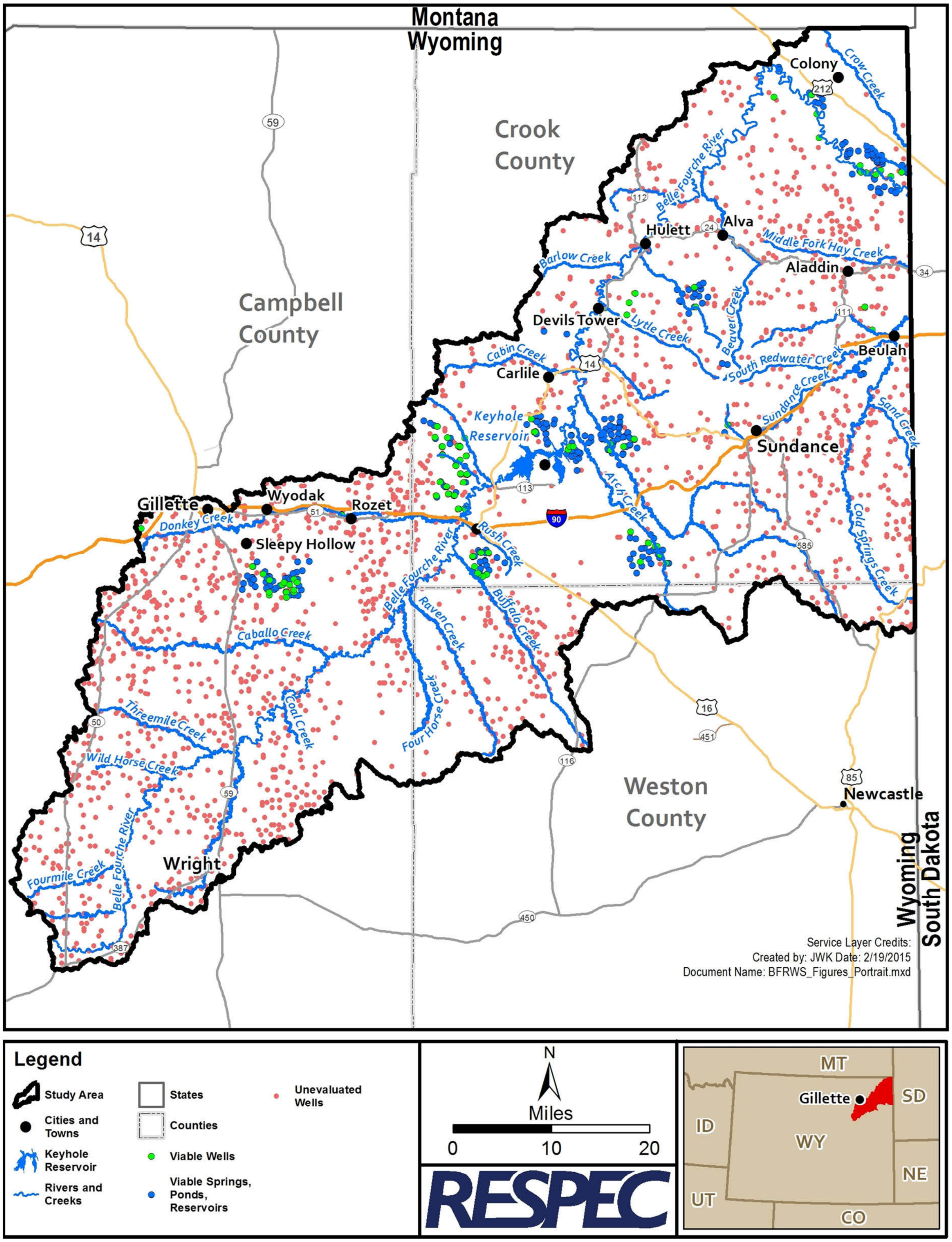

Figure 3.8. Viable Water Sources in the Study Area.

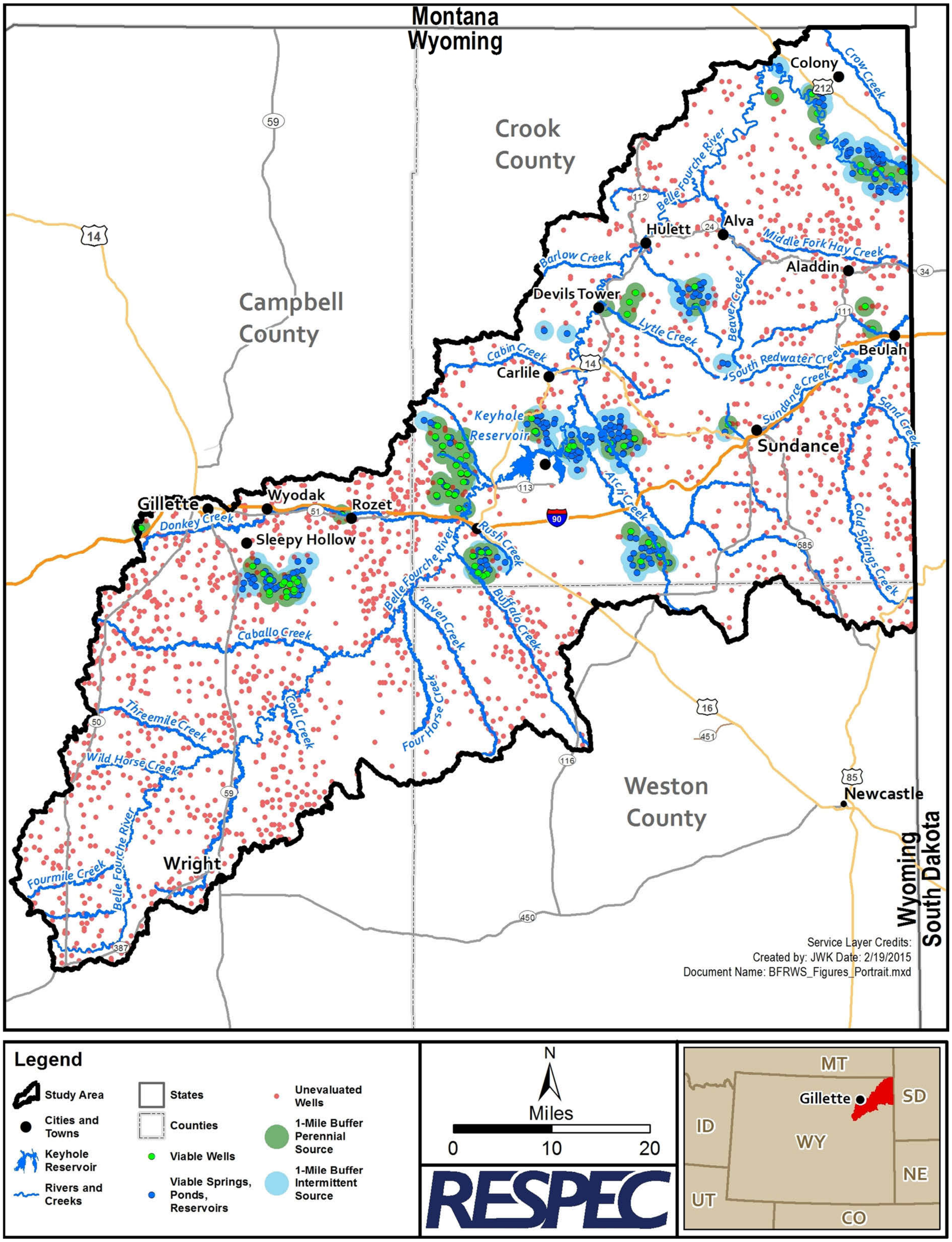

Figure 3.9. Viable Water Sources With a 1-Mile Buffer in the Study Area.

health of a range or forest site and comparing the current vegetation composition to the type of plants the site is capable of growing. The ecological sites and associated descriptions were developed over many years of data collection and range site monitoring and are dependent on the location of a site within defined precipitation zones and existing soil characteristics. ESDs available from the NRCS (*https://esis.sc.egov.usda.gov/Welcome/pgReportLocation.aspx?type=ESD*) describe the following for each ecological site:

- **Site characteristics**—physiographic, climate, soil, and water features
- **Plant communities**—plant species, vegetation states, and ecological dynamics
- **Site interpretations**—management alternatives for the site and its related resources
- **Supporting information**—relevant literature, information, and data sources.

The ESDs and NRCS soil map units are available and have been compiled for approximately 90 percent of the study area; soils data were not available for the remaining 10 percent. Figure 3.10 shows the locations of the major ecological sites within the study area. Five predominant ESDs cover approximately 39 percent of the watershed and are listed in Table 3.10. The loamy (Ly) 10- to 14-inch Northern Plains precipitation zone ESD (R058BY122WY) is the largest zone and covers approximately 352,060 acres (14 percent) of the study area. ESDs covering more than 1 percent of the study area are listed in Table 3.11.

In addition to the ESDs, the NRCS soils data include forage suitability group descriptions (FSGDs), which occur on approximately 127,970 acres within the study area and are also listed in Table 3.11. FSGDs describe one or more individual soil map unit components having similar potentials and limitations for forage production and can be linked or associated to one individual ecological site or to multiple ecological sites. Because ESDs are still being developed and approved for interpreting ecological conditions on forest soils within the watershed, FSGDs could be used as a basic interpretive tool but caution should be exercised when using these for specific pastures, grazing allotments, or management units.

Rangelands contain numerous ESDs. More than one plant community can occur within an ESD given the site characteristics discussed above. Each range ecological site has a specific plant community that has developed because of these factors and is referred to as reference or Historic Climax Plant Community (HCPC). The HCPC describes the potential plant community and potential productivity of each individual range site. Plant communities have distinct forage production potential; the HCPC usually has the greatest potential. The HCPC can be used to compare the current vegetation growing on a site to the plant community that could be grown on the site. This comparison using the HCPC can be an indicator of potential site productivity.

The following descriptions of the HCPC associated with the predominant ESDs within the study area were obtained directly from the NRCS *ESD System for Rangeland and Forestland Data* website that can be accessed online (*https://esis.sc.egov.usda.gov/Welcome/pgReportLocation.aspx?type=ESD*).

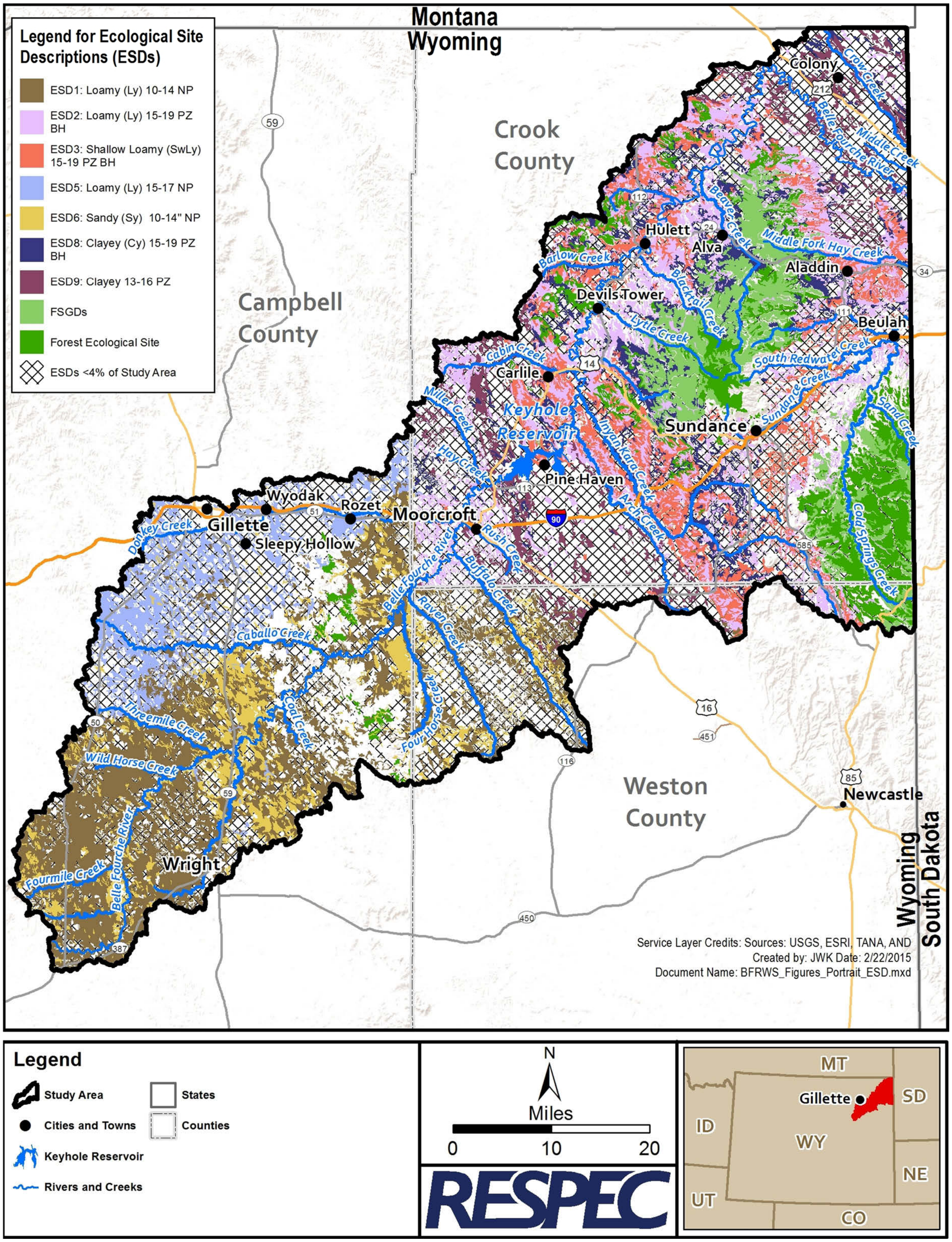

Figure 3.10. Ecological Site Descriptions Within the Watershed.

Table 3.10. Predominant Ecological Sites, Descriptions, and Areas Within the Study Area

Indentifier	Ecological Site I.D.	Description	Area (Acres)	Percent of Study Area
1	R058BY122WY	Loamy (Ly) 10–14-inch Northern Plains Precipitation Zone (PZ)	352,060	14.2
2	R061XY122WY	Loamy (Ly) 15–19-inch Black Hills PZ	234,370	9.4
3	R061XY162WY	Shallow Loamy (SwLy) 15–19-inch Black Hills PZ	150,320	6.0
4	R058BY222WY	Loamy (Ly) 15–17-inch Northern Plains PZ	116,510	4.7
5	R058BY150WY	Sandy (Sy) 10–14-inch Northern Plains PZ	112,530	4.5
Total			**965,790**	**38.8**

Loamy (Ly) 10–14-Inch Northern Plains Precipitation Zone

Rhizomatous Wheatgrasses/Needleandthread/Blue Grama Plant Community is the interpretive plant community for this site and is considered to be the Historic Climax Plant Community (HCPC). This plant community evolved with grazing by large herbivores and is well suited for grazing by domestic livestock. This plant community can be found on areas that are properly managed with grazing and/or prescribed burning, and sometimes on areas receiving occasional short periods of rest. The potential vegetation is about 75 percent grasses or grass-like plants, 15 percent forbs, and 10 percent woody plants. This state is dominated by cool season mid-grasses.

The major grasses include western wheatgrass, needleandthread, and green needlegrass. Other grasses occurring in this state include Cusick's and Sandberg's bluegrass, bluebunch wheatgrass, and blue grama. A variety of forbs and half-shrubs also occur, as shown in the preceding table. Big sagebrush is a conspicuous element of this state, occurs in a mosaic pattern, and makes up 5 to 10 percent of the annual production. Plant diversity is high.

The total annual production (air-dry weight) of this state is about 1,200 pounds per acre, but it can range from about 700 pounds per acre in unfavorable years to about 1,500 pounds per acre in above average years.

This plant community is extremely stable and well adapted to the Northern Great Plains climatic conditions. The diversity in plant species allows for high drought tolerance. This is a sustainable plant community (site/soil stability, watershed function, and biologic integrity).

Table 3.11. Ecological Sites, Descriptions, and Areas for Study Area (Page 1 of 2)

Identifier	Ecological Site I.D.	Description	Area (acres)	Percent of Study Area
1	R058BY122WY	Loamy (Ly) 10–14-inch Northern Plains PZ	352,060	14.2
2	R061XY122WY	Loamy (Ly) 15–19-inch Black Hills PZ	234,370	9.4
3	R061XY162WY	Shallow Loamy (SwLy) 15–19-inch Black Hills PZ	150,320	6.0
4	GFL_PIPO_FEID	Ponderosa-Idaho fescue	120,450	4.8
5	R058BY222WY	Loamy (Ly) 15–17-inch Northern Plains PZ	116,510	4.7
6	R058BY150WY	Sandy (Sy) 10–14-inch Northern Plains PZ	112,530	4.5
7	G062XY000SD	Not suited	100,210	4.0
8	R061XY104WY	Clayey (Cy) 15–19-inch Black Hills PZ	99,410	4.0
9	R060AY011SD	Clayey 13–16-inch PZ	93,380	3.8
10	R061XY158WY	Shallow Clayey (SwCy) 15–19-inch Black Hills PZ	63,600	2.6
11	R058BY162WY	Shallow Loamy (SwLy) 10–14-inch Northern Plains PZ	63,530	2.6
12	R060AY025SD	Shallow Dense Clay	62,670	2.5
13	R058BY166WY	Shallow Sandy (SwSy) 10–14-inch Northern Plains PZ	58,850	2.4
14	R058BY250WY	Sandy (Sy) 15–17-inch Northern Plains PZ	54,280	2.2
15	R060AY010SD	Loamy 13–16-inch PZ	43,510	1.8
16	R058BY104WY	Clayey (Cy) 10–14-inch Northern Plains PZ	34,570	1.4
17	R060AY030SD	Porous Clay	32,780	1.3
18	R060AY017SD	Shallow Clay	32,650	1.3
19	R061XY128WY	Lowland (LL) 15–19-inch Black Hills PZ	32,570	1.3
20	R058BY204WY	Clayey (Cy) 15–17-inch Northern Plains PZ	29,560	1.2
21	R061XY168WY	Thin Upland	28,500	1.1
22	R058BY144WY	Saline Upland (SU) 10–14-inch Northern Plains PZ	25,240	1.0
23	R061XN010SD	Loamy	25,910	1.0
24	R061XY150WY	Sandy (Sy) 15–19-inch Black Hills PZ	22,020	0.9
25	G062XY210SD	Clayey Subsoil	21,060	0.8
26	R060AY026SD	Saline Upland	19,430	0.8
27	R060AY012SD	Thin Upland	18,750	0.8
28	R061XY166WY	Shallow Sandy (SwSy) 15–19-inch Black Hills PZ	18,580	0.7
29	R058BY176WY	Very Shallow (VS) 10–14-inch Northern Plains PZ	16,610	0.7
30	GFL_PIPO_SCSC	Ponderosa Pine-Little Bluestem	16,590	0.7

Table 3.11. Ecological Sites, Descriptions, and Areas for Study Area (Page 2 of 2)

Identifier	Ecological Site I.D.	Description	Area (acres)	Percent of Study Area
31	R058BY262WY	Shallow Loamy (SwLy) 15–17-inch Northern Plains PZ	14,780	0.6
32	R058BY128WY	Lowland (LL) 10–14-inch Northern Plains PZ	14,620	0.6
33	R060AY043SD	Shallow Porous Clay	13,120	0.5
34	R060AY018SD	Dense Clay	11,720	0.5
35	R061XY130WY	Overflow (Ov) 15–19-inch Black Hills PZ	11,700	0.5
36	R061XY016SD	Very Shallow	10,670	0.4
37	R062XY003SD	Subirrigated	10,650	0.4
38	R061XN012SD	Thin Upland	9,080	0.4
39	R058BY130WY	Overflow (Ov) 10–14-inch Northern Plains PZ	8,000	0.3
40	R058BY158WY	Shallow Clayey (SwCy) 10–14-inch Northern Plains PZ	7,930	0.3
41	R060AY999SD	Non-site	7,720	0.3
42	R061XY022SD	Loamy Terrace	7,310	0.3
43	R060AY015SD	Thin Claypan	7,210	0.3
44	R060AY013SD	Claypan	7,010	0.3
45	R060AY040SD	Clayey 16–18-inch PZ	6,180	0.2
46	R061XY009SD	Sandy	5,950	0.2
47	R060AY021SD	Clayey Overflow	5,780	0.2
48	R061XY999SD	Non-site	5,250	0.2
49	R061XN024SD	Shallow Loamy	4,640	0.2
50	G062XY100SD	Loam	3,310	0.1
51	R061XY003SD	Subirrigated	3,110	0.1
52	G062XY300SD	Sand	2,780	0.1
53	R061XY042SD	Lowland	2,690	0.1
54	R058BY106WY	Clayey Overflow (CyO) 10–14-inch Northern Plains PZ	2,540	0.1
55	R058BY206WY	Clayey Overflow (CyO) 15–17-inch Northern Plains PZ	2,250	0.1
56	R062XY012SD	Thin Upland	2,040	0.1
57	R061XY138WY	Saline Lowland (SL) 15–19-inch Black Hills PZ	1,710	0.1
58	R061XY020SD	Loamy Overflow	1,530	0.1
60–73	Various ESDs	ESDs covering less than 0.1 percent of the study Area	5,440	0.2
Total			2,297,220	92.1

Transitions or pathways leading to other plant communities are as follows:

- *No use and no fire for 20 years or more will convert this plant community to the Heavy Sagebrush Plant Community.*
- *Moderate, continuous season-long grazing will convert the plant community to the Mixed Sagebrush/Grass Plant Community.*
- *Moderate continuous season-long grazing, where greasewood occurs adjacent to the site, will convert the plant community to the Greasewood Plant Community.*
- *When cropped annually and then abandoned without reseeding, the site is converted to the Go-back Land Plant Community.*

Loamy (Ly) 15–19-Inch Precipitation Zone, Black Hills

Rhizomatous Wheatgrasses/Needleandthread/Big Bluestem Plant Community is the interpretive plant community for this site and is considered to be the Historic Climax Plant Community (HCPC). This plant community evolved with grazing by large herbivores and is well suited for grazing by domestic livestock. This plant community can be found on areas that are properly managed with grazing and/or prescribed burning, and on areas receiving occasional short periods of rest. The potential vegetation is about 75 percent grasses or grass-like plants, 15 percent forbs, and 10 percent woody plants. A mix of warm and cool season mid-grasses dominates the state.

The major grasses include western wheatgrass, needleandthread, big bluestem, little bluestem, and green needlegrass. Other grasses occurring on the state include threadleaf sedge, Sandberg bluegrass, bluebunch wheatgrass, blue grama, and sideoats grama. A variety of forbs and half-shrubs also occur, as shown in the preceding table. Big sagebrush is a conspicuous element of this state, occurs in a mosaic pattern, and makes up 5 to 10 percent of the annual production. Plant diversity is high.

The total annual production (air-dry weight) of this state is about 2,200 pounds per acre, but it can range from about 1,500 pounds per acre in unfavorable years to about 3,000 pounds per acre in above average years.

This plant community is extremely stable and well adapted to the Black Hills Foot Slopes climatic conditions. The diversity in plant species allows for high drought tolerance. This is a sustainable plant community (site/soil stability, watershed function, and biologic integrity).

Transitions or pathways leading to other plant communities are as follows:

- *No use and no fire for 20 years or more will convert this plant community to the Heavy Sagebrush Plant Community.*
- *Moderate, continuous season-long grazing will convert the plant community to the Mixed Sagebrush/Grass Plant Community.*

- *When cropped annually and then abandoned without reseeding, the state is converted to the Go-back Land Plant Community.*

Shallow Loamy (SwLy) 15–19-Inchprecipitation Zone, Black Hills

Rhizomatous Wheatgrasses/Needleandthread/Blue Grama Plant Community is the interpretive plant community for this site and is considered to be the Historic Climax Plant for this site is the Historic Climax Plant Community. This state evolved with grazing by large herbivores and is well suited for grazing by domestic livestock. Potential vegetation is about 80 percent grasses or grass-like plants, 10 percent forbs, and 10 percent woody plants. The state is dominated by cool season midgrasses.

The major grasses include little bluestem, bluebunch wheatgrass, needleand-thread, sideoats grama, and western wheatgrass. Other grasses occurring on the state include Sandberg bluegrass, blue grama, plains muhly, spikefescue and prairie junegrass. Big sagebrush is a conspicuous element of this state and occurs in a mosaic pattern. Big sagebrush may become dominant on some areas with absence of fire. Natural fire occurred frequently in this community and prevented big sagebrush from being the dominant landscape. Wildfires are actively controlled in recent times so chemical control using herbicides has replaced the historic role of fire on this state. Recently controlled burning has regained some popularity.

The total annual production (air-dry weight) of this state is about 1,400 pounds per acre, but it can range from about 900 pounds per acre in unfavorable years to about 1,800 pounds per acre in above average years.

The state is extremely stable and well adapted to the Black Hills Foot Slopes climatic conditions. The diversity in plant species allows for high drought resistance. This is a sustainable plant community (site/soil stability, watershed function, and biologic integrity).

Transitions or pathways leading to other plant communities are as follows:

- *Protection from grazing and fire will convert this plant community to the Heavy Sagebrush Plant Community.*
- *Moderate, continuous season-long grazing will convert the plant community to the Mixed Sagebrush/Grass Plant Community.*
- *Frequent and severe grazing and brush management will convert the plant community to the Blue Grama Plant Community.*

Loamy (Ly) 15–17-Inch Northern Plains Precipitation Zone

Rhizomatous Wheatgrasses/Needleandthread/Big Bluestem Plant Community is the interpretive plant community for this site and is considered to be the Historic Climax Plant Community (HCPC). This plant community evolved with grazing by *large herbivores and is well suited for grazing by domestic livestock. This plant community can be found on areas that are properly managed with grazing and/or prescribed burning, and sometimes on areas receiving occasional short periods of rest. The potential vegetation is about 75 percent grasses or grass-like plants, 15 percent forbs, and 10 percent woody plants. A mix of warm and cool season mid-grasses dominates the state. The major grasses include western wheatgrass, needleandthread, big bluestem, little bluestem, and green needlegrass. Other grasses occurring on the state include threadleaf sedge, Sandberg's bluegrass, bluebunch wheatgrass, blue grama, and sideoats grama. A variety of forbs and half-shrubs also occur, as shown in the preceding table. Big sagebrush is a conspicuous element of this state, occurs in a mosaic pattern, and makes up 5 to 10 percent of the annual production. Plant diversity is high.*

The total annual production (air-dry weight) of this state is about 1,900 pounds per acre, but it can range from about 1,500 pounds per acre in unfavorable years to about 2,300 pounds per acre in above average years.

This plant community is extremely stable and well adapted to the Northern Great Plains climatic conditions. The diversity in plant species allows for high drought tolerance. This is a sustainable plant community (site/soil stability, watershed function, and biologic integrity).
Transitions or pathways leading to other plant communities are as follows:

- *No use and no fire for 20 years or more will convert this plant community to the Heavy Sagebrush Plant Community.*
- *Moderate, continuous season-long grazing will convert the plant community to the Mixed Sagebrush/Grass Plant Community.*
- *Moderate continuous season-long grazing, where greasewood occurs adjacent to the state, will convert the plant community to the Greasewood Plant Community.*
- *When cropped annually and then abandoned without reseeding, the state is converted to the Go-back Land Plant Community.*

Sandy (Sy) 10–14-Inch Northern Plains Precipitation Zone

Needleandthread/Prairie Sandreed Plant Community is the interpretive plant community for this site and is considered to be the Historic Climax Plant Community (HCPC). This state evolved with grazing by large herbivores and is well suited for grazing by domestic livestock. Potential vegetation is about 75 percent grasses or grass-like plants, 15 percent forbs, and 10 percent woody plants. The state is a mix of warm and cool season midgrasses. The major grasses include needleandthread, prairie sandreed, little bluestem, and Indian ricegrass. Other grasses occurring in the state include rhizomatous wheatgrasses, Sandberg bluegrass, blue grama, and threadleaf sedge. Silver sagebrush and green rabbitbrush are conspicuous components of this state.

The total annual production (air-dry weight) of this state is about 1,200 pounds per acre, but it can range from about 750 pounds per acre in unfavorable years to about 1,600 pounds per acre in above average years.

The state is stable and well adapted to the Northern Great Plains climatic conditions. The diversity in plant species allows for high drought resistance. This is a sustainable plant community (site/soil stability, watershed function, and biologic integrity).

Transitions or pathways leading to other plant communities are as follows:

- *Moderate, Continuous Season-Long grazing will convert the plant community to the Needleandthread/Threadleaf sedge/Fringed sagewort Vegetation State.*
- *Frequent and Severe grazing will convert the plant community to the Threadleaf sedge/Fringed sagewort/Plains Pricklypear Vegetation State.*

3.4.5.7 Range Conditions and Needs

Range conditions depend on a number of factors including, but not limited to, climate and precipitation, soil and water, plants and animals, topography and geology, and natural disturbances. Range condition goals, objectives, and actions for BLM or USFS managed allotments within the study area are detailed in the BLM's proposed and approved RMPs and associated environmental impact statement (EIS) documents for the Buffalo and Newcastle field offices and the USFS Forest Plan and amendments and associated EIS documents for the USFS Douglas and Bearlodge Ranger Districts. Grazing permits or leases for a particular allotment, however, are not included within the RMP, Forest Plan, or EIS. Grazing leases and permits frequently include an AMP, coordinated resource management plan (CRMP), or similar agreement that outlines a grazing plan and is prepared in cooperation with the permittees or operators. These plans often include goals and objectives, management indicators, use patterns, desired conditions, and monitoring techniques to measure progress.

Rather than focusing on specific details or obtaining information from the AMPs, study efforts focused on working with participants and permittees to identify areas where water developments could enhance grazing land conditions. Additionally, study efforts concentrated on identifying areas where participating landowners and managers indicated that developing water sources could assist with improved grazing distribution and could improve rangeland or forestland conditions over time. Taking inventory of range or pasture conditions on a specific property was outside the scope of this study.

Upland plant communities in the majority of the watershed are dominated by grass and sagebrush species. Pine forests and other woodlands dominate the areas of the watershed in and near the Bear Lodge Mountains and the Black Hills. In general, the major desirable grass species in the watershed include rhizomatous wheatgrass, needleandthread, green needlegrass, prairie sandreed, big bluestem, and blue grama. Generally, these plant communities have been altered by surface activities, grazing, wildfires, and invasive or noxious species.

A vital component needed to maintain or improve range conditions is a system of well-distributed, reliable water sources. Dependable water supplies are the foundation for implementing management strategies that can benefit many of the resources such as wildlife and livestock on uplands within the watershed. When viable water sources are available, more grazing management options can be considered by landowners and managers to enhance grazing systems and improve range conditions.

In the absence of well-distributed watering facilities, animals tend to spend more time near perennial or intermittent surface water sources. The animals graze riparian vegetation but underuse adjacent upland vegetation areas. Seasonal or intermittent water sources are often available only during short periods of the grazing season. As a result, continual grazing during critical plant growth periods causes shifts in desirable plant communities, range conditions, and production. During the growing season, grasses and other forage vegetation require varying recovery periods, adequate leaf and root biomass, and sufficient soil moisture to capture sunlight, regrow leaves, restore root reserves, and maintain plant vigor. If these processes do not occur, the grasses and other desirable species will ultimately decrease and less desirable and/or invasive plants will increase in composition and density.

These undesirable shifts in rangeland conditions can be avoided or changed if grazing intensity and timing are adapted to allow plant recovery and regrowth, which would result in desired plant communities and increased production. To accomplish this, landowners and managers typically implement grazing systems with cross fencing or realignment, improved grazing timing and scheduling, and herding or low-stress handling methods. Viable water sources and distribution systems are needed because more animals graze during shorter periods in a specific area or pasture and better water availability and reliability requirements are achieved.

Healthy uplands and rangelands contribute to the function of a watershed by enhancing precipitation infiltration, improving soil percolation, reducing surface water runoff, recharging soil moisture and groundwater, and increasing habitat availability and diversity. Grazing management and rangeland projects routinely benefit livestock and watershed management efforts but can also help in improving wildlife habitat and management. Because the watershed contains species of concern, project planners should consider whether or not the proposed activities are beneficial or detrimental to the habitat requirements of the particular species. Sage-grouse is an example of a species that would benefit from changes in grazing management. Grazing management changes could improve sagebrush, forb, and grass composition. Proposed water tank and troughs should have wildlife escape ramps to provide the sage-grouse access to water but prevent drowning.

Recommended alternatives and proposed conceptual projects for improving livestock/wildlife water sources are included in Section 4.3 of this report. Suggested management options to address other issues and concerns on uplands and rangeland are included in Section 4.6. These recommendations, proposals, and suggestions were developed in consideration of cost-effectiveness, site characteristics and accessibility, and technical and economic feasibility.

3.4.6 Mining and Mineral Resources

The study area contains 40 operating noncoal mines. Information about the mines was obtained from the WDEQ and are summarized in Table 3.12 and Figure 3.11. Scoria and sand/gravel mines constitute the majority of permitted mine operations, within the study area. Other minerals mined include limestone, bentonite, and gypsum. The largest operation within the study area is the Belle Fourche River Mine operated by American Colloid Company on a permitted acreage of approximately 39,000 acres.

Seven active coal mines are located in the western portion of the study area near Gillette, Wyoming. Table 3.13 summarizes these operations, which are also shown in Figure 3.11. The largest operation within the study area is the Cordero Rojo Mine operated by Cordero Mining LLC on a permitted acreage of approximately 21,690 acres.

3.4.7 Oil and Gas Production and Resources

Information and data regarding the active and abandoned oil and gas wells within the study area was obtained from the WOGCC via their website (*http://wogccms.state.wy.us/*) and by communicating with WOGCC staff. Approximately 2,838 producing gas wells, 1,238 producing oil wells, and 6,900 permanently abandoned wells are within the study area. Locations of the active oil and gas wells and permanently abandoned wells are depicted in Figure 3.12.

According to the WSGS, the watershed contains 176,750 acres of oil and gas fields. These fields are located almost exclusively in the western portion of the watershed. In 2013, oil and gas fields within the study area produced approximately 4,593,475 barrels (bbls) of oil, 2,343,823 thousand cubic feet (mcf) of natural gas, and 27,457,959 bbls of water [WOGCC, 2014]. Table 3.14 summarizes the 2013 oil and gas production by field for the oil and gas areas within the watershed. Field locations and pipelines are also shown on Figure 3.12.

3.4.8 Wildlife and Habitat

3.4.8.1 Big Game

The WGFD provides a system of control, propagation, management and protection, and regulation of all wildlife in Wyoming. The WGFD monitors and maintains big game, small game, nongame, and fish populations through studies, surveys, and habitat analysis. They have recorded, mapped, and analyzed data for big game and developed geodata showing hunt areas, herd units, seasonal range, crucial range, parturition area, and migration routes and barriers for antelope, bighorn sheep, bison, elk, mule deer, moose, Rocky Mountain goat, and white-tailed deer.

Table 3.12. Current Mineral Resource Mines Within the Study Area

Permit I.D.	Permitted Mine	Permittee	Commodity	Mine Area (acres)
ET0192	Croell	Croell Redi-Mix Inc.	Sand	8.4
ET0866	Hitt	Eldridge Excavating Inc.	Sand and Gravel	10.0
ET0888	Tenke	Dan Hart Patrol Service, LLC	Limestone	9.9
ET1030	Goodson	Croell Redi-Mix Inc.	Sand and Gravel	4.5
ET1150	Durham Ranch	Basic Energy Service LP	Scoria	10.0
ET1193	Shober	Fuller Construction Inc.	Gravel	10.0
ET1255	Tenke	Tenke, Vince, Arelene & Leslie	Sand and Gravel	10.0
ET1265	Fuller Ranch	Magna Energy Service LLC	Scoria	10.0
ET1387	State/Pickrel	Fuller Construction Inc.	Scoria	4.2
ET1415	Greer	Quality Agg & Construction Inc.	Scoria	2.9
ET1418	Ohman	Quality Agg & Construction Inc.	Scoria	6.3
ET1429	Zimmerschied	Quality Agg & Construction Inc.	Sand and Gravel	10.0
ET1448	Schlautmann	Quality Agg & Construction Inc.	Sand and Gravel	9.6
ET1464	Williams	Earth Work Solutions (WY)	Sand	7.1
ET1475	Swingholm	Dry Creek Trucking LLC	Scoria	3.6
ET1540	Tripp	Gold Star Production Service LLC	Scoria	0.0
PT0267	Colony	Bentonite Performance Minerals LLC	Bentonite	17,347.0
PT0567	Sundance/Vondrisk	Lien, Pete & Sons Inc.	Limestone	208.7
PT0620	Belle Fourche River	American Colloid Co.	Bentonite	39,092.6
PT0621	Upton	American Colloid Co.	Bentonite	19,016.7
PT0663	Vincent Thar	Fuller Construction Inc.	Scoria	41.6
PT0667	Habeck	Hills Material Co.	Limestone	140.5
PT0673	Thar	Magna Energy Service LLC	Scoria	26.3
PT0675	Mcinerney	Quality Agg & Construction Inc.	Sand and Gravel	198.2
PT0677	Neiman	Birdsall Sand & Gravel	Sand and Gravel	730.0
PT0704	Groves	Groves, Urban H	Sand and Gravel	39.4
PT0709	Shober	Magna Energy Service LLC	Sand and Gravel	34.1
PT0711	Rag Scoria	Hettinger LLC	Scoria	158.7
PT0719	Pickrel Pit	Basic Energy Service LP	Scoria	21.9
PT0727	Sundance	Monolith Minerals LLC	Gypsum	720.0
PT0729	Cole Pit	Basic Energy Service LP	Sand and Gravel	54.3
PT0731	Durham Ranch Pit	Basic Energy Service LP	Scoria	41.6
PT0744	Hunter Quarry	Lien, Pete & Sons Inc.	Limestone	522.1
PT0745	Iron Mountain	Black Hills Bentonite LLC	Bentonite	1,662.7
PT0745	Iron Mountain	Black Hills Bentonite LLC	Bentonite	1,662.7
PT0770	East Thar	Quality Agg & Construction Inc.	Scoria	83.3
PT0772	Rogers	Croell Redi-Mix Inc.	Limestone	600.1
PT0789	Lake Ranch	Aggregate Solutions, LLC	Gravel	118.3
PT0793	State Line	Fisher Sand & Gravel Co.	Limestone	133.9
PT0794	Flocchini	Quality Agg & Construction Inc.	Scoria	49.6

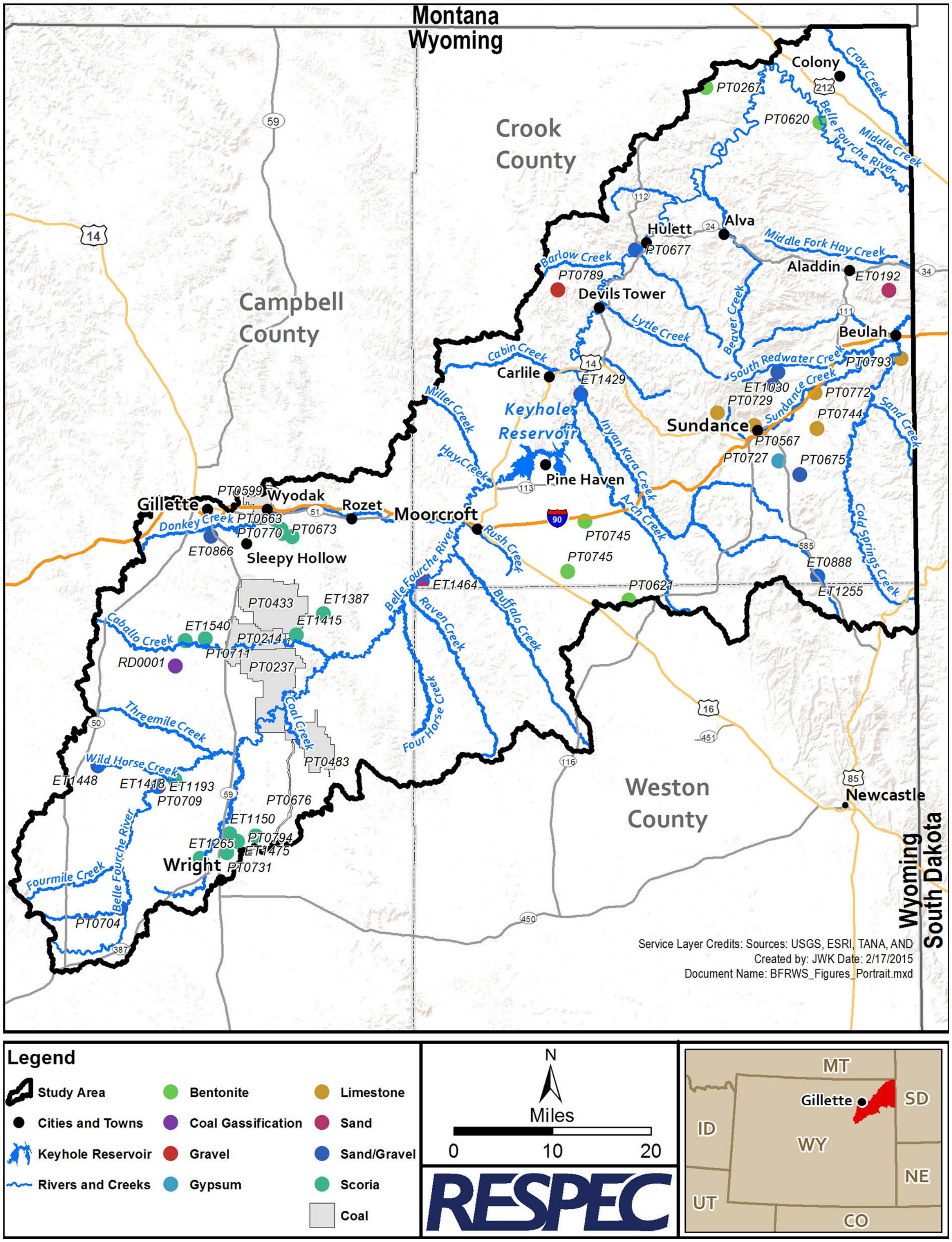

Figure 3.11. Permitted Mines Within the Belle Fourche River Watershed.

Table 3.13. Current Coal Resource Mines Within the Study Area

Permit I.D.	Permitted Mine	Permittee	Mine Area (acres)
PT0214	Belle Ayr	Alpha Coal West Inc.	12,090.6
PT0232	WYODAK	WYODAK Resources Development Corp.	6,031.8
PT0237	Cordero Rojo	Cordero Mining LLC	21,685.0
PT0433	Caballo	Peabody Caballo Mining LLC	19,974.7
PT0483	Coal Creek	Thunder Basin Coal Company LLC	9,741.0
PT0599	Dry Fork	Western Fuels WY Inc.	6,031.5
PT0676	Izita	Thunder Basin Coal Company LLC	1,831.1

Crucial range has been defined as seasonal ranges that are the determining factor affecting a herd's ability to maintain stable and healthy populations. Parturition areas are those where lambing, fawning, or calving occur [WGFD, 2013a]. Within the study area, approximately 199,000 acres (8 percent) have been classified as crucial range for elk, mule deer, or whitetail deer. Figures 3.13 through 3.15 display the herd units, crucial range, and seasonal range for antelope, elk, and mule deer. The entire watershed is seasonal range for antelope, mule deer, and whitetail deer. Over 50 percent of the watershed is seasonal range for elk. Crucial range makes up a much smaller portion of the study area. No parturition areas are classified for any big game species within the study area.

3.4.8.2 Species of Concern

The Wyoming Natural Diversity Database (WYNDD) records and maintains a list of species in Wyoming that are thought to be rare or sensitive. Tracked species are those vulnerable to extirpation because of rarity, inherent vulnerability, or habitat threats. Watched species are those that appear to be presently secure but have limited distribution. Table 3.15 lists the tracked or watched species of amphibians, birds, crustaceans, fish, insects, mammals, mollusks, and reptiles found within the study area [WYNDD, 2014]. The list shows that one endangered species is known to have occurred in the study area: the black-footed ferret (*Mustela nigripes*). Two threatened species occur within the study area: piping plover (*Charadrius melodus*) and the grizzly bear (*Ursus arctos arctos*).

Table 3.15 shows that the sage-grouse is listed as "candidate species; warranted but precluded" because existing information supports a proposal to list the sage-grouse as endangered or threatened, but developing a proposed listing is precluded by higher priority listing activities. In 2011, the Governor of Wyoming issued an executive order to protect and enhance sage-grouse populations and habitat within and outside the core areas. The order requires state agencies to focus management to the greatest extent possible to prevent the sage-grouse from being listed on the endangered species list. The core areas for sage-grouse cover approximately 229,000 acres (9 percent) of the study area and are shown in Figure 3.16.

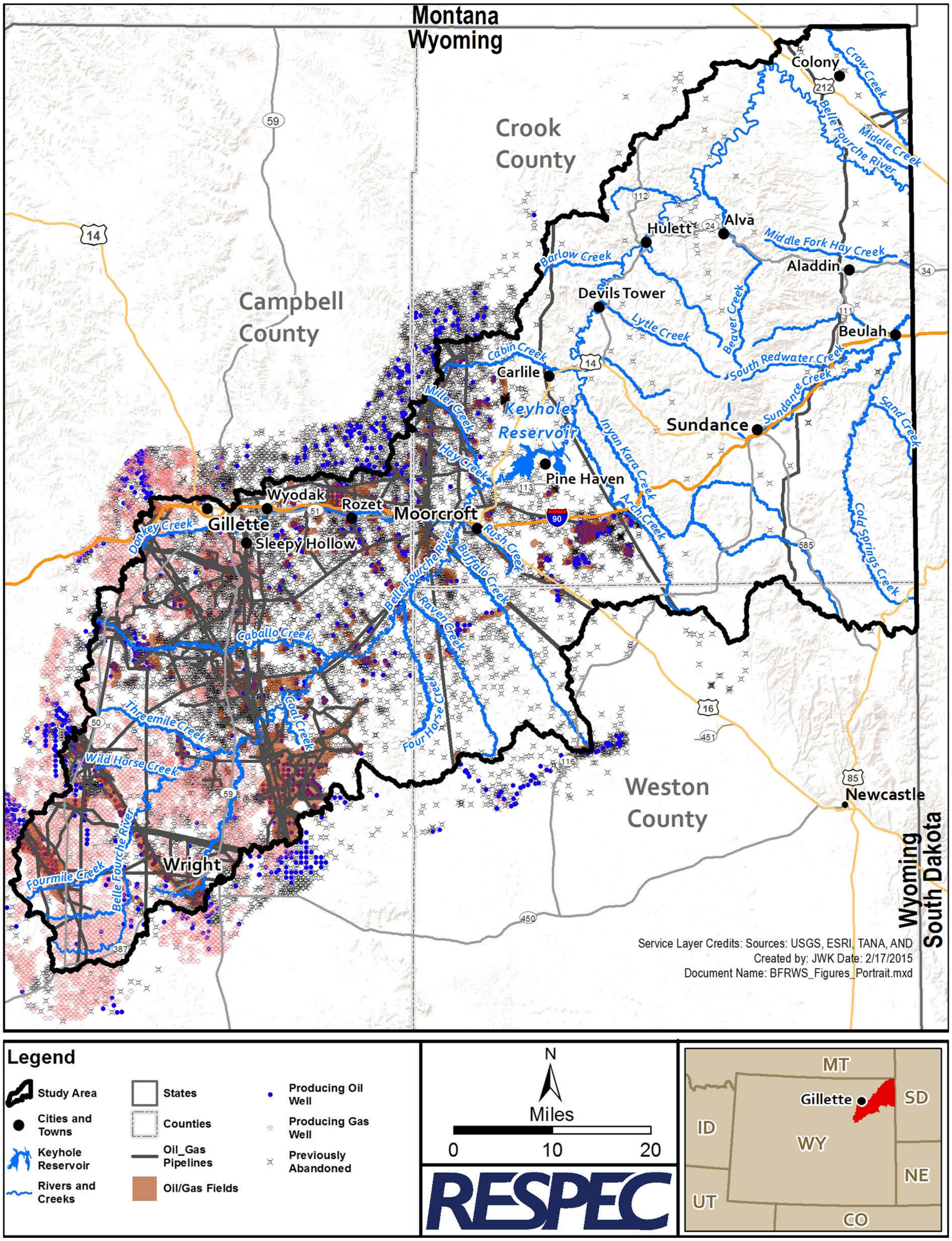

Figure 3.12. Active Oil and Gas Fields and Pipelines Within the Belle Fourche River Watershed.

Table 3.14. 2013 Oil and Gas Production by Field Within the Study Area (Page 1 of 3)

Oil or Gas Field	Oil (bbls)[(a)]	Gas (mcf)[(b)]	Water (bbls)[(a)]
Austin Creek	23,617	680,761	1,486
Am-Kirk	12,255	1,265	248,332
Art Creek	8,753	0	46,645
Barton	945	0	80,147
Bethlehem	3,963	0	0
Bigfoot	19,824	0	634,559
Bone Pile	59,485	0	695,161
Buff	3,459	70,268	110
Butte	1,040	0	0
Coyote Creek	20,132	4,412	1,137,584
Coyote Creek South	21,981	9,010	1,295,926
Cyclone Canyon	NDA	NDA	NDA
Doe	NDA	NDA	NDA
Donkey Creek North	16,719	0	32,579
Eagle Rock	NDA	NDA	NDA
East Fork	1,481	0	0
Eitel	9,561	0	227,945
FD	44,493	0	943,672
Fiddler Creek	23,370	3,810	193,386
Fiddler Creek East	443	0	46,882
Osage	43,331	0	532,516
Fish	35,590	0	0
Four Horse	0	0	0
Gaither Draw	140,834	24,947	76,654
Hartzog Draw	618,227	148,112	2,446,187
Hawk Point	5,938	0	255,650

Table 3.14. 2013 Oil and Gas Production by Field Within the Study Area (Page 2 of 3)

Oil or Gas Field	Oil (bbls)[(a)]	Gas (mcf)[(b)]	Water (bbls)[(a)]
Hay Creek	9,459	120,813	504
House Creek	1,994,732	961,671	5,025,241
House Creek West	11,627	2,462	47,589
Kara	1,623	234	56
K-Bar	210,633	171,688	229,723
Keyhole	24	0	0
Kiehl	33,548	0	898,045
Kitty	57,480	719,220	11,793
Kummerfield West	14,386	0	403,964
Little Powder	NDA	NDA	NDA
Mill – Gillette	4,199	300	24,830
Napier Road	1,600	0	0
Olds	5,072	0	575,401
Olds	5,072	0	575,401
Pine Ridge	3,999	0	311,772
Soap Hole	735	0	5,648
Pinnacle Divide	4,399	0	664
Pleasantville	11,827	0	5,516
Prong Creek	60,573	0	1,380,701
Quest	14,775	40,680	58,377
Rabbit Ears	NDA	NDA	NDA
Rainbow Ranch	14,391	580	493,724
Reel	62,684	0	208,373
Robinson Ranch	13,892	0	1,624,565
Robinson Ranch East	13,191	0	599,727
Robinson Ranch South	9,436	0	153,940

Table 3.14. 2013 Oil and Gas Production by Field Within the Study Area (Page 3 of 3)

Oil or Gas Field	Oil (bbls)[a]	Gas (mcf)[b]	Water (bbls)[a]
Rock Creek	12,219	0	13,300
Rocky Hill	0	0	0
Rozet	166,748	2,781	1,351,553
Rozet East	27,809	0	217,341
Rozet West	19,300	0	702,147
Rozet South	35,662	0	279,749
S-Bar	24	4	0
Slattery	144,761	6,621	1,602,442
Springen Ranch	12,301	0	88,349
Surprise	NDA	NDA	NDA
Thornton	1,272	0	37
Three Mile	NDA	NDA	NDA
Timber Creek	405,907	234	1,097,641
Timber Creek South	796	0	0
Tomcat Creek	5,270	0	607,172
Trava	822	0	2,711
Twenty-One Mile Butte	69,980	34,081	60,495
Wagensen	1,592	10,344	33,310
Wakeman Flats	424	0	422
West Fork	10,177	0	9,779
Widge	13,512	1,114	14,181
Widge North	1,456	0	344
Wind Creek	607	0	117,790
Wood	16,727	9,172	305,108

(a) bbls = One barrel equals 42 (U.S.) gallons of liquid at 60°F at atmospheric pressure.

(b) mcf = 1,000 cubic feet of natural gas.

NDA = No data available.

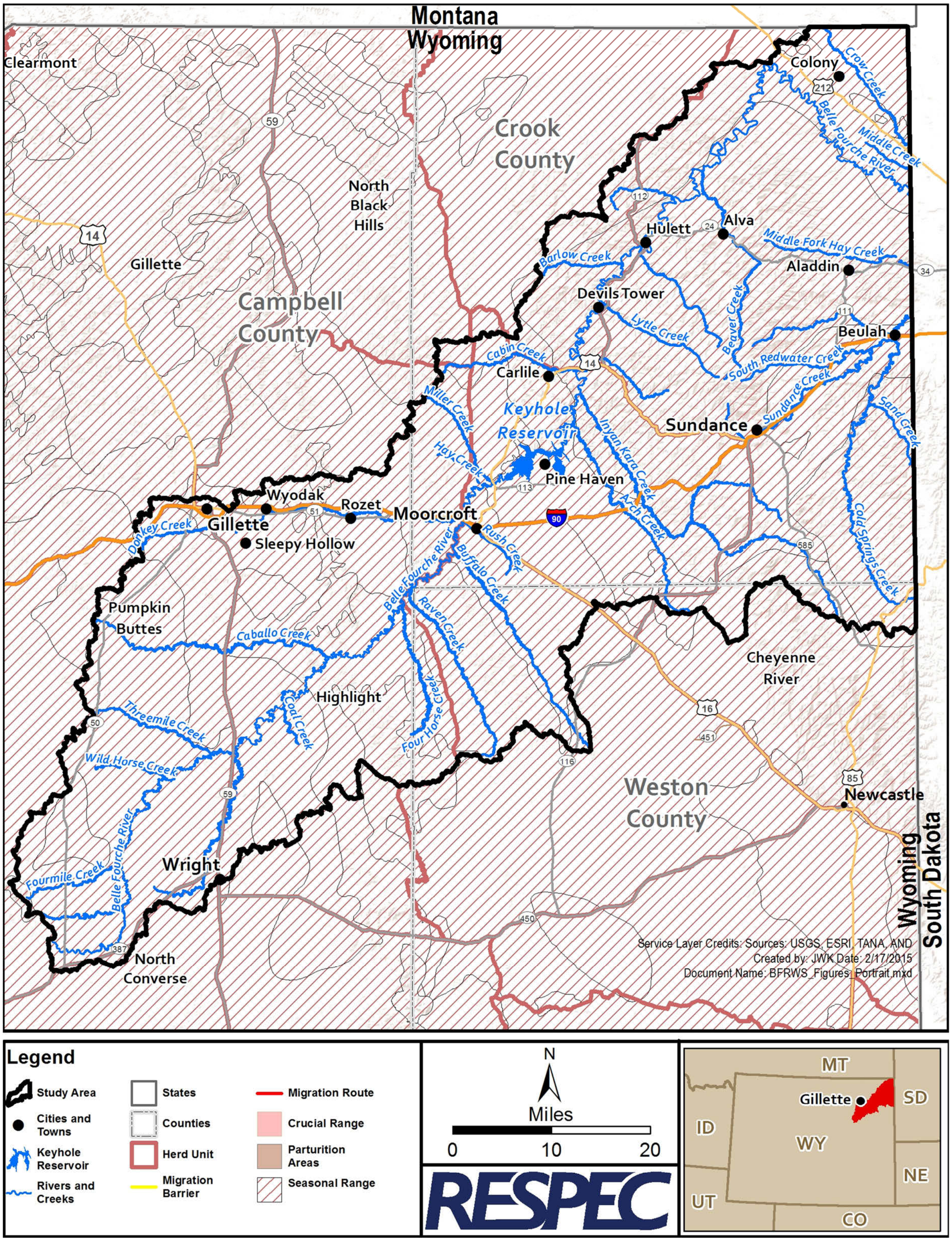

Figure 3.13. Antelope Habitat Within the Belle Fourche River Watershed.

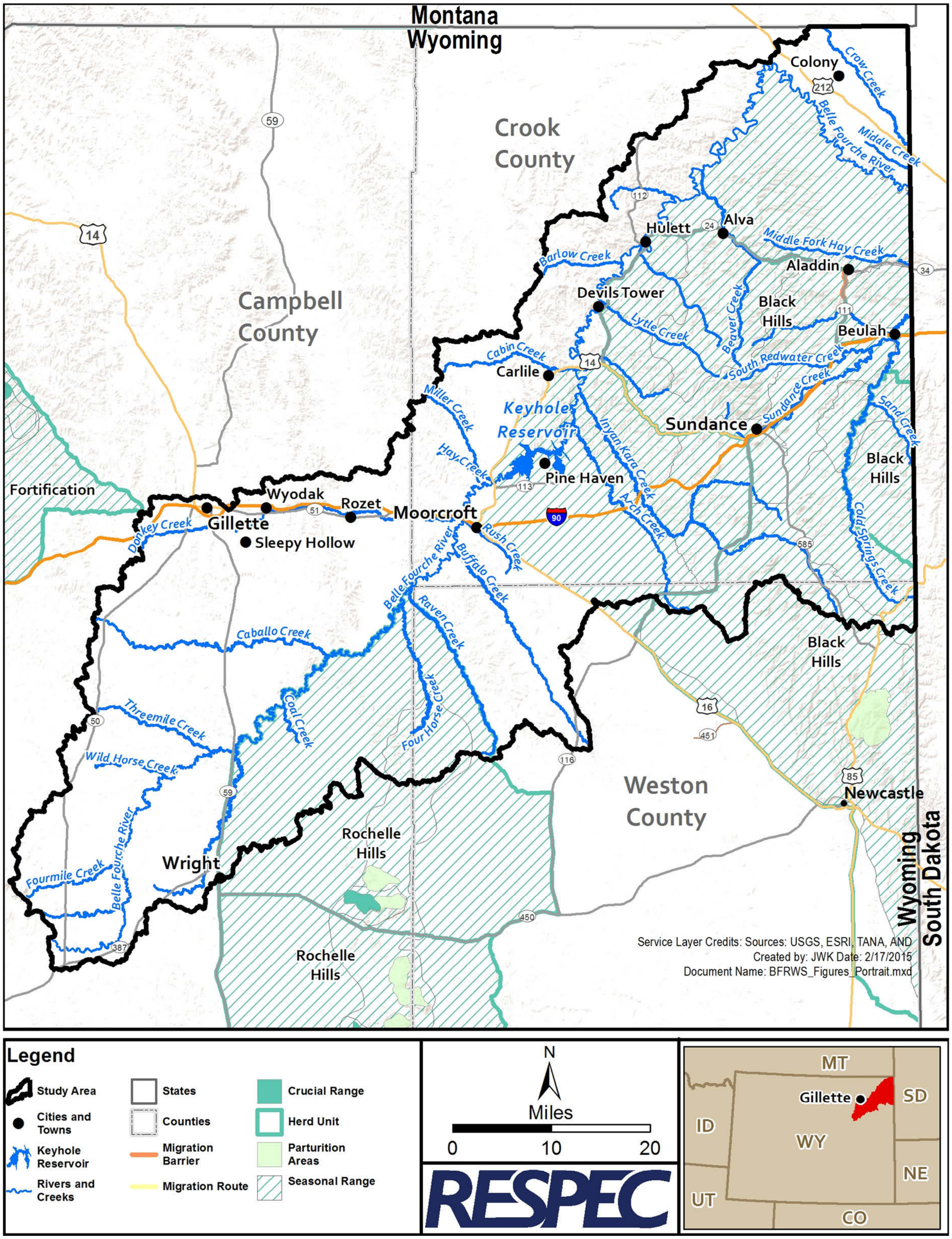

Figure 3.14. Elk Habitat Within the Belle Fourche River Watershed.

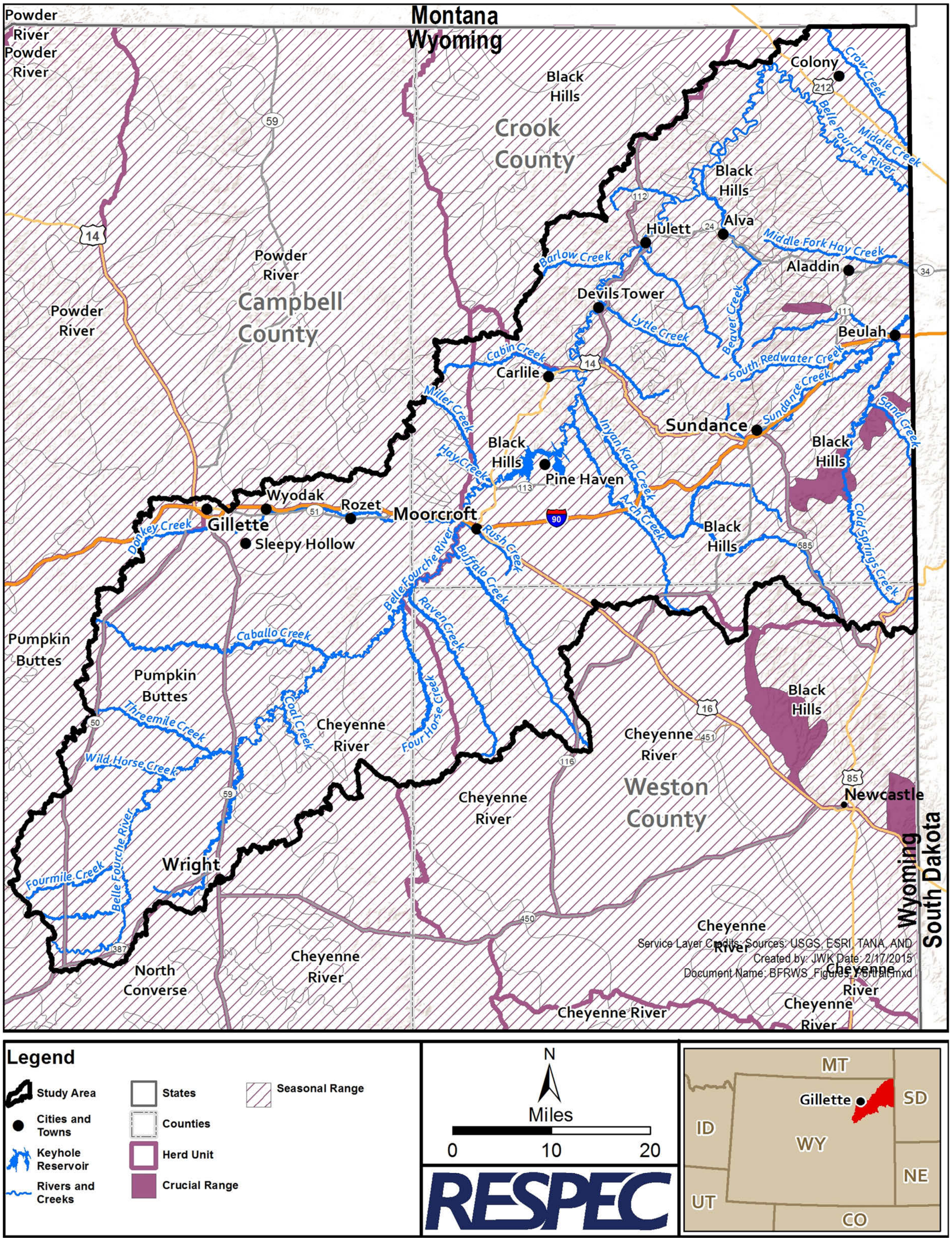

Figure 3.15. Mule Deer Habitat Within the Belle Fourche River Watershed.

Table 3.15. Wyoming Natural Diversity Database: Wildlife Species in the Study Area (Page 1 of 5)

Scientific Name	Common Name	Listing Status	Tracking Status
Amphibian			
Ambystoma mavortium	Tiger Salamander		Watched
Anaxyrus cognatus	Great Plains Toad		Watched
Lithobates pipiens	Northern Leopard Frog	Not Warranted for Listing	Tracked
Bird			
Accipiter gentilis	Northern Goshawk	Not Warranted for Listing	Tracked
Aechmophorus clarkii	Clark's Grebe		Tracked
Ammodramus savannarum	Grasshopper Sparrow		Watched
Aquila chrysaetos	Golden Eagle		Watched
Artemisiospiza nevadensis	Sagebrush Sparrow		Tracked
Asio flammeus	Short-eared Owl		Tracked
Athene cunicularia	Burrowing Owl		Tracked
Aythya collaris	Ring-necked Duck		Watched
Botaurus lentiginosus	American Bittern		Tracked
Bucephala albeola	Bufflehead		Watched
Bucephala clangula	Common Goldeneye		Watched
Buteo regalis	Ferruginous Hawk		Tracked
Calcarius ornatus	Chestnut-collared Longspur		Tracked
Catherpes mexicanus	Canyon Wren		Watched
Centrocercus urophasianus	Greater Sage-grouse	Warranted but Precluded	Tracked
Charadrius melodus	Piping Plover	Listed Threatened	Watched
Charadrius montanus	Mountain Plover	Not Warranted for Listing	Tracked
Chlidonias niger	Black Tern		Tracked
Coccyzus americanus	Yellow-billed Cuckoo		Tracked
Coccyzus erythropthalmus	Black-billed Cuckoo		Tracked
Cygnus buccinator	Trumpeter Swan	Not Warranted for Listing	Tracked
Cygnus columbianus	Tundra Swan		Watched
Dolichonyx oryzivorus	Bobolink		Tracked
Egretta thula	Snowy Egret		Watched
Empidonax hammondii	Hammond's Flycatcher		Watched
Falco columbarius	Merlin		Watched
Gavia immer	Common Loon		Tracked
Grus canadensis	Sandhill Crane		Watched

Table 3.15. Wyoming Natural Diversity Database: Wildlife Species in the Study Area (Page 2 of 5)

Scientific Name	Common Name	Listing Status	Tracking Status
Bird (continued)			
Haliaeetus leucocephalus	Bald Eagle	Delisted, formally monitored	Tracked
Himantopus mexicanus	Black-necked Stilt		Watched
Junco hyemalis	Dark-eyed Junco		Tracked
Junco hyemalis aikeni	White-winged Junco		Watched
Lanius ludovicianus	Loggerhead Shrike		Tracked
Larus argentatus	Herring Gull		Watched
Larus californicus	California Gull		Watched
Larus delawarensis	Ring-billed Gull		Watched
Loxia leucoptera	White-winged Crossbill		Watched
Megascops asio	Eastern Screech-Owl		Watched
Melanerpes lewis	Lewis's Woodpecker		Tracked
Numenius americanus	Long-billed Curlew		Tracked
Nycticorax nycticorax	Black-crowned Night-Heron		Watched
Oreoscoptes montanus	Sage Thrasher		Watched
Oreothlypis virginiae	Virginia's Warbler		Tracked
Pandion haliaetus	Osprey		Watched
Passerina caerulea	Blue Grosbeak		Watched
Passerina cyanea	Indigo Bunting		Watched
Pelecanus erythrorhynchos	American White Pelican		Tracked
Phalaropus lobatus	Red-necked Phalarope		Watched
Picoides arcticus–Black Hills	Black Hills Black-backed Woodpecker	Petition Under Review	Tracked
Picoides dorsalis–Black Hills	Black Hills Three-toed Woodpecker		Tracked
Plegadis chihi	White-faced Ibis		Tracked
Rallus limicola	Virginia Rail		Watched
Recurvirostra americana	American Avocet		Watched
Regulus satrapa	Golden-crowned Kinglet		Watched
Rhynchophanes mccownii	McCown's Longspur		Tracked
Sialia sialis	Eastern Bluebird		Watched
Sitta pygmaea	Pygmy Nuthatch		Tracked
Spiza americana	Dickcissel		Watched
Spizella breweri	Brewer's Sparrow		Watched
Spizella pallida	Clay-colored Sparrow		Watched

Table 3.15. Wyoming Natural Diversity Database: Wildlife Species in the Study Area (Page 3 of 5)

Scientific Name	Common Name	Listing Status	Tracking Status
Bird (continued)			
Sterna forsteri	Forster's Tern		Tracked
Strix nebulosa	Great Gray Owl		Tracked
Tyto alba	Barn Owl		Watched
Vireo olivaceus	Red-eyed Vireo		Watched
Fern and Fern Ally			
Botrychium campestre	Prairie moonwort		Tracked
Botrychium hesperium	Western Moonwort		Tracked
Botrychium lineare	Slender moonwort	Not Warranted for Listing	Tracked
Botrychium minganense	Mingan Island moonwort		Tracked
Botrychium pallidum	Pale moonwort		Tracked
Diphasiastrum complanatum	Ground cedar		Tracked
Equisetum scirpoides	Dwarf scouring rush		Tracked
Equisetum sylvaticum	Woodland horsetail		Tracked
Gymnocarpium dryopteris	Oak fern		Tracked
Lycopodium dendroideum	Tree-like clubmoss		Tracked
Onoclea sensibilis	Sensitive fern		Tracked
Pellaea gastonyi	Gastony's cliff brake		Tracked
Pellaea suksdorfiana	Smooth cliff brake		Tracked
Selaginella rupestris	Ledge spike-moss		Tracked
Fish			
Chrosomus neogaeus	Finescale Dace		Tracked
Couesius plumbeus	Lake Chub		Watched
Hybognathus argyritis	Western Silvery Minnow		Tracked
Platygobio gracilis	Flathead Chub		Watched
Insect			
Dichagyris (Mesembagrotis) reliqua	A Noctuid Moth		Tracked
Hesperia ottoe	Ottoe Skipper		Tracked
Phyciodes batesii	Tawny Crescent		Tracked
Speyeria idalia	Regal Fritillary		Tracked
Mammal			
Antrozous pallidus	Pallid Bat		Tracked
Bos bison bison	Plains Bison	Not Warranted for Listing	Tracked

Table 3.15. Wyoming Natural Diversity Database: Wildlife Species in the Study Area (Page 4 of 5)

Scientific Name	Common Name	Listing Status	Tracking Status
Mammal (continued)			
Canis lupus	Gray Wolf	Proposed for Delisting	Tracked
Corynorhinus townsendii	Townsend's Big-eared Bat		Tracked
Cynomys ludovicianus	Black-tailed Prairie Dog	Not Warranted for Listing	Tracked
Glaucomys sabrinus–Black Hills	Black Hills Flying Squirrel		Tracked
Lasionycteris noctivagans	Silver-haired Bat		Watched
Lasiurus cinereus	Hoary Bat		Watched
Mustela nigripes	Black-footed Ferret	Listed Endangered	Tracked
Mustela nivalis	Least Weasel		Watched
Myotis ciliolabrum	Western Small-footed Myotis		Watched
Myotis evotis	Long-eared Myotis		Watched
Myotis lucifugus	Little Brown Myotis	Petition Under Review	Watched
Myotis septentrionalis	Northern Myotis	Proposed Endangered	Tracked
Myotis thysanodes	Fringed Myotis		Tracked
Myotis volans	Long-legged Myotis		Watched
Myotis yumanensis	Yuma Myotis		Tracked
Ovis canadensis	Bighorn Sheep		Watched
Perognathus fasciatus	Olive-backed Pocket Mouse		Watched
Peromyscus leucopus	White-footed Deermouse		Watched
Sorex haydeni	Hayden's Shrew		Tracked
Sorex nanus	Dwarf Shrew		Watched
Sylvilagus floridanus	Eastern Cottontail		Watched
Tamiasciurus hudsonicus dakotensis	Black Hills Red Squirrel		Tracked
Urocyon cinereoargenteus ocythous	Prairie Gray Fox	Petition Under Review	Watched
Ursus arctos arctos	Grizzly Bear	Listed Threatened	Tracked
Vulpes velox	Swift Fox	Not Warranted for Listing	Tracked
Zapus hudsonius campestris	Bear Lodge Meadow Jumping Mouse		Tracked
Mollusk			
Catinella stretchiana	Sierra Ambersnail		Tracked
Discus shimekii	Striate Disc		Tracked
Lasmigona complanata	White Heelsplitter		Tracked

Table 3.15. Wyoming Natural Diversity Database: Wildlife Species in the Study Area (Page 5 of 5)

Scientific Name	Common Name	Listing Status	Tracking Status
Mollusk (continued)			
Oreohelix strigosa cooperi	Cooper's Rocky Mountain Mountainsnail	Not Warranted for Listing	Tracked
Oreohelix strigosa ssp. 1	Bear Lodge Mountainsnail		Tracked
Oreohelix subrudis	A Mountainsnail		Tracked
Pyganodon grandis	Giant Floater		Tracked
Vertigo arthuri	Callused Vertigo Snail		Tracked
Vertigo paradoxa	Mystery Vertigo		Tracked
Reptile			
Apalone spinifera spinifera	Eastern Spiny Softshell		Watched
Coluber constrictor flaviventris	Eastern Yellow-bellied Racer		Watched
Opheodrys vernalis	Smooth Greensnake		Tracked
Storeria occipitomaculata pahasapae	Black Hills Red-bellied Snake		Tracked
Thamnophis radix	Plains Gartersnake		Watched
Thamnophis sirtalis parietalis	Red-sided Gartersnake		Watched

3.4.8.3 Habitat Priority Areas

As a part of the 2009 Strategic Habitat Plan (SHP), the WGFD has classified areas within the state as Crucial Habitat Priority Areas and Enhancement Habitat Priority Areas. Priority areas were further divided into riparian, aquatic, terrestrial, and combined habitats. Figure 3.17 displays the Habitat Priority Areas within the study area. Crucial, Enhancement, and Combined Habitat Priority Areas are defined by the WGFD [2013d] as follows:

> *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, movement corridors, quality of watershed hydrologic function, etc. The Department will concentrate habitat protection and management activities in these areas.*

Portions of two riparian and three terrestrial Crucial Habitat Priority Areas are within the watershed. The WGFD composed narratives that include habitat value, reason for selection, area description, affected species, and actions/solutions. The following summaries are quotes from the WGFD for each of the areas [WGFD, 2013b].

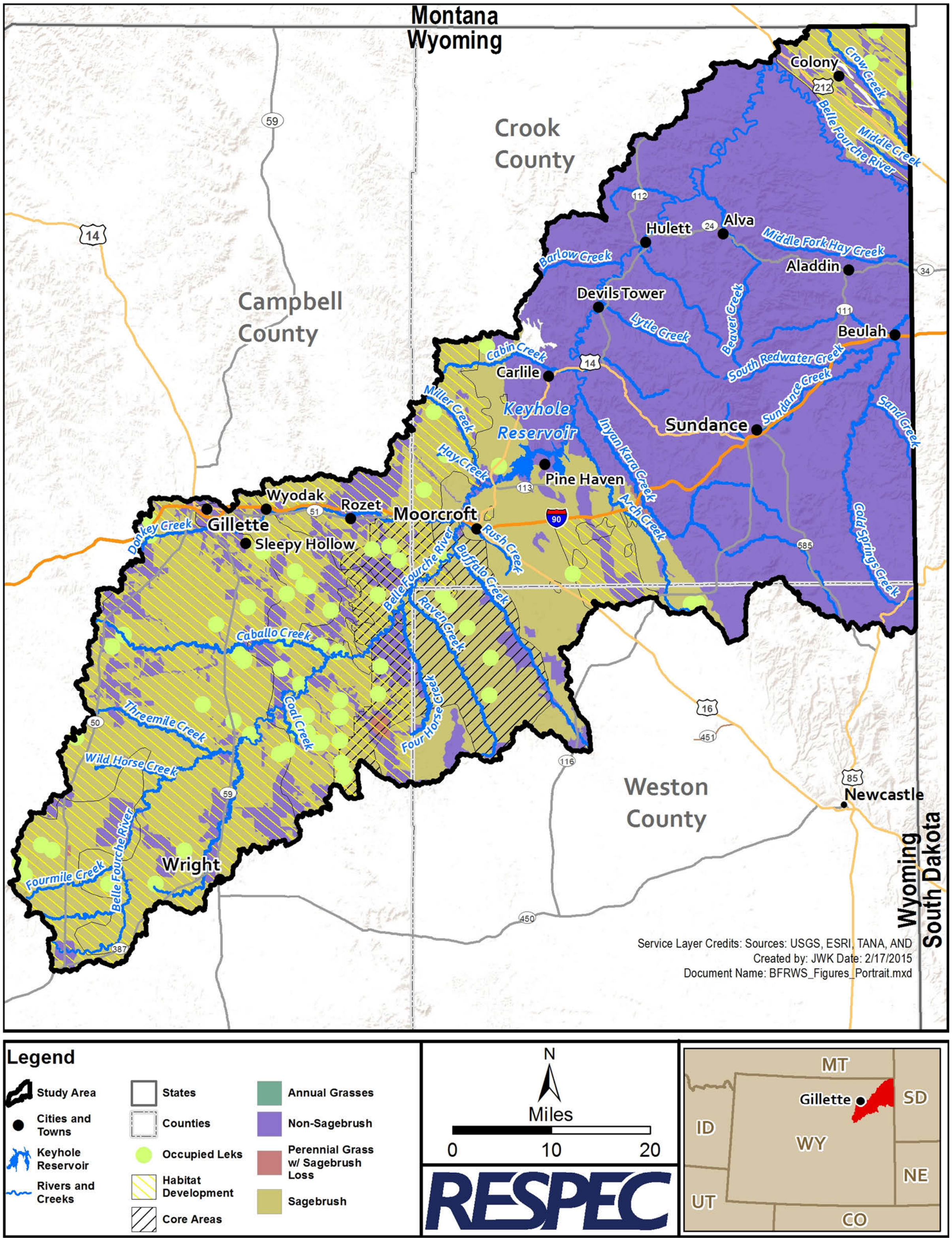

Figure 3.16. Sage-Grouse Distribution and Core Areas Within the Study Area.

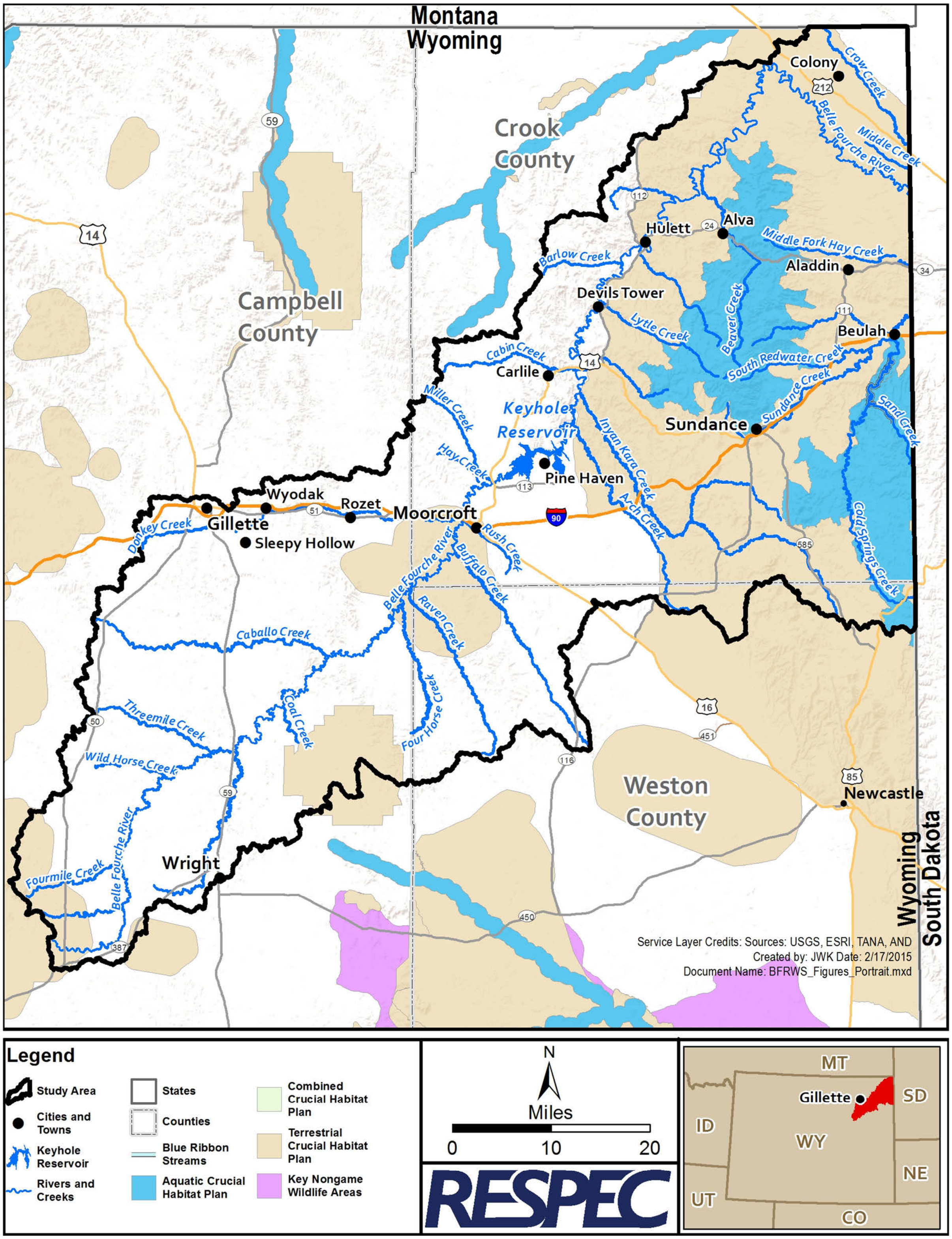

Figure 3.17. Aquatic and Terrestrial Habitat Within the Watershed.

Black Hills Aspen and Riparian Communities (riparian)

Functional riparian habitats connected to their channels that resist flood damage, store water, provide shade and habitat for sport fish, native fish and herpetofauna; an aspen mosaic across the landscape that retains water in the collection basin and contributes to a food-base and dam-building material for beaver.

- *Dominant land uses include livestock grazing, recreation, logging, and limited oil and gas development and irrigation.*
- *Most aspen and willow stands are seral community types. Some natural disturbance is necessary to perpetuate them and retain or expand their abundance on the landscape. Both communities will succeed to shade-tolerant conifer communities or more xeric plant communities if the hydrology of the site is altered considerably. Firewas historically the primary agent regenerating aspen. Willow riparian communities regenerate following disturbances associated with natural hydrologic events provided herbivores allow recruitment to occur.*
- *Herbivory of riparian and aspen resources often limits options to actively treat riparian and aspen habitats. These problems limit opportunities to improve riparian function, and retain or expand aspen, which is an important landscape component for its water cycling benefits, and as a resource for use by beaver. Effective, large-scale treatments cannot occur unless herbivore use can be maintained in-line with (or reduced below on an interim basis) available resources.*

High Productivity Sport Stream Fisheries (riparian)

Functional riparian habitats connected with their channels that resist flood damage, store water, and provide shade, woody debris, water quality, and habitat for sport fisheries, native fish and herpetofauna.

- *The North Tongue River supports a brook, rainbow, and cutthroat trout fishery. Brook and rainbow trout are self-sustaining, and cutthroat trout are augmented through stocking. The South Tongue Wyoming Game and Fish Department rev. 12/8/08 Strategic Habitat Plan Crucial Habitat Area Narrative and main stem Tongue rivers support self-sustaining brook, brown, and rainbow trout fisheries. Mountain whitefish are also found in the main stem Tongue River. The associated riparian corridors also provides habitat for moose, elk, mule deer, beaver, blue (dusky) grouse, waterfowl, and non-game mammals, avifauna, and herpetofauna. Almost the entire stream occurs on public lands administered by the Bighorn National Forest. The primary land uses are livestock grazing, logging, and motorized and non-motorized recreation.*

- *Sand Creek supports a self-sustaining brown and rainbow trout fishery. The mixed community type riparian corridor also has some of the largest bur oak trees in Wyoming, and provides habitat for mule and white-tailed deer, wild turkey, waterfowl, and non-game mammals, avifauna, and herpetofauna. Most of the perennial stream segment occurs on private and state-controlled properties. Predominant land uses include livestock grazing and agricultural production operations, motorized and non-motorized recreation, and exurban development. Proposals to dredge gold have occurred periodically in the intermittent segments of the Sand Creek watershed.*
- *The Middle Fork of the Powder River supports a self-sustaining brook and rainbow trout fishery. Much of the riparian corridor is confined within a canyon. The corridor provides habitat for mule deer, elk, mountain lions, raptors, waterfowl, and non-game mammals, avifauna, and herpetofauna. The Class-1 stream segment occurs on a mixture of public lands administered by the BLM Buffalo and Worland Field Offices, a Department Wildlife Habitat Management Area, state trust lands, and private lands. Predominant land uses include livestock grazing and agricultural production operations, wildlife winter range, and motorized and non-motorized recreation.*

Sagebrush/Mixed Grass Habitats Within Major Sage-Grouse Complexes (terrestrial)

Sagebrush has been demonstrated to be a critical food source for several wildlife species, especially sage grouse, pronghorn and mule deer during various seasons of the year, particularly fall, winter and spring.

Much of the area has been designated as core sage grouse habitat by the Governor's working group.

Supports a number of sagebrush and grassland obligates identified as SGCN in the CWCS report.

Sagebrush-dominated mixed grass communities are being impacted on several fronts by various human activities including but not limited to vegetation chemical manipulation, vegetative community conversions, livestock grazing, subdivisions and energy developments.

- *Montana researchers found three different species of sagebrush comprised 93 percent of the winter diet of pronghorn. Shrubs (primarily sagebrush) are used almost exclusively by pronghorn from November through March and moderately through the other months.*
- *Big sagebrush is a highly nutritious and digestible food source for big game animals such as mule deer. During winter, big sagebrush has a higher crude protein level and digestibility than most other shrubs or grasses. Sagebrush also provides cover (nesting, resting and escape) for a wide variety of game and non-game species (i.e. protective cover for fawns, calves, nesting birds, sage grouse broods, etc.). Research in Montana revealed that, during the*

breeding season, sage grouse utilize habitat with a canopy coverage of big sagebrush ranging from 20-50 percent. Wintering sage grouse were found in an average of 28 percent sagebrush cover and nesting birds in an average of 20-30 percent sagebrush cover. Another species of special concern is the pygmy rabbit. The pygmy rabbit is limited to habitat types that contain tall dense sagebrush.

- *Sagebrush has other assets for wild life in addition to forage and cover. Its thick canopy protects understory vegetation from livestock grazing. Understory vegetation can be a valuable food source for wildlife.*

North Black Hills (terrestrial)

The habitat values that contributed in selecting this area include mule deer crucial winter-yearlong ranges, white-tailed deer crucial winter-yearlong ranges, big game parturition areas, wild turkey seasonal habitats, and watershed hydrologic function.

South Black Hills (terrestrial)

Mule deer crucial winter-yearlong ranges, white-tailed deer crucial winter-yearlong ranges, big game parturition areas, wild turkey seasonal habitats, and watershed hydrologic function

3.4.9 Cultural Resources

The Wyoming State Historic Preservation Office (SHPO) maintains a database of inventoried historic sites within the state. The SHPO makes a spatial data file available that generalizes the cultural resource inventory to the section level. This level of locating archaeological data protects the sites from unauthorized disturbance. The attributes recorded for each section include site count, inventory acres, report numbers, and eligible site number. Figure 3.18 displays the results of the data retrieval graphically. Each section within the study area has been color coded based on the number of sites within it that are determined to be eligible for inclusion in the National Register of Historic Places (Register).

3.4.9.1 Management Considerations

Because cultural resources warrant special consideration within the study area, guidelines have been developed by local historic organizations and state and federal agencies to preserve and protect these resources based on the historical significance and integrity of the resource site and setting. A significant amount of literature exists regarding the historic and cultural resources in the watershed. The documents consist of inventories, evaluations, and plans for protecting the sites from adverse impacts from natural or human-caused deterioration; reducing conflicts with other uses; and preserving the significant cultural, scientific, and recreational values of the sites. These guidelines contain actions or measures that may prohibit surface development and surface disturbance depending on the specific site characteristics.

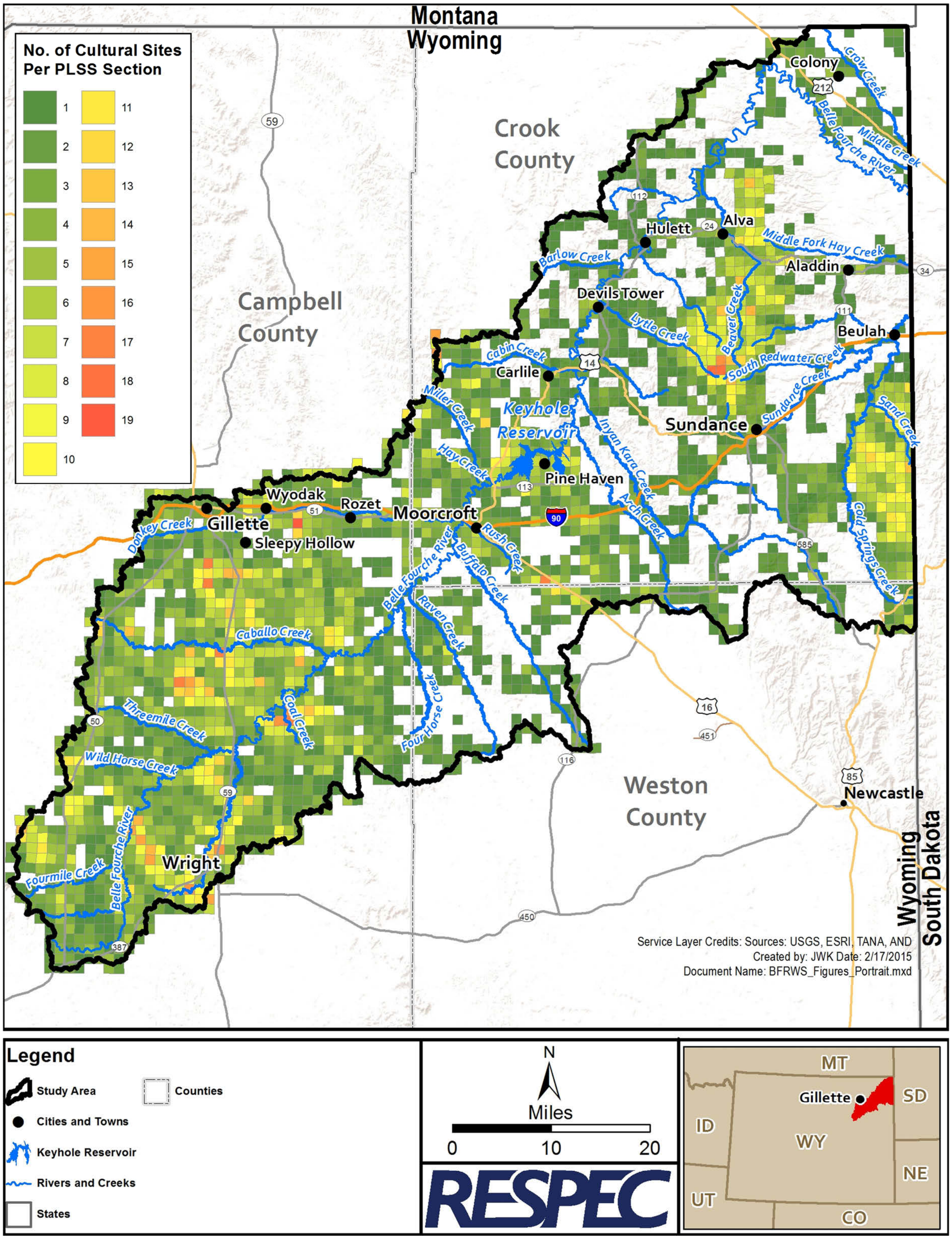

Figure 3.18. Cultural Sites per Section Within the Study Area.

3.5 SETTING AND ENVIRONMENT

The setting and environment for the Belle Fourche River Watershed are discussed in the following sections.

3.5.1 Topography

The Belle Fourche River Watershed covers parts of the Middle Rockies and the Northwestern Great Plains land regions and has a varied topography with mountains, mountain valleys, foothills and steppes, river breaks and valleys, alluvial fans, rolling plains, playas, and sand dunes. Elevations in the study area range from 3,100 feet above mean sea level (msl) along the Belle Fourche River at the study area outlet to 6,636 and 6,650 feet msl at the Warren Peaks. Elevations are greater than 6,500 feet msl in areas of the Bear Lodge Mountains north of Sundance as well as the Black Hills along the Wyoming–South Dakota state line.

The watershed is approximately 90 miles north-south and 90 miles east-west and is bounded on the north by the Upper Little Missouri drainage. On the northwest and the west, the study area is bounded by the Little Powder drainage and the Upper Powder drainage, respectively. On the southwest and south, the study area boundary is the Antelope drainage and the Upper Cheyenne drainage, respectively. The study area is bounded by the Beaver drainage on the southeast and the eastern edge of the study area is defined by the Wyoming–South Dakota state line.

3.5.2 Climate

The wide-ranging topography of the watershed results in a variable climate with typical annual precipitation rates ranging from 11 inches per year in the southwest portion of the watershed to 29 inches per year in the Bear Lodge Mountains near Sundance. Maximum precipitation occurs in the spring and early summer months. Figure 3.19 displays isohyets of average annual precipitation throughout the study area. Data used to produce this plot were obtained from Parameter-Elevation Regressions on Independent Slopes Model (PRISM).

The watershed has a relatively cool climate, including late-spring and early-fall freezing with a relatively short growing season of 125 days. The highest temperatures typically occur in July with an average monthly high of 85°F. January is typically the coldest month within the watershed with an average monthly low of 8°F [Western Regional Climate Center, 2014].

Climatic data were obtained from ten meteorological stations within the study area of which five are under current operation. These meteorological stations are (were) operated and maintained through cooperative agreements with the National Weather Service. Locations of these meteorological stations are illustrated in Figure 3.19. Table 3.16 summarizes the climatic data by month and by station, Figure 3.20 displays the average maximum air temperature trends by month, Figure 3.21 displays the average minimum air temperature trends by month, and Figure 3.22 displays the average monthly precipitation totals.

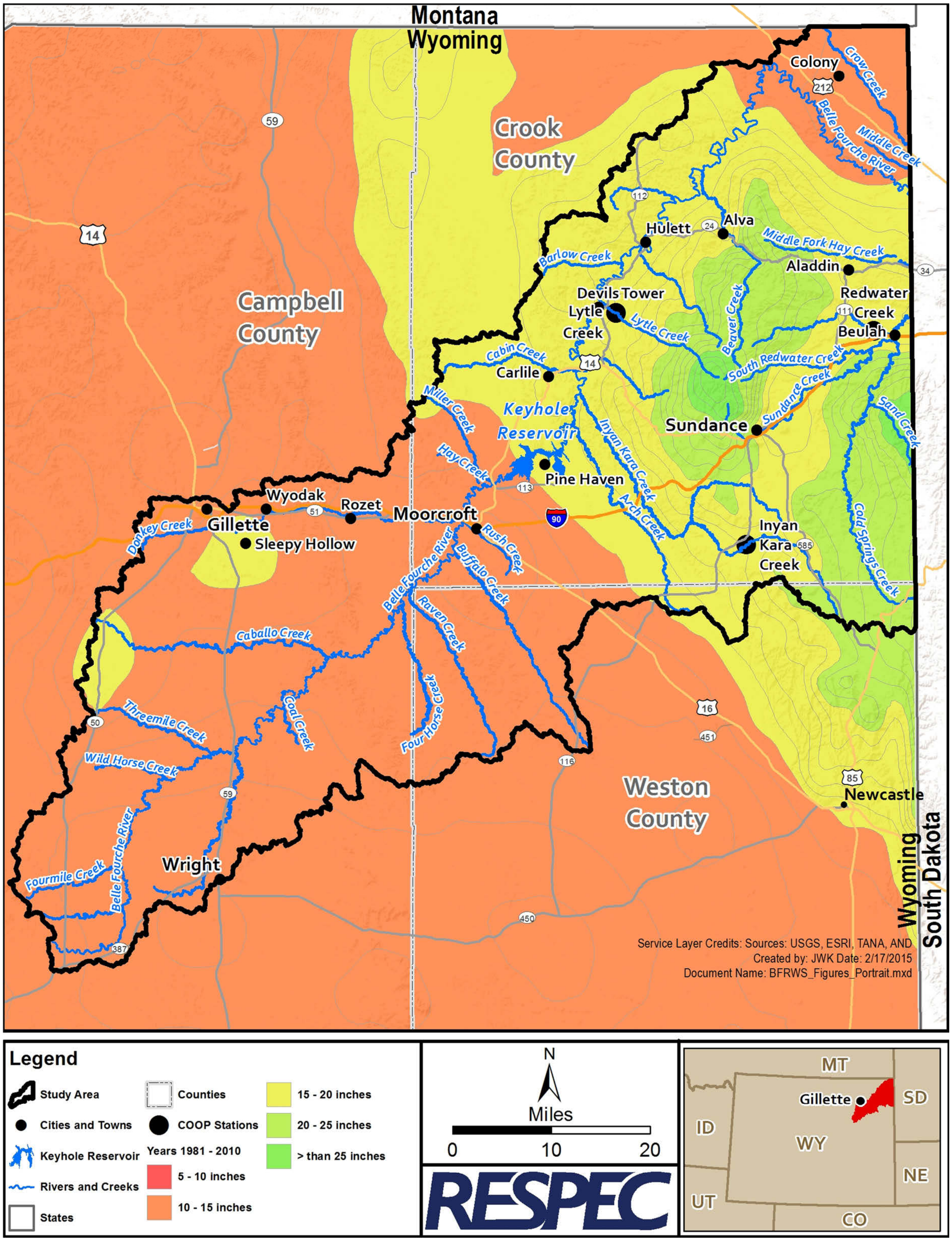

Figure 3.19. Average Annual Precipitation Isohyetals Throughout the Study Area.

Table 3.16. Summary of Monthly Climatic Data for Weather Stations Within the Study Area [Western Regional Climate Center, 2014] (Page 1 of 2)

ALVA, WY (480206) 1943–1996													
Parameter	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Average Maximum Temperature (°F)	35.0	37.2	44.2	55.4	64.4	73.8	80.8	82.1	71.4	60.7	43.7	35.7	57.0
Average Minimum Temperature (°F)	8.2	10.0	18.0	27.6	37.4	45.7	49.6	47.9	37.3	27.8	18.3	9.4	28.1
Average Precipitation (inches)	0.71	0.57	1.39	2.02	3.36	3.40	2.22	1.17	1.19	1.69	0.98	0.72	19.42
ALVA 5 ESE, WY (480200) 1948–2001													
Parameter	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Average Maximum Temperature (°F)	32.8	38.0	42.4	53.2	63.7	73.4	82.2	81.2	70.4	59.4	43.8	36.1	56.4
Average Minimum Temperature (°F)	5.6	10.2	15.7	26.0	35.4	43.7	48.8	47.1	37.6	28.3	17.3	9.8	27.1
Average Precipitation (inches)	0.86	0.84	1.49	2.83	3.75	3.78	2.14	1.67	1.74	1.53	1.15	0.95	22.75
COLONY, WY (481905) 1915–2012													
Parameter	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Average Maximum Temperature (°F)	31.8	35.8	43.7	57.0	67.6	77.5	87.6	86.3	74.7	61.1	44.5	34.8	58.5
Average Minimum Temperature (°F)	11.3	14.8	21.6	32.3	42.3	51.6	58.6	56.7	46.5	35.9	23.9	14.8	34.2
Average Precipitation (inches)	0.40	0.42	0.79	1.56	2.44	2.92	1.77	1.37	1.29	1.03	0.60	0.44	15.02
DEVILS TOWER 2, WY (482466) 1959–2013													
Parameter	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Average Maximum Temperature (°F)	34.1	38.8	48.1	58.9	68.4	78.3	87.3	86.4	75.3	62.5	45.5	35.8	59.9
Average Minimum Temperature (°F)	5.3	10.0	19.0	28.1	37.7	47.0	53.0	50.3	39.9	28.8	17.3	7.6	28.7
Average Precipitation (inches)	0.66	0.67	0.95	1.82	2.78	3.14	1.87	1.57	1.39	1.33	0.74	0.70	17.62
DILLINGER, WY (482580) 1941–2013													
Parameter	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Average Maximum Temperature (°F)	33.4	37.9	45.5	56.4	66.5	77.6	87.6	86.3	74.7	60.8	45.1	35.4	58.9
Average Minimum Temperature (°F)	7.3	12.1	19.7	28.7	38.7	47.3	53.8	52.0	41.2	30.4	18.0	9.3	29.9
Average Precipitation (inches)	0.36	0.51	0.77	1.62	2.61	2.39	1.57	1.13	1.04	0.98	0.53	0.46	13.96

Table 3.16. Summary of Monthly Climatic Data for Weather Stations Within the Study Area [Western Regional Climate Center, 2014] (Page 2 of 2)

GILLETTE 18 SW, WY (483865) 1949-1985

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Maximum Temperature (°F)	31.6	37.2	43.1	54.3	64.7	75.1	85.0	83.7	72.6	60.6	44.1	35.0	57.3
Average Minimum Temperature (°F)	9.8	15.3	19.7	28.6	38.2	46.8	53.5	52.0	41.8	32.7	21.3	13.6	31.1
Average Precipitation (inches)	0.55	0.63	1.05	1.91	2.79	2.93	1.30	1.36	1.10	1.09	0.71	0.61	16.02

GILLETTE 9 ESE, WY (483855) 1902-2013

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Maximum Temperature (°F)	32.2	36.5	44.8	55.6	65.5	76.1	86.3	85.0	73.9	60.3	44.3	35.1	58.0
Average Minimum Temperature (°F)	11.2	14.9	21.6	30.4	39.9	48.5	55.5	54.0	44.1	33.8	22.4	14.3	32.5
Average Precipitation (inches)	0.58	0.56	0.98	1.82	2.72	2.58	1.57	1.20	1.25	1.14	0.68	0.64	15.72

HULETT, WY (484760) 1941-2013

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Maximum Temperature (°F)	34.2	38.9	46.3	57.2	66.9	76.5	86.0	85.4	74.1	62.5	45.5	36.8	59.2
Average Minimum Temperature (°F)	8.6	12.4	19.6	29.1	39.0	48.0	53.9	51.5	41.2	31.3	20.4	11.9	30.6
Average Precipitation (inches)	0.65	0.67	1.03	1.83	2.72	3.17	1.80	1.30	1.33	1.35	0.80	0.62	17.26

MOORCROFT 3 ST, WY (486395) 1903-2012

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Maximum Temperature (°F)	31.2	35.3	43.9	55.7	65.0	76.3	86.1	85.3	73.6	60.2	45.3	34.0	57.7
Average Minimum Temperature (°F)	7.2	11.5	20.0	29.8	38.8	48.7	55.0	53.0	42.3	31.6	20.2	10.0	30.7
Average Precipitation (inches)	0.41	0.43	0.69	1.29	2.60	2.30	1.51	1.27	1.14	0.87	0.47	0.42	13.39

SUNDANCE, WY (488705) 1911-2013

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Maximum Temperature (°F)	31.5	34.9	42.3	54.0	64.3	74.3	83.4	82.1	71.9	58.8	42.7	33.8	56.2
Average Minimum Temperature (°F)	9.3	12.1	18.9	29.2	38.9	47.8	54.6	52.8	43.0	32.6	20.8	12.8	31.1
Average Precipitation (inches)	0.76	0.77	1.07	1.87	2.80	3.17	1.97	1.47	1.38	1.32	0.90	0.77	18.24

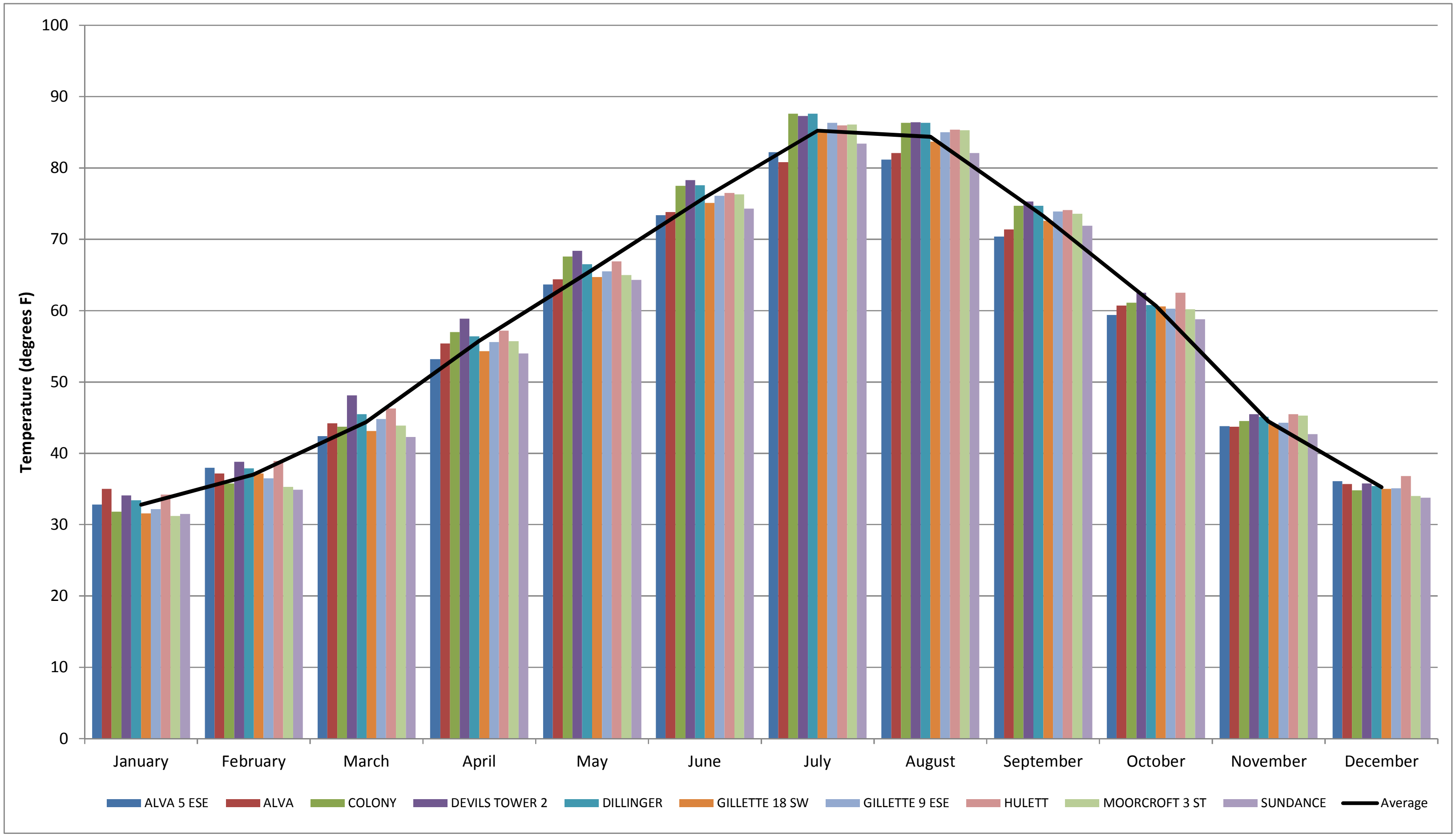

Figure 3.20. Monthly Mean Maximum Temperature for Weather Stations Within the Study Area.

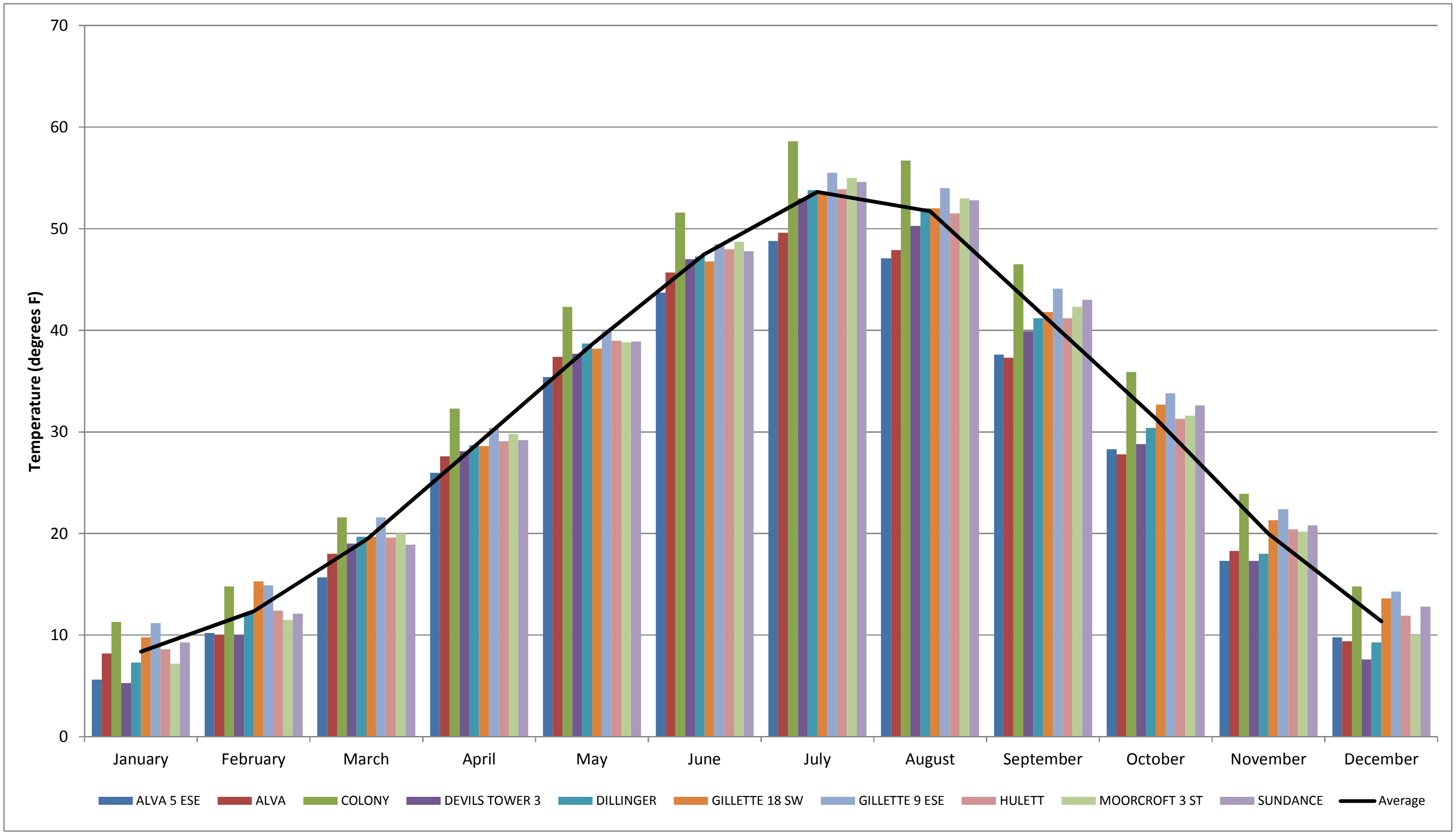

Figure 3.21. Monthly Mean Minimum Temperature for Weather Stations Within the Study Area.

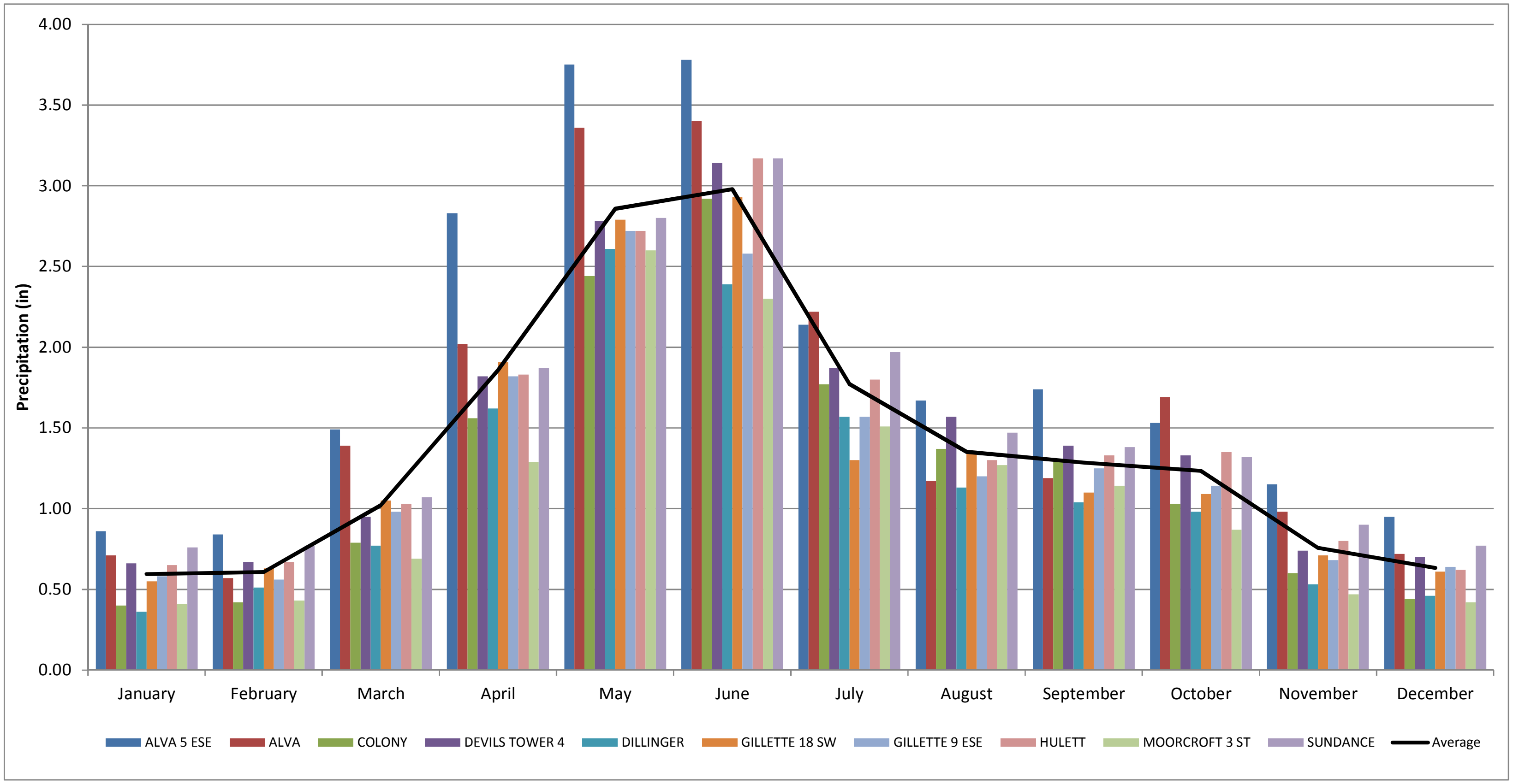

Figure 3.22. Monthly Mean Rainfall Totals for Weather Stations Within the Study Area.

3.5.3 Land Cover

Table 3.17 is a summary of land cover using the NLCD. The NLCD is a 16-category land cover classification method that is applied across the United States. The NLCD uses data derived from Landsat imagery and ancillary data. Approximately 1,213,570 acres (49 percent) of land cover within the study area is comprised of grassland/herbaceous vegetative cover. Approximately 755,150 acres (30 percent) of the watershed is classified as shrub/scrub cover and 425,760 acres (17 percent) as evergreen forest. The remaining areas consist of barren, developed, crops, and other small land-cover classes. An estimated 4,750 acres (7.4 square miles) of water exists, which is 0.2 percent of the study area.

3.5.4 Vegetation

Vegetative cover within the watershed was evaluated using data obtained through the NatureServer developed *Terrestrial Ecological Systems Classification* framework which "defines groups of plant community types that tend to co-occur within the landscapes with similar ecological processes, substrates and/or environmental gradients" [Comer et al., 2003]. These classifications have been performed at various levels from Class (7 levels) to Ecological System (556 levels). The study area contains 40 classifications, but only 9 classifications were 1 percent or more of the total study area.

The NatureServe vegetative classification data within the study were summarized because the NatureServe data including species, distribution and classification provide the basis for LANDFIRE vegetation geospatial data products. LANDFIRE is a vegetation, fire, and fuel mapping program sponsored by the USDI and USDA to create fuel and fire regimes datasets and geospatial layers. A summary of the NatureServe vegetative classifications that were 1 percent or more within the study area is shown in Table 3.18.

3.5.4.1 Existing Vegetation Cover

Existing vegetative cover in the watershed was evaluated by using data obtained through the LANDFIRE program [U.S. Geological Survey, 2010]. LANDFIRE vegetation maps are mostly derived from the NatureServe ecological classifications. Other data are derived from NLCD, National Vegetation Classification Standard (NVCS) Alliances, and LANDFIRE specific types. The LANDFIRE data delineates several attributes relevant to this study, including existing vegetation type (EVT), existing vegetation height (EVH), and existing vegetation cover (EVC).

The LANDFIRE EVT layer represents the species composition present at a given site and are created using decision models, field data, Landsat imagery, elevation, and biophysical gradient data to collect the data necessary to develop wildland fire models [U.S. Geological Survey, 2010]. The LANDFIRE existing vegetation data specify 61 different vegetation classes within the study area. Table 3.19 summarizes the distribution of the wetland and riparian vegetation types in the watershed, which contribute as a whole to less than 1 percent of the study area.

Table 3.17. National Land Cover Dataset Classifications Within the Study Area

Classification	Description	Area (acres)	Percent of Study Area
Grassland and Herbaceous	Gramanoid or herbaceous vegetation, generally greater than 80 percent of total vegetation cover. These areas are not subject to tilling but are used for grazing.	1,213,570	48.8
Shrub and Scrub	Shrubs less than 16 feet tall with canopy typically greater than 20 percent of total vegetation. This class includes shrubs and trees in early successional stages or stunted from environmental conditions.	755,150	30.4
Evergreen Forest	Trees greater than 16 feet tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.	425,760	17.1
Barren Land (Rock/Sand/Clay)	Bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other earthen material. Vegetation accounts for less than 15 percent of total.	17,330	0.7
Developed, Open Space	A mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of cover. These areas commonly include large-lot, single-family housing units, parks, golf courses, and vegetation planted in developments for recreation, erosion control, or aesthetics.	16,030	0.6
Cultivated Crops	Production of annual crops and also perennial woody crops. Crops accounts for greater than 20 percent of total vegetation. This class also includes land being tilled.	12,400	0.5
Pasture and Hay	Grasses, legumes, or mixtures planted for livestock grazing or the production of seed or hay crops on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.	9,220	0.4
Woody Wetlands	Forests or shrublands account for greater than 20 percent and the soil is periodically covered with water.	8,070	0.3
Deciduous Forest	Trees greater than 16 feet tall and greater than 20 percent of vegetation cover. More than 75 percent of the tree species shed foliage in response to a seasonal change.	6,340	0.3
Developed, Low Intensity	A mixture of constructed materials and vegetation. Impervious surfaces account for 20 to 49 percent of total cover. These areas commonly include single-family housing units.	6,300	0.3
Emergent Herbaceous Wetlands	Perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically covered with water.	5,860	0.2
Open Water	Open water, usually less than 25 percent cover of vegetation or soil.	4,750	0.2
Developed, Medium Intensity	A mixture of constructed materials and vegetation. Impervious surfaces account for 50 to 79 percent of the total cover. These areas commonly include single-family housing units.	3,130	0.1
Other	Areas with less than 0.1 percent of the study area.	1,110	<0.1
Total		**2,485,020**	**100.0**

Table 3.18. National Vegetation Classifications Within the Study Area

National Vegetation Classification	Area (acres)	Percent of Study Area
Inter-Mountain Basins Big Sagebrush Steppe	966,670	38.9
Northwestern Great Plains Mixedgrass Prairie	728,110	29.3
Northwestern Great Plains–Black Hills Ponderosa Pine Woodland and Savanna	370,270	14.9
Western Great Plains Dry Bur Oak Forest and Woodland	86,980	3.5
Pasture/Hay	57,160	2.3
Northwestern Great Plains Riparian	37,280	1.5
Western Great Plains Riparian Woodland and Shrubland	34,790	1.4
Quarries, Mines, Gravel Pits and Oil Wells	32,310	1.3
Introduced Upland Vegetation–Annual Grassland	24,850	1.0
All Other Classes, Less Than 0.1 Percent Each	146,600	5.9
Total	**2,485,020**	**100.0**

Table 3.19. Existing Riparian and Wetland Vegetation Types Within the Study Area

Existing Vegetation Type	Area (acres)	Percent of Study Area
Western Great Plains Floodplain Systems	11,200	0.451
Rocky Mountain Montane Riparian Systems	8,310	0.334
Herbaceous Wetlands	3,530	0.142
Recently Burned Herbaceous Wetlands	40	0.002
Total	**23,080**	**0.929**

The LANDFIRE EVT data were analyzed and all classifications are summarized in Table 3.20. The dominant EVTs include Northwestern Great Plains Mixedgrass Prairie (36 percent), Inter-Mountain Basins Big Sagebrush Steppe (20.2 percent), Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna (16.8 percent), and NASS-Close Grown Crop (14.1 percent) all covering a total of 87 percent of the watershed. The remaining 13 percent of the watershed was comprised of a total of 57 vegetation types.

Table 3.20. Existing Vegetation Types (LANDFIRE) Within the Study Area

National Vegetation Classification	Area (acres)	Percent of Study Area
Northwestern Great Plains Mixedgrass Prairie	893,600	36.0
Inter-Mountain Basins Big Sagebrush Steppe	502,870	20.2
Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna	416,190	16.8
NASS-Close Grown Crop	349,740	14.1
Western Great Plains Sand Prairie	77,290	3.1
Inter-Mountain Basins Big Sagebrush Shrubland	30,670	1.2
Introduced Upland Vegetation-Annual Grassland	19,720	0.8
Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland and Shrubland	16,110	0.7
Inter-Mountain Basins Greasewood Flat	14,650	0.6
Barren	14,580	0.6
Western Great Plains Floodplain Systems	11,190	0.5
Developed-Roads	10,820	0.4
Northwestern Great Plains Shrubland	10,520	0.4
Western Great Plains Sparsely Vegetated Systems	10,350	0.4
Introduced Upland Vegetation-Perennial Grassland and Forbland	9,970	0.4
Open Water	8,800	0.4
Rocky Mountain Montane Riparian Systems	8,300	0.3
Northwestern Great Plains Highland White Spruce Woodland	7,210	0.3
Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	6,990	0.3
Developed-Upland Herbaceous	6,720	0.3
Rocky Mountain Aspen Forest and Woodland	6,010	0.2
Quarries-Strip Mines-Gravel Pits	5,800	0.2
NASS-Fallow/Idle Cropland	5,590	0.2
NASS-Row Crop-Close Grown Crop	5,290	0.2
Developed-Upland Shrubland	4,960	0.2
Inter-Mountain Basins Mat Saltbush Shrubland	3,940	0.2
Northern Rocky Mountain Lower Montane-Foothill-Valley Grassland	3,920	0.2
Agriculture-Cultivated Crops and Irrigated Agriculture	3,600	0.1
Herbaceous Wetlands	3,530	0.1
Middle Rocky Mountain Montane Douglas-fir Forest and Woodland	3,030	0.1
Agriculture-Pasture and Hay	2,920	0.1
All Other Classes, Less Than 0.1 Percent Each	10,140	0.4
Total	**2,485,020**	**100.0**

Although data from LANDFIRE can be used to gain a better understanding about the condition of the watershed, proper mapping presentation of LANDFIRE data is challenging because the vegetation classifications are plotted on a 30-meter by 30-meter grid. Therefore, the Wyoming Gap Analysis Program (GAP) data obtained are shown in Figure 3.23. The LANDFIRE datasets are contained within the study's GIS and can be used in future mapping projects. Table 3.21 lists the plant species of concern within the watershed as supplied by WYNDD, which was discussed in Section 3.4.8.2.

3.5.4.2 Vegetative Communities

Vegetative communities within the study area vary throughout the watershed because of the differing ecoregions. The western portion of the watershed, Great Plains Ecoregion, include mostly grass, forb, shrub, and sagebrush communities. In the eastern portion of the watershed, plant communities include pine forests and woodlands, and deciduous forests with an understory consisting of grasses, sedges, and shrubs. In general, the desirable grass species in the watershed include rhizomatous wheatgrass, needleandthread, green needlegrass, prairie sandreed, big bluestem, and blue grama. The following plant community overviews are excerpts and adapted from RMPs, Forest Plans and amendments, and EIS documents from the BLM's Buffalo and Newcastle Field Offices and from the USFS' Thunder Basin National Grassland, Black Hills National Forest, and Douglas and Bearlodge Ranger Districts [BLM, 2003]. These overviews are included to summarize the diverse plant communities within the study area.

Short-Grass Prairie

Short-grass prairie occurs on drought-prone, mildly alkaline, medium- and fine-textured soils. Few shrubs grow consistently in short-grass prairie because the soils are too dry and compacted to support them. Precipitation is an important determinant of the composition of plant species in grasslands. The short-grass prairie plant community commonly includes two dominant vegetation species are blue grama (Bouteloua gracilis) and buffalo grass (Buchloe dactyloides). Other plant species common to the short-grass prairie include western wheatgrass (Pascopyrum smithii), sand dropseed (Sporobolus cryptandrus), needle-and-thread (Hesperostipa comata), scarlet globemallow (Sphaeralcea coccinea), and four-wing saltbush (Atriplex canescens).

Mixed-Grass Prairie

The mixed-grass prairie plant community is typically characterized by several common species including needle-and-thread, western wheatgrass, blue grama, prickly pear cactus (Opuntia spp.), and scarlet globemallow. Wyoming big sagebrush (Artemisia tridentata var. wyomingensis) is a common shrub of this grass community.

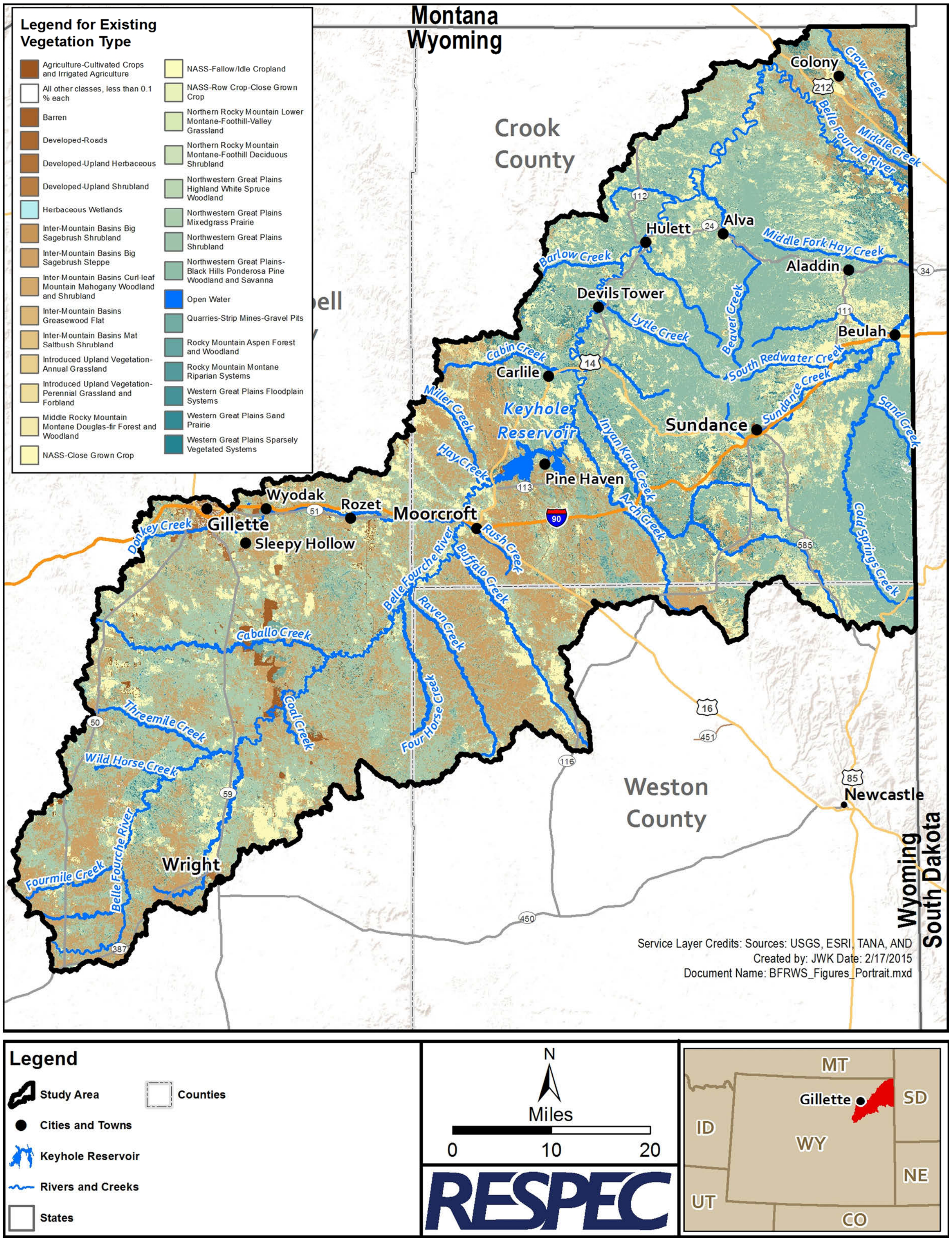

Figure 3.23. Land Cover Gap Analysis Program Analysis Within the Belle Fourche River Watershed.

Table 3.21. Wyoming Natural Diversity Database: Plants Within the Study Area (Page 1 of 2)

Scientific Name	Common Name	Tracking Status
Adoxa moschatellina	Moschatel	Tracked
Amphicarpaea bracteata	Groundnut	Tracked
Aquilegia brevistyla	Small-flower columbine	Tracked
Astragalus barrii	Barr's milkvetch	Watched
Bacopa rotundifolia	Roundleaf water-hyssop	Tracked
Calochortus apiculatus	Pointedtip mariposa-lily	Tracked
Campanula aparinoides	Marsh bellflower	Tracked
Carex alopecoidea	Foxtail sedge	Tracked
Carex concinna	Beautiful sedge	Tracked
Carex eburnea	Ebony sedge	Tracked
Carex emoryi	Emory's sedge	Tracked
Carex foenea	Bronze sedge	Tracked
Carex granularis var. haleana	Meadow sedge	Tracked
Carex intumescens	Great bladder sedge	Tracked
Carex richardsonii	Richardson's sedge	Tracked
Carex rosea	Rosy sedge	Tracked
Carex scoparia	Broom sedge	Tracked
Ceanothus herbaceus	Prairie redroot	Tracked
Centunculus minimus	Chaffweed	Tracked
Circaea lutetiana var. canadensis	Canadian enchanter's nightshade	Tracked
Cyperus erythrorhizos	Red-root flatsedge	Tracked
Cypripedium parviflorum var. pubescens	Large yellow lady's-slipper	Tracked
Dalea enneandra	Nine-anther prairie-clover	Tracked
Dichanthelium linearifolium	Slim-leaf witchgrass	Tracked
Eleocharis ovata	Ovate spikerush	Tracked
Eleocharis tenuis var. borealis	Boreal spikerush	Tracked
Elymus villosus	Hairy wildrye	Tracked
Filago prolifera	Rabbit tobacco	Tracked
Glandularia bipinnatifida	Dakota vervain	Tracked
Helianthemum bicknellii	Plains frostweed	Tracked
Hymenopappus tenuifolius	Chalk-hill woollywhite	Tracked

Table 3.21. Wyoming Natural Diversity Database: Plants Within the Study Area (Page 2 of 2)

Scientific Name	Common Name	Tracking Status
Lechea intermedia	Narrowleaf pinweed	Tracked
Loeflingia squarrosa	Spreading loeflingia	Tracked
Lycopus uniflorus	Northern bugleweed	Tracked
Lythrum alatum var. alatum	Winged loosestrife	Tracked
Machaeranthera bigelovii var. bigelovii	Bigelow's spiny aster	Tracked
Muhlenbergia glomerata	Marsh muhly	Tracked
Myosotis verna	*Spring forget-me-not*	*Tracked*
Oenothera laciniata	Cut-leaved Evening-primrose	Tracked
Phryma leptostachya	Lopseed	Tracked
Physalis virginiana	Virginia ground-cherry	Tracked
Physaria lanata	Woolly twinpod	Tracked
Platanthera orbiculata	Large roundleaf orchid	Tracked
Polygala verticillata	Whorled milkwort	Tracked
Polygonatum biflorum	Common solomon's-seal	Tracked
Potamogeton diversifolius	Water-thread pondweed	Tracked
Prosartes hookeri	Hooker's Fairy Bell	Tracked
Schoenoplectus heterochaetus	Slender bulrush	Tracked
Sparganium eurycarpum	Large bur-reed	Tracked
Sporobolus heterolepis	Northern dropseed	Tracked
Tradescantia bracteata	Long-bract spiderwort	Tracked
Triodanis leptocarpa	Slim-pod Venus' looking-glass	Tracked
Viburnum opulus var. americanum	Highbush cranberry	Tracked
Viola pedatifida	Prairie violet	Tracked
Viola renifolia var. brainerdii	Kidney-leaf white violet	Tracked

Black Hills Prairie Grasslands

In the Black Hills, prairie grasslands generally occur at lower elevations with four primary types of prairies in the Black Hills: mesic tall grass prairie, dry mixed grass prairie, mesic mixed grass prairie, and prairie dog grassland. Mesic tall grass prairie is dominated by big and little bluestem. Two types of dry mixed grass prairie occur on the Black Hills in limited quantities: northern great plains little bluestem prairie and needle and thread-blue grama mixed grass prairie. Mesic mixed grass prairie is comprised of western wheat grass-green needle grass and western wheat grass-needle and thread plant associations. Black-tailed prairie dog town grassland complexes are *found at lower elevations in areas of extensive mixed grass and short grass prairie habitat. Common plants species include buffalo grass, purple three-awn, bracted vervain, and fetid marigold along with non-native species including Canada thistle, cheat grass, common mullein, and hornseed buttercup.*

Black Hills Interior Grasslands

Interior grasslands in the Black Hills occur at higher elevations and are open, park-like valleys, prairies, and grasslands of varying size. These grasslands can be grouped into two main forms: prairie and montane grasslands. Interior prairie grasslands are found on hillsides where the landscape is convex in shape and tends to shed water. In contrast, montane grasslands occur in valley bottoms where water tends to drain, creating more mesic conditions than the interior prairies. Additionally, the soils in these drainages are typically deeper and more fertile than grasslands found on hillsides. Black Hills Montane Grasslands is a grassland type endemic to the Black Hills and occurs at higher elevations on the limestone plateau and the central core. Dominant plant species include prairie dropseed, Richardson's needle grass, and timber oat grass. Common forbs include prairie smoke, threenerve fleabane, sticky geranium, purple meadow rue, and several cinquefoils. Timothy often occurs in montane grassland habitat, however grasslands dominated by timothy are not included in the Black Hills Montane Grassland type because the original composition from early studies is unclear. Timothy-dominated grasslands are fairly common throughout the Black Hills but are less common in the area between Custer, South Dakota and Newcastle, Wyoming.

Black Hills Shrublands

In the Black Hills, there are six types of upland shrublands including big sagebrush, silver sagebrush, mountain mahogany, creeping juniper, three-leaved sumac, and chokecherry shrublands. In general, big sagebrush shrublands are uncommon in the Black Hills and are restricted to the lower elevations of the western and southern flanks of the Hogback Rim. Western wheat grass, blue grama, needle grasses, and prairie junegrass are associated with big sagebrush shrublands which could exist in small amounts in the Black Hills. The silver sagebrush shrubland type occurs in the floodplain of the Belle Fourche River but has not been documented on the Forest. Western snowberry is common within the community and the understory in silver sagebrush shrublands is characterized by Kentucky bluegrass, needle and thread grass, cudweed sagewort, with some western wheat grass also present.

Mountain-mahogany shrublands are the most extensive shrubland type on the Black Hills and are most common in the west-central portion (east of Newcastle, Wyoming) of the Black Hills on low-elevation limestone. These shrublands are patchy and have a relatively sparse herbaceous understory dominated by side-oats grama Three-leaved sumac is usually present in mountain-mahogany shrublands, and Rocky Mountain juniper and ponderosa pine occur as scattered individuals. Creeping juniper shrublands are found only occasionally in the Black Hills; they have been documented *in the eastern foothills and may also occur in the southwestern foothills. Other shrubs that generally occur with creeping juniper include three-leaved sumac, chokecherry, and leadplant. Three-leaved sumac shrublands have only been documented in the Devils Tower National Monument but could exist in the Black Hills. This plant community generally includes three-leaved sumac, fringed sagewort, big sagebrush, bluebunch wheat grass, poison ivy, blue grama, junegrass, and needle and thread grass. Chokecherry shrublands are found in a variety of habitats such as dry draws, scree/talus slopes, and at rock outcrops primarily in the north central core, southwestern foothills, and eastern foothills. In these shrublands, chokecherry is often co-dominant with three-leaved sumac, American plum, and/or western snowberry.*

Wet Meadow

The wet meadow is a grassland community that typically occurs on fine-textured soils in valley bottoms where the water table is high enough to saturate the soil during a portion of the growing season. In addition, this community commonly occurs where springs emerge, along reservoirs, and in irrigated pastures. Depending on salinity and water table, common species include Baltic rush (Juncus balticus), Nebraska sedge (Carex nebrascensis), prairie cordgrass (Spartina pectinata), and redtop bentgrass (Agrostis stolonifera). Species composition in the proximity of human activity, such as reservoirs and irrigated pasture, tends to exhibit dominance by introduced species such as Kentucky bluegrass (Poa pratensis), timothy (Phleum pratense) and smooth brome (Bromus inermis). Wet meadows tend to exist as island habitats surrounded by dominant plant communities such as grasslands or shrublands.

Herbaceous Riparian

The herbaceous riparian plant community consists of a variety of riparian moist grasses, sedges, and rushes, and occurs near drainages including rivers, streams, and creeks. Plant species common to the wet meadow community may include woolly sedge (Carex lanuginosa), common spike-rush (Eleocharis palustris), foxtail barley (Hordeum jubatum), wild licorice (Glycyrrhiza lepidota), and Canada goldenrod (Solidago canadensis).

Sagebrush Shrubland

The sagebrush shrubland plant community may include plant species such as Wyoming big sagebrush, silver sagebrush (Artemisia cana), western wheatgrass, junegrass (Koeleria macran- tha), needle-and-thread grass, Sandberg bluegrass (Poa secunda), prickly pear cactus, scarlet globemallow, and rabbitbrush (Chrysothamnus spp.).

Mixed Foothill Shrubland

The mixed foothill shrubland is dominated by mountain big sagebrush (Artemisia tridentata var. vaseyana) interspersed with antelope bitterbrush (Purshia tridentata), serviceberry (Amelanchier alnifolia), skunkbush sumac (Rhus trilobata), common chokecherry (Prunus virginiana), and snowberry (Symphoricarpos spp.). Common *forbs and grasses found in the mixed foothill shrubland may include lupine (Lupinus spp.), arrowleaf balsamroot (Balsamorhiza sagittata), hairy goldenaster (Heterotheca villosa), basin wildrye (Elymus cinereus), and junegrass. Greasewood shrubland, dominated by greasewood (Sarcobatus vermiculatus), exhibits limited distribution on saline soils near seeps or perched water tables.*

Shrubby Riparian

The shrubby riparian plant community includes a variety of shrubs and herbaceous plants that exist adjacent to draws, gullies, and streams and may include hawthorn (Crataegus spp.), chokecherry, peachleaf willow (Salix amygdaloides), sandbar willow (Salix exigua), other willow species (Salix spp.), silver sagebrush, bluejoint reedgrass (Calamagrostis canadensis), and tufted hairgrass (Deschampsia cespitosa).

Coniferous Forest

The coniferous forest plant community includes Engelmann spruce (Picea engelmannii), Douglas fir (Pseudotsuga menziesii), lodgepole pine (Pinus contorta var. latifolia), ponderosa pine (Pinus ponderosa), limber pine (Pinus flexilis), and juniper (Juniperus spp.), These species tend to form associations based on elevation, exposure, and moisture. Juniper and pine forests tend to be lower in elevation, while spruce and fir forests occur at higher elevations.

Aspen

Aspen communities typically occur in depressions, ravines, valley bottoms, or on the lee sides of wedges. Aspen seedlings are intolerant of drier conditions, and therefore this community distribution is typically dictated by the availability of soil moisture. Quaking aspen (Populus tremuloides) is the dominant species but other plant species occur in aspen stands including common snowberry (Symphoricarpos albus), serviceberry, Woods' rose (Rosa woodsii), western yarrow (Achillea millefolium var. lanulosa), wild geranium (Geranium spp.), mountain brome (Bromus marginatus) and elk sedge (Carex geyeri).

Forested Riparian

The forested riparian plant community includes a variety of deciduous and coniferous tree species that occur along riparian areas. Some common species include plains cottonwood (Populus deltoides), narrow-leaf cottonwood (Populus angustifolia), quaking aspen, boxelder (Acer negundo), green ash (Fraxinus pennsylvanica), Russian olive (Elaeagnus angustifolia), and willow (Salix spp).

Dry Coniferous Forests And Woodlands

Dry coniferous forests and woodlands are relatively open forests with less than 50-percent canopy cover. This ecological group dominates in the Black Hills. Ponderosa pine/bearberry, ponderosa pine/sedge, and ponderosa pine/little bluestem comprise most of the dry coniferous forest cover at higher elevations. Ponderosa pine/sedge, ponderosa pine/little bluestem, and ponderosa pine/western wheat grass *communities are the most extensive types at lower elevations. Three other ponderosa pine types—ponderosa pine/Rocky mountain juniper, ponderosa pine/bluebunch wheat grass, and ponderosa pine/Oregon grape—are locally significant at lower elevations of the Black Hills.*

Mesic Coniferous Forests And Woodlands

Mesic coniferous forests dominate at higher elevations of the Black Hills. These forests typically have canopy cover greater than 60 percent. The most extensive high-elevation associations are ponderosa pine/bearberry, ponderosa pine/common juniper, and ponderosa pine/rough-leaf rice grass. Ponderosa pine/mountain ninebark and ponderosa pine/chokecherry associations occur in scattered locations in the southern and central Black Hills, and ponderosa pine/bur oak is relatively common at middle and lowerelevations of the northern and eastern Black Hills.

3.5.4.3 Targeted Vegetation

Twenty-five designated and prohibited noxious weeds are on the state of Wyoming Weed and Pest Control Act Designated List as shown in Table 3.22 [Wyoming Weed and Pest Council, 2014]. The plants are problematic because they affect desirable plants, land uses, and existing habitats. "Declared weeds" are listed by weed control districts in Campbell, Crook, and Weston Counties in accordance with Declared Pest and Declared Weed Program Participation W.S. 11-5-102(a)(vii).

Table 3.23 through Table 3.25 lists the three declared weeds in Campbell County, six declared weeds in Crook County, and nine declared weeds in Weston County, respectively [Wyoming Weed and Pest Council, 2014]. Wyoming weed control districts meet specific weed or pest needs by offering technical assistance, cost-share programs, and inspection services. The watershed covers portions of three weed and pest districts: Campbell County Weed and Pest, Crook County Weed and Pest, and Weston County Weed and Pest. Within these districts, mapping and analysis work is ongoing, although this data was not acquired for the purposes of this study.

3.5.5 Wetlands

The National Wetlands Inventory (NWI) was completed by the USFWS to map existing wetlands based on vegetative, hydrologic, and soil features using aerial imagery and field verification within the United States. Within the watershed, the NWI geospatial data identifies approximately 21,940 acres of all wetland types, which cover approximately 0.9 percent of the study area. Most of these wetlands are located along the Belle Fourche River corridor and along the tributary drainages, especially toward the headwaters in the western portion of the study area (mainly because of the amount of wetlands associated with lakes, ponds, rivers, and reservoirs in these areas). Wetlands and lake areas directly associated with Keyhole Reservoir account for approximately 4,950 acres (22.6 percent) of the wetlands within the study area.

Table 3.22. State of Wyoming Designated and Prohibited Noxious Weeds

Scientific Name	Common Name
Cirsium arvense L.	Canada thistle
Arctium minus Hill Bernh.	Common burdock
Hypericum perforatum	Common St. Johnswort
Tanacetum vulgare	Common Tansy
Linaria dalmatica L. Mill.	Dalmatian toadflax
Centaurea diffusa Lam.	Diffuse knapweed
Isatis tinctoria L.	Dyers woad
Convolvulus arvensis L.	Field bindweed
Cardaria draba and Cardaria pubescens L. Desv.	Hoary cress (whitetop)
Cynoglossum officinale L.	Houndstongue
Euphorbia esula L.	Leafy spurge
Carduus nutans L.	Musk thistle
Chrysanthemum leucanthemum L.	Ox-eye daisy
Lepidium latifolium L.	Perennial pepperweed
Sonchus arvensis L.	Perennial sowthistle
Carduus acanthoides L.	Plumeless thistle
Lythrum salicaria L.	Purple loosestrife
Agropyron repens L. Beauv.	Quackgrass
Centaurea repens L.	Russian knapweed
Elaeagnus angustifolia L.	Russian olive
Tamarix spp.	Saltcedar
Onopordum acanthium L.	Scotch thistle
Franseria discolor Nutt.	Skeletonleaf bursage
Centaurea maculosa Lam.	Spotted knapweed
Linaria vulgaris L.	Yellow toadflax

Table 3.23. Campbell County Declared Weeds

Scientific Name	Common Name
Xanthium stru marium L.	Common Cocklebur
Hyoscyamus niger L.	Black Henbane
Solanum rostratum Dunal	Buffalobur

Table 3.24. Crook County Declared Weeds

Scientific Name	Common Name
Hyoscyamus niger L.	Black henbane
Cirsium vulgare (Savi) Ten.	Bull thistle
Yucca glauca Nutt.	Great plains yucca
Glycyrrhiza lepidota Pursh	Wild licorice
Verbascum thapsus L.	Common mullein
Potentilla recta L.	Sulphur cinquefoi

Table 3.25. Weston County Declared Weeds

Common Name	Scientific Name
Wild licorice	*Glycyrrhiza lepidota Pursh*
Puncturevine	*Tribulus terrestris L.*
Sulfur cinquefoil	*Potentilla recta L.*
Broom snakeweed	*Gutierrezia sarothrae (Pursh) Britton and Rusby*
Cheatgrass/downy brome	*Bromus tectorum L.*
Musk mustard	*Chorispora tenella (Pallas) DC.*
Black medic	*Medicago lupulina L.*
Common purslane	*Portulaca oleracea L.*
Curly dock	*Rumex crispus L.*

The predominant wetland type is a freshwater emergent wetland, which is defined as an erect rooted herbaceous plant adapted to grow entirely or partly submerged in water, occurring on approximately 11,500 acres within the watershed. The distribution of wetland by type illustrated in Figure 3.24, and the NWI wetlands within the watershed are listed in Table 3.26.

The NWI wetland areas are shown in Figure 3.25. However, because the NWI wetland areas are very small in size relative to the study area and are scarcely visible when presented at the watershed scale, the mapped wetland polygons were outlined with a thicker border to increase their visibility; NWI wetlands do not actually cover the amount of area indicated in the map. Consequently, site-specific wetland delineation and inventories were not part of the scope of this watershed study, and it is recommended that wetland delineation and inventories should be completed before planning future wetland projects.

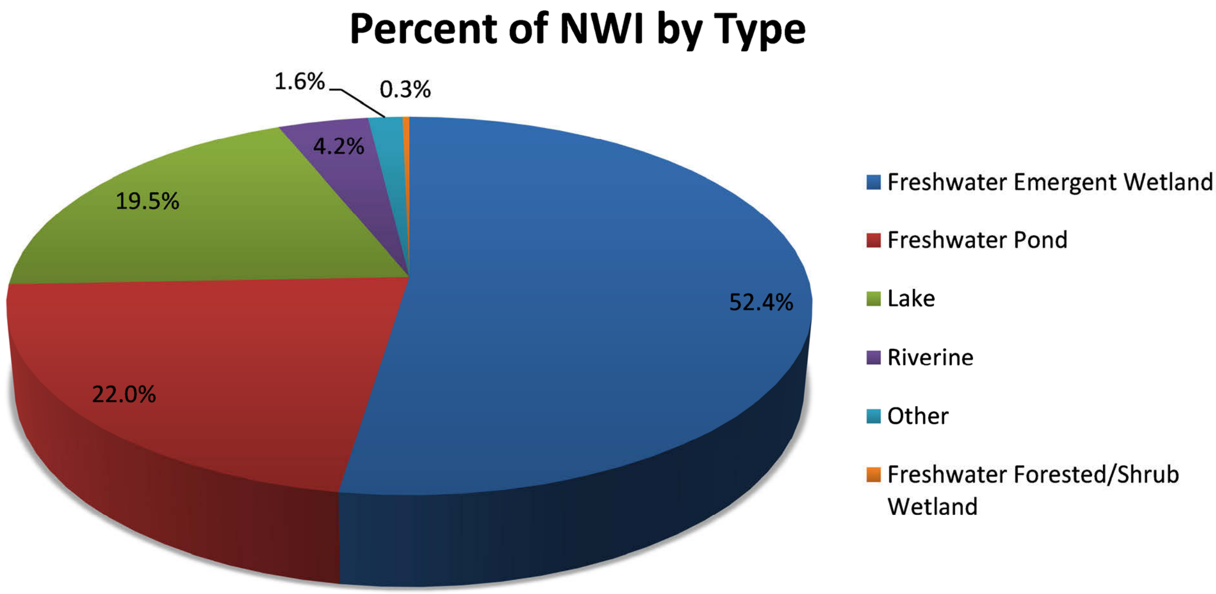

Figure 3.24. Percent Distribution of National Wetlands Inventory Wetland Types Within the Study Area.

Table 3.26. Summary of Wetland Types Within the Study Area

Wetland Type	Area (Acres)	Study Area (%)
Freshwater Emergent Wetland	11,500	0.46
Freshwater Pond	4,820	0.19
Lake	4,280	0.17
Riverine	920	0.04
Other	350	0.01
Freshwater Forested/Shrub Wetland	70	< 0.01
Total	**21,940**	**0.88**

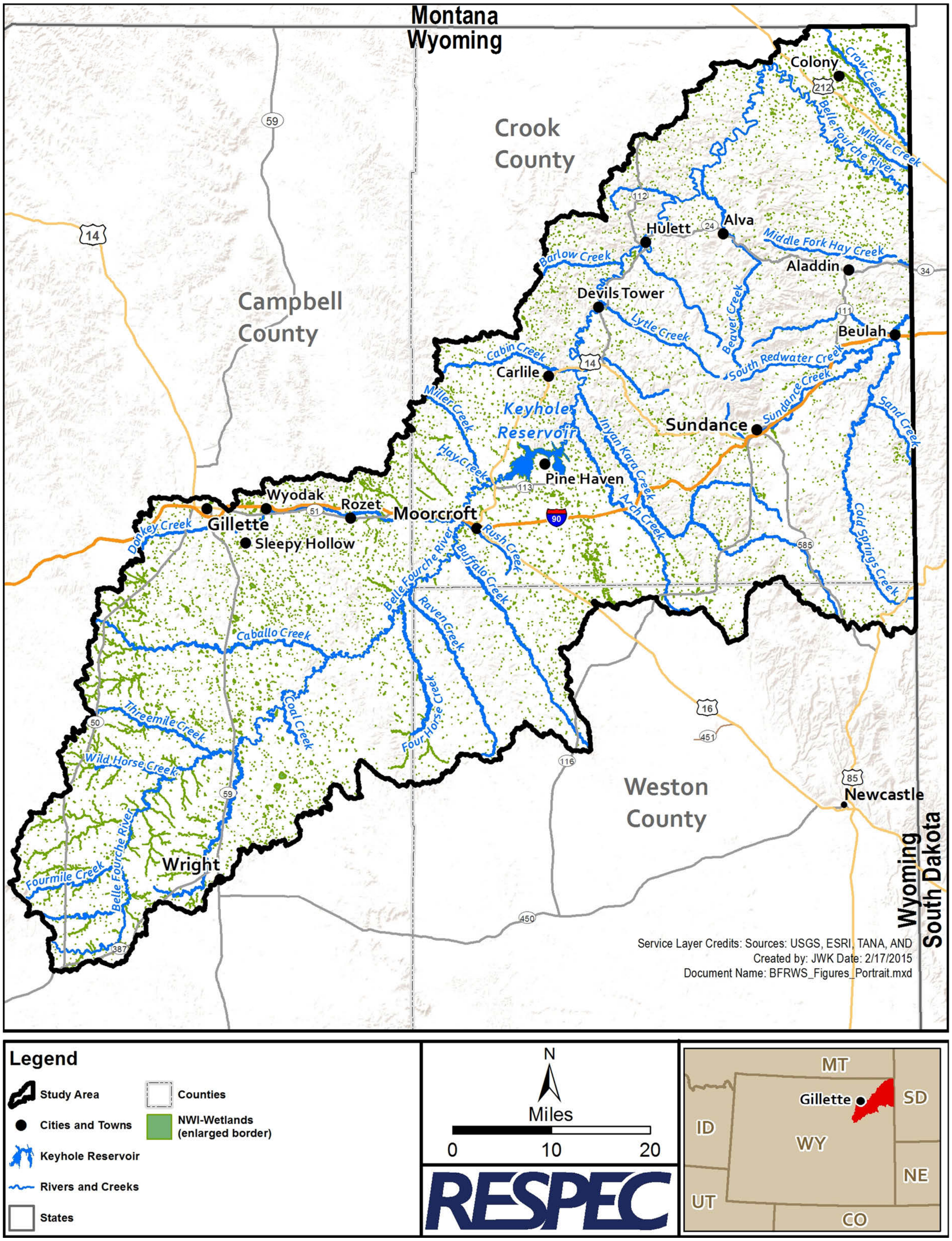

Figure 3.25. National Wetlands Inventory Wetlands Located Within the Study Area.

In the late 1980s, the WGFD and USFWS delineated and prioritized wetland complexes in Wyoming. The later assessment was completed by The Nature Conservancy (TNC) in 2009 [Wyoming Joint Ventures Steering Committee, 2010]. Wetland complexes were delineated based on five spatial density criteria and resulted in identifying 222 individual wetland complexes throughout Wyoming. Three priority complexes are located within the watershed (based on data from Copeland et al. [2010]) and are illustrated in Figure 3.26. Two of these complexes, Belle Fourche and Beaver, are listed as primary focus areas. These areas have TNC diversity ranks in the top five and high project potential. The third complex, Inyan Kara, has a lower integrity score and is listed as having a medium project potential [Wyoming Joint Ventures Steering Committee, 2010].

The U.S. Army Corp of Engineers (USACE) has developed an approach for classifying wetlands that is based on the watershed-level scale. This classification involves considerations founded on hydrogeomorphic characteristics of the differing wetland types. The USACE Wetlands Research Program Technical Report WRP-DE-9 provides the following regarding hydrogeomorphic wetland classifications [Smith et al., 1995]:

> *The hydrogeomorphic classification is based on three fundamental factors that influence how wetlands function, including geomorphic setting, water source, and hydrodynamics. Geomorphic setting refers to the landform of a wetland, its geologic evolution, and its topographic position in the landscape. For example, a wetland may occur in a depressional landform or a valley landform and may occur at the top, middle, or bottom of a watershed. Water source refers to the location of water just prior to entry into the wetland. All water on the land originates as precipitation, but in many cases the water will follow a circuitous path prior to entry into a wetland (Fetter 1988, pg 38).*
>
> *For example, water may enter the wetland directly as precipitation, follow a less direct path over the surface of the ground as overland flow or overbank flow, follow a subsurface path as interflow, throughflow, or baseflow, or any combination of these. Hydrodynamics refers to the energy level of moving water, and the direction that surface and near-surface water moves in the wetland. For example, the level of energy of an isolated wetland is generally lower than a wetland on a river floodplain, and the movement of water in a riverine wetland is generally unidirectional and downstream.*

This classification schema identifies seven wetland types: depressional, lacustrine fringe, tidal fringe, slope, riverine, mineral flat, and organic flat. Within the study area, depressional, lacustrine fringe, slope, and riverine wetlands are likely to be present and the following excerpt from the USACE report describes these four wetland types [Smith et al., 1995]:

> ***Depressional Wetlands***
>
> *Depressional wetlands occur in topographic depressions with a closed elevation contour that allows accumulation of surface water. Dominant sources of water are*

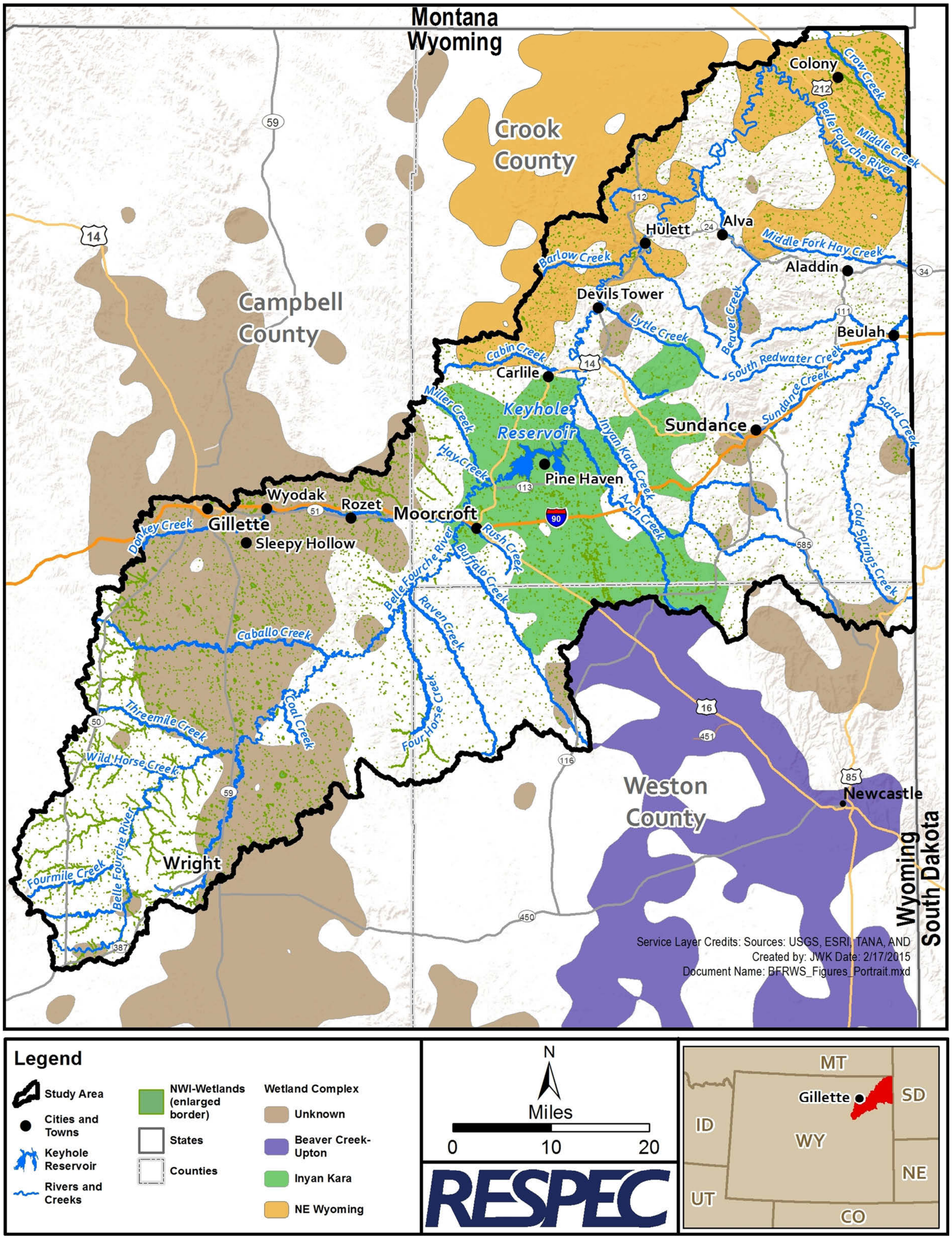

Figure 3.26. Wetland Complexes Within the Study Area [Copeland et al., 2010].

precipitation, groundwater discharge, and interflow from adjacent uplands. The direction of water movement is normally from the surrounding uplands toward the center of the depression. Depressional wetlands may have any combination of inlets and outlets or lack them completely. Depressional wetlands may lose water through intermittent or perennial drainage from an outlet, by evapotranspiration, and, if they are not receiving groundwater discharge, may slowly contribute to groundwater. Dominant hydrodynamics are vertical fluctuations, primarily seasonal. Peat deposits may develop in depressional wetlands. Prairie potholes are a common example of depressional wetlands.

Lacustrine Fringe Wetlands

Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water table in the wetland. In some cases, they consist of a floating mat attached to land. Additional sources of water are precipitation and groundwater discharge, the latter dominating where lacustrine fringe wetlands intergrade with uplands or slope wetlands. Surface water flow is bidirectional, usually controlled by water level fluctuations such as seiches in the adjoining lake. Lacustrine fringe wetlands are indistinguishable from depressional wetlands where the size of the lake becomes so small relative to fringe wetlands that the lake is incapable of stabilizing water tables. Lacustrine wetlands lose water by flow returning to the lake after flooding, by saturation surface flow, and by evapotranspiration. Organic matter normally accumulates in areas sufficiently protected from shoreline wave erosion. Un-impounded marshes bordering the Great Lakes are a common example of lacustrine fringe wetlands.

Slope Wetlands

Slope wetlands normally are found where there is a discharge of groundwater to the land surface. They normally occur on sloping land; elevation gradients may range from steep hillsides to slight slopes. Slope wetlands are usually incapable of depressional storage because they lack the necessary closed contours. Principal water sources are usually groundwater return flow and interflow from surrounding uplands as well as precipitation. Hydrodynamics are dominated by downslope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Slope wetlands lose water primarily by saturation subsurface and surface flows and by evapotranspiration. Slope wetlands may develop channels, but the channels serve only to convey water away from the slope wetland. Fens are a common example of slope wetlands.

Riverine Wetlands

Riverine wetlands occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank flow from the channel or subsurface hydraulic connections between the stream channel and wetlands.

Additional water sources may be interflow and return flow from adjacent uplands, occasional overland flow from adjacent uplands, tributary inflow, and precipitation. When overbank flow occurs, surface flows down the floodplain may dominate hydrodynamics. At their headwater most extension, riverine wetlands often intergrade with slope or depressional wetlands as the channel (bed) and bank disappear, or they may intergrade with poorly drained flats or uplands. Perennial flow is not required.

Riverine wetlands lose surface water via the return of floodwater to the channel after flooding and through saturation surface flow to the channel during rainfall. They lose subsurface water by discharge to the channel, movement to deeper groundwater (for losing streams), and evapotranspiration. Peat may accumulate in off-channel depressions (oxbows) that have become isolated from riverine processes and subjected to long periods of saturation from groundwater sources. Bottomland hardwood floodplains are a common example of riverine wetlands.

3.5.6 Geology

Geologic mapping information and data for the study area were obtained from the USGS and the WSGS. A variety of geological features and rocks from Precambrian metamorphics are exposed in the uplifts to Quaternary alluvium along creeks within the study area. The watershed includes parts of both the Black Hills uplift and the Powder River structural basin. An in-depth discussion of the watershed’s geology was beyond the scope of this study; however, general geologic maps and discussions are presented to define the formations present that could potentially affect development of watershed improvement projects and reservoir storage.

3.5.6.1 Surficial Geologic Units

The surficial geologic units within the watershed predominantly consist of residuum mixed, slopewash and colluvium, and alluvium covering approximately 81 percent of the watershed, as shown in Figure 3.27. The remaining prominent units include clinker mixed, landslide mixed, bedrock, mined areas mixed, eolian mixed, and alluvial fan. These geologic units influence the watershed by providing the parent material and morphology for the soil formations and plant communities within the study area.

3.5.6.2 Bedrock Geologic Units

The bedrock geologic units that underlie the watershed study area predominantly consist of the Wasatch Formation, Cloverly and Morrison Formations, and Sundance and Gypsum Spring Formations. The formations cover approximately 48 percent of the watershed, as shown in Figure 3.28 and listed in Table 3.27. The remaining prominent bedrock features include the Tullock Member of the Fort Union Formation, Greenhorn Formation and Belle Fourche and Mowry Shale, Lebo Member of Fort Union Formation, Spearfish Formation, Minnelusa Formation, alluvium and colluvium, and the Lance Formation.

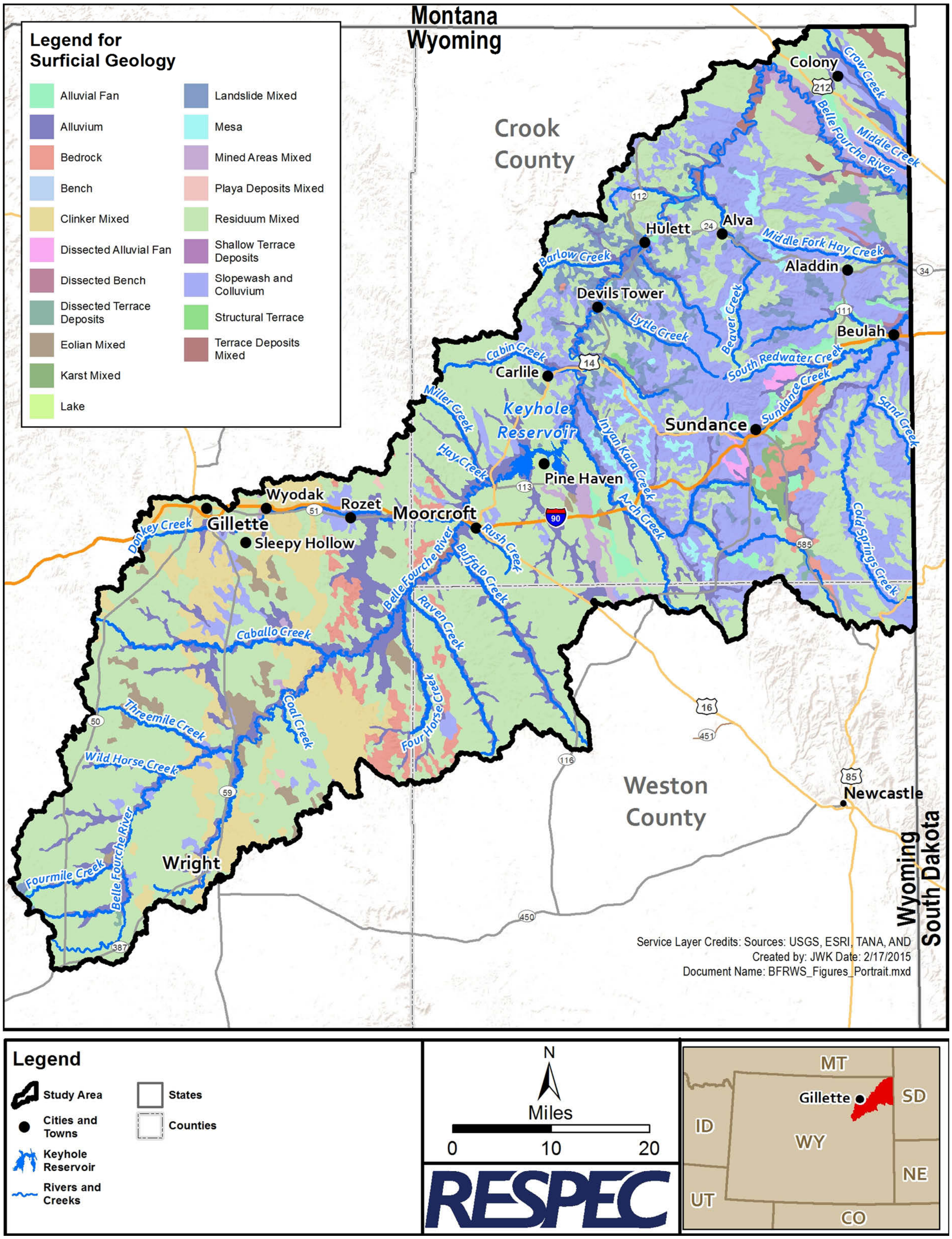

Figure 3.27. Surficial Geology of the Belle Fourche River Watershed.

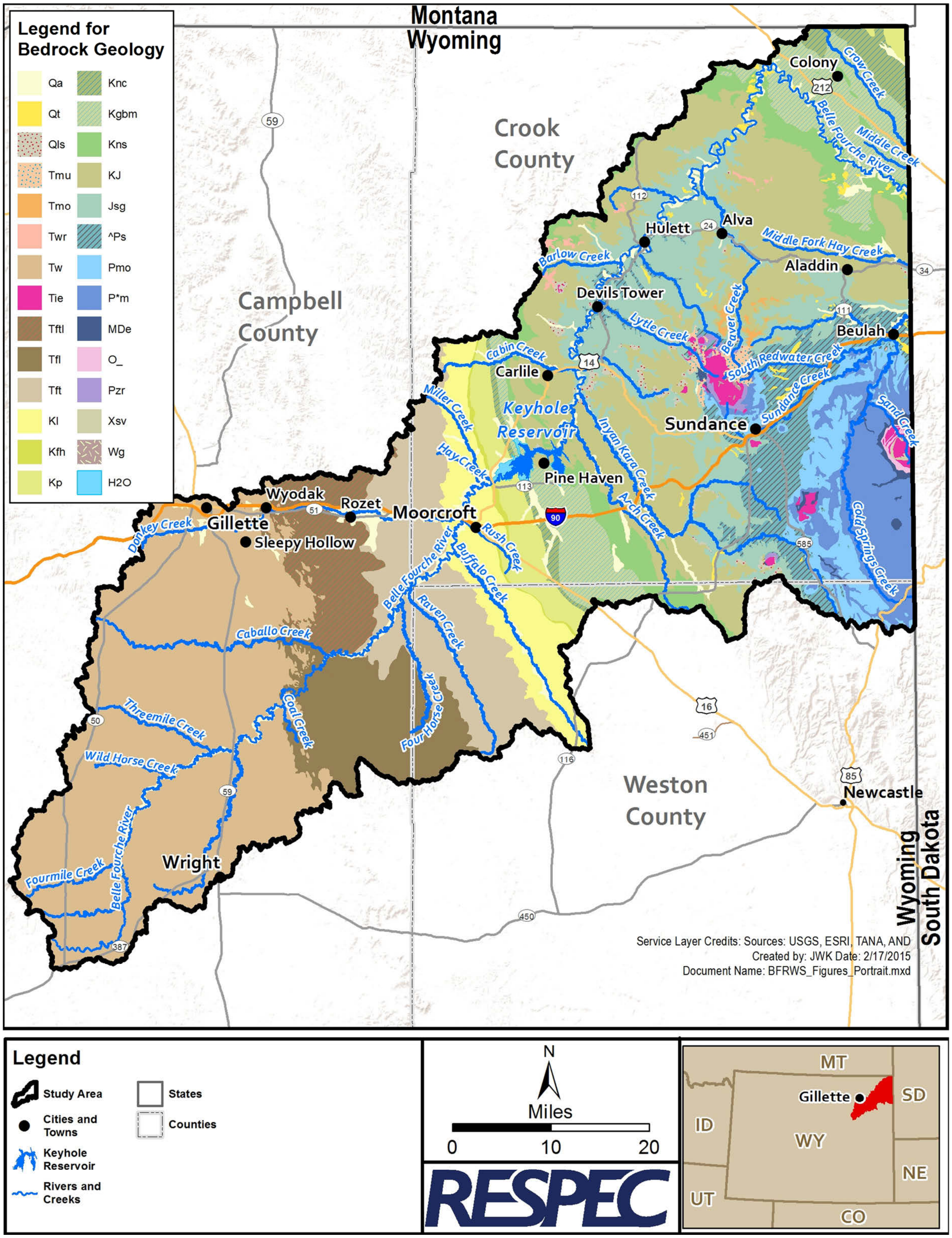

Figure 3.28. Bedrock Geology of the Belle Fourche River Watershed.

Table 3.27. Bedrock Geologic Units Within the Study Area

Unit Symbol	Geologic Unit Name	Area (acres)	Percent of Study Area
Tw	Wasatch Formation	580,740	23.4
KJ	Cloverly and Morrison Formations	379,640	15.3
Jsg	Sundance and Gypsum Spring Formations	221,590	8.9
Tft	Tullock Member of Fort Union Formation	178,180	7.2
Kgbm	Greenhorn Formation, Belle Fourche and Mowry Shales	140,430	5.7
Tfl	Lebo Member of Fort Union Formation	125,710	5.1
@Ps	Spearfish Formation	116,890	4.7
P&m	Minnelusa Formation	110,780	4.5
Qa	Alluvium and colluvium	109,500	4.4
Kl	Lance Formation	101,590	4.1
Kns	Newcastle Sandstone and Skull Creek Shale	90,980	3.6
Tftl	Tongue River and Lebo Members of Fort Union Formation	87,940	3.5
Pmo	Minnekahta Limestone and Opeche Shale	70,160	2.8
Kp	Pierre Shale	52,660	2.1
Knc	Niobrara Formation and Carlile Shale	32,370	1.3
Tie	Intrusive and extrusive igneous rocks	16,030	0.6
Qls	Landslide deposits	11,480	0.5
Qt	Gravel, pediment, and fan deposits	10,570	0.4
water	Water	9,010	0.4
Tmu	Upper Miocene rocks	7,510	0.3
MDe	Pahasapa and Englewood Limestones	7,500	0.3
Kfh	Fox Hills Sandstone	6,390	0.3
Twr	White River Formation	4,440	0.2
Pzr	Madison Limestone, Darby Formation, Bighorn Dolomite, Gallatin Limestone, Gros Ventre Formation, Flathead Sandstone	4,420	0.2
Tmo	Lower Miocene and Upper Oligocene rocks, or rocks equivalent to Upper and Lower Miocene rocks and White River Formation	4,020	0.1
O_	Bighorn Dolomite, Gallatin Limestone, and Gros Ventre Formation	3,010	0.1
Other	Geologic units that comprise less than 0.1 percent of the study area	1,490	<0.1
Total		**2,485,030**	**100.0**

3.5.6.3 Hazardous Geological Features

Figure 3.29 displays the known faults and landslides within the watershed. Landslide deposits were present on the surficial geology and indicate that landslide activity has occurred predominantly in the Bear Lodge Mountains and surrounding foothills as well as a smaller area southwest of Sundance.

3.5.7 Soils

Soils are diverse within the study area because of the variable characteristics of the watershed's underlying geology, topography and elevation, climate and precipitation, and vegetation. Soils vary considerably but usually are loams, with over 68 percent of the study area categorized as loam soils with channery, cobbly, gravelly, sandy, and stony loam surface textures. Soils information and data were obtained from the NRCS and compiled for the portions of the watershed within Campbell, Crook, and Weston Counties. There are four digitized soil surveys cover approximately 95 percent of the watershed. The NRCS published the soil surveys in the northern portion of Campbell County and the southern portions of Campbell, Crook, and Weston Counties in 2007, 2004, 1983, and 1990, respectively. Detailed soils information, ratings, data, and maps can be accessed by visiting the NRCS Web Soil Survey (*http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm*).

Over 560 soil map units are within the watershed. The Lakoa-Butche complex is the largest single map unit and covers 93,724 acres (3.8 percent) of the study area and occurs almost exclusively in the portion of the watershed downstream of Keyhole Reservoir. Other major soil units include the Tollflat-Hickok-Vanocker complex, Samsil-Gaynor complex, Forkwood-Cushman loams, Hilight-Wags-Badland complex, and Rock outcrop-Vanocker complex. Figure 3.30 dipicts general soils that were mapped by using NRCS 1:250,000 map scale soils data.

Table 3.28 lists and Figure 3.31 shows 28 map units that cover approximately 197,190 acres that are rated as partially hydric soils within the watershed. These hydric soils cover approximately 7.9 percent of the study area and occur almost entirely occur above Keyhole Reservoir. Hydric soils were formed under saturated, flooded, or ponded conditions during the growing season to create anaerobic conditions in the soil profile. The categories for the watershed's hydric soil are below:

- 2B3—Aquic, Albolls, Historthels, Histoturbels, Pachic, or Cumulic that are poorly drained and have a water table at a depth of 1 foot or less during the growing season if permeability is less than 6 inches per hour in any layer within a depth of 20 inches.
- 2B3,3—Aquic, Albolls, Historthels, Histoturbels, Pachic, or Cumulic that are poorly drained or very poorly drained and have a water table at a depth of 1 foot or less during the growing season if permeability is less than 6 inches per hour in any layer at a depth of 20 inches and are frequently ponded for long durations during the growing season.
- 4—Soils frequently flooded for long or very long durations during the growing season.

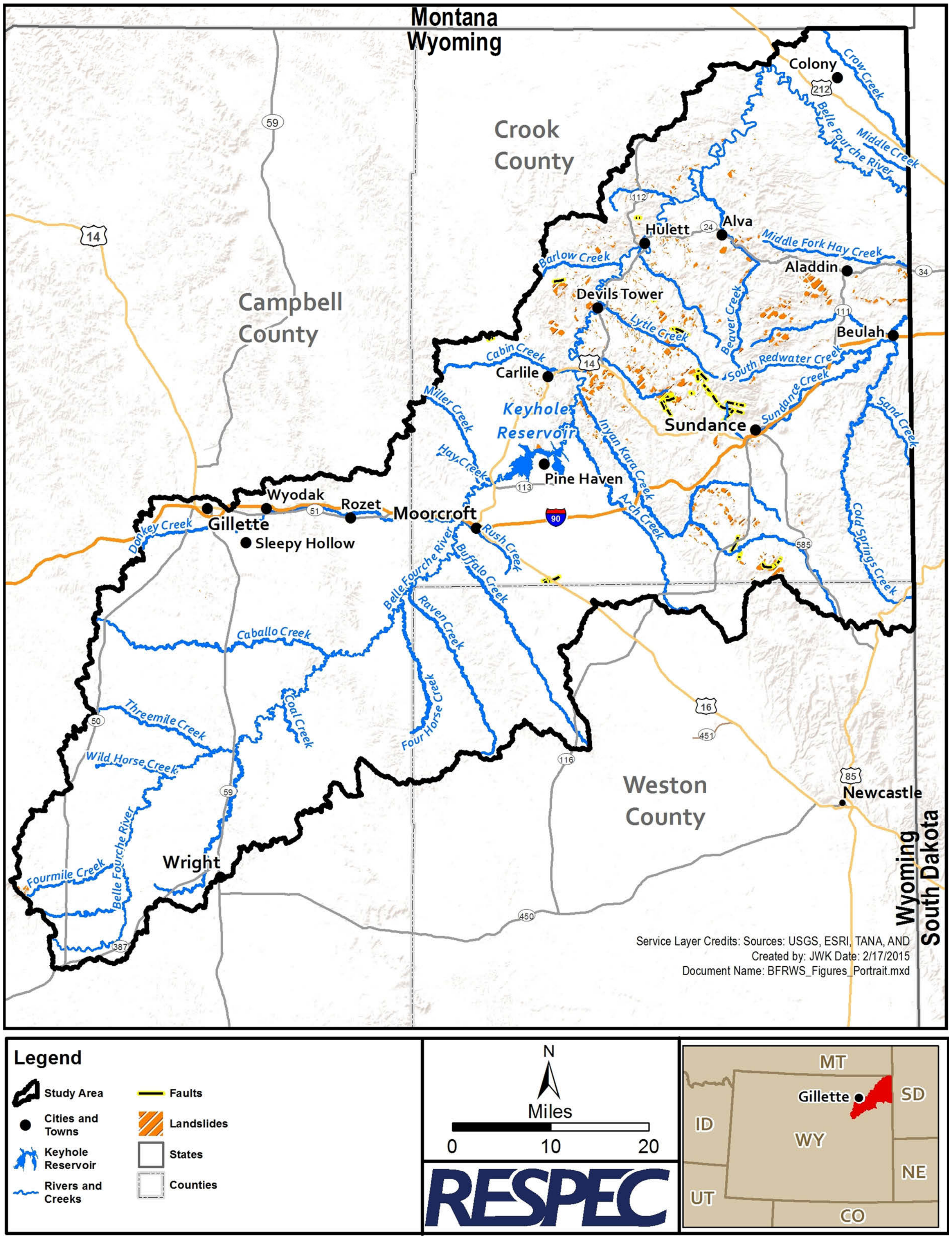

Figure 3.29. Hazardous Geologic Features Within the Study Area.

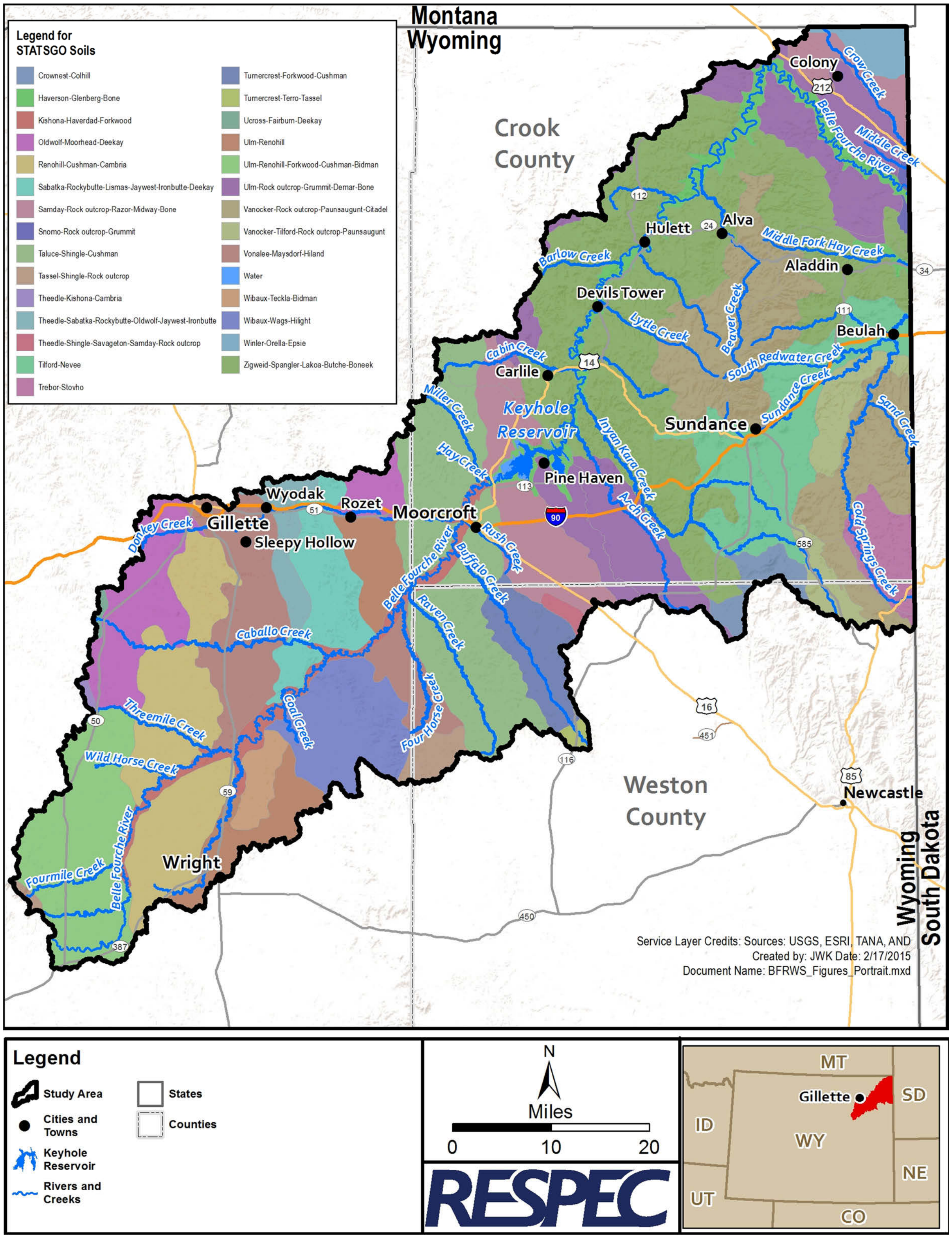

Figure 3.30. 1:250,000 Scale Soils Map of the Study Area.

Table 3.28. Summary of Hydric Soil Map Units Within the Study Area

Map Unit Name	Area (acres)	Percent of Study Area
Hilight-Wags-Badland complex, 3 to 45 percent slopes	43,460	1.75
Forkwood-Ulm loams, 0 to 6 percent slopes	25,090	1.01
Arvada, thick surface-Arvada-Slickspots complex, 0 to 6 percent slopes	19,730	0.79
Bidman-Parmleed loams, 0 to 6 percent slopes	19,210	0.77
Cambria-Kishona-Zigweid loams, 0 to 6 percent slopes	16,310	0.66
Bidman-Ulm loams, 0 to 6 percent slopes	12,960	0.52
Moorhead clay loam, 0 to 6 percent slopes	8,720	0.35
Haverdad loam, 0 to 3 percent slopes	7,320	0.29
Bidman loam, 0 to 6 percent slopes	5,910	0.23
Ustic Torriorthents, gullied	4,110	0.17
Haverdad, occasionally flooded-Kishona clay loams, 0-6 percent slopes	4,070	0.16
Urban land-Deekay-Moorhead complex, 0 to 6 percent slopes	3,180	0.13
Heldt-Bidman complex, saline, 0 to 3 percent slopes	2,860	0.12
Lohmiller silty clay loam, occasionally flooded, 0 to 3 percent slopes	2,790	0.11
Felix clay, ponded, 0 to 2 percent slopes	2,540	0.10
Higgins silt loam, 0 to 3 percent slopes	2,490	0.10
Clarkelen-Embry fine sandy loams, 0 to 4 percent slopes	2,240	0.09
Emigha loam, 0 to 3 percent slopes	2,160	0.09
Colombo loam, occasionally flooded, 0 to 3 percent slopes	1,970	0.08
Moorhead loam, 0 to 6 percent slopes	1,960	0.08
Clarkelen-Keeline association, 0 to 6 percent slopes	1,670	0.07
Aridic Ustorthents, saline, 0 to 4 percent slopes	1,360	0.05
Rockypoint-Iwait association, 0 to 6 percent slopes	1,290	0.05
Platmak loam, 0 to 6 percent slopes	1,290	0.05
Haverdad-Clarkelen complex, 0 to 4 percent slopes	990	0.04
Cordeston silt loam, cool, 0 to 6 percent slopes	890	0.04
Clarkelen-Draknab complex, 0 to 3 percent slopes	380	0.02
Lohmiller clay loam, occasionally flooded, 0 to 3 percent slopes	240	0.01
Total	**197,190**	**7.93**

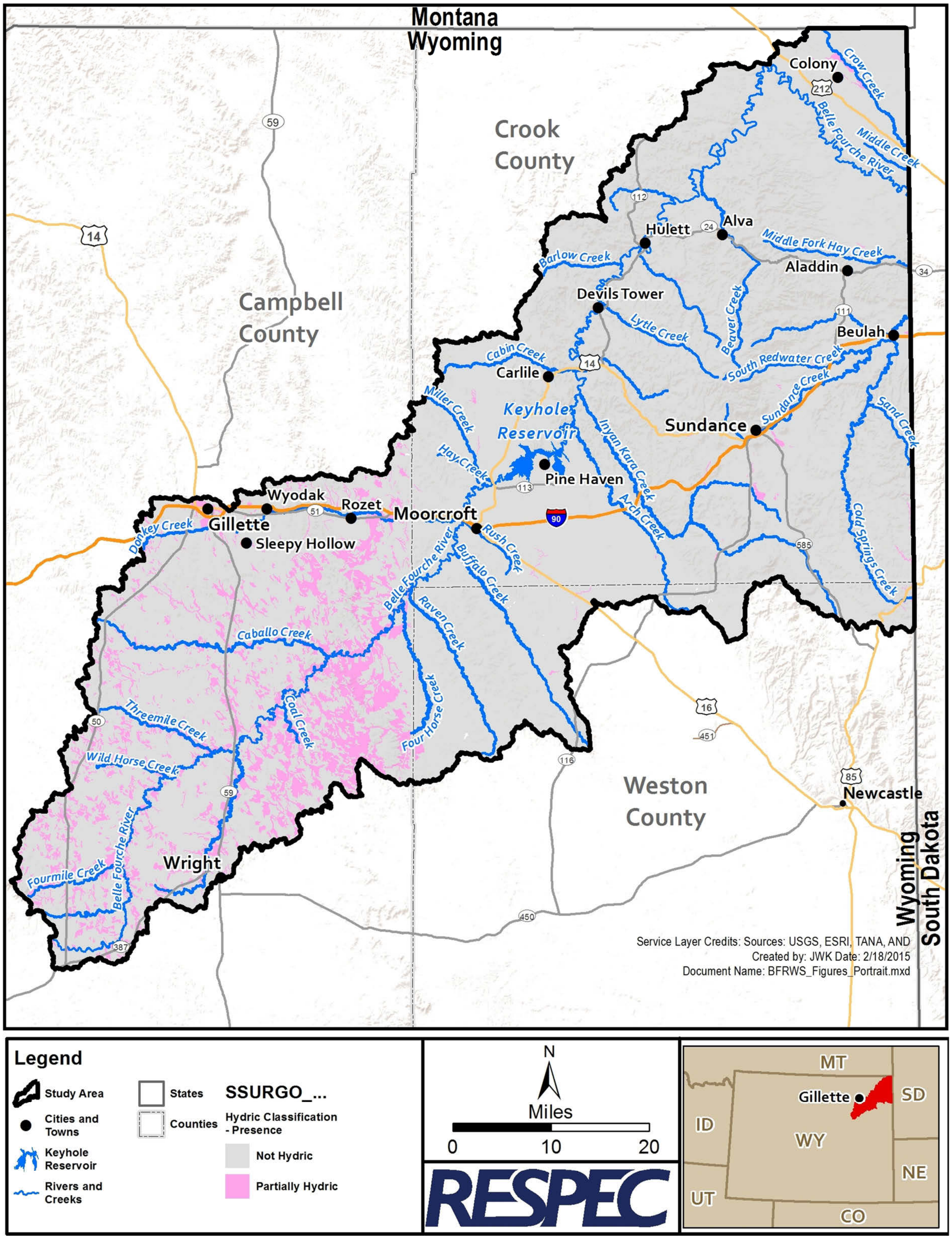

Figure 3.31. Hydric Soils Map Units Within the Study Area.

3.6 HYDROLOGY

3.6.1 Groundwater

Groundwater availability within the watershed is variable because of the diverse aquifer characteristics and hydrogeological properties in the study area. Depending on the specific area of the watershed, groundwater can be found at varying depths; areas near streams and along alluvial valleys have shallower groundwater with depths of 25 feet or less. Other locations within the watershed have deep groundwater aquifers with depths of more than 1,000 feet below the ground surface. Groundwater information and water well databases were obtained from the SEO. Permitted well information, including locations, yields, and depths, was collected and compiled in the study's GIS. Figure 3.32 shows the SEO water wells within the study area.

Groundwater is locally important for livestock/wildlife water, private domestic wells, and municipal water. However, of the approximate 14,000 wells on file with the SEO within the study area, approximately 6,000 of those wells are associated with coal bed methane (CBM) and thousands more are known to have been drilled. Most of the CBM wells are concentrated in the westernmost portion of the study area south of Gillette, Wyoming. In general, pumping from CBM wells has lowered the water tables and altered stream flows and water quality. At its peak in 2009, CBM methods extracted 8 million barrels of water in the Powder River Basin [Stafford and Wittke, 2013]. Water production from CBM wells has declined in recent years, and water levels in some areas show signs of recovery [Stafford and Wittke, 2013]. More information about CBM and groundwater can be found in the WSGS report [Stafford and Wittke, 2013].

Apart from the CBM wells, most of the other wells in the watershed are private wells used for stock and domestic purposes. Well depths average approximately 300 feet but vary from being completed in shallow alluvial aquifers with low water yield to well over 800-feet-deep penetrating deeper aquifers. Deeper bedrock aquifers that serve as a groundwater supply include the Tertiary Fort Union and Wasatch Formations in the western portion of the watershed and Inyan Kara, Minnelusa, and Madison Limestone toward the Black Hills. Numerous other geologic formations, from Precambrian to Quaternary age, yield water to wells and springs in the study area. However, their water-bearing properties and chemical qualities differ greatly and cause low-yield aquifers to be considered locally important for water sources. Most of the watershed has groundwater that is suitable for livestock to drink, which can be developed at depths of less than 1,000 feet. Many small springs and seeps exist within the study area and occur where the water table intersects the ground surface.

Downstream of Keyhole Reservoir, the number and density of springs dramatically increase to over 300 named and unnamed springs. Several of these springs support recharge to alluvium and perennial flows in some sections of the Belle Fourche River and its tributaries, although discharge is subject to pumping impacts and seasonal fluctuations of the water table [Whitcomb and Morris, 1964]. Figure 3.33 illustrates the location of springs mapped by the USGS and the BLM.

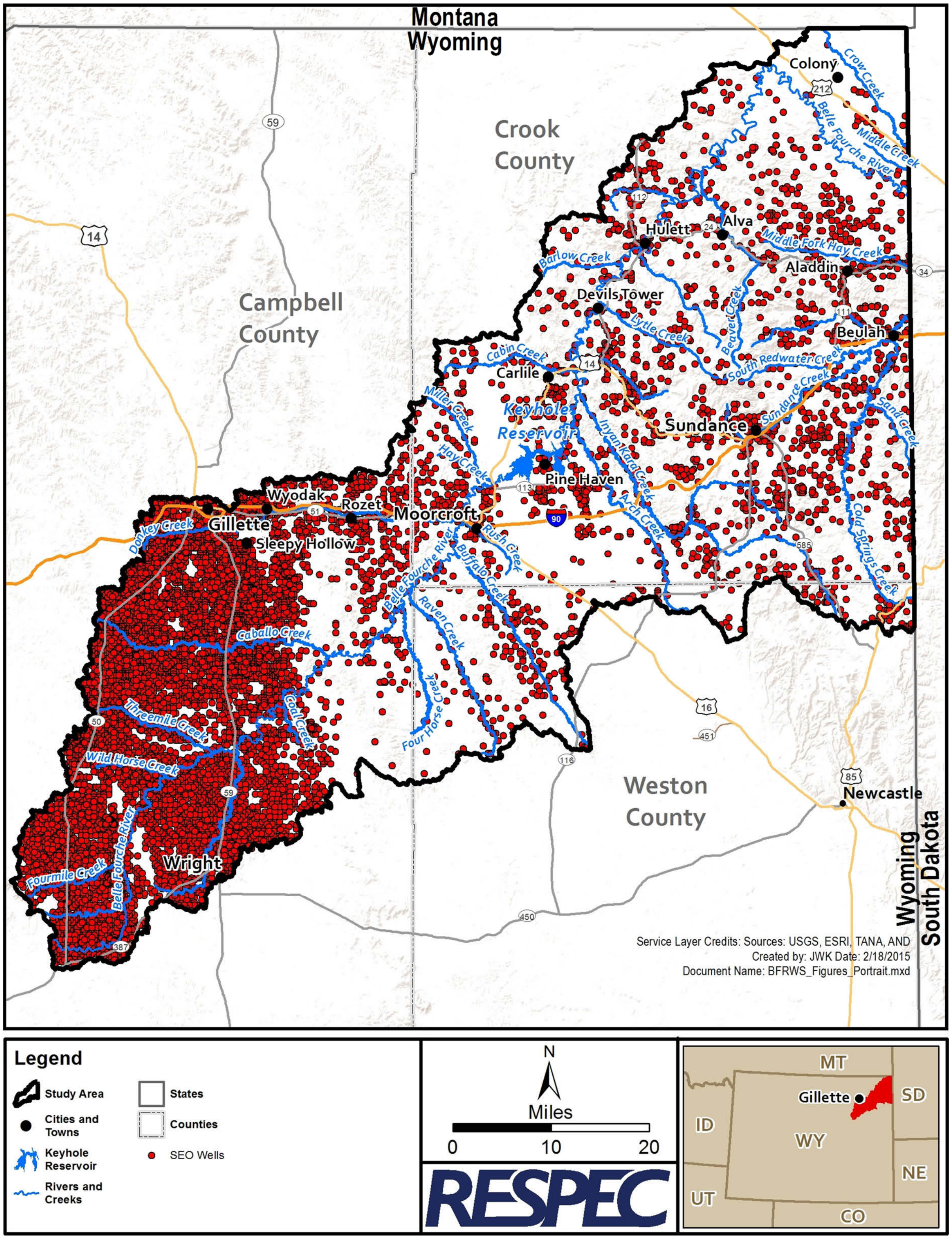

Figure 3.32. Permitted Water Wells Located Within the Study Area.

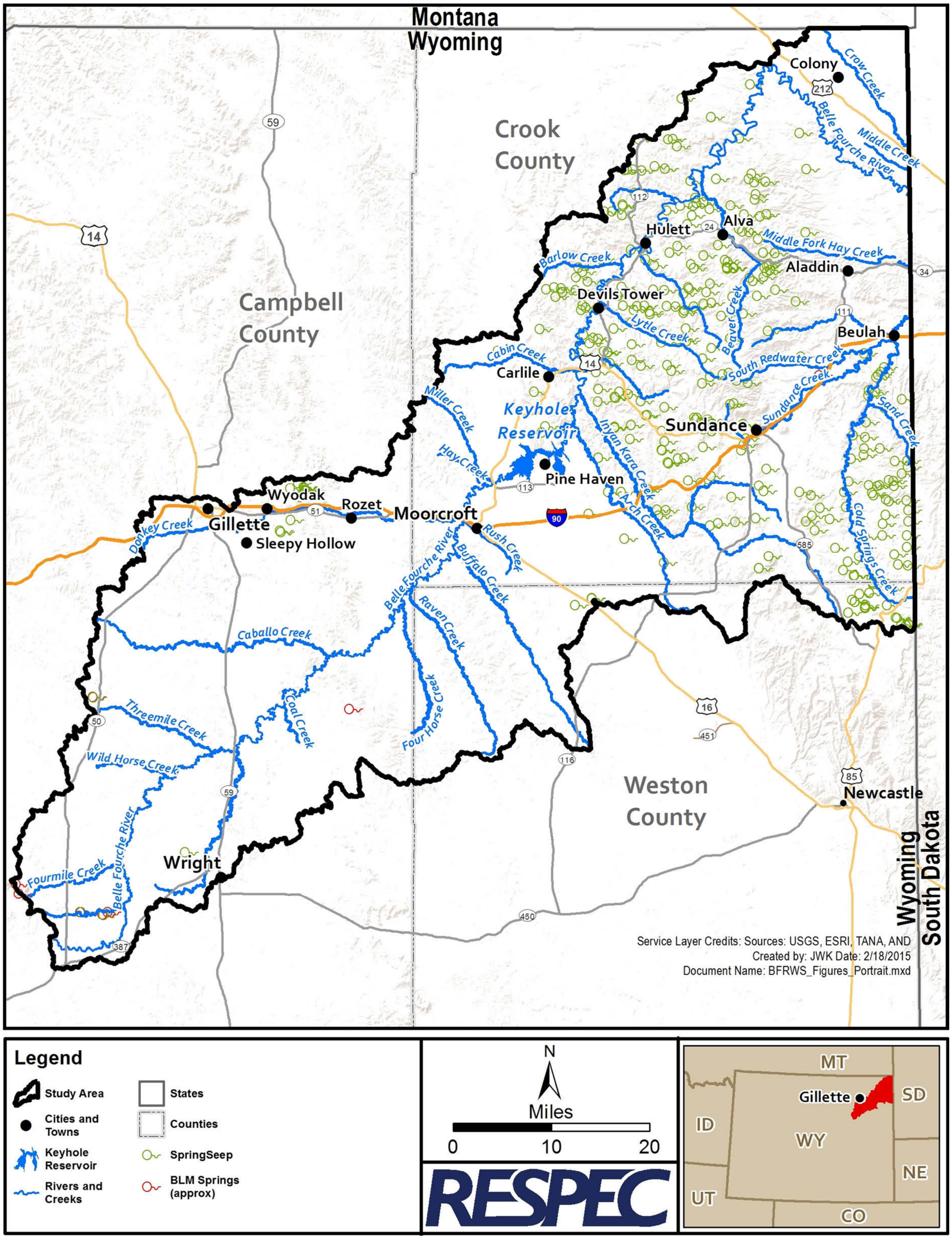

Figure 3.33. Springs Located Within the Study Area.

3.6.1.1 Gillette Regional Water Supply Project

Population increases and growth in Gillette and surrounding communities have increased demand on existing water supplies. Existing water systems and future water needs in the region are being addressed through ongoing planning and construction efforts. In 2009, the city of Gillette requested a regional water master plan for the city and surrounding areas because the growth in Gillette in the last 10 years has put additional pressure on the water resources that Gillette and its neighbors depend on [WWDC, 2009b]. In response, the Gillette Regional Master Plan Level I study was initiated by the WWDC in a joint effort with the city of Gillette and Campbell County with participation from the surrounding communities and rural water districts. The purpose of the study was to investigate the feasibility of implementing a regional water system to serve the growing water supply needs for Gillette and the surrounding area [HDR Engineering Inc., 2009]. Study efforts focused on scoping meetings, population projections, GIS mapping, system governance, available data, water rights, priority recommendations, estimated costs, and system financing [HDR Engineering Inc., 2009].

In 2011, the Wyoming Legislature appropriated funding the Gillette Madison Water Supply project that included the following [WWDC, 2011b]:

1. 50 miles of transmission pipeline ranging in size from 36 inches to 42 inches in diameter
2. New power transmission upgrades and booster pump station near Rozet
3. New electrical system, disinfection facility, and storage tanks at the Pine Ridge wellfield
4. Transmission system will be capable of:
    a. Serving the 2040 population of 57,562 for the Gillette Regional Area
    b. Providing an additional 16,000 gallons per minute (gpm) (23 million gallons per day) to the Gillette Regional Area
5. New Madison Formation Wellfield:
    a. Initially five new wells capable of producing 1,400 gpm per well
    b. Ultimately, 12 to 13 new wells to be developed over the next 30 years
6. Treated water storage tanks in Campbell County and transmission pipeline stub-outs to accommodate future regional extensions to serve existing and future demands from over 40 recognized water districts and subdivisions not currently receiving city water.

In May 2011, a special election was held to consider establishing a capital facilities tax for the regional water project, and it was passed by Campbell County residents by a vote of 3,554 to 721 [WWDC, 2014]. To date, the city of Gillette has completed construction of the two Madison Formation test wells, approximately 5 miles of 36-inch pipe, and 10 miles of 42-inch pipe [WWDC, 2014]. Additionally, the city has ongoing design and construction projects for the Donkey Creek pump station, Pine Ridge disinfection facility, 18-inch blending pipeline, water transmission pipeline between Moorcroft and Pine Ridge, and power transmission upgrades

[WWDC, 2014]. The city of Gillette and Campbell County have developed a Joint Powers Agreement (JPA) that created the JPA Water Rates Panel, which established regional water rates in October 2014 [WWDC, 2014].

3.6.2 Surface Water

The study area begins at the headwaters of the Belle Fourche River approximately 18 miles southwest of Wright, Wyoming, and flows generally northeast where it crosses the Wyoming–South Dakota border approximately 10 miles northeast of Aladdin, Wyoming, as shown in Figure 3.33. The study area includes all of the land draining to the Belle Fourche River and tributaries within Wyoming. The watershed covers approximately 3,883 square miles or 2,485,020 acres in northeast Wyoming. Approximately 11,110 stream miles are located within the watershed and approximately 340 miles of the Belle Fourche River are within the study area. Additionally, approximately 2,180 stream miles are classified as perennial. The Belle Fourche River and its major tributaries, Arch Creek, Beaver Creek, Buffalo Creek, Caballo Creek, Cabin Creek, Cold Springs Creek, Donkey Creek, Four Horse Creek, Inyan Kara Creek, Lytle Creek, Miller Creek, Oak Creek, Redwater Creek, Sand Creek, Sundance Creek, and Wind Creek occur within the watershed.

The USGS has delineated watersheds through a hydrologic classification that divides and subdivides the nation into continually smaller watersheds. These organized levels watersheds are called “hydrologic units” and assigned a Hydrologic Unit Code (HUC). The HUC identifies the level based on the size and locale of the unit. The classification currently has six levels. The first level divides the nation into 21 regions, which is referred to as a HUC-2 because a two-digit code identifies each region. Each of these regions is further split into second, third, fourth, fifth, and sixth levels that represent HUC-4, HUC-6, HUC-8, HUC-10, and HUC-12, respectively. As expected, a HUC-12 is represented by 12 digits, assigning it to all of the above levels.

Table 3.29 provides an example of the HUC system as it refers to Upper Buffalo Creek (a tributary to the Belle Fourche River). Figure 3.34 displays the HUCs within the study area. The study area was defined by the Wyoming portion of the sixth order HUC 101202 that drains to the Belle Fourche River. The watershed contains three ten-digit cataloging units: 10120201–Upper Belle Fourche, 10120202–Lower Belle Fourche, and 10120203–Redwater. Table 3.30 summarizes the HUC system as it pertains to the Belle Fourche River and its tributaries.

3.6.2.1 U.S. Geological Survey Gaging Stations

The USGS has operated multiple streamflow gaging stations within the study area. Figure 3.35 illustrates the period of record for all gages and shows that up to 13 gages were operated simultaneously. Currently, 10 active USGS gages are within the watershed, as shown in Figure 3.36. A total of 21 (10 active and 11 inactive) USGS gaging stations have been in operation within the study area and are listed in Table 3.31.

Table 3.29. Representation of Hydrologic Unit Levels Within the Study Area

Region	10	Missouri Region	Second order HUC
Subregion	1012	Cheyenne	Fourth order HUC
Accounting Unit	101202	Belle Fourche	Sixth order HUC
Cataloging Unit	10120201	Upper Belle Fourche	Eighth order HUC
8 Subbasins	1012020104	Caballo Creek	Tenth order HUC
52 Subbasins	101202010407	Upper Buffalo Creek	Twelfth order HUC

Historical USGS discharge data and historical monthly mean discharge rates were analyzed to develop a relationship for seasonality for all of the gaging stations within the study area. As shown in Table 3.32, monthly mean discharge rates reflect typical seasonal runoff patterns. Gages on the Belle Fourche River report highest discharge rates in spring and early summer months (March, April, May, and June). The latter part of the summer and fall season exhibit declining discharge rates. Increases in observed discharge rates throughout the spring and early summer months at the Belle Fourche River gages can be attributed to snowmelt and early spring runoff. Decreases in streamflow in the latter part of the summer and fall months indicate the transition to typical winter baseflow stream conditions throughout the study area.

Gages on tributaries to the Belle Fourche River have later and smaller peak mean discharge rates than the gages located on the river. Peak discharges typically occur in the months of May and June and are significantly smaller than peak discharges observed on the river. Historical monthly mean hydrographs of gaging stations on the Belle Fourche River are plotted in Figure 3.37 and Figure 3.38 for gages located on tributaries.

The USBR historically operated and maintained one automated hydrologic monitoring station, deemed HYDROMET station, on streams within the study area. Operation of this station, which is located on the Belle Fourche River at the Wyoming–South Dakota border, has been transferred to the USGS. The related USGS station number for this site is 06430500.

3.6.2.2 Wyoming Water Development Commission Temporary Gaging Stations

In addition to the USGS gaging stations, three temporary gaging stations were installed to obtain additional streamflow data. These gaging stations and their locations are listed in Table 3.33 and shown in Figure 3.39. The gages consist of pressure transducers with built-in dataloggers protected by polyvinyl chloride (PVC) housings. The transducer setup for Lytle Creek is depicted in Figure 3.40. Transducers were programmed to collect water at 15-minute intervals throughout the study period and then translated from depth to streamflow. All three

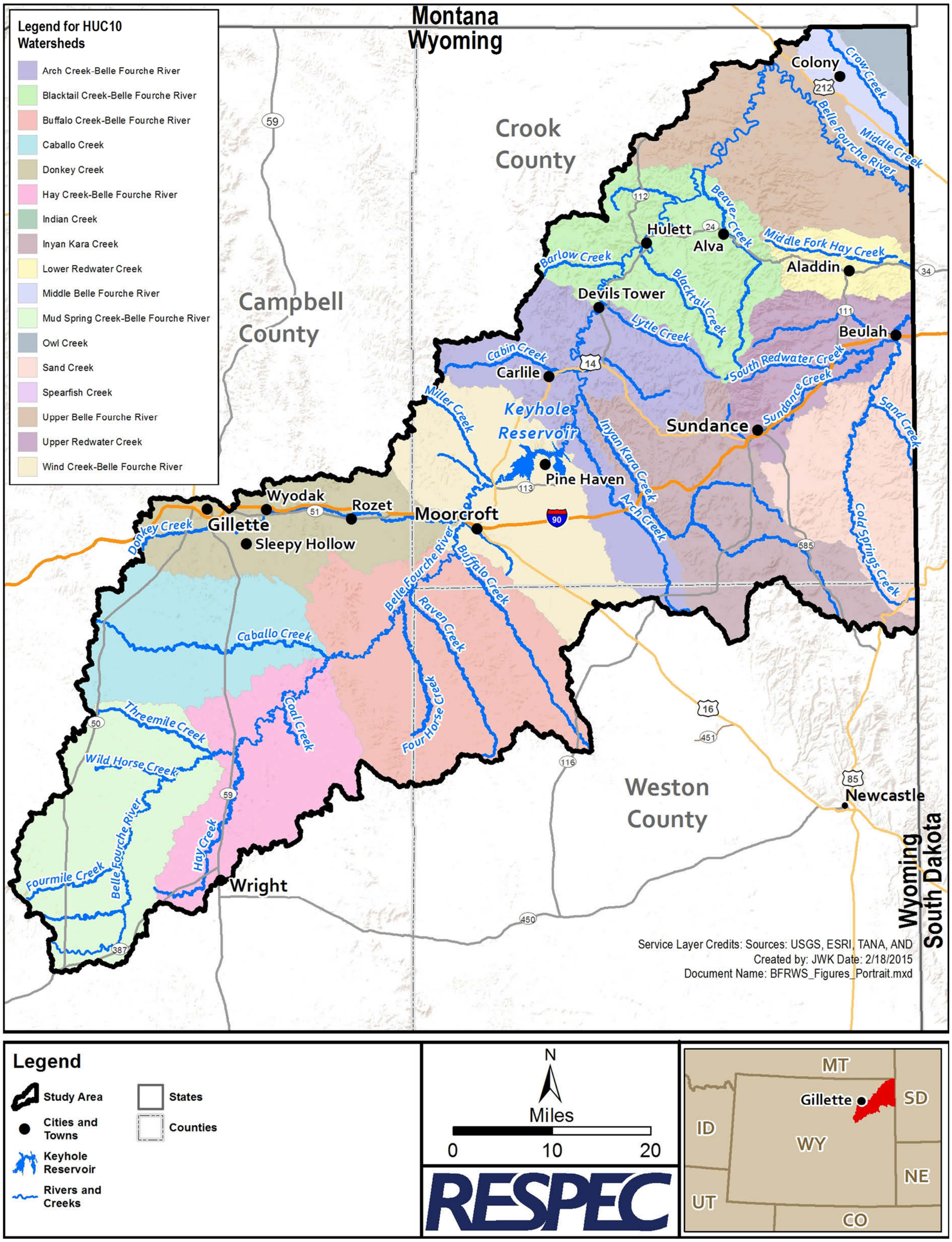

Figure 3.34. Hydrologic Units Within the Study Area.

Table 3.30. Hydrologic Unit Codes Within the Belle Fourche River Watershed (Page 1 of 5)

HUC 2	HUC 4	HUC 6	HUC 8	HUC 10		HUC 12		Area (sq. mi.)
				Number	Name	Number	Name	
Region 10: Missouri	Subregion 1012: Cheyenne	Accounting Unit 101202: Belle Fourche	Cataloging Unit 10120201: Upper Belle Fourche	1012020101	Mud Spring Creek-Belle Fourche River	101202010101	All Night Creek-Belle Fourche River	72.2
						101202010102	Fourmile Creek	37.8
						101202010103	Rocky Butte Gulch-Belle Fourche River	42.3
						101202010104	Mud Spring Creek	60.0
						101202010105	Durham Reservoir-Belle Fourche River	46.7
						101202010106	Wild Horse Creek	52.1
						101202010107	Threemile Creek	41.6
				1012020102	Hay Creek-Belle Fourche River	101202010201	Rattlesnake Creek-Belle Fourche River	57.1
						101202010202	Upper Hay Creek	47.7
						101202010203	Lower Hay Creek	48.2
						101202010204	Coal Creek	74.0
						101202010205	Dry Creek-Belle Fourche River	54.7
				1012020103	Caballo Creek	101202010301	Upper Caballo Creek	64.5
						101202010302	Hoe Creek	59.4
						101202010303	Lower Caballo Creek	50.5
						101202010304	Bone Pile Creek	44.4
						101202010305	Tisdale Creek	41.7
						101202010301	Upper Caballo Creek	64.5

Table 3.30. Hydrologic Unit Codes Within the Belle Fourche River Watershed (Page 2 of 5)

HUC 2	HUC 4	HUC 6	HUC 8	HUC 10		HUC 12		Area (sq. mi.)
				Number	Name	Number	Name	
Region 10: Missouri	Subregion 1012: Cheyenne	Accounting Unit 101202: Belle Fourche	Cataloging Unit 10120201: Upper Belle Fourche	1012020104	Buffalo Creek-Belle Fourche River	101202010401	Yellow Hammer Creek-Belle Fourche River	66.4
						101202010402	Timber Creek-Belle Fourche River	51.5
						101202010403	Upper Four Horse Creek	53.3
						101202010404	Lower Four Horse Creek	49.6
						101202010405	Coyote Creek-Belle Fourche River	36.4
						101202010406	Raven Creek	80.0
						101202010407	Upper Buffalo Creek	64.1
						101202010408	Lower Buffalo Creek	66.5
				1012020105	Wind Creek-Belle Fourche River	101202010501	Rush Creek-Belle Fourche River	47.8
						101202010502	Trail Creek-Belle Fourche River	35.8
						101202010503	Miller Creek	48.0
						101202010504	Lone Tree Creek-Belle Fourche River	32.3
						101202010505	Upper Wind Creek	56.2
						101202010506	Lower Wind Creek	58.4
						101202010507	Deer Creek	29.0
						101202010508	Mule Creek	24.1
						101202010401	Yellow Hammer Creek-Belle Fourche River	66.4
						101202010402	Timber Creek-Belle Fourche River	51.5

Table 3.30. Hydrologic Unit Codes Within the Belle Fourche River Watershed (Page 3 of 5)

HUC 2	HUC 4	HUC 6	HUC 8	HUC 10		HUC 12		Area (sq. mi.)
				Number	Name	Number	Name	
Region 10: Missouri	Subregion 1012: Cheyenne	Accounting Unit 101202: Belle Fourche	Cataloging Unit 10120201: Upper Belle Fourche	1012020106	Donkey Creek	101202010601	Headwaters Donkey Creek	64.6
						101202010602	Upper Donkey Creek	60.6
						101202010603	Dry Donkey Creek	26.0
						101202010604	Middle Donkey Creek	56.1
						101202010605	Lower Donkey Creek	47.9
				1012020107	Arch Creek-Belle Fourche River	101202010701	Spring Creek-Belle Fourche River	38.6
						101202010702	Upper Arch Creek	41.9
						101202010703	Lower Arch Creek	48.8
						101202010704	Cabin Creek	66.4
						101202010705	Miller Creek	55.1
						101202010706	Lake Creek-Belle Fourche River	49.5
						101202010707	Lytle Creek	38.0
				1012020108	Inyan Kara Creek	101202010801	Upper Inyan Kara Creek	62.4
						101202010802	Middle Inyan Kara Creek	53.6
						101202010803	Beaver Creek	57.7
						101202010804	Lower Inyan Kara Creek	62.0
						101202010805	Mason Creek	51.6
						101202010806	Houston Creek	50.5

Table 3.30. Hydrologic Unit Codes Within the Belle Fourche River Watershed (Page 4 of 5)

HUC 2	HUC 4	HUC 6	HUC 8	HUC 10		HUC 12		Area (sq. mi.)
				Number	Name	Number	Name	
Region 10: Missouri	Subregion 1012: Cheyenne	Accounting Unit 101202: Belle Fourche	Cataloging Unit 10120201: Upper Belle Fourche	1012020109	Blacktail Creek-Belle Fourche River	101202010901	Whitetail Creek-Belle Fourche River	38.8
						101202010902	Barlow Creek	44.9
						101202010903	Blacktail Creek	42.7
						101202010904	Buck Creek-Belle Fourche River	69.3
						101202010905	Sourdough Creek	22.1
						101202010906	Upper Beaver Creek	50.5
						101202010907	Lower Beaver Creek	43.3
			Cataloging Unit 10120202: Lower Belle Fourche	1012020201	Upper Belle Fourche River	101202020101	Deer Creek	23.6
						101202020102	Arnold Creek-Belle Fourche River	42.2
						101202020103	Medicine Creek-Belle Fourche River	39.3
						101202020104	Spring Creek-Belle Fourche River	56.2
						101202020105	Horse Creek	15.4
						101202020106	Kilpatrick Creek-Belle Fourche River	38.1
						101202020107	Deep Creek	35.5
						101202020108	Oak Creek	43.8
						101202020109	Belle Fourche River-Grummit Canyon Creek	48.3
						101202020110	Middle Creek-Belle Fourche River	34.6
				1012020202	Middle Belle Fourche River	101202020202	Upper Crow Creek	65.2
						101202020203	Lower Crow Creek	46.7
				1012020203	Owl Creek	101202020301	Owl Creek-Shaue Gulch	54.9
						101202020302	Owl Creek-Ruben Creek	61.3

Table 3.30. Hydrologic Unit Codes Within the Belle Fourche River Watershed (Page 5 of 5)

HUC 2	HUC 4	HUC 6	HUC 8	HUC 10 Number	HUC 10 Name	HUC 12 Number	HUC 12 Name	Area (sq. mi.)
Region 10: Missouri	Subregion 1012: Cheyenne	Accounting Unit 101202: Belle Fourche	Cataloging Unit 10120203: Redwater	1012020301	Upper Redwater Creek	101202030101	North Redwater Creek-Redwater Creek	58.3
						101202030102	South Redwater Creek	65.8
						101202030103	Sundance Creek	49.6
						101202030104	Lower Redwater Creek	49.0
						101202030105	Crow Creek-Redwater Creek	40.8
				1012020302	Sand Creek	101202030201	Cold Springs Creek	70.3
						101202030202	Grand Canyon	51.8
						101202030203	Sand Creek	70.0
						101202030204	Red Canyon Creek	83.0
						101202030205	Bear Gulch	25.0
				1012020304	Lower Redwater Creek	101202030405	North Fork Hay Creek	38.7
						101202030406	South Fork Hay Creek	30.8
						101202030407	Hay Creek	53.7

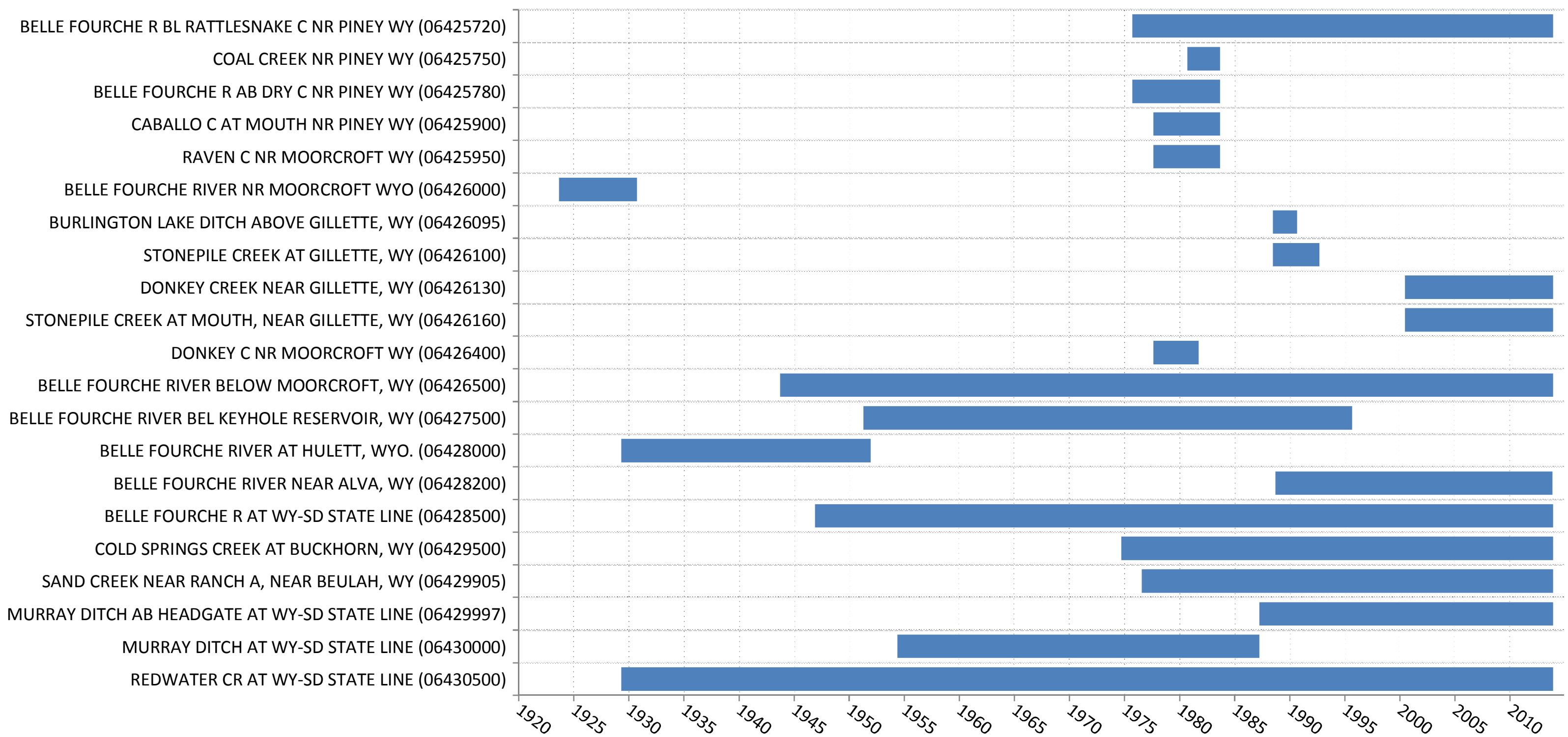

Figure 3.35. Period of Record for U.S. Geological Survey Streamflow Gages Within the Study Area.

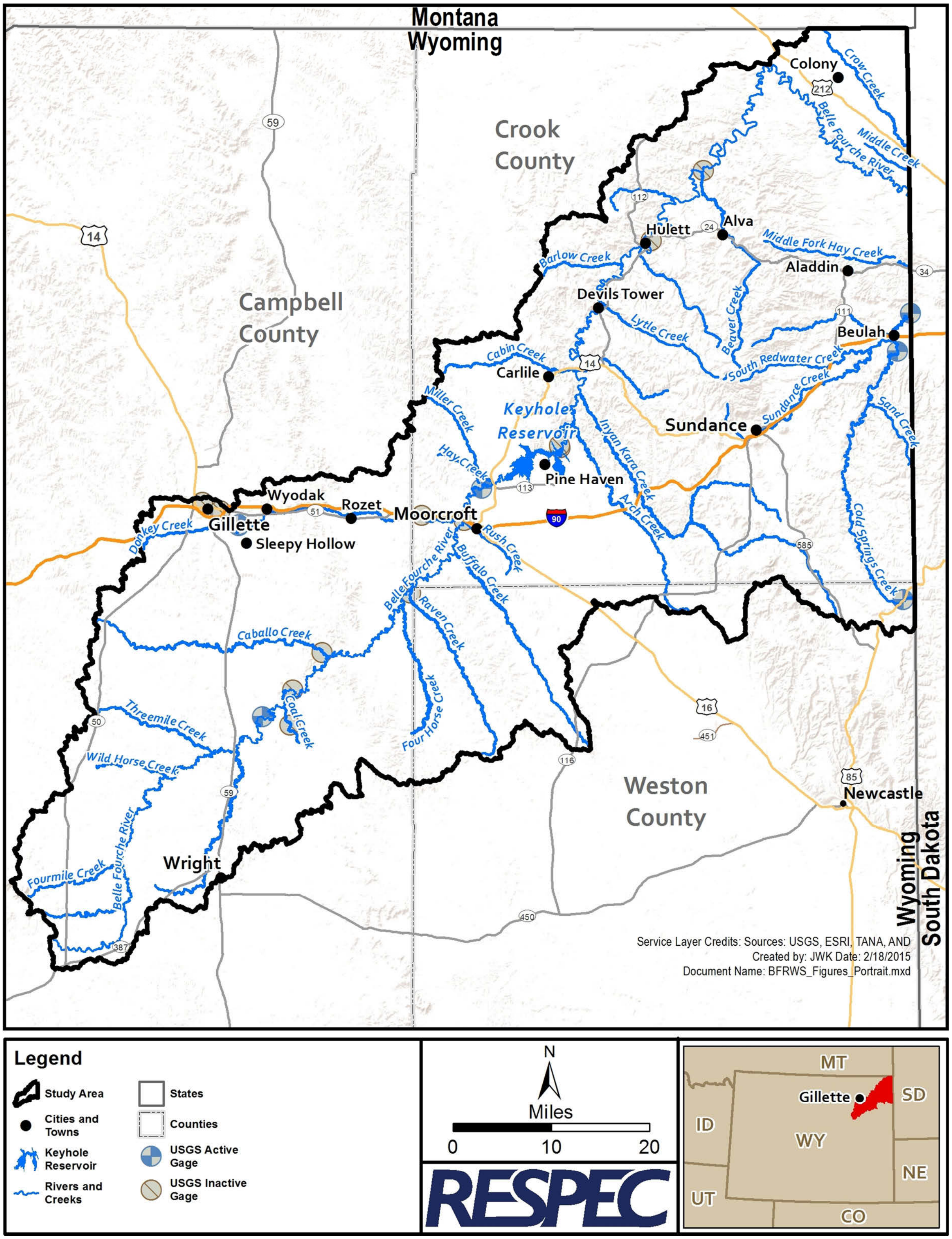

Figure 3.36. U.S. Geological Survey Gages Within the Study Area.

Table 3.31. U.S. Geological Survey Stations and Status Within the Study Area

USGS Station Number	Station Name	Period of Record	Drainage Area (sq. mi.)	Latitude	Longitude	Gage Elevation (ft, NGVD29)
06425720	Belle Fourche R Bl Rattlesnake C Nr Piney, WY	10/01/1975–Current	495	43°59’04”	105°23’16”	4,535
06425750	Coal Creek Nr Piney, WY	10/01/1980–09/30/1983	72	43°58’22”	105°19’53”	4,540
06425780	Belle Fourche R Ab Dry C Nr Piney, WY	10/01/1975–09/30/1983	594	44°01’30”	105°19’35”	4,463
06425900	Caballo Creek At Mouth Nr Piney, WY	08/31/1977–09/30/1983	260	44°04’48”	105°15’59”	4,382
06425950	Raven Creek Nr Moorcroft, WY	08/30/1977–09/30/1983	79	44°10’04”	105°05’11”	4,242
06426000	Belle Fourche River Nr Moorcroft, WY	09/01/1923–09/30/1930	1,380	44°16’30”	104°58’35”	4,133
06426095	Burlington Lake Ditch Above Gillette, WY	07/15/1988–09/30/1990	4,560	44°18’03”	105°30’47”	4,556
06426100	Stonepile Creek At Gillette, WY	07/15/1988–09/30/1992	11	44°17’18”	105°28’35”	4,520
06426130	Donkey Creek Near Gillette, WY	07/05/2000–Current	63	44°16’00”	105°26’17”	4,460
06426160	Stonepile Creek At Mouth, Near Gillette, WY	07/05/2000–Current	15	44°16’04”	105°26’17”	4,460
06426400	Donkey Cr Nr Moorcroft, WY	08/31/1977–10/08/1981	238	44°16’58”	105°03’48”	4,202
06426500	Belle Fourche River Below Moorcroft, WY	10/01/1943–Current	1,690	44°19’19”	104°56’24”	4,110
06427500	Belle Fourche River Bel Keyhole Reservoir, WY	05/01/1951–09/30/1995	1,954	44°23’05”	104°46’50”	4,031
06428000	Belle Fourche River At Hulett, WY	05/01/1929–12/31/1951	2,800	44°40’54”	104°36’05”	3,742
06428200	Belle Fourche River Near Alva, WY	10/01/1988– Current	2,948	44°47’22”	104°28’51”	3,600
06428500	Belle Fourche R At WY-SD State Line	12/01/1946–Current	3,241	44°44’56”	104°03’04”	3,096
06429500	Cold Springs Creek At Buckhorn, WY	10/01/1974–Current	22	44°09’14”	104°04’39”	6,090
06429905	Sand Creek Near Ranch A, Near Beulah, WY	08/16/1976–Current	275	44°31’13”	104°05’00”	3,570
06429997	Murray Ditch Ab Headgate At WY-SD State Line	04/23/1987–Current	NA	44°34’35”	104°03’20”	3,440
06430000	Murray Ditch At WY-SD State Line	06/01/1954–04/22/1987	NA	44°34’49”	104°03’13”	3,452
06430500	Redwater Cr At WY-SD State Line	05/01/1929–Current	481	44°34’19”	104°03’11”	3,410

Table 3.32. Historical Monthly Mean Discharge Rates for U.S. Geological Survey Gaging Stations Within the Study Area (Page 1 of 2)

USGS Station Number	Period of Record	Historical Monthly Mean Discharge (cfs)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
06425720	Belle Fourche River Below Rattlesnake Creek Near Piney,WY	0.9	2.5	4.7	3.0	8.3	4.0	2.6	1.1	0.3	0.4	0.7	0.7
06425750	Coal Creek Near Piney, WY	0.8	2.4	0.6	0.3	3.3	0.3	2.1	1.5	1.0	0.6	0.0	0.1
06425780	Belle Fourche River Above Dry Creek Near Piney, WY	0.8	3.7	10.9	2.4	19.5	5.2	4.3	3.2	1.3	0.4	0.1	0.2
06425900	Caballo Creek at Mouth Near Piney, WY	0.2	0.7	5.0	0.7	18.0	1.8	2.3	1.0	0.4	0.3	0.2	0.0
06425950	Raven Creek Near Moorcroft, WY	0.0	1.4	4.0	0.1	1.8	0.1	0.2	0.3	0.0	0.1	0.0	0.0
06426000	Belle Fourche River Near Moorcroft, WY	4.7	39.0	114.0	549.8	55.6	74.6	65.3	57.1	23.7	22.5	7.9	4.5
06426095	Burlington Lake Ditch Above Gillette, WY	NDA	NDA	NDA	0.5	0.6	0.7	0.7	0.6	0.9	0.5	NDA	NDA
06426100	Stonepile Creek at Gillette, WY	NDA	NDA	NDA	1.1	0.8	0.7	0.7	0.3	0.3	0.3	NDA	NDA
06426130	Donkey Creek Near Gillette, WY	0.6	1.4	5.3	3.0	7.7	3.7	0.9	0.5	0.3	1.1	0.6	0.4
06426160	Stonepile Creek at Mouth, Near Gillette, WY	3.9	4.3	5.5	5.6	9.2	5.9	4.5	4.7	4.4	4.7	4.2	4.0
06426400	Donkey Creek Near Moorcroft, WY	0.6	1.1	47.2	4.1	63.8	3.0	0.5	0.1	0.3	0.9	0.5	0.9

Table 3.32. Historical Monthly Mean Discharge Rates for U.S. Geological Survey Gaging Stations Within the Study Area (Page 2 of 2)

USGS Station Number	Period of Record	Historical Monthly Mean Discharge (cfs)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
06426500	Belle Fourche River Below Moorcroft, WY	3.7	17.9	59.0	27.3	67.7	58.1	17.5	9.6	5.0	6.6	3.2	2.8
06427500	Belle Fourche River Below Keyhole Reservoir, WY	1.5	4.2	17.3	14.0	33.0	35.2	65.7	66.3	17.3	2.3	1.6	1.5
06428000	Belle Fourche River At Hulett, WY	5.4	43.7	211.3	166.1	124.7	184.3	54.0	19.3	39.6	15.9	7.4	6.2
06428200	Belle Fourche River Near Alva, WY	NDA	NDA	96.0	106.1	175.3	140.6	84.5	67.1	32.2	12.4	NDA	NDA
06428500	Belle Fourche River at WY-SD State Line	20.1	43.0	169.5	181.1	225.9	194.4	93.0	71.7	34.5	29.2	26.9	17.6
06429500	Cold Springs Creek at Buckhorn, WY	4.2	4.3	4.6	4.9	4.7	4.8	4.6	4.7	4.6	4.4	4.3	4.2
06429905	Sand Creek Near Ranch A, Near Beulah, WY	20.3	19.8	20.4	21.6	30.2	29.4	25.8	23.6	22.3	21.9	22.0	21.3
06429997	Murray Ditch Above Headgate at WY-SD State Line	0.0	0.0	0.0	0.7	2.4	5.0	10.4	8.9	7.5	5.4	0.4	0.0
06430000	Murray Ditch at WY-SD State Line	0.0	0.0	0.0	0.2	2.0	4.0	10.3	11.0	7.7	5.1	1.2	0.0
06430500	Redwater Creek at WY-SD State Line	33.4	34.4	36.2	39.6	56.3	50.2	26.6	25.1	27.5	30.8	34.8	34.3

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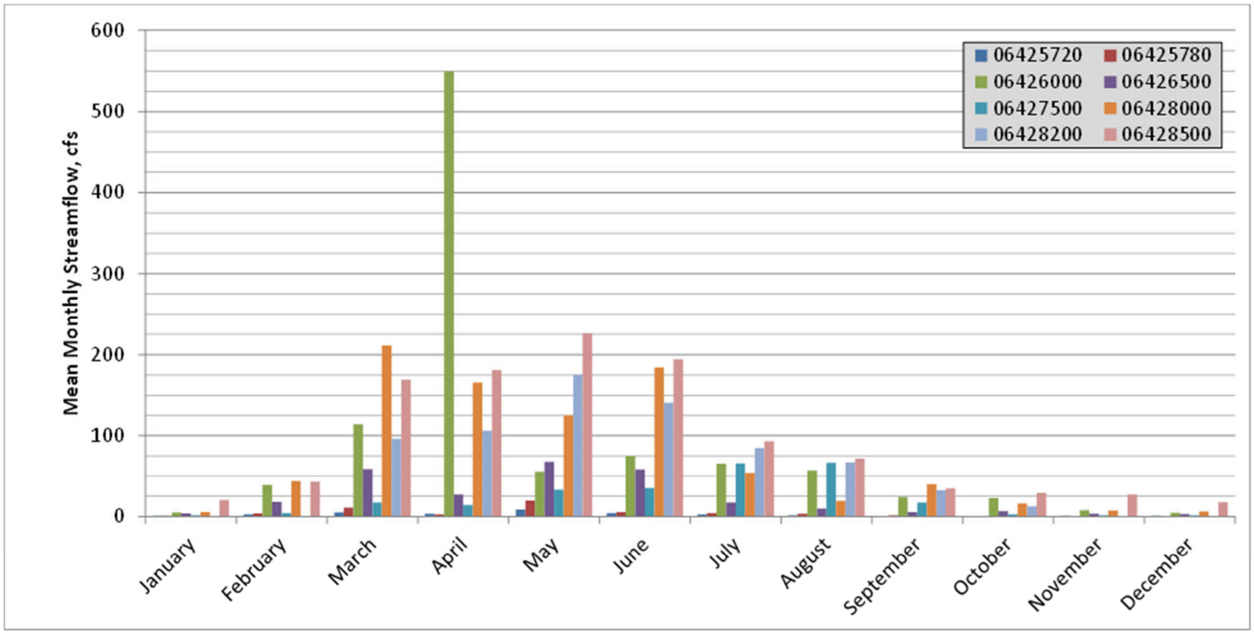

Figure 3.37. Historical Mean Monthly Streamflow for U.S. Geological Survey Gaging Stations on the Belle Fourche River Within the Study Area.

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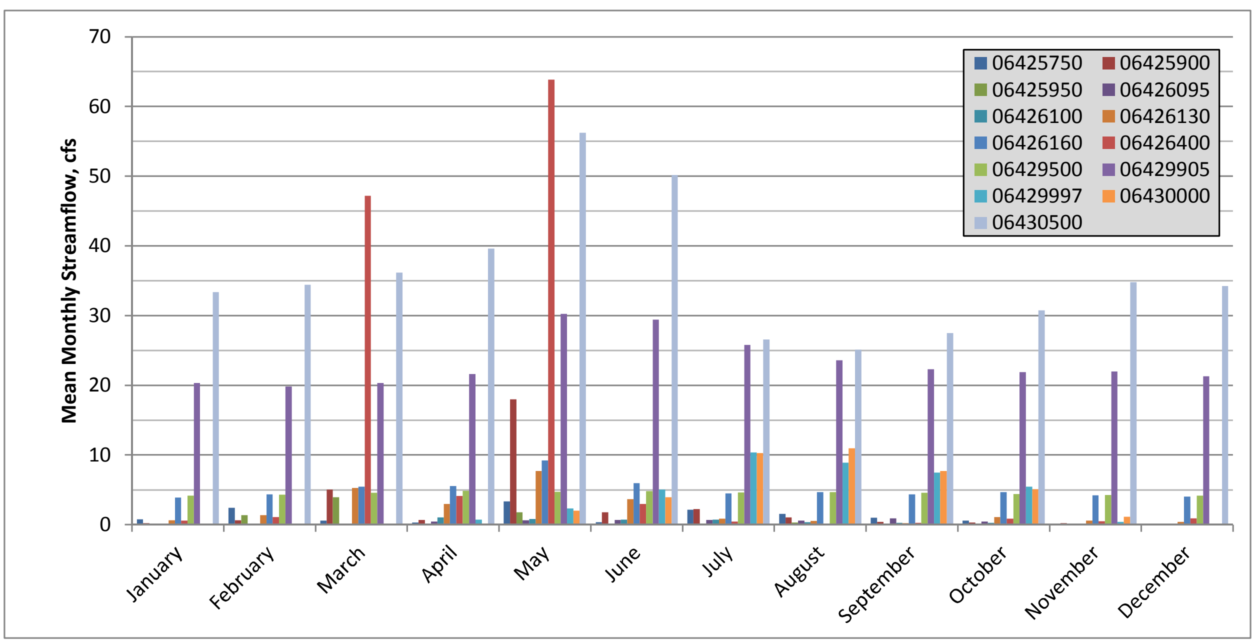

Figure 3.38. Historical Mean Monthly Streamflow for U.S. Geological Survey Gaging Stations on Tributaries to the Belle Fourche River Within the Study Area.

gages were installed by the consultant and WWDO staff in April 2013. Transducers were retrieved in November 2013 and reinstalled in the spring of 2014. Data were collected throughout the spring and summer of 2014 before the gages were removed in November 2014. The data collected at these sites provide insight to the hydrologic processes in portions of the Belle Fourche River Watershed that lack any historic gages. This information will reduce uncertainty associated with the existing hydrologic regime.

Table 3.33. Wyoming Water Development Commission Temporary Stream Gages Within the Study Area

Gage Name and Identifier	General Location	Drainage Area (acres)	Latitude/ Longitude	Elevation (ft)
Inyan Kara Creek (IKC)	Located approximately 0.7 mile south off of Highway 116, roughly 1.5 stream miles downstream (west) of the Inyan Kara Bridge on Crook County Road 62.	55,080	44.238418 104.399562	4,762
Lytle Creek (LC)	Located approximately 250 yards to the north off of Crook County Road 196, roughly 1.5 miles southeast from the intersection of Highway 24 and County Road 196 near Devils Tower National Monument.	20,760	44.579980 104.663618	3,940
Redwater Creek (RC)	Located approximately 0.5 mile south off of Crook County Road 115, roughly 2.5 miles along County Road 115 northwest of the junction of Old Highway 14 and County Road 115.	35,390	44.550809 104.133888	3,582

Rating curves were developed for each of the three gages to convert continuous water depth (stage) recordings to streamflow. Flow measurements and stage were recorded several times each year. Using a least-squares regression, a stage/discharge equation was fit to the manual measurements by maximizing the coefficient of determination.

Site surveys were also completed and included a gage cross section, channel slope, and observations of bed and overbank conditions. This allowed for using other flow calculation equations, such as Manning's formula, as a means to validate or modify the rating curve. Continuous stage data collected by the transducers was then converted to flow by using the rating curve at each site. Table 3.34 summarizes the results of the temporary stream gaging effort and the streamflow statistics and yield estimates for each of the three WWDC gaging stations.

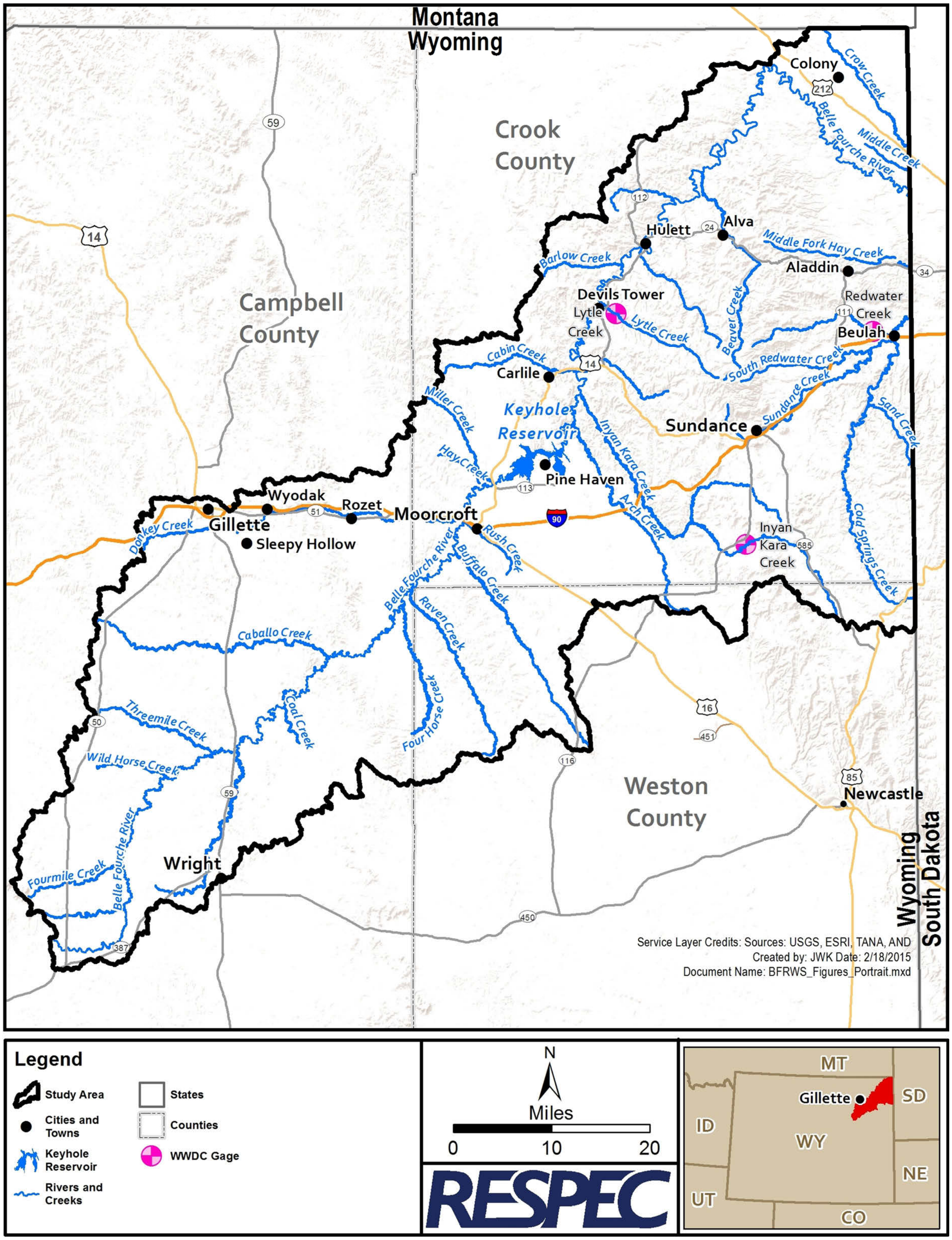

Figure 3.39. Locations of Temporary Stream Gages Within the Study Area.

Figure 3.40. Temporary Stream Gage and Transducer Installed on Lytle Creek.

Inyan Kara Creek (IKC)

The Inyan Kara Creek gaging site was installed on April 19, 2013. Flows in Inyan Kara Creek at this site were generally low during the 2013 gaging period with the exception of a large event peak June 1. The average flow was 3.8 cfs with the June 1 peak reaching 125 cfs. The transducer was removed in October and returned to the stream on March 13, 2014. The gaging site was able to record a large snowmelt event in April and a season high peak of 44.4 cfs in June. The average flow during the 2014 gaging period was 10.4 cfs. The pressure transducer was removed on November 7. Hydrographs from the 2013 and 2014 gaging periods are illustrated in Figure 3.41.

Lytle Creek (LC)

The Lytle Creek gaging site was installed on April 19, 2013. Lytle Creek had low base flows after an early springmelt. The average flow during the 2013 gaging period was 6.2 cfs with a peak flow of 263.8 cfs occurring on June 1. The transducer was removed from the creek on October 14. For the 2014 monitoring period, the pressure transducer was placed on March 13 and high flow events from spring snowmelt and precipitation occurred in April and May with a peak flow of 34.2 cfs occurring on May 7. The average 2014 flow was 6.9 cfs; and the transducer was removed on October 25. Hydrographs from the 2013 and 2014 monitoring periods are illustrated in Figure 3.42.

Table 3.34. Summary of Temporary Stream Gage Hydrology

Stream Gage	IKC	LC	RC
Drainage Area (mi^2)	86	32	55
2013			
Start Date	04/19/13	04/19/13	04/19/13
End Date	10/04/13	11/14/13	12/22/13
Average Flow (cfs)	3.8	6.2	4.8
Median Flow (cfs)	2.1	3.2	2.7
Total Yield (ac-ft)	1,249	2,554	2,372
Mean Yield (ac-ft/mi^2)	14.5	78.7	42.9
Peak Flow (cfs)	124.7	263.8	135.7
Date of Peak	06/01/13	06/01/13	06/01/13
Minimum Flow (cfs)	1.5	0.5	0.0
2014			
Start Date	03/13/14	03/13/14	04/18/14
End Date	11/7/14	10/25/14	11/9/14
Average Flow (cfs)	10.4	6.9	7.9
Median Flow (cfs)	9.1	3.9	4.8
Total Yield (ac-ft)	4,931	3,111	3,229
Mean Yield (ac-ft/mi^2)	57.3	95.9	58.4
Peak Flow (cfs)	44.4	34.2	84.6
Date of Peak	06/22/14	05/07/14	06/25/14
Minimum Flow (cfs)	4.9	0.7	2.7

ac-ft/mi^2 = acre-feet per square mile

Redwater Creek (RC)

The Redwater Creek gaging station was installed on April 19, 2013. Three high flow spikes occurred in May and June with the highest peak of 135.7 cfs occurring on June 1. Average flow for the period was 4.8 cfs. The transducer stopped recording on December 22, 2013, and was reactiviated on April 18, 2014. The 2014 hydrograph reflects more effects from spring snowmelt and precipitation runoff than the site did in 2013, although the 2014 peak flow was lower at 84.6 cfs occurring on June 25. The average flow in 2014 was 7.9 cfs. Hydrographs from the 2013 and 2014 monitoring periods are displayed in Figure 3.43.

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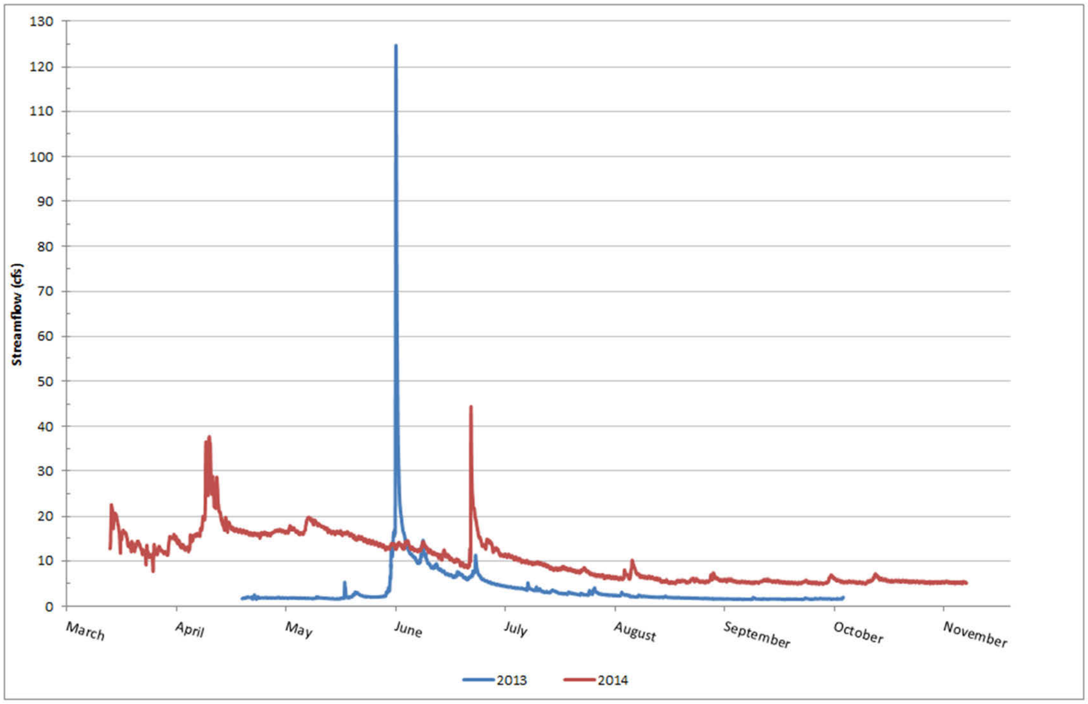

Figure 3.41. Hydrographs at Inyan Kara Creek for the 2013 and 2014 Gaging Periods.

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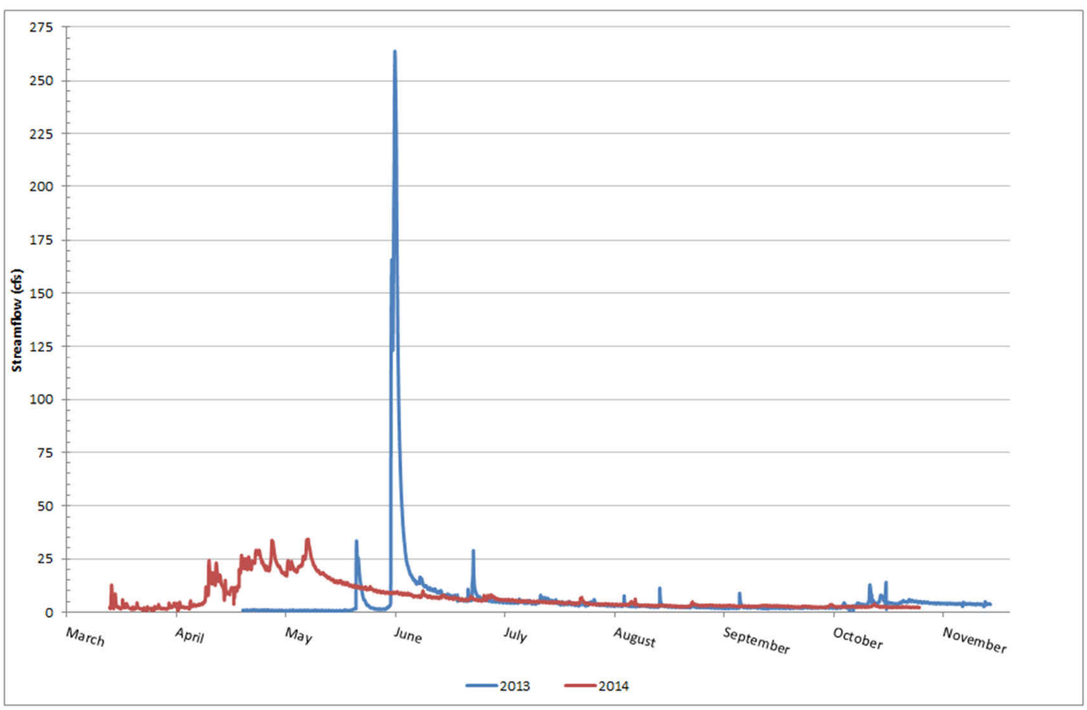

Figure 3.42. Hydrographs at Lytle Creek for 2013 and 2014 Gaging Periods.

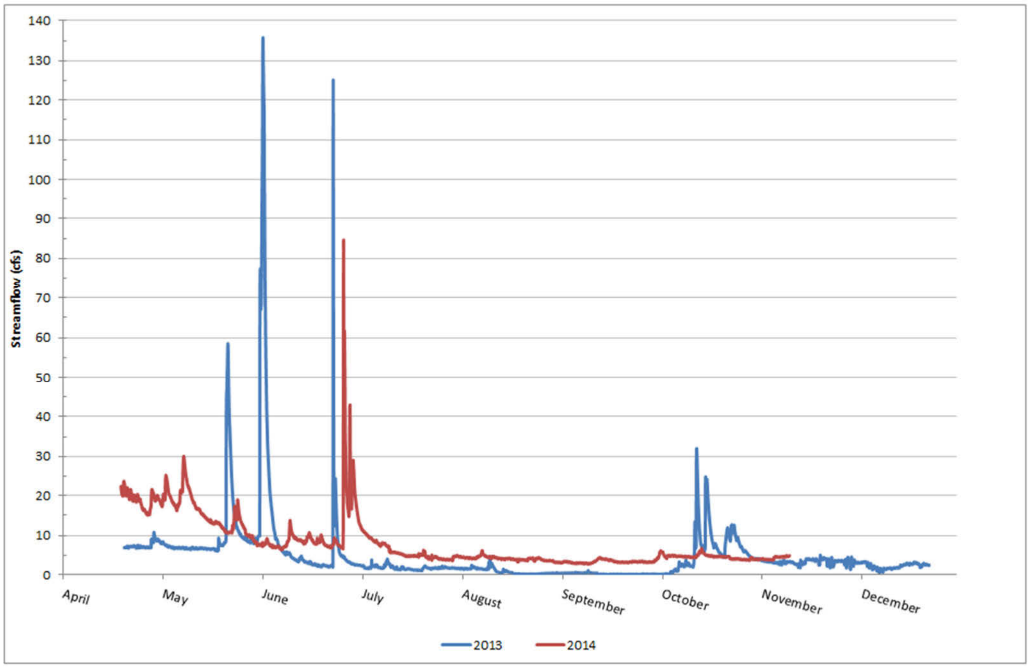

Figure 3.43. Hydrographs at Redwater Creek for the 2013 and 2014 Gaging Periods.

3.6.2.3 Wyoming Water Development Commission Temporary Gage Hydrology Summary

At each of the temporary stream gaging stations, streamflow was used to characterize hydrology of the respective drainage areas for both monitoring periods. In addition to those characteristics previously mentioned, median flow, total yield, mean yield, and minimum flow were included. The temporary gage stations results are shown in Table 3.34.

The Inyan Kara Creek gaging station has the largest drainage area at 86 square miles. Throughout the gaging periods, the IKC drainage produced a mean yield of 14.5 acre-feet per square mile (ac-ft/mi^2) in 2013 and 57.3 ac-ft/mi^2 in 2014. The Redwater Creek gaging station has the second largest drainage area at 55 square miles. The gage showed watershed yields of 2,372 acre-feet in 2013 and 3,229 acre-feet in 2014, which resulted in respective mean yields of 42.9 ac-ft/mi^2 and 58.4 ac-ft/mi^2. The drainage area for the Lytle Creek gaging station is 32 square miles. Yields at the gaging station for the monitoring periods were 2,544 ac-ft in 2013 and 3,111 ac-ft in 2014. The resulting mean yields are 78.7 ac-ft/mi^2 and 95.9 ac-ft/mi^2, respectively.

3.7 STREAM GEOMORPHOLOGY

3.7.1 General

The field of fluvial geomorphology is the study of how land is formed under processes associated with running water. The balance between processes such as erosion, deposition, and sediment transport determines the character and condition of a stream. The objective of the geomorphic evaluation of the study area is to determine the nature of this balance.

The condition of a stream can be assessed with respect to its basic form (width, depth, and slope) as well as its state of equilibrium, or geomorphic stability [Thorne et al., 1996; Johnson et al., 1999]. Stable, or equilibrium, channels are defined as those that have achieved a balance between flow energy and sediment delivery, such that sediment is transported at the rate at which it is delivered, and the form and pattern of the channel is maintained [Thorne et al., 1996]. Dynamically stable channels are adjustable in nature and "stability" does not preclude lateral migration and associated dynamics such as bank erosion and sediment deposition.

In geomorphically stable conditions, minor changes in either sediment supply or transport energy result in gradual adjustment of channel form to accommodate those changes [Lane, 1955]. Channels destabilize when changes in those factors are extreme enough that rapid and dramatic alterations in pattern or form occur. Common indicators of channel instability include active downcutting and accelerated bank erosion, major changes in channel width/depth ratios, and increased flooding because of sediment deposition. Geomorphic function is achieved when a channel is in equilibrium while undergoing processes such as lateral migration, sediment reworking, and occasional overbank flooding that effectively create and sustain quality habitat elements, such as bars; pool/riffles; step/pools; and healthy, regenerating riparian corridors.

A commonly used term today for this type of stability is dynamic equilibrium. A stream in dynamic equilibrium has adjusted its width, depth, and slope such that the channel is neither aggrading nor degrading. However, change may be occurring in the stream bank, erosion may result, and bank stabilization may be necessary, even on the banks of a stream in dynamic equilibrium. The equilibrium concept of streams discussed above can also be described by various qualitative relationships. One of the most widely used relationships is the one proposed by Lane [1955] which states that:

$$Q_s D_{50} \alpha Q_w S \tag{3-1}$$

where Q_w is the water discharge, S is the slope, Q_s is the bed material load, and D_{50} is the median size of the bed material. This relationship, commonly referred to as Lane's Balance, is illustrated in Figure 3.44. This graphic indicates that a change in any of the four variables will cause a change in the others such that equilibrium is restored. When a channel is in equilibrium, it will have adjusted these four variables such that the sediment being transported into the reach is transported out, without significant deposition of sediment in the bed (aggradation), or excessive bed scour (degradation). Note that by this definition of stability, a channel is free to migrate laterally by eroding one of its banks and accreting the one opposite at a similar rate.

In summary, a stable river, from a geomorphic perspective, is one that has adjusted its width, depth, and slope such that there is no significant aggradation or degradation of the stream bed or significant planform changes (meandering to braided). By this definition, a stable river is not in a static condition but, rather, is in a state of dynamic equilibrium where it is free to adjust laterally through bank erosion and bar building [Watson et al., 1999]. Impairments to geomorphic function reflect a significant loss of the functional potential of the green channel segment. These impairments are typically described in general, qualitative terms, and any rehabilitation of impaired channel segments requires a more thorough, site-specific assessment of impacts, impairments, and feasible remedies.

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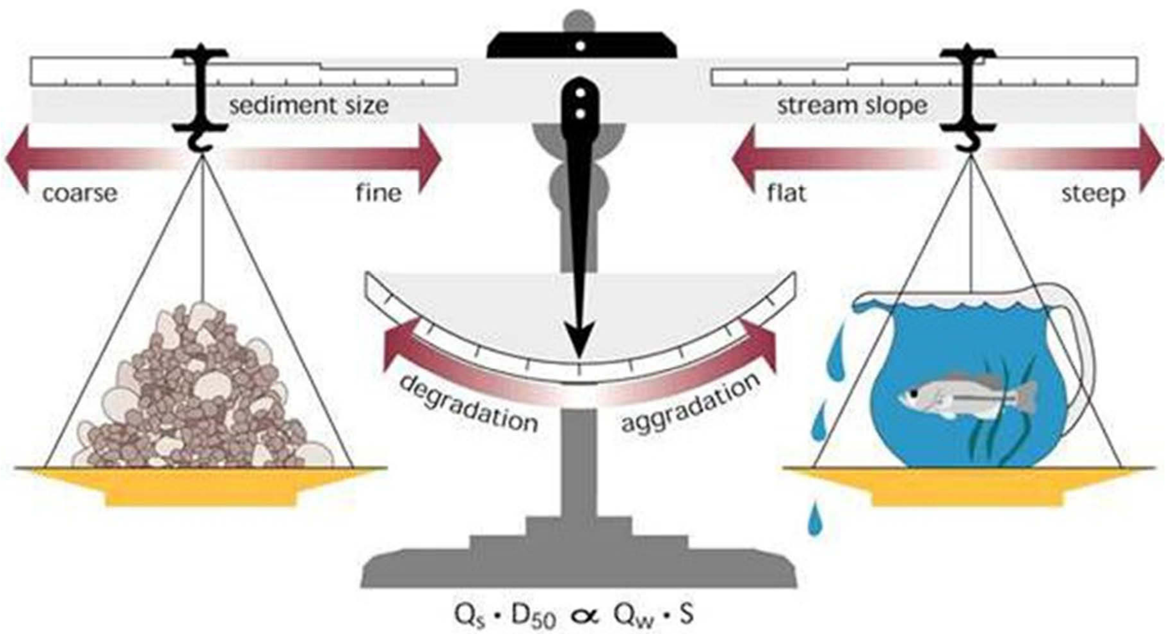

Figure 3.44. Graphical Rendition of Lane's Balance [Watson et al., 1999].

3.7.2 Rosgen Classification System

The literature presents descriptions of numerous systems for classifying and evaluating stream systems. Of these, perhaps the most widely used today is the Rosgen Classification System [Rosgen, 1996]. This system, based on the stream's existing channel morphology, was used in this study. Parameters such as the sinuosity, slope, width/depth ratio, and size of channel materials are evaluated and used to classify the stream into one of the various "types" included in the system.

The Rosgen System has four levels of classification, with each being more detailed than the previous level. Figure 3.45 illustrates the hierarchy of the assessment levels and the general nature of effort associated with each. Much of the Level I geomorphic characterization is qualitative and uses aerial imagery and topographic maps. Streams are divided into eight broad types on the basis of their channel and floodplain geometry.

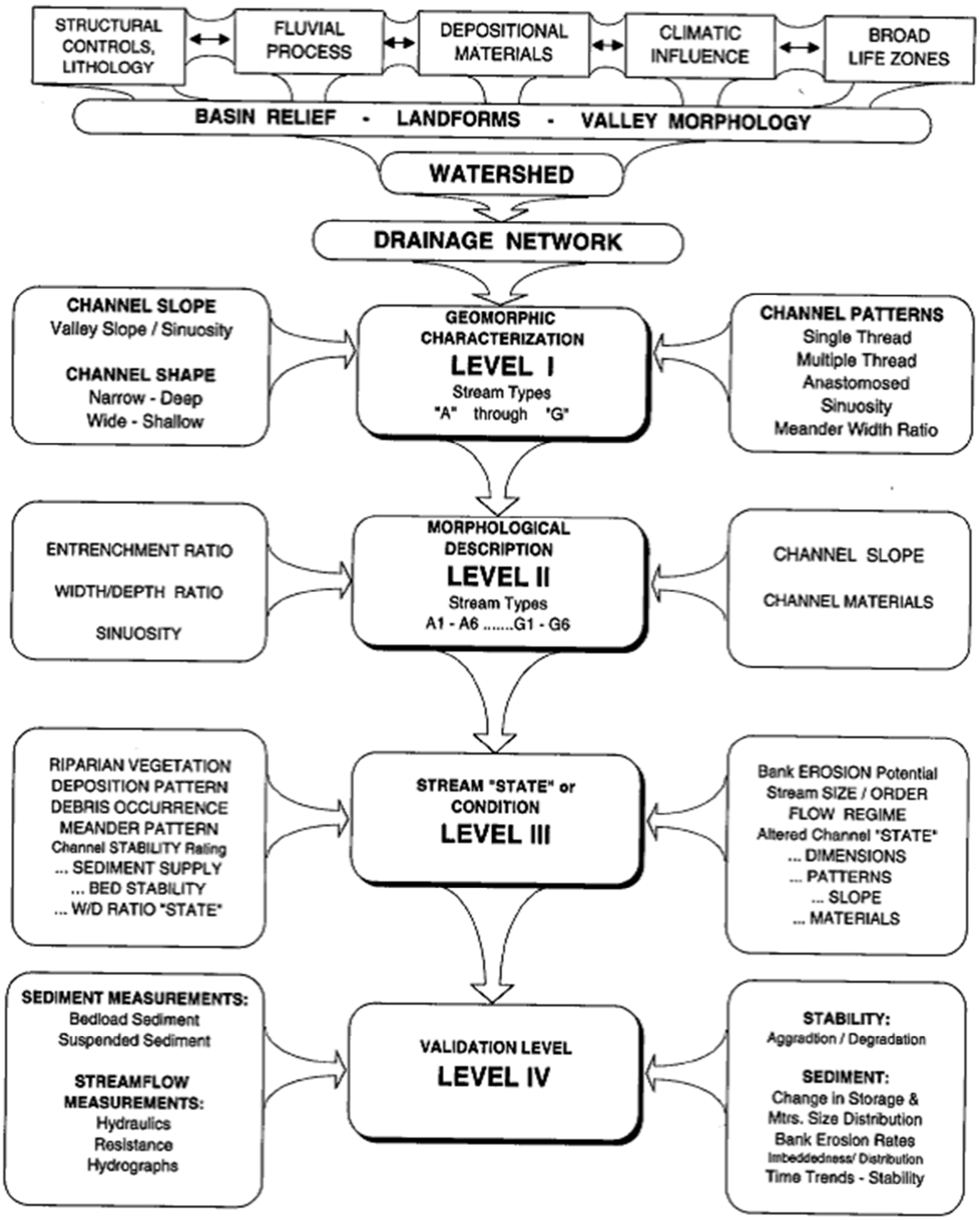

Figure 3.45. Hierarchy of the Rosgen Stream Classification System.

The purpose of the Level I geomorphic classification is to provide an inventory of the study area's overall stream morphology, character, and condition. It is intended to serve as an initial assessment for use in more detailed assessments and to determine the location and approximate percentage of stream types within the study area. Rosgen classification system stream types can be thought of in their relative location in the watershed, from their headwaters through lowlands. The major stream types reflect their location in the watershed. For example, "A" type streams are located in headwaters; "C" and "E" stream types are located in meandering lowlands.

The Level II characterization provides a more detailed description of the stream using measurements at selected locations. Stream types are subdivided into 94 subtypes based on the degree of entrenchment, width-to-depth ratio, water surface slope, channel bed materials, and sinuosity, as shown in Figure 3.46. The Level II characterization is more quantitative than the Level I effort. Levels III and IV require more extensive data collection and quantification of stream characteristics. This study effort included Level I evaluation of the Belle Fourche River and its major tributaries. Level II characterizations were conducted on three selected streams.

3.7.2.1 Level I Methods

The Level I classification effort was conducted primarily using existing information incorporated into the project GIS. Several analytical tools were developed and integrated into the GIS to evaluate various geomorphic parameters (sinuosity, slope, and stream station determination). The data incorporated in the project GIS include digital aerial photography, USGS topographic maps, a digital elevation model (DEM), and digitized hydrography information. The most current data available were used in the geomorphic evaluation. Because the DEM was limited to a 10-meter grid, elevations and subsequent slope calculations are approximate. Stream alignments were digitized using 2012 aerial photography and represent the best available estimate of current channel alignment.

The streams evaluated were divided into reaches based on the definable geographic factors (e.g., confluences with tributaries, major road crossings) or where their geomorphic character displayed changes. Each reach was evaluated in light of the characteristics required at the Level I classification. These parameters, as indicated in Figure 3.46, were channel slope, channel shape, channel patterns, and valley morphology. Note that in the Level I classification, these parameters are not typically quantified and the relative magnitude (i.e., "moderate," "slightly") is used to classify the stream.

Based on this initial effort, potential reference reaches can be identified for further study in Level II classification efforts. The end product of the Level I classification is the determination of the major stream types, A through G. Figure 3.47 shows the major stream types within the Rosgen Classification System along with their relative locations within a typical watershed. Brief descriptions of the various stream types encountered in the watershed are presented in the following text.

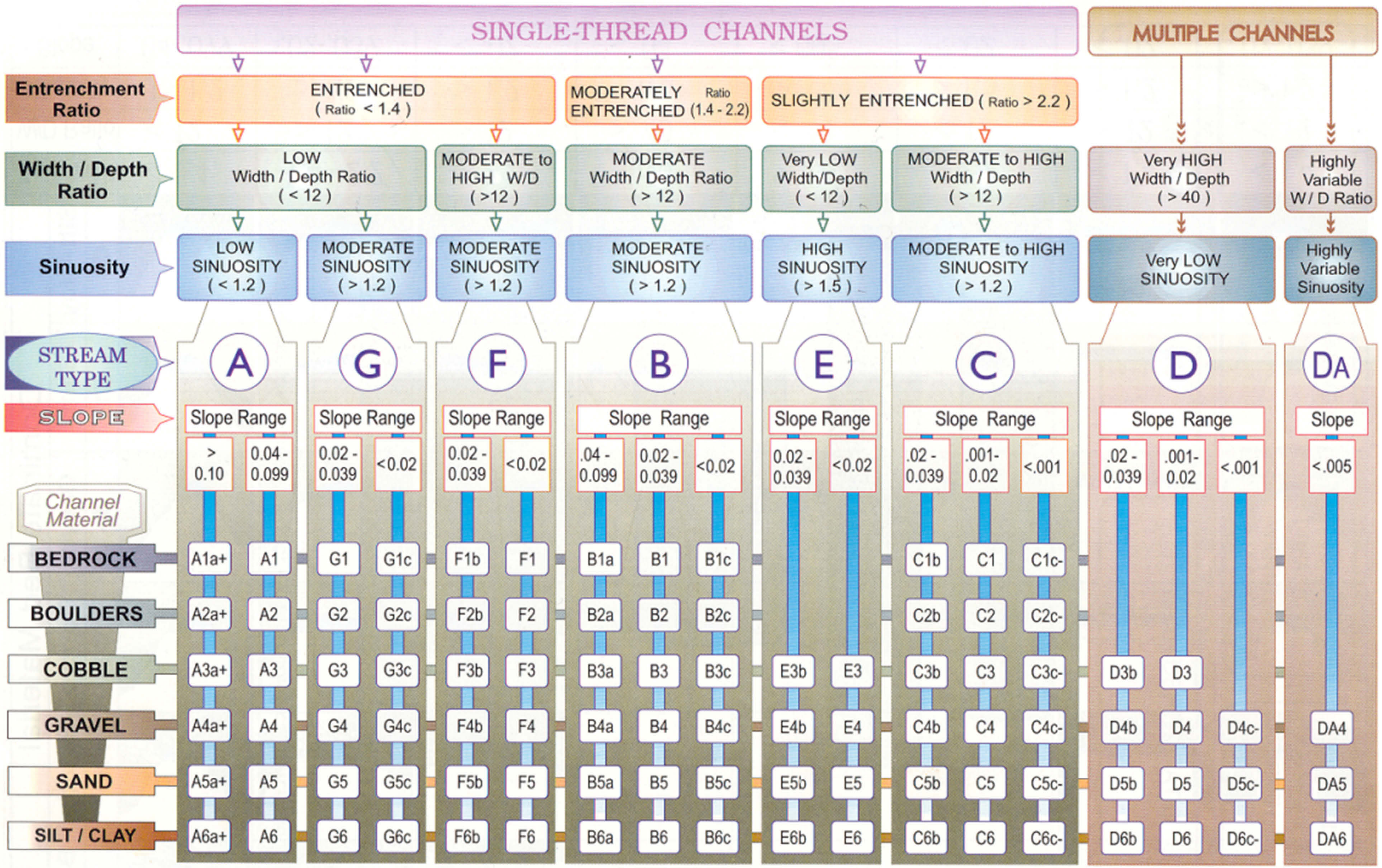

Figure 3.46. Rosgen Classification System Matrix [Rosgen, 1996].

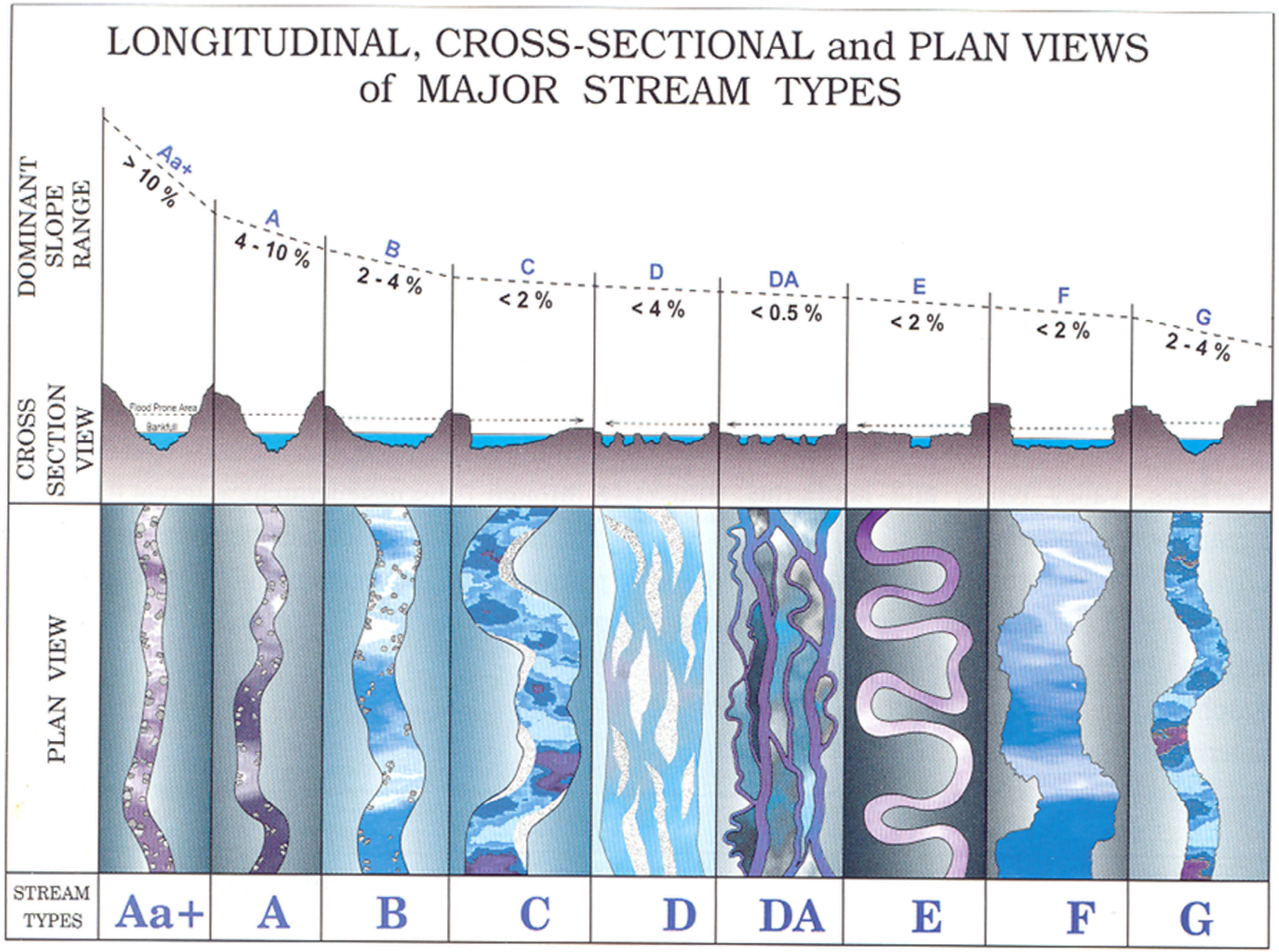

Figure 3.47. Major Stream Types Within the Rosgen Classification System.

A-Type Channels are relatively steep channels that form in headwater areas as well as within bedrock canyons. These channels are entrenched and confined by steep valley margins such that little to no floodplain area borders them. As the boundaries of A-type channels are typically highly resistant to erosion, these stream types are generally quite resilient with respect to human impacts. The most common cause of geomorphic change within A-type channels is from large-scale sediment transport events, (landslides, debris flows, and debris jam failure) that may result in blockage or deflection of channel flow.

B-Type Channels tend to form downstream of headwater channels, in areas of moderate slope where the watershed transitions from headwater environments to valley bottoms as shown in Figure 3.48. B-type channels are characterized by moderate slopes, moderate entrenchment, and stable channels. Because of the relatively steep channel slopes and stable channel boundaries, B-type channels are moderately resistant to human impacts, although, their reduced slopes relative to headwater areas can make them prone to sediment deposition and subsequent adjustment following a large sediment transport event (such as an upstream landslide, debris flow, or flood).

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Figure 3.48. Example of a B-Type Channel: Whitelaw Creek.

C-Type Channels are typically characterized by relatively low slopes, meandering planforms (i.e., the shape one would see if viewing from above, as on a map or aerial photographs), and pool/riffle sequences as shown in Figure 3.49. The channels tend to occur in broad alluvial valleys and are typically associated with broad floodplain areas; they are not entrenched and still have "access" to their floodplains. C-type channels tend to be relatively sinuous and follow a meandering course within a single channel. In systems in which the boundaries of C-type channels are composed of alluvial sediments, channels tend to be dynamic in nature and susceptible to rapid adjustment in response to disturbance.

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Figure 3.49. Example of a C-Type Channel: Belle Fourche River.

E-Type Channels are somewhat similar to C-type channels, because they form as single threads with defined, accessible floodplain areas. However, E-type channels are different in that they tend to have fine-grained channel margins, which provide cohesion and support dense bank vegetation. The fine-grained, vegetation-reinforced banks allow for steep banks; very sinuous planforms; and relatively deep, U-shaped channels to develop. E-type channels commonly form in low-gradient areas with fine-grained source areas, mountain meadows, and in beaver- dominated environments. E-type channels tend to have very stable planforms, and efficient sediment transport capacities because of low width/depth ratios.

F-Type Channels typically have relatively low slopes (< 2 percent), similar to C- and E-type channel. The primary difference between C/E-type channels and F-type channels is with respect to entrenchment. F-type channels are entrenched, which means that the floodplain is quite narrow relative to the channel width. The entrenchment of alluvial F-type channels typically is an indicator of a historic downcutting event. F-type channels may form in resistant boundary materials (e.g., U-shaped bedrock canyons) and relatively erodible alluvial materials (e.g., arroyos). When the boundary materials are erodible, the steep valley walls are prone to instability, and channel widening occurs in the entrenched channel as shown in Figure 3.50.

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Figure 3.50. Example of a F-Type Channel: Lytle Creek.

G-Type Channels are narrow, steep, entrenched gullies. G-type channels typically have high bank erosion rates and a high sediment supply. Channel degradation and sideslope rejuvenation processes are typical.

3.7.2.2 Level I Classification Results

The results of the Level I classification effort are presented in Table 3.35 and graphically in Figure 3.51. This figure displays a map of the study area depicting the various stream types as well as the reach designations used in the classification effort. Within the mountainous areas, the channels are steep and bounded by very coarse, resistant materials that include hillslope colluvium and bedrock. Rocks here are harder igneous and metamorphic Precambrian rocks. Channel change in these upper subreaches typically results from punctuated hillslope processes rather than gradual channel migration. The channels are A-type or B-type channels, which reflects their steep slope and stable boundaries.

As stream channels descend into the lower basin, the lateral confinement is reduced, the slope lessens, and the boundary materials become less coarse. As a result of these downstream changes in boundary conditions, the lower subreaches tend to display meandering channel

Table 3.35. Summary of Rosgen Level I Classification Results in the Study Area

Name	Reach Number	Station (Distance From Mouth)		Reach Length (ft)	Sinuosity	Slope	Rosgen Type
		Station Start (ft)	Station End (ft)				
Arch Creek	1	0	117,648	117,648	2.02	0.002	F
	2	117,648	236,287	118,639	1.62	0.004	B
Belle Fourche River	1	0	514,078	514,078	2.27	0.001	C
	2	514,078	814,261	300,183	2.09	0.001	C
	3	814,261	1,149,811	335,550	2.13	0.001	C
	4	1,149,811	1,517,797	367,986	2.21	0.001	C
	5	1,517,797	1,778,984	261,187	2.12	0.002	C
Buffalo Creek	1	0	179,769	179,769	2.49	0.001	E
	2	179,769	275,292	95,523	1.6	0.004	C
Caballo Creek	1	0	54,915	54,915	1.78	0.002	C
	2	54,915	95,479	40,564	NA	NA	NA
	3	95,479	264,763	169,284	2.09	0.003	C
Cold Springs Creek	1	0	112,733	112,733	1.67	0.01	C
	2	112,733	196,189	83,456	1.31	0.01	B
Donkey Creek	1	0	110,094	110,094	2.31	0.001	C/F
	2	110,094	241,035	130,941	2.04	0.001	C/F
	3	241,035	387,827	146,792	1.95	0.003	C
Four Horse Creek	1	0	69,157	69,157	2.13	0.001	C/F
	2	69,157	186,463	117,306	2.58	0.002	C/F
Inyan Kara Creek	1	0	152,434	152,434	2.42	0.002	C/F
	2	152,434	315,719	163,285	2.42	0.003	C/F
	3	315,719	457,662	141,943	2.13	0.004	C/F
	4	457,662	493,304	35,642	1.19	0.015	B
Lytle Creek	1	0	74,124	74,124	1.79	0.009	C/F
	2	74,124	118,298	44,174	1.23	0.041	B
Redwater Creek	1	0	89,880	89,880	2.04	0.003	C/F
	2	89,880	170,335	80,455	1.41	0.021	C/F
Sand Creek	1	0	88,840	88,840	1.81	0.008	B
	2	88,840	142,025	53,185	1.19	0.038	A
Wind Creek	1	0	66,550	66,550	2.06	0.001	C
	2	66,550	189,578	123,028	1.9	0.003	B

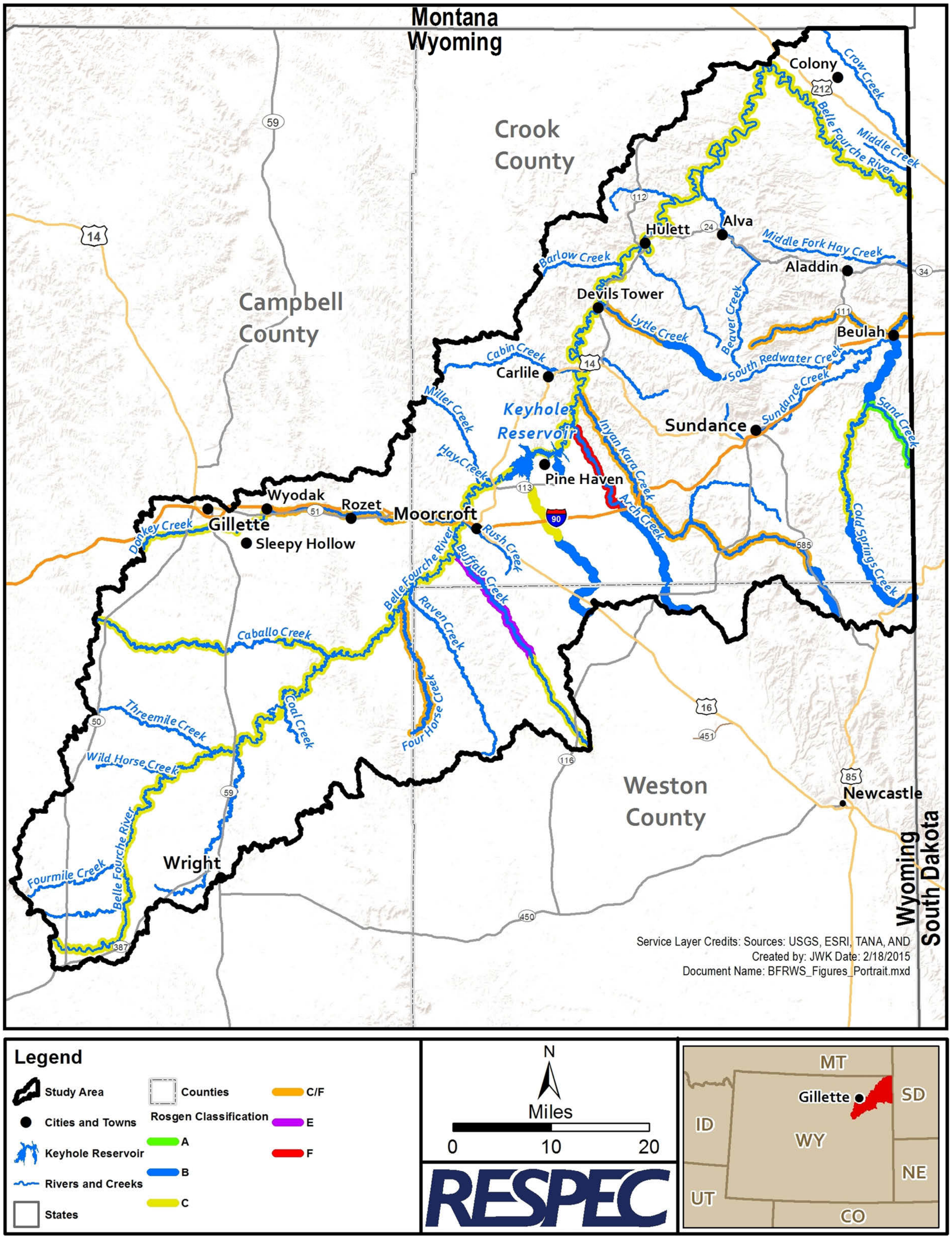

Figure 3.51. Major Stream Types Within the Rosgen Classification System [Rosgen, 1996].

Dynamics, pool/riffle development, and increased lateral channel migration. The channels change from B-type channels, which are located in transition zones at the foot of the mountains, to C-type channels, which are gravel-bed-meandering streams that dominate the lower basin.

As is clearly evident in table 3-35, many of the channels were classified as either F-type channels in at least portions of their extent. F-type stream classifications denote channels that are entrenched and have "disconnected" from their floodplains. These channels are typically erosive, actively downcutting, or widening.

Based on the GIS classification effort followed by field verification, a conclusion was made that the majority of stream channels within the study area are entrenched to some degree. Entrenchment occurs for a variety of reasons, including the presence of erosive soils coupled with land use practices (including road construction, energy development, and grazing) Observations of channel conditions revealed entrenchment ranging from slight to severe. In the case of many streams in the watershed, channels appear to have stabilized or be in the process of stabilizing following episodes of incision. The photograph in Figure 3.52 is an entrenched reach of Redwater Creek.

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Figure 3.52. Entrenched Reach of Redwater Creek.

Many of the first-order tributaries in the lower portions of the basin can be classified as G-Type channels or gullies. These channels are highly erosive, generate high sediment volumes, and can result in the loss of productive lands and destabilized upland conditions. Observation of many of these channels indicates that while the major stream channels appear to have achieved a level of stability, the upper reaches of the watershed are still undergoing a level of destabilization. These channels could be responding to one or more stimuli, including but not necessarily limited to channel realignment (straightening), road and culvert construction, land management practices, or base-level lowering associated with main channel incision.

3.7.3 Field Stream Assessment

3.7.3.1 Background

Field stream channel assessments were conducted at the following sites selected on three tributaries within the study area:

- Inyan Kara Creek within Sections 6 and 7, Township 49 North, Range 63 West
- Redwater Creek within Section 26, Township 53 North, Range 61 West
- Whitelaw Creek within Section 9, Township 52 North, Range 63 West.

The purpose of the field assessment was to obtain a more detailed morphological description of the system. This objective was accomplished by obtaining field data pertaining to channel entrenchment, dimensions, patterns, profile, and boundary materials. During the field investigation, the entire study reach was walked and the following tasks were completed:

- Observations were made of the general geomorphic condition of the stream channel, including channel degradation, bank erosion, and pool/riffle sequence. GPS locations were measured that correspond to the extent of bank erosion, pools, riffles, and other features affecting the geomorphic condition of the study reach.
- Much of the geomorphic characterization effort depends on the concept of "bankfull stage," which corresponds to "the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends or meanders, and generally doing work that results in the average morphologic characteristics of channels" [Dunne and Leopold, 1978]. The relative elevation of bankfull stage at each location was identified by observing several key indicators, including the presence of a floodplain, depositional features, vegetative indicators, and staining on rocks.
- Detailed evaluations were conducted at ten locations, and the following tasks were completed at each location:
  - Channel cross section and profile were surveyed
  - Observations of bankfull and high water indicators were noted
  - Bed material was characterized by recording pebble counts
  - Channel conditions were documented and photographed
  - GPS locations were measured.

Additionally, field personnel recorded the following general observations of geomorphic conditions:

- Quantifying basic geomorphic parameters (width/depth ratios and entrenchment ratios) and determining stream type using the Rosgen stream classification system were completed.
- Cross-section locations were selected for more detailed data collection. Sites that represented typical reaches within the study area were selected.
- At each of the cross-section locations, numerous tasks were completed. Several geomorphic parameters were evaluated including channel slope, channel shape, channel patterns, valley morphology, entrenchment ratio, width depth ratio, and channel materials. In addition, a determination of bankfull stage was completed at each station.

Within the GIS, the following tasks were completed:

- Evaluation of channel alignment and sinuosity
- Qualitative evaluation of channel migration where possible by comparing aerial photography obtained in previous years.

Using this information, Rosgen Level II classifications were performed at cross sections selected to represent typical stream channel conditions. In addition to the Rosgen classification effort, the Channel Evolution Model (CEM) proposed by Schumm [1981; Schumm et al., 1984] was considered. The CEM was developed based on the concept that one can observe data developed from different locations to infer landform development through time, by commonly employing a technique termed location-for-time substitution. This technique assumes that by observing channel form as one moves downstream along a channel, the effect of physical processes at one location through time can be predicted; that is, changing location is substituted for changing time.

The CEM consists of five channel-reach types as shown in Figure 3.53. The CEM illustrates the evolutionary phases typically encountered in an incised channel. These evolutionary phases range from strong disequilibrium to a new state of quasi-equilibrium. Quasi-equilibrium implies that the system is not static and changes through time, but over a period of years, the average condition is one of stability. The model is based on the assumption that moving downstream through the system is equivalent to remaining in place and monitoring changes from the passage of time. The response at any given location in the channel can then be estimated from the morphology of downstream channel locations.

The channel reach types in the CEM are labeled Types I through V and are assumed to occur consecutively in the downstream direction. The CEM assumes each channel type will occur in turn at a given location as the channel evolves. Type I reaches are located upstream of the actively degrading reach and have not yet experienced significant bed or bank instabilities. These reaches are generally characterized by U-shaped cross sections with little or no recently deposited sediment stored in the channel bed.

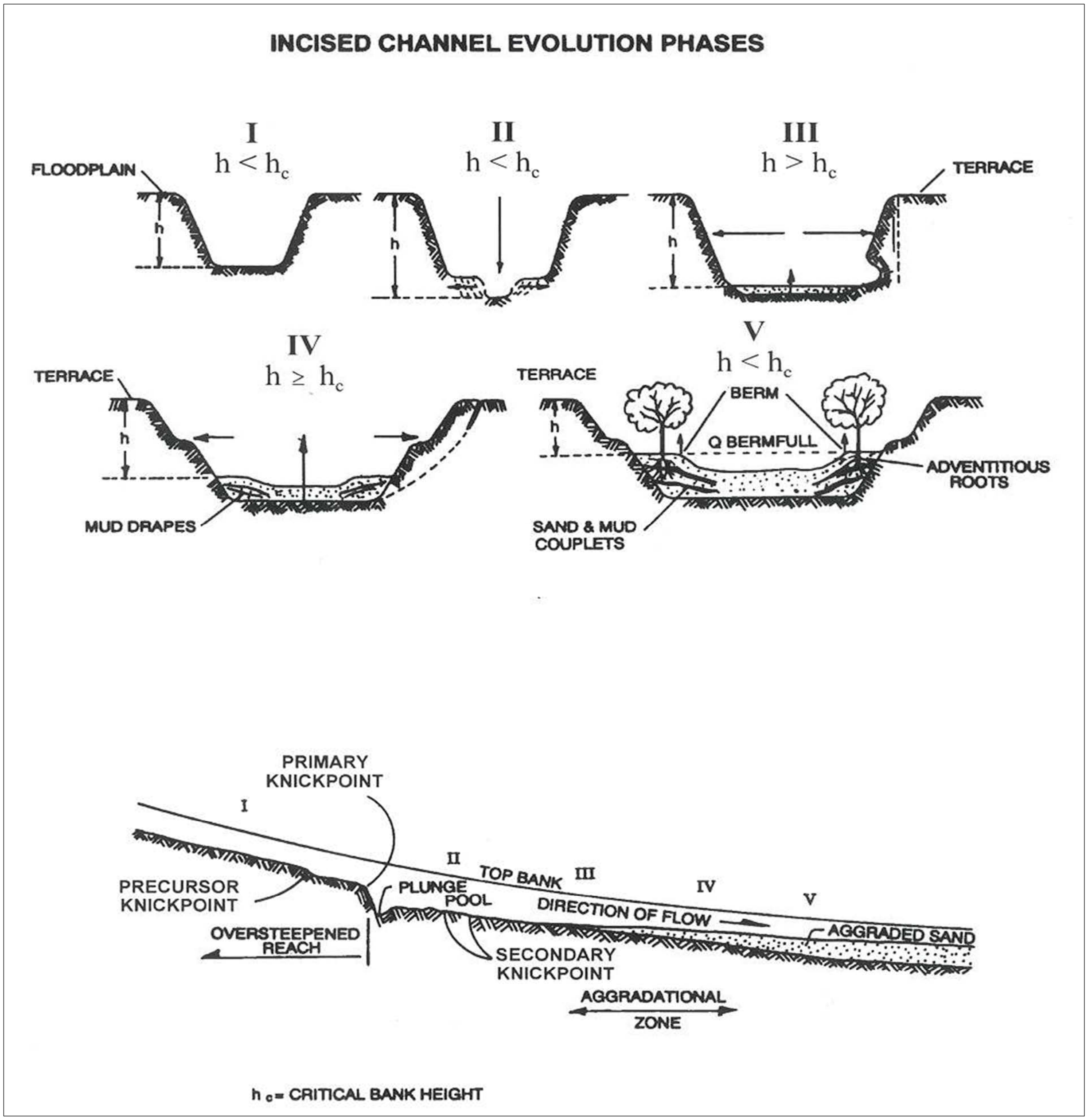

Figure 3.53. Channel Evolution Model Channel Types [Schumm et al., 1984].

Type II reaches are encountered immediately downstream of Type I reaches. Bed degradation is the dominant process in the Type II reach. Type II channels are over-steepened reaches where the sediment transport capacity exceeds the sediment supply. Although the channel is actively degrading in a Type II reach, the bank heights (*h*) do not exceed the critical bank height (*hc*) and, therefore, reach-scale geotechnical bank instability is not encountered.

As bed degradation continues, the bank heights and angles continue to increase. When the bank heights exceed the critical bank height for stability in Type III reaches, mass failures (geotechnical instability) begin. The dominant process in the Type III reach is channel widening. In places, the Type III reach may continue to exhibit slight degradation. However, the reduced sediment transport capacity resulting from the longitudinal channel slope decreasing, combined with increased sediment supply from upstream because of instability and from bank failures within the reach, often results in the initiation of sediment deposition on the channel.

Type IV reaches are downstream of Type III reaches and represent the first manifestation of the incising channel returning to a new state of dynamic equilibrium. In the Type IV reach, geotechnical bank instabilities and channel widening may continue but at a much reduced rate. The sediment supply from upstream (Type III) exceeds the sediment transport capacity and results in aggradation of the Type IV channel bed. The Type IV reach is also characterized by the development of berms, which are depositional features along margins of the over-widened channel. These berms represent the beginning of a new inner channel with dimensions adjusted to the flow and sediment regime.

Type V reaches represent a state of dynamic equilibrium with a balance between sediment transport capacity and sediment supply. Bank heights in the Type V channel are generally less than the critical bank height and, therefore, reach-scale geotechnical bank instability ceases. However, local bank failures can still exist as part of the meander process, or as the result of constrictions, obstructions, or other local factors. The berms, which were initiated in the Type IV reach, have now become colonized by riparian vegetation forming a compound channel within the larger, incised channel. The equilibrium channel of Type V is of a compound shape, with a smaller, inner channel bounded by a narrow floodplain. The original floodplain of the Type I channel is now a terrace.

The CEM addresses the channel stability status within a system context. Dynamic equilibrium in a Type V reach simply implies that system stability has been attained. A Type V reach may exhibit considerable erosion that is part of the natural meander process or other local process, yet still be classified as being in dynamic equilibrium.

3.7.3.2 Results Summary

Field assessment data, Rosgen Level II parameters and stream types, and CEM channel types are summarized for the selected sites on Inyan Kara Creek, Redwater Creek, and Whitelaw Creek where cross sections were selected to represent typical stream channel conditions within the study area. The field assessment results and corresponding stream and channel classification types are listed in Table 3.36. A brief discussion of each of the selected sites are also included in the sections below.

Table 3.36. Geomorphic Parameters at Selected Sites on Inyan Kara Creek, Redwater Creek, and Whitelaw Creek Within the Study Area

Parameter	Inyan Kara Creek			Redwater Creek			Whitelaw Creek	
Cross Section	1	2	3	1	2	3	1	2
Bankfull Depth (ft)	1.71	4.88	3.24	3.10	3.26	3.17	1.17	1.39
Bankfull Width (ft)	6.6	14.2	12.0	8.0	6.0	9.7	10.0	5.5
Width/Depth Ratio	3.88	2.91	3.70	2.58	1.84	3.06	8.50	3.96
Floodprone Depth (ft)	3.42	9.76	6.49	6.20	6.50	6.30	2.30	2.78
Floodprone Width (ft)	91.3	50.0	119.0	31.0	23.0	15.0	33.0	63.0
Entrenchment Ratio	13.0	3.5	9.9	12.0	3.8	1.6	3.3	11.4
Slope	0.0008	0.0010	0.0090	0.0007	0.0250	0.0038	0.0180	0.0240
Sinuosity	1.52	2.80	2.75	2.40	1.96	2.24	1.34	1.28
Rosgen Stream Type	E5b/F	E5b/F	E5b/F	C5c/F	E5b/F	C5c/F	C4b	C4b
Schumm CEM Type	IV to V	IV to V	IV to V	IV to V	IV to V	IV to V	I	I

Inyan Kara Creek (IKC)

Within the study reach of Inyan Kara Creek, the channel bed and banks appear to currently be generally stable and are well vegetated. Localized bank erosion was noted but appears to be the result of localized processes in lieu of systemic destabilization. Small headcuts or knick zones were noted but, again, these appear to be limited and of relative minor magnitude. Three cross sections were surveyed and channel conditions evaluated to categorize the stream within the Rosgen stream classification system. Cross-section locations were selected to characterize the typical conditions encountered during the field evaluation.

Based strictly on the values in Table 3.36, Inyan Kara Creek would likely be classified as a E5b-type channel. As previously discussed, E-type channels possess low width/depth ratios, are highly sinuous, and are only slightly entrenched. Based on the field observations, Inyan Kara Creek is clearly entrenched and isolated from its floodplain. The low entrenchment ratios measured at the surveyed cross sections are artifacts of the presence of an entrenched floodplain forming as the channel stabilizes following historic incision.

Based on observations of geomorphic processes occurring within the study reach; the classification has been amended with an F-type. Figure 3.54 displays a photo of the channel at Cross Section 2 and shows that the channel is considerably entrenched within its historic floodplain. Comparison of Inyan Kara Creek and the ambient and the geomorphic processes observed for the CEM types; it appears that the channel is likely in the Type IV to V stages where active incision and degradation have subsided and channel widening has been initiated. Formation of local berms and benches within the entrenched channel indicates stability while the limited bank erosion indicates channel widening may be occurring.

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Figure 3.54. Inyan Kara Creek: Typical Channel Reach. The bench with snow within the entrenched channel is considerably entrenched within its historic floodplain.

Redwater Creek (RC)

The selected reach on Redwater Creek also shows conditions similar to those on Inyan Kara Creek. The channel is obviously entrenched; little, if any, connection currently exists between the channel and the floodplain. Few indicators of active channel degradation were noted, however, indicating that the incision may have ceased and the channel is currently “healing.” Entrenched floodplains were noted in several locations, which indicates the channel is recovering from historic incision by forming stable geomorphic features within its current entrenched cross section. The presence of mature boxelder trees on these features indicates that the current conditions have been vertically stable for a number of years, as shown in Figure 3.55.

Figure 3.55. Mature Boxelder Trees Established on Entrenched Floodplain of Redwater Creek.

For the most part, banks are well vegetated and appear stable. Localized bank erosion was evident, however, indicating that channel banks exceed critical bank height and are failing as the channel adjusts to historic incision by widening. Figure 3.56 depicts a location on Redwater Creek where this process is evident. Three cross sections were surveyed and channel conditions evaluated to categorize the stream within the Rosgen classification. Cross-section locations were selected to characterize the typical conditions encountered during the field evaluation.

Based strictly on the values in Table 3.36, Redwater Creek would likely be classified as a C5c or E5b-type channel. As previously discussed, E-type channels possess low width/depth ratios, are highly sinuous, and are only slightly entrenched. C-type channels possess higher width/ depth ratios and are “connected” to their floodplains. Based on field observations, Redwater Creek is also clearly entrenched and isolated from its floodplain. The low entrenchment ratios measured at the surveyed cross sections are artifacts of the presence of an entrenched floodplain forming as the channel stabilizes following historic incision. Based on observations of geomorphic processes occurring within the study reach, the classification has been amended with an F-type. Figure 3.57 is a photograph of the channel that clearly indicates the channel is considerably entrenched within its historic floodplain.

Comparing Redwater Creek and the ambient and the geomorphic processes observed for the CEM types, it appears that the channel is likely in the Type IV to V stages where active incision and degradation have subsided and channel widening has been initiated. An entrenched and vegetated floodplain forming indicates vertically stable conditions. Evidence of channel widening (bank erosion) exists, as would be expected in the CEM Type IV channel.

RSI-2264-15-058

Figure 3.56. Evidence of Channel Widening of Redwater Creek.

RSI-2264-15-059

Figure 3.57. Entrenched Conditions of Redwater Creek.

Whitelaw Creek (WC)

Historic season-long livestock grazing practices in the mid- to late twentieth century resulted in damaged upland and riparian areas and degraded streambanks on Whitelaw Creek. Following establishment of a Coordinated Resource Management (CRM) and partnering of WDEQ, landowners, and several local agencies initiated the Whitelaw Riparian Improvement Project in 1992. Best management practices (BMPs) focusing on improving riparian conditions, stabilizing stream banks, and enhancing water quality through improved grazing management were implemented.

Monitoring conducted by the WDEQ and observations made during this Level I study indicate that the strategies have been successful and generally stable geomorphic conditions exist. The study reach was assessed by the consultant staff in the company of the landowner. Little evidence of channel instability was noted. Streambanks were generally low and stable. The channel bed is well armored with gravels, cobbles, and boulders that provide a condition resilient to disturbance. Stream banks were well vegetated. Based on the values in Table 3.36, the study reach on Whitelaw Creek, as shown in Figure 3.58, is classified as a C5b-type.

RSI-2264-15-060

Figure 3.58. Typical Conditions of Whitelaw Creek.

Comparing Whitelaw Creek and the ambient and the geomorphic processes observed for the CEM types indicates that the channel is likely in the Type I stage. Type I reaches are located upstream of the actively degrading reach and have not yet experienced significant bed or bank instabilities. These reaches are generally characterized by U-shaped cross sections with little or no recently deposited sediment stored in the channel bed. In the case of Whitelaw Creek, the

Type I designation is not based on the observation of a degraded reach downstream, but of generally stable conditions at the actual site. Existence of coarse bed materials (gravels, cobbles, and boulders) would likely prevent significant channel incision from occurring.

3.7.4 Channel Conditions

Stream channels within the study area show conditions that are indicative of common impairments or disturbances to the channel. These disturbances or impairments can result from natural and/or man-made events and appear to fall into three broad and interrelated categories: channel degradation, riparian vegetation degradation, or riparian degradation. Channel degradation involves entrenchment of streambeds, loss of aquatic habitat, and vertical instability. Riparian vegetation degradation involves impaired riparian condition and habitat, and riparian degradation generally involves bank erosion and physical disturbance of banks.

Reaches of perennial streams commonly displayed indications of riparian degradation as evidenced by bank erosion, loss of riparian habitat, channel widening, and channel degradation. Channels classified as F-type channels (common in the lower portions of the study area reaches of these streams) are entrenched and consequently have lost connection with their floodplains. Some streams are heavily incised and restoration could be problematic. Multiple approaches to restoration can be applied to incised river channels [Rotar and Boyd, 1999]. Common objectives in such restoration efforts are to promote channel stability and connect the channel to its historic floodplain. The reconnection of the channel to its historic floodplain requires raising the channel bed, which can be achieved through grade controls and channel infilling, or even reconstruction of a new channel. These approaches can have difficult and costly challenges, however, such as tying in the project end points to the incised channel grade or preventing postproject channel relocation (avulsion).

Another approach to incised channel stabilization is to completely armor the channel banks and add grade-control structures. This process will reduce sediment inputs but will not provide a dynamic, functional channel configuration. Perhaps the most geomorphically beneficial approach to incised channel restoration is to promote the natural recovery process of channel widening and incised floodplain development. This can be achieved by encouraging the development of a new floodplain surface adjacent to the channel to provide an area for flood energy dissipation and new riparian corridor establishment. Any work in incised channels requires an assessment of the status of the current channel stability, so that the potential for further downcutting is known and accommodated for in the channel restoration design.

3.8 WATER QUALITY

3.8.1 Stream Classifications

The Water Quality Division of the WDEQ has classified waterbodies in the state of Wyoming into two parts: primary (Table A) and secondary (Table B). Table A classifications are those either named on the USGS 1:500,000 scale hydrologic map or those specifically classified by the

WDEQ. Table B classifications are taken from the WGFD's "Streams and Lakes Inventory" and are based on the presence or absence of fish species. Where classifications differ, Table A takes precedence. Table 3.37 shows the use designation associated with each classification. Over 500 surface waterbodies with classifications in the watershed, and 115 of these waters are classified by the WDEQ. Table 3.38 shows the waterbody count by surface water classification within the study area. Sand Creek is designated as the only Class 1, Outstanding Water in the watershed as defined in the WDEQ's Water Quality Rules and Regulations, Chapter 1 [WDEQ, 2013].

Table 3.37. Wyoming Surface Water Classification and Use Designations

Designated Use	Surface Water Classification										
	1	2AB	2A	2B	2C	3A	3B	3C	4A	4B	4C
Drinking Water	X	X	X								
Game Fish	X	X		X							
Nongame Fish	X	X		X	X						
Fish Consumption	X	X		X	X						
Other Aquatic Life	X	X	X	X	X	X	X	X			
Recreation	X	X	X	X	X	X	X	X	X	X	X
Wildlife	X	X	X	X	X	X	X	X	X	X	X
Agriculture	X	X	X	X	X	X	X	X	X	X	X
Industry	X	X	X	X	X	X	X	X	X	X	X
Scenic Value	X	X	X	X	X	X	X	X	X	X	X

Table 3.38. Water Classification Totals Within the Study Area

Surface Water Classification	Waterbody Type	
	River, Stream, Creek, or Draw	Reservoir, Pond, Pit, Dam, or Lake
1	1	0
2AB	29	207
2C	2	5
3B	129	176
4C	2	0
Total	**163**	**388**

3.8.2 Wyoming Pollutant Discharge Elimination System Permitted Discharges

The watershed has 157 Wyoming Pollution Discharge Elimination System (WYPDES) point source discharge permits with a total of 952 outfalls, as shown in Figure 3.59. A list of WYPDES permits is in Table 3.39. Of the WYPDES permits, five are listed with a permit type of Sanitary Wastewater: City of Gillette (WY0020125), Town of Moorcroft (WY0021741), Wright Water and Sewer District (WY0025992), Crestview Estates Homeowners Association (WY0030449), and the Town of Pine Haven (WY0054127). The study area does not have any permitted Municipal Separate Storm Sewer Systems (MS4s).

3.8.3 Waters Requiring Total Maximum Daily Loads

The watershed has several waterbodies listed as impaired in the state of Wyoming's 2012 Integrated Report [WDEQ, 2012]. Fecal coliform loadings have resulted in exceedances of the recreational use criterion in several waters, including three reaches of the Belle Fourche River, Donkey Creek, and Stonepile Creek. One reach of the Belle Fourche River also has exceedances of the warm water fishery and aquatic life other than fish criteria because of ammonia and chloride loadings. Gillette Fishing Lake has exceedances of the cold water fishery and aquatic life other than fish criteria because of phosphate and sediment loadings. Impaired waterbodies within the study area are shown in Figure 3.60. Table 3.40 summarizes the locations, use, and impairments of these waterbodies.

Total Maximum Daily Load (TMDL) assessments for the Belle Fourche River, Donkey Creek, and Stonepile Creek were completed in August 2013. Pollutant sources, load allocations, and estimated reductions necessary for the reaches to meet water quality criteria and attain designated uses were included in the TMDL. Ammonia exceedances in the Belle Fourche River occurred during winter months when flows were low. Potential sources include the Gillette WWTP, Wright Water and Sewer District, Gillette area runoff, Wyodak, and the Moorcroft wastewater lagoon [Tetra Tech Inc., 2013]. Chloride exceedances in the Belle Fourche River occurred mainly during low flow periods during winter months. Donkey Creek is believed to be the major source carrying chlorides into the Belle Fourche River. The chlorides in Donkey Creek are believed to be from deicing agents used on roads and sidewalks within the Gillette area. Occasional exceedances in the summer are thought to be from dust control agents, irrigation return flows, and oil treaters or coal mines [Tetra Tech Inc., 2013].

E. coli exceedances in Stonepile Creek occur more often during summer months with exceedances occurring throughout all flow regimes. *E. coli* exceedances in Donkey Creek occur during summer months throughout all flow regimes. High bacteria loads from Stonepile Creek also contribute to Donkey Creek. In the Belle Fourche River above Keyhole Reservoir, *E. coli* exceedances occurred through all but the low flow zone during summer months. Based on available data, no exceedances of the winter standard were sampled. *E. coli* samples in the Belle Fourche River below Keyhole Reservoir exceeded the water quality standards less frequently than in other upstream reaches. Keyhole Reservoir aids in settling out *E. coli* bacteria loadings.

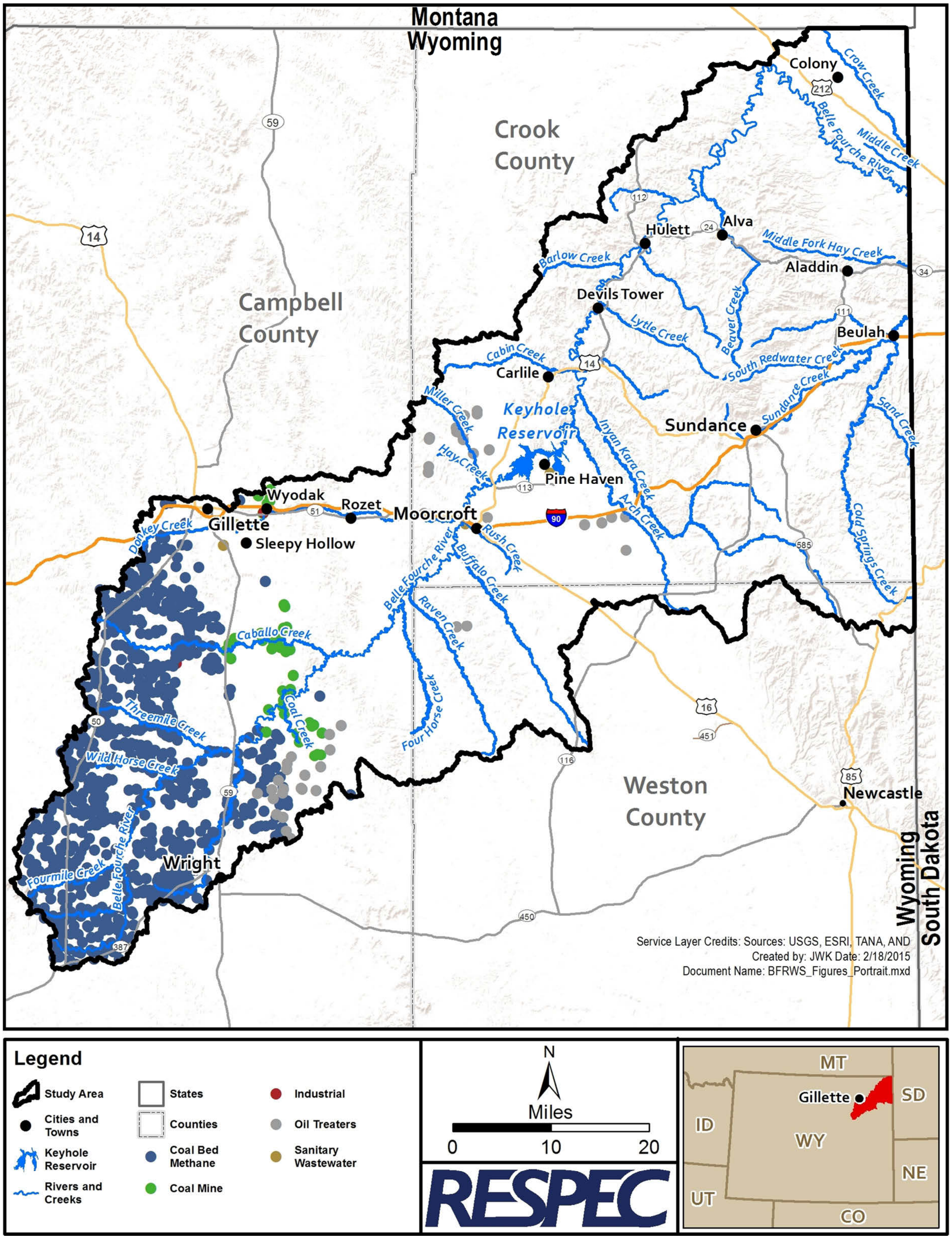

Figure 3.59. Wyoming Pollutant Discharge Elimination System Permitted Locations Within the Belle Fourche River Watershed.

Table 3.39. Wyoming Pollution Discharge Elimination System Permitted Discharges Within the Belle Fourche River Watershed (Page 1 of 8)

WYPDES Permit No.	Permittee	Facility Name	Permit Type	Outfalls
WY0000299	Ranch Oil Company	Robinson Ranch Unit	Oil Treaters	1
WY0000663	Beren Corporation	South Wood Field Schuricht	Oil Treaters	1
WY0001261	Wyodak Resources Development Corporation	Wyodak Mine	Coal Mine	7
WY0001384	PacifiCorp	Wyodak Plant	Industrial	1
WY0001643	Amwest Petroleum, Inc.	Wood Tank Battery	Oil Treaters	1
WY0001678	Nova Energy, Inc.	Wood B Battery	Oil Treaters	1
WY0001686	Amwest Petroleum, Inc.	Wood A Tank Battery	Oil Treaters	1
WY0002372	Ballard Energy 1992 Limited	Donkey Creek Field, Government	Oil Treaters	1
WY0003514	Alpha Coal West, Inc.	Belle Ayr Mine	Coal Mine	10
WY0020125	Gillette, City of	Gillette WWTF	Sanitary Wastewater	1
WY0020508	Citation Oil and Gas Corporation	Meyer C Lease Battery	Oil Treaters	1
WY0021741	Moorcroft, Town of	Moorcroft Wastewater Lagoon	Sanitary Wastewater	1
WY0023761	Cordero Mining, LLC	Cordero Rojo Mine	Coal Mine	16
WY0024091	Thunder Basin Coal Company, LLC	Black Thunder Mine	Coal Mine	1
WY0024741	Kaiser Francis Oil Company	Wood 395-3, Wells 1 and 2	Oil Treaters	1
WY0024759	Kaiser Francis Oil Company	Wood 395-2 Federal 768	Oil Treaters	1
WY0025470	Ellbogen, John P., LTD	Davis-Meyer-Muddy Batteries	Oil Treaters	3
WY0025755	Peabody Caballo Mining, LLC	Caballo Mine	Coal Mine	7
WY0025992	Wright Water and Sewer District	Wright Wastewater Treatment	Sanitary Wastewater	1
WY0026239	CKT Energy, LLC	Turner Sand Unit Tract I-Mohawk Federal #3 Batteries	Oil Treaters	2
WY0026450	Resolute Wyoming, Inc.	Resolute Emergency Discharges	Oil Treaters	13
WY0026531	Resolute Wyoming, Inc.	Resolute Hilight Field	Oil Treaters	9
WY0028011	BW Oil LLC	Tupper Federal W-39082-A	Oil Treaters	1

Table 3.39. Wyoming Pollution Discharge Elimination System Permitted Discharges Within the Belle Fourche River Watershed (Page 2 of 8)

WYPDES Permit No.	Permittee	Facility Name	Permit Type	Outfalls
WY0028193	Thunder Basin Coal Company, LLC	Coal Creek Mine	Coal Mine	9
WY0030449	Crestview Estates Homeowners Association	Crestview Estates W&S District	Sanitary Wastewater	1
WY0031771	Anderson Management Company	W.D. Federal #1	Oil Treaters	1
WY0032832	Amwest Petroleum, Inc.	Art Creek Federal #1	Oil Treaters	1
WY0033383	Win Oil Company	Barton Lease Tank #4554	Oil Treaters	1
WY0033596	Amwest Petroleum, Inc.	L.A. Johnson, #f21-5G	Oil Treaters	1
WY0034096	Ferreira Oil Properties, LLC	Barton Field	Oil Treaters	1
WY0034100	BW Oil LLC	Soaphole Dakota Unit, Bertram	Oil Treaters	1
WY0034169	Amwest Petroleum, Inc.	Baum #43-17	Oil Treaters	1
WY0034959	Anderson Management Company	Bertolet Consolidated Battery	Oil Treaters	1
WY0035521	Three Forks Resources, LLC	Climax #7-2	Oil Treaters	1
WY0035599	Amwest Petroleum, Inc.	Twiford Forney 1,3,4 and The Baum 2-17 lease.	Oil Treaters	1
WY0036439	Amwest Petroleum, Inc.	Tara Federal #1	Oil Treaters	1
WY0036838	US Department of Energy	Hoe Creek Remediation	Industrial	1
WY0037117	Yates Petroleum Corporation	Belle Federal #1 CBM Wells	Coal Bed Methane	3
WY0037150	Patriot Energy Resources, LLC	Terra Wells CBM Project	Coal Bed Methane	8
WY0037184	WPX Energy Rocky Mountain, LLC	Carter Prospect CBM Wells	Coal Bed Methane	5
WY0037354	Resolute Wyoming, Inc.	CBMA Coal Bed Methane Wells	Coal Bed Methane	4
WY0037389	Yates Petroleum Corporation	House Creek CS State #1-5 CBM Wells	Coal Bed Methane	5
WY0037435	Yates Petroleum Corporation	K-Bar CS State #1 CBM Wells	Coal Bed Methane	5
WY0037451	Yates Petroleum Corporation	Niles Hill CS State #1 CBM Wells	Coal Bed Methane	2
WY0037605	Patriot Energy Resources, LLC	Geer CBM 43-8	Coal Bed Methane	5

Table 3.39. Wyoming Pollution Discharge Elimination System Permitted Discharges Within the Belle Fourche River Watershed (Page 3 of 8)

WYPDES Permit No.	Permittee	Facility Name	Permit Type	Outfalls
WY0037672	WPX Energy Rocky Mountain, LLC	Three Mile Creek CBM Wells	Coal Bed Methane	15
WY0037745	Yates Petroleum Corporation	Riverbend CS State #1,2,3,4 CBM Wells	Coal Bed Methane	1
WY0037877	Hilcorp Energy Company	Bone Pile #2 CBM Wells	Coal Bed Methane	10
WY0037940	Yates Petroleum Corporation	Thrush CS Fee #1-4 CBM Wells	Coal Bed Methane	5
WY0038075	WPX Energy Rocky Mountain, LLC	Heiland Prospect CBM Project	Coal Bed Methane	1
WY0038113	High Plains Gas, LLC	Stonepile CS State #1 CBM Wells	Coal Bed Methane	1
WY0038580	WPX Energy Rocky Mountain, LLC	Moser Draw Area CBM Wells	Coal Bed Methane	13
WY0038750	Yates Petroleum Corporation	Groves CS Fee #14,15,16,17 CBM Wells	Coal Bed Methane	3
WY0038768	Yates Petroleum Corporation	Willard CS Fee #3,4,5&6	Coal Bed Methane	2
WY0038831	Rim Operating, Inc.	Coal Creek CBM Project	Coal Bed Methane	4
WY0039471	WPX Energy Rocky Mountain, LLC	Hoe Creek North CBM Project	Coal Bed Methane	24
WY0039756	Patriot Energy Resources, LLC	Pronghorn Creek A CBM Project	Coal Bed Methane	7
WY0040096	WPX Energy Rocky Mountain, LLC	Liberty CBM Operation	Coal Bed Methane	8
WY0040100	WPX Energy Rocky Mountain, LLC	Plemmons CBM Operation	Coal Bed Methane	9
WY0040118	WPX Energy Rocky Mountain, LLC	Persson CBM Operation	Coal Bed Methane	10
WY0040207	Devon Energy Production Co., LP	Rocky Butte 1 CBM Project	Coal Bed Methane	5
WY0040215	Devon Energy Production Co., LP	Mud Springs #1	Coal Bed Methane	4
WY0040223	Devon Energy Production Co., LP	Billie Creek CBM Project	Coal Bed Methane	11
WY0040231	Devon Energy Production Co., LP	Belle Fourche 3 CBM Project	Coal Bed Methane	4

Table 3.39. Wyoming Pollution Discharge Elimination System Permitted Discharges Within the Belle Fourche River Watershed (Page 4 of 8)

WYPDES Permit No.	Permittee	Facility Name	Permit Type	Outfalls
WY0040258	Devon Energy Production Co., LP	Belle Fourche 1 CBM Project	Coal Bed Methane	3
WY0040967	Yates Petroleum Corporation	McCullough & Moore CS CBM Wells	Coal Bed Methane	4
WY0041131	Yates Petroleum Corporation	Hoe Creek CS Fed CBM Wells	Coal Bed Methane	3
WY0041157	Hilcorp Energy Company	Coyote CBM Operations	Coal Bed Methane	5
WY0041181	DNR Oil and Gas, Inc.	Buff CBM Facility	Coal Bed Methane	10
WY0041297	Hilcorp Energy Company	Hill Reservoir CBM Project	Coal Bed Methane	4
WY0041394	Devon Energy Production Co., LP	Hay Creek 1 CBM Project	Coal Bed Methane	8
WY0041556	Lance Oil and Gas Company, Inc.	Antler CBM Project	Coal Bed Methane	13
WY0041599	Lance Oil and Gas Company, Inc.	Breene CBM Facility	Coal Bed Methane	12
WY0041637	WPX Energy Rocky Mountain, LLC	Wild Horse East CBM Project	Coal Bed Methane	5
WY0041653	WPX Energy Rocky Mountain, LLC	Spring Draw CBM Project	Coal Bed Methane	26
WY0041823	High Plains Gas, LLC	Middle Prong Wild Horse Creek	Coal Bed Methane	33
WY0041858	High Plains Gas, LLC	House Creek S. Prong Wild Horse Creek	Coal Bed Methane	4
WY0041866	WPX Energy Rocky Mountain, LLC	Pleasantville Comet CBM Wells	Coal Bed Methane	7
WY0041874	WPX Energy Rocky Mountain, LLC	Pleasantville Star	Coal Bed Methane	13
WY0041882	Lance Oil and Gas Company, Inc.	North Wright Hay Creek CBM Project	Coal Bed Methane	8
WY0041921	Hilcorp Energy Company	Doud/Tripp Headers CBM Project	Coal Bed Methane	5
WY0041955	Hilcorp Energy Company	Bell Road CBM Project	Coal Bed Methane	3
WY0041963	Hilcorp Energy Company	Lange Trust Project CBM	Coal Bed Methane	2

Table 3.39. Wyoming Pollution Discharge Elimination System Permitted Discharges Within the Belle Fourche River Watershed (Page 5 of 8)

WYPDES Permit No.	Permittee	Facility Name	Permit Type	Outfalls
WY0042161	Yates Petroleum Corporation	Donkey CS State 1,2 & 3 CBM Wells	Coal Bed Methane	1
WY0042234	WPX Energy Rocky Mountain, LLC	North Pleasantville 1 CBM	Coal Bed Methane	3
WY0042242	WPX Energy Rocky Mountain, LLC	North Pleasantville 2 CBM Wells	Coal Bed Methane	4
WY0042340	WPX Energy Rocky Mountain, LLC	All Night Creek CBM Project	Coal Bed Methane	22
WY0042471	High Plains Gas, LLC	Groves Ranch CBM Project	Coal Bed Methane	4
WY0042820	WPX Energy Rocky Mountain, LLC	Pleasantville Mercury CBM	Coal Bed Methane	12
WY0043401	WPX Energy Rocky Mountain, LLC	Hoe Creek Orion CBM Wells	Coal Bed Methane	5
WY0043443	WPX Energy Rocky Mountain, LLC	Hoe Creek Sputnik CBM Wells	Coal Bed Methane	5
WY0043460	WPX Energy Rocky Mountain, LLC	Hoe Creek Asteroid CBM Wells	Coal Bed Methane	8
WY0043575	Emerald Operating Company	Haight/Mankin Ranch CBM Wells	Coal Bed Methane	3
WY0044300	Black Diamond Energy, Inc.	Marquiss Pod	Coal Bed Methane	6
WY0045764	WPX Energy Rocky Mountain, LLC	Ohman	Coal Bed Methane	10
WY0045781	WPX Energy Rocky Mountain, LLC	Jimmy	Coal Bed Methane	6
WY0046001	Yates Petroleum Corporation	Starlight CS Federal Lease	Coal Bed Methane	1
WY0046094	Yates Petroleum Corporation	Moore & Dickson CS Wells	Coal Bed Methane	3
WY0046221	Yates Petroleum Corporation	Groves Ickes & Edra CS Fee Leases	Coal Bed Methane	9
WY0046345	WPX Energy Rocky Mountain, LLC	Caballo Creek 1 Area	Coal Bed Methane	7
WY0046604	Anadarko Petroleum Corporation	Wright POD	Coal Bed Methane	1
WY0046647	Pure Petroleum, LLC	SE Kitty-Section 24 Project	Coal Bed Methane	2

Table 3.39. Wyoming Pollution Discharge Elimination System Permitted Discharges Within the Watershed (Page 6 of 8)

WYPDES Permit No.	Permittee	Facility Name	Permit Type	Outfalls
WY0046680	WPX Energy Rocky Mountain, LLC	Hilda	Coal Bed Methane	16
WY0047244	Anadarko Petroleum Corporation	Pinette Draw POD CBM Facility	Coal Bed Methane	1
WY0047279	E&B Natural Resources Mgmt Corp.	Kudzu Section 25 CBM Project	Coal Bed Methane	3
WY0047635	Yates Petroleum Corporation	Adria, Jesse, Prime CS Fee Leases	Coal Bed Methane	5
WY0048445	Resolute Wyoming, Inc.	Opal Area	Coal Bed Methane	34
WY0048526	WPX Energy Rocky Mountain, LLC	All Night Creek Unit #4 (K-Bar Draw)	Coal Bed Methane	12
WY0048542	WPX Energy Rocky Mountain, LLC	All Night Creek Unit #6	Coal Bed Methane	8
WY0048551	WPX Energy Rocky Mountain, LLC	All Night Creek Unit #7	Coal Bed Methane	11
WY0048569	WPX Energy Rocky Mountain, LLC	All Night Creek Unit #9	Coal Bed Methane	7
WY0048836	Yates Petroleum Corporation	Church CS Fee Lease	Coal Bed Methane	3
WY0048984	Yates Petroleum Corporation	Thrush POD	Coal Bed Methane	9
WY0049034	Yates Petroleum Corporation	Ridgerunner POD	Coal Bed Methane	3
WY0049115	Yates Petroleum Corporation	Jeanne and Thelma CS Fee Leases	Coal Bed Methane	3
WY0049301	Sands Oil Company	Skyline CBM Facility	Coal Bed Methane	4
WY0049352	Yates Petroleum Corporation	Wava CS	Coal Bed Methane	13
WY0049417	Yates Petroleum Corporation	Muley CS Fed #06, #07	Coal Bed Methane	2
WY0049425	Yates Petroleum Corporation	Bunn, Hay, Jolie and Thrush CS Leases	Coal Bed Methane	1
WY0049671	Yates Petroleum Corporation	Meek, Little and Hanslip CS Leases	Coal Bed Methane	10
WY0049778	Yates Petroleum Corporation	Greasewood CS State	Coal Bed Methane	2

Table 3.39. Wyoming Pollution Discharge Elimination System Permitted Discharges Within the Watershed (Page 7 of 8)

WYPDES Permit No.	Permittee	Facility Name	Permit Type	Outfalls
WY0049794	Hilcorp Energy Company	Eaglette Header Discharge	Coal Bed Methane	1
WY0049808	Hilcorp Energy Company	Buffalo Header Discharge	Coal Bed Methane	5
WY0049948	Lance Oil and Gas Company, Inc.	Rocky Butte & Wild Horse	Coal Bed Methane	6
WY0049956	Lance Oil and Gas Company, Inc.	North Wright Hay Creek 3	Coal Bed Methane	21
WY0050334	Langley Energy, Inc.	Tuit-Hay Creek	Coal Bed Methane	1
WY0050369	WPX Energy Rocky Mountain, LLC	Pumpkin Buttes 1	Coal Bed Methane	8
WY0050385	Yates Petroleum Corporation	Albatross POD	Coal Bed Methane	8
WY0050407	Yates Petroleum Corporation	Riverbend POD	Coal Bed Methane	8
WY0050491	Yates Petroleum Corporation	Antler POD CS Federal	Coal Bed Methane	2
WY0050814	Lance Oil and Gas Company, Inc.	Savageton Prospect 1	Coal Bed Methane	32
WY0051128	Yates Petroleum Corporation	Rocky Butte Pod	Coal Bed Methane	7
WY0051225	Yates Petroleum Corporation	Hen/Rooster CS State-Caballo Outfalls	Coal Bed Methane	1
WY0051349	Benchmark Energy, LLC	Marquiss Infrastructure-Jackalope Hdr	Coal Bed Methane	2
WY0051420	Yates Petroleum Corporation	Wags Pinnacle	Coal Bed Methane	3
WY0051608	Lance Oil and Gas Company, Inc.	Pumpkin Buttes Ranch CBM Wells	Coal Bed Methane	8
WY0051616	Lance Oil and Gas Company, Inc.	Wagensen	Coal Bed Methane	7
WY0051659	Yates Petroleum Corporation	Savageton CS State Lease	Coal Bed Methane	6
WY0052337	Bill Barrett Corporation	Hardzog Draw Facility	Coal Bed Methane	17
WY0052370	Denbury Onshore, LLC	Hartzog Draw CBM	Coal Bed Methane	29

Table 3.39. Wyoming Pollution Discharge Elimination System Permitted Discharges Within the Watershed (Page 8 of 8)

WYPDES Permit No.	Permittee	Facility Name	Permit Type	Outfalls
WY0052434	BW Oil LLC	State Lease #66-327	Oil Treaters	1
WY0052744	Hilcorp Energy Company	Panther POD	Coal Bed Methane	2
WY0053473	Bill Barrett Corporation	South Butte Section 16	Coal Bed Methane	1
WY0053619	E&B Natural Resources Mgmt Corp.	Marquiss CBM Project	Coal Bed Methane	3
WY0054127	Pine Haven, Town of	Pine Haven WWTP	Sanitary Wastewater	1
WY0054216	L and J Operating, Inc.	Rourke Field - 2	Coal Bed Methane	1
WY0054348	L and J Operating, Inc.	Sprigler Field 2	Coal Bed Methane	1
WY0054763	Yates Petroleum Corporation	Blanche	Coal Bed Methane	1
WY0055034	Bill Barrett Corporation	Greasewood Creek	Coal Bed Methane	1
WY0055336	Black Diamond Energy, Inc.	Scott Wells	Coal Bed Methane	1
WY0055468	Yates Petroleum Corporation	Hoe Creek Wells	Coal Bed Methane	1
WY0055662	E&B Natural Resources Mgmt Corp.	Kudzu	Coal Bed Methane	1
WY0056171	Yates Petroleum Corporation	All Day POD-Cottonwood Creek	Coal Bed Methane	1
WY0094145	WYTEX Ventures, LLC	Lynde Trust	Coal Bed Methane	53

A TMDL assessment for sediment and total phosphorus was completed for Gillette Fishing Lake in February 2013. Pollutant sources, load allocations, and estimated reductions necessary for the lake to meet water quality criteria and attain designated uses were included in the TMDL. According to the report, sediment and phosphorus loadings are delivered to the lake from nonpoint sources in the Gillette Fishing Lake Watershed. Subwatersheds adjacent to the lake are the primary contributors of sediment and phosphorus from stormwater runoff. Internal loadings also contribute to the current load in the lake [HDR Engineering Inc., 2013].

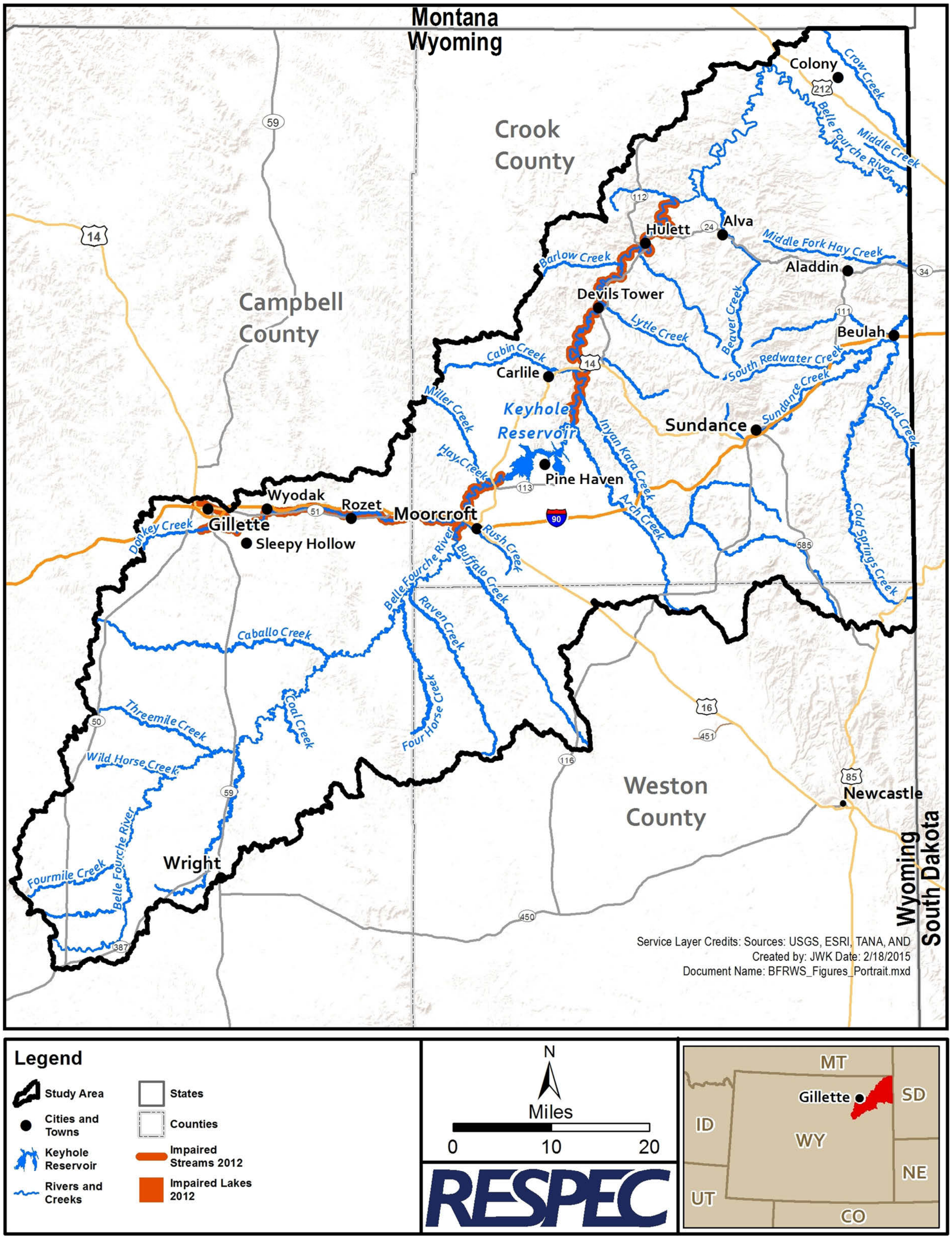

Figure 3.60. Impaired Waterbodies Within the Belle Fourche River Watershed.

Table 3.40. Summary of 2012 Impaired Waterbodies Within the Belle Fourche River Watershed

Waterbody	305(b) Identifier	Location	Class	Miles	Use	Cause	List Date	TMDL Date
Belle Fourche River	WYBF-101202010501_01	From the confluence with Donkey Creek to a point 6.2 miles upstream	2ABww	6.2	Recreation	Fecal Coliform	1996	2009
Belle Fourche River	WYBF-101202010504_00	From the confluence with Keyhole Reservoir upstream to the confluence with Donkey Creek	2ABww	14.2	Recreation, Warm Water Fishery, Aquatic Life Other Than Fish	Fecal Coliform, Ammonia, Chloride	1996 2008	2009
Donkey Creek	WYBF-101202010600_01	From the confluence with the Belle Fourche River upstream to Brorby Boulevard within the city of Gillette	3B	61.4	Recreation	Fecal Coliform	2000	2009
Stonepile Creek	WYBF-101202010602_01	From the confluence with Donkey Creek upstream to the junction of Highways 14/16 and 59	3B	7.6	Recreation	Fecal Coliform	2002	2009
Belle Fourche River	WYBF-101202010904_00	From the confluence with Arch Creek downstream to the confluence with Sourdough Creek	2ABww	60.7	Recreation	Fecal Coliform	1996	2009
Gillette Fishing Lake	WYBF-101202010601_01	Within the city of Gillette	2AB	15.4 ac	Cold Water Fishery, Aquatic Life Other Than Fish	Phosphate, Sediment	1996	2008

3.9 WATER STORAGE

Water storage development within the watershed has been impacted by the Belle Fourche River Compact of 1943, which divides the water in northeast Wyoming between Wyoming and South Dakota. The compact recognizes all rights in Wyoming existing as of the date of the compact, and permits Wyoming unlimited use for stock water reservoirs not exceeding 20 acre-feet in capacity. Wyoming is allowed to use 10 percent of the available flow of the Belle Fourche River in excess of the amount that is needed to supply the water rights in existence at the date of the contract. No reservoir constructed subsequent to the date of the compact solely to use the water allocated to Wyoming shall have a capacity greater than 1,000 acre-feet.

Because of institutional constraints related to the Belle Fourche River Compact that could limit the opportunity to create new reservoir projects or increase existing storage reservoirs through enlargement, the water storage investigations focused on existing stock ponds and potential upland water storage facilities less than 20 acre-feet. However, study participants identified some potential sites and possible opportunities for water storage within the study area. Water storage reservoirs within the watershed have been the subject of several past studies and are summarized in Section 3.9.3 of this report.

Additional storage reservoirs or enlargements to existing reservoirs may be limited by the institutional constraints identified above; however, improvements to fully realize and sustain the capacity of the existing reservoirs are not limited by these constraints. During the completion of this study, the water users identified problems with several existing reservoirs and associated facilities that severely limited the potential to store water in these facilities. Accordingly, site visits and initial reviews were conducted on some of the stock ponds, stock reservoirs, irrigation regulation reservoirs, and previously and newly proposed sites that were identified by participants and are summarized in the Chapter 4.0.

3.9.1 Major Reservoirs

The Wyoming SEO developed a list of major reservoirs within the Northeast Wyoming Basin. To qualify as major, a reservoir must have storage capabilities of 1,000 acre-feet or more and also serve multiple users. Two reservoirs within the Belle Fourche River Watershed are considered major: Keyhole Reservoir and Gillette Lake.

Keyhole Dam and Reservoir, located on the Belle Fourche River northeast of Moorcroft, is the largest storage facility developed within the study area. Keyhole Unit was authorized by the Flood Control Act of 1944. The USBR began constructing Keyhole Dam in June 1950 and completed the project in March 1952. Keyhole Reservoir began releasing waters on April 20, 1953. The Keyhole Unit, consisting of Keyhole Dam and Reservoir, is a multipurpose facility that provides storage for irrigation, flood control, fish and wildlife benefits, conservation, recreation, sediment control, and municipal and industrial water supply.

Keyhole Reservoir provides supplemental water to the 57,068-acre Belle Fourche Unit located approximately 150 miles downstream in western South Dakota. Keyhole Reservoir also provides supplemental water to the irrigators in the CCID. The Belle Fourche River Compact allocates 10 percent of unappropriated flow in the Belle Fourche River to Wyoming and 90 percent to South Dakota, which is reflected in the contracted storage in Keyhole Reservoir. Presently, USBR's contracted storage space in Keyhole Reservoir includes 7.7 percent to the Belle Fourche Irrigation District (BFID), 9.7 percent to the CCID, and 0.3 percent to the Keyhole Country Club. The remaining storage space is uncontracted and held by the United States. The storage held by the United States also serves to provide storage and reservoir elevations that are important to the recreation interests at Keyhole Reservoir. The following excerpt was taken from USBR's outlook and operating plans for water year 2013 [USBR, 2014] and gives a good background for Keyhole Unit:

> *Keyhole Reservoir (P-S MBP) located on the Belle Fourche River below Moorcroft, Wyoming, has a conservation capacity of 188,671 acre-feet (182,079 acre-feet active) and 140,463 acre-feet of exclusive flood control space. It was constructed to furnish a supplemental irrigation supply to 57,000 acres in the Belle Fourche Unit and for flood control. Keyhole Reservoir is subject to the Belle Fourche River Compact, and the inflows and storage in the reservoir are allocated 10 percent to Wyoming users and 90 percent to South Dakota users, subject to prior rights. On January 3, 1963, the Belle Fourche Irrigation District executed a long-term contract for the use of 7.7 percent of active storage space in the reservoir. This space will be used to store water belonging to the irrigation district under its prior water right along with the District's pro rata share of storable inflows to Keyhole Reservoir. On January 1, 1985, the Crook County Irrigation District's contract for 18,080 acre-feet of space in Keyhole Reservoir became effective. The allocated space is used by each organization to store its pro rata share of inflows to Keyhole Reservoir. The flood control space at Keyhole Reservoir is all located above an ungated spillway. The spillway capacity is 11,000 cfs at maximum water surface elevation. The downstream safe channel capacity is 3,000 cfs. Formulas for forecasting inflows have not been developed. Research by the Soil Conservation Service during water years 1992 through 1994 show that inflow forecasting to Keyhole Reservoir is not reliable since there is no consistent snow pack and precipitation is highly cyclical. No further efforts to develop forecast models are planned.*
>
> *Reclamation's Sedimentation and River Hydraulics Group of the Technical Service Center in Denver conducted a sedimentation survey of Keyhole Reservoir in 2003 and provided a survey report and new area and capacity tables in July 2005. The last survey was done in 1978. Keyhole Reservoir accumulated 5,082 acre-feet of sediment since the last survey. Since construction in 1952, Keyhole has accumulated 12,495 acre-feet of sediment. The sedimentation rate from 1952 through 2003 has averaged 240 acre-feet per year. The new Area and Capacity Tables were first used in Water Year (WY) 2006."* [USBR, 2006]

The USBR has reservoir data records for Keyhole dating back to 1952. As shown in Figure 3.61, reservoir storage varies by year because wet and dry cycles significantly impact the volume of water stored in Keyhole Reservoir. For the period of record for Keyhole Reservoir (1952 to 2013 full water year data), the watershed yield has averaged 16,150 acre-feet per water year (October 1 to September 30). Inflows to Keyhole Reservoir are extremely variable with the highest inflows occurring in water year 1978 at 100,300 acre-feet and the lowest inflow occurring in water year 2000 at –13,500 acre-feet [USBR, 2013]. Inflows are presented as computed inflows with evaporation being a part of the equation to compute inflows. During dry periods when inflows are computed for Keyhole Reservoir with evaporation as part of the computation, inflows become negative. This must be factored in when assessing water availability in the drainage and many reservoir drainages in the west. For the period of record for Keyhole Reservoir, evaporation has exceeded inflows to Keyhole Reservoir nearly 20 percent of the time.

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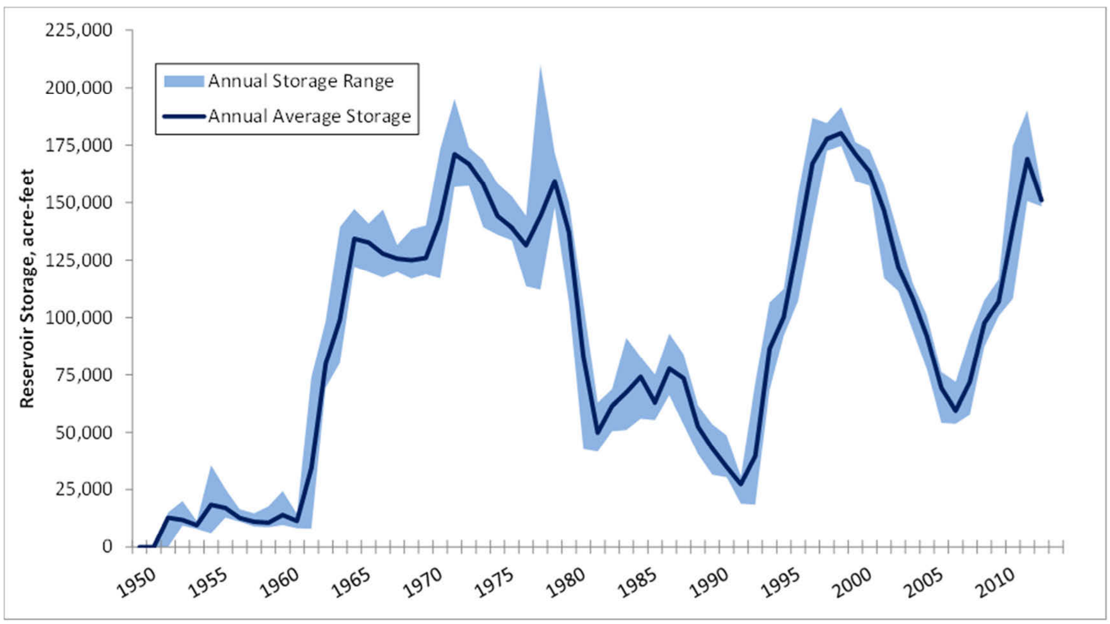


Figure 3.61. Annual Water Storage in Keyhole Reservoir.

Reservoir storage fluctuates seasonally because of spring inflows, summer and fall irrigation releases, and evaporation, which results in an average annual storage change of 27,350 acre-feet. Snowmelt and spring storms create the largest inflows during February through June. The largest outflows occur in May through August during irrigation season. Average monthly inflow and outflows to Keyhole Reservoir can be found in Table 3.41. Again, it should be noted that inflows are calculated rather than measured and, because of evaporation losses, inflows can be calculated as negative values.

Gillette Lake, owned and maintained by the city of Gillette, was constructed on Donkey Creek in 1949. Gillette Lake provides popular fishing and recreation opportunities because it is located on the southern edge of Gillette within a city park. The lake has a surface area of 48.5 acres with a capacity of 2,080 acre-feet. Gillette Lake has a history of sedimentation issues severely limit the reservoir's ability to store water. Sediment removal from the lake occurred by dredging in 1973 and again in 1984 [Campbell County Conservation District, 2005]. A sediment and phosphorus TMDL study was completed in 2013 and an overview is included in Section 3.8.3.

Table 3.41. Average Monthly Inflow and Outflow Volumes to Keyhole Reservoir From 1952 to 2014

Month	Average Monthly Volumes (acre-feet)	
	Inflow	Outflow
January	473	4
February	2,785	102
March	6,922	754
April	2,541	865
May	5,052	1,609
June	3,386	1,859
July	–830	3,970
August	–1,776	3,646
September	–1,673	714
October	–290	64
November	–298	163
December	143	6

3.9.2 Minor Reservoirs and Stock Ponds

Over 2,100 stock pond and reservoir permits within the study area have been filed with the SEO. According to the SEO, a permit is required before commencing construction of any dam or reservoir involving the storage or impoundment of water in Wyoming. Permit age ranges from the year 1901 to 2000. The permitted minor reservoirs within the study area have a combined potential storage of 121,250 acre-feet. The majority of the ponds are small with only three having storage volumes greater than 1,000 acre-feet and approximately 6.3 percent with storage volumes greater than 20 acre-feet. Figure 3.62 shows the locations of the permitted ponds and reservoirs in the study area.

3.9.3 Previously Proposed Water Storage Development

Several previous studies on potential reservoir development have been completed throughout the years and the WWDC has compiled a list of proposed reservoirs from these studies. Table 3.42 lists reservoir and dam projects proposed in different studies for the Belle Fourche River Watershed.

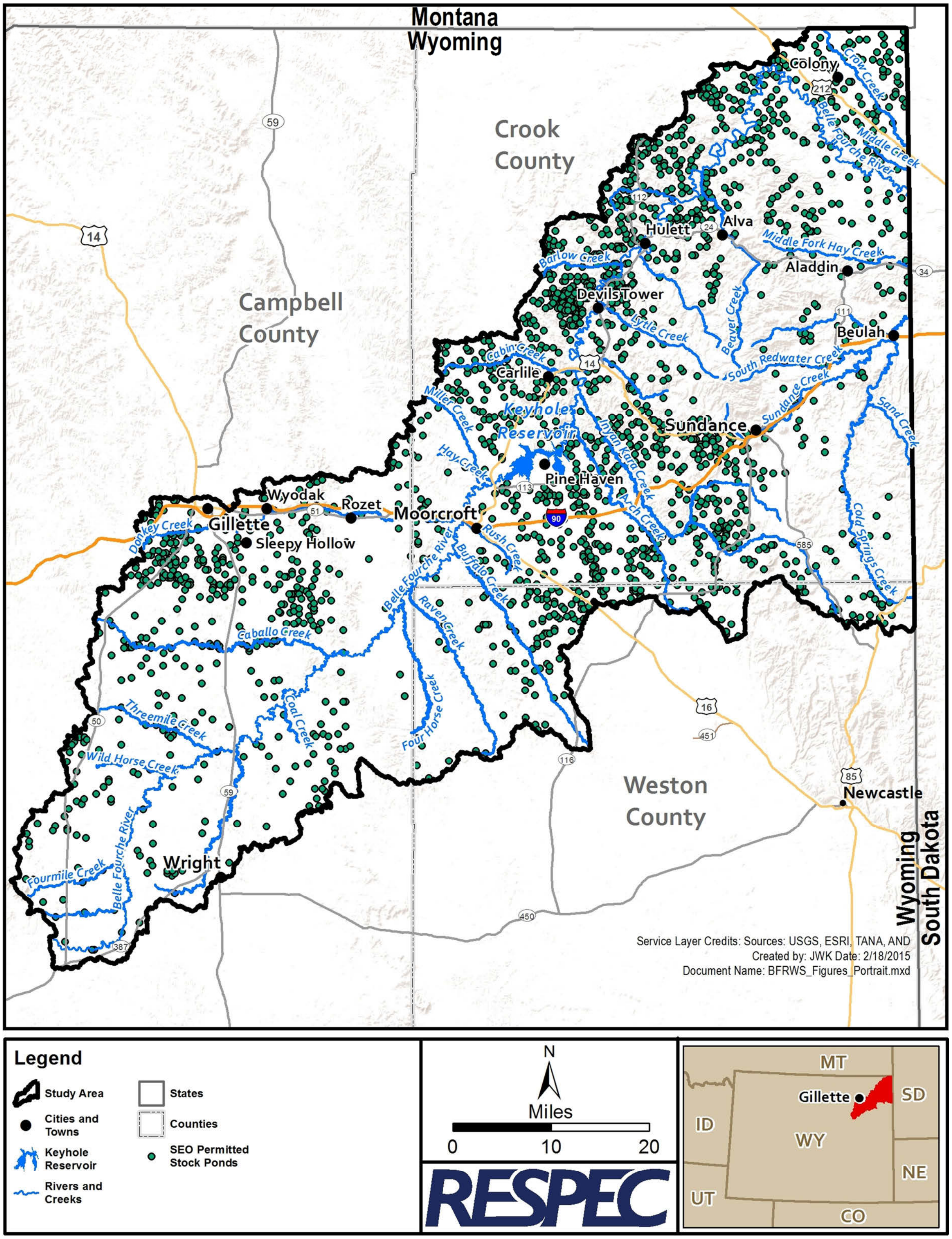


Figure 3.62. Wyoming State Engineer's Office Permitted Stock Ponds and Reservoirs Within the Belle Fourche River Watershed.

Table 3.42. Previously Proposed Reservoirs Within the Belle Fourche River Watershed (Page 1 of 2)

Project Name/ Water Source	Approximate Location	Estimated Storage (ac-ft)	Water Use	Estimated Cost ($)
Revised Project List, Irrigation and Storage, State of Wyoming by Drainage Basins, **Report Only), [Wyoming State Planning and Water Conservation Board, 1937], located at the Wyoming Water Development Commission**				
Caballo Scheme #1 Reservoir	Near Moorcroft, Crook County	10,000	A	1,500,000
Caballo Scheme #2 Reservoir	Near Moorcroft, Crook County	60,000	A	3,300,000
Caballo Reservoir	T47-51N, R67-70W, Weston County	58,790	A	1,000,000
Antelope Reservoir	Sec 1, T49N, R73W, Campbell County	1,649	A	20,000
Gillette Reservoir Enl.	Sec 22, T50N, R72W, Campbell County	3,248	A	20,000
Water Resources of Missouri River Basin in Wyoming (Belle Fourche), **Level 1, [Wyoming State Engineer's Office, 1939], located at the Wyoming Water Development Commission and State Library**				
Antelope/Donkey Creek	Sec 1, T49N, R73W, Campbell County	1,649	A	20,000
Caballo/Belle Fourche	Sec 2, T47N, R70W, Campbell County	58,787	A	1,011,210
City Gillette Enl./ Donkey and Stonepile	Sec 22, T50N, R72W, Campbell County	3,248	M, A	20,000
Livingston/Inyan Kara	Sec 8, 9, 16, T49N, R62W, Crook County	1,008	A	37,260
Shipwheel/Belle Fourche	Sec 31, T49N, R68W, Weston County	6,308	A	212,000
Report on Proposed Arch Creek Reservoir, Crook County, Wyoming, **Level 2, [Wyoming State Planning and Water Conservation Board, 1939] located at the Wyoming Water Development Office and State Library**				
Arch Creek Reservoir	Sec 32, T49N, R64W, Crook County	361	A	6,100
Crook County Reservoir Project Level 1, **[ESA Consultants, Inc., 1999], prepared for the Wyoming Water Development Commission, located at the Wyoming Water Development Office and the State Library**				
Crook County Res Alt 2/ Lytle Creek	Sec 15&16, T53N, R65W, Crook County	100	A, R	375,400
Crook County Res Alt 3/ Lytle Creek	Sec 15&16, T53N, R65W, Crook County	1,000	A, R	8,929,100
Crook County Res Alt 4/ Lytle Creek	Sec 15&16, T53N, R65W, Crook County	2,800	A, R	14,401,600

Table 3.42. Previously Proposed Reservoirs Within the Belle Fourche River Watershed (Page 2 of 2)

Project Name/ Water Source	Approximate Location	Estimated Storage (ac-ft)	Water Use[(a)]	Estimated Cost ($)
***Northeast Wyoming River Basins Plan* (Report Only), [HKM Engineering, Inc. et al., 2002], prepared for the Wyoming Water Development Commission, located at the Wyoming Water District Office and State Library**				
Inyan Kara Creek Res	Sec 1, T51N, R66W, Crook County	1,000	A, M, R	
Driskill No. 1 Res Enl.	Sec 12, T55N, R64W, Crook County	2,800	A, M, R	
Miller Creek Res	Sec 15, T52N, R64W, Crook County	1,000	A, M, R	
Lytle Creek Res	Sec 15, T53N, R64W, Crook County	1,000	A, M, R	
Blacktail Creek Res	Sec 33, T53N, R64W, Crook County	1,000	A, M, R	
Beaver Creek Res	Sec 20, T55N, R63W, Crook County	1,000	A, M, R	
***Crook County Reservoirs and Water Management Study Level 1*, [Short Elliot Hendrickson, Inc., 2006] prepared for the Wyoming Water Development Commission, located at the Wyoming Water District Office and State Library**				
Blacktail Creek	Sec 30, T54N, R64W, Crook County	2,800	A, R	17,100,000
Lytle Cr	Sec 16, T53N, R65W, Crook County	1,000	A, R	11,900,000
Oak Cr	Sec 18, T55N, R60W, Crook County	3,100	A, R	18,200,000
Pine Cr	Sec 4, T55N, R61W, Crook County	1,900	A, R	7,500,000
Miller Cr	Sec 8, T52N, R65W, Crook County	500	A, R	6,400,000
Lower Inyan Kara Cr	Sec 6, T51N, R65W, Crook County	12,600	A, R	29,300,000
Upper Inyan Kara Cr	Sec 11, T50N, R65W, Crook County	6,400	A, R	16,400,000
Redwater Cr	Sec 21, T53N, R60W, Crook County	16,800	A, R	31,800,000

(a) Water Use Codes: A = Agriculture, M = Municipal, R = Recreation.

Using information found for the general location of the sites (township, range, and section), proposed locations were mapped and can be seen in Figure 3.63. Of the previous studies completed within the watershed, the most recent is the *Crook County Reservoirs and Water Management Study Level I* [Short Elliott Hendrickson Inc., 2006]. The purpose of this study was to assess the current and potential future needs for water in the Belle Fourche River basin below Keyhole Dam including the Redwater Creek subbasin. Alternative concepts and sites for new storage were evaluated.

The study was performed in two major phases. Phase I included assessing the potential for enhanced conservation and water management in the study area; identification and quantifying

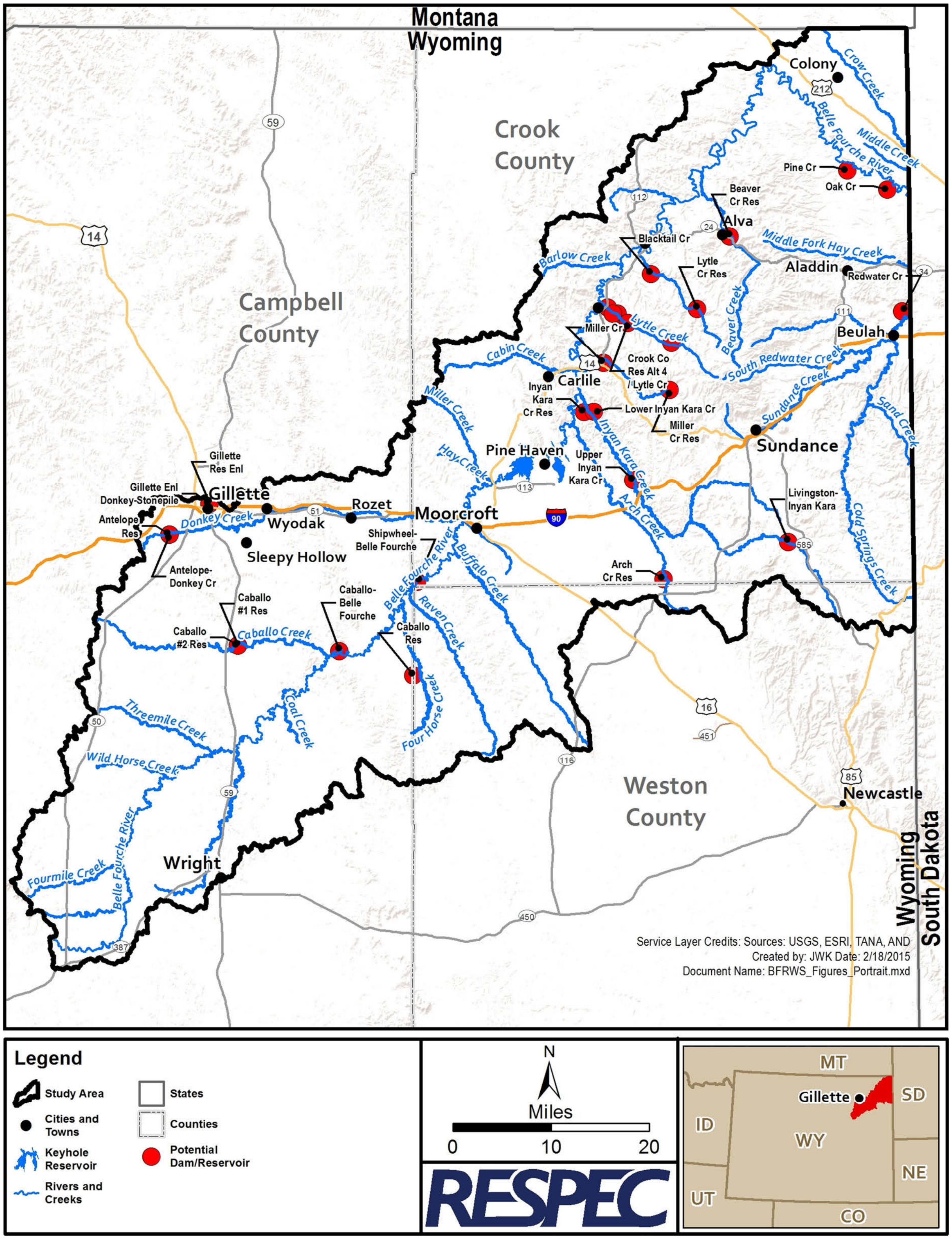


Figure 3.63. Previously Proposed Reservoir and Dam Project Locations Within the Belle Fourche River Watershed.

existing and potential future water needs; and identifying, characterizing, and screening alternative storage concepts and sites to meet the identified needs. Alternative storage concepts and sites found to meet Phase I specifications were then evaluated in more detail in Phase II which included preparing conceptual designs and order-of-magnitude cost estimates, evaluating permitting/environmental constraints and mitigation, and performing economic analyses with project financing options.

Of more than 29 sites identified in Phase I, five alternatives with a total of eight dams were studied in Phase II. The report further describes the conceptual designs including anticipated geological conditions and property ownership, permitting and environmental constraints, and economic analysis and project funding for each of the five alternatives. The following summaries of the five alternatives were taken from the *Crook County Reservoirs and Water Management Study Level I* [Short Elliott Hendrickson Inc., 2006]:

> ***Alternative 1 – Blacktail Creek (1A) and/or Lytle Creek (1B) Sites***
>
> ***Rationale.*** *Blacktail and Lytle Creeks are centrally located tributaries to the Belle Fourche River with annual available flows substantially greater than necessary to support a storage reservoir in excess of the 1,000 acre-foot Compact limitation. The confluences of both creeks are located above approximately two-thirds of the total dry year shortages on the main stem of the Belle Fourche River and its tributaries above the state line. Both creeks are also above approximately 3,000 acres of new potentially irrigable land in the Belle Fourche River valley between their confluences and the state line. Blacktail Creek joins the Belle Fourche River above the currently irrigated lands of 10 of the 17 CCID members, and Lytle Creek is above 11 of the 17.*
>
> ***Concept.*** *Alternatives 1A and 1B were selected for advancement to Phase II of this study as representative of the potential to construct moderate size reservoirs located on tributaries with confluences with the Belle Fourche River that are as far downstream as practical (to result in lower conveyance losses as compared to serving needs/demands from release of Keyhole Reservoir storage), but still above the majority of current and potential future beneficiaries of their storage. Alternative 1A on Blacktail Creek is conceptually sized to serve either a substantial portion (on the order of 60 percent) of the existing normal and dry year shortages at the lower end of the study area, or on the order of 20-25 percent of potential new irrigable lands along the Belle Fourche River valley. The reservoir capacity selected for this study is intended to maximize storage of normal year annual flows and accommodate some carry-over storage. If only supplemental irrigation needs were to be served, a larger reservoir with substantial carry-over storage would be evaluated as likely more efficient and cost-effective.*
>
> *Alternative 1B on Lytle Creek was selected as the 1,000 acre-foot option previously studied (ESA Consultants, 1999). For this study, it is assumed that this storage would serve a portion of the existing supplemental irrigation needs in the lower basin rather than irrigation of new acreage. This dam and reservoir were sized to comply with the Compact limitation of storage capacity for new reservoirs in the Belle Fourche basin in*

Wyoming, and allow order of magnitude assessment of the impacts of this limitation on cost per acre-foot of storage as compared to the similar Alternative 1A for which the Compact limitation is waived in this study.

Alternative 2 – Oak Creek (2A) and Pine Creek (2B) Sites

Rationale. *Approximately 55 percent of the existing dry year shortage on irrigated lands along the main stem of the Belle Fourche River (or 33 percent of the total shortage including tributaries to the main stem) occurs below the confluence of Pine (Deep) Creek near the downstream end of the study area. These shortages are currently addressed with releases from CCID's storage share in Keyhole Reservoir. These releases are reported to experience on the order of 50 percent conveyance loss by the time they reach the area of downstream shortages. Although significant in terms of their aggregate size, these current shortages are only experienced by 2 of the 17 current CCID members.*

Of the local tributaries to the Belle Fourche River at the lower end of the study area, Pine Creek and Oak Creek have significantly higher available annual flows (approximately 1,200 and 1,500 acre-feet in normal years) as compared to the other tributaries (which range from about 200 to 500 acre feet). The confluence of Pine Creek with the Belle Fourche River is located above 100 percent of the existing local dry year shortage, while Oak Creek's confluence is above only about 20 percent of the local shortage. As a result, storage in an Oak Creek reservoir could only serve the 80 percent of need above its confluence with the Belle Fourche River through an exchange.

There are about 340 acres of potential new irrigable ground that could be served by direct release from a Pine Creek reservoir. About 230 of those acres could be served by an Oak Creek reservoir. The corresponding potential future annual irrigation demand is on the order of 700 to 1000 acre-feet, respectively.

Concept. *Ideally, the local shortages (and/or potential future irrigation demands) at the downstream end of the study area would be addressed by constructing local storage to minimize conveyance losses. Thus, the concept considered for this Level I study is to construct reservoirs in both Pine Creek and Oak Creek with a minimum combined capacity to address the greater of the existing local needs versus potential future demands. This means storing enough water (with only minimum carry-over) required to address the total existing dry year downstream shortages. During normal years, the combined estimated yield of the two reservoirs would be on the order of three times the yield necessary to cover the normal year supplemental irrigation needs. If operated only for supplemental irrigation during dry and normal years, the reservoir pool levels would be relatively stable. This could result in some recreational benefit.*

If this alternative were to advance to the next level of study, it would be important to consider serving the same local need by constructing only one of the two reservoirs but with substantial carry-over storage. A potential advantage of this approach is the economy of scale in building a single larger reservoir instead of two smaller reservoirs. However, a single larger reservoir at either site may well result in the need for a more *expensive full PMF spillway, which would tend to cancel some (or possibly outweigh) the economy of scale inherent in one dam and reservoir.*

A key considerations with this alternative (whether constructed with one or two reservoirs) is that the proposed local storage would only directly serve the needs of 2 of the 17 current CCID members. The only potential additional benefit identified during the study would involve a "long-distance" exchange in which dry year shortages in the upper Inyan Kara Creek basin (in the extreme upstream portion of the study area) were met by additional local (i.e., Upper Inyan Kara Creek) direct-flow diversion which would be replenished by releases from carry-over storage at the reservoir(s) constructed under this Alternative 2. For this to be feasible in the first instance, such an exchange could only occur when the additional diversions in the upper basin did not create new or additional shortages along the main stem of the

Alternative 3 – Miller Creek Site

Rationale. *Miller Creek is reasonably representative of the several drainages on the west facing slope of the Bear Lodge Mountains which are moderately productive in terms of annual available flows as compared to many other of the tributaries to the main stem of the Belle Fourche River within the study area. The estimated normal year annual available flow in Miller Creek is more than adequate to support a reservoir capacity up to the Compact limitation of 1000 acre-feet. The confluence of Miller Creek also is above 12 of 17 of the current CCID members' irrigated lands, and above significantly more existing dry year shortages and potential future irrigation demand than its maximum potential yield.*

Concept. *Alternative 3 was selected to examine the potential of developing a number of small, dispersed reservoirs to meet at least some significant portion of the overall downstream current needs and potentially some future irrigation needs. Given the characteristics summarized above, a Miller Creek site was identified as a surrogate to represent a typical small dam and reservoir site. In this concept, the reservoir is sized at 500 acre-feet to evaluate the potential nature and scope of technical and environmental/cultural issues and order of magnitude cost of "small" reservoirs, and to be able to compare them to the moderate to large reservoirs represented by the other alternatives studied. It is envisioned that, if feasible, some number (perhaps as many as 5 to 10) of these smaller reservoirs could be developed over time to meet one or some combination of several optional portions of the overall needs. These could include addressing: 1) some to most of the existing irrigation shortages on the main stem Belle Fourche River; 2) potential new main stem irrigation within a relatively short distance below the confluence of the tributary to the main stem; and/or 3) potential new irrigation on the tributary itself.*

Given the existing needs for supplemental irrigation water, it is technically conceivable that enough of these "small" sites could be developed on selected tributaries to fully meet those needs. If found economically feasible to pursue in a subsequent study, it would be necessary to identify the appropriate location and size of each of such a set of dams and reservoirs to minimize to the degree practical *conveyance losses to the lands served by each site and maximize the number of beneficiaries of the releases. It would also be appropriate in such a later study to evaluate the economic and institutional potential of constructing the projects over a period of years (perhaps as much as 20-25 years) to minimize the annual debt service to the project participants(s). For the purposes of this Level I study, the economic analysis assumes that all yield from a Miller Creek reservoir would be used to serve existing downstream supplemental irrigation demand, and only the economics of this single site are considered.*

Alternative 4 – Lower Inyan Kara Creek (4A) or Upper Inyan Kara Creek (4B) Site

Rationale. *Inyan Kara Creek has the highest annual available flow of any of the tributaries to the main stem Belle Fourche River. The confluence of Inyan Kara Creek and the Belle Fourche River is high in the basin, only about eight miles below Keyhole Dam. As a result, a reservoir on Inyan Kara Creek could serve by gravity essentially any of the currently or potential future irrigated acreage on the main stem within the study area. Inyan Kara Creek is above approximately half of the total current dry year shortages and potential additional irrigation needs in the study area. Furthermore, Inyan Kara Creek is above all but one of the current CCID members' irrigated lands.*

As a result, a large reservoir on lower Inyan Kara Creek (Alternative 4A) is best located to serve the most current needs and future demands, and has the potential to store the most water of any of the main stem tributaries above the state line. However, releases from storage in an Inyan Kara Creek reservoir to serve main stem needs and demands would result in essentially the same conveyance losses as the current supplemental irrigation releases from Keyhole Dam. A more modest reservoir located higher in the Inyan Kara Creek basin (Alternative 4B) could conceivably serve at least some of the existing dry year shortages in the upper Inyan Kara Creek basin by exchange, and all potential new irrigated lands in the valley downstream to the tributary with the Belle Fourche River.

Concept. *As noted above, two different reservoir sites/sizes were evaluated on Inyan Kara Creek. The choice between these two sub-alternatives in a subsequent study (should the project advance) would depend primarily on the needs and demands to be served.*

Alternative 4A, the Lower Inyan Kara Creek dam and reservoir, is located about 2½ miles above the confluence with the Belle Fourche River. The primary concept for reservoir storage on lower Inyan Kara Creek is to maximize storage of available flows for later release to serve current shortages on the main stem, potential new irrigated acreage along the main stem, or some combination of these needs. This site is located and the dam and reservoir are sized to maximize the potential yield to serve the greatest amount of needs possible (but without significant carry-over storage). Alternative 4A is sized to meet essentially the full current downstream main stem dry year shortage, including accommodating an assumed overall 50 percent conveyance loss at the state line. Alternatively, this sub-alternative could serve on the order of half *of the estimated potential future main stem irrigation need (again accounting for order of magnitude conveyance losses).*

The third option for this site would be to serve some combination of both current needs and potential future demands. If Alternative 4A was operated exclusively to serve the existing downstream dry year shortages (in place of releases from Keyhole Reservoir), the reservoir pool could be kept relatively high during most years. This would result in the potential for significantly greater recreational benefits than operating for new irrigation. In the latter case, a seasonal fill and essentially full release would be the most efficient mode of operation. This would result in a widely fluctuating pool level and seasonally diminishing water surface area.

Sub-Alternative 4B is a smaller dam and reservoir located higher on Inyan Kara Creek. This site is located above much of the potential future irrigable lands in the Inyan Kara valley, but below enough of the higher elevation drainage area to still result in significant yield. The dam site also would result in a normal reservoir pool that would not inundate Interstate 90. Alternative 4B is envisioned at this level of study to operate primarily to serve current dry year shortages in the upper Inyan Kara basin by an exchange of direct-flow diversions for release of storage from the Alternative 4B reservoir. (Note that for the purposes of this study it is assumed that such an exchange would not result in harm to downstream or senior water rights.

Modeling to evaluate the degree to which current needs could be met without harm to existing rights is beyond the scope of this study but would be necessary if the concept were to advance to a next level of study.) These upper basin dry year shortages aggregate to on the order of 2700 acre-feet. No other single reservoir site appears feasible to serve more than a very small fraction of the dispersed areas of shortage in the upper Inyan Kara basin. The proposed Alternative 4B site could also serve the potential new irrigated lands in the valley of Inyan Kara Creek to the confluence with the Belle Fourche River. Assuming that much of the storage in Alternative 4B would be for dry year release, operating pool level would generally be maintained fairly high with only modest normal seasonal releases if new tributary acreage was to be irrigated. Thus, this site could provide relatively high quality flat water recreational benefits.

Alternative 5 – Redwater Creek Site

Rationale. *The total normal year available flow in the Redwater Creek Basin below the confluence with Sand Creek (just above the Wyoming – South Dakota state line) is approximately 28,000 acre-feet. This represents approximately 35 percent of the total normal year available flow in the study area below Keyhole Reservoir. Redwater Creek flows are on the order of 2½ times the flow in the next most productive tributary (Inyan Kara Creek, just below Keyhole Reservoir) and 5-10 times the available flow in any other of the most productive tributaries to the main stem Belle Fourche River in Wyoming. However, the major portion of the Redwater Creek available flow is not realized until the tributary flows from Sand Creek are included. Sand Creek's* *confluence with Redwater Creek is just above Beulah, Wyoming close to the Wyoming-South Dakota state line.*

Redwater Creek leaves Wyoming just southeast of Beulah and flows through South Dakota to its confluence with the Belle Fourche River at Belle Fourche, South Dakota. The confluence is above the diversion to Belle Fourche Reservoir. Although beyond the scope of this study to determine, it is believed that a significant portion of the annual available flow in Redwater Creek may be lost to use in South Dakota due to limitations in the capacity of the existing diversion into Belle Fourche Reservoir and the reservoir's storage capacity. This assumption is based in part on the fact that the Belle Fourche Irrigation District (BFID) has called for sometimes significant releases from Keyhole Reservoir as supplemental irrigation water during dry years. Also, some interest was expressed by participants from South Dakota at the 2004 Belle Fourche River Compact Meeting in the idea of further evaluating the potential of significant storage on Redwater Creek and the associated Compact and related issues.

Releases from Keyhole Reservoir to the BFID (and to CCID) experience substantial net conveyance losses in the Belle Fourche River. It is believed that this loss is on the order of 50 percent by the time flows reach the state line, and it is assumed that additional losses accrue between there and Belle Fourche Reservoir. The conveyance distance from Keyhole Reservoir to Belle Fourche Reservoir is approximately five times the conveyance distance from the Alternative 5 reservoir on Redwater Creek. Thus, even if order of magnitude conveyance losses on Redwater Creek were similar to those on the main stem Belle Fourche River, actual losses from release of storage from a Redwater Creek reservoir may be substantially less, perhaps on the order of 80 percent less just due to the shorter conveyance distance. If confirmed with subsequent study, this factor may provide additional incentive to consider storage in Redwater Creek to cover as much as possible of the dry year supplemental irrigation needs currently provided by the BFID's storage in Keyhole Reservoir.

Finally, there may be some future interest in South Dakota to bring new lands under irrigation that could be served by storage on Redwater Creek. Although beyond the scope of the current investigations, it is conjectured that this might, for example, involve increased corn production to support the growing ethanol industry in South Dakota and the Upper Midwest, or additional alfalfa production to support growth in the pellet feed industry.

Concept. *In discussions during the Scoping Meeting and subsequently with WWDC staff and CCID representatives, it was agreed that one alternative for this study should examine the potential to capture as much of the available flow on Redwater Creek as appeared practical. It was understood that the evaluation of this alternative would disregard the current Compact storage limitation of 1,000 acre-feet in Wyoming, and would not attempt to quantify potential benefits or assess the current interest of South Dakota irrigators in the concept. Rather, the evaluation was to look at the conceptual-level practicality of storing the maximum amount of available flow in Wyoming possible in terms of dam and reservoir location and size, order-of magnitude cost, and potential environmental and cultural resources issues.*

Given this preliminary evaluation, a decision could be made later by Wyoming and South Dakota as to their mutual interest in pursuing further investigation of this concept. Any such investigation would have to consider and/or evaluate a number of key factors, including but not limited to the following:

- *Agreement between the states to modify the current Compact limitation of a maximum storage capacity of 1,000 acre-feet solely for Wyoming's benefit.*
- *Quantification of current and projected needs in South Dakota for additional storage above Belle Fourche Reservoir.*
- *Quantification of potential reductions in conveyance losses as compared to releases from Keyhole Dam.*
- *Potential for exchange of releases from a Redwater Creek reservoir for use in South Dakota with commensurate additional diversions from the main stem of the Belle Fourche River (and/or its tributaries) within Wyoming; including an appropriate adjustment for conveyance losses (or reduction of such losses).*

In general terms, the benefits that could accrue to one or both states under a joint project to construct a Redwater Creek dam and reservoir include:

- *Storage of Wyoming's full 10 percent allotment of available flow in the Redwater Creek basin (approximately 2,800 acre-feet per year).*
- *Use of Wyoming's stored available flow for use elsewhere in the Belle Fourche River basin by in-state exchange.*
- *Storage of a significant portion of South Dakota's allotment of Redwater Creek flows that are believed to be currently unused due to lack of sufficient diversion and/or storage capacity in South Dakota.*
- *Potential to support future expansion of corn, alfalfa and possibly other irrigated crop production in South Dakota.*
- *More efficient use of available flows from the study area by additional diversions of flow in the main stem Belle Fourche River during periods of shortage that would be "made up" to South Dakota by releases from storage in a maximized Redwater Creek reservoir.*
- *Recreational benefits of a nearly 700 surface acre reservoir located close to Sundance and Gillette, Wyoming and Belle Fourche and Rapid City, South Dakota.*

Given the very significant intra-state and Compact issues involved, and uncertainty at this level of study as to even the order of magnitude of quantitative potential benefits that may accrue to each state, it is not feasible to perform more than a very abbreviated economic analysis of this alternative. The most that is practical at this time is to identify the order of magnitude project cost and potential debt service under an assumed set of financing conditions.

4.0 BELLE FOURCHE RIVER WATERSHED MANAGEMENT AND REHABILITATION PLAN

4.1 OVERVIEW

The objective of this Level I Watershed Study is to generate a watershed management and rehabilitation plan that is technically sound, practical in nature, and economically feasible. In conjunction with the development of the study's GIS, the inventory focused on assessing the watershed and the identifying and evaluating improvements to address those issues described in Chapter 3.0. Potential improvements were developed and categorized into the following:

- **Irrigation System Conservation and Rehabilitation.** The inventory and evaluation of the existing infrastructure was completed and improvements identified for rehabilitating existing structures and the potential conservation of existing irrigation diversions.

- **Livestock/Wildlife Upland Watering Opportunities.** Based on an evaluation of existing water sources and the condition of upland grazing resources, potential upland water source development projects were identified.

- **Grazing Management Opportunities.** Based on a review of the pertinent ESDs and the ambient vegetation and soil conditions, grazing management strategies are presented.

- **Surface Water Storage Opportunities.** The results of previous investigations pertaining to developing water storage opportunities within the watershed were incorporated.

- **Stream Channel Condition and Stability.** 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.

- **Wetlands Enhancement Opportunities.** Opportunities to establish new wetlands or enhance existing wetlands exist within the watershed were defined.

- **Other Watershed Management Opportunities.** For each of the categories described above, a series of recommended projects were prescribed in the following portions of this chapter. These plans have been prepared to provide an overview of potential improvements that can partially or fully address the key issue identified within the watershed.

In this chapter, the conceptual plans developed within each watershed component are described and evaluated with respect to providing benefits to improving the existing water supply through conservation. For the purposes of tracking individual components of the watershed management plan, each component was designated a unique project or “improvement” number. The following prefixes were used for each improvement to describe the category of the watershed management plan it falls under:

- Project Components “I”: Irrigation system rehabilitation components (Section 4.4)
- Project Components “LW”: Livestock/wildlife upland watering opportunities (Section 4.5)
- Project Components “G”: Grazing management opportunities (Section 4.6)
- Project Components “S”: Surface water storage opportunities (Section 4.7)
- Project Components “C”: Stream channel stability components (Section 4.8)
- Project Components “W”: Wetlands enhancement opportunities (Section 4.9)
- Project Components “O”: Other watershed management opportunities (Section 4.10).

4.2 POTENTIAL EFFECTS AND BENEFITS OF WATERSHED MANAGEMENT PLAN COMPONENTS

The WWDC Level I Watershed Study is a fundamental landscape analysis confined to a hydrologically connected drainage area or watershed and is focused on two primary components. The first component is identifying the physical attributes of that analysis area. This is accomplished by conducting a comprehensive inventory of the natural resources and subsequently using that inventory to articulate a description of the current natural resource conditions. The second component is a long-range plan that outlines management and/or rehabilitation opportunities and activities that address ecological enhancement and watershed function.

Such activities, in the conservation community, are commonly referred to as best management practices (BMPs) or conservation practices. These BMPs and conservation practices are eligible for grant funding assistance through the WWDC’s Small Water Project Program (SWPP). The WWDC’s SWPP funds are mainly used for installing BMPs and conservation practices such as stock ponds, water wells, buried water delivery pipelines, stock tanks, spring developments, solar platforms and pumps, wetland enhancement and restoration, windmills, and irrigation diversion and conveyance improvements.

One or more benefits can result from implementing BMPs and conservation practices. Such benefits can be quantitative, qualitative, or both. Benefits can be local or global and specific or surrogate, depending on multiple factors unique and specific to the BMP or conservation practice, ecological site, watershed, or major land resource area. BMPs and conservation practices also provide opportunities to relieve grazing pressure on riparian areas and create the potential to induce improvements to soil health, plant community diversity, and improved forage production. They allow for grazing deferment in the event that rest is required because of invasive species control efforts, which can also stimulate water release.

Benefits to ecosystem functionality and landscape health can be and is a response to soil health, water infiltration/percolation, and a functioning water cycle. Expected project benefits can be related to watershed function, including collecting and storing water, ecological enhancements such as plant and animal habitat and stream corridor or riverine stability, and societal values including economic stability and open space maintenance. Multiple benefits can result from improvement opportunities for water resources, which are critical to meet the daily water demands of the resident population of humans and animals; develop, increase, or extend irrigation water availability; and improve fishery habitat and potential recreational benefits.

4.2.1 Natural Resources Conservation Service Conservation Effects Assessment

In 2003, in the interest of government accountability, Congress and the Office of Management and Budget requested information from the U.S. Department of Agriculture (USDA) about the effectiveness of its conservation programs. In response, the Conservation Effects Assessment Project (CEAP) was initiated by the NRCS to provide quantitative information about the environmental impacts of its conservation practices on agricultural lands within the contiguous 48 United States. The CEAP is a joint effort of the NRCS, Agricultural Research Service (ARS), National Institute for Food and Agriculture, other federal agencies, and university scientists to quantify the environmental effects of NRCS conservation practices and programs and to develop the science base for managing the agricultural landscape for environmental quality. Initially focused on croplands, the CEAP effort has been expanded to include wildlife, wetlands, pastures, and rangelands.

The CEAP findings have been used to guide USDA conservation policy and program development that will assist conservationists, farmers, and ranchers with informed conservation decisions" [Spaeth et al., 2013]. The end product of the CEAP is a literature review and a concise collection of information from hundreds of published scientific papers, journals, and additional references. Consequently, the CEAP documents provide a valuable source of information pertaining to various BMPs incorporated in this plan and are referenced throughout the remainder of this section.

4.2.2 Watershed Function

Identifying improvement opportunities for hydrologic and watershed function, including water quantity, yield and use, is an essential element of the Level I Watershed Study. Hydrologically, the following three fundamental watershed functions [Black, 1997]:

1. Collecting water from rainfall, snowmelt, and storage that becomes runoff
2. Storing various amounts and durations
3. Discharging of water as runoff.

Watershed characteristics such as geologic structure, soils, landform, topography, vegetation, and climate influence the capture or collection of precipitation, infiltration and storage of surface water and groundwater, and runoff or discharge of water.

Implementing BMPs and conservation practices can affect water resource quantity through improved plant communities, vegetative diversity, and ecological site health achieved from water development. Creating reliable water sources in areas devoid of such allows for establishing grazing systems and changes in grazing distribution. Hydrological responses to grazing are strongly contingent on the vegetative community composition, with communities that provide greater cover and obstruction to overland flow, such as midgrass-dominated communities having greater hydrological function, including infiltration rate, than shortgrass-dominated communities [Wood and Blackburn, 1981; Thurow, 1991; NRCS, 2011].

Poor water distribution has been the primary cause of poor livestock distribution [Holechek, 1997]. Livestock distribution and grazing behavior can be modified by adjusting the location of supplemental feed and water, implementing patch burns, and herding in addition to the traditional practice of fencing [Williams, 1954; Ganskopp, 2001; Fuhlendorf and Engle, 2004; Bailey, 2005]. The NRCS [2011] reviewed many studies and found that water distribution, steep slopes, and high elevations clearly influenced livestock distribution. Also sufficient evidence existed to recommend that the NRCS increase the role of herding and supplement placement along with water development and fences for managing livestock distribution [NRCS, 2011].

Soil vegetative cover is widely recognized as a critical factor in maintaining soil surface hydrologic condition and reducing soil erosion [Gifford, 1985; NRCS, 2011]. Stocking rates, regardless of grazing system, that reduce soil surface vegetative cover below a site-specific threshold increases detachment and mobilization of soil particles because of raindrop impact, decreases soil organic matter and soil aggregate stability, increases soil surface crusting, reduces soil surface porosity; thus, infiltration decreases and soil erosion and sediment transport increases [Blackburn, 1984]. Sufficient vegetative cover, critical soil cover, or residual biomass must remain during and following grazing to protect soil surface condition (e.g., porosity, aggregate stability, and organic matter) and hydrologic properties (e.g., infiltration); however, these site-specific vegetation cover requirements vary depending on cover type (e.g., vegetation, litter, or rock), soil type, rainfall intensities, and water quality goals [Gifford, 1985]. The erosive energy of water and the long-term reduction of organic matter additions to soil detrimentally affect numerous soil properties, including the increase of bulk density, disruption of biotic crusts, reduced aggregate stability, and organic matter content, which collectively reduce infiltration rate and increase sediment yield and runoff [NRCS, 2011].

These efforts can increase water infiltration/percolation, stimulate spring flows, and increase flow volume and duration. An example of restoring watershed function and water quantity was in a 74,000-acre watershed in West Texas near San Angelo where West Rocky Creek (a dry, intermittent stream for decades) started flowing again [Moseley, 1983; Wiedenfeld, 1986]. In the early part of the twentieth century, West Rocky Creek was a year-long, flowing stream until the late 1910s, when it became an intermittent stream and by 1935, the springs feeding the creek had been dried up by mesquite and other invading woody plants [Moseley, 1983; Wiedenfeld, 1986].

During the 1950s and 1960s, ranchers and landowners on five ranches, covering about one-half of the watershed, began conservation work including root-plowing, reseeding, tree-dozing, aerial spraying, and chaining of mainly mesquite and juniper brush. This limited water availability for native grasses such as sideoats grama, buffalograss, curly mesquite, and tobosa [Moseley, 1983]. Approximately 30,000 acres (70 percent) of the mesquite was removed from the watershed, and the original prairie was restored [Moseley, 1983; Wiedenfeld, 1986]. In the mid- to late-1960s, one of the five ranchers noticed that a spring, which was dry since 1935, had started flowing again, and by replacing the water-hungry brush with a good grass cover, more rainfall soaked into the aquifer and recharged the dormant springs and flow began on all five ranches by 1970 [Moseley, 1983]. Ongoing grazing management on each ranch enhanced the cover of grasses in the watershed with soils producing an estimated 2,000 to 2,500 pounds of forage per acre, which helps retard brush succession; the ranchers periodically must maintain and control brush to keep the preferred vegetation balance [Moseley, 1983].

In southeast Arizona, long-term data on soils, vegetation, hydrology, and climate have been collected for over 5 decades on the Walnut Gulch Experimental Watershed, which is operated by the USDA's ARS. The Walnut Gulch Experimental Watershed is one of the most intensively instrumented, semiarid, experimental watersheds in the world, with a 10- to 100-year record of abiotic and biotic measurements and photographs [Moran et al., 2008]. Researchers studied the interaction between rainfall intensity and soils and vegetation by comparing the frequency of runoff-producing summer events between a shrub-dominated watershed and a grass-dominated watershed and found that higher rainfall intensities are needed to produce runoff on the grassed watershed [USDA, 2013]. The results also indicate that the grassland plant community is producing more plant material than the shrubland, with close to the same amount of precipitation input, which makes the grassland ecosystem more water-use efficient [USDA, 2013]. Researchers found that runoff quantities at the watershed scale are controlled by infiltration of water into alluvial channels and distribution of thunderstorm rainfall [USDA, 2013].

4.2.3 Ecological Enhancement

An ecological enhancement is any activity that improves an ecosystem, such as stabilizing erosive soils; increasing soil quality; planting or maintaining native grasses, shrubs, or trees; removing and controlling invasive species; and improving or maintaining riparian/wetland areas. Ecological sites are complex and varied within the study area as described in Section 3.4.5.6 and Figure 3.10. The potential benefits achieved from project activities and implementations that influence the condition of those ecological sites and characteristics are also just as complex and varied.

Conjunctive to soil function is plant community diversity, health and productivity and subsequent forage diversity, production and wildlife habitat. Benefits accrued to water quality are significant because improvements to the chemical, physical, and biological constituents of a waterbody produce both local site enhancements and those transferred downstream. Wetland enhancement and restoration provides benefits to ecological stabilization and contributions to water quality and quantity. Ecologically, watersheds function by providing diverse sites and pathways along which vital chemical reactions occur and furnishing habitat for the flora and fauna that constitute the biological elements of ecosystems [Black, 1997].

4.2.3.1 Plant and Animal Habitat

Locations of conservation practices and rangeland infrastructure can have a large, indirect impact on overall vegetation change with the spatial design of infrastructure, including fence locations, watering points, and feeders that are used to modify patterns of animal movement and forage utilization, taking into account livestock behavior and the template of topography and plant communities to which livestock respond [Laca, 2009; NRCS, 2011]. Using rangelands for sustainable livestock production has the potential to ensure that the wildlife habitat will continue into the future [NRCS, 2011]. Wildlife responses to conservation practices are usually species and even species-habitat specific, meaning not only that each species may respond differently to any specific practice, but also that a single species may respond differently to the same practice in different vegetation associations or conditions [NRCS, 2011].

Free-stranding water has been considered to be a resource that limits distribution and abundance of many species of wildlife in arid regions of the United States, and water developments have been used since the 1940s to improve wildlife habitat [Simpson et al., 2011]. Simpson et al. [2011] compiled and evaluated available literature for evidence of the effects of water sources on wildlife populations. Positive effects of water developments on wildlife have been documented, and species thought previously not to use free-standing water developments do so when it is available [Simpson et al., 2011]. Additionally, researchers studied the effects of wildlife water developments in southwestern Arizona and found that water developments were used by a diverse array of wildlife, including mule deer, game birds, and several nongame species [Rosenstock et al., 2004].

4.2.3.2 Stream Corridors and Riparian/Wetland Areas

Reducing the impact to riparian plant communities by developing upland water resources can result in in-stream corridor benefits. Riparian plant community diversity and regeneration of preferred important woody species can help restore local water tables, trap sediments, increase wildlife habitat and migration corridors, and stabilize stream banks (which can affect localized land loss). In addition, aquatic population benefits can accrue and recreation potential can be realized.

Livestock distribution practices such as water developments, supplement placement, and herding are effective means of managing the intensity and season of livestock grazing in riparian areas [NRCS, 2011]. The season of grazing also determines livestock grazing effects on riparian plant communities, particularly woody plants, and can be managed to conserve riparian habitats and their associated services [NRCS, 2011]. Sufficient evidence exists in peer-reviewed studies to suggest that NRCS riparian grazing management would maintain or enhance key riparian vegetation attributes (i.e., species composition, root mass and root density, cover, and biomass). It would also enhance stream channel and riparian soil stability, which will in turn support ecosystem services, such as flood and pollutant attenuation and high-quality riparian habitat [NRCS, 2011]. Peer-reviewed literature generally supports the effectiveness of water developments, supplement placement, and herding for reducing riparian vegetation utilization, or time spent in riparian areas [NRCS, 2011].

4.2.4 Societal Value

Natural resource stewardship not only has economic value in terms of forage, livestock, and wildlife production relationships, but also can have noneconomic value placed on those conservation practices by society. Those values can even influence the perception of those implementing conservation practices and can be as much of an influence in the decision process to implement conservation as is an economic value. Additionally, a BMP or conservation practice can possibly provide an ecological service to accrue more value to society in general than to a local landowner. Ecosystem services are defined as those things or experiences produced by natural systems on which humans place value [NRCS, 2011]. Ecosystem services benefit society in diverse ways while each of the conservation practices can potentially produce different kinds, qualities, and amounts of these goods and services, depending on location, natural potentials, current states, and other factors.

Noneconomic values can and should be considered in determining watershed enhancement programs, particularly when considering public investment in conservation. NRCS [2011] found little to no research exists showing the direct noneconomic effects of BMPs and conservation practices on individuals, households, or social systems but acknowledged that producers likely realize psychological benefits from conservation because stewardship typically ranks high among the management goals of livestock producers [Huntsinger and Fortmann, 1990; Sayre, 2004]. Moreover, producers who believe strongly in a responsibility to society are more likely to engage in environmentally sound management practices, such as invasive weed control and riparian protection [Kreuter et al., 2005].

In 2012, in cooperation with the Wyoming Stock Growers Association (WGSA), University of Wyoming, and University of California-Davis, research scientists with the USDA's ARS Rangeland Resources Research Unit in Cheyenne, Wyoming, who were investigating the effects of rangeland management decision making, asked WGSA producer members about their goals, ranching operations, and management practices via a mail survey. A total of 307 ranchers responded to the survey [Kachergis et al., 2013; Mealor, 2013]. Livestock production and forage production were the top management goals, with ecosystem characteristics that support these goals (e.g., soil health and water quality) second [Kacheris et al., 2013; Mealor, 2013].

In addition to other social values and ecological enhancements, open spaces have long been held with high value to Wyoming and other western region states. From a ranching industry perspective, tourism interest, outdoor recreationist activity, or a real-estate value, open space is significant. Preservation of our custom and culture has been and continues to be a focal point of consideration. Open spaces are critical for upland/riparian conductivity, wildlife migrations and habitat, and recreational opportunity. Open space is valued for preservation of cultural resources and for reducing or preventing of land conversion to a condition that can be stewarded to an improved ecological condition.

4.3 IRRIGATION INVENTORY

Three planning efforts, listed below, regarding irrigation water storage, management, and needs have been completed within the study area on behalf of the WWDC:

- *Final Report, Crook County Reservoir Project – Level I*, prepared by ESA Consultants Inc., July 1999.
- *Northeast Wyoming River Basins Plan Final Report*, prepared by HKM Engineering Inc., Lord Consulting, and Watts and Associates, February 2002.
- *Crook County Reservoirs and Water Management Study – Level I*, prepared by Short Elliot Hendrickson Inc., in association with Anderson Consulting Engineers, Inc., Watts and Associates, Inc., February 2006.

These previous planning efforts primarily focused on identifying and assessing irrigation water storage needs within the project area. The inventory efforts of this Level I study primarily focused on assessing and evaluating current irrigation infrastructure needs and potential system improvements within the study area. Specific irrigation structures, inventories, and evaluations were conducted at the request of irrigators and water users. Irrigators' concerns are included in this report to provide guidance on future investigations or potential projects. In general, each landowner identified the structures to be evaluated during the site visit. Typically, the landowners accompanied field crews during the inventory.

4.4 IRRIGATION SYSTEM RECOMMENDATIONS

This plan and its alternatives provide the irrigators and landowners with an assessment of conditions associated with the irrigation delivery infrastructure and associated hydraulic structures. The landowner or manager could use the alternatives in this plan as a starting point from which they could select projects for further design and for potential funding assistance from the WWDC's SWPP, the NRCS Environmental Quality Incentives Program (EQIP), or other participating conservation or watershed programs.

4.4.1 Summary of the Inventory of Irrigation System Projects

Irrigation system inventory efforts associated with this project consisted of evaluating structures, ditch conditions, and water storage structures at the request of interested landowners and stakeholders. At the request of those individuals who requested to participate in the study, irrigation system components were inventoried. The recommendations included herein are not all inclusive. Additional irrigation structures that are in need of rehabilitation or replacement are located throughout the watershed. Because of their location within the study area, these additional projects are eligible to apply for funding through the WWDC's SWPP.

Based upon the results of the field inventory, conceptual rehabilitation plans were developed for each structure. In an effort to assist the irrigator or landowner, the CCID, the CCCD, and the CCNRD in prioritizing potential improvements to each irrigation delivery system, relative priorities were defined as follows:

- **Priority 1:** Install, replace, or rehabilitate aging infrastructure critical to the diversion and delivering water.
- **Priority 2:** Install, replace, or rehabilitate aging infrastructure critical to operating, measuring, and managing the irrigation diversions.
- **Priority 3:** Install, replace, or rehabilitate aging infrastructure to provide improvements in efficiency and conservation on farms.

The information in this plan provides the landowners with an assessment of the conditions associated with the structures that were inventoried during the fieldwork. The following improvements were identified after the field investigation and assessment of the data collection efforts. In Sections 4.4.1.1 through 4.4.1.16, the individual structures inventoried and assessed are discussed. Each irrigation system improvement was assigned a unique identifier within the watershed plan. The structures inventoried and their respective component identifiers in the watershed management plan are summarized in Table 4.1. This information has been incorporated in the study's GIS. Figures 4.1 through 4.4 illustrate the typical conditions of the inventoried irrigation diversion and headgate structures within the study area.

Table 4.1. Summary of Recommended Irrigation System Improvements (Page 1 of 2)

Item Number	Description	Priority
I-01	• Rehabilitate diversion structure and headgate on North Redwater Creek • Install irrigation regulating reservoir • Rehabilitate approximately 5,610 feet of 12-inch plastic irrigation pipe (PIP) pipeline and flume	1
I-02	• Rehabilitate diversion structure and headgate. • Rehabilitate approximately 2,620 feet of 12-inch PIP pipeline and flume	1
I-03	• Rehabilitate the diversion and check structure on Lytle Creek • Install irrigation regulating reservoir • Install approximately 7,040 feet of 15-inch PIP pipeline • Install approximately 2,400 feet of 12-inch PIP pipeline • Install approximately 2,480 feet of 12-inch PIP pipeline, headgate, and flume • Install approximately 2,140 feet of 10-inch PIP pipeline and headgate	1
I-03A I-03B	• Install diversion and pump • Install approximately 1,300 feet of 8-inch PIP pipeline and pump • Rehabilitate the diversion structure and pump	3
I-04 I-04A	• Rehabilitate irrigation reservoir and dam • Install diversion structure and headgate • Install approximately 5,890 feet of 12-inch PIP pipeline • Install irrigation regulating reservoir • Install diversion structure and headgate • Install approximately 6,740 feet of 12-inch PIP pipeline	3
I-05	• Rehabilitate Pine (Deep) Creek Reservoir (see Section 4.7.1.4)	3
I-06	• Install diversion structure and headgate • Install approximately 7,020 feet of 12-inch PIP pipeline • Install approximately 650 feet of 10-inch PIP pipeline	3
I-07	• Rehabilitate Oak Creek Reservoir (see Section 4.7.1.5)	2
I-08	• Install diversion structure and headgate • Install irrigation regulating reservoir • Install approximately 4,510 feet of 12-inch PIP pipeline	2

Table 4.1. Summary of Recommended Irrigation System Improvements (Page 2 of 2)

Item Number	Description	Priority
I-09	• Install diversion structure and headgate • Install irrigation regulating reservoir • Install approximately 2,470 feet of 12-inch PIP pipeline	3
I-10	• Install two diversion structures and pumps • Install approximately 4,760 feet of 12-inch PIP pipeline	3
I-11	• Install diversion structure and headgate • Install irrigation regulating reservoir • Install approximately 4,540 feet of 12-inch PIP pipeline	3
I-12	• Install diversion structure and pump • Install approximately 1,820 feet of 12-inch PIP pipeline	3
I-13	• Rehabilitate Mule Shoe Reservoir (see Section 4.7.1.9)	3
I-14	• Install diversion structure and headgate • Install approximately 8,920 feet of 12-inch PIP pipeline	3
I-15	• Install two diversion structures and headgates • Install approximately 6,800 feet of 12-inch PIP pipeline	2

4.4.1.1 Irrigation Component I-01: North Redwater Irrigation Pipeline Project

Rehabilitation of the diversion structure and headgate is needed on the North Redwater Creek. This project involves the following components:

- **Item No. I-01.1:** Rehabilitate diversion structure and headgate on North Redwater Creek
- **Item No. I-01.2:** Install irrigation regulating reservoir
- **Item No. I-01.3:** Install 3,520 feet of 12-inch PIP pipeline
- **Item No. I-01.4:** Install approximately 2,090 feet of 12-inch PIP pipeline.

4.4.1.2 Irrigation Component I-02: South Redwater Irrigation Pipeline Project

Rehabilitation of the diversion structure and headgate is needed on South Redwater Creek to supply water to Irrigation Component I-01. This project involves the following components:

- **Item No. I-02.1:** Rehabilitate structure and headgate on South Redwater Creek
- **Item No. I-02.2**: Install approximately 2,620 feet of 12-inch PIP pipeline.

RSI-2264-15-066

Figure 4-1. Diversion and Headgate Structure on North Redwater Creek.

RSI-2264-15-067

Figure 4-2. Outlet and Diversion Structure at Driskill #1 Reservoir on Lytle Creek.

RSI-2264-15-068

Figure 4-3. Headgate Structure on Lateral Ditch on Oak Creek.

RSI-2264-15-069

Figure 4-4. Irrigation Pump and Diversion Structure on the Belle Fourche River.

4.4.1.3 Irrigation Component I-03: Lytle Creek Irrigation Pipeline Project

Rehabilitation of the diversion structure and headgate on Lytle Creek is needed to supply water to the proposed regulating reservoir. This project involves the following components:

- **Item No. I-03.1:** Rehabilitate the diversion and check structure on Lytle Creek
- **Item No. I-03.2:** Install irrigation regulating reservoir
- **Item No. I-03.3:** Install approximately 7,040 feet of 15-inch PIP pipeline
- **Item No. I-03.4:** Install approximately 2,400 feet of 12-inch PIP pipeline
- **Item No. I-03.5:** Install approximately 2,480 feet of 12-inch PIP pipeline and flume
- **Item No. I-03.6:** Install approximately 2,140 feet of 10-inch PIP pipeline and headgate.

4.4.1.4 Irrigation Component I-03A and I-03B: Bear Lodge Irrigation Diversion Project

Installation or rehabilitation of a diversion/pump structure is needed. This project involves the following components:

- **Item No. I-03A.1:** Install diversion and pump
- **Item No. I-03A.2:** Install approximately 1,300 feet of 8-inch PIP pipeline and pump
- **Item No. I-03B.1:** Rehabilitate the diversion structure and pump.

4.4.1.5 Irrigation Component I-04 and I-04A: Helmer Reservoir Irrigation Pipeline Project

Installation or rehabilitation of a diversion/pump structure is needed. This project involves the following components:

- **Item No. I-04.1:** Install diversion structure and headgate
- **Item No. I-04.2:** Install irrigation regulating reservoir
- **Item No. I-04.3:** Install approximately 6,740 feet of 12-inch PIP pipeline
- **Item No. I-04A.1:** Install diversion structure and headgate
- **Item No. I-04A.2:** Rehabilitate irrigation reservoir and dam
- **Item No. I-04A.3:** Install 5,890 feet of 12-inch PIP pipeline.

4.4.1.6 Irrigation Component I-05: Pine (Deep) Creek Reservoir Rehabilitation Project

Rehabilitation of the Pine (Deep) Creek Reservoir is needed. This project involves the following components:

- **Item No. I-05.1:** Rehabilitate Pine (Deep) Creek Reservoir and dam.

4.4.1.7 Irrigation Component I-06: Pine (Deep) Creek Reservoir Irrigation Pipeline Project

Installation of a diversion structure and headgate would supply irrigation water to new areas. This project involves the following components:

- **Item No. I-06.1:** Install diversion structure and headgate
- **Item No. I-06.2:** Install approximately 7,020 feet of 12-inch PIP pipeline
- **Item No. I-06.3:** Install approximately 650 feet of 10-inch PIP pipeline.

4.4.1.8 Irrigation Component I-07: Oak Creek Reservoir Rehabilitation Project

Rehabilitation of the Oak Creek Reservoir is needed. This project involves the following components:

- **Item No. I-07.1:** Rehabilitate irrigation reservoir on Oak Creek.

4.4.1.9 Irrigation Component I-08: Oak Creek Reservoir Irrigation Pipeline Project

Installation of a diversion structure, regulating reservoir, and pipeline would supply irrigation water to new areas. This project involves the following components:

- **Item No. I-08.1:** Install diversion structure and headgate
- **Item No. I-08.2:** Install irrigation regulating reservoir
- **Item No. I-08.3:** Install approximately 4,510 feet of 12-inch PIP pipeline.

4.4.1.10 Irrigation Component I-09: Christofferson Reservoir Rehabilitation and Irrigation Pipeline Project

Installation of a diversion structure, regulating reservoir, and pipeline would supply irrigation water to new areas. This project involves the following components:

- **Item No. I-09.1:** Install diversion structure and headgate
- **Item No. I-09.2:** Install irrigation regulating reservoir
- **Item No. I-09.3:** Install approximately 2,470 feet of 12-inch PIP pipeline.

4.4.1.11 Irrigation Component I-10: Bear Gulch Irrigation Pipeline Project

Installation of two diversion structures and pumps would supply irrigation water to two new areas. This project involves the following components:

- **Item No. I-10.1:** Install two diversion structures and pumps
- **Item No. I-10.2:** Install approximately 4,760 feet of 12-inch PIP pipeline.

4.4.1.12 Irrigation Component I-11: Horse Creek Reservoir and Irrigation Pipeline Project

Installation of a diversion structure, regulating reservoir, and pipeline would supply irrigation water to new areas. This project involves the following components:

- **Item No. I-11.1:** Install diversion structure and headgate
- **Item No. I-11.2:** Install irrigation regulating reservoir
- **Item No. I-11.3:** Install approximately 4,540 feet of 12-inch PIP pipeline.

4.4.1.13 Irrigation Component I-12: Iron Creek Irrigation Pipeline Project

Installation of a diversion structure and pump would supply irrigation water to new areas. This project involves the following components:

- **Item No. I-12.1:** Install diversion structure and pump
- **Item No. I-12.2:** Install approximately 1,820 feet of 12-inch PIP pipeline.

4.4.1.14 Irrigation Component I-13: Mule Shoe Reservoir Rehabilitation Project

Rehabilitation of the Mule Shoe Reservoir is needed. This project involves the following components:

- **Item No. I-13.1:** Rehabilitate reservoir and dam.

4.4.1.15 Irrigation Component I-14: Rand Ditch Irrigation Pipeline Rehabilitation Project

Installation of a diversion structure and headgate would supply irrigation water to new areas. This project involves the following components:

- **Item No. I-14.1:** Install diversion structure and headgate
- **Item No. I-14.2:** Install approximately 8,920 feet of 12-inch PIP pipeline.

4.4.1.16 Irrigation Component I-15: Wood Ditch Irrigation Pipeline Rehabilitation Project

Installation of a diversion structure and headgate would supply irrigation water to new areas. This project involves the following components:

- **Item No. I-15.1:** Install two diversion structures and headgates
- **Item No. I-15.2:** Install approximately 6,800 feet of 12-inch PIP pipeline.

4.5 LIVESTOCK AND WILDLIFE UPLAND WATERING SOURCES

4.5.1 Alternative Watering Opportunities

Water requirements for wildlife and livestock depend on the type, density, and seasonality of the grazing animals, along with the topography, water availability, and plant communities. Existing upland wildlife and livestock water sources that were evaluated in the study area were presented and discussed in Section 3.4.5.5. Circular areas around the water sources with a radius of 1 mile or 5,280 feet were delineated for existing sources that provide water to wildlife and livestock. The purpose of the areas is to display the recommended minimum spacing distances between available and viable water sources for livestock and wildlife within the study area. These areas for evaluated and unevaluated water sources are shown in Figure 3.9. Buffers were not delineated for perennial and intermittent rivers or creeks.

The purpose of evaluating viable livestock/wildlife watering sources and facilities is to provide alternatives to unreliable supplies, nonuniform used rangelands, and nonfunctioning riparian areas. The study area contains areas where water sources are insufficient to meet the requirements for wildlife and livestock. A large portion of these sources are reservoirs located on intermittent streams that have inconsistent and unreliable runoff patterns. Because of this uncertainty, some areas could benefit from upland water development. Participating landowners identified places where existing water sources could be improved.

Many springs located within the study area could be developed as upland water sources for wildlife and livestock. However, before initiating any spring development project, a site-specific assessment should be performed to confirm that sufficient yield is present and to identify necessary conservation measures. Moreover, any final plan and design of an upland water project should consider the available water yield, topography of the site, component material and specifications, and number of animals served by the system.

For the purposes of this study, conceptual wildlife and livestock water components and associated facilities were created and located on parcels, allotments, and pastures for landowners who participated in the study. The typical project component was assumed to consist of a rubber tire stock tank providing approximately 1,200 gallons of livestock and wildlife water supplied by a well and solar pump via a high-density polyethylene (HDPE) pipeline. The stock tank would provide a volume of water for approximately 80 cattle per day assuming a daily requirement of 15 gallons per head per day. Additionally, closed storage tanks were included in the components because these tanks would allow better use of existing sources.

The project components in this study are conceptual only and are described in general for this report. Before installation, the actual locations; specifications; alignments; volumes; and lengths of pipelines, tanks, wells, and pumps should be determined. Installing wildlife ramps in the proposed water tanks and incorporating all valves, fittings, and appurtenances to facilitate management of flows and water levels are also recommended.

4.5.2 Upland Livestock/Wildlife Water Development Projects

Study meetings held in Gillette, Hulett, Moorcroft, and Sundance provided an opportunity to meet interested landowners and grazing allotment permittees, gain study area input, hear local resource concerns, and answer questions about the study. Participation in the study was voluntary and a list of interested participants was created after these meetings. On-site, individual meetings were scheduled and conducted with study participants. During these meetings, the study team listened to the participants' concerns about water needs and visited potential project sites.

The participant meetings and the information about existing water sources resulted in identifying areas within the study area in need of upland water development and several conceptual water development projects. These proposed projects were developed to provide reliable water sources for livestock and wildlife in areas lacking sufficient sources within the watershed. Several water source alternatives and conceptual project components are presented in Section 4.5.2.1 through Section 4.5.2.67. These project designs are conceptual only and, if initiated, would require additional design work before installation. The proposed projects and components in the watershed management plan are summarized in Table 4.2. Figure 4.5 displays the general location of all of the proposed livestock/wildlife water projects.

Because federal and state lands cover approximately 17 percent of the study area and are intermingled with private lands, some of the upland water development projects would involve coordination with the BLM, USFS, and OSLI before initiating construction. Additionally, some projects could potentially involve cooperation among multiple landowners because of the locations of wells and routes for pipelines. For these projects spanning multiple landowners, written agreements would be necessary to outline the specific responsibilities and liabilities of the parties involved with each individual project. Moreover, environmental evaluations would be required for any potential effects identified for a specific project or project component, especially on federal and state lands. Therefore, coordination is necessary with the BLM and USFS before implementing any project on federal land, and coordination with the OSLI is required before constructing any improvements on state land.

The upland livestock/wildlife water development plan has 67 components that are described in Section 4.5.2.1 through Section 4.5.2.67. These sections summarize well construction, stock pond rehabilitation, and pipeline installation components. Figure 4.6 through Figure 4.69 displays the conceptual plan maps of these proposed livestock/wildlife water development and rehabilitation projects within the study area. Future upland livestock/wildlife water projects are eligible for application funding through the WWDC's SWPP because of their geographic location within the study area. However, these projects would need additional information and coordination with interested landowners before applications are submitted to the WWDO by any local sponsors.

Table 4.2. Summary of Livestock/Wildlife Upland Water Development Components (Page 1 of 3)

Item Number	Plan Component	Priority	Project Name	Description	Solar Pump	Well Construct	Spring Development	Pipeline	Stock Tank	Storage Tank	Stock Pond Rehab-Construct	Fence
1	LW-01	1	Coyote Draw	Pipeline and Tank				13,700	5			
2	LW-02	1	Coyote	Stock Reservoir							1	
3	LW-03	1	Coyote Draw	Stock Reservoir							1	
4	LW-04	2	Gold Mine Draw	Pipeline and Tank				6,600	2			
5	LW-05	2	Hallie Draw	Well, Solar Pump, and Tank	1	1		5,300	3			
6	LW-06	1	Spring/East Bluff	Pipeline and Tank				5,100	2			
7	LW-07	2	Strips/West Bluff	Pipeline and Tank				1,400	2			
8	LW-08	2	East Dry Creek	Well, Pipeline, and Tank		1		400	1			
9	LW-09	3	Vore Draw	Pipeline and Tank				2,700	1			
10	LW-10	1	Whitelaw	Solar Pump and Storage Tank	1					1		
11	LW-10A	2	Divide Allotment	Pipeline and Tank			1	700	2			7,000
12	LW-11	1	Eagle Ridge 1	Spring Development and Tank	1		1	900	2			200
13	LW-12	2	Eagle Ridge 2	Spring Development and Tank	1		1	400	1			
14	LW-12A	2	Marr	Stock Reservoir							1	
15	LW-13	3	Porcupine	Stock Reservoir							1	
16	LW-14	1	Johnson Draw	Well, Solar Pump, and Tank	1	1		400	2			6,400
17	LW-15	2	Shenandoah #4	Well, Solar Pump, and Tank	1	1		1,900	2			
18	LW-16	1	Dry Creek #2	Well, Solar Pump, and Tank	1	1		3,500	2			
19	LW-17	1	Miller Creek #1	Well, Solar Pump, and Tank	1	1		400	1			
20	LW-18	2	Dry Creek #4	Well, Solar Pump, and Tank	1	1		400	1			
21	LW-19	2	Dry Creek #3	Well, Solar Pump, and Tank	1	1		400	1			
22	LW-20	3	Hay Creek #1 and #2	Well, Solar Pump, and Tank	1	1		400	1			

Table 4.2. Summary of Livestock/Wildlife Upland Water Development Components (Page 2 of 3)

Item Number	Plan Component	Priority	Project Name	Description	Solar Pump	Well Construct	Spring Development	Pipeline	Stock Tank	Storage Tank	Stock Pond Rehab-Construct	Fence
23	LW-21	3	Miller Creek #2	Well, Solar Pump, and Tank	1	1		400	1			
24	LW-22	3	Dry Creek #5	Well, Solar Pump, and Tank	1	1		400	1			
25	LW-23	1	Corral Creek #1	Well, Pipeline, and Tank		1		5,000	4		1	
26	LW-24	2	Alvin Creek	Pipeline and Tank				2,000	2			
27	LW-25	2	Corral Creek #2	Well, Pipeline, and Tank	1	1		1,100	2	1		
28	LW-26	3	Corral Creek #3	Spring Development, Pipeline, Tank	1		1	2,900	2	1		
29	LW-27	1	Eggie Basin	Pipeline and Tank				5,700	2			
30	LW-28	3	Pine Ridge	Well, Pipeline, and Tank	1	1		3,400	2	1		
31	LW-29	3	Little Draw #1	Well, Pipeline, and Tank	1	1		400	1			
32	LW-30	2	Alma	Stock Reservoir							1	
33	LW-31	2	Lower Alma	Stock Reservoir							1	
34	LW-32	3	Mikel Creek	Well, Pipeline, and Tank	1	1		400	1			
35	LW-33	3	Little Draw #2	Well, Pipeline, and Tank	1	1		3,500	2			
36	LW-34	3	Sage Draw	Well, Pipeline, and Tank	1	1		400	2			
37	LW-35	1	Tobey Draw	Pipeline, Tank, and Stock Reservoir				4,700	2			
38	LW-35A	3	Noecker	Stock Reservoir							1	
39	LW-35B	3	Dinky	Stock Reservoir							1	
40	LW-36	2	Line Creek	Spring Development, Pipeline, Tank	1		1	1,700	2			
41	LW-37	1	Little Wright Draw	Well, Pipeline, and Tank	1	1		6,200	3	1		
42	LW-38	2	Busby Draw	Well, Pipeline, and Tank	1	1		400	1			
43	LW-39	2	Wolfe Draw	Pipeline and Tank				3,800	2			
44	LW-40	1	Kruger #1	Well and Pipeline		1		1,900				

Table 4.2. Summary of Livestock/Wildlife Upland Water Development Components (Page 3 of 3)

Item Number	Plan Component	Priority	Project Name	Description	Solar Pump	Well Construct	Spring Development	Pipeline	Stock Tank	Storage Tank	Stock Pond Rehab-Construct	Fence
45	LW-41	2	Kruger #2	Pipeline and Tank				11,400	4			
46	LW-42	2	Kruger #3	Pipeline and Tank				14,300	4			
47	LW-42A	2	Oak Creek	Well, Pipeline, and Tank	1	1		6,000	3			
48	LW-43	3	Kilpatrick Creek	Pipeline and Tank				12,900	4			
49	LW-44	1	Newland #4	Stock Reservoir							1	
50	LW-44A	3	Iron Creek	Well, Pipeline, and Tank	1	1		400	1			
51	LW-45	1	Sawmill	Well, Tank, and Stock Pond	1	1		400	1		1	
52	LW-46	2	Bear Gulch	Well, Pipeline, and Tank	1	1		400	1		1	
53	LW-46A	3	Bear	Stock Reservoir							1	
54	LW-46B	3	Bear Gulch	Stock Reservoir							1	
55	LW-47	3	Shield	Stock Reservoir							1	
56	LW-47A	3	Left Creek	Stock Reservoirs							1	
57	LW-48	2	Left Creek	Spring Development, Pipeline, Tank			1	1,300	1			
58	LW-49	3	Vines Draw	Well, Pipeline, and Tank	1	1		400	1		1	
59	LW-50	3	Grubb #3	Stock Reservoir							1	
60	LW-50A	3	Brimmer	Stock Reservoir							1	
61	LW-51	3	Arkansas Creek	Wildlife Guzzler and Pond				400	1		1	
62	LW-52	3	Upper Sundance	Well, Pipeline, and Tank	1	1		400	1			
63	LW-53	2	East Rupe	Spring Development, Pipeline, Tank			1	800	1		1	
64	LW-54	1	Bennor #2	Well, Pipeline, and Tank		1		10,500	5			
65	LW-55	2	Donkey Creek	Well, Pipeline, and Tank		1		4,700	3		1	
66	LW-56	1	Kester #1	Spring Development, Pipeline, Tank			1	1,800	3			10,400
67	LW-57	2	Kester #2	Spring Development, Pipeline, Tank			1	400	1		1	

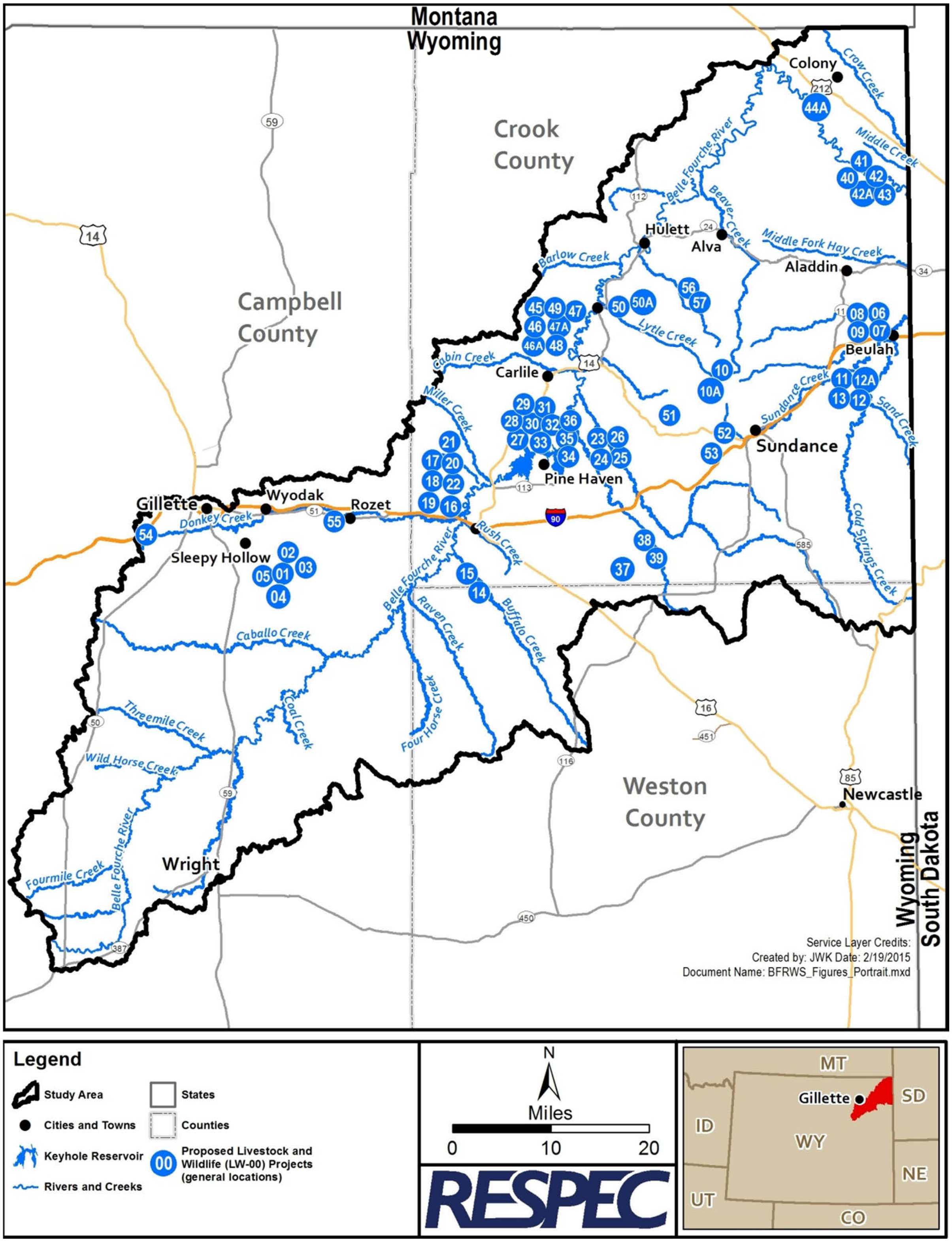


Figure 4-5. Proposed Upland Wildlife and Livestock Water Supply Projects in the Study Area.

4.5.2.1 LW-01: Coyote Draw Pipeline and Tank Project

This alternative would involve extending an existing pipeline supplied from an existing well, pump, and storage tank (> 20,000-gallon capacity) to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.6 would be installed:

- From the existing pipeline, well, pump, and storage tank (> 20,000-gallon capacity), a buried HDPE pipeline would be installed northerly to supply three stock tanks (1,200-gallon capacity each). This pipeline would require installing 7,000 linear feet of 2-inch pipeline.
- From the installed pipeline and stock tanks, the other HDPE pipeline would be installed northeasterly to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 6,700 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

4.5.2.2 LW-02: Coyote Stock Reservoir Rehabilitation Project

In addition to the developing livestock/wildlife water sources described in the *LW-01: Coyote Draw Pipeline and Tank Project*, this alternative as shown in Figure 4.7 would provide for rehabilitating a stock reservoir and associated wetlands. The existing stock reservoir is located on Coyote Creek within Section 19 of Township 49 North, Range 70 West in Campbell County. However, the structures are at risk of being breached because of the downstream channel headcutting.

This project would include rehabilitating the Coyote Stock Reservoir (Permit No. P3126S). The reservoir has a permitted total capacity of 6.05 acre-feet. This stock reservoir could be rehabilitated to provide an additional source of livestock/wildlife water along with restoring functions of the associated wetland and riparian areas. This alternative would involve installing an inlet and outlet pipe control structure in the reservoir embankment and stabilizing the installed structures and spillway with rock riprap. This alternative includes the following features:

- Inspecting the embankment and rehabilitation of problem areas as needed. The embankment is approximately 300 feet long and less than 10 feet high at its highest point. The top-width of the embankment is approximately 15 feet wide.
- Installing an inlet and outlet control mechanism to control reservoir water levels. The installed structures would be stabilized with rock riprap.
- Excavating the earthen, grass-lined spillway to adequately convey necessary water volumes and stabilizing with rock riprap for spillway protection.
- Contingent on determining adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.
- As delineated, the project involves privately owned lands only.

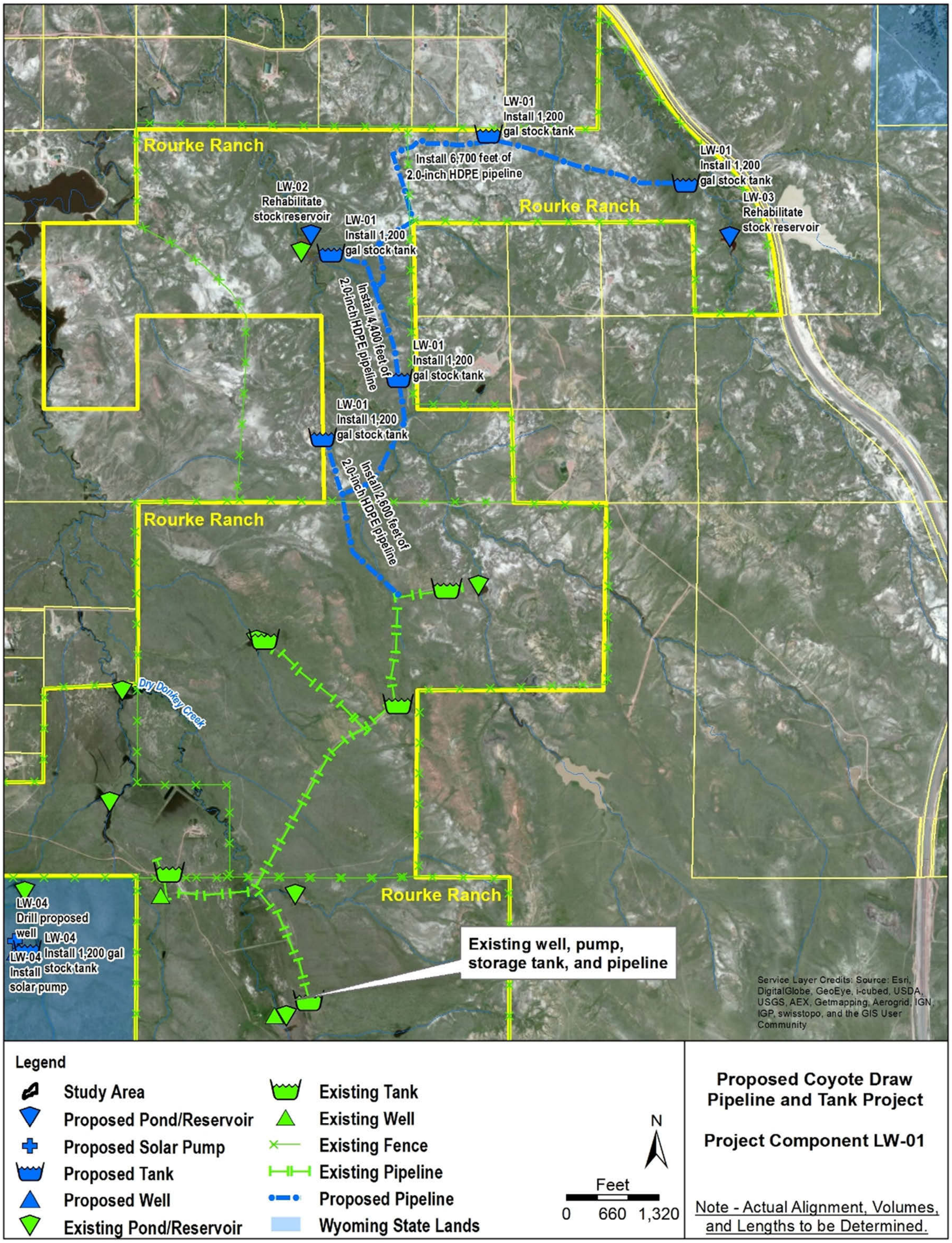


Figure 4-6. Proposed LW-01: Coyote Draw Pipeline and Tank Project.

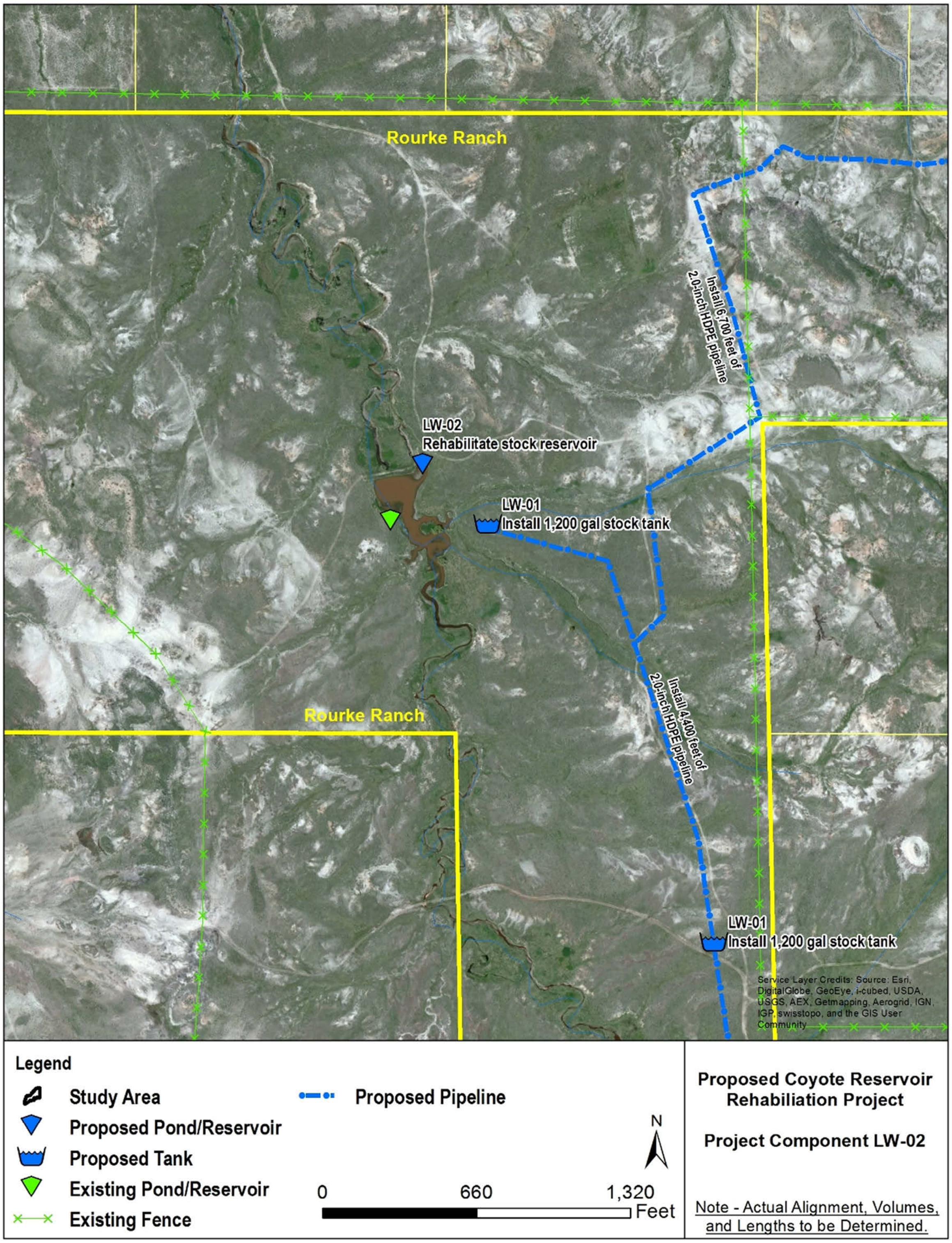


Figure 4-7. Proposed LW-02: Coyote Stock Reservoir Rehabilitation Project.

4.5.2.3 LW-03: Coyote Draw Stock Reservoir Rehabilitation Project

In addition to developing livestock/wildlife water sources described in the *LW-01: Coyote Draw Pipeline and Tank Project*, this alternative as shown in Figure 4.8 would provide for rehabilitating a stock reservoir and associated wetlands. The existing stock reservoir is located on an unnamed tributary to Dry Donkey Creek within Section 20 of Township 49 North, Range 70 West in Campbell County. However, the structures are at risk of being breached because of the downstream channel headcutting.

This stock reservoir could be rehabilitated to provide an additional source of livestock/wildlife water along with restoring function of the associated wetland and riparian areas. This alternative would involve installing an inlet and outlet pipe control structure in the reservoir embankment and stabilizing the installed structures and spillway with rock riprap. The stock reservoir encompasses 0.8 acre with a total capacity of less than 2 acre-feet. This alternative would include the following features:

- Inspecting the embankment and rehabilitation of problem areas as needed. The embankment is approximately 250 feet long and less than 8 feet high at its highest point. The top-width of the embankment is approximately 12 feet wide.
- Installing an inlet and outlet control mechanism to control reservoir water levels. The installed structures would be stabilized with rock riprap.
- Excavating the earthen, grass-lined spillway to adequately convey necessary water volumes and stabilizing with rock riprap for spillway protection.
- Contingent on determining adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.
- As delineated, the project involves privately owned lands only.

4.5.2.4 LW-04: Gold Mine Draw Pipeline and Tank Project

This alternative would involve extending an existing pipeline supplied from an existing well, pump, and storage tank (> 20,000-gallon capacity) to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.9 would be installed:

- From the existing pipeline, well, pump, and storage tank (> 20,000-gallon capacity), a buried HDPE pipeline would be installed southwesterly to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 6,600 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

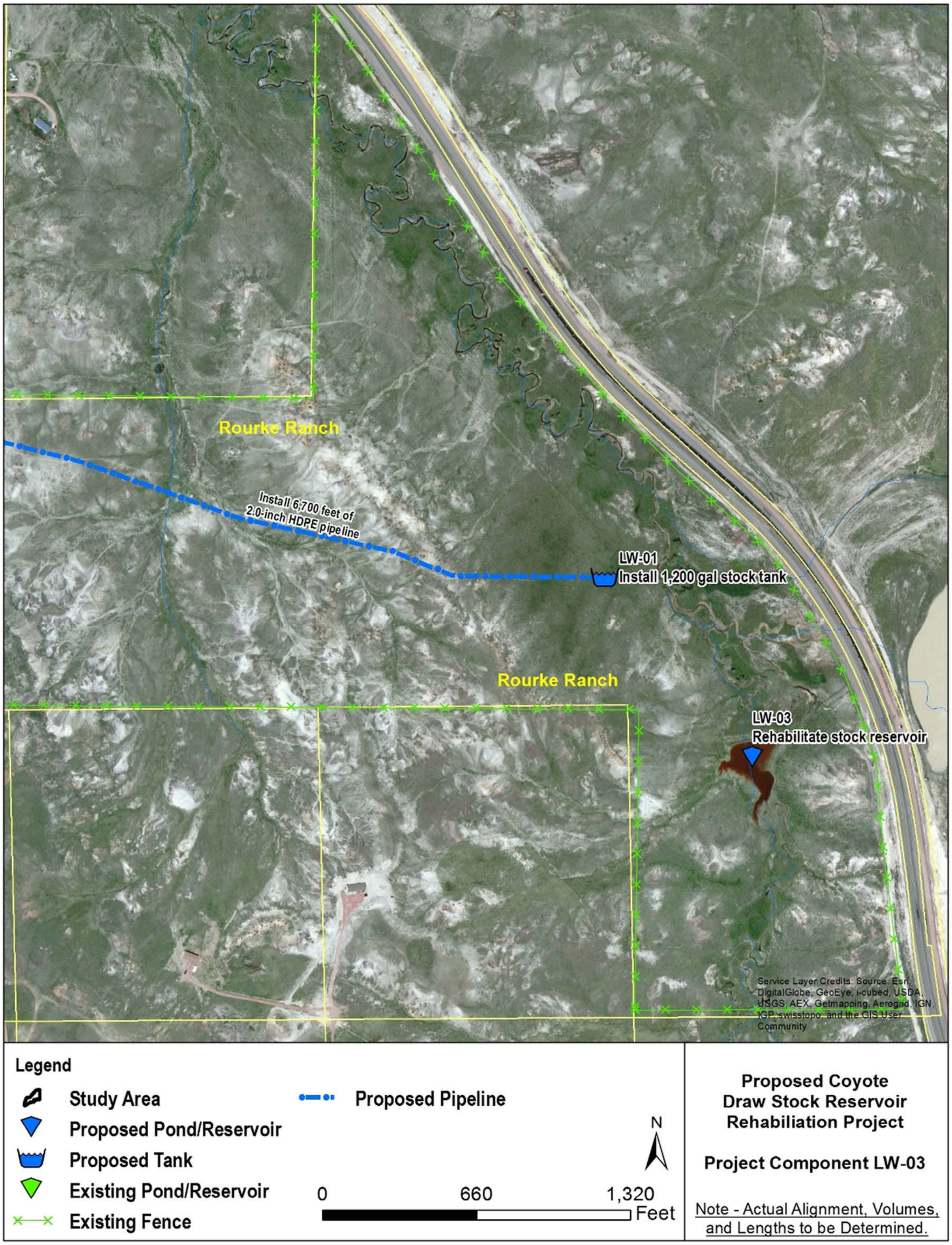


Figure 4-8. Proposed LW-03: Coyote Draw Stock Reservoir Rehabilitation Project.

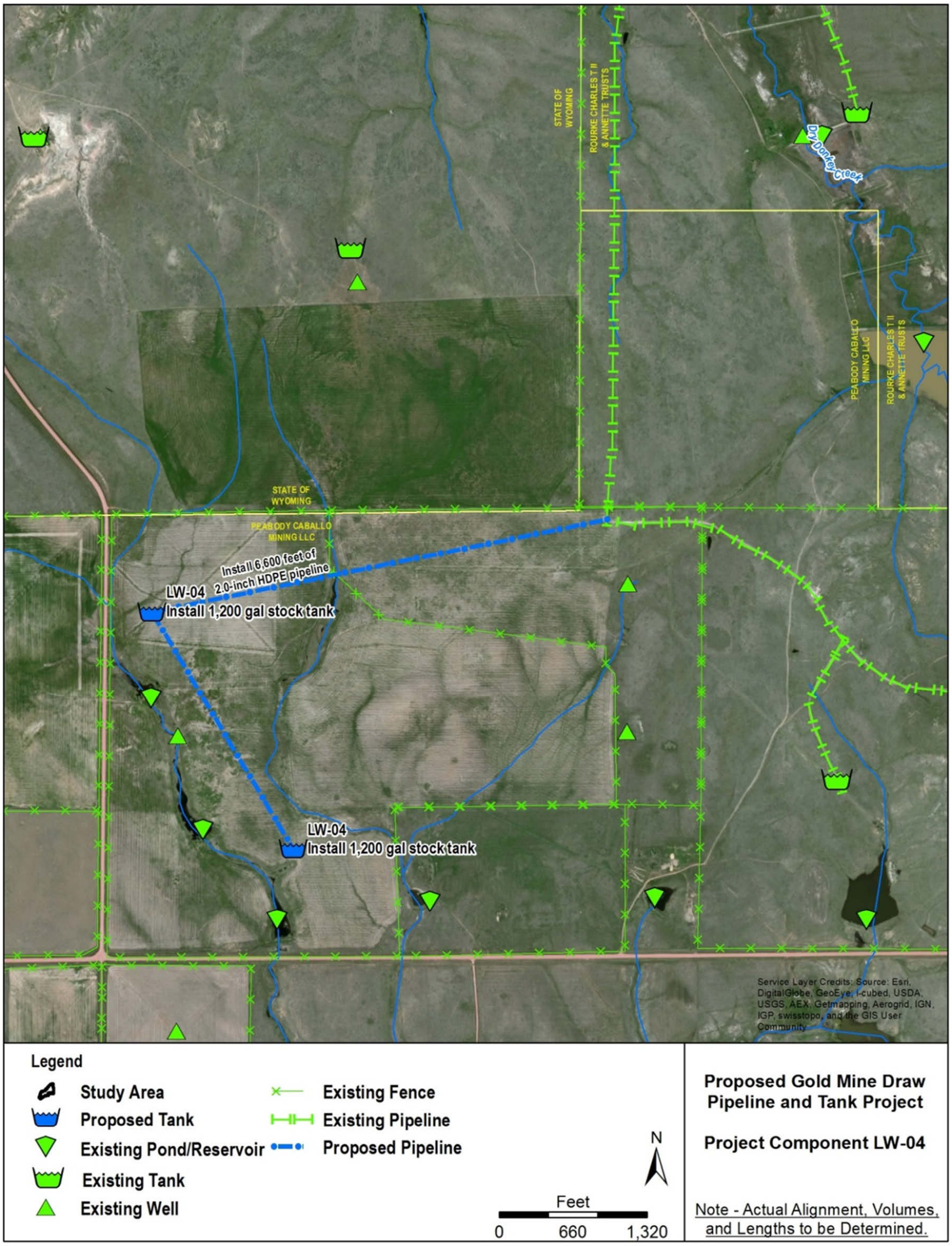


Figure 4-9. Proposed LW-04: Gold Mine Draw Pipeline and Tank Project.

4.5.2.5 LW-05: Hallie Draw Well, Solar Pump, and Tank Project

This alternative would involve drilling a new well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.10 would be installed:

- A new well would be drilled to supply water and equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply three stock tanks (1,200-gallon capacity). This pipeline would require installing 5,300 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

4.5.2.6 LW-06: Spring/East Bluff Pipeline and Tank Project

This alternative would involve extending an existing pipeline supplied from an existing well, pump, and storage tank (> 1,800-gallon capacity) to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.11 would be installed:

- From the existing tank, pipeline, well, pump, and storage tank (> 1,800-gallon capacity), a buried HDPE low-pressure pipeline would be installed southeasterly to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 5,100 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

4.5.2.7 LW-07: Strips/West Bluff Pipeline and Tank Project

This alternative would involve extending an existing pipeline supplied from an existing well and pump to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.12 would be installed:

- From the existing pipeline, well, and pump, a buried HDPE low-pressure pipeline would be installed northerly to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 1,400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

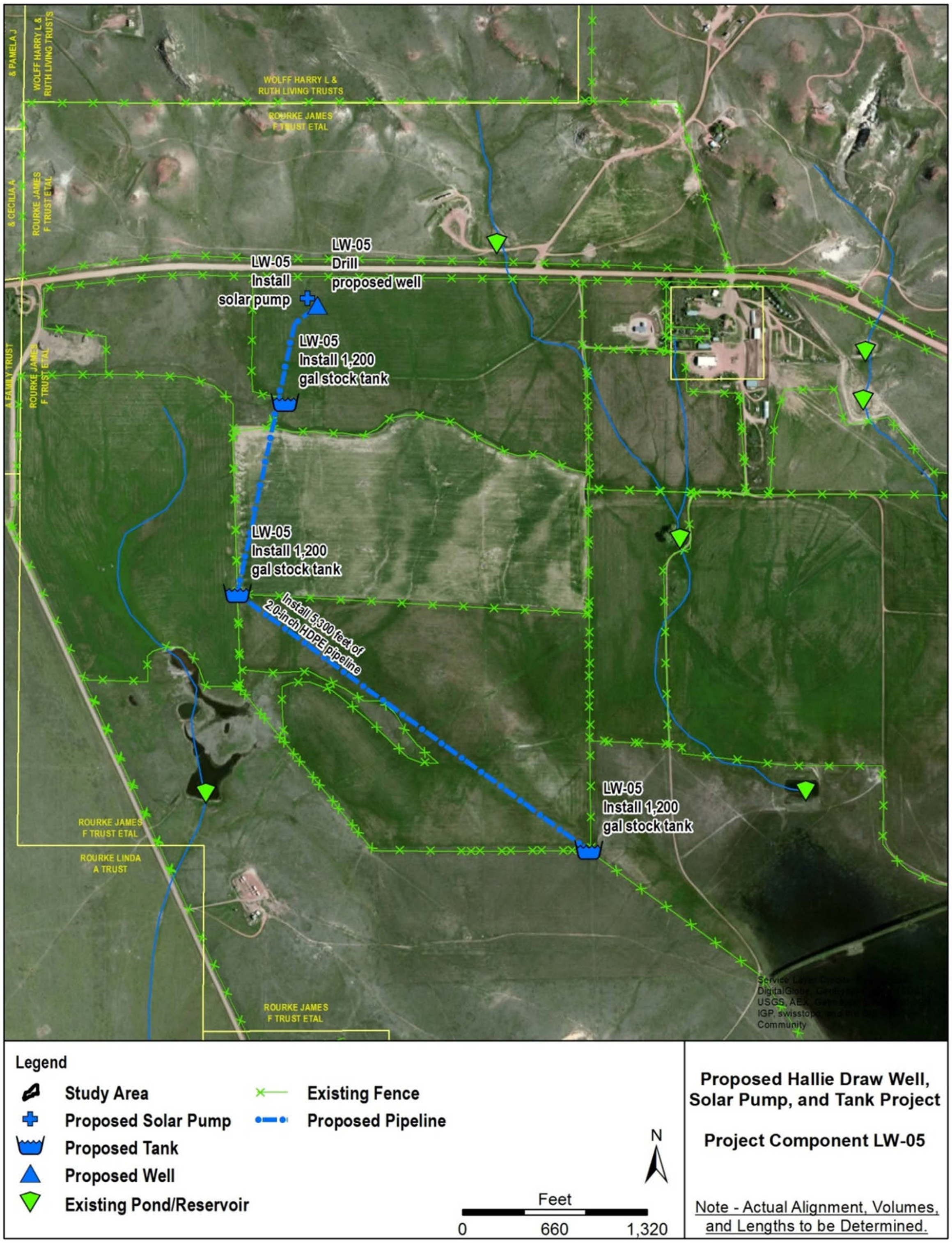


Figure 4-10. Proposed LW-05: Hallie Draw Well, Solar Pump, and Tank Project.

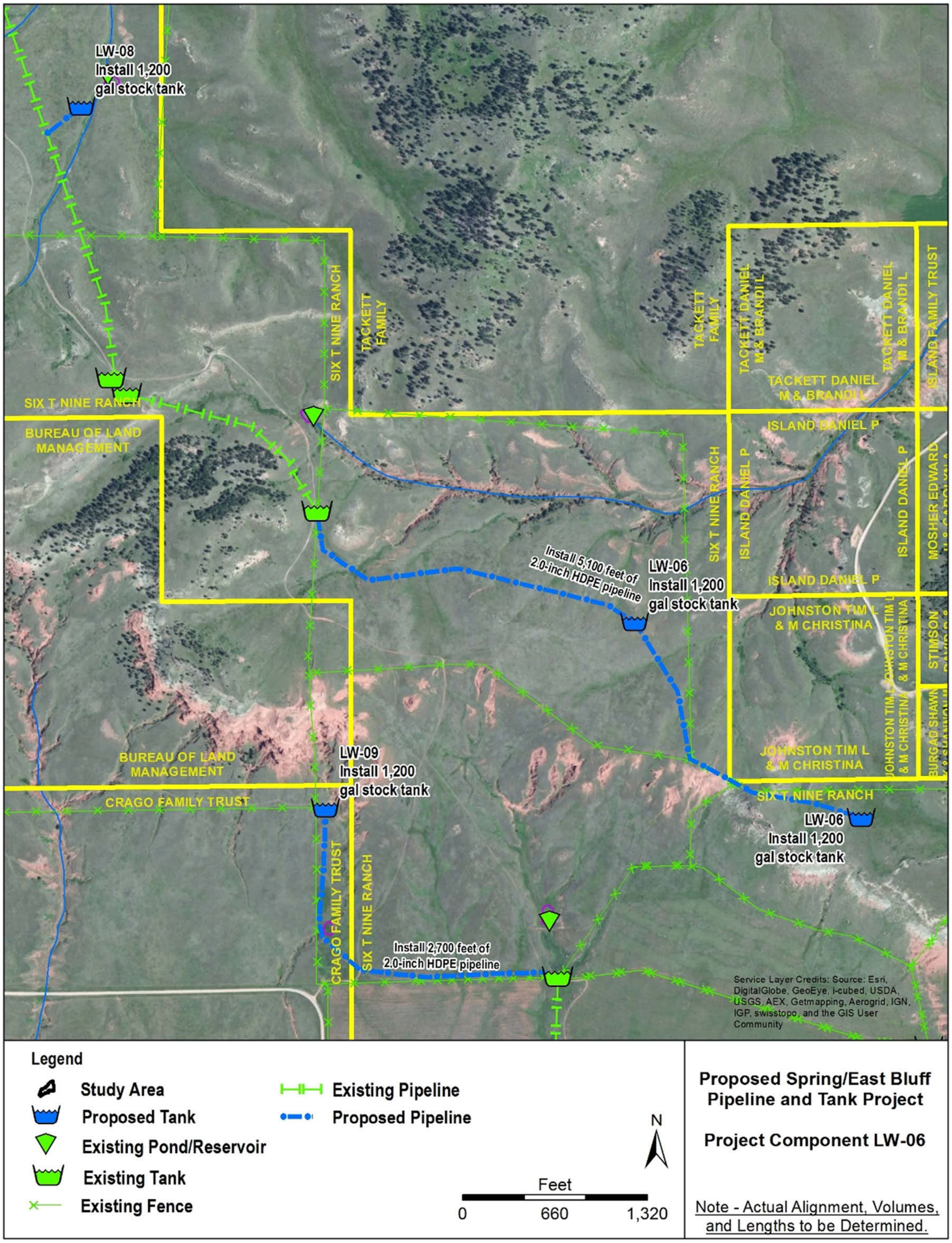


Figure 4-11. Proposed LW-06: Spring/East Bluff Pipeline and Tank Project.

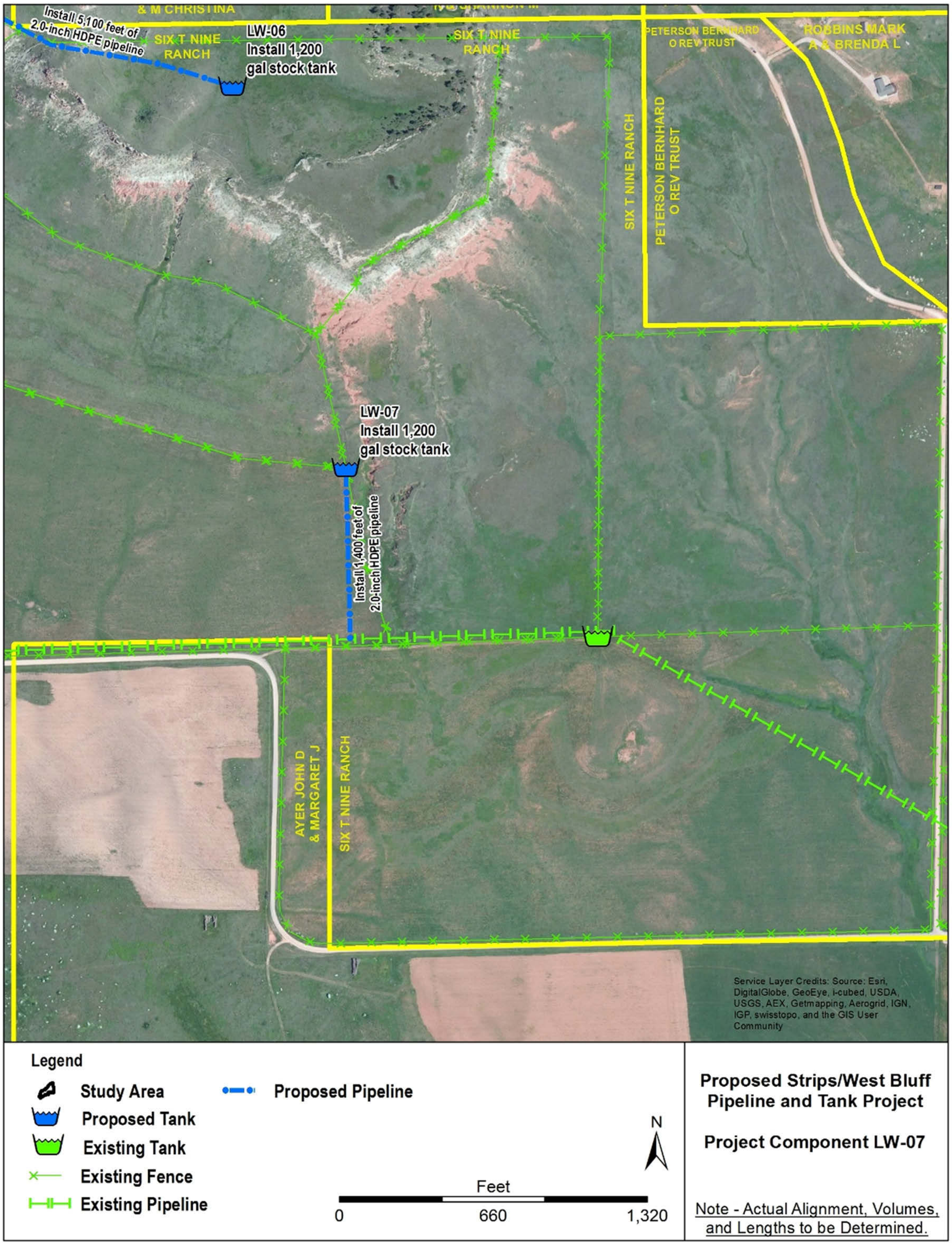


Figure 4-12. Proposed LW-07: Strips/West Bluff Pipeline and Tank Project.

4.5.2.8 LW-08: East Dry Creek Pipeline and Tank Project

This alternative would involve extending an existing pipeline supplied from an existing well and pump to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.13 would be installed:

- From the existing pipeline, well, and pump, a buried HDPE low-pressure pipeline would be installed northerly to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

4.5.2.9 LW-09: Vore Draw Pipeline and Tank Project

This alternative would involve extending an existing pipeline supplied from an existing well and pump to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.14 would be installed:

- From the existing pipeline, well, and pump, a buried HDPE low-pressure pipeline would be installed northwesterly to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 2,700 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

4.5.2.10 LW-10: Whitelaw Solar Pump and Tank Project

This alternative would involve installing a storage tank and a solar pump system to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.15 would be installed:

- From an existing spring development and buried pipeline, a storage tank (~ 2,900-gallon capacity) would be installed to supply adequate water to an existing livestock/wildlife system.
- From the storage tank, a solar platform consisting of solar panel; solar-powered pump; batteries; and regulators, connections, and appurtenances would be installed to supply water via the existing buried pipelines to five existing stock tanks.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the existing stock tanks.

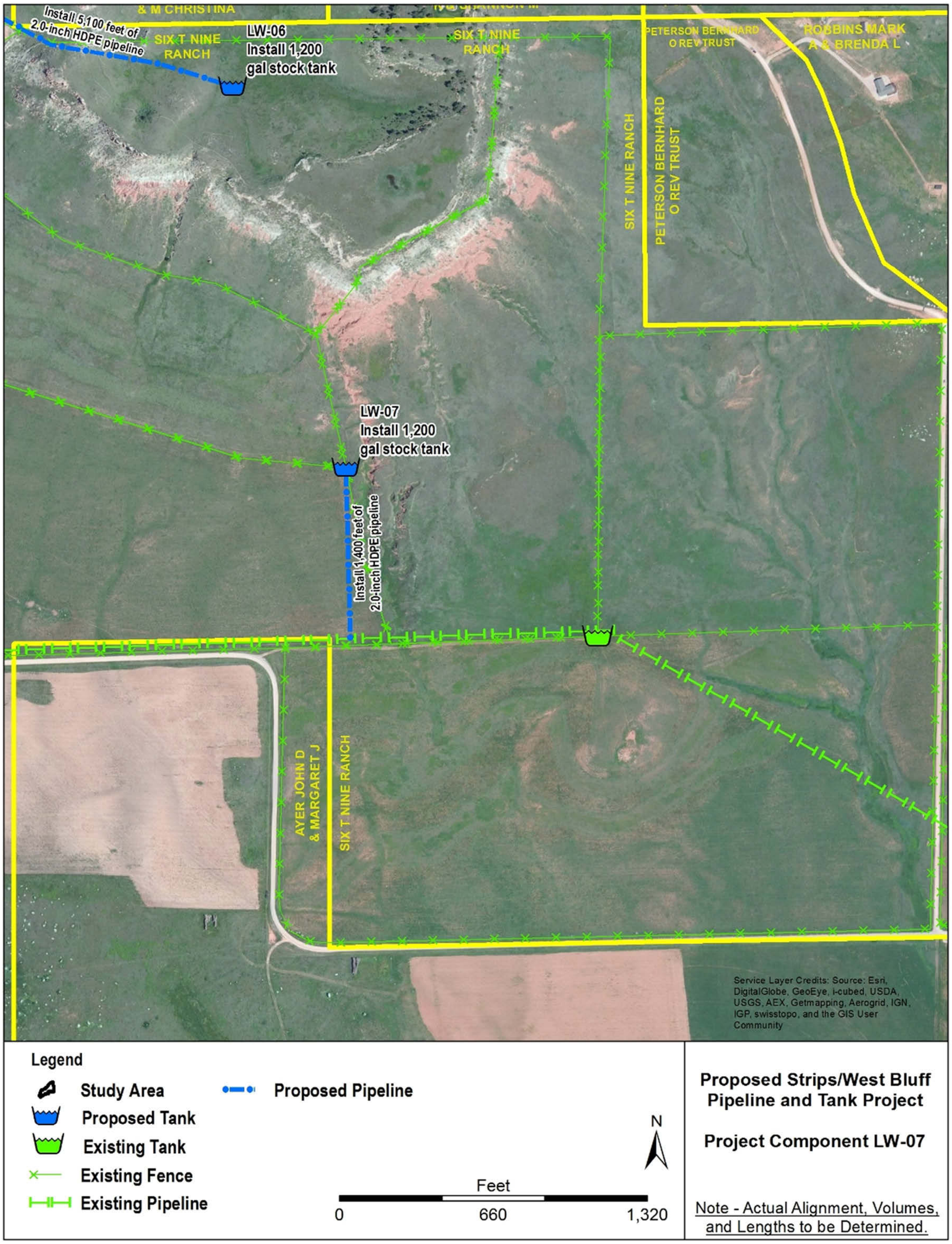


Figure 4-13. Proposed LW-08: East Dry Creek Pipeline and Tank Project.

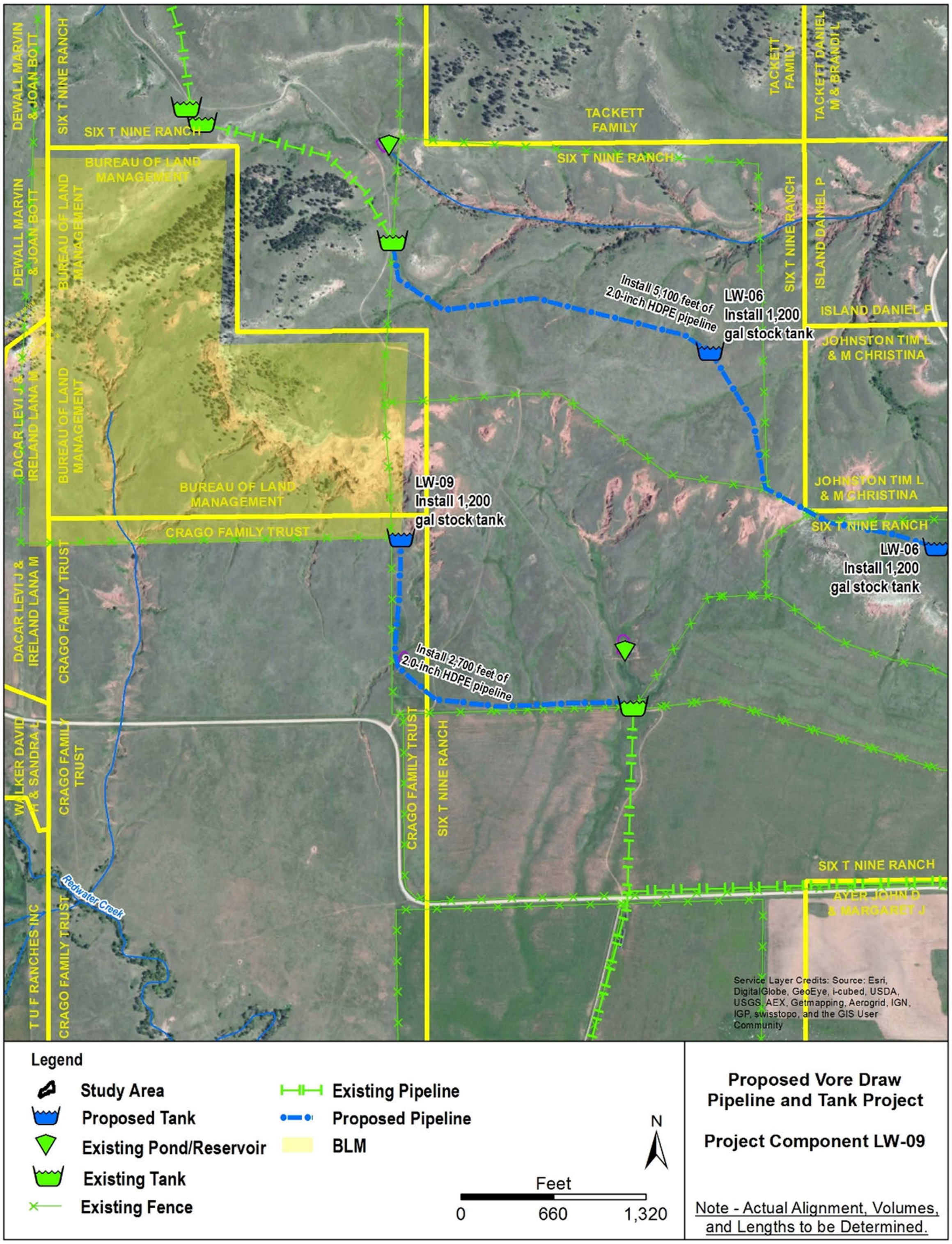


Figure 4-14. Proposed LW-09: Vore Draw Pipeline and Tank Project.

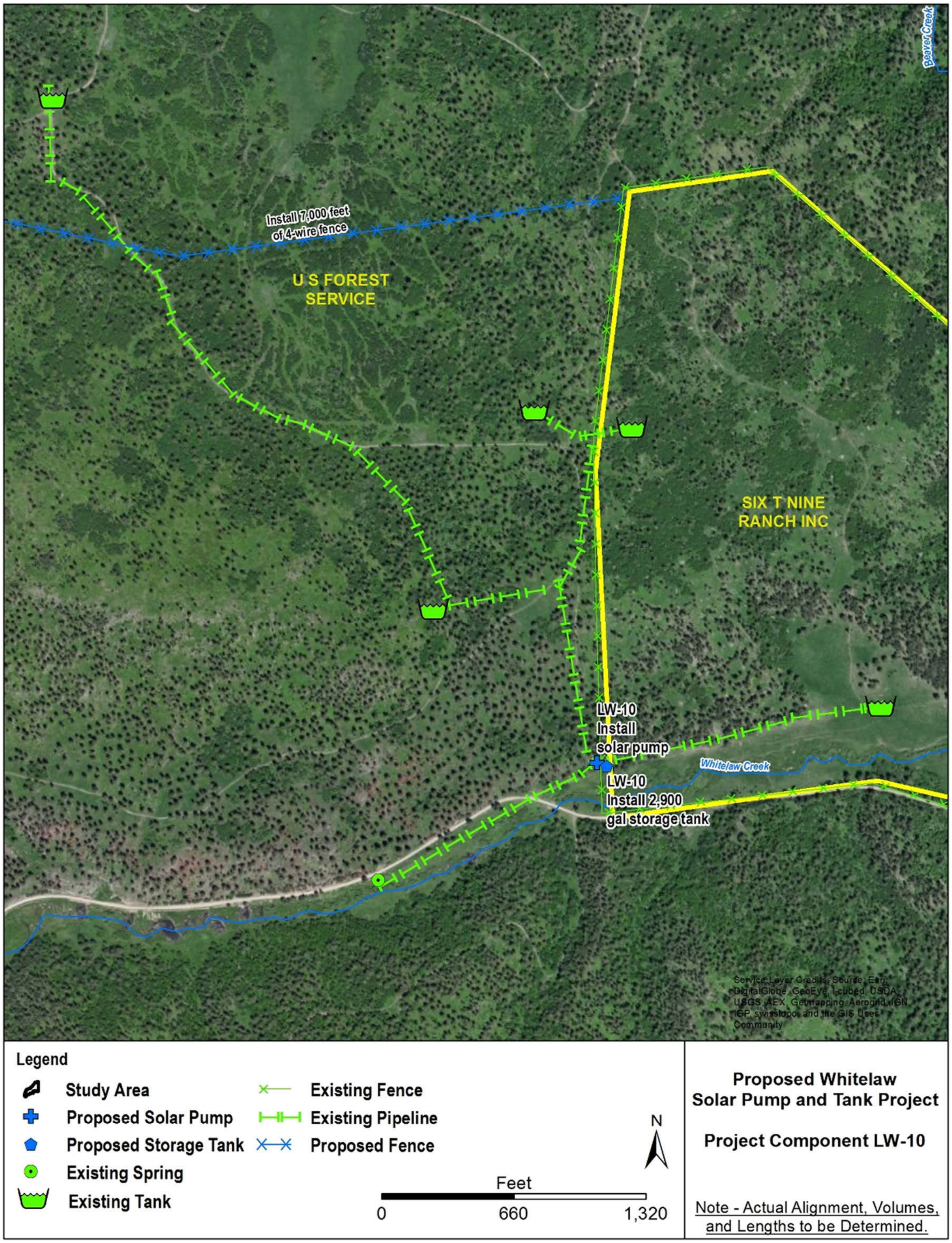


Figure 4-15. Proposed LW-10: Whitelaw Solar Pump and Tank Project.

4.5.2.11 LW-10A: Divide Allotment Spring Development and Tank Project

This alternative would involve rehabilitating an existing spring development and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.16 would be installed:

- The existing spring would be rehabilitated and equipped with collection pipe, spring box, and appurtenances.
- From the rehabilitated spring, a buried HDPE low-pressure pipeline would be installed to supply water to two stock tanks (1,200-gallon capacity each). This pipeline would be aligned easterly and require installing 700 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

4.5.2.12 LW-11: Eagle Ridge 1 Spring Development and Tank Project

This alternative would involve rehabilitating an existing spring development and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.17 would be installed:

- The existing spring would be rehabilitated and equipped with collection pipe, spring box, and appurtenances.
- From the rehabilitated spring, a solar platform consisting of solar panel; solar-powered pump; batteries; and regulators, connections, and appurtenances would be installed to supply water via a buried HDPE low-pressure pipeline to two stock tanks (1,200-gallon capacity each). This pipeline would be aligned northerly and require installing 900 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

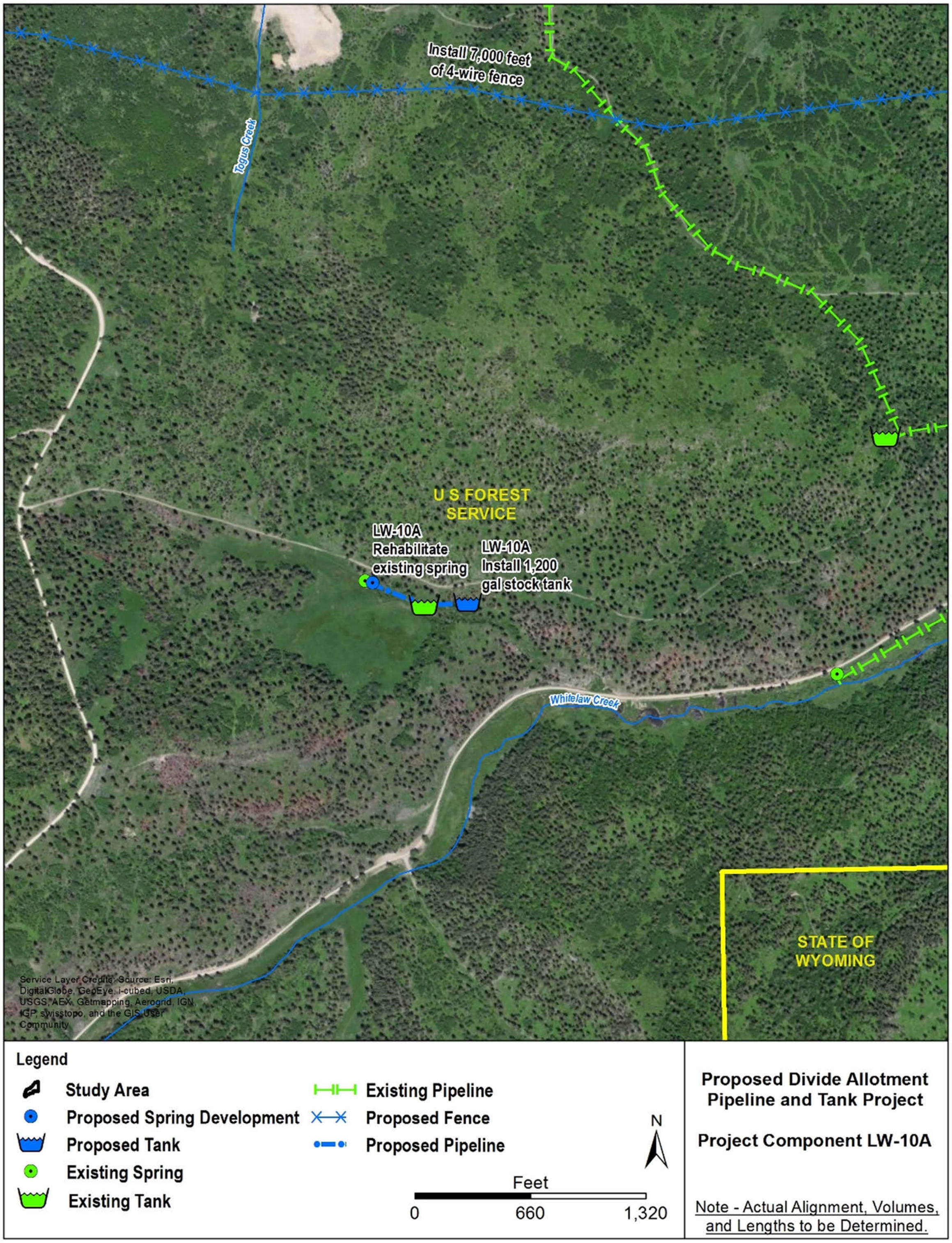


Figure 4-16. Proposed LW-10A: Divide Allotment Spring Development Project.

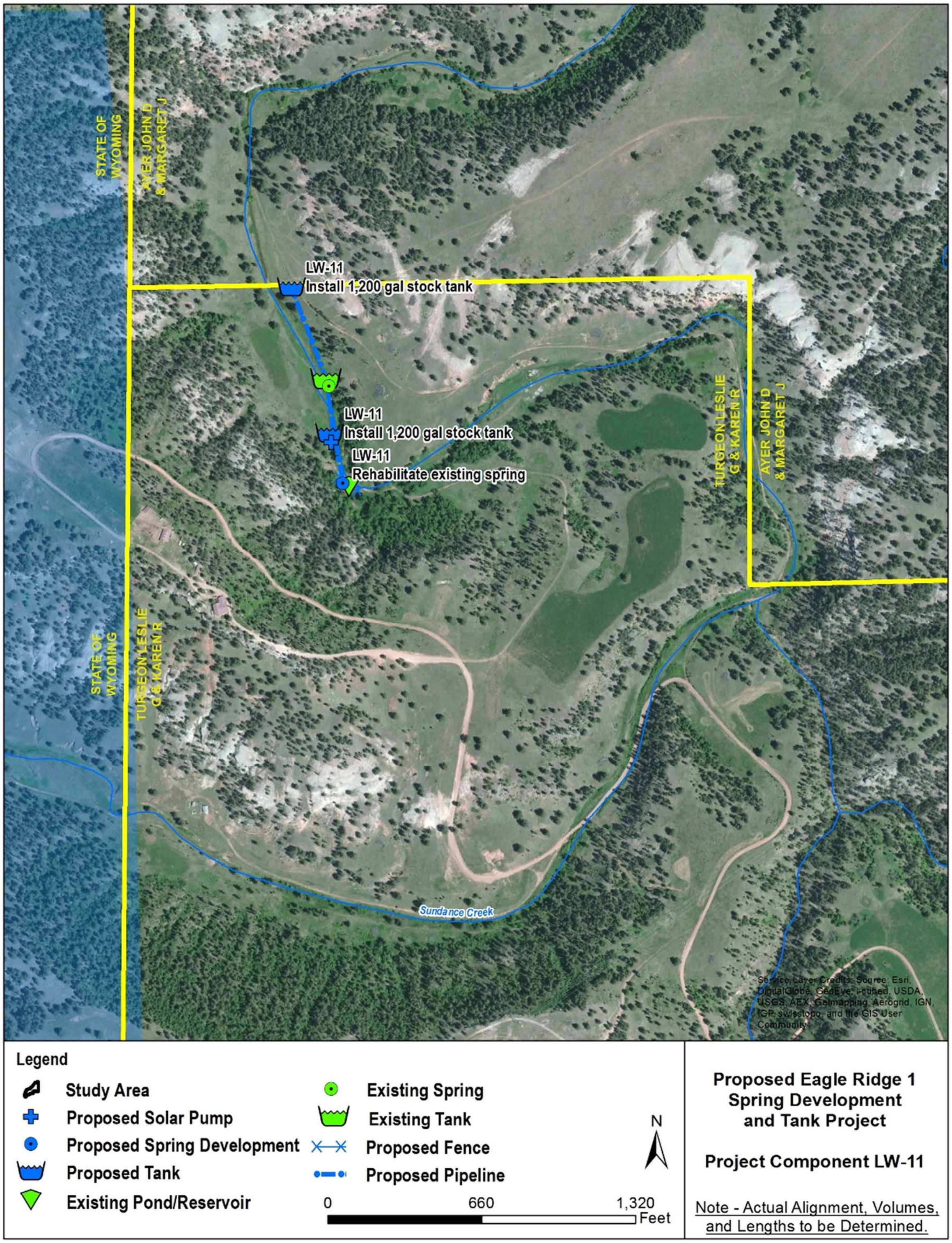


Figure 4-17. Proposed LW-11: Eagle Ridge 1 Spring Development and Tank Project.

4.5.2.13 LW-12: Eagle Ridge 2 Spring Development and Tank Project

This alternative would involve rehabilitating an existing spring development and stock pond supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.18 would be installed:

- The existing spring would be rehabilitated and equipped with collection pipe, spring box, and appurtenances.
- From the rehabilitated spring, a solar platform consisting of solar panel; solar-powered pump; batteries; and regulators, connections, and appurtenances would be installed to supply water via a buried HDPE low-pressure pipeline to a stock tank (1,200-gallon capacity). This pipeline would be aligned northerly and require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

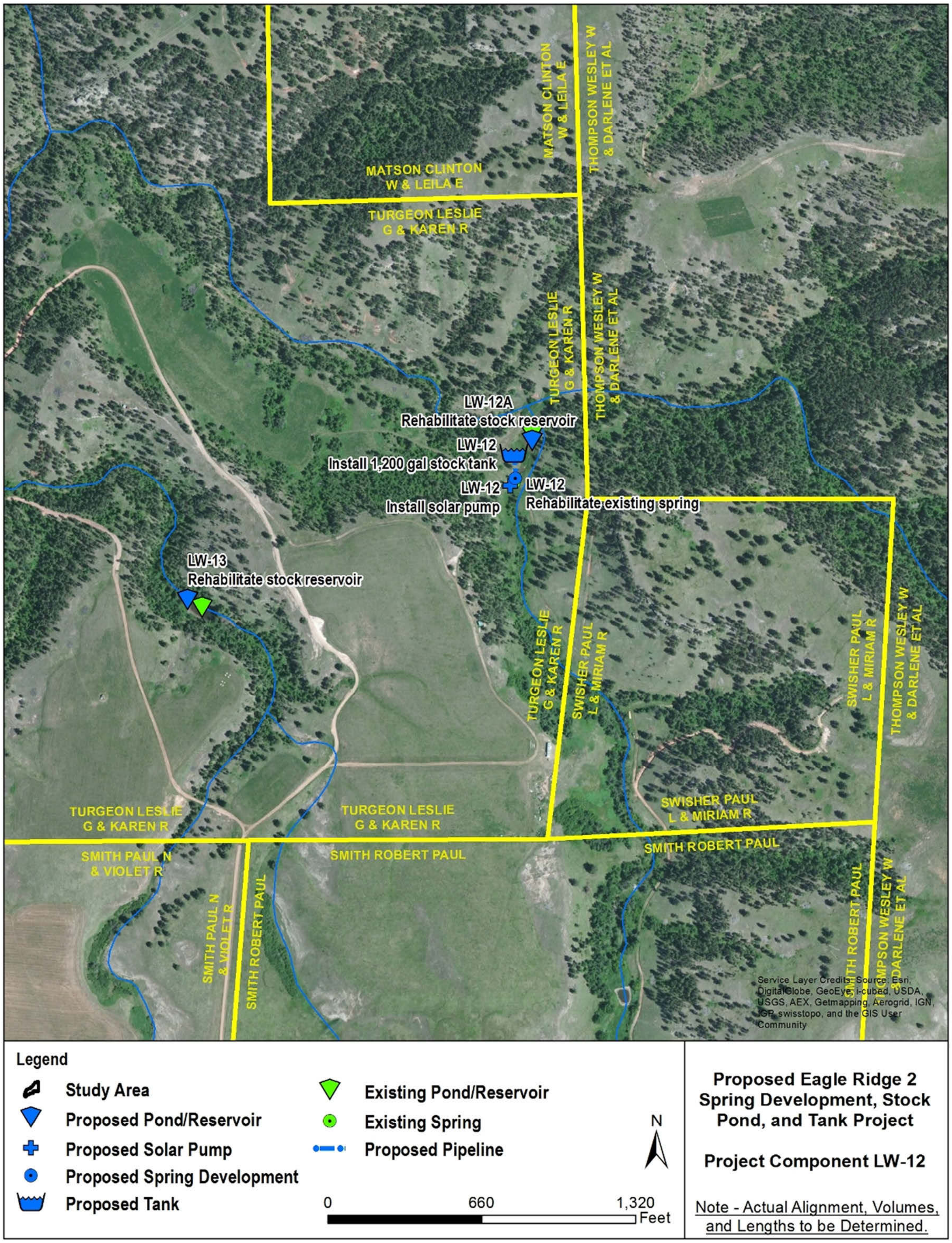


Figure 4-18. Proposed LW-12: Eagle Ridge 2 Spring Development and Tank Project.

4.5.2.14 LW-12A: Marr Stock Reservoir Rehabilitation Project

In addition to developing livestock/wildlife water sources described in the *LW-12: Eagle Ridge 2 Spring Development and Tank Project*, this alternative as shown in Figure 4.19 would provide for rehabilitating a stock reservoir and associated wetlands. The existing stock reservoir is located on Smith Draw, an intermittent tributary to Sundance Creek, within Section 15 of Township 52 North, Range 61 West in Crook County. Currently, the stock reservoir experiences seepage loss of the impounded water behind the embankment.

This project would include rehabilitating the Marr Stock Reservoir (Permit No. P425S). The reservoir has a permitted total capacity of 1.74 acre-feet. This stock reservoir could be rehabilitated to provide an additional source of livestock/wildlife water along with restoring function of the associated wetland and riparian areas. This alternative includes the following features:

- Inspecting the embankment and rehabilitation of problem areas as needed. The embankment is approximately 150 feet long and less than 15 feet high at its highest point. The top-width of the embankment is approximately 10 feet wide.
- Investigating site-specific soil and geologic conditions to define the extent necessary to excavate existing sediment and to determine if alternatives to bentonite liner treatment should be considered because of karstic bedrock or other conditions of the underlying bedrock formation.
- Installing an inlet and outlet control mechanism to control reservoir water levels. The installed structures would be stabilized with rock riprap.
- Excavating the spillway to adequately convey overflow volumes and stabilizing with rock riprap for protection.
- Potential construction options for reducing seepage in small stock ponds and reservoirs include the installation of geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Potential options are detailed in the NRCS Construction Specifications for Pond Sealing or Lining (NRCS WY-521A, WY-521C, or WY-521D).
- Contingent on determining adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.
- As proposed, the project involves private lands only.

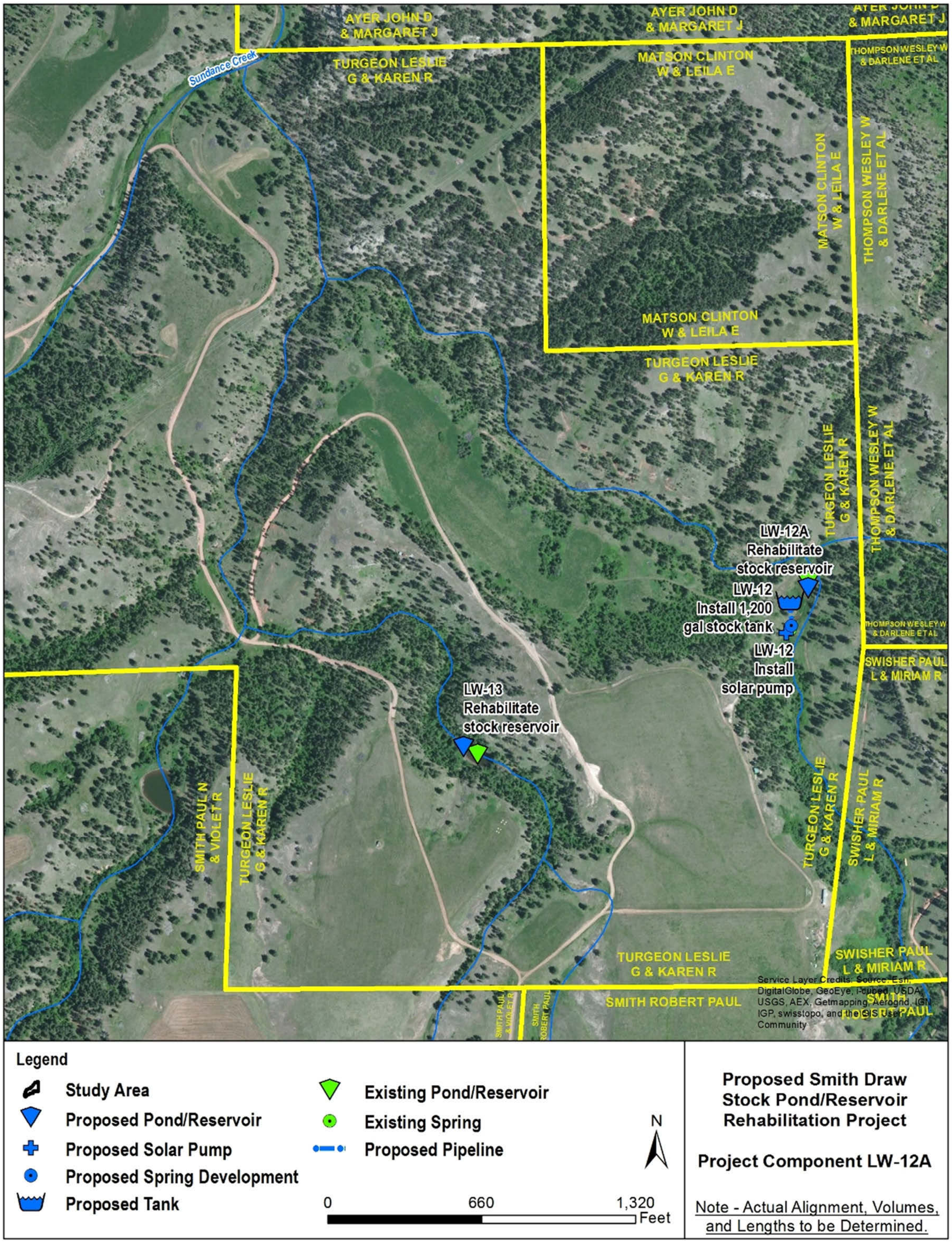


Figure 4-19. Proposed LW-12A: Marr Stock Reservoir Rehabilitation Project.

4.5.2.15 LW-13: Porcupine Stock Reservoir Rehabilitation Project

This alternative as shown in Figure 4.20 would provide for rehabilitating a stock reservoir and associated wetlands. The existing stock reservoir is located on Porcupine Draw, an intermittent tributary to Sundance Creek, within Section 22 of Township 52 North, Range 61 West in Crook County. Currently, the stock reservoir experiences seepage loss of the impounded water behind the embankment. In addition, the structure is at risk of being breached because of the downstream channel headcutting.

This project would include rehabilitating the Porcupine Stock Reservoir (Permit No. P3587S). The reservoir has a permitted total capacity of 1.9 acre-feet. This stock reservoir could be rehabilitated to provide an additional source of livestock/wildlife water along with restoring function of the associated wetland and riparian areas. This alternative would include the following features:

- Inspecting the embankment and rehabilitation of problem areas as needed. The embankment is approximately 120 feet long and less than 10 feet high at its highest point. The top-width of the embankment is approximately 8 feet wide.
- Investigating site-specific soil and geologic conditions to define the extent necessary to excavate existing sediment and to determine if alternatives to bentonite liner treatment should be considered because of karstic bedrock or other conditions of the underlying bedrock formation.
- Installing an inlet and outlet control mechanism to control reservoir water levels. The installed structures would be stabilized with rock riprap.
- Excavating the spillway to adequately convey overflow volumes and stabilizing with rock riprap for protection.
- Potential construction options for reducing seepage in small stock ponds and reservoirs include the installation of geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Potential options are detailed in the NRCS Construction Specifications for Pond Sealing or Lining (NRCS WY-521A, WY-521C, or WY-521D).
- Contingent on determining adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.
- As proposed, the project involves private lands only.

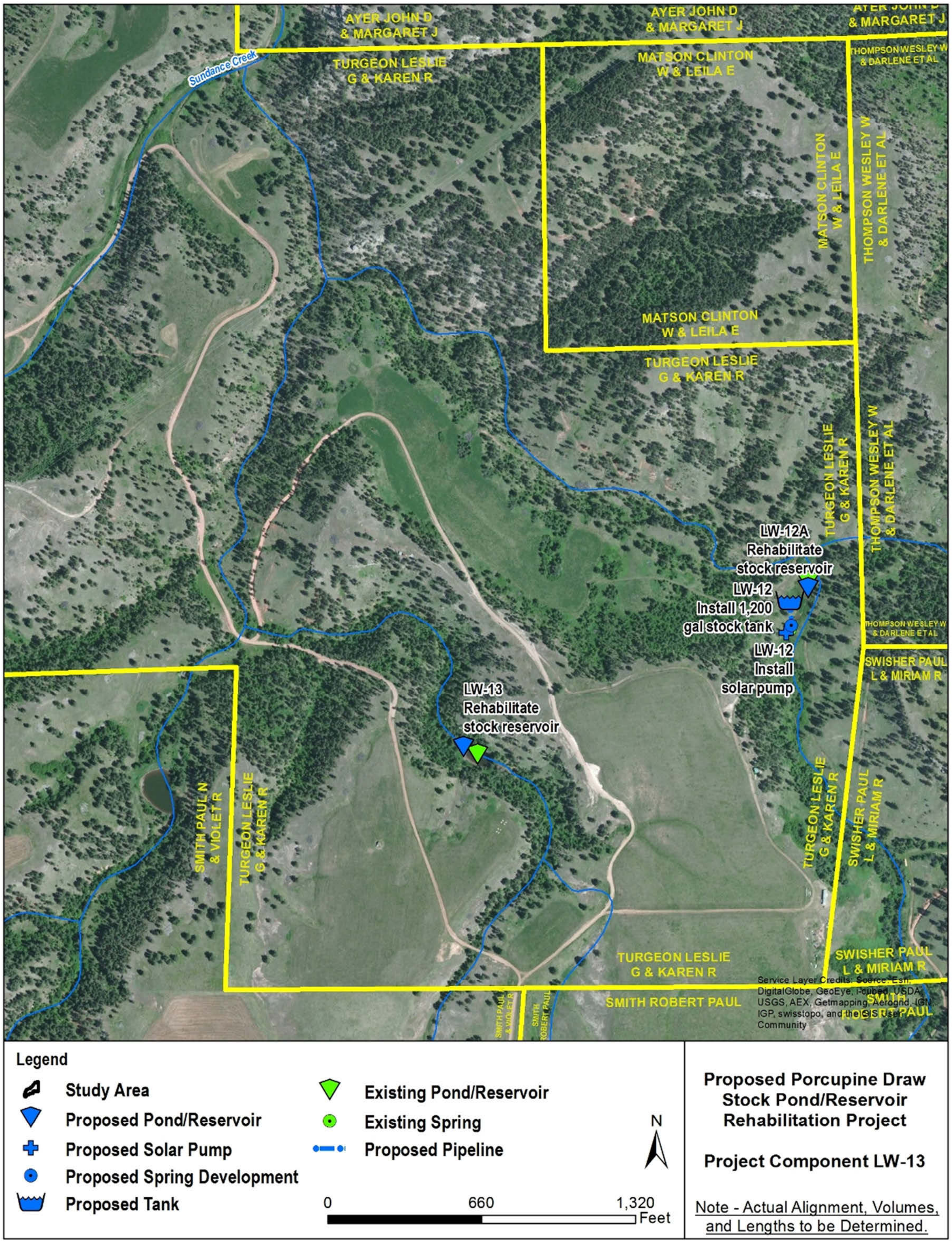


Figure 4-20. Proposed LW-13: Porcupine Stock Reservoir Rehabilitation Project.

4.5.2.16 LW-14: Johnson Draw Well and Tank Rehabilitation Project

This alternative would involve rehabilitating an existing well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.21 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tanks.

4.5.2.17 LW-15: Shenandoah #4 Well and Tank Rehabilitation Project

This alternative would involve rehabilitating an existing well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.22 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed northerly to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 1,900 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tanks.

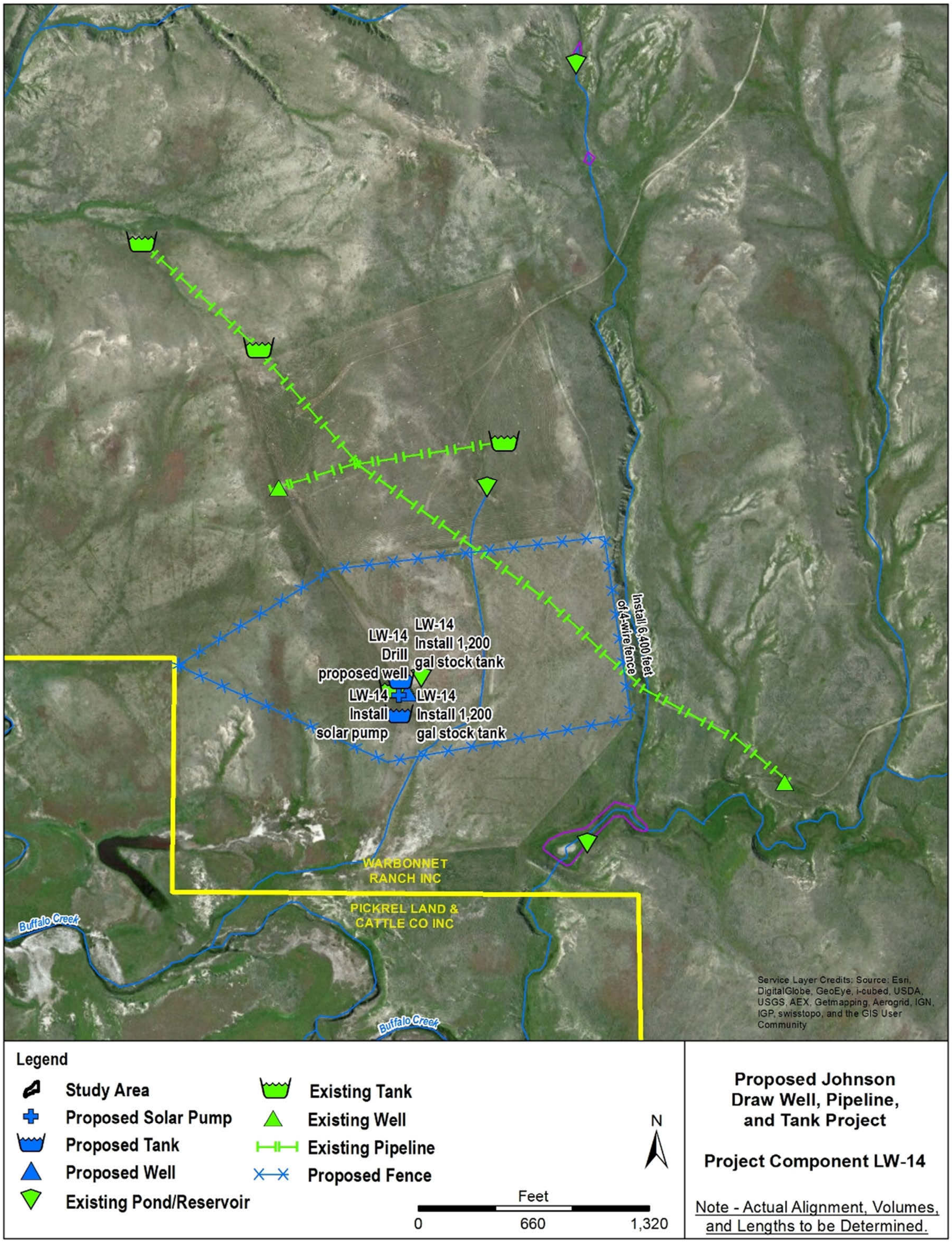


Figure 4-21. Proposed LW-14: Johnson Draw Well and Tank Rehabilitation Project.

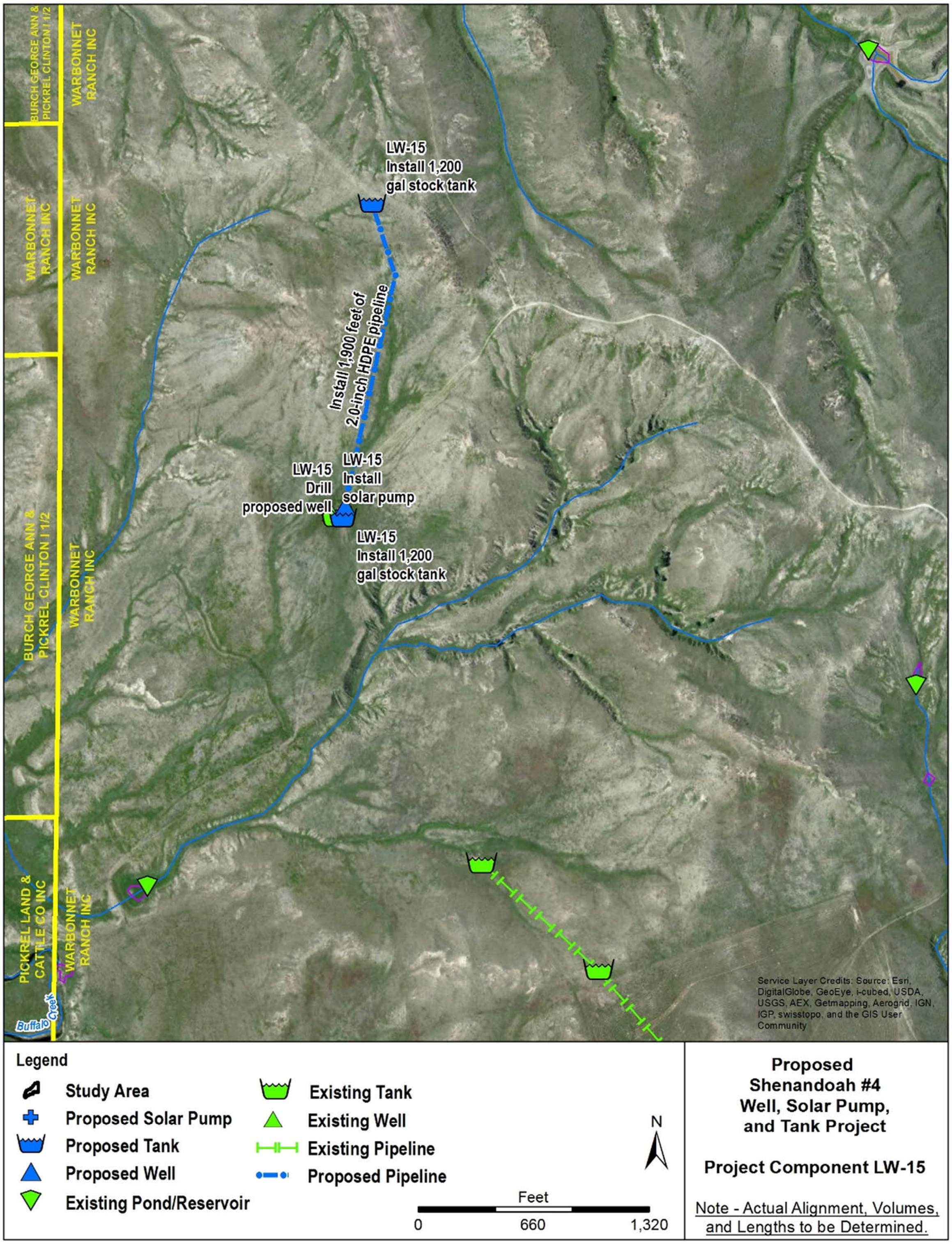


Figure 4-22. Proposed LW-15: Shenandoah #4 Well and Tank Rehabilitation Project.

4.5.2.18 LW-16: Dry Creek #2 Well and Tank Rehabilitation Project

This alternative would involve rehabilitating an existing well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.23 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed easterly to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 3,500 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

4.5.2.19 LW-17: Miller Creek #2 Well and Tank Rehabilitation Project

This alternative would involve rehabilitating an existing well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.24 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

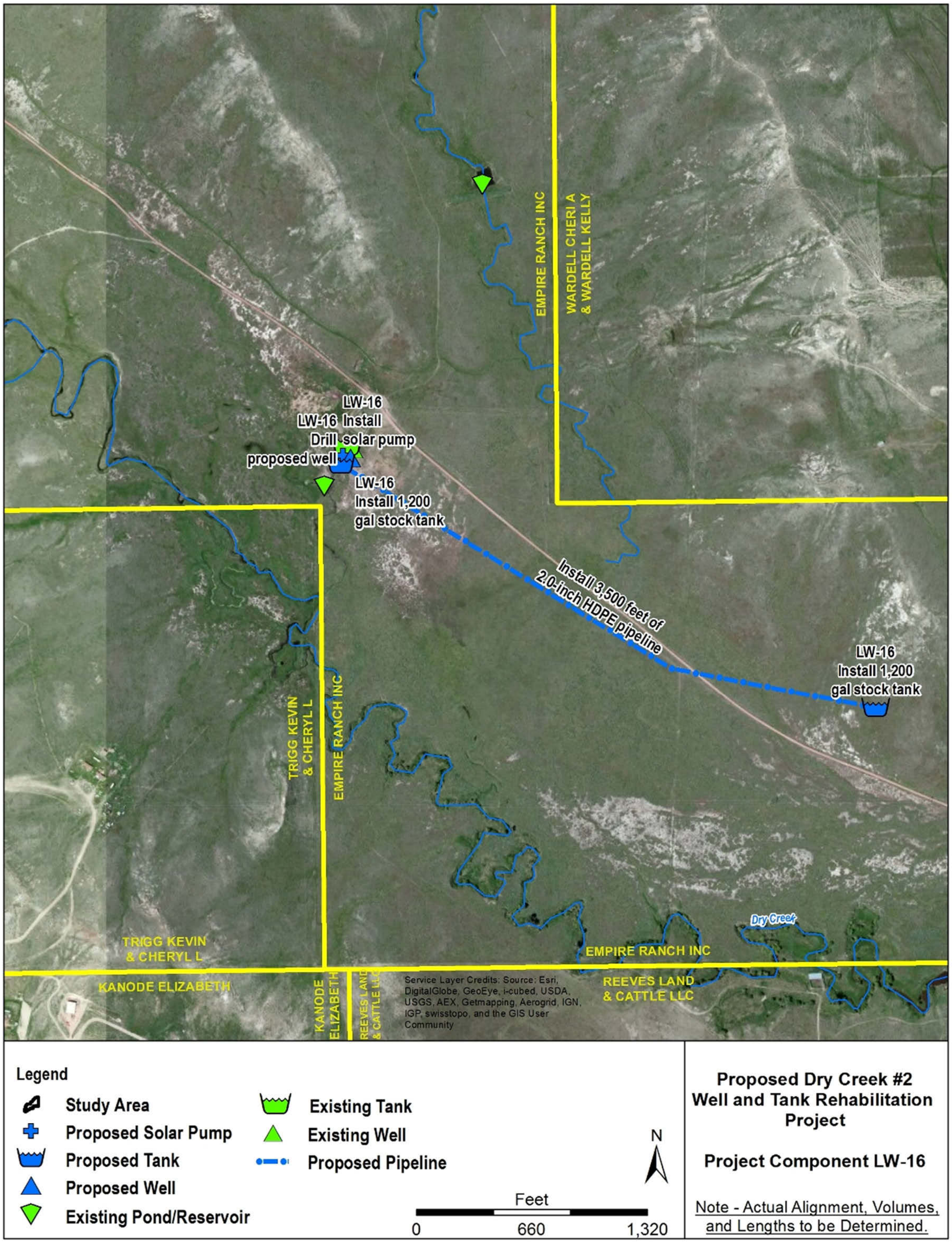


Figure 4-23. Proposed LW-16: Dry Creek #2 Well and Tank Rehabilitation Project.

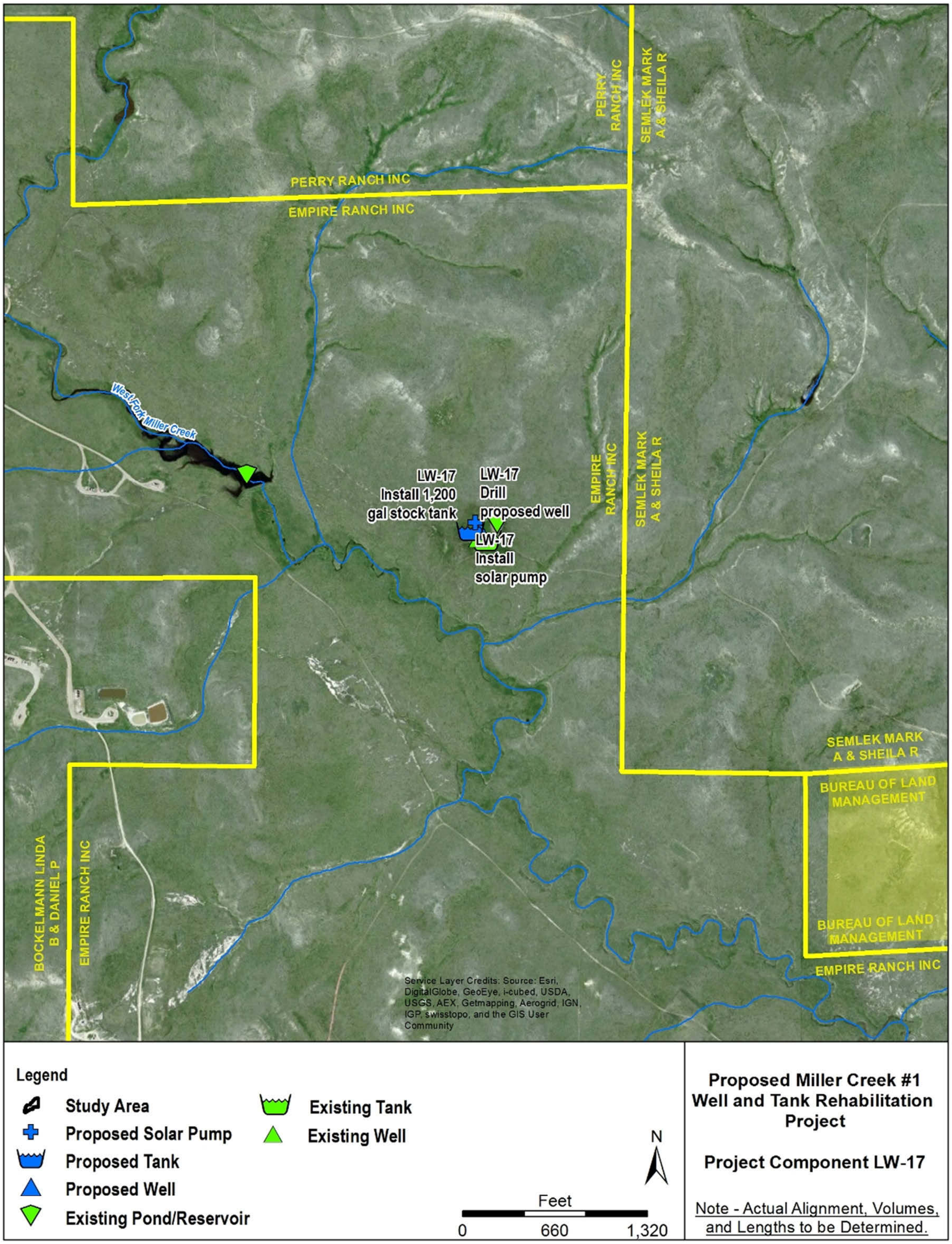


Figure 4-24. Proposed LW-17: Miller Creek #2 Well and Tank Rehabilitation Project.

4.5.2.20 LW-18: Dry Creek #4 Well and Tank Rehabilitation Project

This alternative would involve rehabilitating an existing well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.25 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

4.5.2.21 LW-19: Dry Creek #3 Well and Tank Rehabilitation Project

This alternative would involve rehabilitating an existing well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.26 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

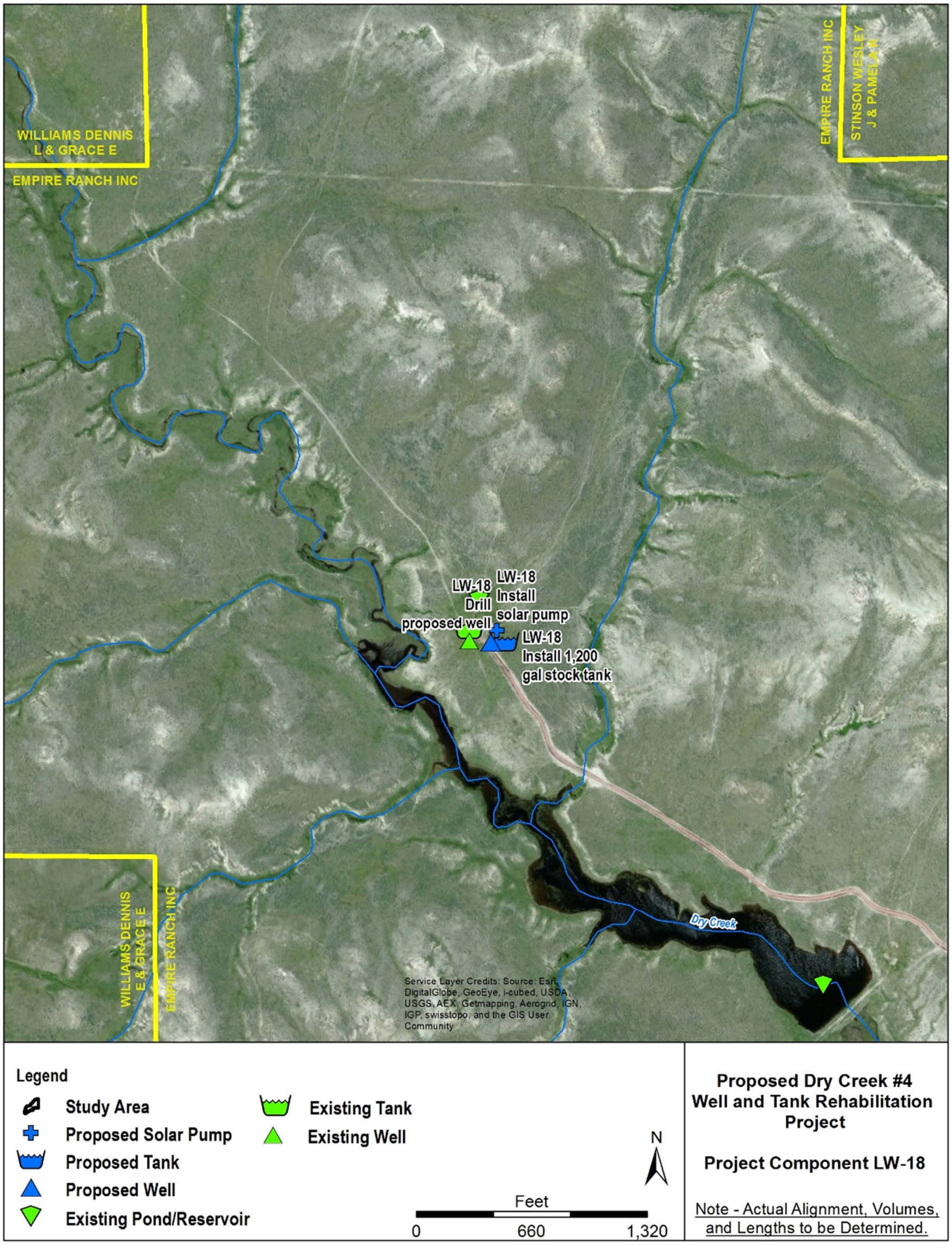


Figure 4-25. Proposed LW-18: Dry Creek #4 Well and Tank Rehabilitation Project.

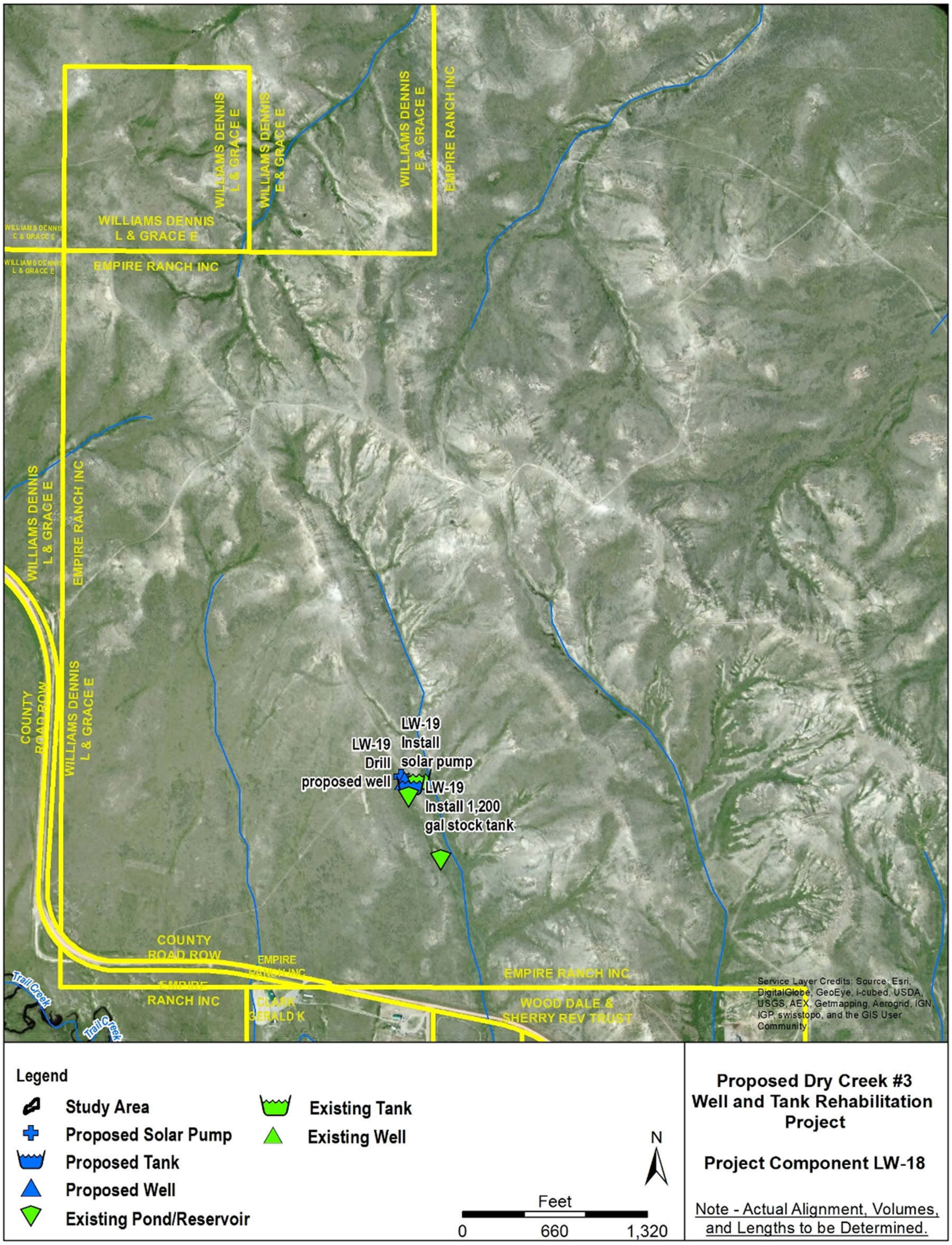


Figure 4-26. Proposed LW-19: Dry Creek #3 Well and Tank Rehabilitation Project.

4.5.2.22 LW-20: Hay Creek #1 and #2 Wells and Tank Rehabilitation Project

This alternative would involve rehabilitating an existing well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.27 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a pump and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Another existing well would be rehabilitated to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

4.5.2.23 LW-21: Miller Creek #2 Well and Tank Rehabilitation Project

This alternative would involve rehabilitating an existing well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.28 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

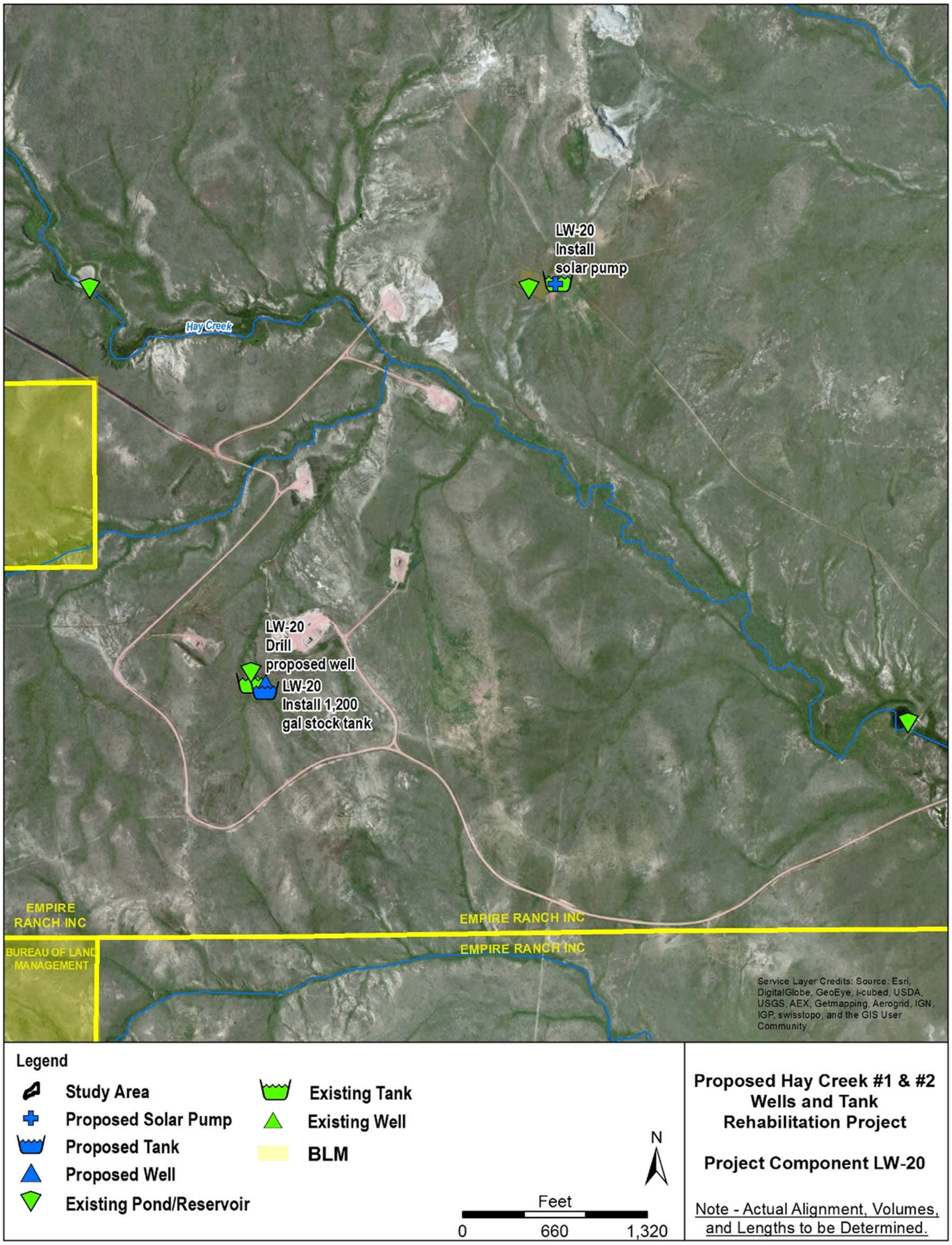


Figure 4-27. Proposed LW-20: Hay Creek #1 and #2 Wells and Tank Rehabilitation Project.

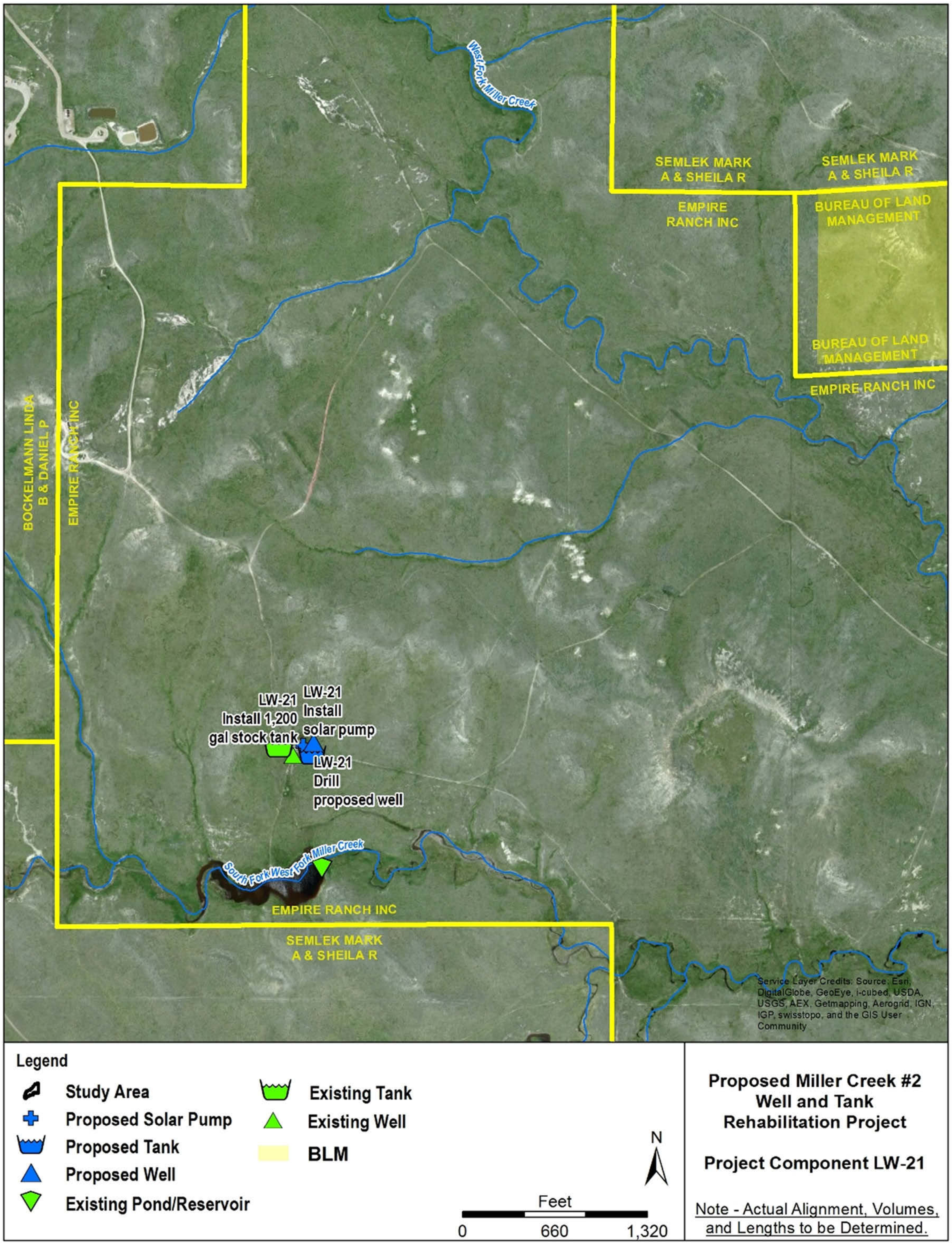


Figure 4-28. Proposed LW-21: Miller Creek #2 Well and Tank Rehabilitation Project.

4.5.2.24 LW-22: Dry Creek #5 Well and Tank Rehabilitation Project

This alternative would involve rehabilitating an existing well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.29 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

4.5.2.25 LW-23: Corral Creek #1 Well and Tank Rehabilitation Project

This alternative would involve rehabilitating an existing well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.30 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a pump and appurtenances.
- From the well and pump, two buried HDPE low-pressure pipelines would be installed to supply water to four stock tanks.
- One pipeline would be aligned northeasterly to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 2,000 linear feet of 2-inch pipeline.
- The other pipeline would require installing approximately 3,000 linear feet of 2-inch pipeline southeasterly from the well and pump to two stock tanks (1,200-gallon capacity each).
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

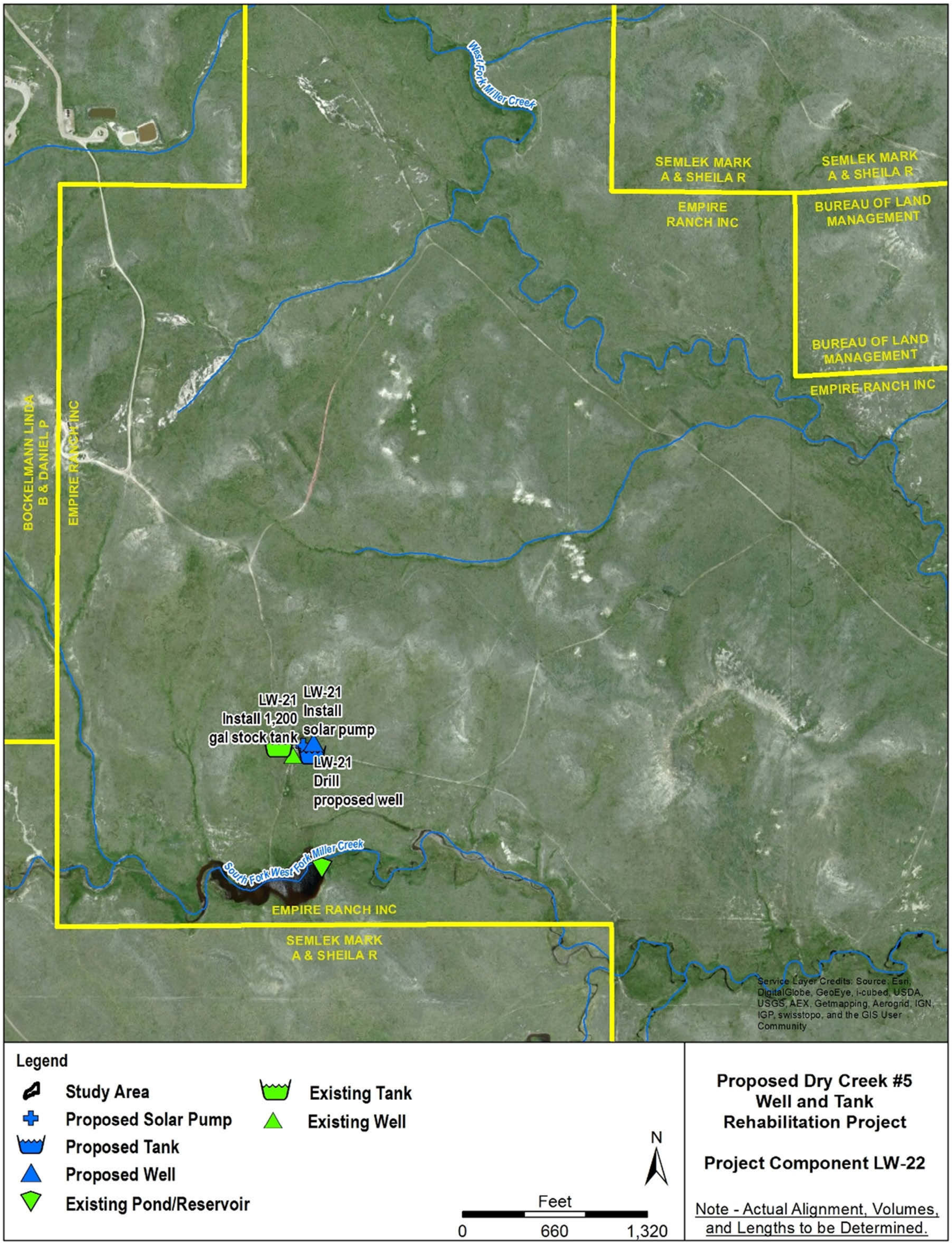


Figure 4-29. Proposed LW-22: Dry Creek #5 Well and Tank Rehabilitation Project.

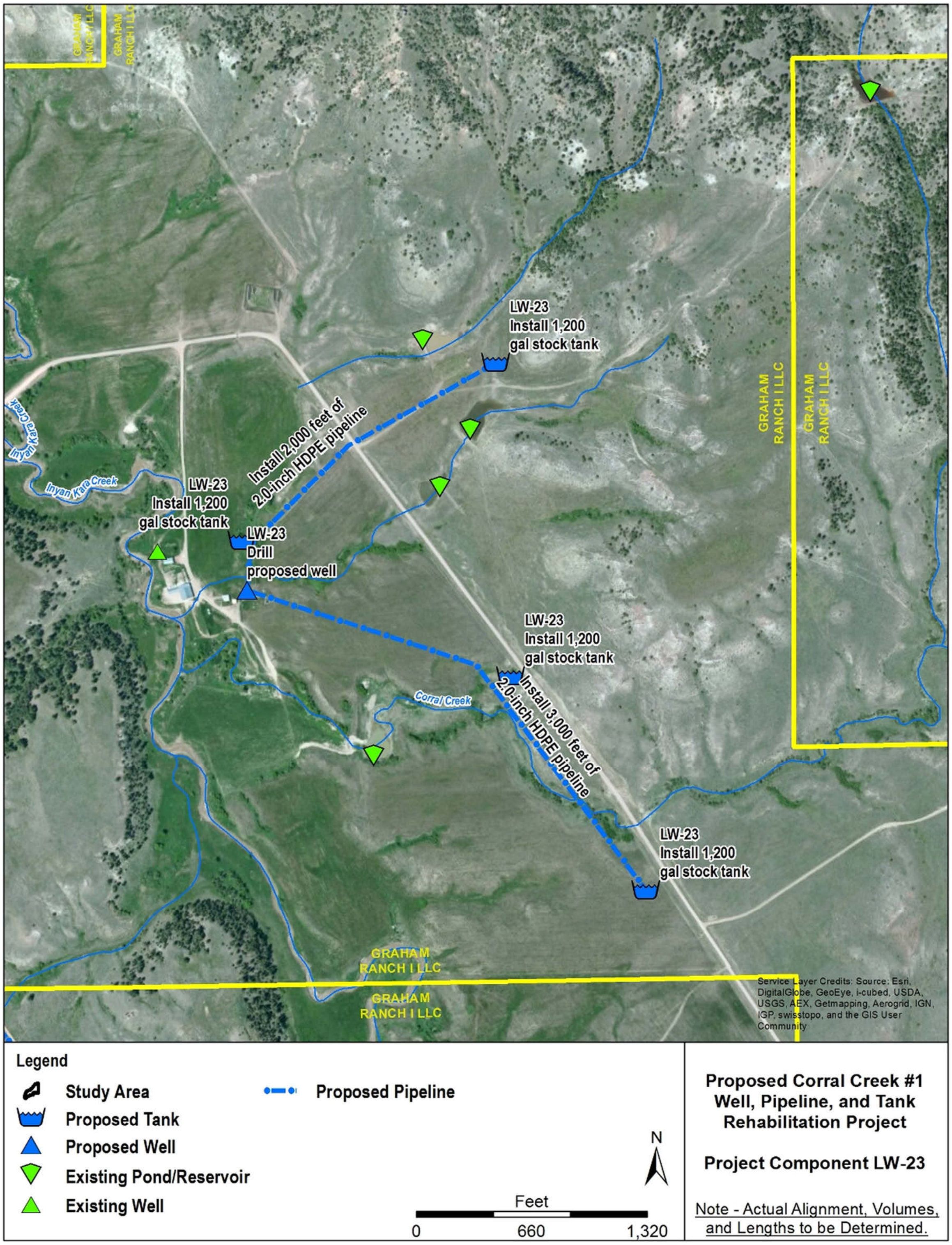


Figure 4-30. Proposed LW-23: Corral Creek #1 Well and Tank Rehabilitation Project.

4.5.2.26 LW-24: Alvin Creek Pipeline and Tank Project

This alternative would involve extending an existing pipeline supplied from an well and pump to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.31 would be installed:

- From the existing pipeline, well, and pump, a buried HDPE pipeline would be installed northwesterly to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 2,000 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

4.5.2.27 LW-25: Corral Creek #2 Well and Tank Rehabilitation Project

This alternative would involve rehabilitating an existing well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.32 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed easterly to supply a storage tank (~ 2,900-gallon capacity). This pipeline would require installing 300 linear feet of 2-inch pipeline.
- From the storage tank (~ 2,900-gallon capacity), a buried HDPE pipeline would be installed northerly to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 800 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

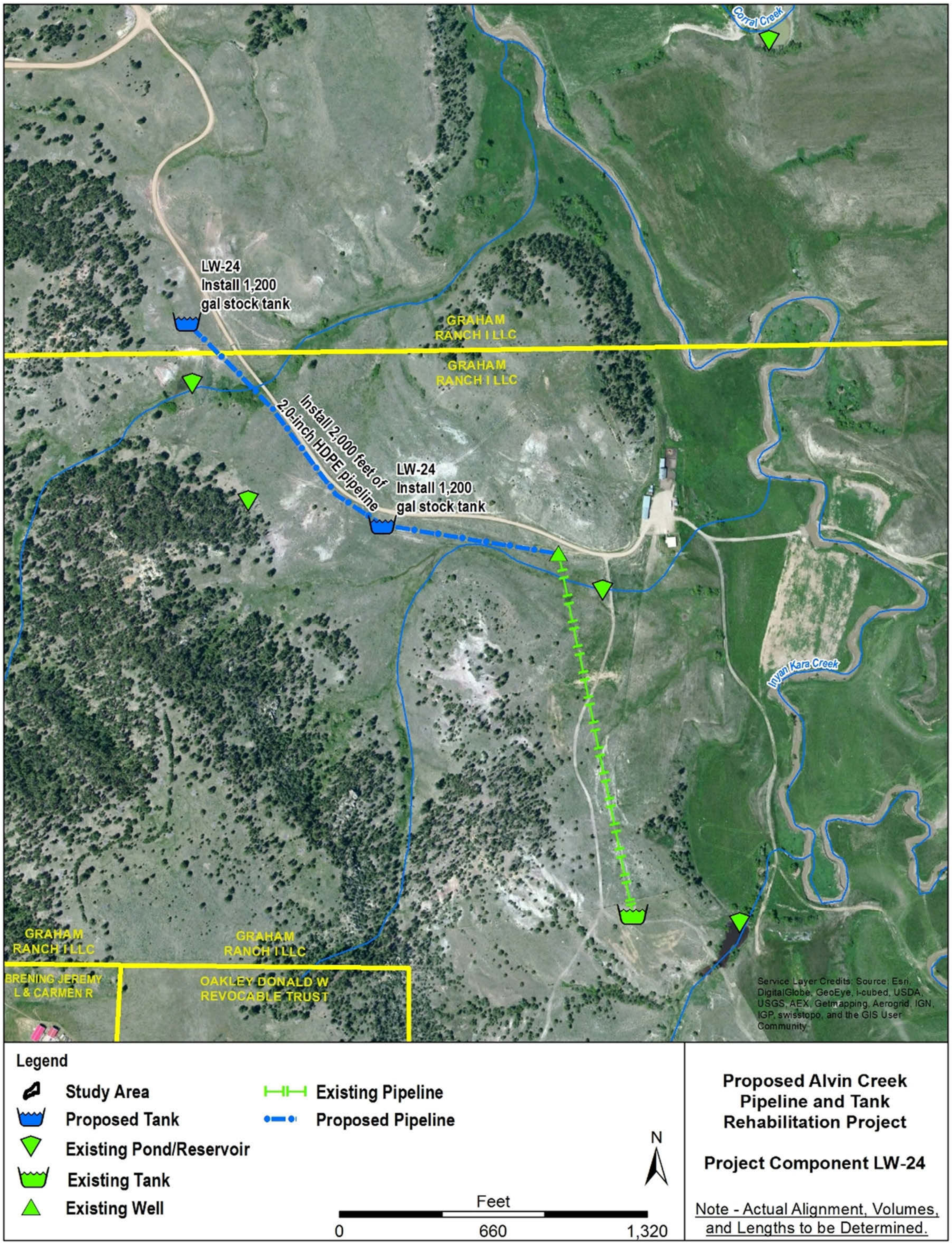


Figure 4-31. Proposed LW-24: Alvin Creek Pipeline and Tank Project.

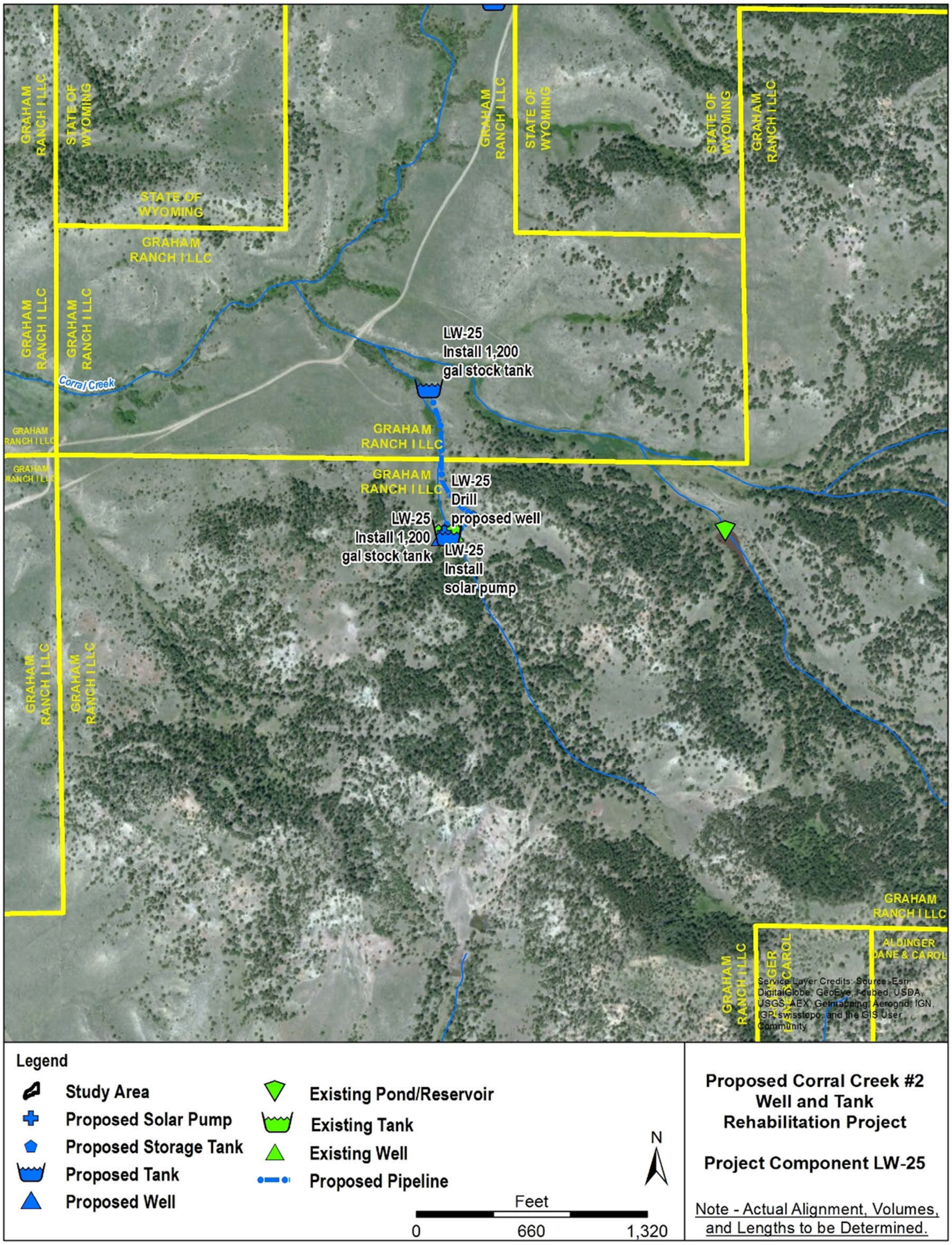


Figure 4-32. Proposed LW-25: Corral Creek #2 Well and Tank Rehabilitation Project.

4.5.2.28 LW-26: Corral Creek #3 Spring Development and Tank Project

This alternative would involve rehabilitating an existing spring and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.33 would be installed:

- The existing spring would be rehabilitated and equipped with collection pipe, spring box, and appurtenances.
- From the rehabilitated spring, a buried HDPE low-pressure pipeline would be installed to supply water to a storage tank (~ 2,900-gallon capacity).
- From the storage tank, a solar platform consisting of solar panel; solar-powered pump; batteries; and regulators, connections, and appurtenances would be installed to supply water via two buried HDPE low-pressure pipelines to two stock tanks (1,200-gallon capacity each).
- One pipeline would be aligned northerly to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 1,700 linear feet of 2-inch pipeline.
- The other pipeline would require installing approximately 1,200 linear feet of 2-inch pipeline southerly from the storage tank and solar pump to a stock tank (1,200-gallon capacity).
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

4.5.2.29 LW-27: Eggie Basin Pipeline and Tank Project

This alternative would involve extending an existing pipeline supplied from an existing spring development, solar pump, and storage tank (~ 2,900-gallon capacity) to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.34 would be installed:

- From the existing pipeline, spring development, solar pump, and storage tank (approximately 2,900-gallon capacity), a buried HDPE pipeline would be installed south-westerly to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 2,800 linear feet of 2-inch pipeline.
- From the installed pipeline and stock tanks, the other HDPE pipeline would be installed westerly to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 2,900 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

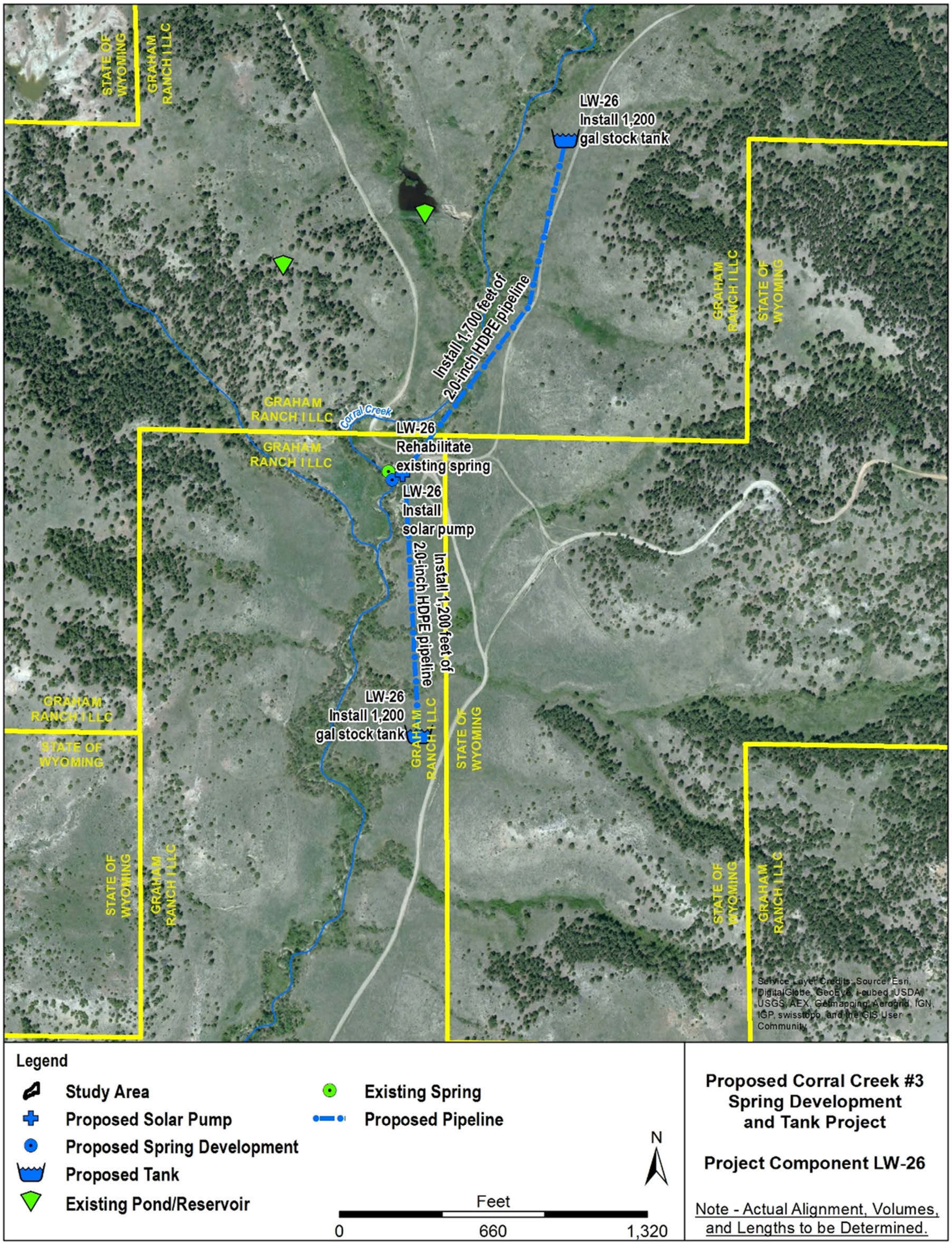


Figure 4-33. Proposed LW-26: Corral Creek #3 Spring Development and Tank Project.

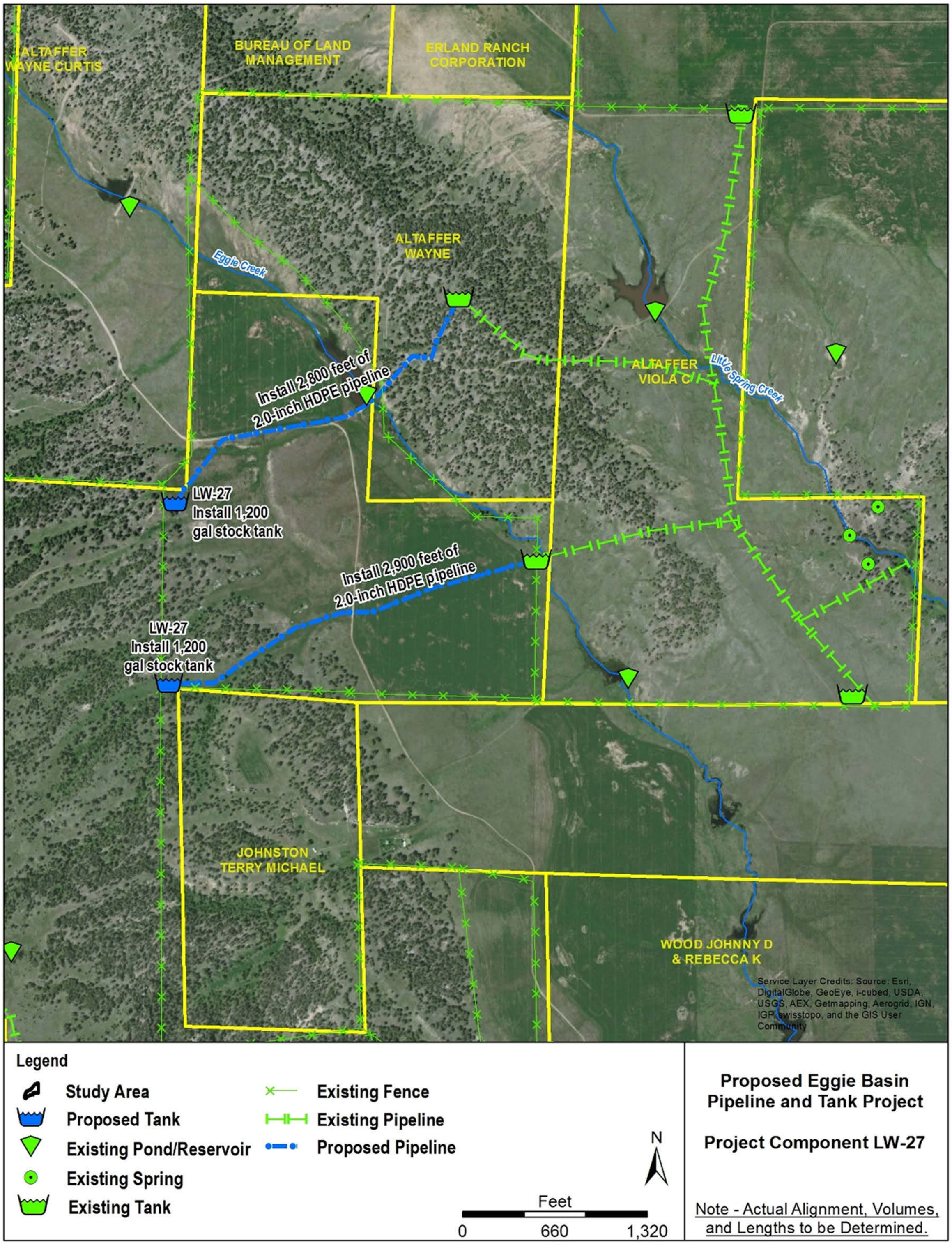


Figure 4-34. Proposed LW-27: Eggie Basin Pipeline and Tank Project.

4.5.2.30 LW-28: Pine Ridge Well and Tank Project

This alternative would involve drilling a new well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.35 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply water to a storage tank (approximately 2,900-gallon capacity).
- From the storage tank (approximately 2,900-gallon capacity), a buried HDPE pipeline would be installed southerly to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 3,400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

4.5.2.31 LW-29: Little Draw #1 Well and Tank Project

This alternative would involve drilling a new well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.36 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

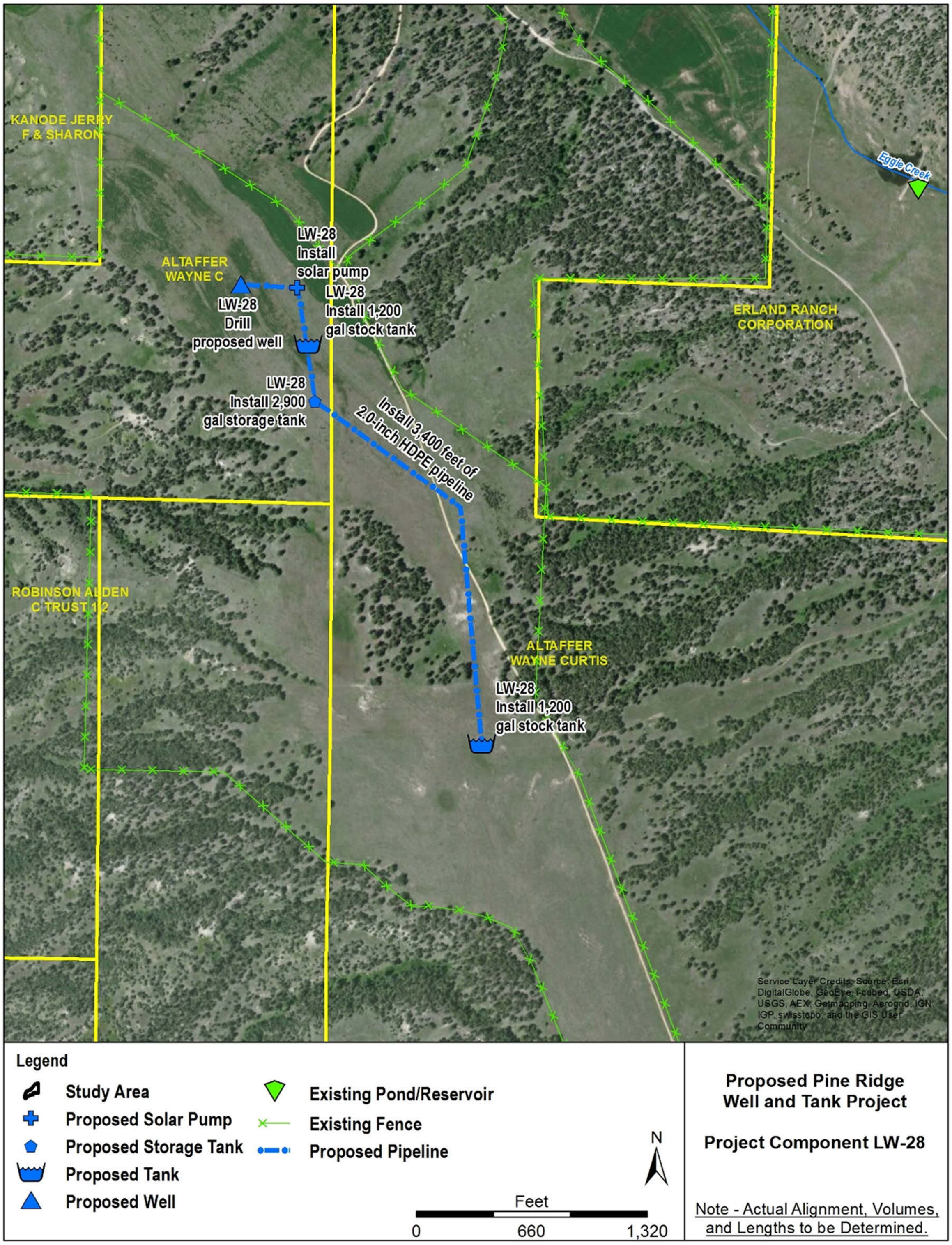


Figure 4-35. Proposed LW-28: Pine Ridge Well and Tank Project.

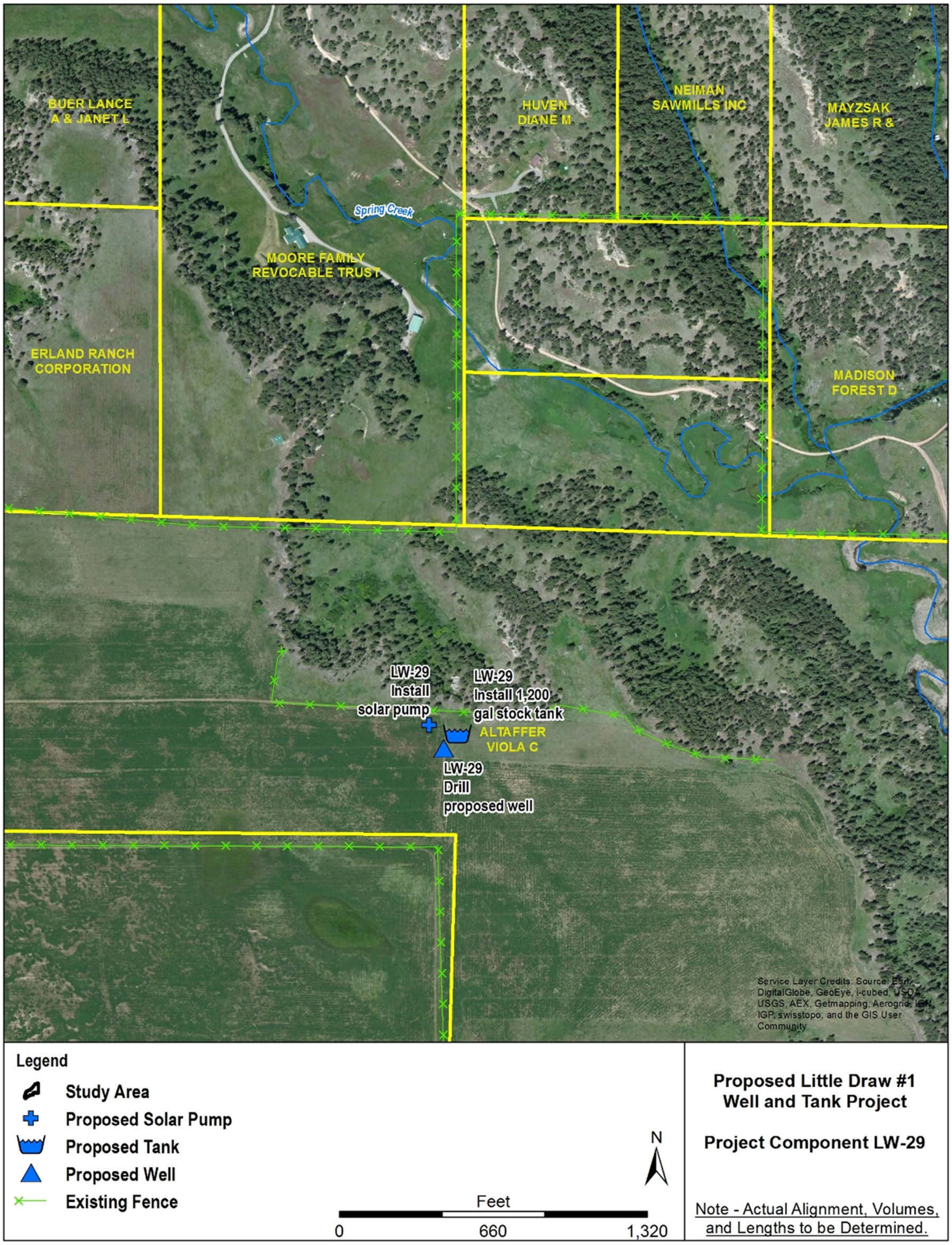


Figure 4-36. Proposed LW-29: Little Draw #1 Well and Tank Project.

4.5.2.32 LW-30: Alma Reservoir Rehabilitation Project

This alternative as shown in Figure 4.37 would provide for rehabilitating a stock reservoir and associated wetlands. The existing stock reservoir is located on Mikel Creek, an intermittent tributary to Spring Creek, within Section 6 of Township 51 North, Range 66 West in Crook County. Currently, the stock reservoir has problems related to the dam embankment and outlet facilities and is not capable of providing necessary storage.

This project would include rehabilitating the Alma Stock Reservoir (Permit No. P4565S). The reservoir has a permitted total capacity of 11.44 acre-feet. This stock reservoir could be rehabilitated to provide an additional source of livestock/wildlife water along with restoring function of the associated wetland and riparian areas. This alternative would involve installing an inlet and outlet pipe control structure in the reservoir embankment and stabilizing the installed structures and spillway with rock riprap. This alternative includes the following features:

- Inspecting the embankment and rehabilitation of problem areas as needed. The embankment is approximately 400 feet long and less than 15 feet high at its highest point. The top-width of the embankment is approximately 15 feet wide.
- Installing an inlet and outlet control mechanism to control reservoir water levels. The installed structures would be stabilized with rock riprap.
- Investigating site-specific soil and geologic conditions to define the extent necessary to excavate existing sediment and to determine if alternatives to bentonite liner treatment should be considered because of karstic bedrock or other conditions of the underlying bedrock formation.
- Excavating the earthen, grass-lined spillway to adequately convey necessary water volumes and stabilizing with rock riprap for spillway protection.
- Contingent on determining adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.
- As delineated, the project involves privately owned lands only.

4.5.2.33 LW-31: Lower Alma Reservoir Rehabilitation Project

This alternative, also illustrated in Figure 4.37, would provide for rehabilitating a stock reservoir and associated wetlands. The existing stock reservoir is directly downstream of the Alma Stock Reservoir (Permit No. P4565S) and also located on Mikel Creek, an intermittent tributary to Spring Creek, within Section 6 of Township 51 North, Range 66 West in Crook County. Currently, the stock reservoir has problems related to dam embankment and outlet facilities and experiences seepage loss of the impounded water behind the embankment.

This stock reservoir could be rehabilitated to provide an additional source of livestock/wildlife water along with restoring function of the associated wetland and riparian

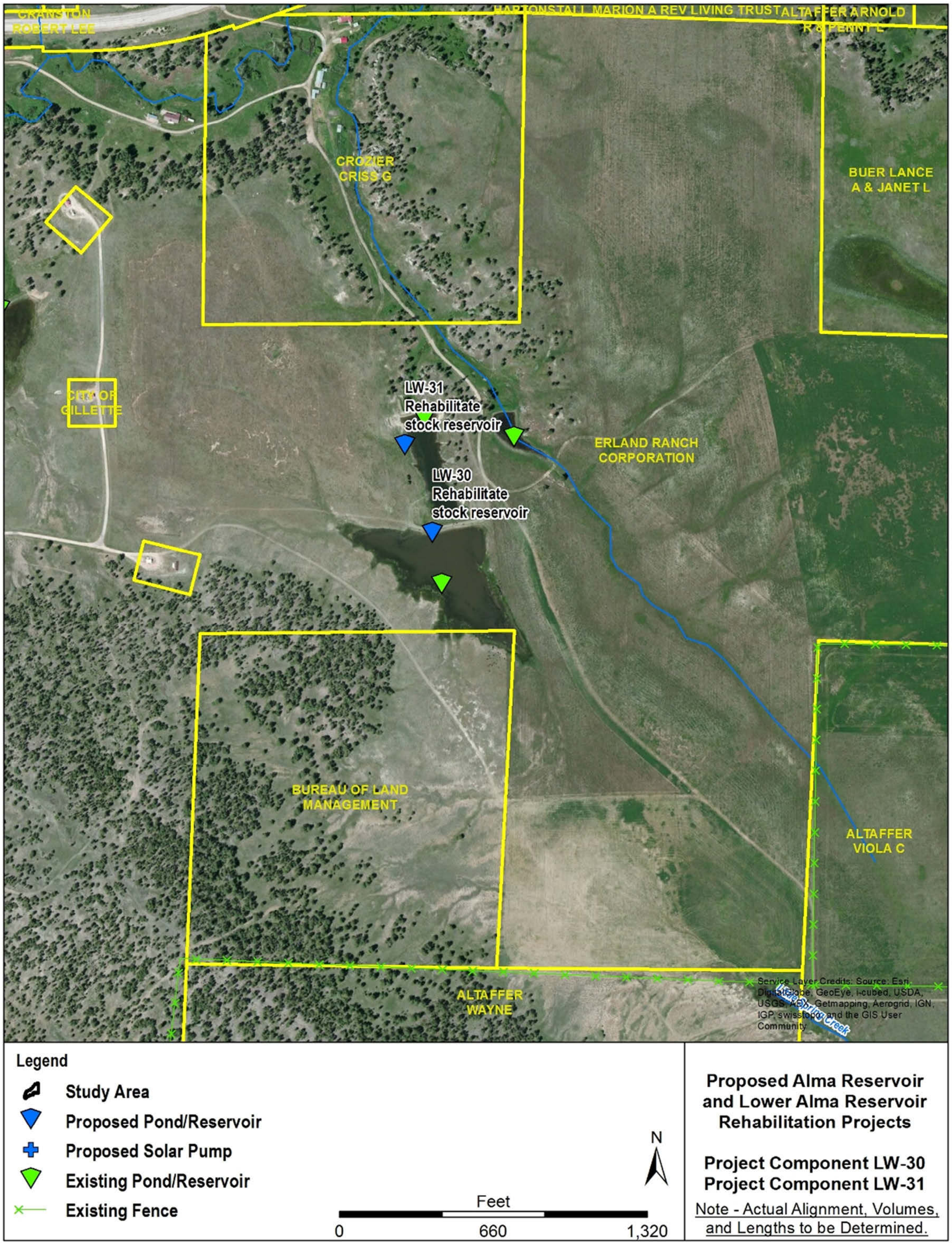


Figure 4-37. Proposed LW-30 and LW-31: Alma and Lower Alma Reservoirs Projects.

areas. The stock reservoir encompasses 1.2 acres with a total capacity of less than 2 acre-feet. This alternative would include the following features:

- Inspecting the embankment and rehabilitation of problem areas as needed. The embankment is approximately 200 feet long and less than 15 feet high at its highest point. The top-width of the embankment is approximately 10 feet wide.
- Investigating site-specific soil and geologic conditions to define the extent necessary to excavate existing sediment and to determine if alternatives to bentonite liner treatment should be considered because of karstic bedrock or other conditions of the underlying bedrock formation.
- Installing an inlet and outlet control mechanism to control reservoir water levels. The installed structures would be stabilized with rock riprap.
- Excavating the spillway to adequately convey overflow volumes and stabilizing with rock riprap for protection.
- Contingent on determining adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.
- Potential construction options for reducing seepage in small stock ponds and reservoirs include the installation of geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Potential options are detailed in the NRCS Construction Specifications for Pond Sealing or Lining (NRCS WY-521A, WY-521C, or WY-521D).
- As delineated, the project involves privately owned lands only.

4.5.2.34 LW-32: Mikel Creek Well and Tank Project

This alternative would involve drilling a new well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.38 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

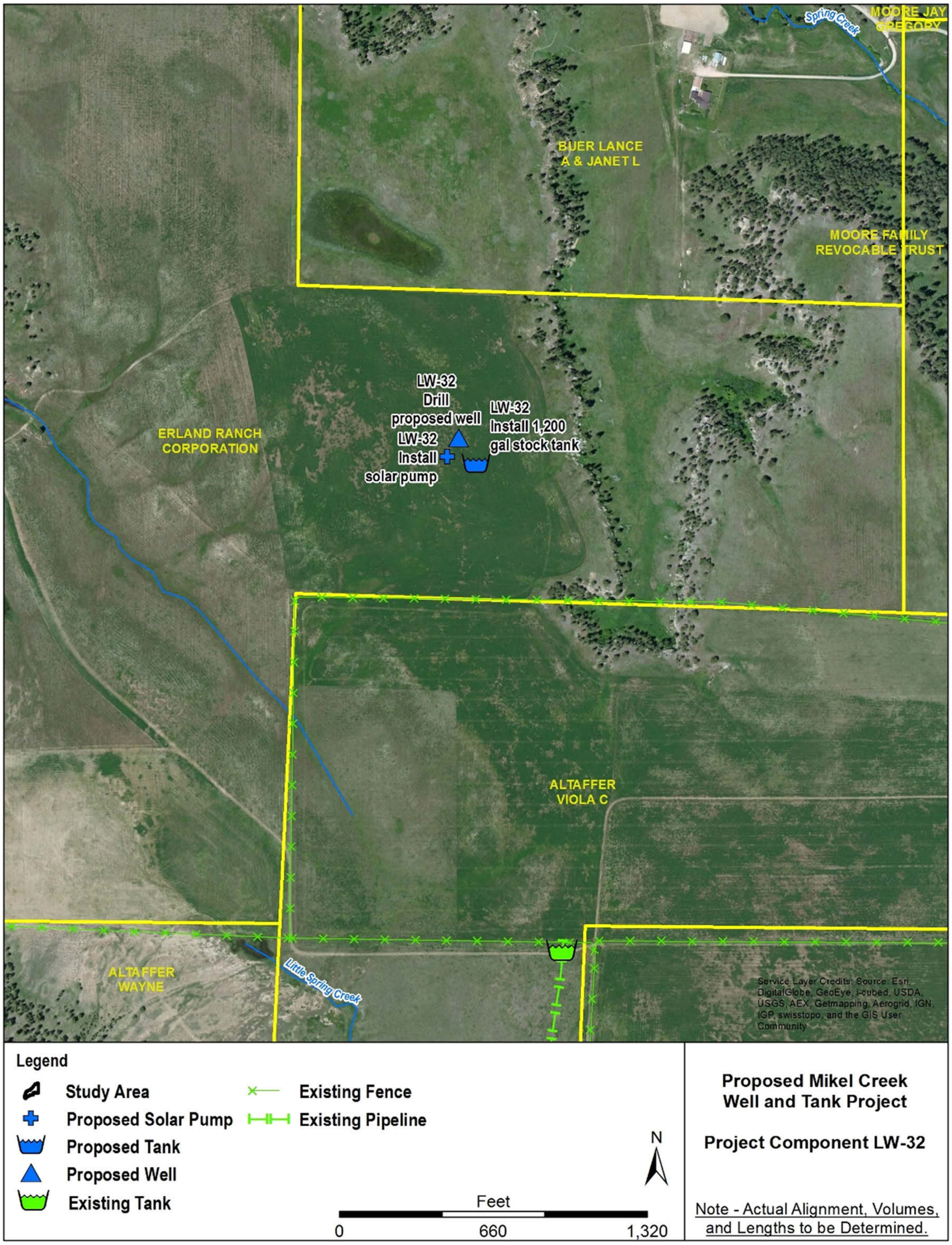


Figure 4-38. Proposed LW-32: Mikel Creek Well and Tank Project.

4.5.2.35 LW-33: Little Draw #2 Well and Tank Project

This alternative would involve drilling a new well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.39 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed southeasterly to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 3,500 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

4.5.2.36 LW-34: Sage Draw Well and Tank Rehabilitation Project

This alternative would involve rehabilitating an existing well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.40 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Additionally, another stock tank (1,200-gallon capacity) would be installed from an existing pipeline, well, and pump to supply water for the proposed project.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

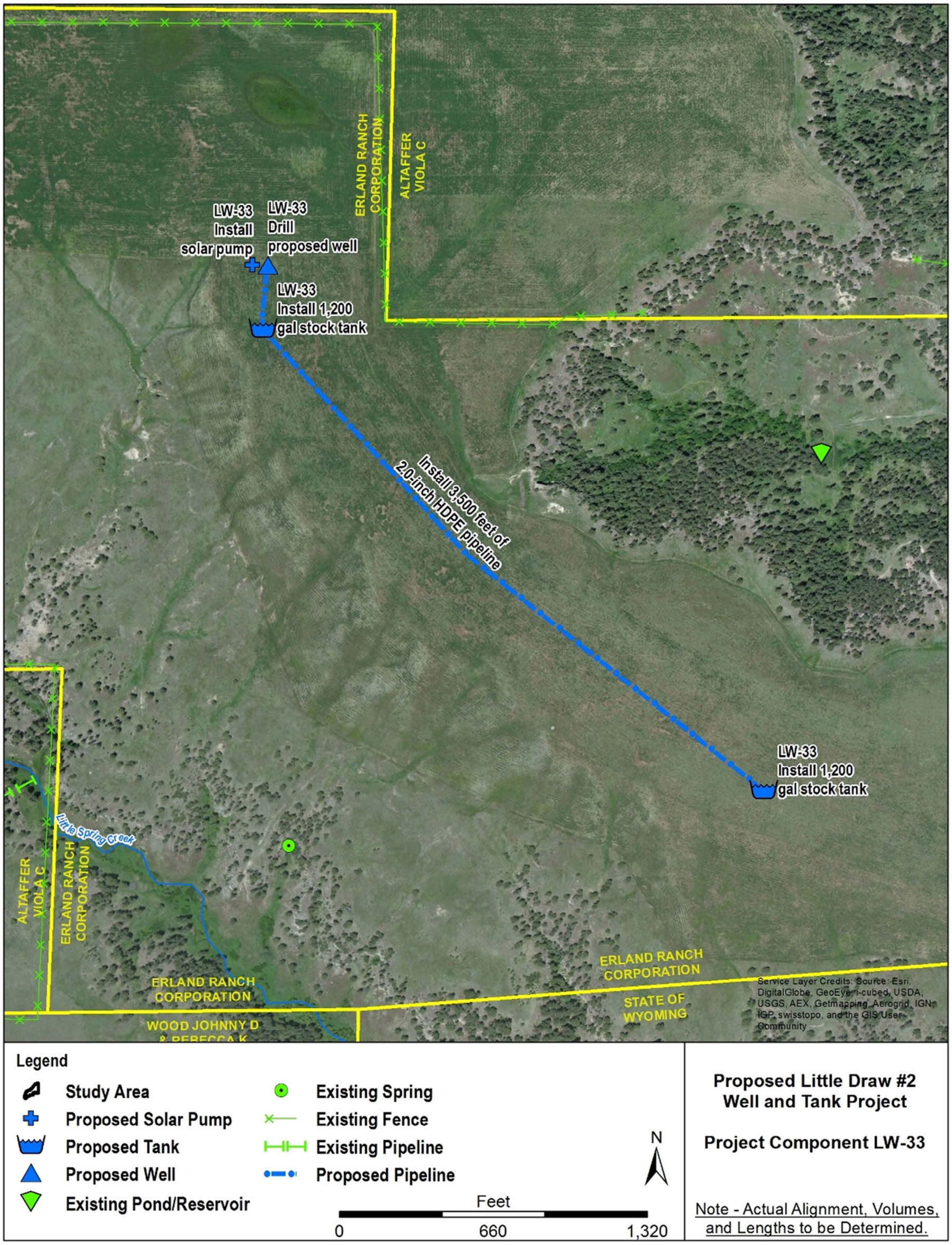


Figure 4-39. Proposed LW-33: Little Draw #2 Well and Tank Project.

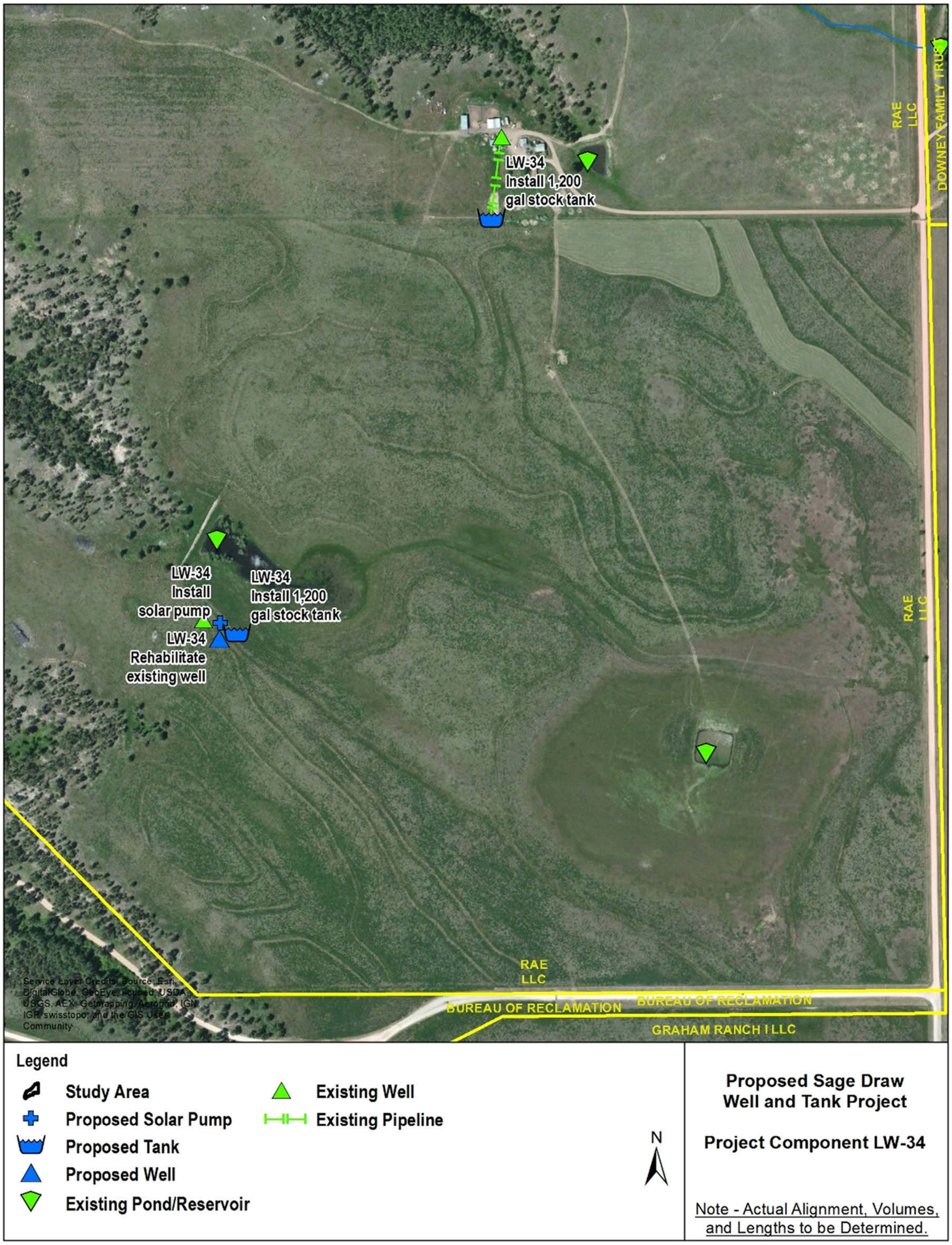


Figure 4-40. Proposed LW-34: Sage Draw Well and Tank Rehabilitation Project.

4.5.2.37 LW-35: Tobey Draw Pipeline and Tank Project

This alternative would involve extending an existing pipeline supplied from a well and pump to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.41 would be installed:

- From the existing pipeline, well, and pump, a buried HDPE pipeline would be installed northwesterly to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 2,300 linear feet of 2-inch pipeline.
- The other pipeline would require installing approximately 2,400 linear feet of 2-inch pipeline northeasterly from the existing pipeline, well, and pump to a stock tank (1,200-gallon capacity).
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

4.5.2.38 LW-35A: Noecker Stock Reservoir Rehabilitation Project

In addition to developing livestock/wildlife water sources described in the *LW-35: Tobey Draw Pipeline and Tank Project*, this alternative as shown also in Figure 4.41, would provide for rehabilitating a stock reservoir and associated wetlands. The existing stock reservoir is located on Tobey Draw, an intermittent tributary to the Belle Fourche River, within Section 23 of Township 51 North, Range 66 West in Crook County. Currently, the stock reservoir experiences seepage loss of the impounded water behind the embankment.

This project would include rehabilitating the Noecker Stock Reservoir (Permit No. P4565S). The reservoir has a permitted total capacity of 4.87 acre-feet. This stock reservoir could be rehabilitated to provide an additional source of livestock/wildlife water along with restoring function of the wetland and riparian areas. This alternative would include the following features:

- Inspecting the embankments and rehabilitation of problem areas as needed. The embankment is approximately 260 feet long and less than 10 feet high at its highest point. The top-width of the embankment is approximately 10 feet wide.
- Investigating site-specific soil and geologic conditions to define the extent necessary to excavate existing sediment and to determine if alternatives to bentonite liner treatment should be considered because of karstic bedrock or other conditions of the underlying bedrock formation.
- Potential construction options for reducing seepage in small stock ponds and reservoirs include the installation of geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Potential options are detailed in the NRCS Construction Specifications for Pond Sealing or Lining (NRCS WY-521A, WY-521C, or WY-521D).
- As proposed, the project involves private lands only.

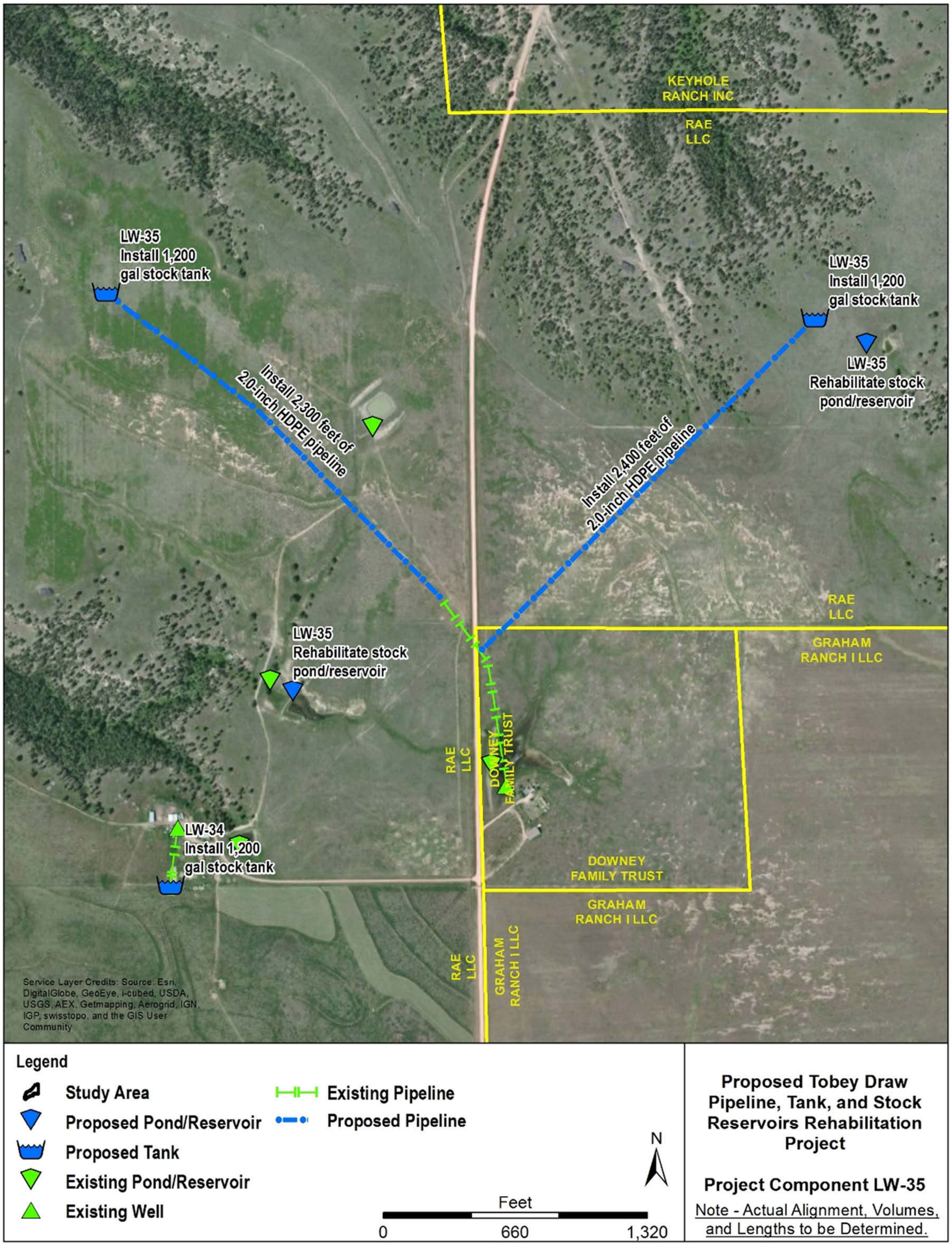


Figure 4-41. Proposed LW-35: Tobey Draw Pipeline and Tank Project; LW-35A: Noecker Stock Reservoir Rehabilitation Project; and LW-35B: Dinky Stock Reservoir Rehabilitation Project.

4.5.2.39 LW-35B: Dinky Stock Reservoir Rehabilitation Project

In addition to developing livestock/wildlife water sources described in the *LW-35: Tobey Draw Pipeline and Tank Project*, this alternative as shown also in Figure 4.41, would also provide for rehabilitating a stock reservoir and associated wetlands. The existing stock reservoir is located on Gill Creek, an intermittent tributary to Arch Creek, within Section 23 of Township 51 North, Range 66 West in Crook County. Currently, the stock reservoir experiences seepage loss of the impounded water behind the embankment.

This project would include rehabilitating the Dinky Stock Reservoir (Permit No. P4294S). The reservoir has a permitted total capacity of 0.79 acre-feet. This stock reservoir could be rehabilitated to provide an additional source of livestock/wildlife water along with restoring function of the associated wetland and riparian areas. This alternative would include the following features:

- Inspecting the embankments and rehabilitation of problem areas as needed. The embankment is approximately 80 feet long and less than 10 feet high at its highest point. The top-width of the embankment is approximately 10 feet wide.
- Investigating site-specific soil and geologic conditions to define the extent necessary to excavate existing sediment and to determine if alternatives to bentonite liner treatment should be considered because of karstic bedrock or other conditions of the underlying bedrock formation.
- Potential construction options for reducing seepage in small stock ponds and reservoirs include the installation of geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Potential options are detailed in the NRCS Construction Specifications for Pond Sealing or Lining (NRCS WY-521A, WY-521C, or WY-521D).
- As proposed, the project involves private lands only.

4.5.2.40 LW-36: Line Creek Spring Development and Tank Project

This alternative would involve rehabilitating an existing spring development and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.42 would be installed:

- The existing spring would be rehabilitated and equipped with collection pipe, spring box, and appurtenances.
- From the rehabilitated spring, a solar platform consisting of solar panel; solar-powered pump; batteries; and regulators, connections, and appurtenances would be installed to supply water via a buried HDPE low-pressure pipeline to two stock tanks (1,200-gallon capacity each). This pipeline would be aligned westerly and require installing 1,700 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

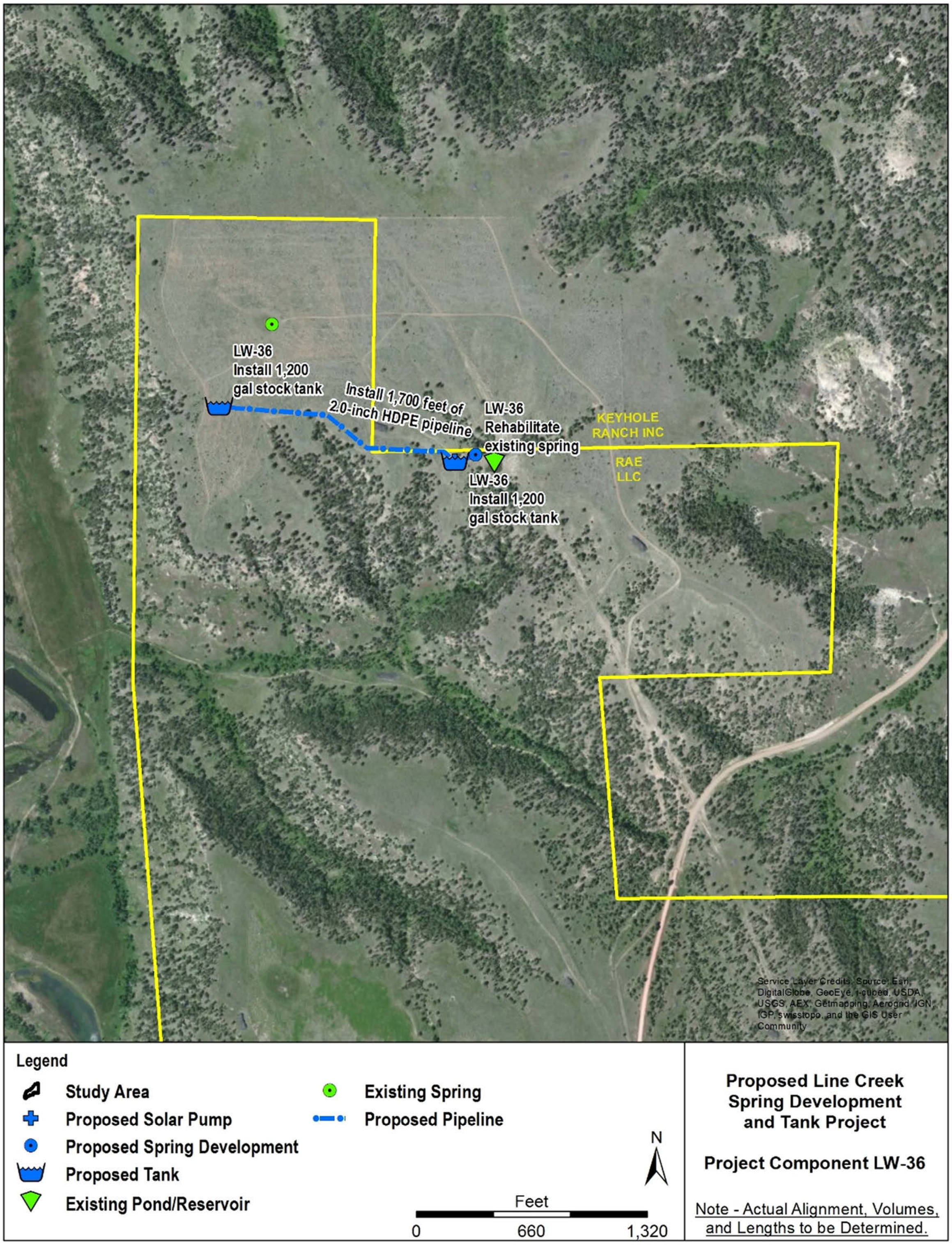


Figure 4-42. Proposed LW-36: Line Creek Spring Development and Tank Project.

4.5.2.41 LW-37: Little Wright Draw Well, Pipeline, and Tank Project

This alternative would involve drilling a new well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.43 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply water to a storage tank (~ 2,900-gallon capacity).
- From the storage tank (~ 2,900-gallon capacity), a buried HDPE pipeline would be installed northerly to supply three stock tanks (1,200-gallon capacity each). This pipeline would require installing 6,200 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

4.5.2.42 LW-38: Busby Draw Well and Tank Project

This alternative would involve drilling a new well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.44 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

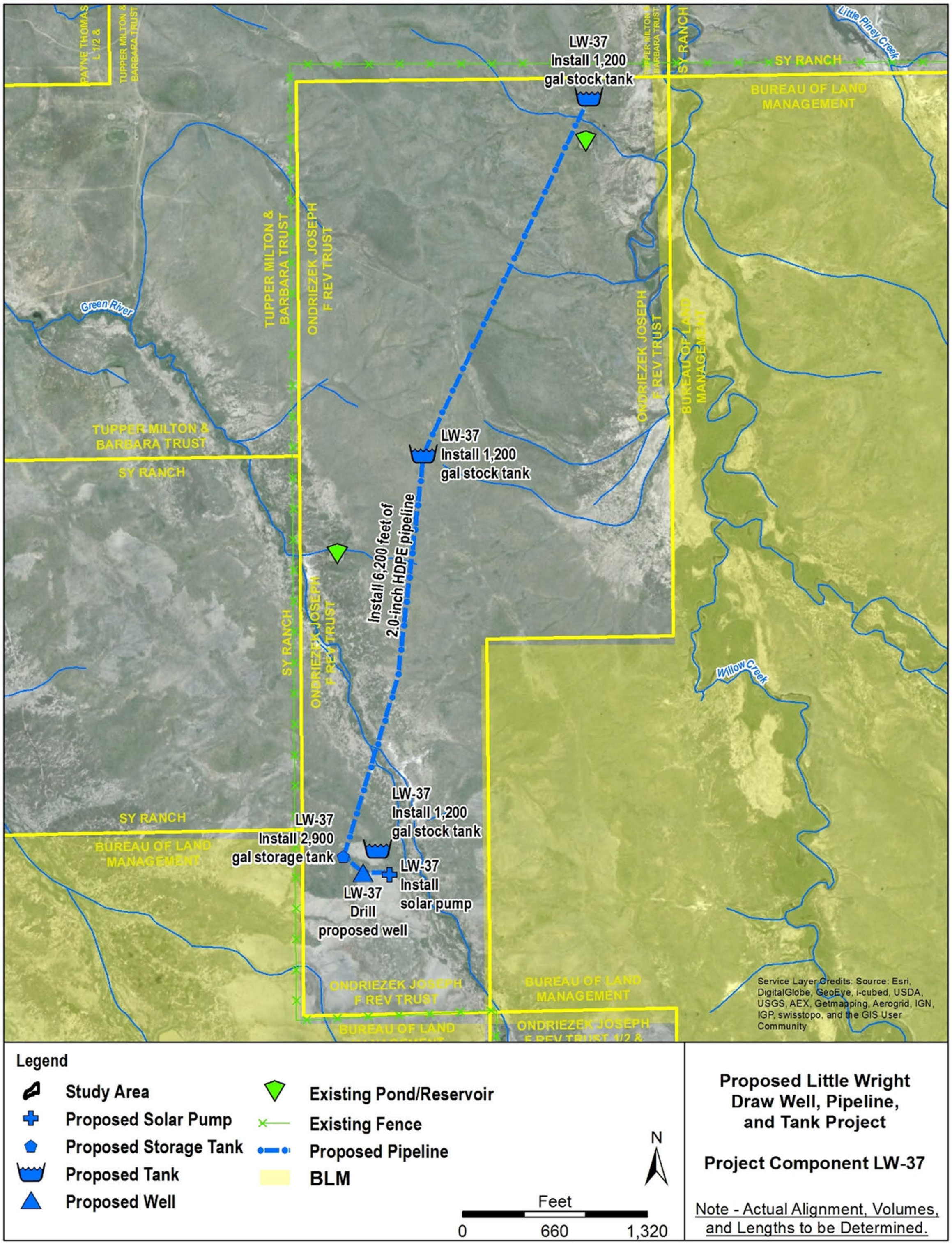


Figure 4-43. Proposed LW-37: Little Wright Draw Well, Pipeline, and Tank Project.

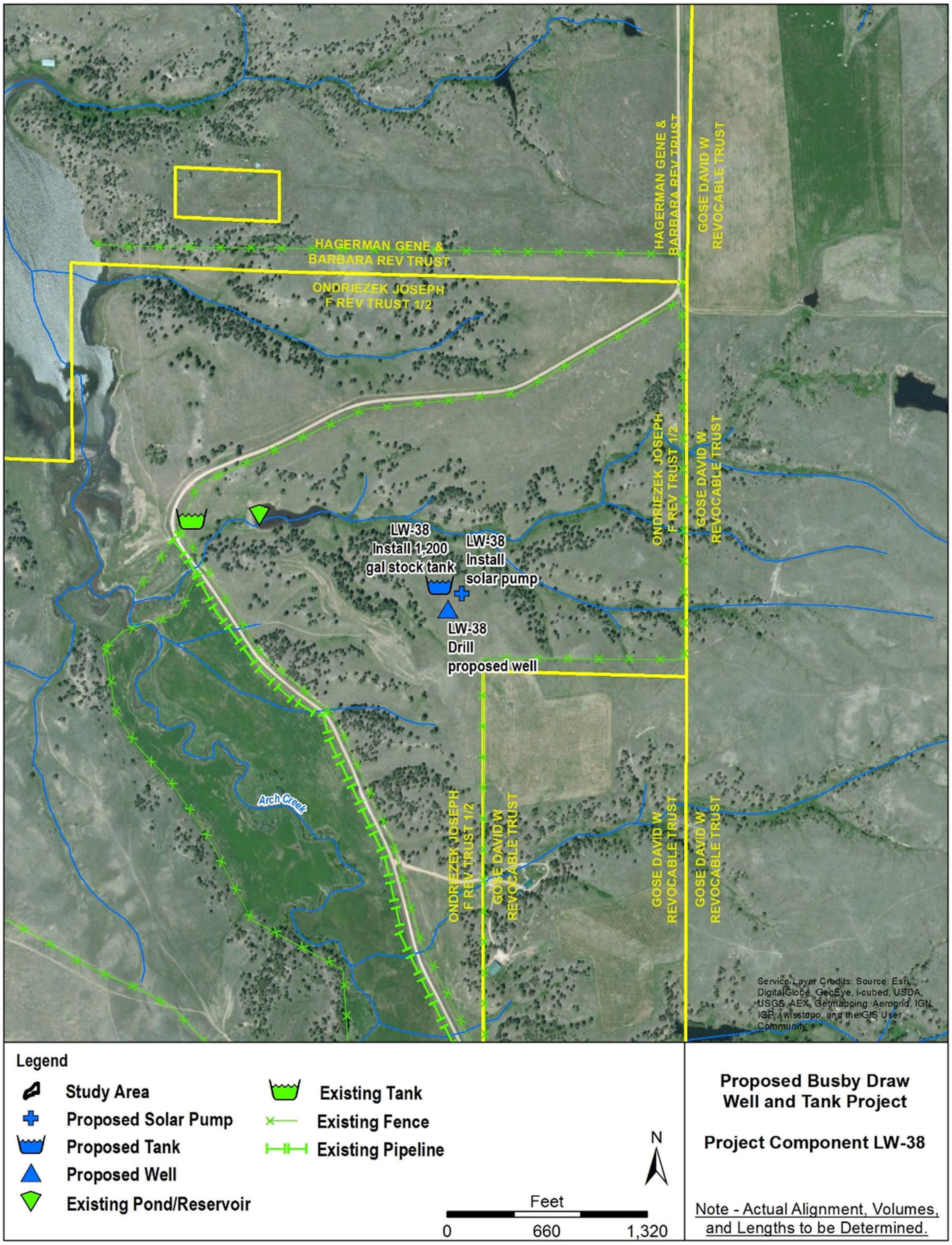


Figure 4-44. Proposed LW-38: Busby Draw Well and Tank Project.

4.5.2.43 LW-39: Wolfe Draw Pipeline and Tank Project

This alternative would involve extending an existing pipeline supplied from a well and pump to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.45 would be installed:

- From the existing pipeline, well, and pump, a buried HDPE pipeline would be installed easterly to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 3,800 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

4.5.2.44 LW-40: Kruger #1 Well and Pipeline Project

This alternative would involve drilling a new well and extending an existing pipeline supplied from a proposed well to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.46 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a pump and appurtenances.
- From the proposed well and pump, a buried HDPE pipeline would be installed easterly to supply four existing stock tanks (1,200-gallon capacity each). This pipeline would require installing 1,900 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

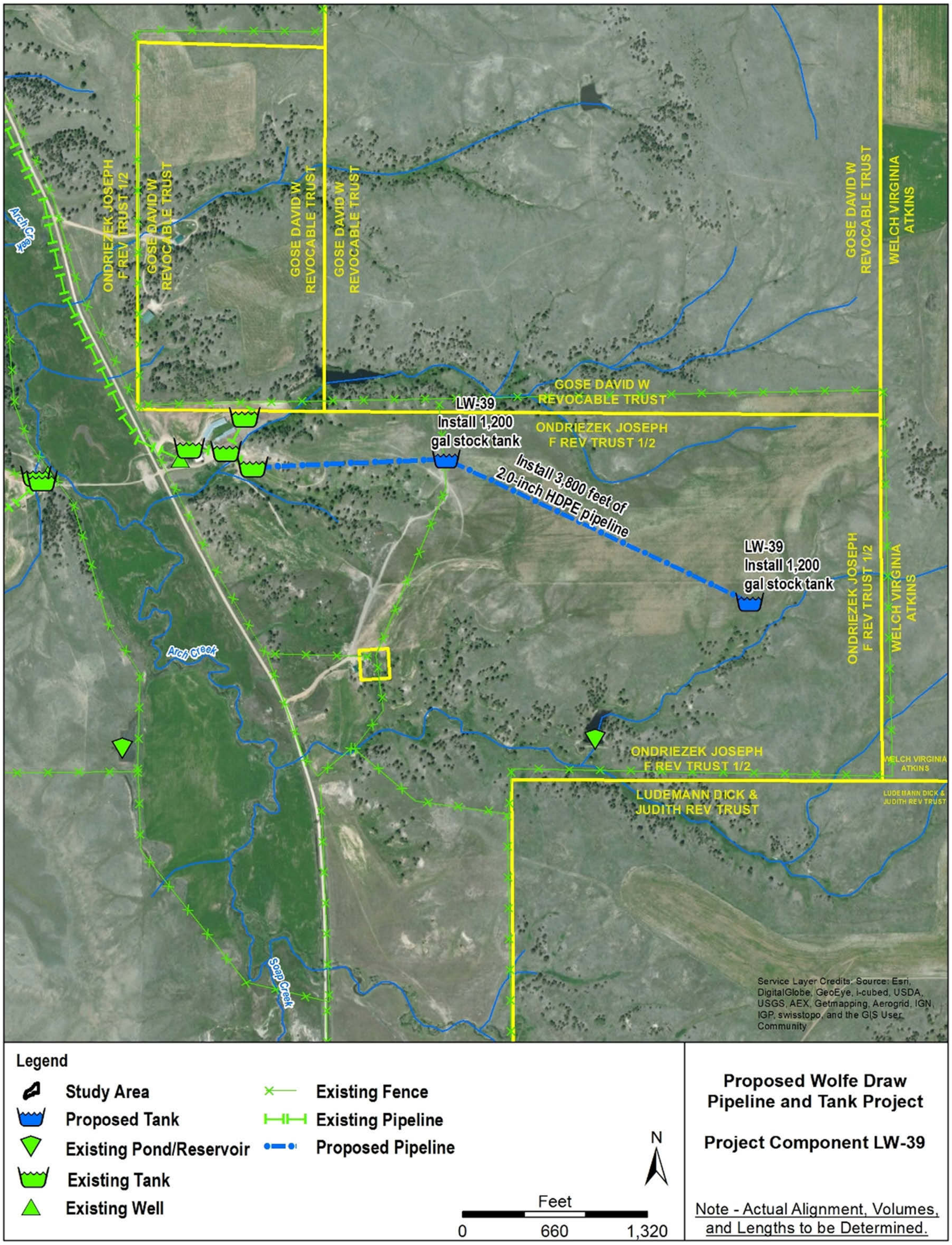


Figure 4-45. Proposed LW-39: Wolfe Draw Pipeline and Tank Project.

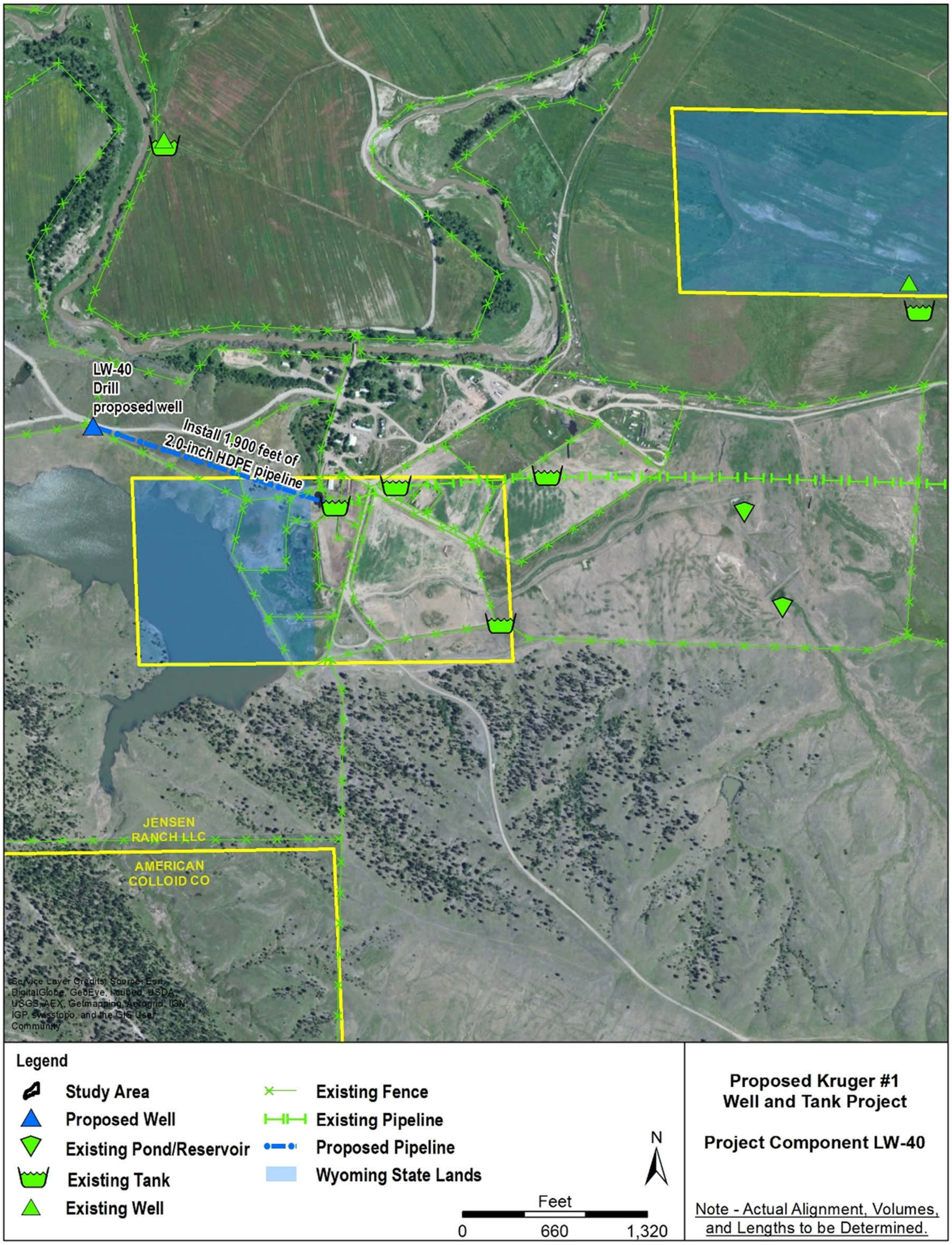


Figure 4-46. Proposed LW-40: Kruger #1 Well and Pipeline Project.

4.5.2.45 LW-41: Kruger #2 Pipeline and Tank Project

This alternative would involve extending an existing pipeline supplied from a proposed well, pump, pipeline, and stock tanks to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.47 would be installed:

- From the existing pipeline, proposed well, and pump, a buried HDPE pipeline would be installed easterly to supply three stock tanks (1,200-gallon capacity each). This pipeline would require installing 7,900 linear feet of 2-inch pipeline.
- From the proposed pipeline and stock tanks, another HDPE pipeline would be installed northerly to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 1,200 linear feet of 2-inch pipeline.
- From the proposed pipeline and stock tanks, another HDPE pipeline would be installed northerly to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 2,300 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

4.5.2.46 LW-42: Kruger #3 Pipeline and Tank Project

This alternative would involve extending an existing pipeline described in the *LW-41: Kruger #2 Pipeline and Tank Project*, supplied from an existing well, pump, pipeline, and stock tanks to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.48 would be installed:

- From the existing pipeline, proposed well, and pump, a buried HDPE pipeline would be installed southerly to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 7,200 linear feet of 2-inch pipeline.
- From the proposed pipeline and stock tanks, another HDPE pipeline would be installed westerly to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 3,800 linear feet of 2-inch pipeline.
- From the proposed pipeline and stock tanks, another HDPE pipeline would be installed southerly to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 3,300 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

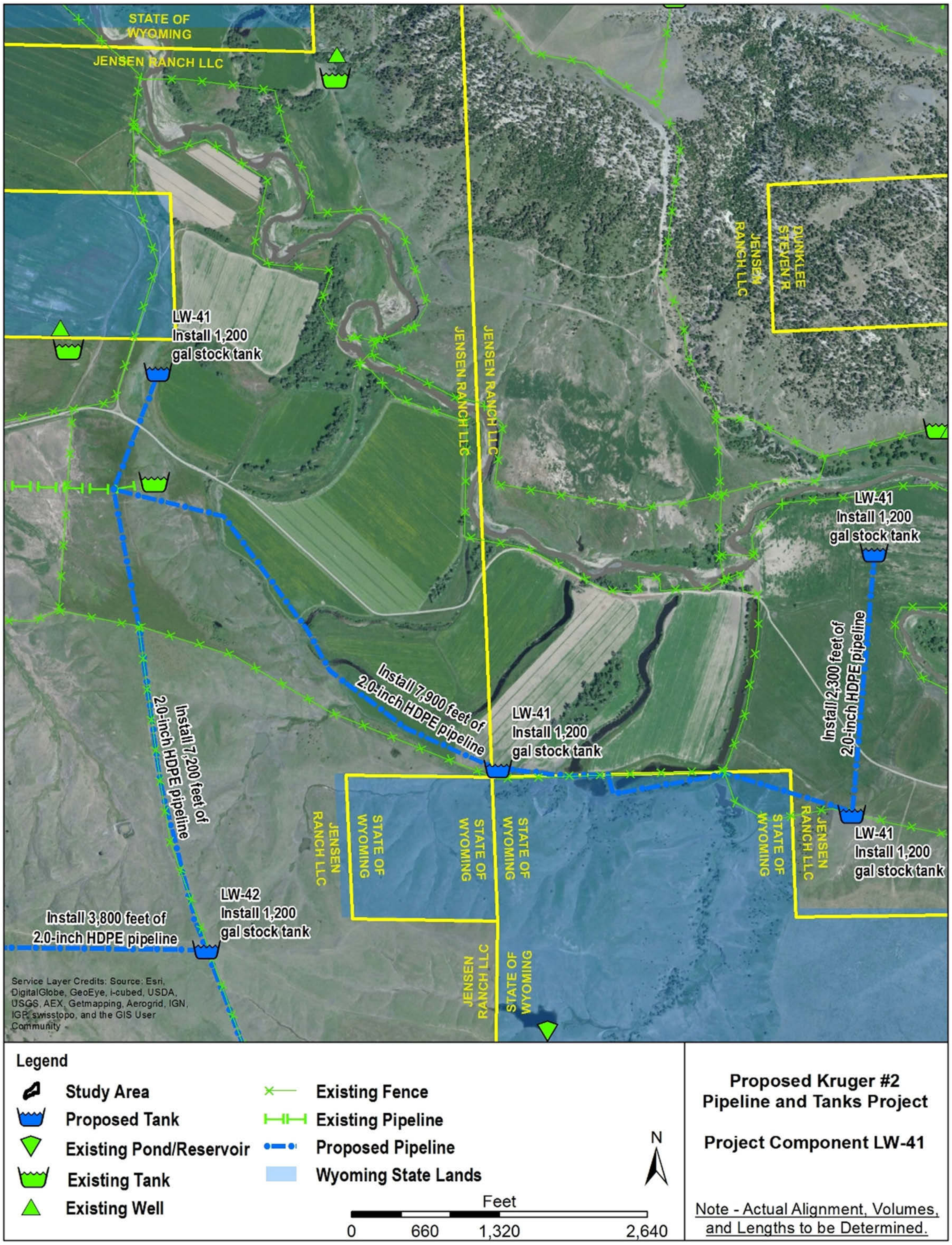


Figure 4-47. Proposed LW-41: Kruger #2 Pipeline and Tank Project.

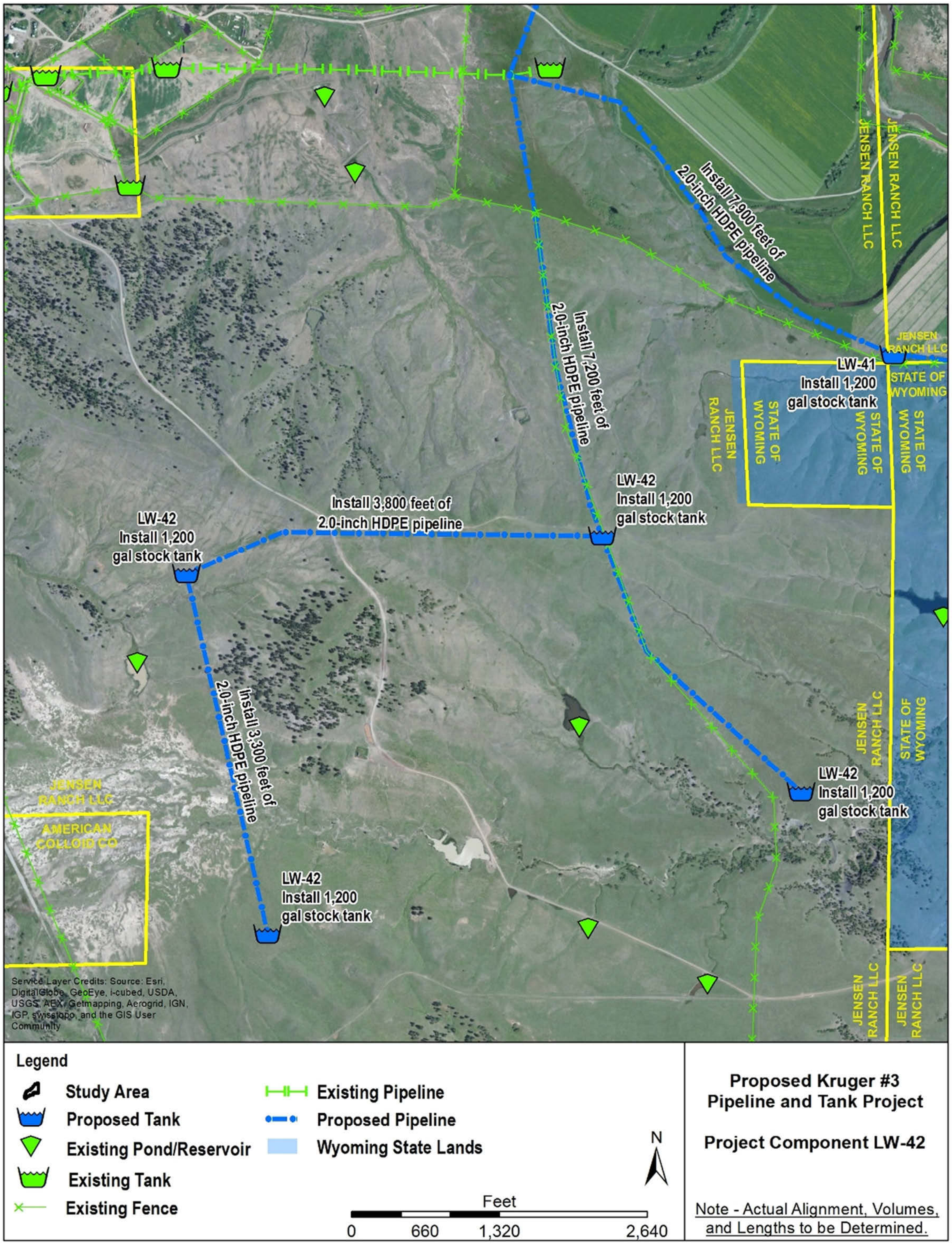


Figure 4-48. Proposed LW-42: Kruger #3 Pipeline and Tank Project.

4.5.2.47 LW-42A: Oak Creek Well and Tank Project

This alternative would involve drilling a new well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.49 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed southeasterly to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 3,500 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

4.5.2.48 LW-43: Kilpatrick Creek Pipeline and Tank Project

This alternative would involve extending an existing pipeline supplied from an existing well, pump, pipeline, and stock tanks to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.50 would be installed:

- From the existing pipeline, well, and pump, a buried HDPE pipeline would be installed northwesterly to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 9,000 linear feet of 2-inch pipeline.
- From the proposed pipeline and stock tanks, another HDPE pipeline would be installed southerly to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 3,900 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

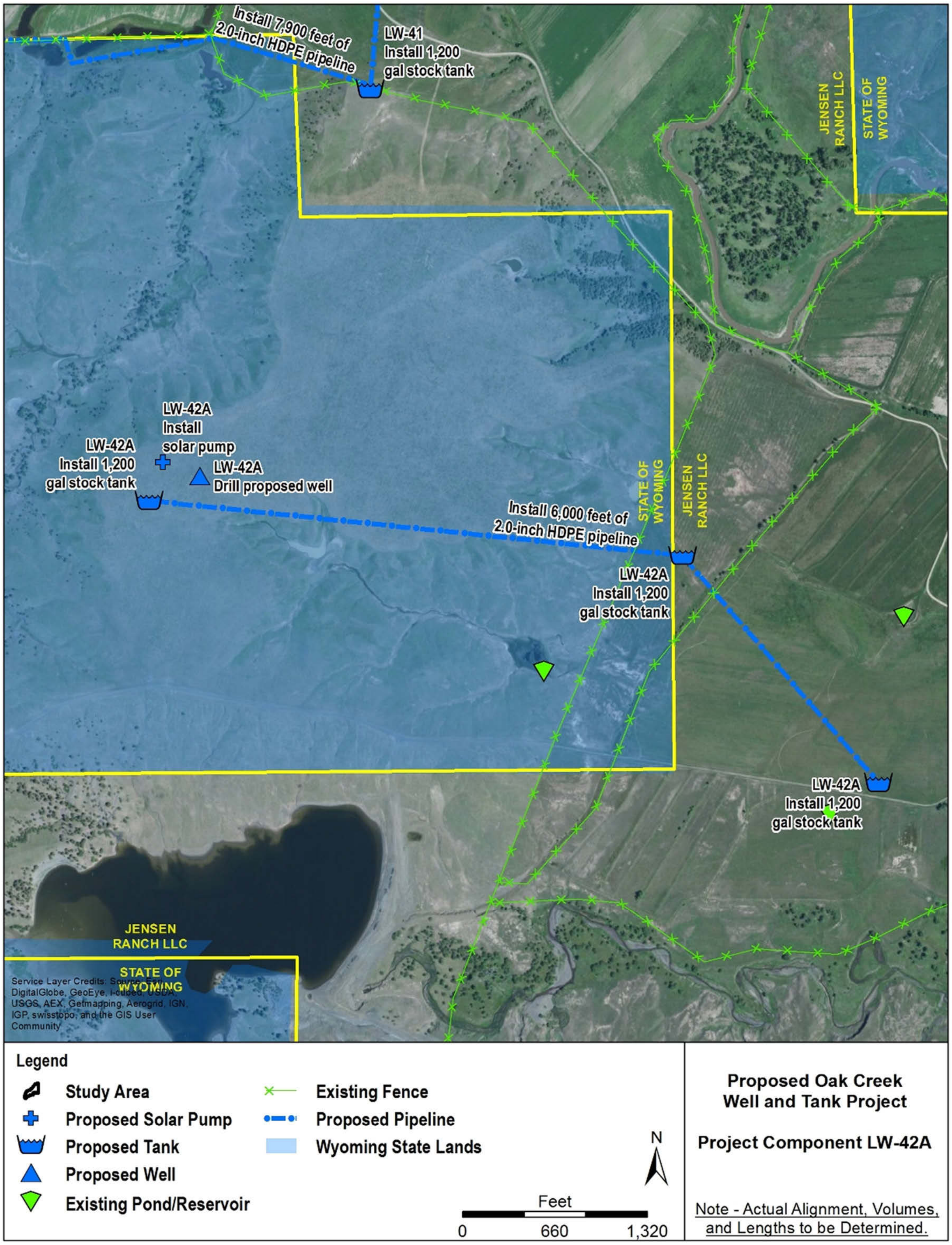


Figure 4-49. Proposed LW-42A: Oak Creek Well and Tank Project.

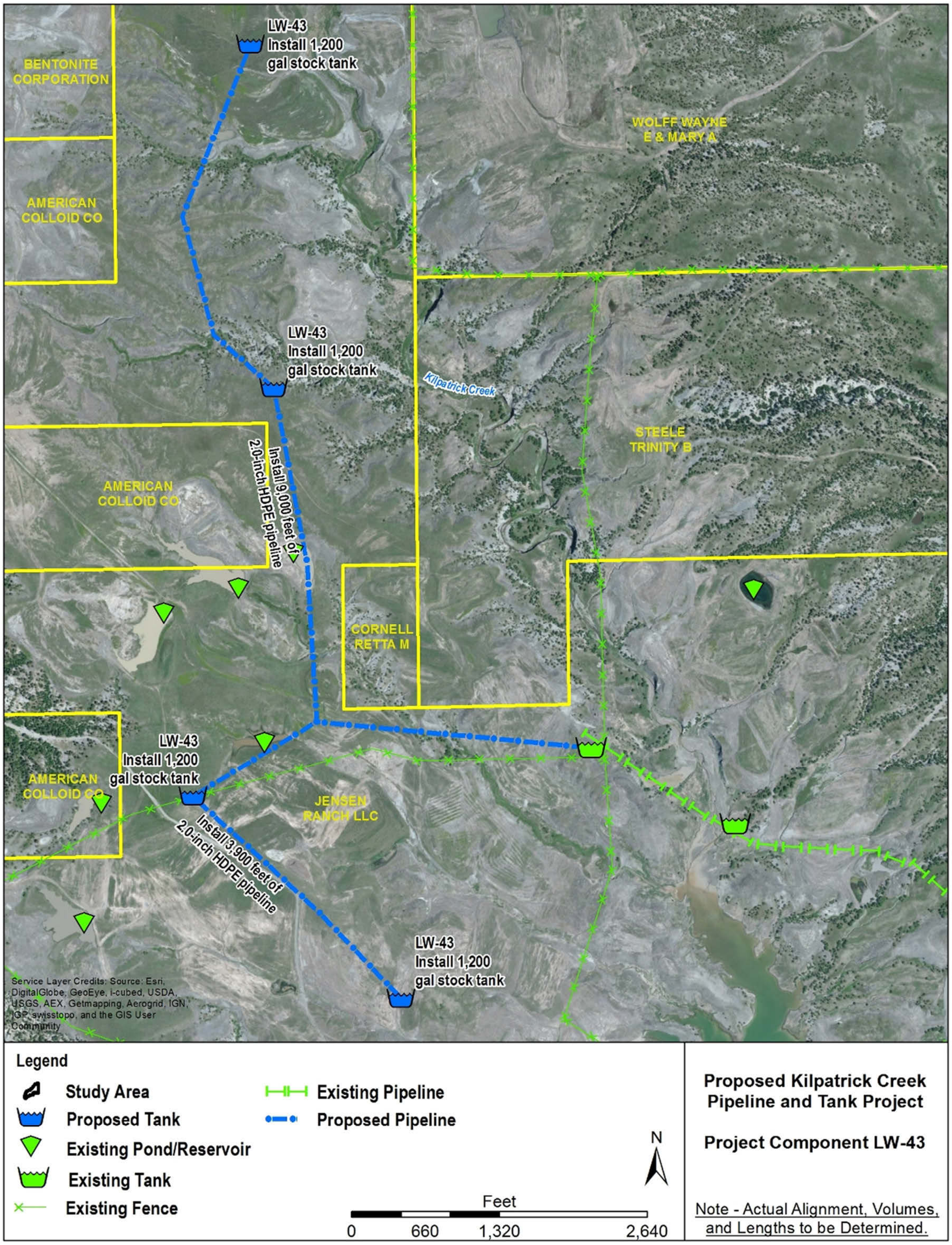


Figure 4-50. Proposed LW-43: Kilpatrick Creek Pipeline and Tank Project.

4.5.2.49 LW-44: Newland #4 Stock Reservoir Rehabilitation Project

This alternative as shown in Figure 4.51 would provide for rehabilitating a stock reservoir and associated wetlands. The existing stock reservoir is located on Iron Creek, a tributary to the Belle Fourche River, within Section 36 of Township 57 North, Range 62 West in Crook County. Currently, the stock reservoir has problems related to dam embankment and outlet facilities and experiences seepage loss of the impounded water behind the embankment.

This project would include rehabilitating the Newland #4 Stock Reservoir (Permit No. P6205R). The reservoir has a permitted total capacity of 53.45 acre-feet. This stock reservoir could be rehabilitated to provide an additional source of livestock/wildlife water along with restoring function of the wetland and riparian areas. This alternative would include the following features:

- Inspecting the embankment and rehabilitation of problem areas as needed. The embankment is approximately 600 feet long and less than 20 feet high at its highest point. The top-width of the embankment is approximately 12 feet wide.
- Installing an inlet and outlet control mechanism to control reservoir water levels. The installed structures would be stabilized with rock riprap.
- Excavating the spillway to adequately convey overflow volumes and stabilizing with rock riprap for protection.
- Contingent on determining adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.
- Potential construction options for reducing seepage in small stock ponds and reservoirs include the installation of geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Potential options are detailed in the NRCS Construction Specifications for Pond Sealing or Lining (NRCS WY-521A, WY-521C, or WY-521D).
- As delineated, the project involves state-owned lands only.

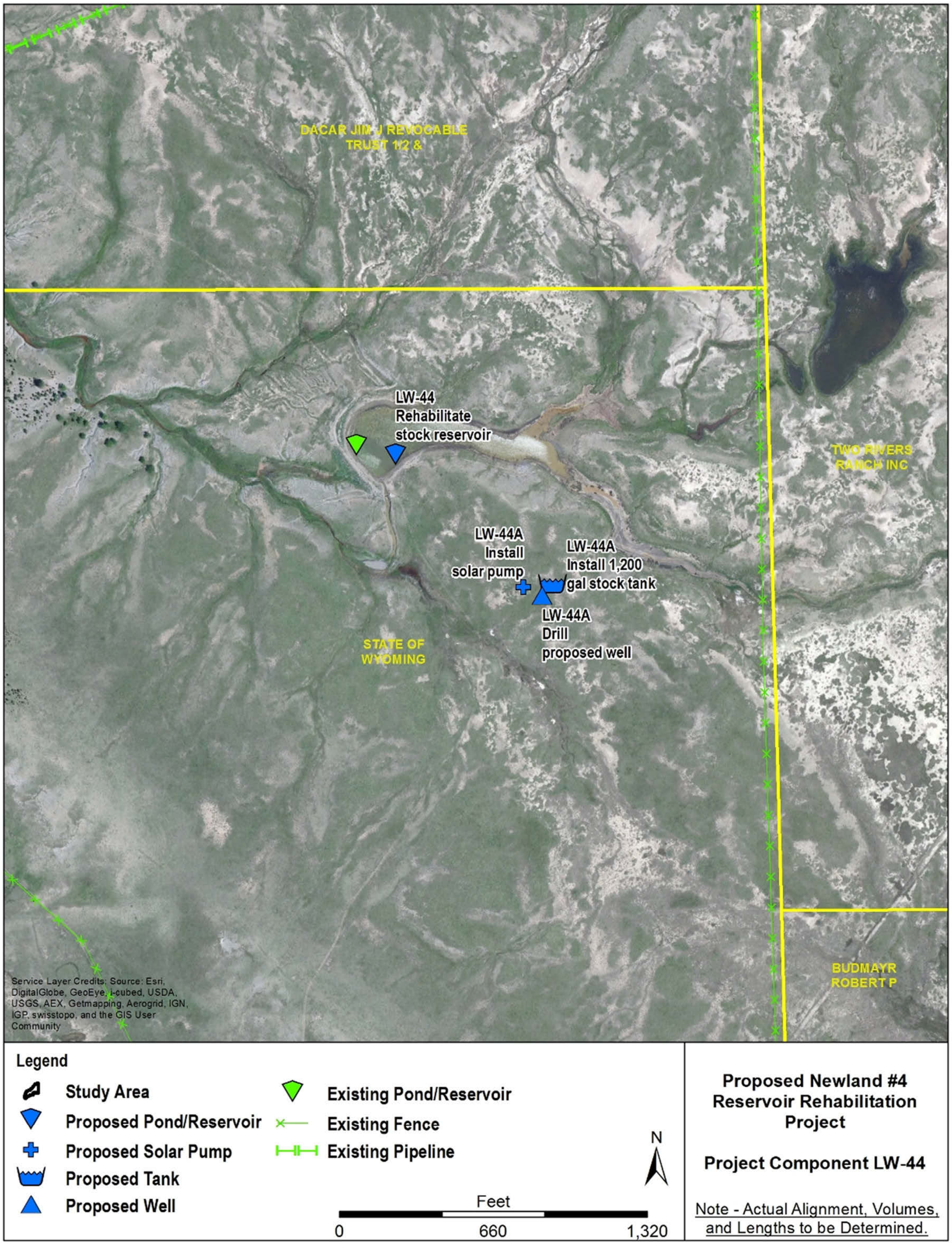


Figure 4-51. Proposed LW-44: Newland #4 Stock Reservoir Rehabilitation Project.

4.5.2.50 LW-44A: Iron Creek Well and Tank Project

This alternative would involve drilling a new well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.52 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

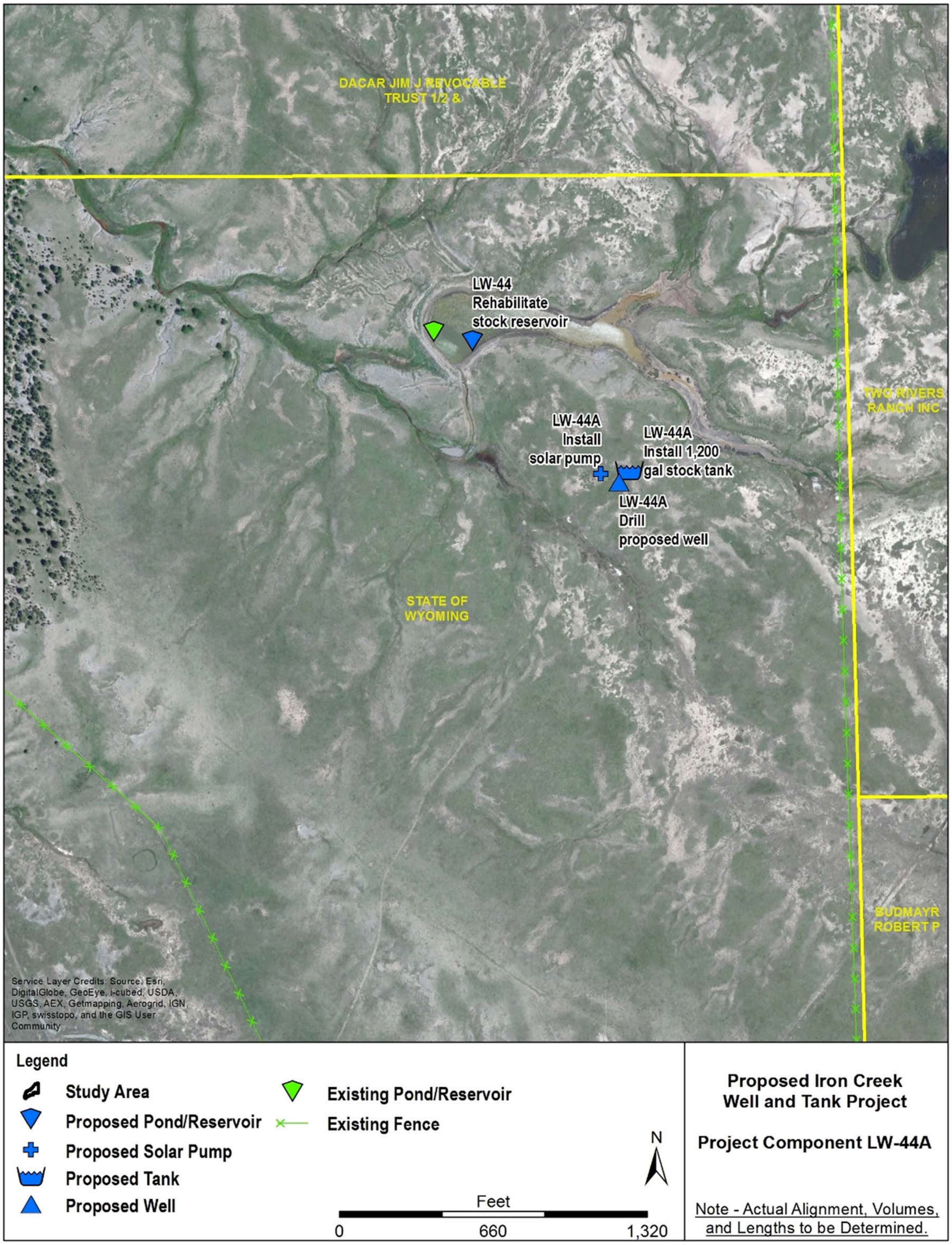


Figure 4-52. Proposed LW-44A: Iron Creek Well and Tank Project.

4.5.2.51 LW-45: Sawmill Well, Tank, and Stock Pond/Reservoir Project

This alternative would involve drilling a new well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.53 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

In addition to installing a well, solar pump, pipeline, and stock tank, this alternative would also provide for constructing a stock pond/reservoir to provide an additional source of livestock/wildlife water along with providing associated wetland areas. This alternative would include the following features:

- A small stock pond/reservoir would have a capacity of less than 2 acre-feet and would be constructed to collect overflow.
- Investigating site-specific soil and geologic conditions to define the extent necessary to excavate existing sediment and to determine if alternatives to bentonite liner treatment should be considered because of karstic bedrock or other conditions of the underlying bedrock formation.
- As proposed, the project involves private lands only.

4.5.2.52 LW-46: Bear Gulch Well and Tank Project

This alternative would involve drilling a new well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.54 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

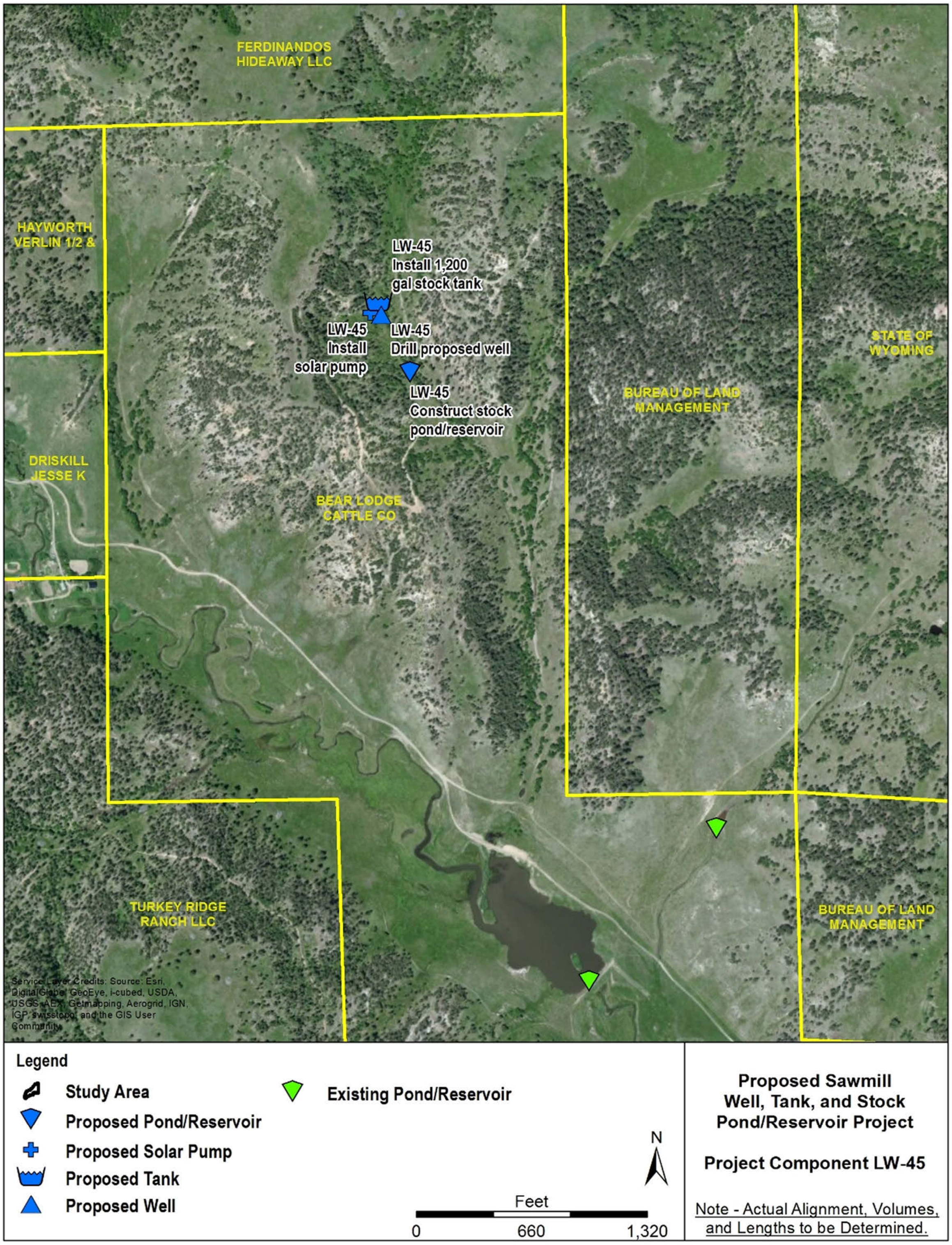


Figure 4-53. Proposed LW-45: Sawmill Well, Tank, and Stock Pond/Reservoir Project.

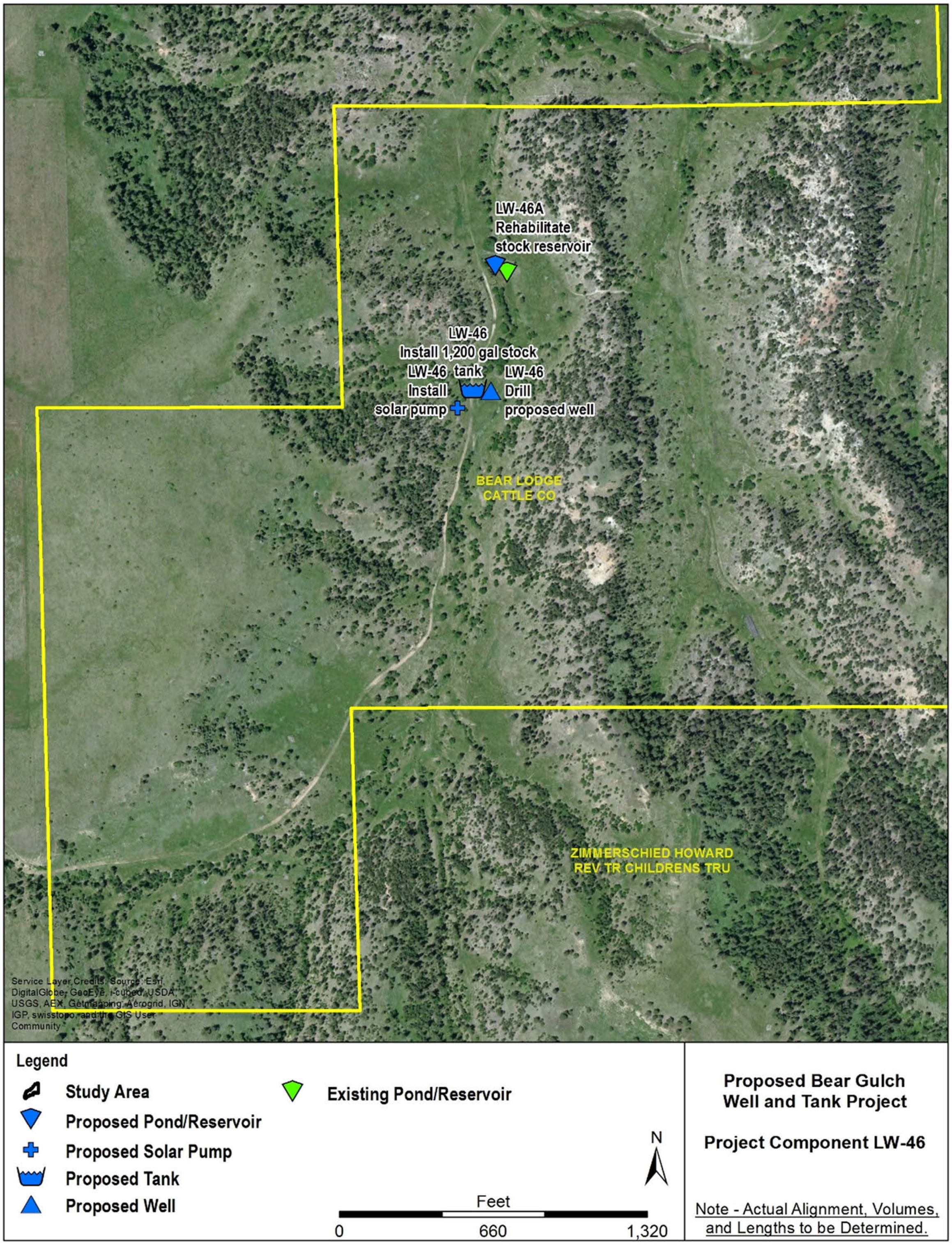


Figure 4-54. Proposed LW-46: Bear Gulch Well and Tank Project.

4.5.2.53 LW-46A: Bear Stock Reservoir Rehabilitation Project

This alternative as shown also in Figure 4.55 would provide for rehabilitating a stock reservoir and associated wetlands. The existing stock reservoir is located on Bear Gulch, a tributary to Left Creek, within Section 29 of Township 53 North, Range 62 West in Crook County. Currently, the stock reservoir has problems related to dam embankment and outlet facilities and experiences seepage loss of the impounded water behind the embankment.

This project would include rehabilitating the Bear Stock Reservoir (Permit No. P4312S). The reservoir has a permitted total capacity of 1.09 acre-feet. This stock reservoir could be rehabilitated to provide an additional source of livestock/wildlife water along with restoring function of the wetland and riparian areas. This alternative would include the following features:

- Inspecting the embankment and rehabilitation of problem areas as needed. The embankment is approximately 130 feet long and less than 10 feet high at its highest point. The top-width of the embankment is approximately 10 feet wide.
- Investigating site-specific soil and geologic conditions to define the extent necessary to excavate existing sediment and to determine if alternatives to bentonite liner treatment should be considered because of karstic bedrock or other conditions of the underlying bedrock formation.
- Installing an inlet and outlet control mechanism to control reservoir water levels. The installed structures would be stabilized with rock riprap.
- Excavating the spillway to adequately convey overflow volumes and stabilizing with rock riprap for protection.
- Contingent on determining adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.
- Potential construction options for reducing seepage in small stock ponds and reservoirs include the installation of geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Potential options are detailed in the NRCS Construction Specifications for Pond Sealing or Lining (NRCS WY-521A, WY-521C, or WY-521D).
- As delineated, the project involves privately owned lands only.

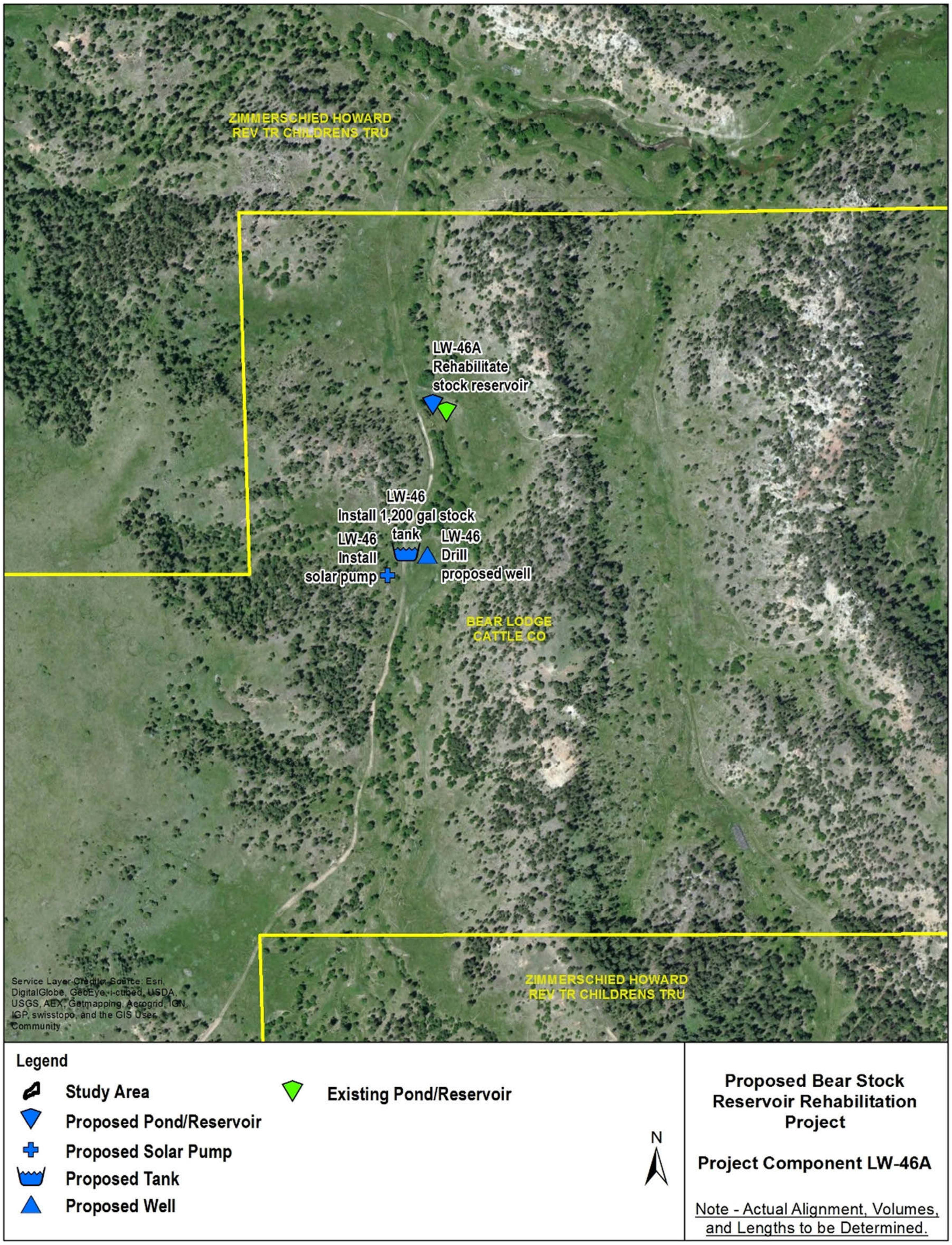


Figure 4-55. Proposed LW-46A: Bear Stock Reservoir Rehabilitation Project.

4.5.2.54 LW-46B: Bear Gulch Stock Reservoir Rehabilitation Project

This alternative as shown also in Figure 4.56 would provide for rehabilitating a stock reservoir and associated wetlands. The existing stock reservoir is located on Bear Gulch, a tributary to Left Creek, within Section 20 of Township 53 North, Range 62 West in Crook County. Currently, the stock reservoir has problems related to dam embankment and outlet facilities.

This stock reservoir could be rehabilitated to provide an additional source of livestock/wildlife water along with restoring function of the associated wetland and riparian areas. The stock reservoir encompasses 1.6 acres with a total capacity of less than 5 acre-feet. This alternative would include the following features:

- Inspecting the embankment and rehabilitation of problem areas as needed. The embankment is approximately 220 feet long and less than 10 feet high at its highest point. The top-width of the embankment is approximately 10 feet wide.
- Installing an inlet and outlet control mechanism to control reservoir water levels. The installed structures would be stabilized with rock riprap.
- Excavating the spillway to adequately convey overflow volumes and stabilizing with rock riprap for protection.
- Contingent on determining adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.
- Potential construction options for reducing seepage in small stock ponds and reservoirs include the installation of geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Potential options are detailed in the NRCS Construction Specifications for Pond Sealing or Lining (NRCS WY-521A, WY-521C, or WY-521D).
- As delineated, the project involves privately owned lands only.

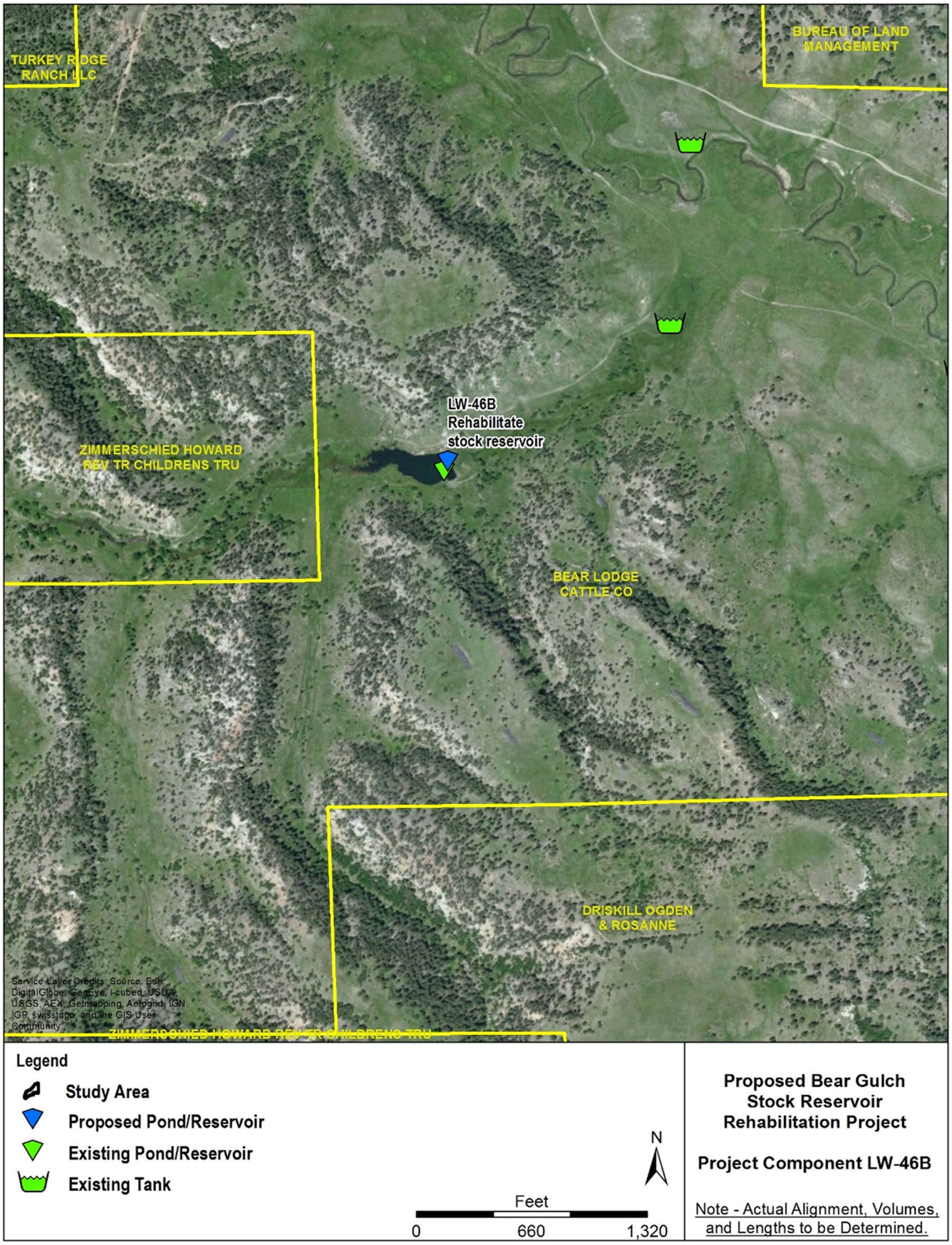


Figure 4-56. Proposed LW-46B: Bear Gulch Stock Reservoir Rehabilitation Project.

4.5.2.55 LW-47: Shield Stock Reservoir Rehabilitation Project

This alternative as shown also in Figure 4.57 would provide for rehabilitating a stock reservoir and associated wetlands. The existing stock reservoir is located on Bear Gulch, a tributary to Left Creek, within Section 27 of Township 53 North, Range 62 West in Crook County. Currently, the stock reservoir has problems related to dam embankment and outlet facilities and experiences seepage loss of the impounded water behind the embankment.

This project would include rehabilitating the Shield Stock Reservoir (Permit No. P2471S). The reservoir has a permitted total capacity of 2.38 acre-feet. This stock reservoir could be rehabilitated to provide an additional source of livestock/wildlife water along with restoring function of the wetland and riparian areas. This alternative would include the following features:

- Inspecting the embankment and rehabilitation of problem areas as needed. The embankment is approximately 100 feet long and less than 10 feet high at its highest point. The top-width of the embankment is approximately 10 feet wide.
- Investigating site-specific soil and geologic conditions to define the extent necessary to excavate existing sediment and to determine if alternatives to bentonite liner treatment should be considered because of karstic bedrock or other conditions of the underlying bedrock formation.
- Installing an inlet and outlet control mechanism to control reservoir water levels. The installed structures would be stabilized with rock riprap.
- Excavating the spillway to adequately convey overflow volumes and stabilizing with rock riprap for protection.
- Contingent on determining adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.
- Potential construction options for reducing seepage in small stock ponds and reservoirs include the installation of geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Potential options are detailed in the NRCS Construction Specifications for Pond Sealing or Lining (NRCS WY-521A, WY-521C, or WY-521D).
- As delineated, the project involves privately owned lands only.

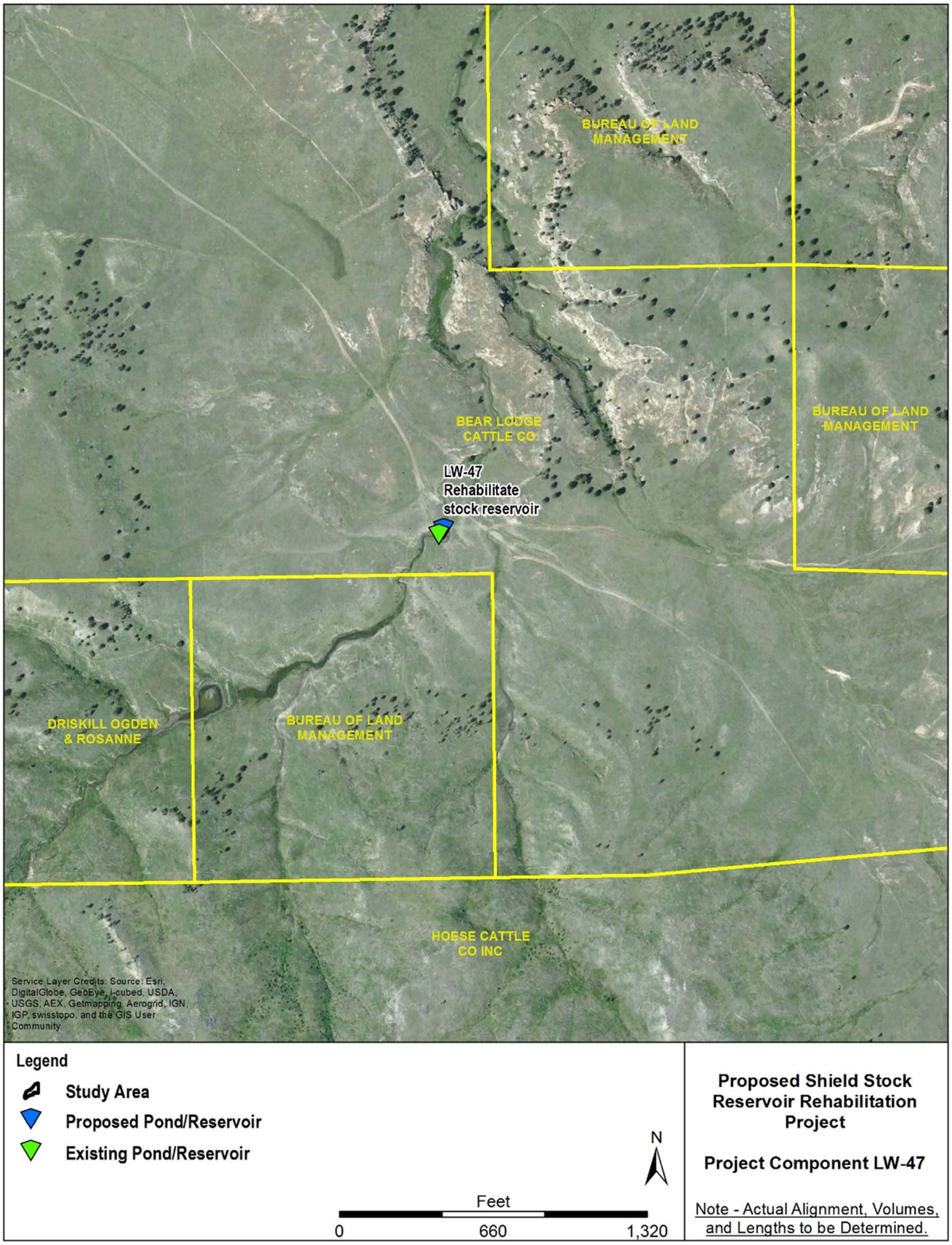


Figure 4-57. Proposed LW-47: Shield Stock Reservoir Rehabilitation Project.

4.5.2.56 LW-47A: Left Creek Stock Reservoirs Rehabilitation Project

This alternative as shown in Figure 4.58 would provide for reconstructing and repairing two breached stock reservoirs. The stock reservoirs are located on Left Creek, a tributary to the Belle Fourche River, within Section 22 of Township 53 North, Range 62 West in Crook County. The stock reservoirs have been breached, which has resulted in failure of the embankments.

This alternative includes reconstructing and repairing the breached reservoirs that could provide additional sources of livestock/wildlife water and potential fisheries, as well as restoring functions of the wetland and riparian areas. This alternative would include the following features:

- Removing the existing breached embankments and constructing new embankments at the same locations.
- The upper stock reservoir's embankment was approximately 500 feet long and less than 15 feet high at its highest point. The top-width of the embankment is approximately 15 feet wide.
- The lower stock reservoir's embankment was approximately 450 feet long and less than 15 feet high at its highest point. The top-width of the embankment is approximately 15 feet wide.
- Investigating site-specific soil and geologic conditions to determine the feasibility of reconstruction alternatives and identify any other conditions of the underlying bedrock formation.
- Installing an inlet and outlet control mechanism to control reservoir water levels. The installed structures would be stabilized with rock riprap.
- Excavating the spillway to adequately convey overflow volumes and stabilizing with rock riprap for protection.
- Contingent on determining adequate sources of borrow material and rock riprap for a dam embankment reconstruction and repair and spillway stabilization.
- As delineated, the project involves privately owned lands only.

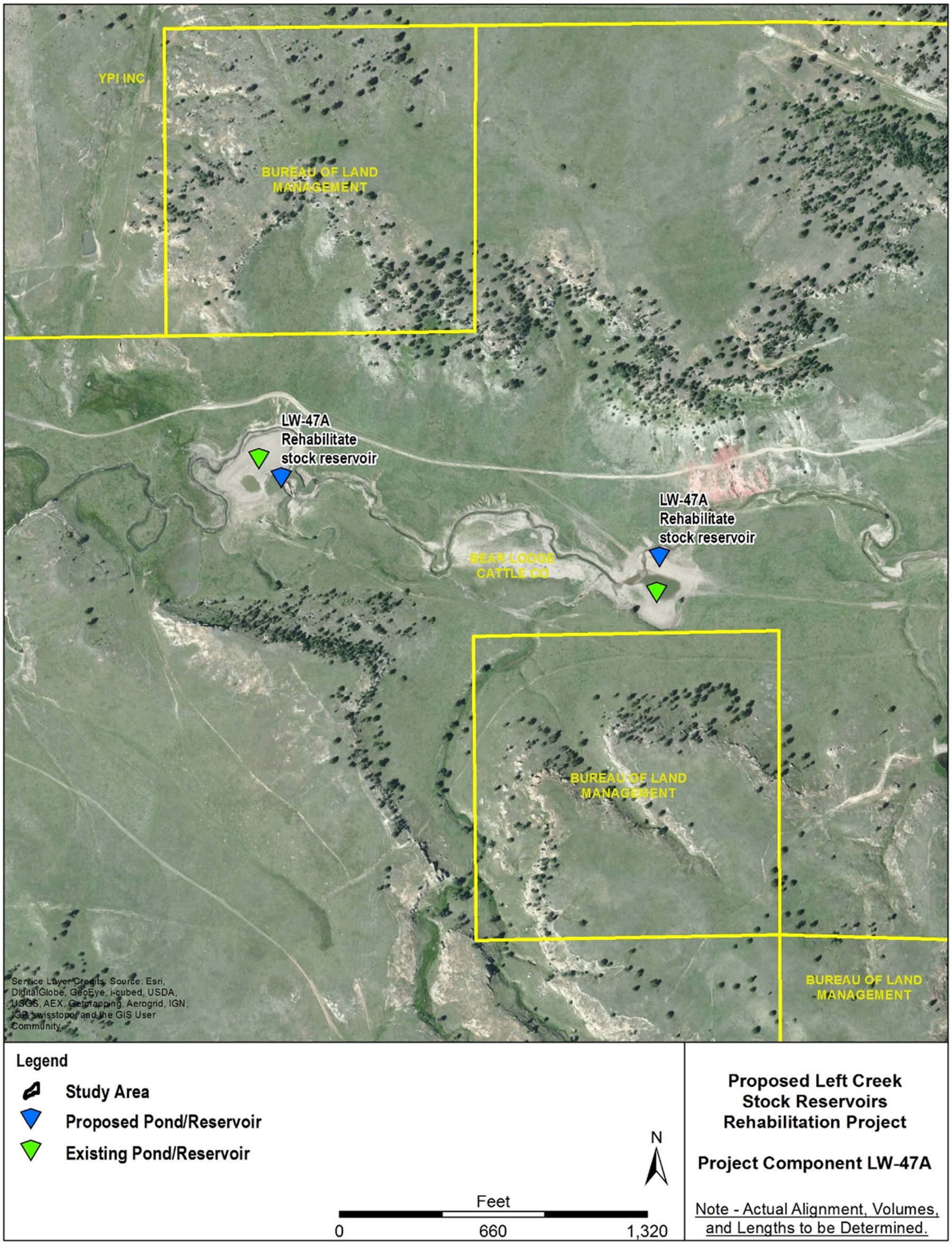


Figure 4-58. Proposed LW-47A: Left Creek Stock Reservoirs Rehabilitation Project.

4.5.2.57 LW-48: Left Creek Spring Development and Tank Project

This alternative would involve rehabilitating an existing spring development and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.59 would be installed:

- The existing spring would be rehabilitated and equipped with collection pipe, spring box, and appurtenances.
- From the rehabilitated spring, a buried HDPE low-pressure pipeline to a stock tank (1,200-gallon capacity) would be installed to provide livestock/wildlife water. This pipeline would be aligned westerly and require installing 1,300 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

4.5.2.58 LW-49: Vines Draw Well, Tank, and Stock Pond Project

This alternative would involve drilling a new well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.60 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

In addition to installing a well, solar pump, pipeline, and stock tank, this alternative would also provide for constructing a stock pond/reservoir to provide an additional source of livestock/wildlife water along with providing associated wetland areas. This alternative would include the following features:

- A small stock pond/reservoir would have a capacity of less than 2 acre-feet and would be constructed to collect overflow.
- Investigating site-specific soil and geologic conditions to define the extent necessary to excavate existing sediment and to determine if alternatives to bentonite liner treatment should be considered because of karstic bedrock or other conditions of the underlying bedrock formation.
- As proposed, the project involves private lands only.

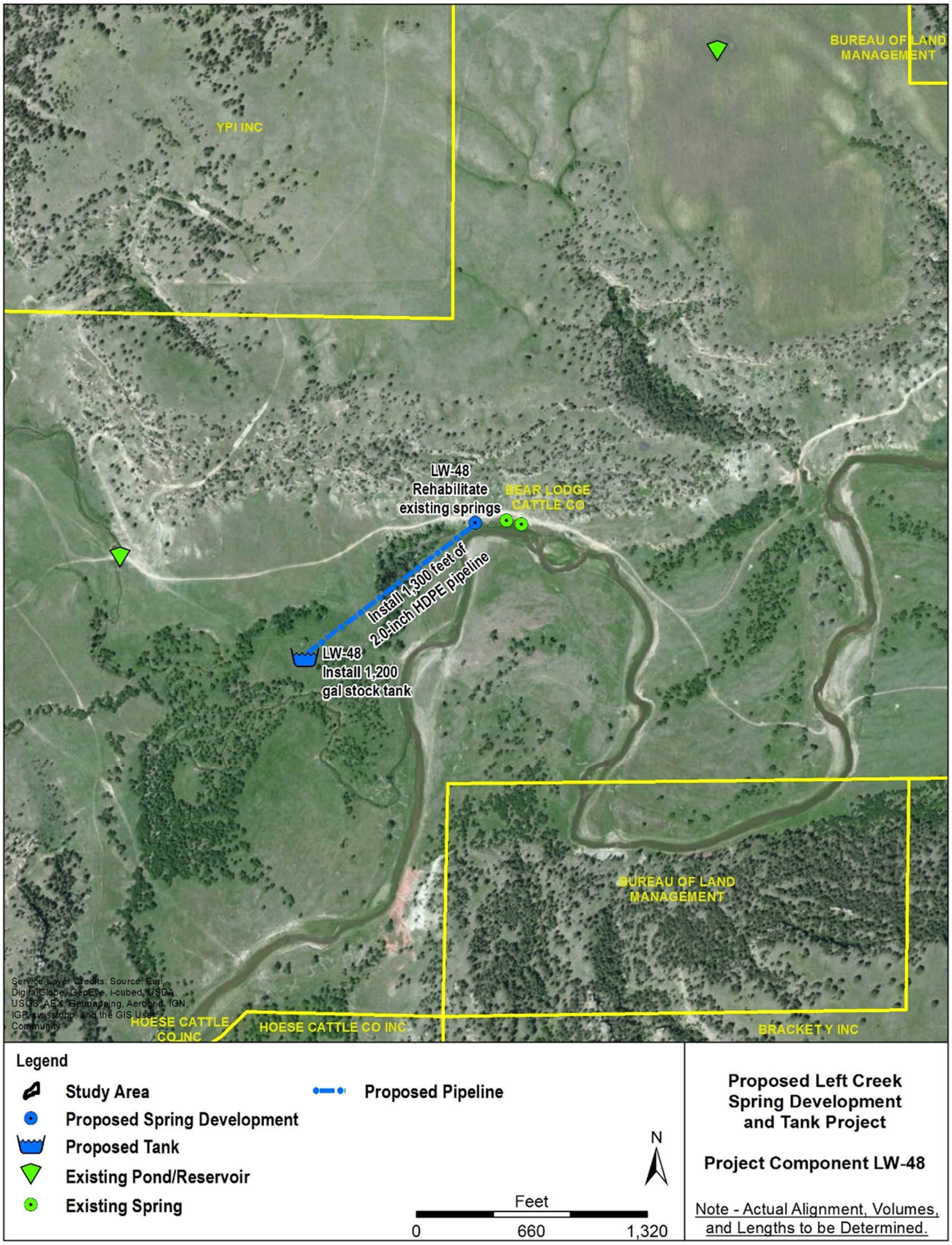


Figure 4-59. Proposed LW-48: Left Creek Spring Development and Tank Project.

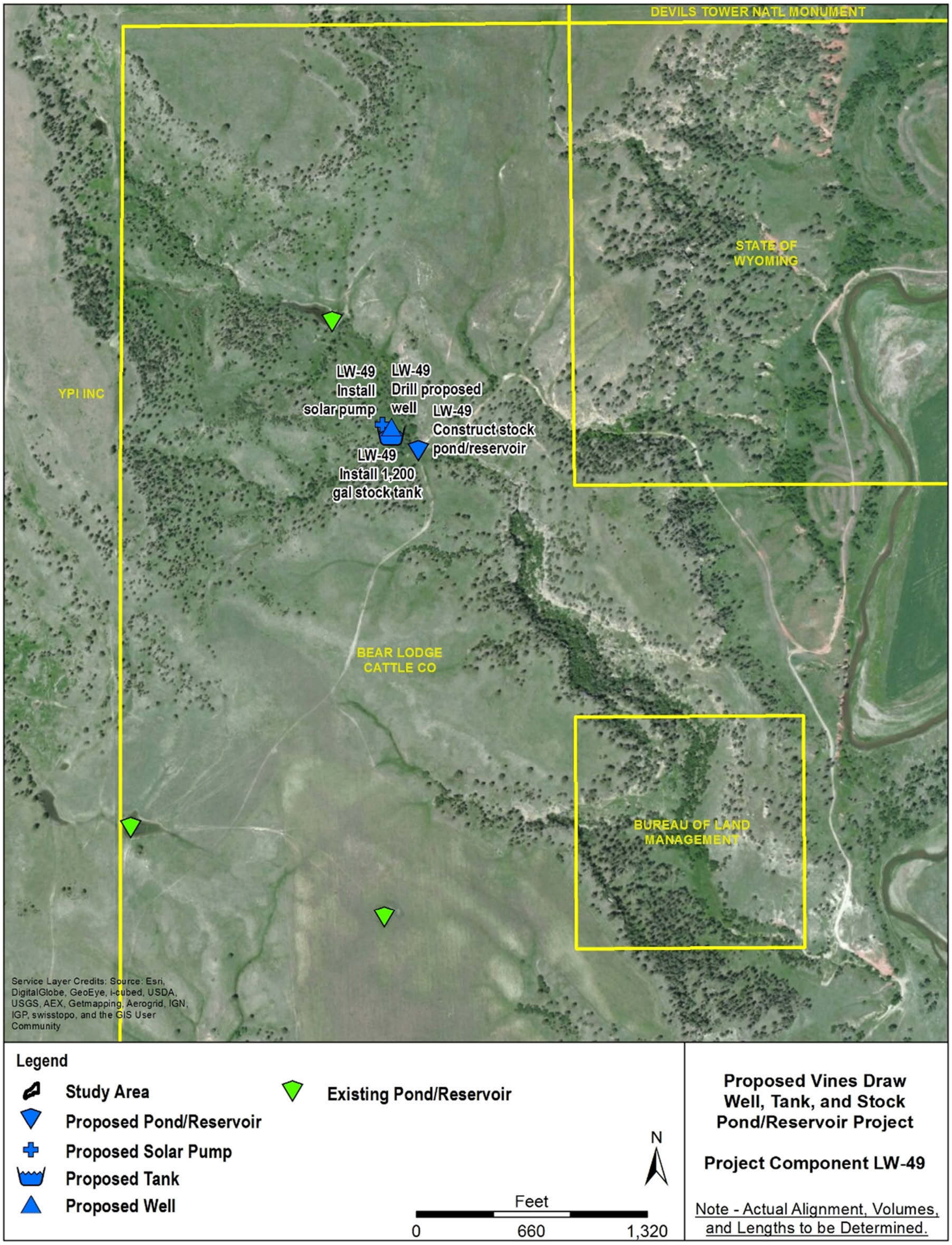


Figure 4-60. Proposed LW-49: Vines Draw Well, Tank, and Stock Pond Project.

4.5.2.59 LW-50: Grubb #3 Stock Reservoir Rehabilitation Project

This alternative as shown also in Figure 4.61 would provide for rehabilitating a stock reservoir and associated wetlands. The existing stock reservoir is located on East Brimmer Creek, a tributary to the Belle Fourche River, within Section 10 of Township 53 North, Range 65 West in Crook County. Currently, the stock reservoir has problems related to dam embankment and outlet facilities and experiences seepage loss of the impounded water behind the embankment.

This project would include rehabilitating the Grubb #3 Stock Reservoir (Permit No. P2215S). The reservoir has a permitted total capacity of 1.06 acre-feet. This stock reservoir could be rehabilitated to provide an additional source of livestock/wildlife water along with restoring function of the wetland and riparian areas. This alternative would include the following features:

- Inspecting the embankment and rehabilitation of problem areas as needed. The embankment is approximately 100 feet long and less than 10 feet high at its highest point. The top-width of the embankment is approximately 10 feet wide.
- Investigating site-specific soil and geologic conditions to define the extent necessary to excavate existing sediment and to determine if alternatives to bentonite liner treatment should be considered because of karstic bedrock or other conditions of the underlying bedrock formation.
- Installing an inlet and outlet control mechanism to control reservoir water levels. The installed structures would be stabilized with rock riprap.
- Excavating the spillway to adequately convey overflow volumes and stabilizing with rock riprap for protection.
- Contingent on determining adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.
- Potential construction options for reducing seepage in small stock ponds and reservoirs include the installation of geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Potential options are detailed in the NRCS Construction Specifications for Pond Sealing or Lining (NRCS WY-521A, WY-521C, or WY-521D).
- As delineated, the project involves privately owned lands only.

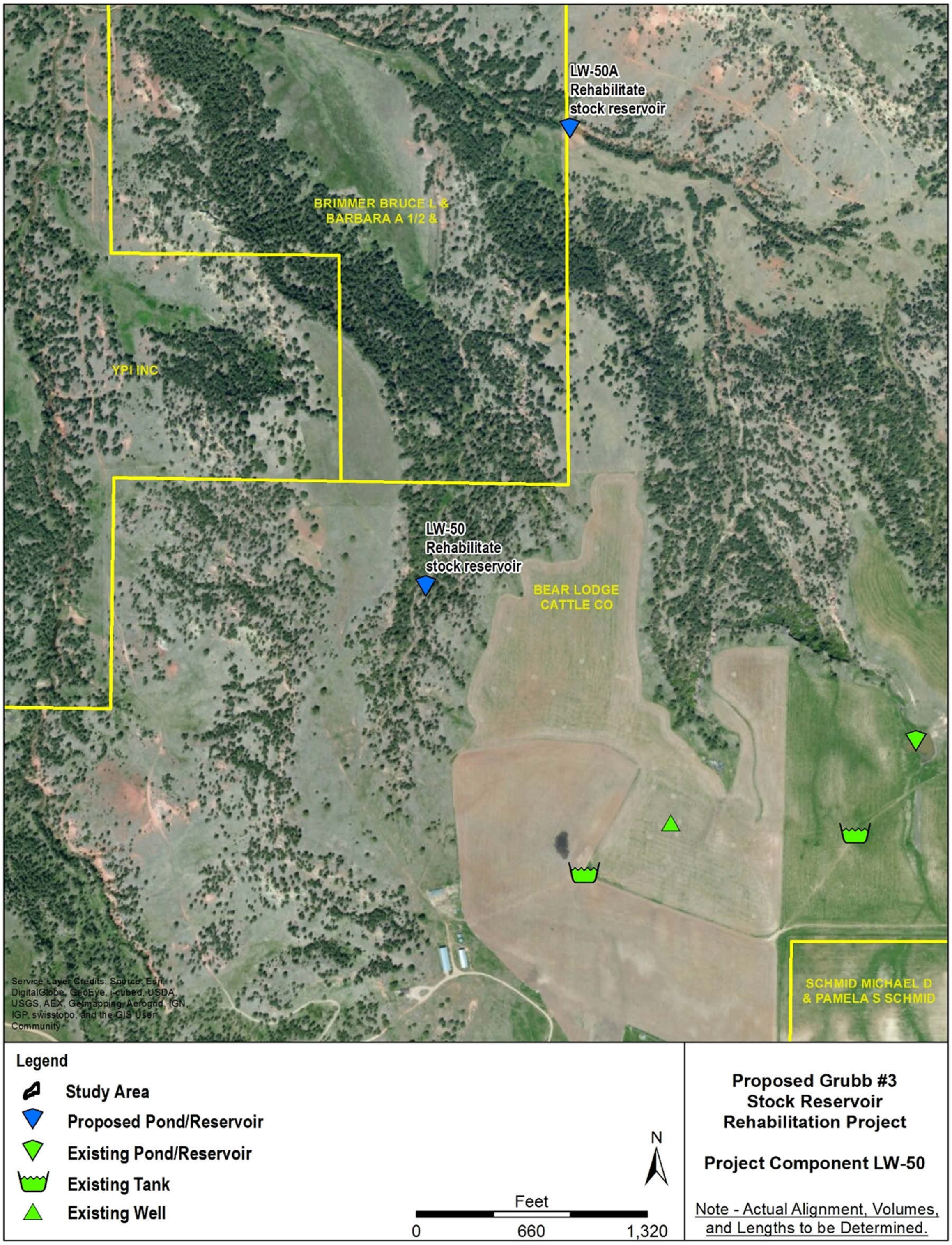


Figure 4-61. Proposed LW-50: Grubb #3 Stock Reservoir Rehabilitation Project.

4.5.2.60 LW-50A: Brimmer Stock Reservoir Rehabilitation Project

This alternative as shown also in Figure 4.62 would provide for rehabilitating a stock reservoir and associated wetlands. The existing stock reservoir is located on East Brimmer Creek, a tributary to the Belle Fourche River, within Section 2 of Township 53 North, Range 65 West in Crook County. Currently, the stock reservoir has problems related to dam embankment and outlet facilities and experiences seepage loss of the impounded water behind the embankment.

This alternative includes reconstructing and repairing of the breached reservoirs that could provide additional sources of livestock/wildlife water, potential fisheries, as well as restoring the functions of the wetland and riparian areas. This alternative would include the following features:

- Inspecting the embankment and rehabilitation of problem areas as needed. The embankment is approximately 100 feet long and less than 10 feet high at its highest point. The top-width of the embankment is approximately 10 feet wide.
- Investigating site-specific soil and geologic conditions to define the extent necessary to excavate existing sediment and to determine if alternatives to bentonite liner treatment should be considered because of karstic bedrock or other conditions of the underlying bedrock formation.
- Installing an inlet and outlet control mechanism to control reservoir water levels. The installed structures would be stabilized with rock riprap.
- Excavating the spillway to adequately convey overflow volumes and stabilizing with rock riprap for protection.
- Contingent on determining adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.
- Potential construction options for reducing seepage in small stock ponds and reservoirs include the installation of geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Potential options are detailed in the NRCS Construction Specifications for Pond Sealing or Lining (NRCS WY-521A, WY-521C, or WY-521D).
- As delineated, the project involves privately owned lands only.

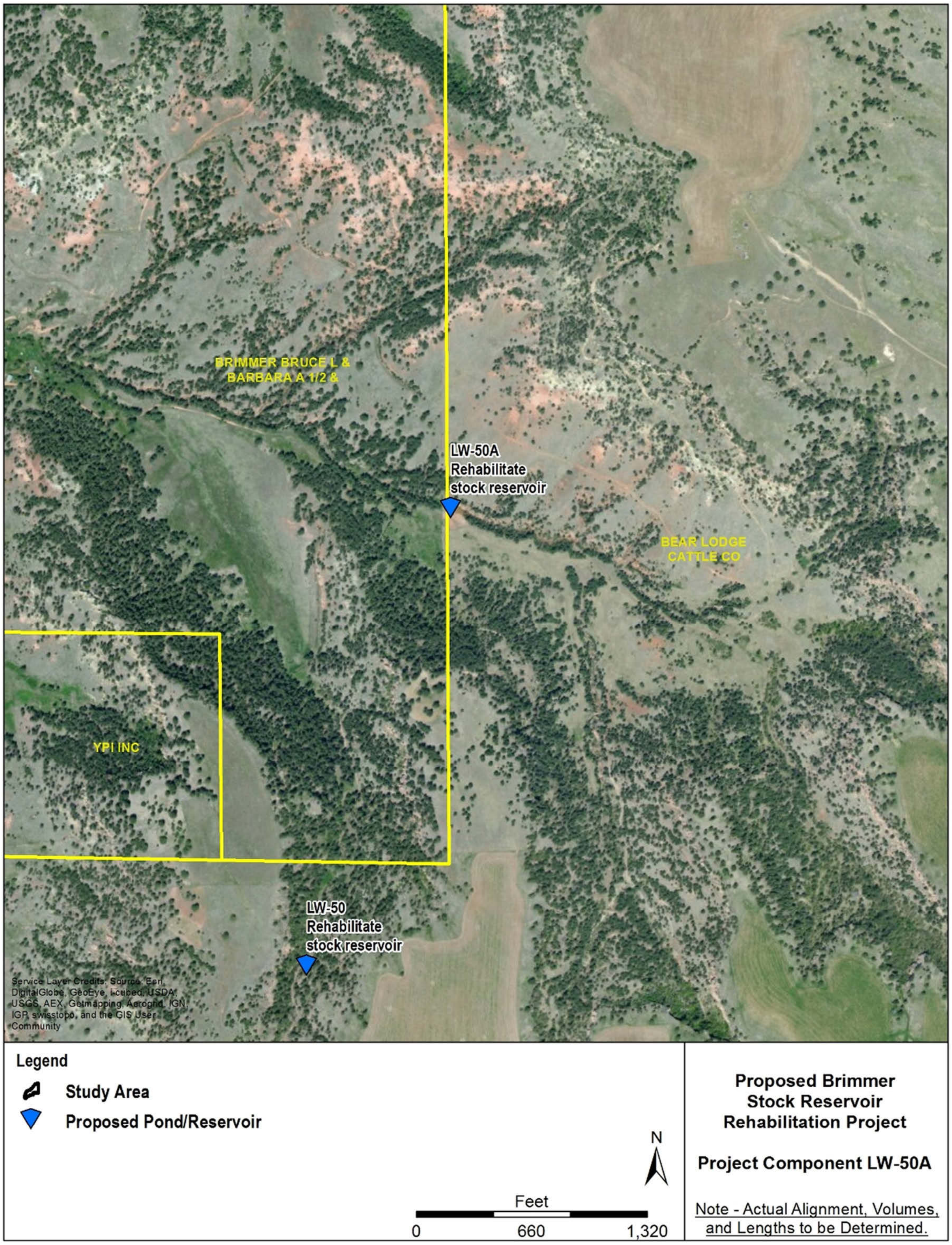


Figure 4-62. Proposed LW-50A: Brimmer Stock Reservoir Rehabilitation Project.

4.5.2.61 LW-51: Arkansas Creek Wildlife Guzzler and Pond Project

This alternative would involve installing a water harvesting catchment (NRCS Conservation Practice WY-636) or "wildlife guzzler" system and a small pond for supplying water to a portion of the watershed lacking adequate wildlife upland water sources. Under this alternative, the following components as shown in Figure 4.63 would be installed:

- A water harvesting catchment or collection surface, typically made of impervious textured HDPE, corrugated metal sheeting, UV protected plastic sheeting, or fiberglass sheeting would be installed on the ground surface or elevated with a support structure secured and protected by fencing from trampling by wildlife or livestock. A catchment storage tank (1,000-gallon capacity) would be installed underground to collect and store wildlife water.
- From the catchment and storage tank, a buried HDPE low-pressure pipeline would be installed to provide wildlife water for a wildlife guzzler tank and/or integral drinker and overflow pipe. This pipeline would be aligned southerly and require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

In addition to installing a catchment, storage tank, pipeline, and wildlife guzzler tank/drinker, this alternative would also provide for constructing a small pond to provide an additional source of wildlife water along with providing associated wetland areas. This alternative would include the following features:

- A small stock pond would have a capacity of less than 1 acre-foot and would be constructed to collect overflow.
- Investigating site-specific soil and geologic conditions to define the extent necessary to excavate existing sediment and to determine if alternatives to bentonite liner treatment should be considered because of karstic bedrock or other conditions of the underlying bedrock formation.
- As proposed, the project involves private lands only.

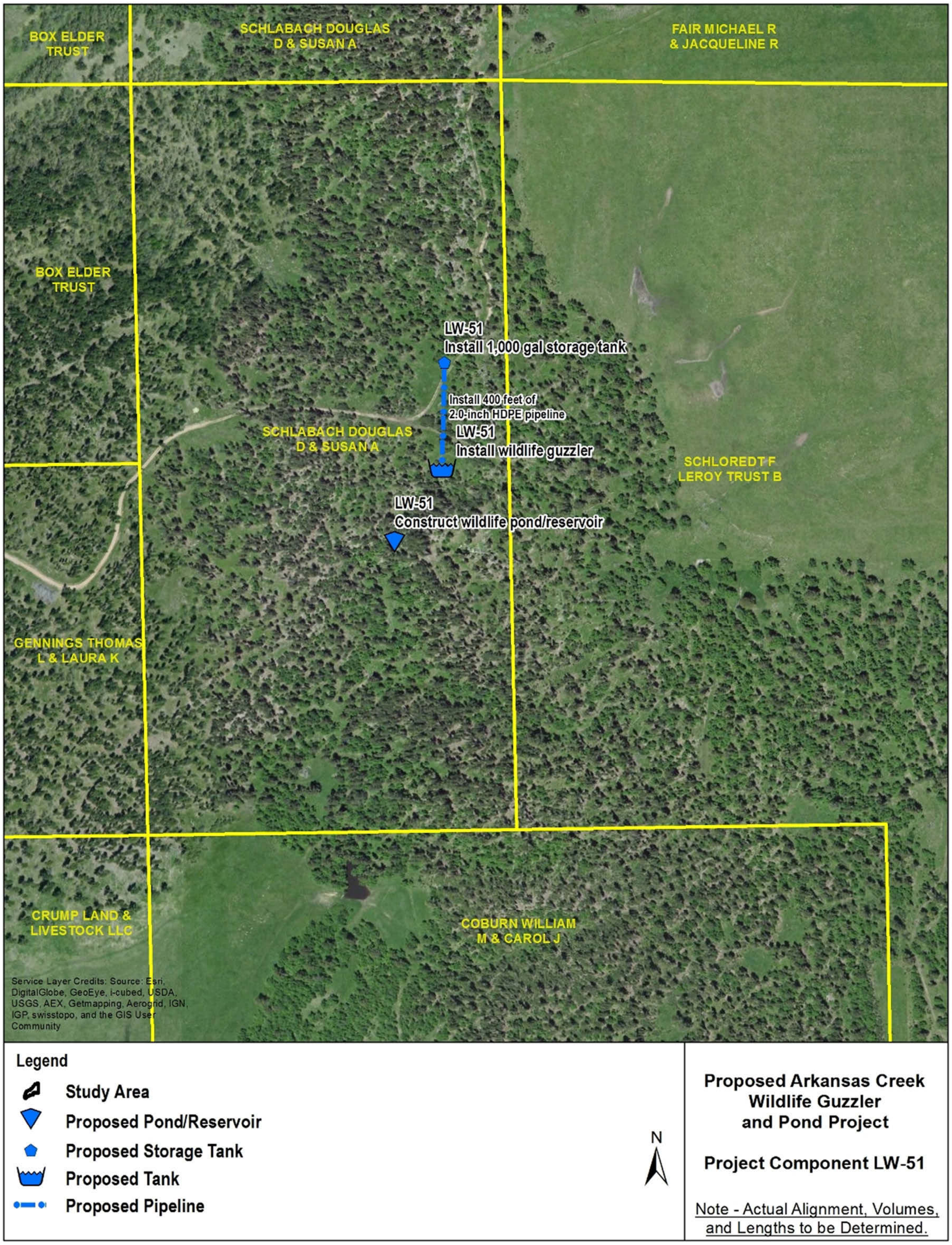


Figure 4-63. Proposed LW-51: Arkansas Creek Wildlife Guzzler and Pond Project.

4.5.2.62 LW-52: Upper Sundance Creek Well and Tank Project

This alternative would involve drilling a new well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.64 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

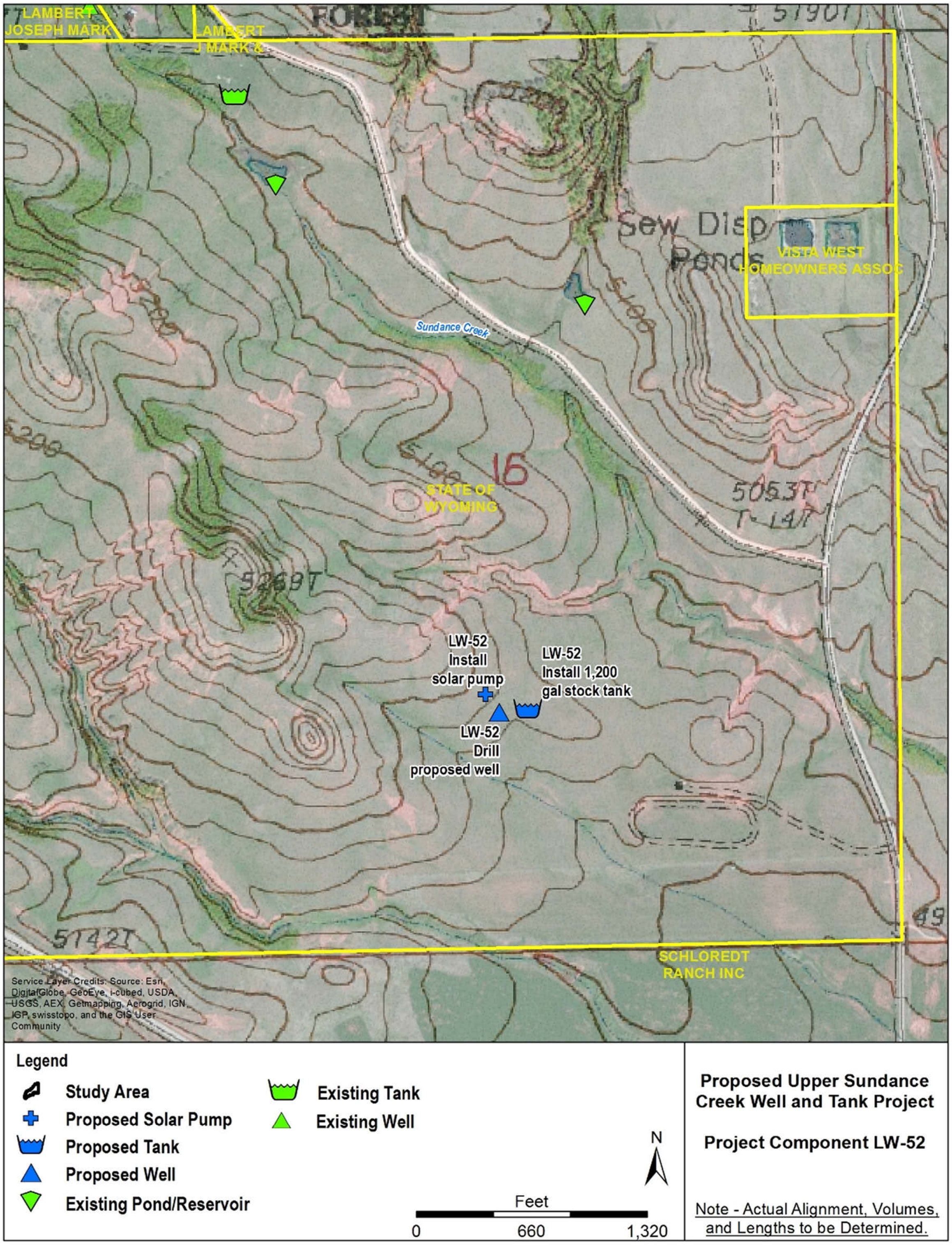


Figure 4-64. Proposed LW-52: Upper Sundance Creek Well and Tank Project.

4.5.2.63 LW-53: East Rupe Spring Development and Tank Project

This alternative would involve rehabilitating an existing spring and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.65 would be installed:

- The existing spring would be rehabilitated and equipped with collection pipe, spring box, and appurtenances.
- From the rehabilitated spring, a buried HDPE low-pressure pipeline to a stock tank (1,200-gallon capacity) would be installed to provide livestock/wildlife water. This pipeline would be aligned westerly and require installing 800 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

In addition to installing a spring development, pipeline, and stock tank, this alternative would also provide for rehabilitating a spring-fed stock pond to provide an additional source of livestock/wildlife water and providing associated wetland areas. This alternative would include the following features:

- Inspecting the embankment and rehabilitation of problem areas as needed.
- Investigating site-specific conditions to define the extent necessary of removing obstructions, excavating sediments, rock, slope-wash materials, and vegetation.
- Installing an inlet and outlet control mechanism to control pond water levels. The installed structures would be stabilized with rock riprap.
- Contingent on determining adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.
- As delineated, the project involves privately owned lands only.

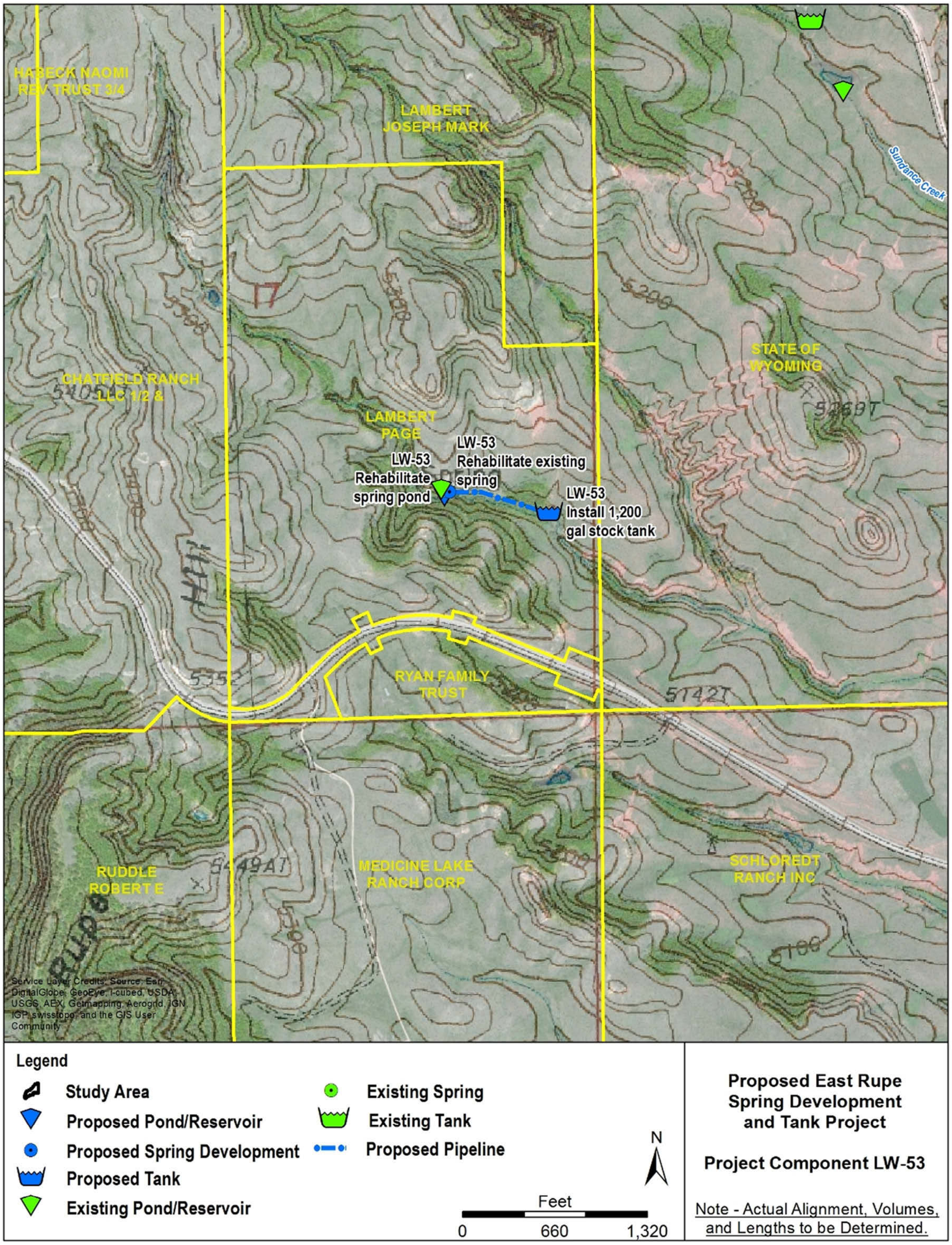


Figure 4-65. Proposed LW-53: East Rupe Spring Development and Tank Project.

4.5.2.64 LW-54: Bennor #2 Well, Pipeline, and Tank Rehabilitation Project

This alternative would involve rehabilitating an existing well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.66 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a pump and appurtenances.
- From the well and pump, three buried HDPE low-pressure pipelines would be installed to supply water to five stock tanks.
- One pipeline would be aligned southerly to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 3,200 linear feet of 2-inch pipeline.
- Another pipeline would require installing approximately 1,900 linear feet of 2-inch pipeline westerly from the proposed pipeline and stock tanks to a stock tank (1,200-gallon capacity).
- Another pipeline would require installing approximately 5,400 linear feet of 2-inch pipeline easterly from the proposed pipeline and stock tanks to two stock tanks (1,200-gallon capacity each).
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

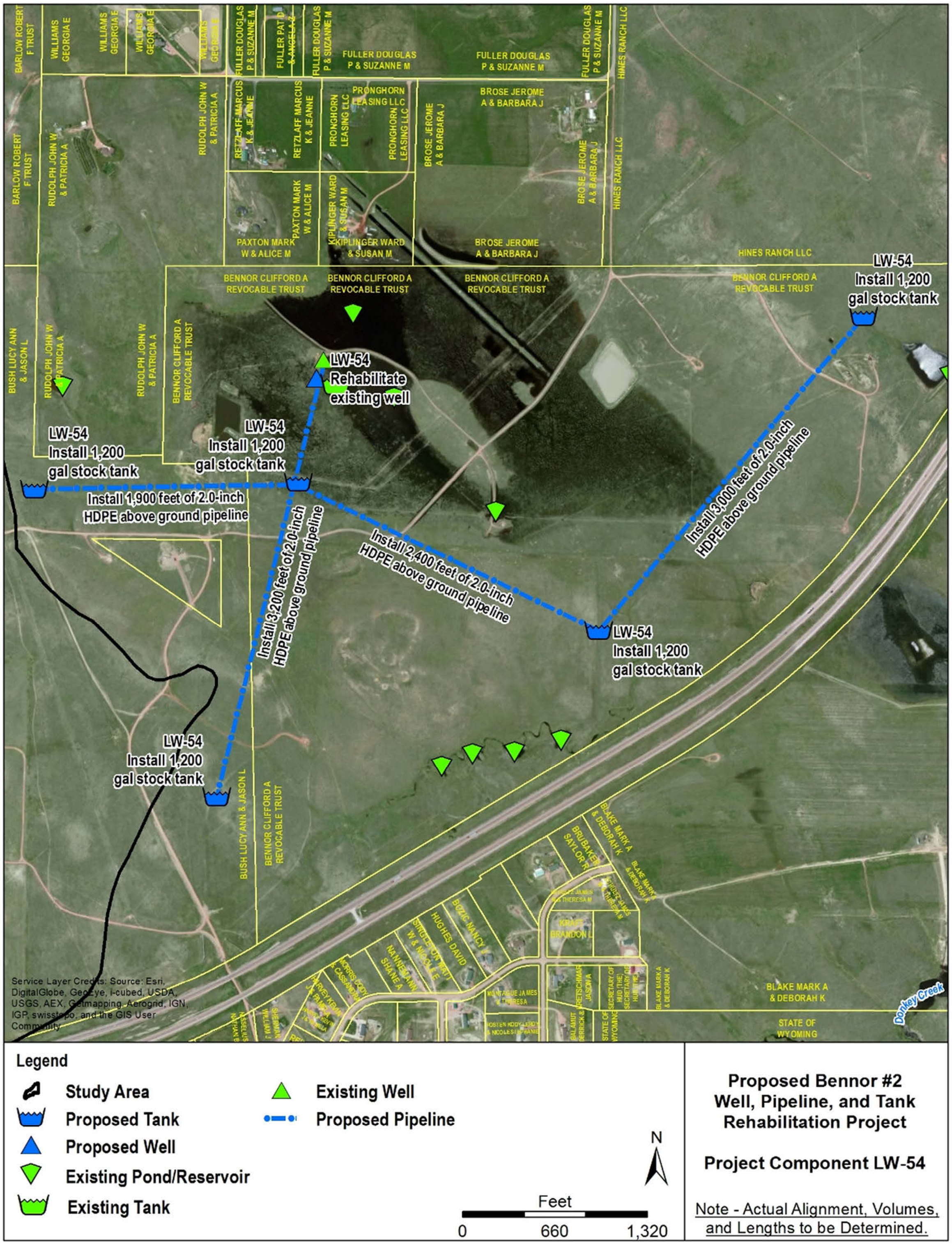


Figure 4-66. Proposed LW-54: Bennor #2 Well, Pipeline, and Tank Rehabilitation Project.

4.5.2.65 LW-55: Donkey Creek Well, Pipeline, and Tank Rehabilitation Project

This alternative would involve rehabilitating an existing well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.67 would be installed:

- A new well would be drilled to supply water. The well would be equipped with a pump and appurtenances.
- From the well and pump, two buried HDPE low-pressure pipelines would be installed to supply water to two stock tanks.
- One pipeline would be aligned easterly to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 2,200 linear feet of 2-inch pipeline.
- The other pipeline would require installing approximately 2,500 linear feet of 2-inch pipeline westerly from the well to a stock tank (1,200-gallon capacity).
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

In addition to installing a well, pump, pipeline, and stock tanks, this alternative would also provide for rehabilitating a stock pond to provide an additional source of livestock/wildlife water and providing associated wetland areas. This alternative would include the following features:

- Inspecting the embankments and rehabilitation of problem areas as needed. The pond is approximately 220 feet wide by 540 feet long with embankments less than 15 feet high at its highest point. The top-width of the embankment is approximately 10 feet wide.
- Investigating site-specific soil and geologic conditions to define the extent necessary to excavate existing sediment and to determine if alternatives to bentonite liner treatment should be considered because of karstic bedrock or other conditions of the underlying bedrock formation.
- Potential construction options for reducing seepage in small stock ponds and reservoirs include the installation of geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Potential options are detailed in the NRCS Construction Specifications for Pond Sealing or Lining (NRCS WY-521A, WY-521C, or WY-521D).
- As proposed, the project involves private lands only.

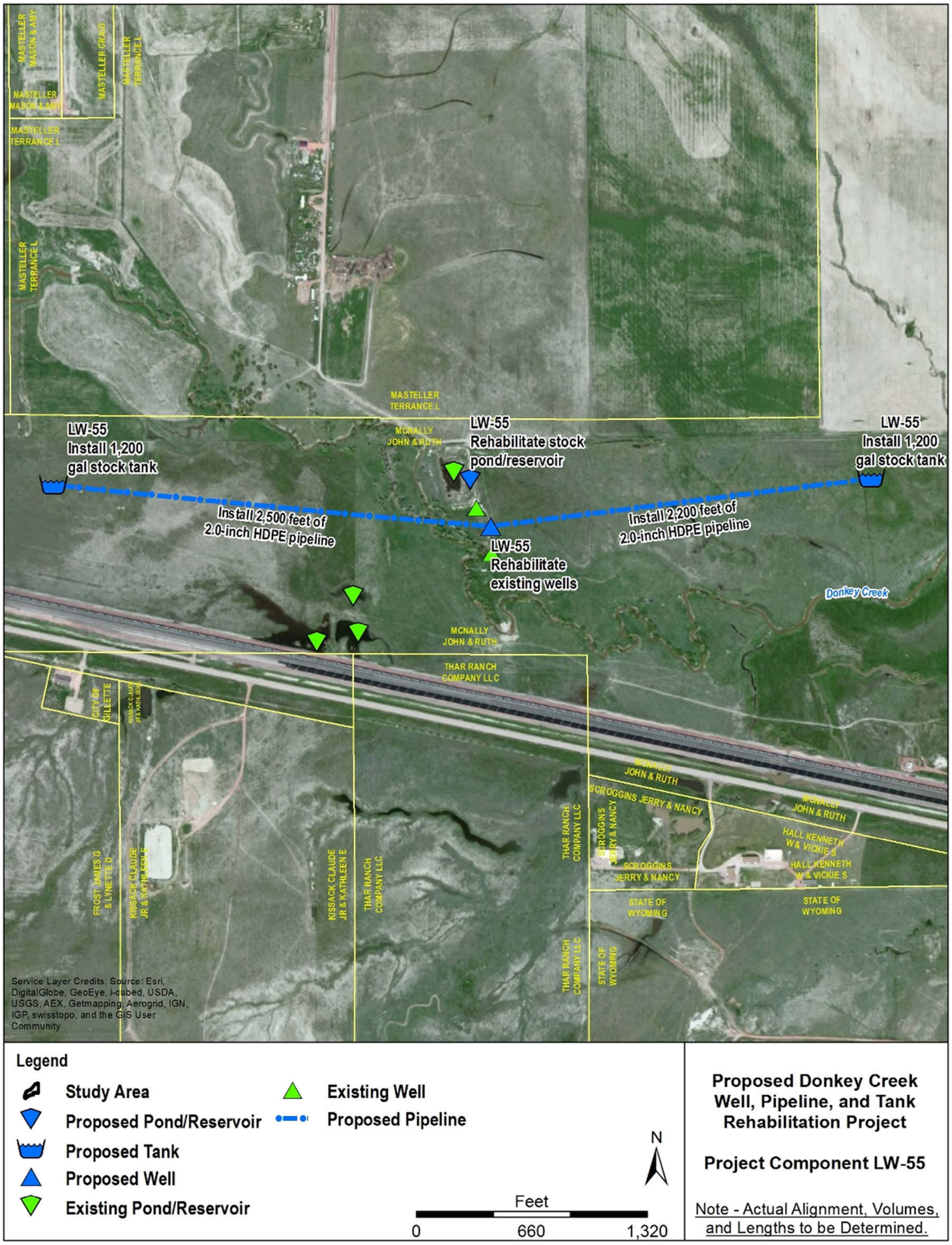


Figure 4-67. Proposed LW-55: Donkey Creek Well, Pipeline, and Tank Rehabilitation Project.

4.5.2.66 LW-56: Kester #1 Spring Development, Pipeline, and Tank Project

This alternative would involve rehabilitating an existing spring and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.68 would be installed:

- The existing spring would be rehabilitated and equipped with collection pipe, spring box, and appurtenances.
- From the rehabilitated spring, a buried HDPE low-pressure pipeline to supply three stock tanks (1,200-gallon capacity each) would be installed to provide livestock/wildlife water. This pipeline would be aligned westerly and require installing 1,800 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

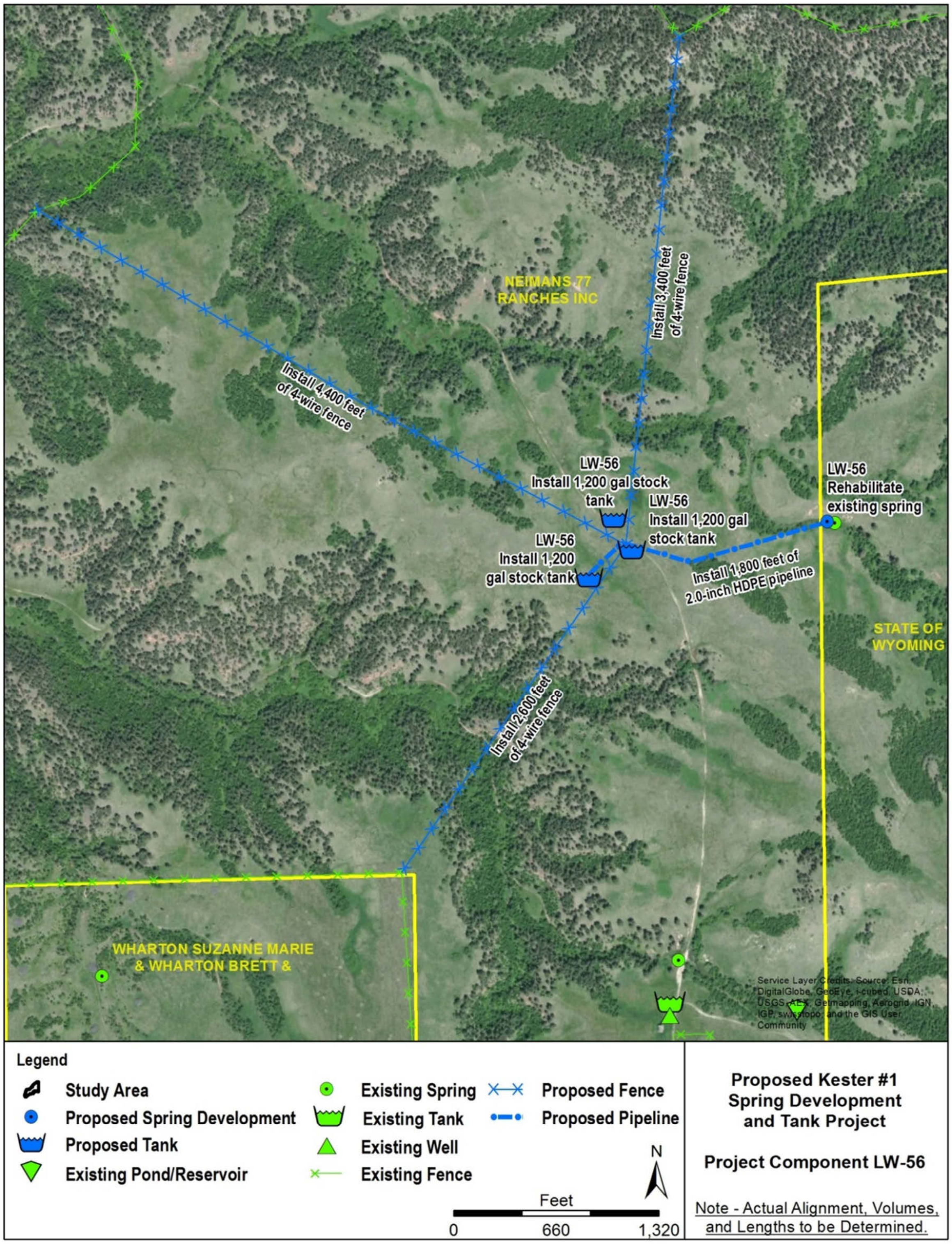


Figure 4-68. Proposed Kester #1 Spring Development, Pipeline, and Tank Project.

4.5.2.67 LW-57: Kester #2 Spring Development, Pipeline, and Tank Project

This alternative would involve rehabilitating an existing spring and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components as shown in Figure 4.69 would be installed:

- The existing spring would be rehabilitated and equipped with collection pipe, spring box, and appurtenances.
- From the rehabilitated spring, a buried HDPE low-pressure pipeline to supply a stock tank (1,200-gallon capacity each) would be installed to provide livestock/wildlife water. This pipeline would be aligned westerly and require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate managing flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

In addition to rehabilitating an existing spring, pipeline, and stock tanks, this alternative would also provide for rehabilitating a stock pond to provide an additional source of livestock/wildlife water and providing associated wetland areas. This alternative would include the following features:

- A small stock pond/reservoir would have a capacity of less than 2 acre-feet and would be constructed to collect overflow.
- Investigating site-specific soil and geologic conditions to define the extent necessary to excavate existing sediment and to determine if alternatives to bentonite liner treatment should be considered because of karstic bedrock or other conditions of the underlying bedrock formation.
- As proposed, the project involves state lands only.

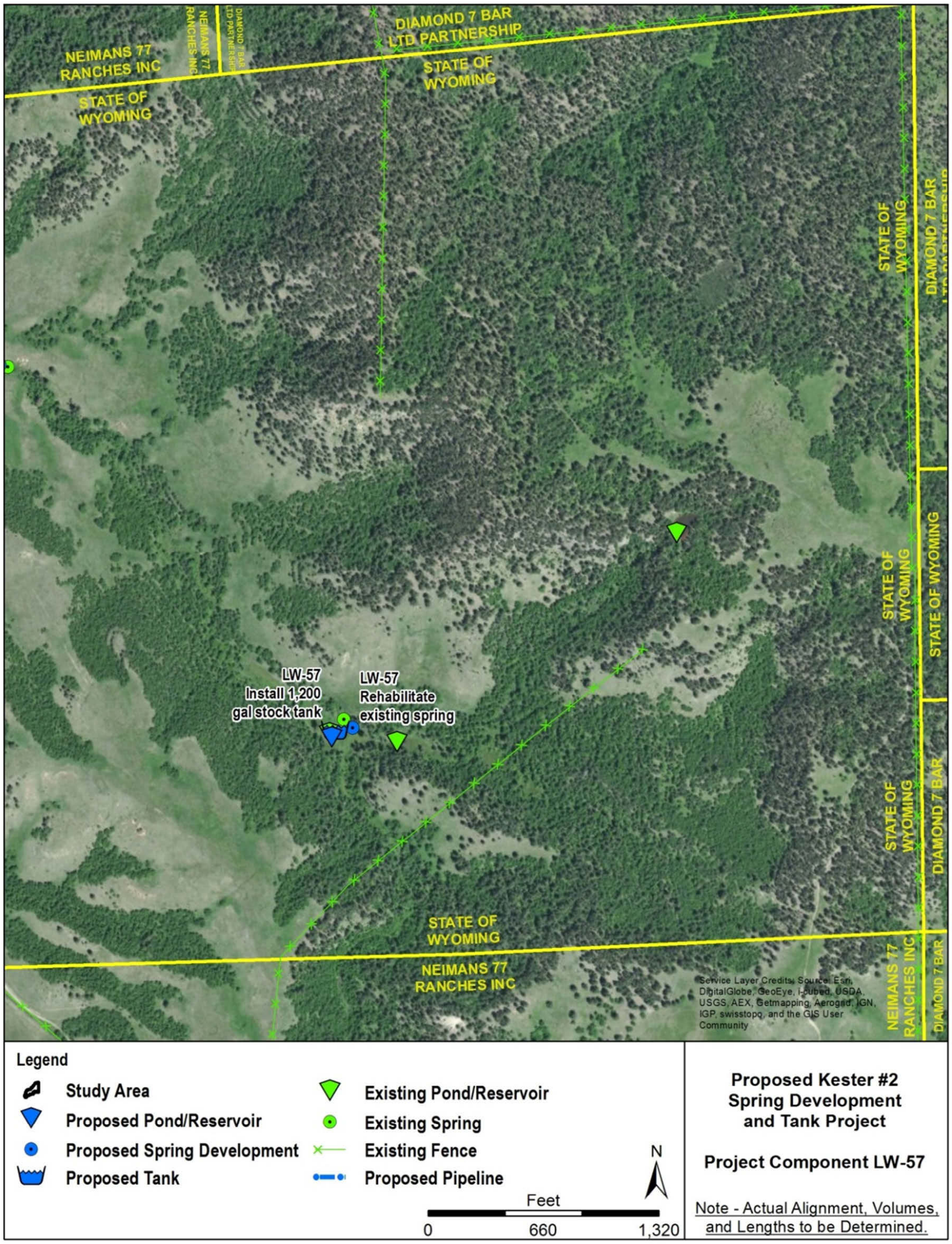


Figure 4-69. Proposed Kester #2 Spring Development, Tank, and Stock Pond Project.

4.5.3 Additional Upland Management Opportunities

Guzzlers are artificial catchments that provides sources of water in remote areas for wildlife. Larger systems could be employed for livestock watering purposes. They rely entirely on precipitation; therefore, their reliability is only as good as can be expected in a water short region. Installing guzzler water systems may be considered in areas where wildlife water is needed and other options are unavailable. Figure 4.70 shows a guzzler near Thermopolis, Wyoming. The major components of a guzzler system include the following items:

- **Catchment apron** – typically made of textured HDPE; secured with rocks placed on a grid and protected by fencing from trampling by wildlife or livestock.
- **Catchment outlet** – pipe boot, clamps, and well screen.
- **HDPE pipe** – typically 1.5-inch to 2-inch, 160 psi, SDR 11.
- **Catchment tank** – HDPE tank sized to accommodate wildlife or livestock watering needs with integral drinker (ideally with no float valve required) and overflow adapter.
- **Small animal escape ladder** – installed in the storage tank.
- **Overflow pipe** – with erosion protection at discharge.

RSI-2264-15-136

Figure 4-70. An Example of an Installed Wildlife Guzzler System.

4.6 GRAZING MANAGEMENT OPPORTUNITIES

4.6.1 State and Transition Models

In Section 3.4.5.6 of Chapter 3.0, the ecological sites within the watershed were presented and the concept of the ESD was discussed. The ESD for a given ecological site contains a wealth of information pertaining to the site and its vegetative community. Within each ESD, there is a State and Transition Model (STM), which describes the patterns, causes, and indicators that cause vegetation to change from one plant community to a different group of plant species, and the management actions needed to restore to a desirable plant community. Simply, a STM is a diagram that shows the current understanding of vegetation responses on a given site to grazing practices, range management, or environmental disturbances. STMs help landowners and managers to determine changes in vegetation and soils that are reversible compared to changes that are costly or unlikely. In addition to grazing management, an STM can also be useful in developing management options for wildfire and prescribed burns, watershed infiltration and runoff, invasive and pest species, recreation, woodlands, and forests.

When landowners and managers become aware of the predicted responses shown in an STM on a particular range site, they can then use the information to develop appropriate rangeland treatments and implement necessary grazing practices to begin the transition from undesirable vegetation to a desirable plant community. The STM also includes a Historic Climax Plant Community (HCPC), which describes the potential plant community generally having the greatest forage production or ecological potential for a given site. The HCPC can be used to compare the current vegetation growing on a site to what plant community could potentially be grown on the site. Consequently, land management strategies can be developed that results in restoring the HCPC, given the right conditions. The ESDs and their associated STMs for the five predominant ESDs within the watershed were obtained directly from the NRCS and are detailed in Sections 4.6.1.1 through 4.6.1.5. The five predominant ESDs within the mapped area of the watershed are likely to be one of the following:

- *R058BY122WY Loamy (Ly) 10-14 inch Northern Plains Precipitation Zone*
- *R061XY122WY Loamy (Ly) 15-19 inch Precipitation Zone, Black Hills*
- *R061XY162WY Shallow Loamy (SwLy) 15-19 inch Precipitation Zone, Black Hills*
- *R058BY222WY Loamy (Ly) 15-17 inch Northern Plains Precipitation Zone*
- *R058BY150WY Sandy (Sy) 10-14 inch Northern Plains Precipitation Zone.*

4.6.1.1 Loamy (Ly) 10–14-Inch Northern Plains Precipitation Zone

The most predominant ecological site in the watershed is the Loamy (Ly) 10–14-inch Northern Plains Precipitation Zone (PZ) (R058BY122WY), which covers approximately

352,060 acres (14.2 percent) of the study area. The STM for the Loamy (Ly) 10–14-inch Northern Plains Precipitation Zone ESD is shown in Figure 4.71.

Rhizomatous Wheatgrasses/Needleandthread/Blue Grama Plant Community

This plant community is the interpretive plant community for this site and is considered to be the HCPC. This plant community evolved with grazing by large herbivores and is well suited for grazing by domestic livestock. It can be found on areas that are properly managed with grazing and/or prescribed burning, and sometimes on areas receiving occasional short periods of rest. The potential vegetation is about 75 percent grasses or grass-like plants, 15 percent forbs, and 10 percent woody plants. This state is dominated by cool-season midgrasses.

The major grasses include western wheatgrass, needleandthread, and green needlegrass. Other grasses occurring in this state include Cusick's and Sandberg's bluegrass, bluebunch wheatgrass, and blue grama. A variety of forbs and half-shrubs also occur, as shown in the preceding table. Big sagebrush is a conspicuous element of this state, occurs in a mosaic pattern, and makes up 5 to 10 percent of the annual production. Plant diversity is high.

The total annual production (air-dry weight) of this state is approximately 1,200 pounds per acre, but it can range from approximately 700 pounds per acre in unfavorable years to approximately 1,500 pounds per acre in above-average years. This plant community is extremely stable and well adapted to the Northern Great Plains climatic conditions. The diversity in plant species allows for high drought tolerance. This is a sustainable plant community (site/soil stability, watershed function, and biologic integrity).

Transitions or pathways leading to other plant communities are as follows:

- No use and no fire for 20 years or more will convert the plant community to the Heavy Sagebrush Plant Community
- Moderate, continuous season-long grazing will convert the plant community to the Mixed Sagebrush/Grass Plant Community
- Moderate continuous season-long grazing, where greasewood occurs adjacent to the site, will convert the plant community to the Greasewood Plant Community
- When cropped annually and then abandoned without reseeding, the site is converted to the Go-Back Land Plant Community.

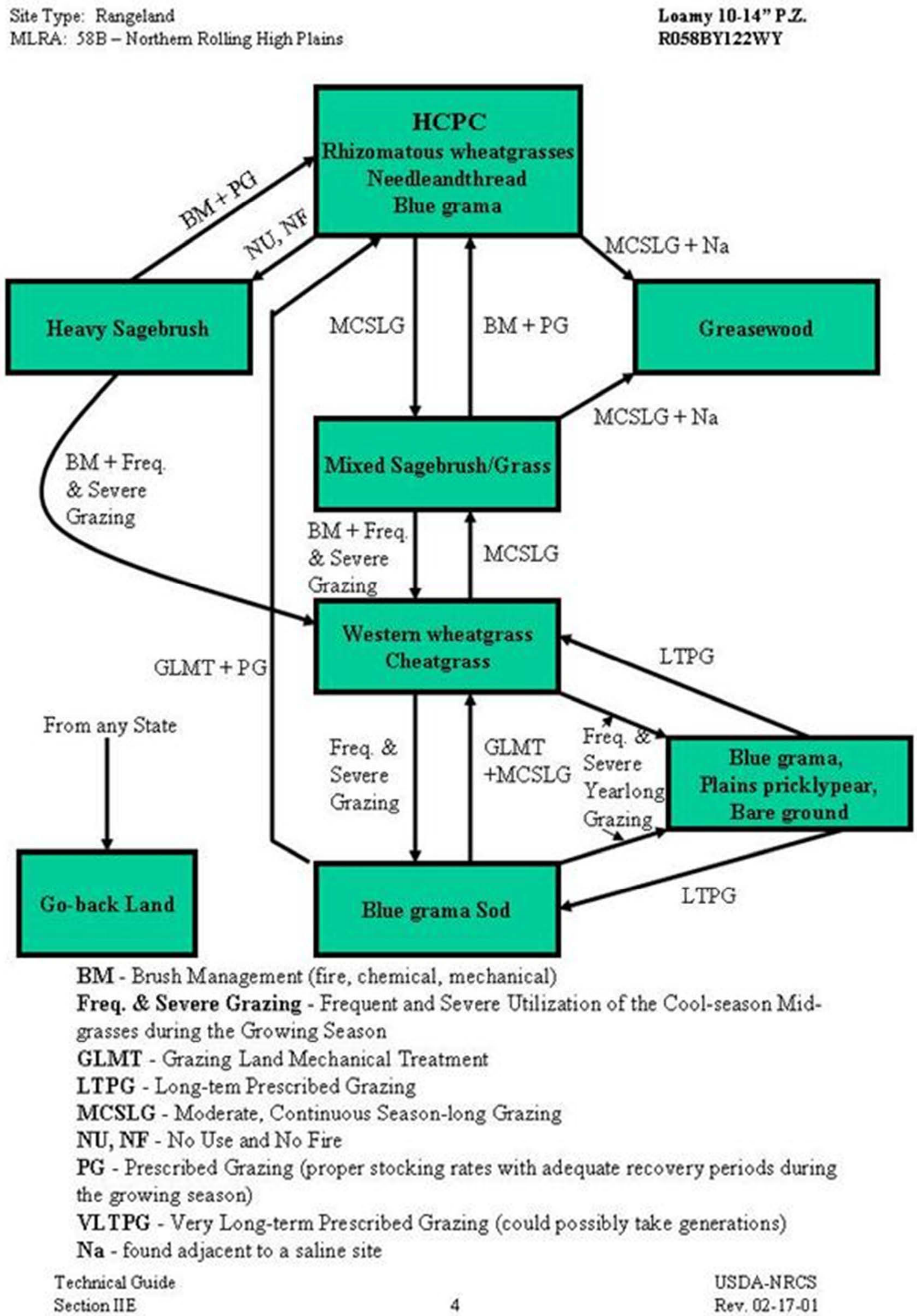


Figure 4-71. State and Transition Model: Loamy (Ly) 10–14-Inch Northern Plains Precipitation Zone.

4.6.1.2 Loamy (Ly) 15–19-Inch Black Hills Precipitation Zone

The second most predominant ecological site in the watershed is the Loamy (Ly) 15–19-inch Precipitation Zone, Black Hills (R061XY122WY) covering approximately 234,370 acres (9.4 percent) of the study area. The STM for the Loamy (Ly) 15–19-inch Precipitation Zone, Black Hills ESD is shown in Figure 4.72.

Rhizomatous Wheatgrasses/Needleandthread/Big Bluestem Plant Community

This plant community is the interpretive plant community for this site and is considered to be the HCPC. This plant community evolved with grazing by large herbivores and is well suited for grazing by domestic livestock. It can be found on areas that are properly managed with grazing and/or prescribed burning, and on areas receiving occasional short periods of rest. The potential vegetation is about 75 percent grasses or grass-like plants, 15 percent forbs, and 10 percent woody plants. A mix of warm and cool-season midgrasses dominates the state.

The major grasses include western wheatgrass, needleandthread, big bluestem, little bluestem, and green needlegrass. Other grasses occurring on the state include threadleaf sedge, Sandberg bluegrass, bluebunch wheatgrass, blue grama, and sideoats grama. A variety of forbs and half-shrubs also occur, as shown in the preceding table. Big sagebrush is a conspicuous element of this state, occurs in a mosaic pattern, and makes up 5 to 10 percent of the annual production. Plant diversity is high.

The total annual production (air-dry weight) of this state is approximately 2,200 pounds per acre, but it can range from approximately 1,500 pounds per acre in unfavorable years to approximately 3,000 pounds per acre in above-average years. This plant community is extremely stable and well adapted to the Black Hills Foot Slopes climatic conditions. The diversity in plant species allows for high drought tolerance. This is a sustainable plant community (site/soil stability, watershed function, and biologic integrity).

Transitions or pathways leading to other plant communities are as follows:

- No use and no fire for 20 years or more will convert the plant community to the Heavy Sagebrush Plant Community
- Moderate, continuous season-long grazing will convert the plant community to the Mixed Sagebrush/Grass Plant Community
- When cropped annually and then abandoned without reseeding, the state is converted to the Go-Back Land Plant Community.

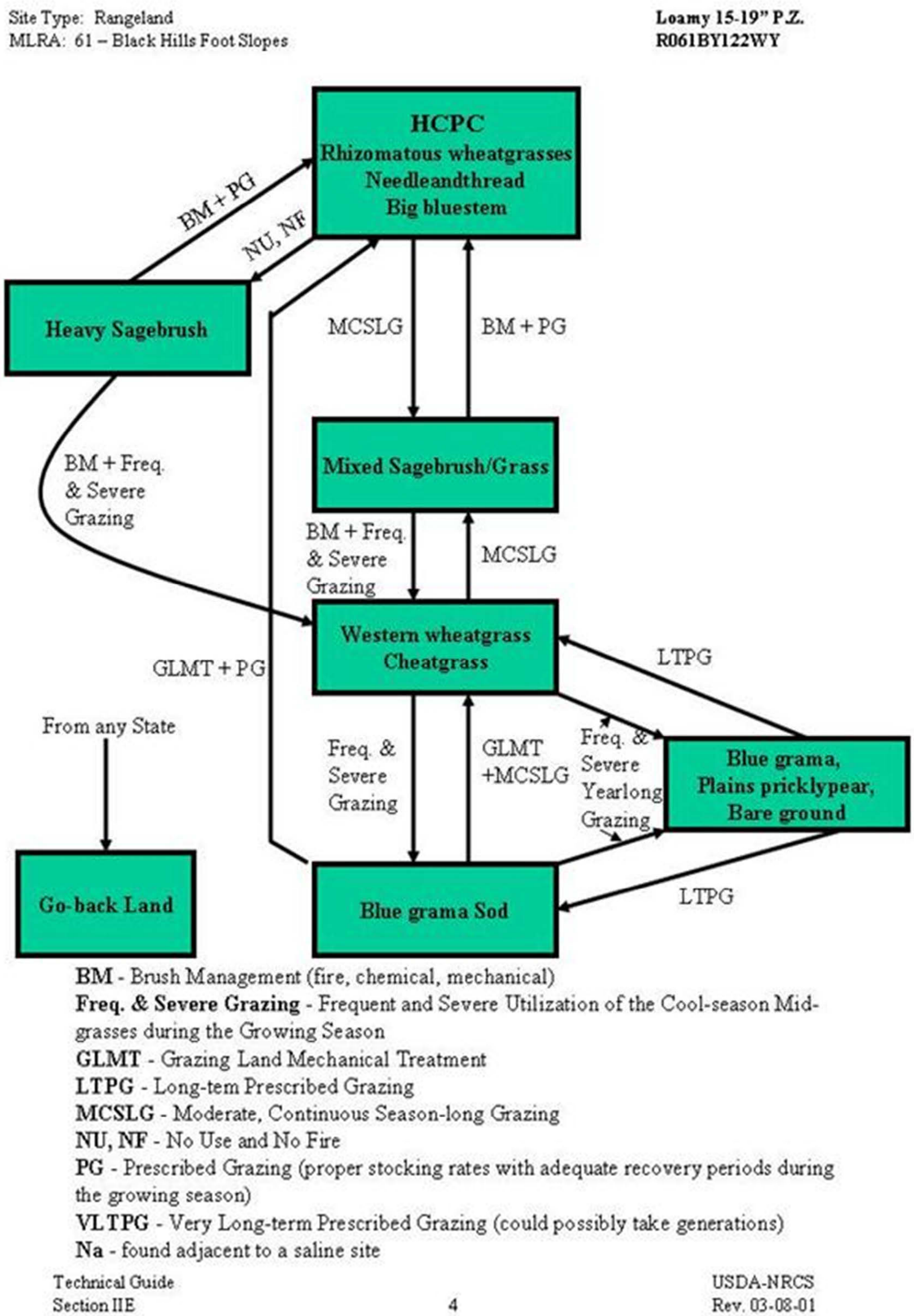


Figure 4-72. State and Transition Model: Loamy (Ly) 15–19-Inch Black Hills Precipitation Zone.

4.6.1.3 Shallow Loamy (SwLy) 15–19-Inch Black Hills Precipitation Zone

The third most predominant ecological site in the watershed is the Shallow Loamy (SwLy) 15–19-inch Black Hills PZ (R061XY162WY) covering approximately 150,320 acres (6.0 percent) of the study area. The STM for the Shallow Loamy (SwLy) 15–19-inch Black Hills PZ ESD is shown in Figure 4.73.

Rhizomatous Wheatgrasses/Needleandthread/Blue Grama Plant Community

The interpretive plant community for this site is the HCPC. This state evolved with grazing by large herbivores and is well suited for grazing by domestic livestock. Potential vegetation is about 80 percent grasses or grass-like plants, 10 percent forbs, and 10 percent woody plants. The state is dominated by cool-season midgrasses.

The major grasses include little bluestem, bluebunch wheatgrass, needleandthread, sideoats grama, and western wheatgrass. Other grasses occurring on the state include Sandberg bluegrass, blue grama, plains muhly, spikefescue and prairie junegrass. Big sagebrush is a conspicuous element of this state and occurs in a mosaic pattern. Big sagebrush may become dominant on some areas with absence of fire. Natural fire occurred frequently in this community and prevented big sagebrush from being the dominant landscape. Wildfires are actively controlled in recent times so chemical control using herbicides has replaced the historic role of fire on this state. Recently, controlled burning has regained some popularity.

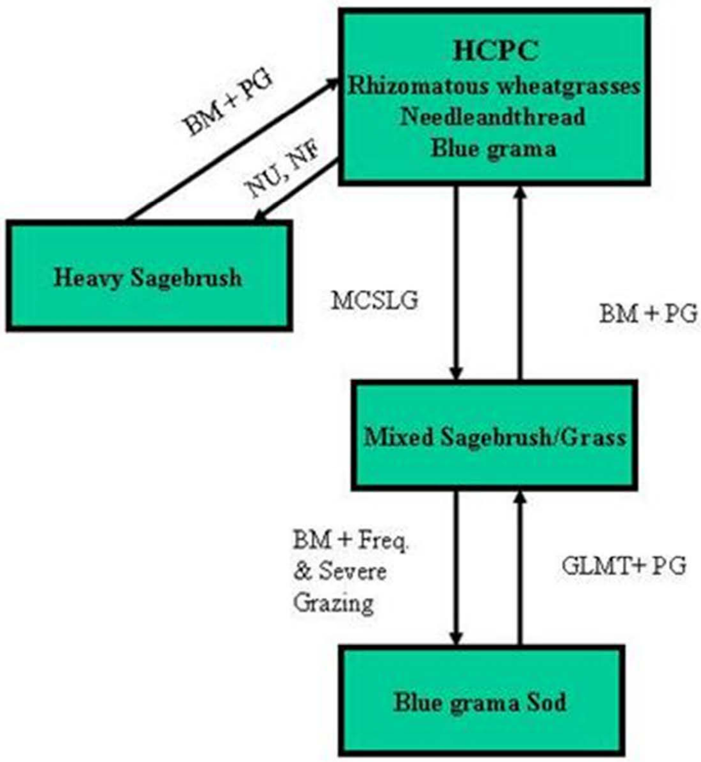
The total annual production (air-dry weight) of this state is approximately 1,400 pounds per acre, but it can range from approximately 900 pounds per acre in unfavorable years to approximately 1,800 pounds per acre in above-average years. The state is extremely stable and well adapted to the Black Hills Foot Slopes climatic conditions. The diversity in plant species allows for high drought resistance. This is a sustainable plant community (site/soil stability, watershed function, and biologic integrity).

Transitions or pathways leading to other plant communities are as follows:

- Protection from grazing and fire will convert the plant community to the Heavy Sagebrush Plant Community
- Moderate, continuous season-long grazing will convert the plant community to the Mixed Sagebrush/Grass Plant Community
- Frequent and severe grazing and brush management will convert the plant community to the Blue Grama Plant Community.

Site Type: Rangeland
MLRA: 61 – Black Hills Foot Slopes

Shallow Loamy 15-19" P.Z
R061XY162WY



BM - Brush Management (fire, chemical, mechanical)
Freq. & Severe Grazing - Frequent and Severe Utilization of the Cool-season Mid-grasses during the Growing Season
GLMT - Grazing Land Mechanical Treatment
LTPG - Long-tem Prescribed Grazing
MCSLG - Moderate, Continuous Season-long Grazing
NU, NF - No Use and No Fire
PG - Prescribed Grazing (proper stocking rates with adequate recovery periods during the growing season)
VLTPG - Very Long-term Prescribed Grazing (could possibly take generations)
Na - found adjacent to a saline site

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Figure 4-73. State and Transition Model: Shallow Loamy (SwLy) 15–19-Inch Black Hills Precipitation Zone.

4.6.1.4 Loamy (Ly) 15–17-Inch Northern Plains Precipitation Zone

The fourth most predominant ecological site within the watershed is the Loamy (Ly) 15-17-inch Northern Plains PZ (R058BY222WY) covering approximately 116,510 acres (4.7 percent) of the study area. The STM for the Loamy (Ly) 15-17 inch Northern Plains PZ ESD is shown in Figure 4.74.

Rhizomatous Wheatgrasses/Needleandthread/Big Bluestem Plant Community

The interpretive plant community for this site is the HCPC. This plant community evolved with grazing by large herbivores and is well suited for grazing by domestic livestock. This plant community can be found on areas that are properly managed with grazing and/or prescribed burning, and sometimes on areas receiving occasional short periods of rest. The potential vegetation is about 75 percent grasses or grass-like plants, 15 percent forbs, and 10 percent woody plants. A mix of warm- and cool-season midgrasses dominates the state. The major grasses include western wheatgrass, needleandthread, big bluestem, little bluestem, and green needlegrass. Other grasses occurring on the state include threadleaf sedge, Sandberg's bluegrass, bluebunch wheatgrass, blue grama, and sideoats grama. A variety of forbs and half-shrubs also occur, as shown in the preceding table. Big sagebrush is a conspicuous element of this state, occurs in a mosaic pattern, and makes up 5 to 10 percent of the annual production. Plant diversity is high.

The total annual production (air-dry weight) of this state is approximately 1,900 pounds per acre, but it can range from approximately 1,500 pounds per acre in unfavorable years to approximately 2,300 pounds per acre in above-average years. This plant community is extremely stable and well adapted to the Northern Great Plains climatic conditions. The diversity in plant species allows for high drought tolerance. This is a sustainable plant community (site/soil stability, watershed function, and biologic integrity).

Transitions or pathways leading to other plant communities are as follows:

- No use and no fire for 20 years or more will convert the plant community to the Heavy Sagebrush Plant Community.
- Moderate, continuous season-long grazing will convert the plant community to the Mixed Sagebrush/Grass Plant Community.
- Moderate continuous season-long grazing, where greasewood occurs adjacent to the state, will convert the plant community to the Greasewood Plant Community.
- When cropped annually and then abandoned without reseeding, the state is converted to the Go-Back Land Plant Community.

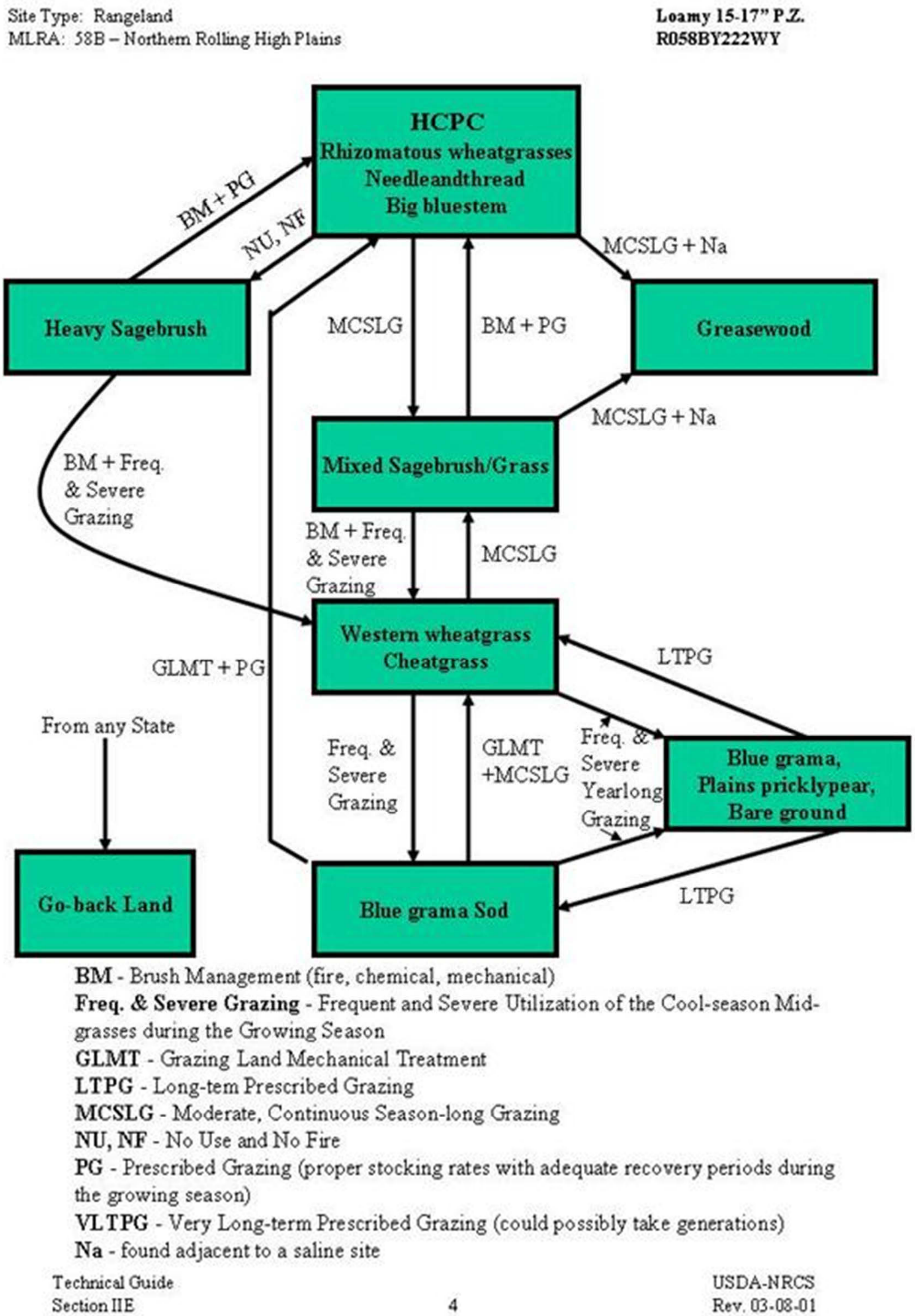


Figure 4-74. State and Transition Model: Loamy (Ly) 15–17-Inch Northern Plains Precipitation Zone.

4.6.1.5 Sandy (Sy) 10–14-Inch Northern Plains Precipitation Zone

The fifth most predominant ecological site in the watershed is the Sandy (Sy) 10–14-inch Northern Plains PZ (R058BY150WY) covering approximately 112,530 acres (5.0 percent) of the study area. The STM for the Sandy (Sy) 10–14-inch Northern Plains PZ ESD is shown in Figure 4.75.

Needleandthread/Prairie Sandreed Plant Community

The interpretive plant community for this site is the HCPC. This state evolved with grazing by large herbivores and is well suited for grazing by domestic livestock. Potential vegetation is about 75 percent grasses or grass-like plants, 15 percent forbs, and 10 percent woody plants. The state is a mix of warm- and cool-season midgrasses. The major grasses include needleandthread, prairie sandreed, little bluestem, and Indian ricegrass. Other grasses occurring in the state include rhizomatous wheatgrasses, Sandberg bluegrass, blue grama, and threadleaf sedge. Silver sagebrush and green rabbitbrush are conspicuous components of this state.

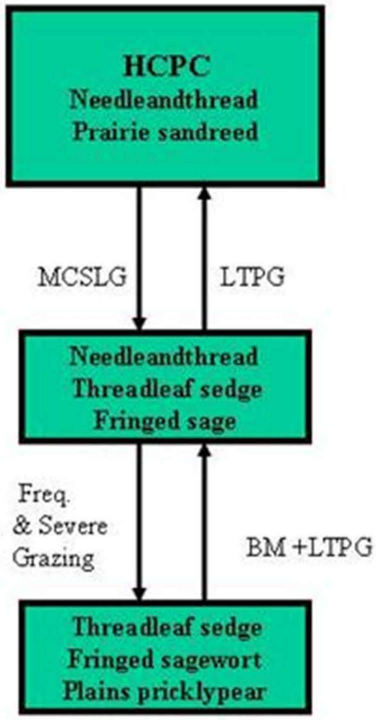
The total annual production (air-dry weight) of this state is approximately 1,200 pounds per acre, but it can range from approximately 750 pounds per acre in unfavorable years to approximately 1,600 pounds per acre in above-average years. The state is stable and well adapted to the Northern Great Plains climatic conditions. The diversity in plant species allows for high drought resistance. This is a sustainable plant community (site/soil stability, watershed function, and biologic integrity).

Transitions or pathways leading to other plant communities are as follows:

- Moderate, Continuous Season-Long grazing will convert the plant community to the Needleandthread/Threadleaf sedge/Fringed sagewort Vegetation state.
- Frequent and Severe grazing will convert the plant community to the Threadleaf sedge/Fringed sagewort/Plains Pricklypear vegetation state.

Site Type: Rangeland
MLRA: 58B – Northern Rolling High Plains

Sandy 10-14" P.Z.
R058BY150WY



BM - Brush Management (fire, chemical, mechanical)
Freq. & Severe Grazing - Frequent and Severe Utilization of the Cool-season Mid-grasses during the Growing Season
GLMT - Grazing Land Mechanical Treatment
LTPG - Long-tem Prescribed Grazing
MCSLG - Moderate, Continuous Season-long Grazing
NU, NF - No Use and No Fire
PG - Prescribed Grazing (proper stocking rates with adequate recovery periods during the growing season)
VLTPG - Very Long-term Prescribed Grazing (could possibly take generations)
Na - found adjacent to a saline site

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Figure 4-75. State and Transition Model: Sandy (Sy) 10–14-Inch Northern Plains Precipitation Zone.

4.6.2 Range and Grazing Management Components of the Watershed Plan

Based on the information presented previously, the following items are presented for inclusion in the watershed management plan:

- **Watershed Plan Component G-1:** Water developments can be used to expand grazing distribution to areas that do not currently have reliable water. Riparian area plant community condition can be enhanced by development of water into upland areas.
- **Watershed Plan Component G-2:** Fencing can be used to enhance grazing management options and to facilitate the planned grazing system.
- **Watershed Plan Component G-3:** Strategic salting and herding are other tools that can be used to enhance grazing distribution.
- **Watershed Plan Component G-4:** Most range improvement practices that improve watershed conditions may also improve wildlife habitat. Wildlife needs should be considered when installing practices such as wildlife-friendly fences, wildlife escape ramps from tanks, and wildlife watering facilities.
- **Watershed Plan Component G-5:** Strategies recommended in the STMs associated with NRCS descriptions of the ecological sites found within the watershed should be adopted and employed to optimize range conditions through prescribed grazing management and BMPs.
- **Watershed Plan Component G-6:** Prescribed fire may be used as a tool to assist in restoring range health areas benefitting by this treatment according to the STMs. Delineation of specific areas potentially benefitting from this practice was beyond the scope of this Level I project. However, based upon input from landowners and land managers and observations made during the completion of this investigation, it is evident that there are areas that would likely benefit from prescribed fires.
- **Watershed Plan Component G-7:** Application of chemicals may be used as a tool to assist in restoring range health areas benefitting by this treatment according to the STMs. Delineation of specific areas potentially benefitting from this practice was beyond the scope of this Level I project. However, based on input from landowners and land managers and observations made during the completion of this investigation, it is evident that there are areas which would likely benefit from chemical application for control of range (e.g., Big Sagebrush).

These tools can be used to maintain and/or improve watershed function particularly when coupled with implementation of appropriate grazing management strategies.

4.7 SURFACE WATER STORAGE OPPORTUNITIES

4.7.1 Potential Projects and Alternatives

Investigations to identify large water storage reservoirs within the watershed have been the subject of several past studies and are summarized in Section 3.9.3 of this report. During this study, the scope of investigating water storage opportunities focused on existing stock ponds and potential upland water storage facilities less than 20 acre-feet. However, water users identified problems with several existing reservoirs and associated facilities that severely limited the potential to store water in these facilities. Additionally, participants identified potential sites and possible opportunities for larger water storage facilities within the study area. Accordingly, site visits and initial reviews were conducted on some of the stock ponds, stock reservoirs, storage reservoirs, and previously proposed sites identified by participants.

A "long list" of ten potential surface water storage sites were identified within the watershed as listed in Table 4.3 and shown in Figure 4.76. Preliminary information about these potential projects and alternatives are described in Section 4.7.1.1 through 4.7.10. These alternatives involve mostly rehabilitation of existing facilities in need of update or repair, along with enlargement of existing facilities, and construction of new facilities. Additionally, relevant information about these potential sites was collected to provide an initial screening of these alternatives based on environmental, hydrologic, geologic, potential benefits, costs, and other data. This information was organized in an evaluation matrix presented in Section 4.7.2.

Table 4.3. Potential Storage Project Sites Identified Within the Study Area

Item Number	Potential Storage Project Site	Potential and Project Alternative Type
S-01	S-01: Dry Creek	New
S-02	S-02: Driskill #1 Reservoir	Rehabilitation and Enlargement
S-03	S-03: Washington Memorial Reservoir (Sundance Pond)	Rehabilitation and Enlargement
S-04	S-04: Pine (Deep) Creek Reservoir (2B)	Rehabilitation and Enlargement
S-05	S-05: Oak Creek Reservoir (2A)	Rehabilitation and Enlargement
S-06	S-06: Horse Creek	New
S-07	S-07: Newland #4 Reservoir	Rehabilitation
S-08	S-08: Christofferson Draw	Rehabilitation and Enlargement
S-09	S-09: Mule Shoe Reservoir	Rehabilitation and Enlargement
S-10	S-10: Sunset Reservoir (Hemler Dam)	Rehabilitation

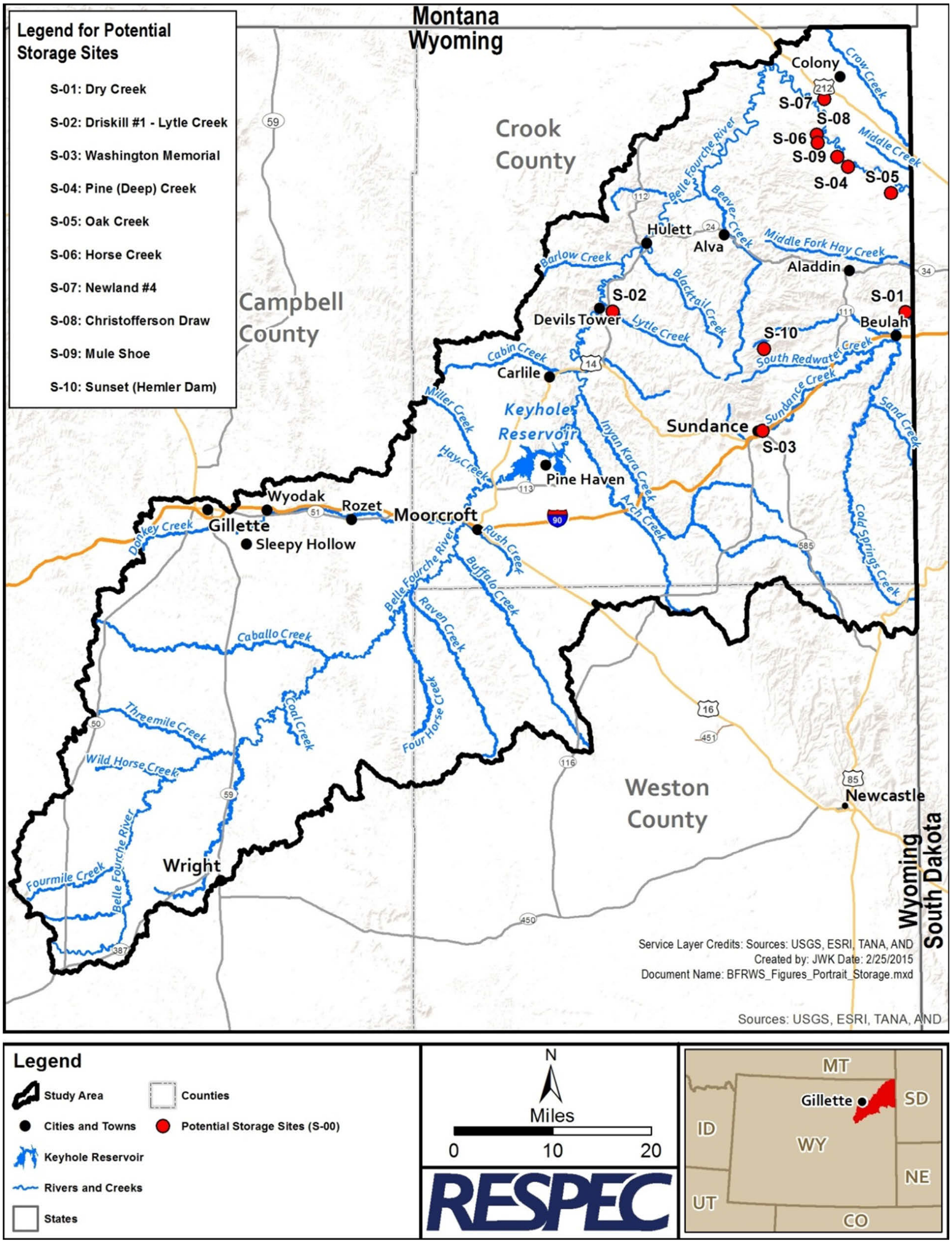

Figure 4-76. Map of the Potential Storage Sites Within the Study Area.

4.7.1.1 S-01: Dry Creek

This potential site is located on Dry Creek, a tributary to Redwater Creek, and is within the Belle Fourche River Watershed – Redwater Subbasin. The potential site is located in Section 17 of Township 53 North, Range 60 West in Crook County. A view of the site from the county road is shown in Figure 4.77. The potential site is located approximately 2.5 miles north of Beulah, Wyoming, on a 960-acre parcel owned by the state of Wyoming, as illustrated in Figure 4.78.

RSI-2264-15-143

Figure 4-77. A View of the Potential Site on Dry Creek Storage Site.

This potential site would involve constructing a new reservoir at this location. Consequently, a detailed investigation of geologic structure should be completed along with identifying the permitting requirements. This work can be accomplished through by evaluating potential alternatives completed during a WWDC Level II Phase I study.

This site alternative is limited to storage provided by Dry Creek and possibly diversions from Redwater Creek. Additional coordination with the SEO should be conducted before proceeding with any future work because of the constraints regarding the Belle Fourche River Compact and permitting through the USACE. Lastly, although this potential site's reservoir embankment and storage pool are almost entirely contained within lands owned by the state of Wyoming, as mapped in Figure 4.78, a small portion of the storage pool would inundate privately owned lands, which must be considered in any future studies related to this potential storage site.

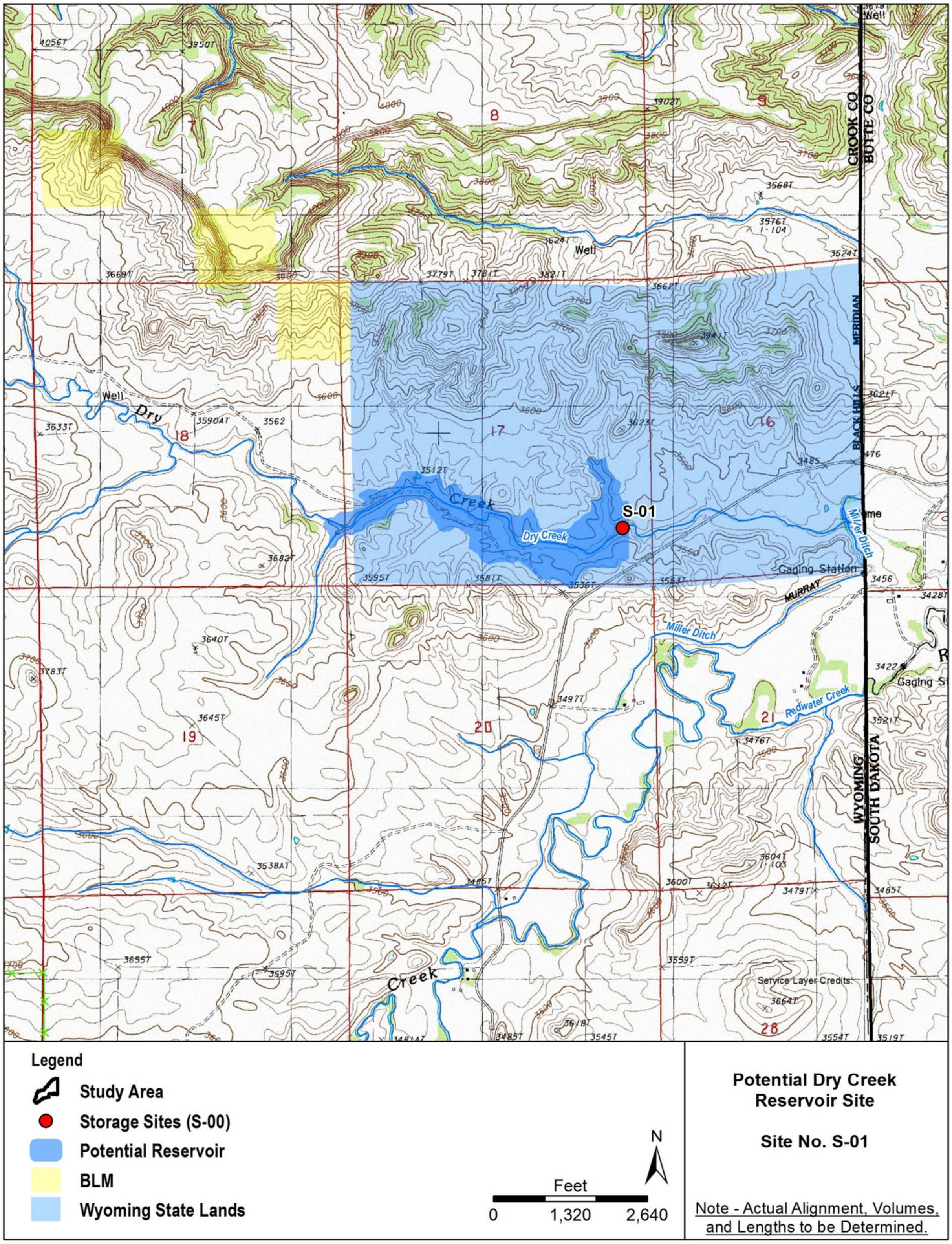

Figure 4-78. Map of the S-01: Dry Creek Storage Site.

4.7.1.2 S-02: Driskill #1 Reservoir

The Driskill #1 Reservoir is located on Lytle Creek near Devils Tower, Wyoming. The reservoir and dam are located on Lytle Creek, a tributary to the Belle Fourche River, and is within the Subbasin below Keyhole Reservoir. The reservoir is located in Section 16 of Township 53 North, Range 65 West in Crook County. The reservoir was permitted in 1976 (Permit No. P8232R) with a total capacity of 104.59 acre-feet. The reservoir's inlet and spillway structures are shown in Figure 4.79 and Figure 4.80.

This reservoir and alternatives storage sites were studied in 1999 and reported in the *Final Report, Crook County Reservoir Project – Level I* [ESA Consultants Inc., 1999], and then was evaluated in 2006 and included in the *Crook County Reservoirs and Water Management Study – Level I* [Short Elliot Hendrickson Inc., 2006]. This alternative includes conclusions from Alternative 3 of ESA Consultants Inc. [1999] and Short Elliot Hendrickson Inc. [2006] and is shown in Figure 4.81. Alternative 3/1B includes the potential to construct a moderate-sized reservoir located on Lytle Creek as a 1,000 acre-foot option. This alternative was previously studied and was assumed that this storage would serve a portion of the existing supplemental irrigation needs in the lower portion of the study area rather than irrigation of new acreage. This dam and reservoir were sized to comply with the Belle Fourche River Compact limitation of storage capacity for new reservoirs.

The design for Alternative 3 described in ESA Consultants Inc. [1999] was assumed, and the associated cost escalated to 2006 dollars in Short Elliot Hendrickson Inc. [2006]. These costs were not updated for the purposes of this study effort. This alternative had key factors influencing the previously completed conceptual design and estimated costs and included the site's anticipated geological conditions, flood hydrology, associated spillway sizing, land ownership, access considerations, and permitting/environmental constraints and mitigation [Short Elliot Hendrickson Inc., 2006]. Several technical issues have been identified that may significantly impact the feasibility and cost of this alternative including the number of irrigated acres and CCID members served, Sundance and/or Gypsum geologic conditions, marginal foundational strength, and known cultural resource sites [Short Elliot Hendrickson Inc., 2006].

4.7.1.3 S-03: Washington Memorial Reservoir (Sundance Pond)

Washington Memorial Reservoir, known locally as Sundance Pond, is located on Sundance Creek in Washington Park within the city of Sundance, Wyoming. The reservoir and dam are located on Sundance Creek, a tributary to Redwater Creek, and is within the Redwater Subbasin. The Washington Memorial Reservoir is located in Section 13 of Township 51 North, Range 63 West in Crook County. The reservoir was permitted in 1933 (Permit No. P4565S) with a capacity of 22.78 acre-feet and then enlarged to a permitted capacity of 31.41 acre-feet in 1987 (Permit No. P9215R).

In 2012, the *Washington Memorial Reservoir (P9215R) 2012 Inundation Map Project* was completed by States West Water Resources Corporation [2012] for the Wyoming SEO to

RSI-2264-15-145

Figure 4-79. A View of Driskill #1 Reservoir's Inlet Structure.

RSI-2264-15-146

Figure 4-80. A View of Driskill #1 Reservoir's Emergency Spillway.

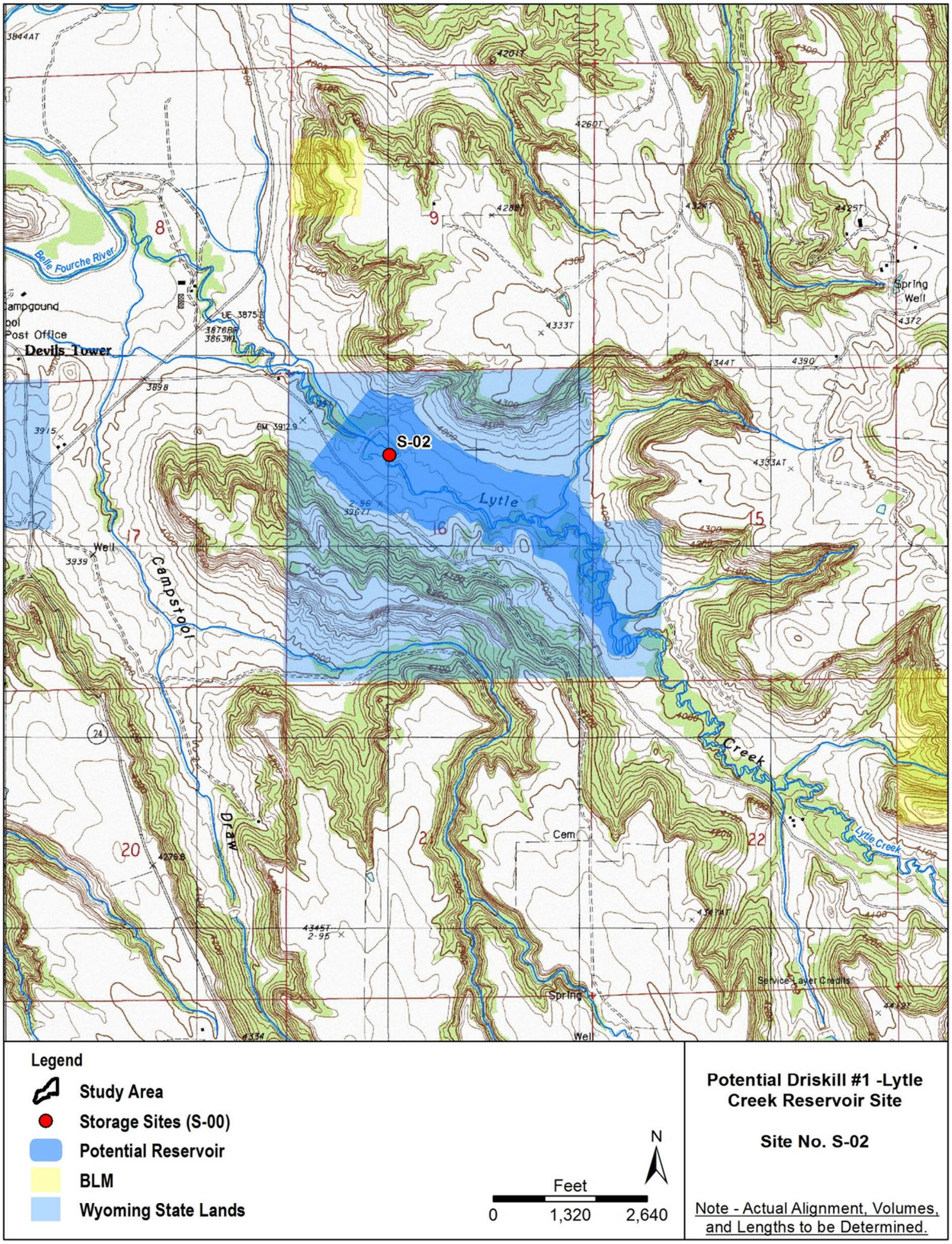

Figure 4-81. Map of the S-02: Driskill #1 Reservoir Storage Site on Lytle Creek.

compute the inundation areas resulting from a clear weather breach of Washington Memorial Reservoir Dam. A dam breach analysis of Washington Memorial Reservoir was also conducted to determine the resulting outflow hydrograph using the USACE HEC-HMS 3.5 [States West Water Resources Corporation, 2012].

This alternative would provide for rehabilitating the reservoir, embankment, outlet facilities, and associated wetland and riparian areas. The reservoir's inlet and spillway structures are shown in Figure 4.82 and Figure 4.83. The alternative would involve installing an inlet and outlet pipe control structure in the reservoir embankment and stabilizing the installed structures and spillway with rock riprap. This reservoir could be rehabilitated to provide an additional source of wildlife and fisheries water along with restoring function of the wetland and riparian areas. The reservoir's embankment and storage pool involves city, county, and private lands as shown in Figure 4.84. This alternative would include the following features:

- Inspecting the embankment and rehabilitation of problem areas as needed. The embankment is approximately 500 feet long and less than 25 feet high at its highest point. The top-width of the embankment is approximately 20 feet wide.
- Investigating the reservoir's inlet and outlet facilities along with soil and bedrock geologic conditions to define the extent necessary for excavating sediment, restoring wetland and riparian vegetation, and rehabilitating the reservoir's function.
- Installing an inlet/outlet control mechanism to control reservoir water levels.
- Excavating the eroded spillway to adequately convey necessary water volumes and stabilizing with rock riprap for spillway protection.
- Contingent on determining adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.

4.7.1.4 S-04: Pine (Deep) Creek Reservoir (2B)

The Pine Creek Reservoir storage site is located on Deep Creek, a tributary to the Belle Fourche River, and is within the Subbasin below Keyhole Reservoir. The site is located in Section 4 of Township 55 North, Range 61 West in Crook County. Although no permit information was available for the breached structure, the site was studied as Alternative 2B – Pine Creek in Short Elliot Hendrickson Inc. [2006]. A view looking upstream from the existing breached dam structure at this site is shown in Figure 4.85. Also, a view of the existing breached dam is shown in Figure 4.86.

This alternative includes conclusions from Alternative 2B of Short Elliot Hendrickson Inc. [2006] and a map of the alternative site is shown in Figure 4.87. Approximately 55 percent of the existing dry year shortage on irrigated are along the Belle Fourche River occurs below the confluence of Pine (Deep) Creek. Pine Creek has approximately 1,200 acre-feet of available annual flows in normal years [Short Elliot Hendrickson Inc., 2006].

RSI-2264-15-148

Figure 4-82. A View of Washington Memorial Reservoir's Inlet Structure and Emergency Spillway.

RSI-2264-15-149

Figure 4-83. A View of Washington Memorial Reservoir's Emergency Spillway.

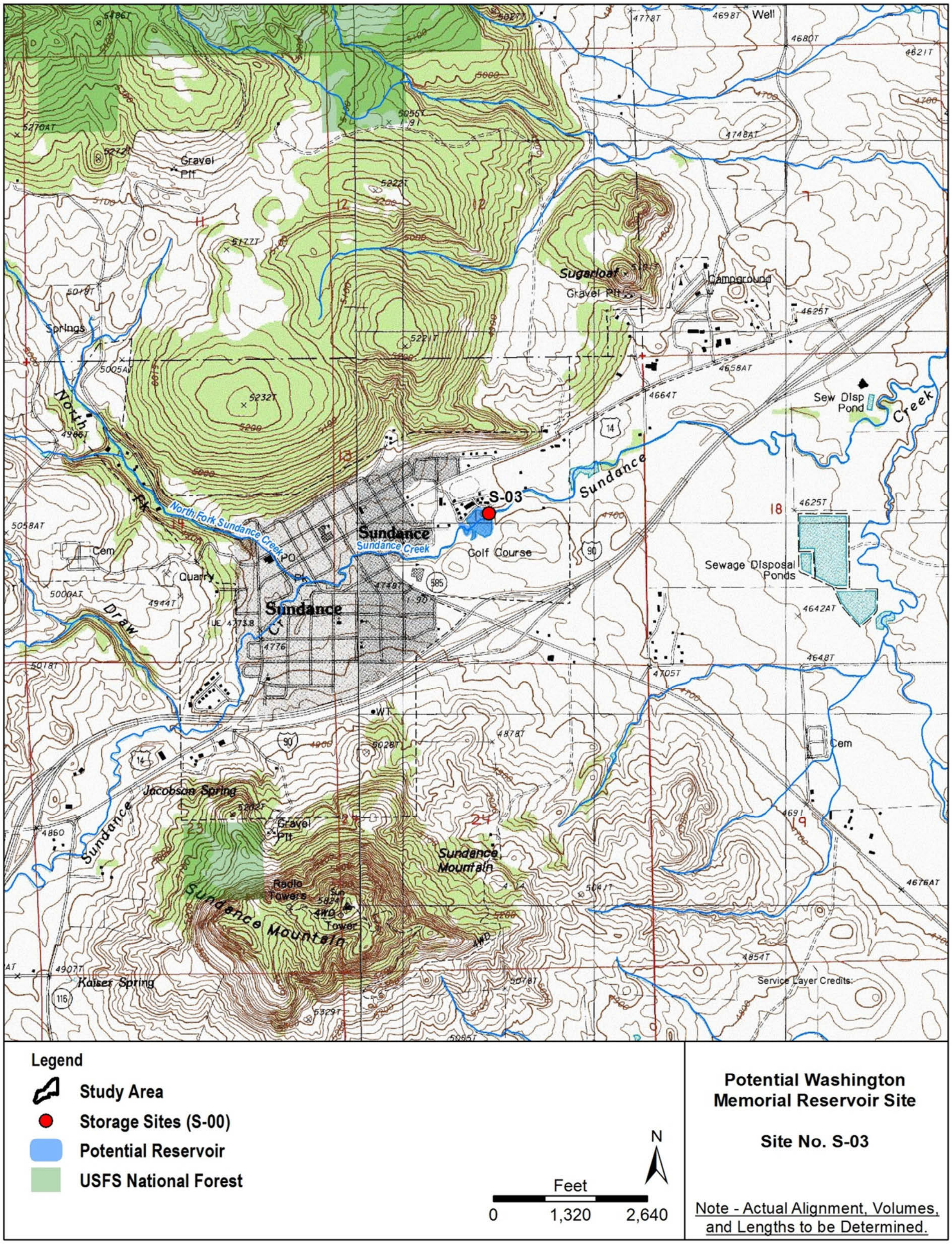

Figure 4-84. Map of the S-3: Washington Memorial Reservoir Storage Site.

RSI-2264-15-151

Figure 4-85. A View Looking Upstream From Pine (Deep) Creek Reservoir's Breached Dam.

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Figure 4-86. A View of Pine (Deep) Creek Reservoir's Breached Dam.

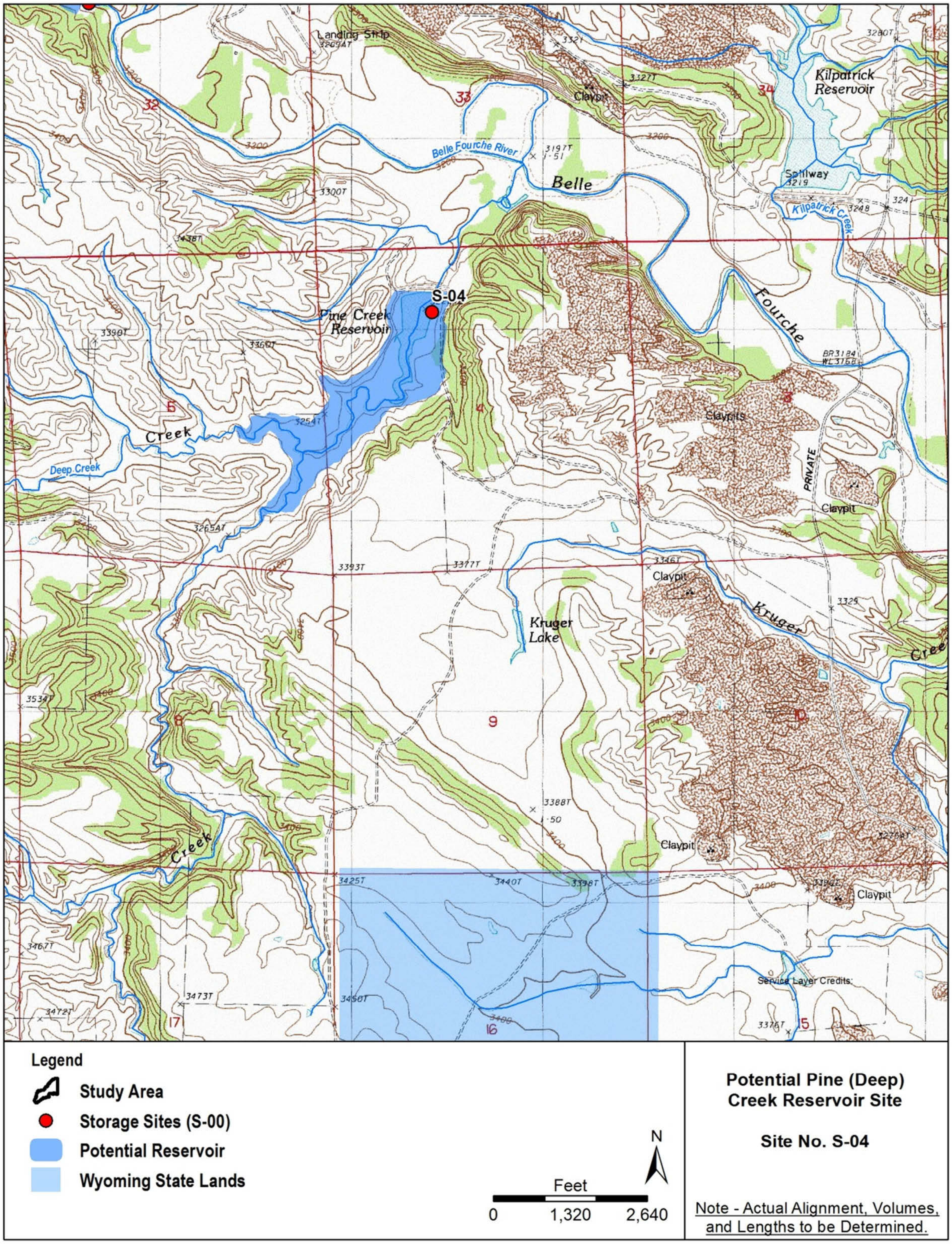

Figure 4-87. Map of the S-04: Pine (Deep) Creek Reservoir Storage Site.

Alternative 2B includes the potential to construct a moderate-sized reservoir located on Pine Creek to minimize conveyance losses and serve a portion of the existing supplemental irrigation needs and possibly deliver irrigation water to approximately 340 acres of potential new irrigable ground. However, the current water shortages are experienced by two of the 17 CCID members. A single large reservoir at this site or Oak Creek may result in the need for a more expensive full probable maximum flood (PMF) spillway, which would probably increase costs and offset any benefits from the economy of scale by constructing just one reservoir [Short Elliot Hendrickson Inc., 2006].

Additionally, a portion of the Pine Creek site is possibly underlain by Skull Creek Shale, which warrants caution because the formation is relatively weak and soft where weathered near surface and thus require more detailed investigations to determine whether or not this site could support construction of a roller-compacted concrete (RCC) gravity dam. Another potential problem at this site is the presence of highly erodible, friable Newcastle sandstone in the lower right abutment of the existing structure, which resulted in severe, erosional downcutting in an unlined spillway and would require protection against piping if the material were used in constructing an earthen dam. The cost of this alternative was estimated in 2006 dollars in Short Elliot Hendrickson Inc. [2006] and was not updated for this study.

4.7.1.5 S-05: Oak Creek Reservoir (2A)

The Oak Creek Reservoir is located on Oak or Alum Creek near the Wyoming-South Dakota state line. The reservoir and dam are located on Oak or Alum Creek, a tributary to the Belle Fourche River, and is within the Subbasin below Keyhole Reservoir. The reservoir is located in Section 18 of Township 55 North, Range 60 West in Crook County. The reservoir was permitted in 1975 (Permit No. P7668R) with a total capacity of 914.77 acre-feet. The reservoir is shown in Figure 4.88 and an irrigation ditch below the reservoir in shown in Figure 4.89.

This site was studied as Alternative 2A – Oak Creek in Short Elliot Hendrickson Inc. [2006]. This alternative includes conclusions from Alternative 2A of Short Elliot Hendrickson Inc. [2006] and a map of the alternative site is shown in Figure 4.90. Approximately 20 percent of the existing dry year shortage on irrigated are along the Belle Fourche River occurs below the confluence of Oak Creek. Pine Creek has approximately 1,500 acre-feet of available annual flows in normal years [Short Elliot Hendrickson Inc., 2006].

Alternative 2B includes the potential to enlarge the reservoir located on Oak Creek to minimize conveyance losses and serve a portion of the existing supplemental irrigation needs and possibly deliver irrigation water to approximately 230 acres of potential new irrigable ground. However, the current water shortages are experienced by one of the 17 CCID members. Similar to the Pine Creek site, a single large reservoir on Oak Creek may result in the need for a more expensive full PMF spillway, which would probably increase costs and offset any benefits from the economy of scale by constructing just one reservoir [Short Elliot Hendrickson Inc., 2006].

RSI-2264-15-154

Figure 4-88. A View of Oak Creek Reservoir.

RSI-2264-15-155

Figure 4-89. A View of a Downstream Irrigation Ditch From Oak Creek Reservoir.

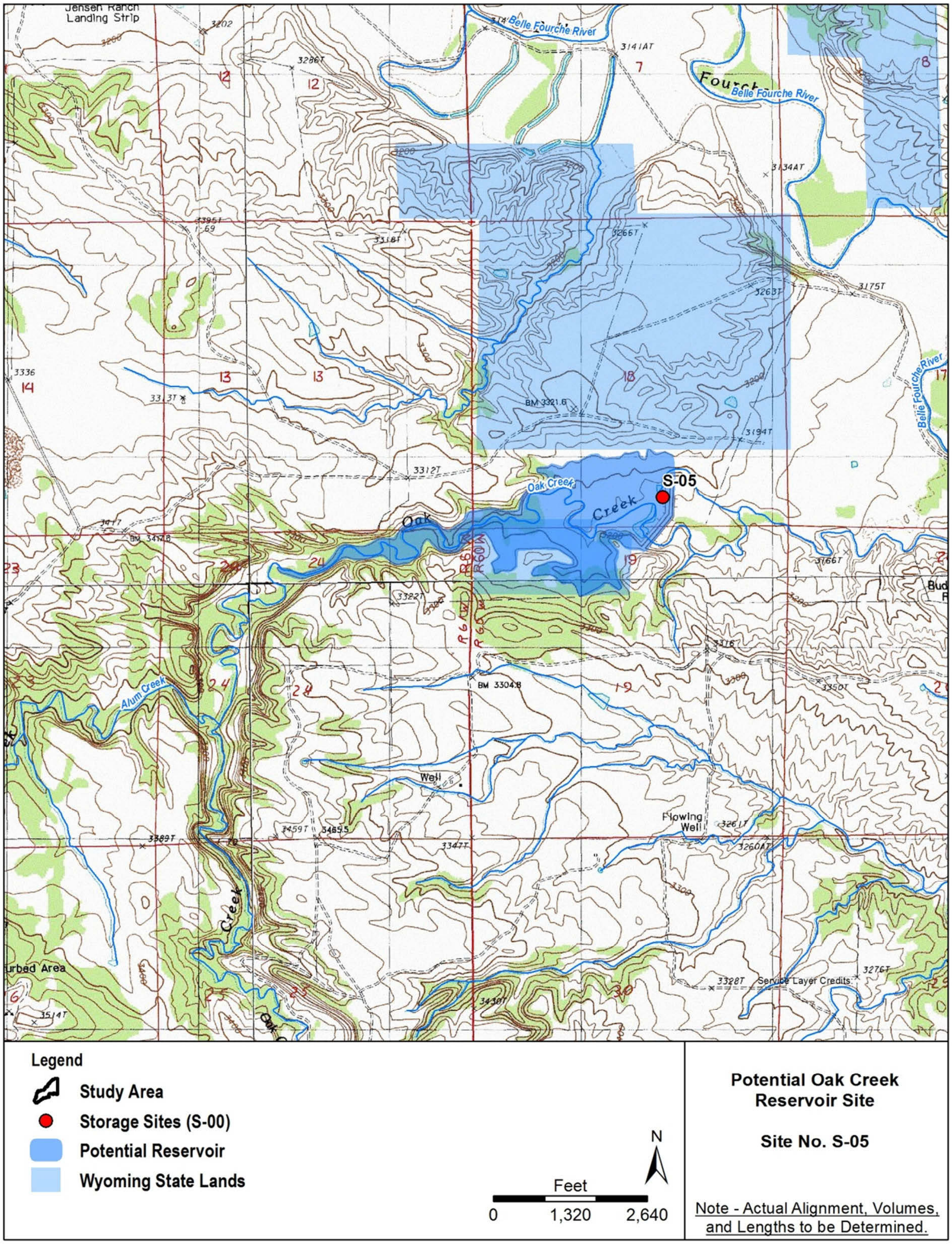

Figure 4-90. Map of the S-05: Oak Creek Reservoir Storage Site.

Additionally, the Oak Creek site is underlain by Skull Creek Shale, which warrants caution because the formation is relatively weak and soft where weathered near surface and thus require more detailed investigations to determine whether or not this site could support construction of an RCC gravity dam. Another potential issue that needs more investigation is the possible presence of weak layers, such as bentonitic claystone or clay, in the foundation because if these layers are present at depths in the foundation too deep to economically remove, but shallow enough to be impacted by the load of either an earthen or RCC dam, they could induce foundation and dam instability. Furthermore, as part of any future in-depth investigation, this site should be checked for the presence of gypsiferous interbeds or gypsum-enriched units which could be problematic, especially if used as a source of impervious fill for the dam or embankment [Short Elliot Hendrickson Inc., 2006]. The cost of this alternative was estimated in 2006 dollars in Short Elliot Hendrickson Inc. [2006], and was not updated for this study effort.

4.7.1.6 S-06: Horse Creek

The Horse Creek storage site is located on Horse Creek, a tributary to the Belle Fourche River, and is within the Subbasin below Keyhole Reservoir. The site is located in Section 24 of Township 56 North, Range 62 West in Crook County. A view of the site is shown in Figure 4.91. The site is located approximately 7 miles south of Colony, Wyoming, on private lands, as illustrated in Figure 4.92. This alternative would involve constructing a new reservoir at this site, thus requiring a detailed investigation of geologic structure and identifying permitting requirements.

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Figure 4-91. A View Looking Downstream of the Horse Creek Storage Site.

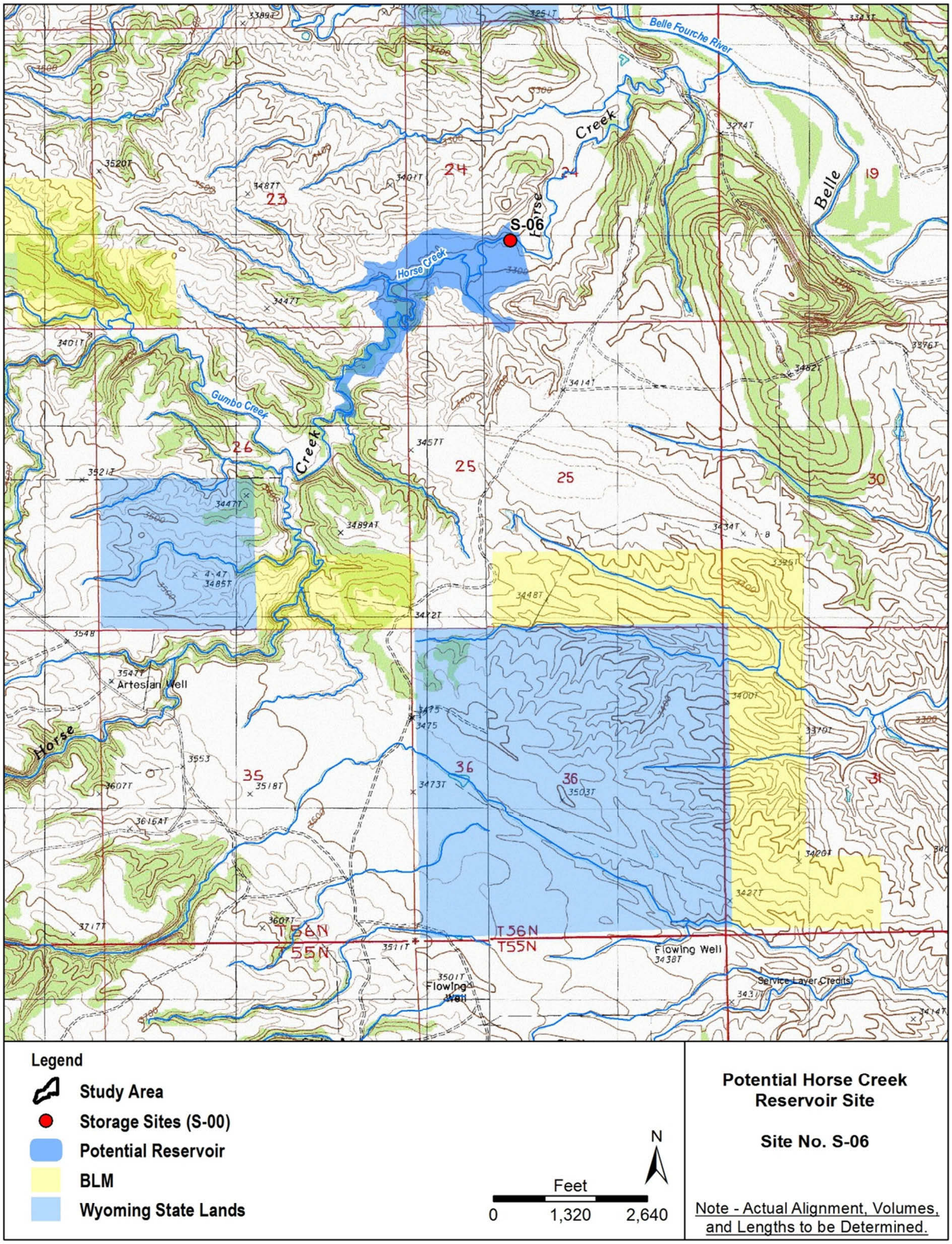

Figure 4-92. Map of the S-06: Horse Creek Storage Site.

This alternative is limited to storage provided by Horse Creek, which was estimated to be approximately 514 acre-feet of available annual flows in normal years [Short Elliot Hendrickson Inc., 2006]. This site is estimated to have similar available annual flows as the existing 55-acre Kilpatrick Reservoir located downstream on Kilpatrick Creek. It is assumed that this alternative storage site would serve a portion of the existing supplemental irrigation needs in the lower portion of the study area and would be sized to comply with the Belle Fourche River Compact limitation of storage capacity for new reservoirs. However, this site is similar to others because the current water shortages are experienced by two of the 17 CCID members [Short Elliot Hendrickson Inc., 2006]. Additionally, coordination with the WWDO and SEO should be conducted before proceeding with any future work because of the constraints regarding the Belle Fourche River Compact. Lastly, this potential site's reservoir embankment and storage pool could be entirely contained within private lands owned by a single parcel owner, as mapped in Figure 4.92.

4.7.1.7 S-07: Newland #4 Reservoir

Newland #4 Reservoir is located on Cow Creek, an intermittent tributary to Iron Creek, which is also an intermittent tributary to the Belle Fourche River. The Newland #4 Reservoir is located in Section 36 of Township 57 North, Range 62 West in Crook County. The reservoir was permitted in 1954 (Permit No. P6205R) with a capacity of 53.45 acre-feet. This alternative would provide for either relocating onto Iron Creek or rehabilitating the existing reservoir facilities and associated wetland and riparian areas. A view of the reservoir and dam is shown in Figure 4.93, and a map of the potential relocation site on Iron Creek is shown in Figure 4.94.

RSI-2264-15-159

Figure 4-93. A View of Newland #4 Reservoir Dam.

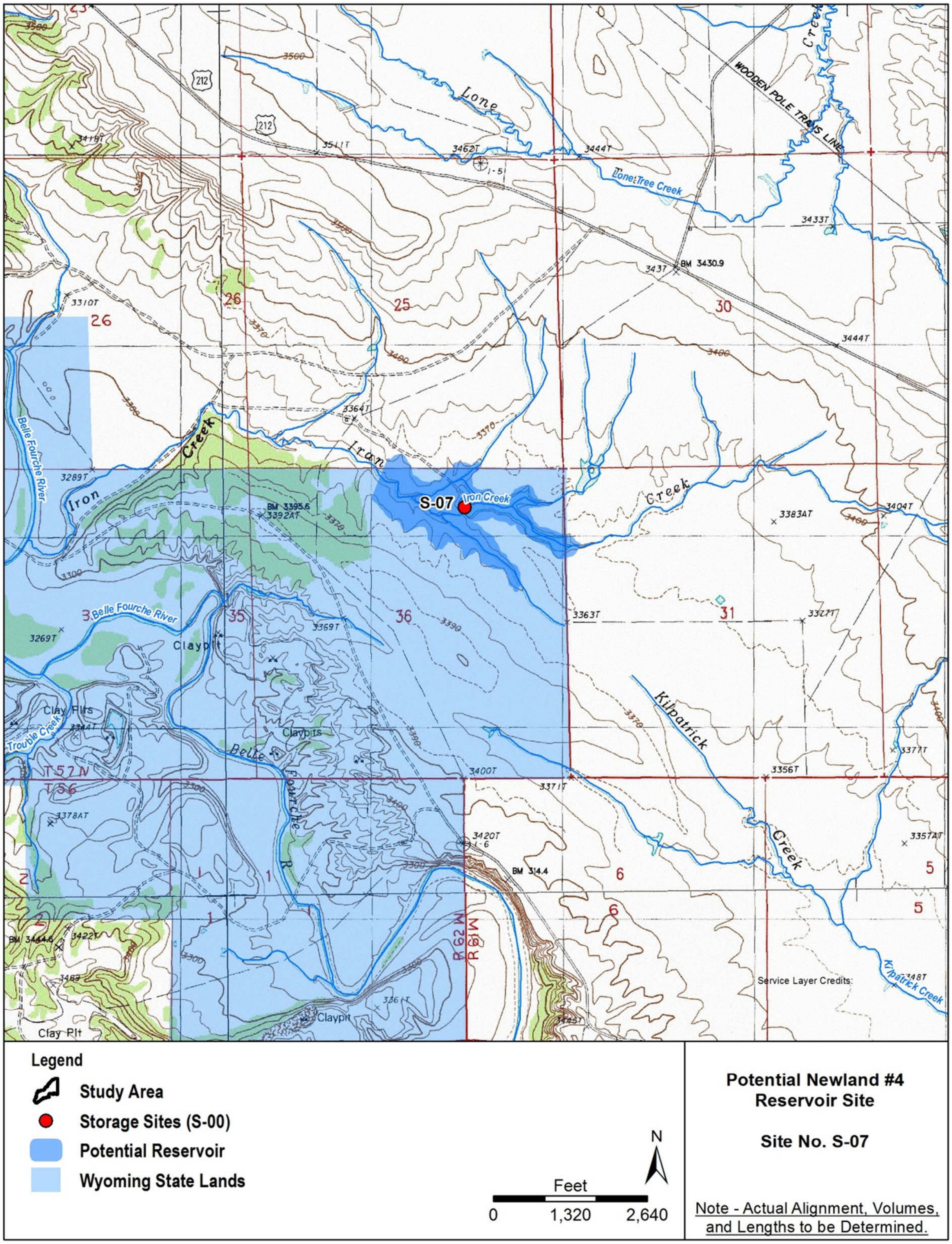

Figure 4-94. Map of the S-07: Newland #4 Reservoir Storage Site.

The alternative involving rehabilitation of the existing reservoir facilities includes installing an inlet and outlet pipe control structure in the embankment and stabilizing the installed structures and spillway with rock riprap. This reservoir could be rehabilitated to provide an additional source of livestock and wildlife water along with restoring function of the associated wetland and riparian areas. The reservoir's embankment is approximately 589 feet long and 21 feet high at its highest point with an embankment volume of approximately 6,564 cubic yards. The existing reservoir is located entirely on state of Wyoming land but the relocated and/or enlarged facility would involve state of Wyoming and privately owned lands as shown in Figure4.94.

4.7.1.8 S-08: Christofferson Draw

The Christofferson Draw storage site is located on Christofferson Draw, a tributary to the Belle Fourche River, and is within the Subbasin below Keyhole Reservoir. The site is located in Section 13 of Township 56 North, Range 62 West in Crook County. A view looking upstream from the existing breached dam is shown in Figure 4.95. The site is located approximately 6.3 miles south of Colony, Wyoming, on private lands, as illustrated in Figure 4.96. This alternative would involve constructing a new reservoir at this site, thus requiring a detailed investigation of geologic structure and identifying permitting requirements. An existing breached dam structure is present at the site.

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Figure 4-95. A View Upstream of the Breached Dam at the Christofferson Draw Storage Site.

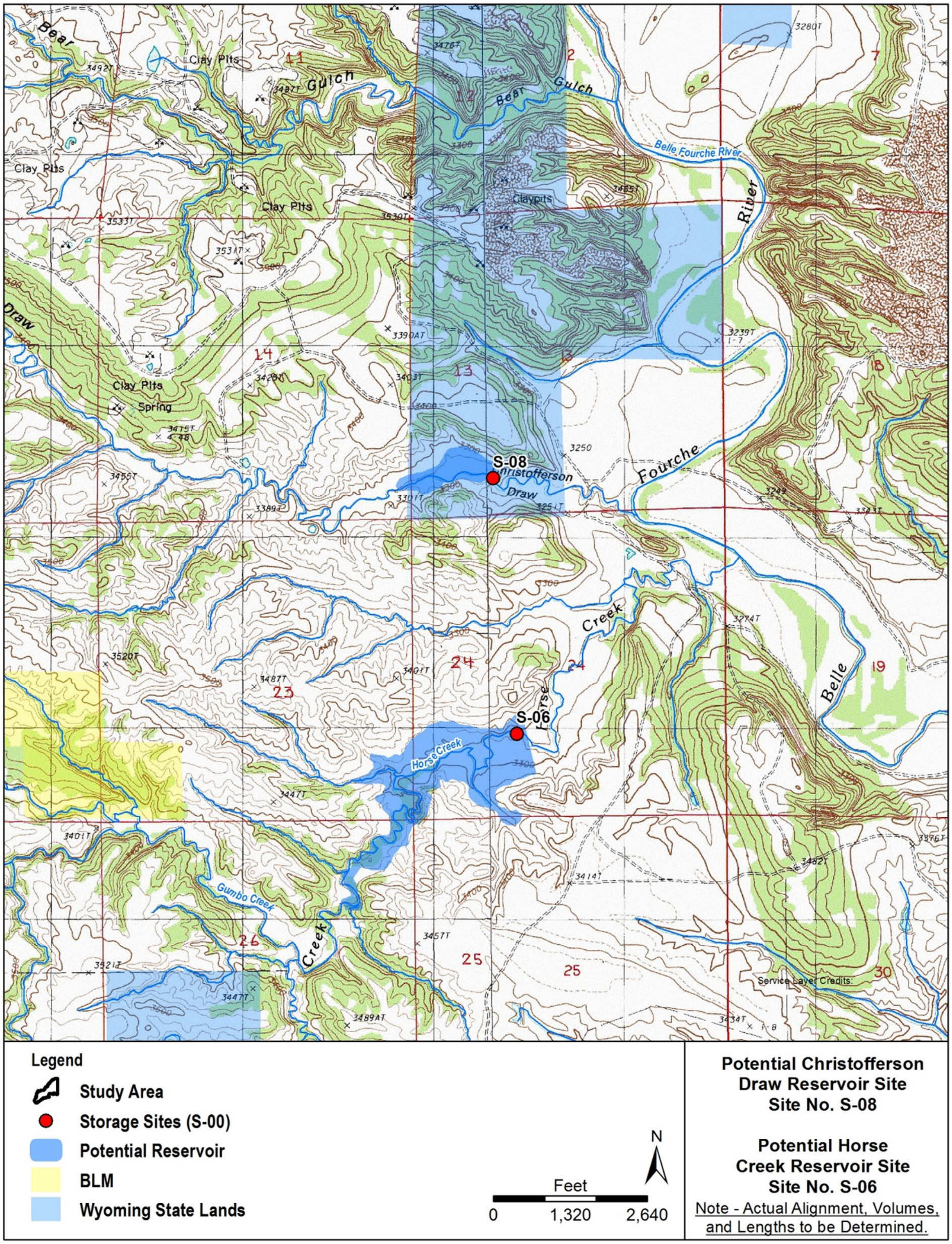

Figure 4-96. Map of the S-08: Christofferson Draw Storage Site.

This alternative is limited to storage provided by Christofferson Draw, which is an intermittent stream throughout much of its drainage area. Because storage opportunities are limited for this site, this alternative may only involve constructing a new reservoir facility to provide an additional source of livestock and wildlife water along with restoring function of the associated wetland and riparian areas. Any future investigations within the lower portion of the study area should include a preliminary investigation into whether or not an indirect source of water could be supplied from the Belle Fourche River to this site as an off-channel alternative. Additionally, coordination with the WWDO and SEO should be conducted before proceeding with any future work because of the constraints regarding the Belle Fourche River Compact. The existing breached reservoir is located entirely on state of Wyoming land but a newly constructed reservoir and/or enlarged facility would involve state of Wyoming and privately owned lands as shown in Figure 4.96.

4.7.1.9 S-09: Mule Shoe

The Mule Shoe storage site is located on an unnamed, intermittent tributary to the Belle Fourche River and is within the Subbasin below Keyhole Reservoir. The site is located in Section 32 of Township 56 North, Range 61 West in Crook County. A view looking upstream from the existing breached dam is shown in Figure 4.97. The site is located approximately 8.1 miles south of Colony, Wyoming, on private lands as illustrated in Figure 4.98. This alternative would involve constructing a new reservoir at this site, thus requiring a detailed investigation of geologic structure and identifying permitting requirements. An existing breached dam structure is present at the site.

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Figure 4-97. A View Looking Upstream From the Breached Dam at the Mule Shoe Storage Site.

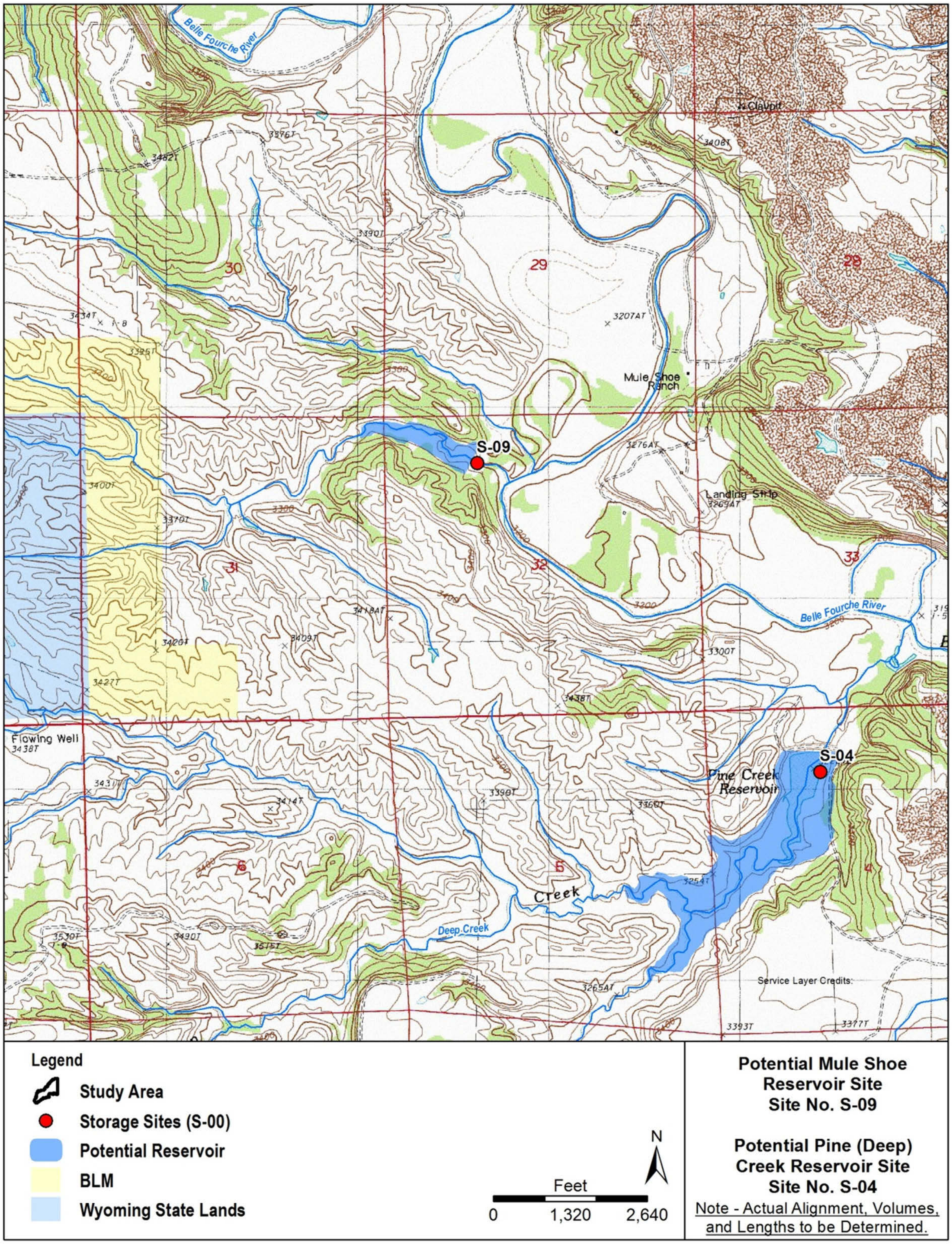

Figure 4-98. Map of the S-09: Mule Shoe Storage Site.

This alternative is limited to storage provided by an unnamed, intermittent tributary, which is also intermittent throughout much of its drainage area. Because storage opportunities are limited for this site, this alternative may only involve constructing a new reservoir facility to provide an additional source of livestock and wildlife water along with restoring function of the associated wetland and riparian areas. Any future investigations within the lower portion of the study area should include a preliminary investigation into whether or not an indirect source of water could be supplied from the Belle Fourche River to this site as an off-channel alternative. Additionally, coordination with the WWDO and SEO should be conducted before proceeding with any future work because of the constraints regarding the Belle Fourche River Compact. Lastly, this potential site's reservoir embankment and storage pool could be entirely contained within private lands owned by a single parcel owner, as mapped in Figure 4.98.

4.7.1.10 S-10: Sunset Reservoir (Hemler Dam)

Sunset Reservoir, known locally as Hemler Dam, is located on Redwater Creek, a tributary to the Redwater River, and is within the Redwater Subbasin. The Sunset Reservoir is located in Section 1 of Township 52 North, Range 63 West in Crook County. The reservoir was permitted in 1951 (Permit No. P5870R) with a capacity of 8.0 acre-feet and then enlarged to a permitted capacity of an additional 7.25 acre-feet in 1958 (Permit No. P6810.0R). A view looking across the dam embankment from the left abutment is shown in Figure 4.99. The site is located approximately 8.3 miles north of Sundance, Wyoming, within the Black Hills National Forest on National Forest lands, as illustrated in Figure 4.100.

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Figure 4-99. A View of Hemler Dam on Sunset Reservoir on April 23, 2014.

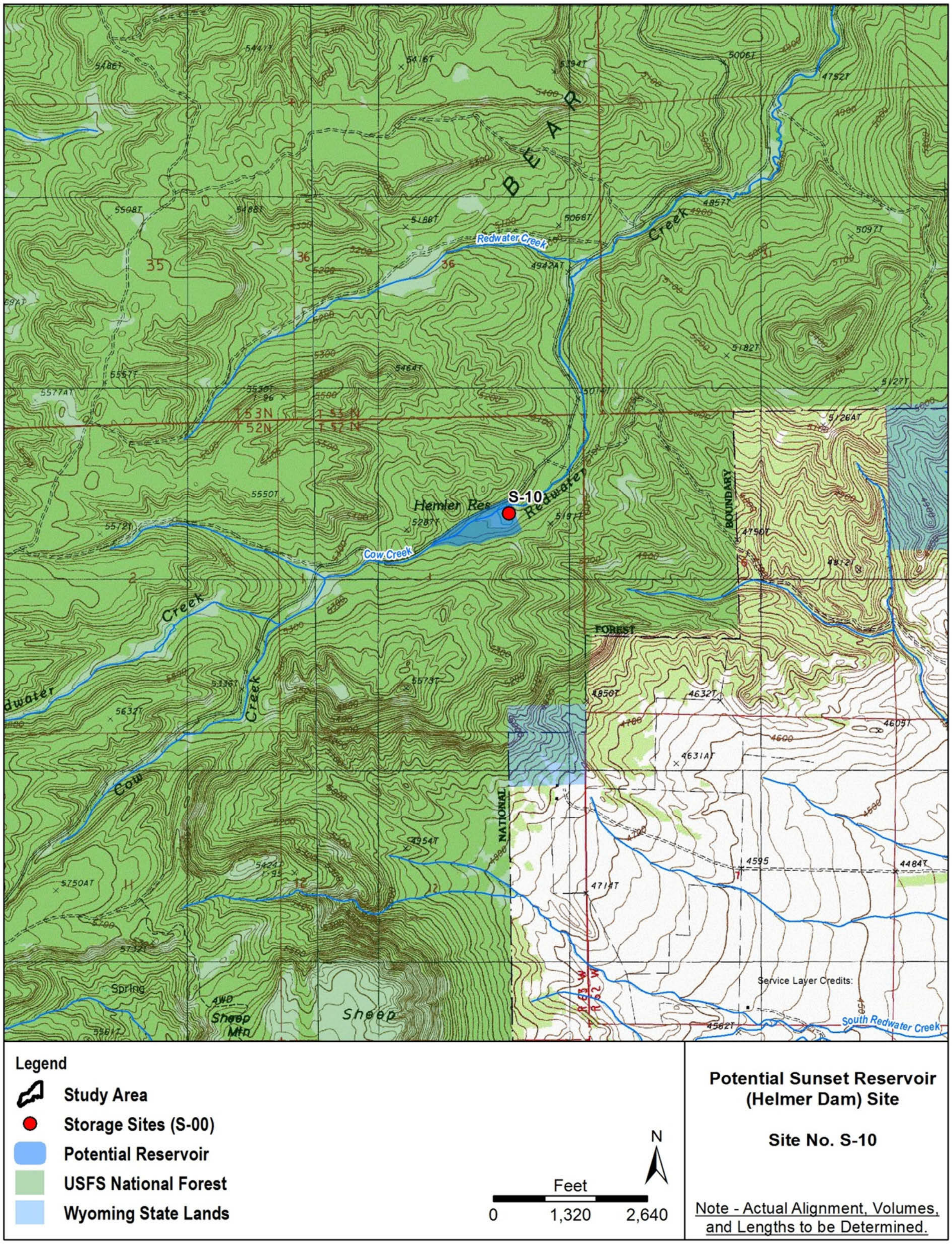

Figure 4-100. Map of the S-10: Sunset Reservoir (Hemler Dam) Storage Site.

The alternative is limited in storage opportunities and only involves rehabilitating the existing reservoir facilities for proper operation and maintenance of the existing storage and outlet facilities. Specific rehabilitation needs regarding irrigation water conveyance are discussed in Section 4.4.1.5. The reservoir's embankment is approximately 350 feet long and 24 feet high at its highest point with an embankment volume of approximately 13,330 cubic yards. The existing reservoir is located entirely on National Forest land within the Black Hills National Forest as shown in Figure 4.100.

4.7.2 Initial Screening of Potential Storage Sites

A "long list" of ten potential surface water storage sites was identified within the watershed as listed in Table 4.3 and shown in Figure 4.76. Information about these potential projects and alternatives was described previously in Section 4.7.1.1 through 4.7.10. Those alternatives involve mostly rehabilitating existing facilities in need of update or repair, along with enlarging existing facilities, and constructing new facilities.

From that long list of ten sites, a "short list" of five potential sites was created that includes sites that may provide substantial storage opportunities separate from those sites with minimal volumes, rehabilitation needs, or solely provide livestock/wildlife water. The short list of potential sites was included in an initial screening of these alternatives based on environmental, hydrologic, geologic, potential benefits, costs, and other data. The short list of potential sites for storage opportunities includes the following:

- S-01: Dry Creek
- S-02: Driskill #1 Reservoir
- S-04: Pine (Deep) Creek Reservoir (2B)
- S-05: Oak Creek Reservoir (2A)
- S-06: Horse Creek.

An evaluation matrix was prepared for a "short list" of the potential storage sites and initially summarizes the relevant attributes of each these opportunities within the study area. Information about the short list of five potential storage sites was compiled from the results of the watershed inventory and study's GIS and is presented as the Reservoir Evaluation Matrix in Table 4.4. The following attributes are included in the evaluation matrix:

- **Category A: Reservoir Description.** On-channel versus off-channel sites. On-channel sites are intended to store water associated with the stream impounded, and off-channel sites are located on tributaries and store mainstem waters via diversions. Off-channel sites are generally simpler to implement because of typically reduced environmental impacts and permitting mitigation requirements.

— Direct Supply Source: the stream upon which the dam is placed (all sites).

— Indirect Supply: the stream that would be used to fill the dam (off-channel sites only).

Table 4.4. Reservoir Evaluation Matrix (Page 1 of 6)

Site Number	S-01	S-02	S-04	S-05	S-06
Site Name	**Dry Creek**	**Driskill #1 Reservoir Lytle Creek (1B)**	**Pine (Deep) Creek Reservoir (2B)**	**Oak Creek Reservoir (2A)**	**Horse Creek**
Ranked Priority	**1**	**2**	**2**	**2**	**1**
Alternative Type	**New Construction**	**Enlargement**	**New Construction**	**Enlargement**	**New Construction**
Latitude	44.578724	44.583047	44.793204	44.753836	44.828572
Longitude	–104.071858	–104.673	–104.186217	–104.098225	–104.248755
Category A: Reservoir Description					
On-Channel/Off-Channel	On Channel	On Channel	On Channel	On Channel	On Channel
Direct Supply Source	Dry Creek	Lytle Creek	Deep Creek	Alum/Oak Creek	Horse Creek
Indirect Supply Source	Redwater Creek	NA	NA	NA	NA
Supply Mechanism	Existing Diversion	Mainstem Dam	Mainstem Dam	Mainstem Dam	Mainstem Dam
Category B: Watershed					
Contributing Drainage Area –Direct (square miles)	11.4	33.1	34.9	42.8	14.1
Contributing Drainage Area –Indirect (square miles)	474.7	NA	NA	NA	NA
Maximum Elevation (feet MSL)	4,279	6,636	4,696	4,892	4,190

Table 4.4. Reservoir Evaluation Matrix (Page 2 of 6)

Site Number	S-01	S-02	S-04	S-05	S-06
Site Name	Dry Creek	Driskill #1 Reservoir Lytle Creek (1B)	Pine (Deep) Creek Reservoir (2B)	Oak Creek Reservoir (2A)	Horse Creek
Ranked Priority	1	2	2	2	1
Alternative Type	New Construction	Enlargement	New Construction	Enlargement	New Construction
Minimum Elevation (feet MSL)	3,460	3,900	3,228	3,200	3,280
Maximum Basin Relief (feet)	819	2,736	1,468	1,692	910
Mean Annual Precipitation					
Category C: Reservoir Statistics					
Existing Capacity (acre-feet)	0	105	0	915	0
Enlargement (acre-feet)	1,500 - 2,000	1,000	1,900	3,100	500
Surface Area (acres)	85	121	103	133	60
Category D: Dam Description					
Dam					
Project Type	New Construction	Enlargement	New Construction	Enlargement	New Construction
Proposed Type	Earthen	RCC	Earthen	RCC	RCC
Method of Reservoir Fill	On channel/ Supply Canal	None/ On channel	None/ On channel	None/ On channel	None/ On channel

Table 4.4. Reservoir Evaluation Matrix (Page 3 of 6)

Site Number	S-01	S-02	S-04	S-05	S-06
Site Name	Dry Creek	Driskill #1 Reservoir Lytle Creek (1B)	Pine (Deep) Creek Reservoir (2B)	Oak Creek Reservoir (2A)	Horse Creek
Ranked Priority	1	2	2	2	1
Alternative Type	New Construction	Enlargement	New Construction	Enlargement	New Construction
Category E: Hydrology					
Hydrology Method	NE Wyoming River Basin Plan: Node 5.10	NE Wyoming River Basin Plan: Node 69.02	NE Wyoming River Basin Plan: Node 75.02	NE Wyoming River Basin Plan: Node 75.02	NE Wyoming River Basin Plan: Node 75.02
Storage Availability					
Normal Year (available)	28,382	2,261	1,167	1,464	514
Dry Year (available)	18,836	424	405	508	178
Category F: Geology					
Dam Embankment Foundation	C	B	C	C	B
Reservoir Pool Area	C	B	C	C	B
Contributing Watershed	C	B	B	B	B

Table 4.4. Reservoir Evaluation Matrix (Page 4 of 6)

Site Number	S-01	S-02	S-04	S-05	S-06
Site Name	Dry Creek	Driskill #1 Reservoir Lytle Creek (1B)	Pine (Deep) Creek Reservoir (2B)	Oak Creek Reservoir (2A)	Horse Creek
Ranked Priority	1	2	2	2	1
Alternative Type	New Construction	Enlargement	New Construction	Enlargement	New Construction
Category G: Environmental/Infrastructure					
Environmental Issues					
Wetlands (acres impacted) From NWI data	Low	Medium	Medium	Medium	Low
Game: Antelope	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range
Game: Elk	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range
Game: Moose	None	None	None	None	None
Game: Mule Deer	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range
Game: Whitetailed Deer	Crucial Range/ Seasonal Range	None	None	None	None
Sage-Grouse Leks Within 2 Miles	No	No	No	No	No
Sage-Grouse Core Population Area	None of pool in Core Area	None of pool in Core Area	None of pool in Core Area	None of pool in Core Area	None of pool in Core Area
WDEQ Stream Classification	2AB	2AB	2AB	2AB	2AB

Table 4.4. Reservoir Evaluation Matrix (Page 5 of 6)

Site Number	S-01	S-02	S-04	S-05	S-06
Site Name	Dry Creek	Driskill #1 Reservoir Lytle Creek (1B)	Pine (Deep) Creek Reservoir (2B)	Oak Creek Reservoir (2A)	Horse Creek
Ranked Priority	1	2	2	2	1
Alternative Type	New Construction	Enlargement	New Construction	Enlargement	New Construction
Irrigated Acreage Inundated	0	0	0	0	0
Infrastructure					
Residences	0	0	0	0	0
Transportation	0	0.5 miles dirt	0	0	0
Category H: Economic Considerations					
Estimated Construction Cost	$7,500,000	$12,000,000	$8,000,000	$18,200,000	$6,000,000
Total Project per ac-ft of Storage	$5,000	$12,000	$4,300	$5,900	$12,000
Category I: Ownership					
Embankment	State	State	Private	Private	Private
Impoundment	State/Private	State/Private	Private	State/Private	Private
Category J: Potential Benefits					
Location Relative to Demand (irrigated acres downstream)	Low	Moderate	High	High	Moderate

Table 4.4. Reservoir Evaluation Matrix (Page 6 of 6)

Site Number	S-01	S-02	S-04	S-05	S-06
Site Name	Dry Creek	Driskill #1 Reservoir Lytle Creek (1B)	Pine (Deep) Creek Reservoir (2B)	Oak Creek Reservoir (2A)	Horse Creek
Ranked Priority	1	2	2	2	1
Alternative Type	New Construction	Enlargement	New Construction	Enlargement	New Construction
Demand Potential (downstream shortages) (dry/normal)	Low	Moderate	High	High	Moderate
Potential for Flood Protection	Moderate	Moderate	Low	Low	Low

- **Category B: Watershed Description.** Basic quantifiable attributes of the directly contributing watershed (e.g., basin area, elevations, and relief).
- **Category C: Reservoir Statistics.** Basic quantifiable attributes associated with the reservoir pool (e.g., maximum storage and surface area).
- **Category D: Dam Statistics.** Basic quantifiable attributes associated with impoundment structure (e.g., height, length, and volume).
- **Category E: Hydrology.** Physically present in the stream. Based on hydrologic estimation procedures, this value represents the amount of water expected to be physically passing the site in a given year.

— Available for storage—based on the Belle Fourche River and Redwater Models included in the Northeast Wyoming River Basin planning model completed as part of the *Northeast Wyoming River Basins Plan Final Report* [HKM Engineering Inc. et al., 2002] and Short Elliot Hendrickson Inc. [2006].

— This value represents the amount of water at the site which is available for storage without causing shortages downstream.

— Indirect supply source—the waterbody identified as a supply source for the site if an off-channel reservoir.

- **Category F: Geology.** Bedrock geology and surficial geology were assigned relative 'grades' based on the relative feasibility of constructing a reservoir at each site given the local geologic conditions. The scale ranges from "A," which indicates no potential problems identified to "F," which indicates fatal flaws associated with local geology. For this Level I site screening effort, no subsurface investigation was completed. The geologic investigation was completed primarily using existing mapping within the study's GIS. Consequently, there was insufficient information to assign an A or F to any of the sites.
- **Category G: Environmental/Infrastructure.**

— Wetlands: Quantified acreage using LANDFIRE and NWI databases.

— Game habitat: Type of game range affected by the embankment and reservoir: (seasonal, crucial, or parturition range).

— WYDEQ Classification: Determined from Tables A and B of Wyoming Department of Environmental Quality Surface Water Standards (e.g., Class 1, Class 2AB, and Class 3, as discussed in Section 3.8.1).

— Irrigated acres inundated: irrigated acres flooded by the embankment and pool.

- **Category H: Economic Considerations.** Conceptual level cost estimate and comparative project cost per acre-foot of storage.
- **Category I: Ownership.** Property ownership plays an important role in determining the relative feasibility of development of storage alternatives. For the purposes of this study, it was assumed based upon previous investigations, that the relative feasibility to construct a reservoir alternative from an ownership perspective would be as follows:

— Private Ownership: Least difficult assuming landowner concurrence
— State Ownership: Moderately difficult
— Federal Ownership: Most difficult

This assumption does not mean to say that sites on federally owned lands should not be investigated further. It merely indicates that the permitting and consents process could be more problematic than with privately or state-owned parcels. Likewise, it is not meant to imply that privately owned lands are available. The state has indicated they are not interested in condemnation of private lands for the purposes of constructing reservoirs.

- **Category J: Potential Benefits.** Quantifiable and qualified benefits associated with each site (ex. Irrigated acres benefitting). The Project GIS was used to quantify many of the attributes associated with the sites. For example, quantification of irrigated acres and wetlands affected by each site could be easily determined. Contributing watershed areas were delineated and their characteristics quantified using the GIS in conjunction with a digital elevation model.

Relative priorities were assigned to the sites based on the following criteria:

- *Priority 1 Sites*: These sites represent the most potentially feasible of the sites evaluated and provide the most benefit at the least cost or environmental impact. These sites would be recommended for further evaluation in future investigations.
- *Priority 2 Sites*: These sites, while potentially feasible, contained attributes making them less desirable for further study than the Priority 1 Sites. For example, some sites showed potential benefits commensurate with Priority 1 sites but their costs were higher. Designation as a Priority 2 site does not preclude the alternative being included in future Level II, Phase 1 studies.
- *Priority 3 Sites*: These sites contained either 'fatal flaws' which eliminated them from recommendation for further study (e.g., location within the wilderness area), or other attributes causing them to be highly unlikely to be implemented.

4.8 STREAM CHANNEL CONDITION AND STABILITY

4.8.1 Stream Channel Rehabilitation

With respect to overall stream stabilization efforts, various approaches can be taken during channel restoration and stabilization efforts, including "hard" engineering, "soft" approaches, and combinations of the two. Examples of "hard" approaches include constructing channel structures or reconstructing channels themselves. Selecting the appropriate mitigation and restoration technique depends upon site-specific information and critical review of hydrologic and hydraulic data. Installing an inappropriate structures or improper installation could exacerbate conditions.

For instance, methods of restoring incised channels may include constructing gradient restoration facilities (i.e., drop structures and check structures) within the incised channel. Figure 4.101 is a diagram of a typical stream channel stabilization strategy for a small channel experiencing minor downcutting or bank erosion. A vortex weir can be placed within a problematic reach to serve as a grade-control structure as well as directing and centralizing streamflow. Weir configuration can be varied to provide additional functions such as facilitating irrigation diversions. Figure 4.102 is a photograph of a typical installation.

Reestablishing preincision channel elevations can be accomplished by means of check dams. The photograph in Figure 4.103 is a large-scale check dam on Muddy Creek near Baggs, Wyoming. This structure is a good example of how gradient restoration strategies can be used to restore diversion capabilities at headgates that are rendered inoperable by changes in channels.

Examples of "soft" approaches include a variety of BMPs. Examples of applicable BMPs designed for channel restoration activities include those that result in reducing, or at least temporarily excluding, wildlife and livestock from accessing designated riparian zones, and establishing riparian buffers. The proposed livestock/wildlife water developments discussed previously (and others that may be identified in the future) can be considered range management BMPs that will help restore over time those areas of channel impairment that have resulted from overusing riparian areas or adjacent uplands. Figure 4.104 is a photograph of willow fascine installation; this strategy could be employed on perennial channels or intermittent where sufficient flow exists to support the vegetation to restore riparian habitat and stabilize streambanks.

These examples of "hard" and "soft" approaches represent both extremes of the continuum of channel restoration strategies that exist. In practice, a combination of strategies that are integrated into a cohesive plan provides the most effective solution. Table 4.3 presents a summary of some of these channel restoration strategies that can be employed during future restoration efforts. Additionally, this Level I project included additional stream channel assessment on portions of Inyan Kara Creek, Redwater Creek, and Whitelaw Creek within the study area. These field assessments are discussed in Section 3.7.3. The purpose of the field assessment was to obtain more detailed morphological description of the system. This was accomplished by obtaining field data pertaining to channel entrenchment, dimensions, patterns, profile, and boundary materials.

Based on the information presented above, the following items are presented for inclusion in the Watershed Management Plan:

- **Channel Stabilization Recommendation 1:** Install stream channel degradation/incision mitigation measures based upon site-specific evaluation of conditions. Appropriate measures could be "hard" engineering, "soft" approaches, or combinations of both.
- **Channel Stabilization Recommendation 2:** Install stream bank erosion mitigation measures based upon site-specific evaluation of conditions. Appropriate mitigation measures could be "hard" engineering, "soft" approaches, or combinations of both.

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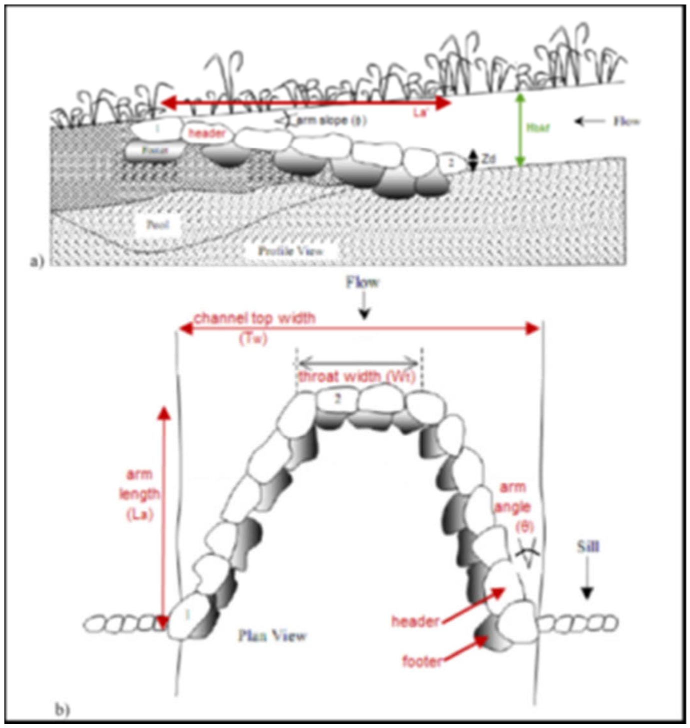

Figure 4-101. Rock Vortex Weir Structure Diagram (Adapted From Rosgen [2006]).

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Figure 4-102. Stream Stabilization Structure: Rock Vortex Weir.

Figure 4-103. Channel Gradient Restoration Feature on Muddy Creek Near Baggs, Wyoming. The Top Photograph is viewed downstream from the dam at incised channel; the bottom photograph is viewed upstream at restored gradient.

- **Channel Stabilization Recommendation 3:** Initiate routine monitoring of completed stream restoration projects to determine their effectiveness and viability. Repairs should be made as necessary or as soon as is practical.
- **Channel Stabilization Recommendation 4:** Place in-stream structures, stabilizing banks, planting native vegetation, restoring floodplains, and enhancing riparian areas and wetlands.

RSI-2264-15-170

Figure 4-104. Willow Fascine Installation.

4.9 WETLANDS ENHANCEMENT OPPORTUNITIES

Wetland creation and enhancement opportunities exist within the watershed. As explained in Section 3.5.5, existing wetland locations represent a variety of sites where wetlands could either be established or enhanced by restoring channel or hydric soil conditions. Some sites are disconnected floodplains and associated wetland features along the Belle Fourche River corridor and its tributaries. Wetlands in the watershed have been influenced by regulated flows, geomorphic changes, and agricultural and urban activities, but they still provide important wildlife habitat.

Figure 3.33 delineates the existing wetlands and hydric soils within the watershed to delineate areas where wetland enhancement could occur. However, it is recommended that potential wetland creation and enhancement projects in the study area consider site-specific conditions regarding the contributing surface water, groundwater, soil, and underlying geologic formation.

4.10 OTHER WATERSHED MANAGEMENT OPPORTUNITIES

The Weed and Pest Districts in Campbell, Crook, and Weston Counties have effective programs for detecting, treating, and controlling noxious and invasive weeds and pests. The districts are adept at encouraging landowners and managers to participate in control and treatment programs. Based on the information presented in Chapter 3.0, the following items are presented for inclusion in the Watershed Management Plan:

- **Watershed Management Recommendation 1:** Coordinate with the weed and pest districts where noxious weed control is needed in small acreages and provide improved grazing management techniques or planting of preferred trees, shrubs, and grasses that could help prevent weed reinfestation.
- **Watershed Management Recommendation 2:** Coordinate with the weed and pest districts, landowners, the NRCS, the USFS, and the BLM on noxious and invasive species control areas where livestock water development and improved grazing techniques could avoid reinfestation and improve preferred forage vegetation.

4.11 THE BELLE FOURCHE RIVER WATERSHED MANAGEMENT PLAN

The information presented in this section provides recommendations for improvements associated with the following:

- Irrigation system rehabilitation components
- Livestock/wildlife upland watering opportunities
- Grazing management opportunities
- Storage opportunities
- Stream channel condition and stability
- Wetland enhancement opportunities
- Other watershed management opportunities.

Table 4.5 lists the itemized components of the Belle Fourche River Watershed Management Plan. The conceptual cost estimates are tabulated in Chapter 6.0 of this report.

4.12 POTENTIAL EFFECTS AND BENEFITS OF WATERSHED MANAGEMENT PLAN COMPONENTS

In the following sections, the potential effects and benefits associated with key BMPs and conservation practices are discussed in relation to the various plan components: Livestock/Wildlife water supply (Components LW), irrigation system rehabilitation (Components I), and storage (Components S). The intent of this discussion is to provide the decision makers with the background necessary to make informed decisions regarding future planning efforts.

Table 4.5. Belle Fourche River Watershed Management Plan (Page 1 of 4)

Plan Item	Description	Priority
	Irrigation Components	
I-01	Rehabilitate diversion structure and headgate	1
I-01	Rehabilitate 3,520 feet of 12-inch PIP pipeline and flume	1
I-01	Install irrigation regulating reservoir	1
I-02	Rehabilitate diversion structure and headgate	1
I-02	Rehabilitate 2,620 feet of 12-inch PIP pipeline and flume	1
I-03	Rehabilitate diversion structure and headgate	1
I-03	Install 3,900 feet of 15-inch PIP pipeline	1
I-03	Install 2,480 feet of 12-inch PIP pipeline, headgate, flume	1
I-03	Install 2,140 feet of 10-inch PIP pipeline and headgate	1
I-03	Install irrigation regulating reservoir	1
I-03A	Install diversion and pump	3
I-03B	Rehabilitate diversion structure and pump	3
I-04	Install diversion structure and headgate	3
I-04	Install 5,890 feet of 12-inch PIP pipeline	3
I-04	Install 6,740 feet of 12-inch PIP pipeline	3
I-04	Install irrigation regulating reservoir	3
I-04A	Install diversion structure and headgate	3
I-04A	Rehabilitate reservoir and dam	3
I-05	Install 2,840 feet of 12-inch PIP pipeline	3
I-05	Rehabilitate reservoir and dam Pine Cr 2B	3
I-06	Install diversion structure and headgate	3
I-06	Install 4,180 feet of 12-inch PIP pipeline	3
I-06	Install 650 feet of 10-inch PIP pipeline	3
I-07	Install 4,510 feet of 12-inch PIP pipeline	2
I-07	Oak Creek Reservoir Oak Creek 2A	2
I-08	Install diversion structure and headgate	2
I-08	Install 570 feet of 12-inch PIP pipeline	2

Table 4.5. Belle Fourche River Watershed Management Plan (Page 2 of 4)

Plan Item	Description	Priority
Irrigation Components (cont.)		
I-08	Install irrigation regulating reservoir	2
I-09	Install diversion structure and headgate	3
I-09	Install 2,470 feet of 12-inch PIP pipeline	3
I-09	Install irrigation regulating reservoir	3
I-10	Install diversions and pumps	3
I-10	Install 1,300 feet of 12-inch PIP pipeline	3
I-10	Install 3,460 feet of 12-inch PIP pipeline	3
I-11	Install diversion structure and headgate	3
I-11	Install 4,540 feet of 12-inch PIP pipeline	3
I-11	Install irrigation regulating reservoir	3
I-12	Install diversion and pump	3
I-12	Install 1,820 feet of 12-inch PIP pipeline	3
I-13	Rehabilitate reservoir and dam	3
I-14	Install diversion structure and headgate	2
I-14	Install 8,920 feet of 12-inch PIP pipeline	2
Livestock/Wildlife Water Supply Projects		
LW-01	Pipeline and Tank	1
LW-02	Stock Reservoir	1
LW-03	Stock Reservoir	1
LW-04	Pipeline and Tank	2
LW-05	Well, Solar Pump, and Tank	2
LW-06	Pipeline and Tank	1
LW-07	Pipeline and Tank	2
LW-08	Well, Pipeline, and Tank	2
LW-09	Pipeline and Tank	3
LW-10	Solar Pump and Storage Tank	1

Table 4.5. Belle Fourche River Watershed Management Plan (Page 3 of 4)

Plan Item	Description	Priority
LW-10A	Pipeline and Tank	2
LW-11	Spring Development and Tank	1
LW-12	Spring Development and Tank	2
LW-12A	Stock Reservoir	2
LW-13	Stock Reservoir	3
LW-14	Well, Solar Pump, and Tank	1
LW-15	Well, Solar Pump, and Tank	2
LW-16	Well, Solar Pump, and Tank	1
LW-17	Well, Solar Pump, and Tank	1
LW-18	Well, Solar Pump, and Tank	2
LW-19	Well, Solar Pump, and Tank	2
LW-20	Well, Solar Pump, and Tank	3
LW-21	Well, Solar Pump, and Tank	3
LW-22	Well, Solar Pump, and Tank	3
LW-23	Well, Pipeline, and Tank	1
LW-24	Pipeline and Tank	2
LW-25	Well, Pipeline, and Tank	2
LW-26	Spring Development, Pipeline, Tank	3
LW-27	Pipeline and Tank	1
LW-28	Well, Pipeline, and Tank	3
LW-29	Well, Pipeline, and Tank	3
LW-30	Stock Reservoir	2
LW-31	Stock Reservoir	2
LW-32	Well, Pipeline, and Tank	3
LW-33	Well, Pipeline, and Tank	3
LW-34	Well, Pipeline, and Tank	3
LW-35	Pipeline, Tank, and Stock Reservoir	1

Table 4.5. Belle Fourche River Watershed Management Plan (Page 4 of 4)

Plan Item	Description	Priority
LW-35A/B	Stock Reservoirs	3
LW-36	Spring Development, Pipeline, Tank	2
LW-37	Well, Pipeline, and Tank	1
LW-38	Well, Pipeline, and Tank	2
LW-39	Pipeline and Tank	2
LW-40	Well and Pipeline	1
LW-41	Pipeline and Tank	2
LW-42/42A	Well, Pipeline and Tank	2
LW-43	Pipeline and Tank	3
LW-44	Stock Reservoir	1
LW-44A	Well, Pipeline, and Tank	3
LW-45	Well, Tank, and Stock Pond	1
LW-46	Well, Pipeline, and Tank	2
LW-46A	Stock Reservoirs	3
LW-47/47A	Stock Reservoirs	3
LW-48	Spring Development, Pipeline, Tank	2
LW-49	Well, Pipeline, and Tank	3
LW-50/50A	Stock Reservoirs	3
LW-51	Wildlife Guzzler and Pond	3
LW-52	Well, Pipeline, and Tank	3
LW-53	Spring Development, Pipeline, Tank	2
LW-54	Well, Pipeline, and Tank	1
LW-55	Well, Pipeline, and Tank	2
LW-56	Spring Development, Pipeline, Tank	1
LW-57	Spring Development, Pipeline, Tank	2

The NRCS prepares network effects diagrams (NEDs) of conservation practices or BMPs which act together to achieve desired purposes. The NEDs “are flow charts of direct, indirect and cumulative effects resulting from installation of the practices. Completed network diagrams are an overview of expert consensus on the direct, indirect and cumulative effects of installing proposed practice installation.

Benefits associated with a particular conservation practice or BMP can be classified as direct, indirect, or cumulative. Direct and indirect benefits would be considered measureable or tangible benefits. For example, constructing a reservoir designed to augment late-season irrigation water supplies provides the direct or measurable benefit of providing a supply of water commensurate with its storage capacity. An indirect benefit could be the habitat provided to wildlife. Likewise, the same reservoir could provide the cumulative benefit of increased income to producers and improved health of the local economy.

As previously discussed, such benefits can be quantitative, qualitative, or both. Benefits can be local or global and specific or surrogate, depending on multiple factors unique and specific to the BMP, ecological site, watershed, or major land resource area. Project benefits can be related to ecological enhancement, water quantity, economic stability, stream corridor or riverine stability, or maintenance of open spaces. Where appropriate, the NRCS NED for the conservation practice is presented within this document.

4.12.1 Irrigation Rehabilitation Projects

The Watershed Management Plan includes seven recommendations. These projects include various forms of irrigation improvements and rehabilitation projects.

Irrigation Water Conveyance—Pipeline

The rehabilitation and replacement of existing irrigation system delivery conveyance structures help to efficiently deliver or convey water from a source of supply or diversion structures to areas of application or storage to facilitate management of irrigation water. The practice reduces erosion, conserves water, and protects water quality. Underground pipelines serve as an integral part of the irrigation water distribution system and significantly improve the overall efficiency of the system.

Strategies defining placement of irrigation water conveyance pipelines typically involve the following:

- Rehabilitation/replacement of existing structures
- Mitigation of seepage losses
- Enhanced delivery of irrigation water
- Reduction in annual operation and maintenance costs
- Improvement in ditch management and efficiency through water management
- Facilitation of irrigation water management plans

- Economic practicality
- Physical feasibility.

Effects and benefits of rehabilitating and improving water conveyance for irrigation systems are numerous and are displayed in the NRCS's NED in Figure 4.105. As shown in this figure, direct and indirect benefits associated with this BMP include:

- Water availability for irrigation
  - — Plant growth and productivity
- Infiltration and evaporation losses
  - — Increased plant growth and productivity
  - — Decreased leaching of nutrients
- Erosion associated with practice
  - — Decreased sediment delivery to surface waters

Cumulative effects/benefits of provision of reliable water supplies are described as:

- Positive impacts to income and stability of individual producers and the community
- Improved aquatic health of humans, domestic animals and wildlife
- Improved stream fauna and environmental quality.

4.12.2 Livestock/Wildlife Water Supply Projects

The Watershed Management Plan includes 36 recommendations. These projects include various forms of water facilities, water wells, spring developments, pipelines, and stock ponds.

Water Facilities

The development of reliable watering facilities in areas otherwise lacking reliable sources of water for livestock and wildlife, help to promote improved rangeland conditions in several ways. Water facilities may be associated with wells, springs, streams, ponds or hauled water. ***Reliable sources of water are integral aspects of any range management plan involving distribution of livestock.***

Placing water facilities typically involves the following strategies:

- Facilitation of prescribed grazing management plans
- Alternative water supplies to riparian sources
- Provision of a reliable source where no other sources may exist
- Optimization of upland range resources.

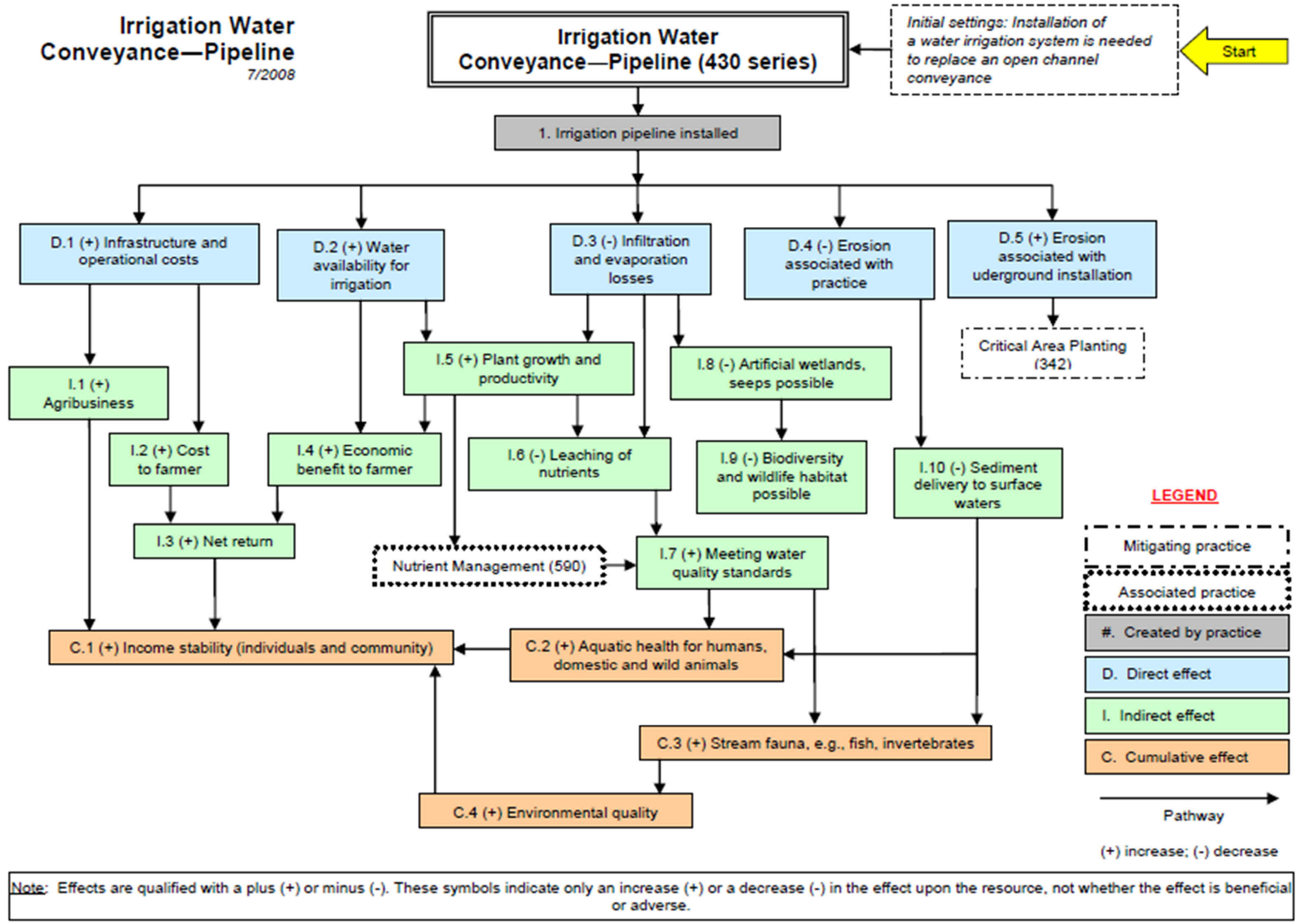


Figure 4-105. Network Effects Diagrams for Irrigation Conveyance—Pipeline.

The benefits of providing reliable water facilities for livestock and wildlife are numerous and are displayed in the NRCS's NED in Figure 4.106. As shown in this figure, direct and indirect benefits associated with this BMP include the following:

- Controlled access to streams, ponds, water supplies, and sensitive areas (when combined with proper fencing),
  - Decreased loading of pathogens, sediments, and nutrients to existing surface waters,
- Improved water quality, quantity, and distribution of livestock and wildlife
  - Increased plant productivity
  - Improved wildlife habitat
  - Increased species diversity
  - Increased livestock food sources

Cumulative benefits of provision of reliable water supplies include the following:

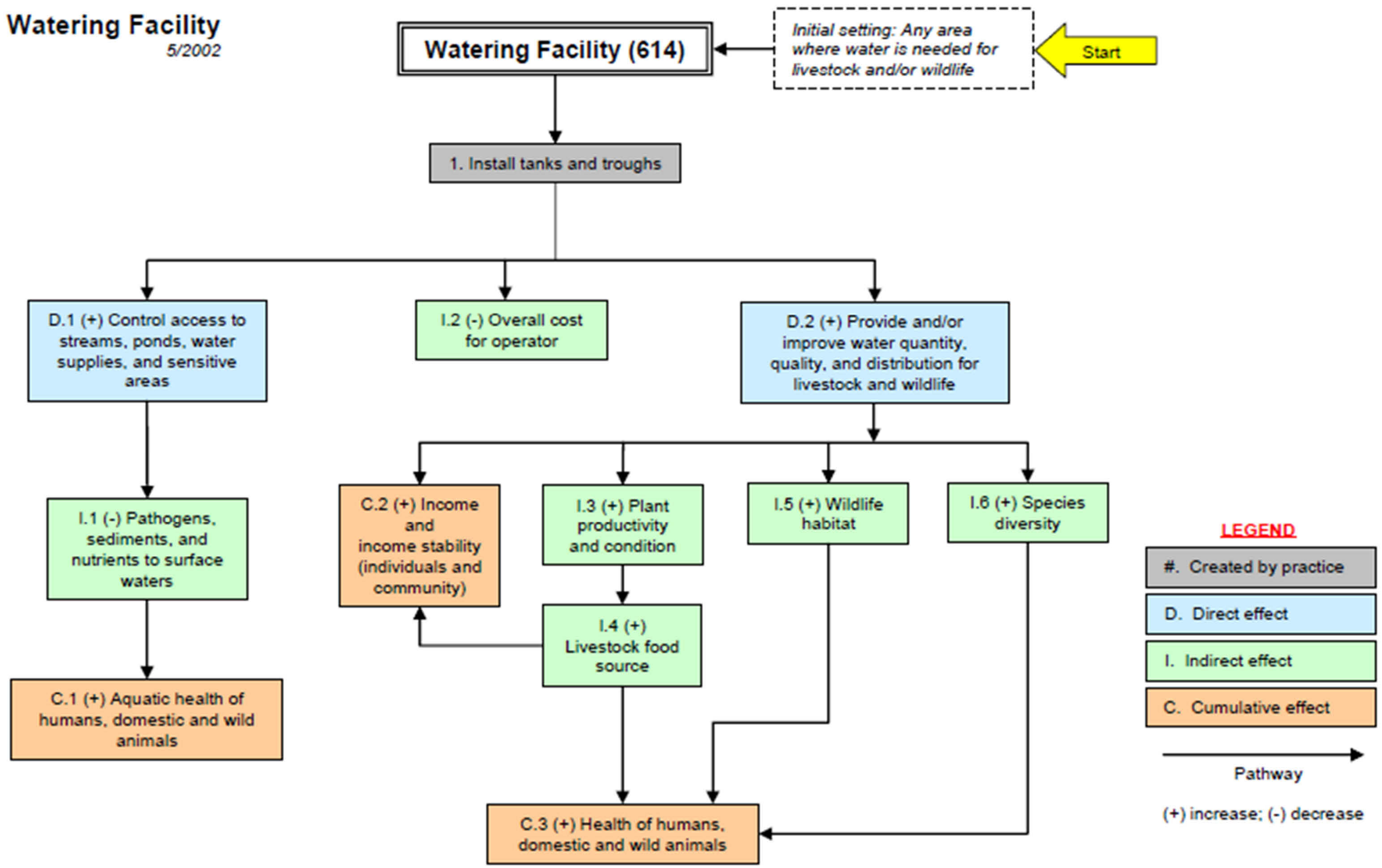
- Positive impacts to income and stability of individual producers and the community,
- Improved aquatic health of humans, domestic animals and wildlife, and
- Improved health of humans, domestic animals, and wildlife.

4.12.3 Grazing Management Alternatives

The Watershed Management Plan includes seven recommendations. These alternatives include conservation practices and BMPs such as water developments, fencing, salting and herding, ecological sites and STMs, prescribed fire, and application of chemicals along with other tools that can be used to facilitate and enhance grazing distribution and optimize range conditions through prescribed grazing practices.

Prescribed Grazing

Prescribed grazing is the controlled harvest of vegetation with grazing animals managed with the intent to achieve a specific objective. Prescribed grazing may be applied on lands where grazing and/or browsing animals are managed. A grazing schedule is prepared for allotments and pastures to be grazed. Removal of vegetation by the grazing animals is in conformity with realistic yield goals, plant growth needs, and management goals. Duration and intensity of grazing is based on desired plant health and expected productivity of the forage species to meet management objectives.



Note: Effects are qualified with a plus (+) or minus (-). These symbols indicate only an increase (+) or a decrease (-) in the effect upon the resource, not whether the effect is beneficial or adverse.

Figure 4-106. Network Effects Diagrams for Watering Facility.

Strategies for applying prescribed grazing involve managing the intensity, frequency, duration, distribution, and season of grazing by:

- Defining landowner and/or manager goals and objectives
- Identifying needs for reliable water sources and supplies
- Conducting feed and forage inventories and analyses
- Conducting range condition and health evaluations and assessments
- Managing desirable and undesirable plant communities to meet grazing objectives

Benefits of implementing prescribed grazing and associated BMPs and conservation practices are numerous and are displayed in the NRCS's NED in Figure 4.108. As shown in this figure, direct and indirect benefits associated with this BMP include the following:

- Increased control of livestock grazing, feeding, watering locations
  - — Decreased loading of pathogens, sediments, and nutrients to surface waters,
- Increased manure distribution
  - — Increased soil quality
  - — Reduced contaminants, pathogens, and sediments to receiving waters
- Soil erosion and compaction
- Increased plant productivity and maintenance
  - — Increased livestock production and health
  - — Increased wildlife health and populations

Cumulative benefits of implementing prescribing grazing could include:

- Positive impacts to income and stability of individual producers and the community
- Improved water quality and aquatic habitat
- Improved health of humans, domestic animals and wildlife.

4.12.4 Stream Channel Restoration Projects

The Watershed Management Plan includes four recommendations. These alternatives include conservation practices and BMPs such as installation of stream channel degradation/incision and streambank erosion mitigation measures based upon site-specific evaluation of conditions along with routine monitoring of completed stream projects to identify necessary maintenance repairs and determine their effectiveness. Appropriate measures could be 'hard' engineering, 'soft' approaches, or combinations of both.

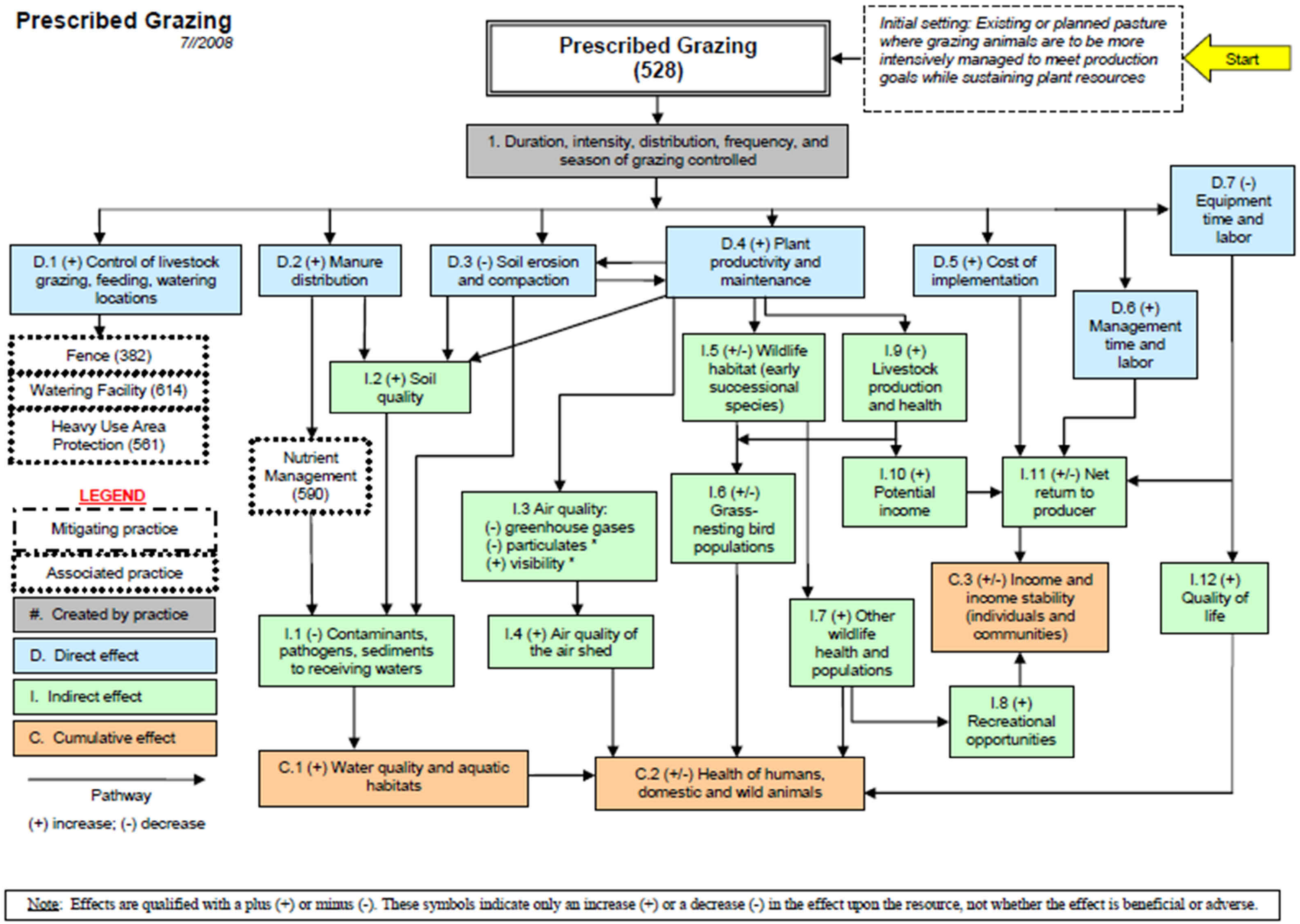


Figure 4-107. Network Effects Diagrams for Prescribed Grazing.

Streambank and Shoreline Protection

Streambank and shoreline protection is the stabilization and protection of streambanks, constructed channels, and shorelines of lakes and reservoirs.

Strategies for applying streambank and shoreline protection involve:

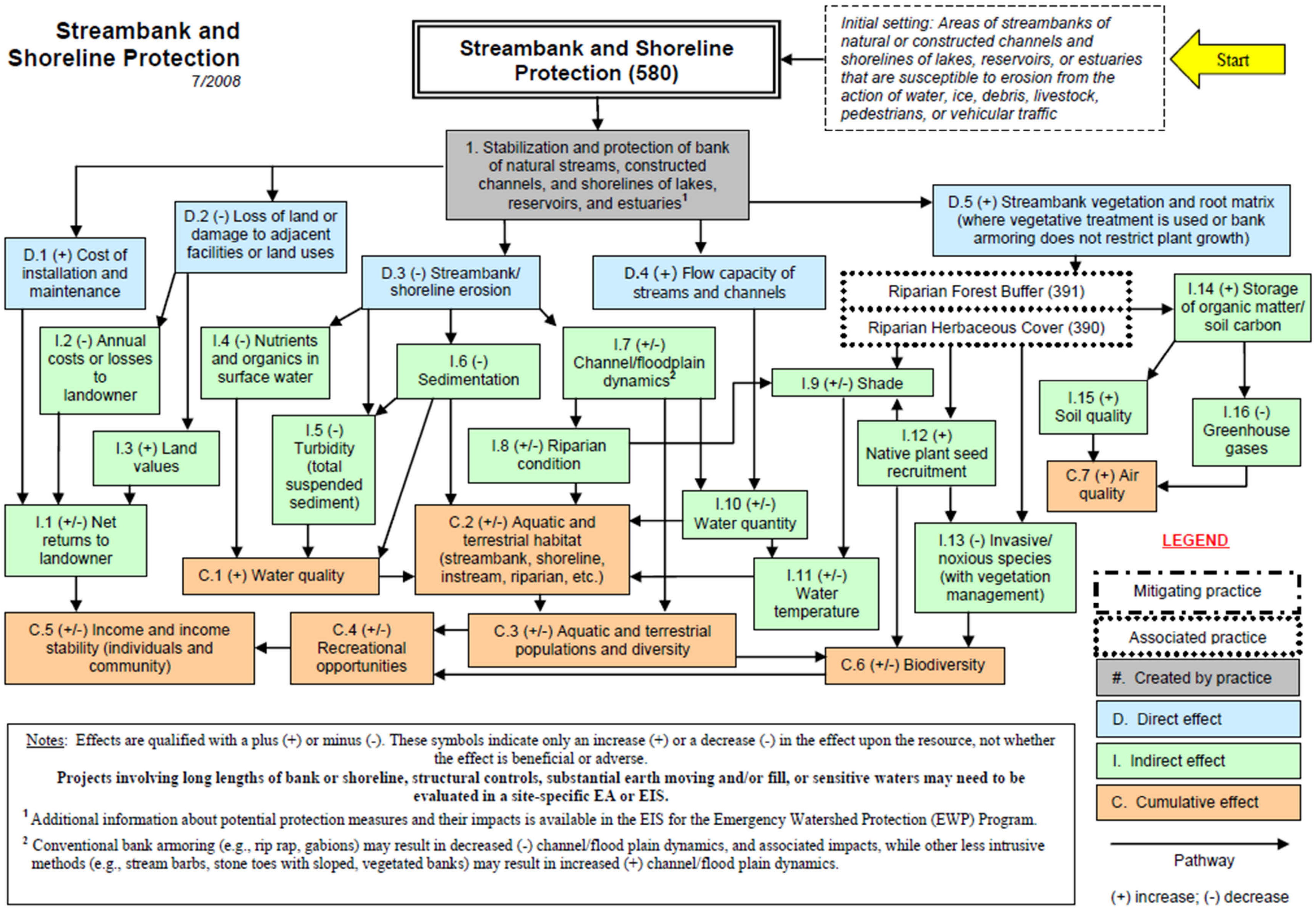
- Streambanks of natural or constructed channels and shorelines of lakes and reservoirs where they are susceptible to erosion
- Various materials may be used for protection of streambanks and shorelines
- A site-specific assessment should be conducted to determine if the causes are local or systemic 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.

Benefits of implementing streambank and shoreline protection and associated BMPs and conservation practices are numerous and are displayed in the NRCS's NED in Figure 4.109. As shown in this figure, direct and indirect benefits associated with this BMP 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.



Notes: Effects are qualified with a plus (+) or minus (-). These symbols indicate only an increase (+) or a decrease (-) in the effect upon the resource, not whether the effect is beneficial or adverse.

Projects involving long lengths of bank or shoreline, structural controls, substantial earth moving and/or fill, or sensitive waters may need to be evaluated in a site-specific EA or EIS.

[1] Additional information about potential protection measures and their impacts is available in the EIS for the Emergency Watershed Protection (EWP) Program.

[2] Conventional bank armoring (e.g., rip rap, gabions) may result in decreased (-) channel/flood plain dynamics, and associated impacts, while other less intrusive methods (e.g., stream barbs, stone toes with sloped, vegetated banks) may result in increased (+) channel/flood plain dynamics.

Figure 4-108. Network Effects Diagrams for Streambank and Shoreline Protection.

5.0 PERMITS

5.1 OVERVIEW

Information regarding the initial permitting and regulatory process for the proposed projects outlined in Chapter 4.0 of this report are contained in the following sections. The purpose of this preliminary analysis is to determine the known and probable reviews or assessments, permits and clearances, and other requirements that may be encountered in pursuing implementation of the proposed projects and watershed management recommendations within the watershed. These processes usually involve permit application and environmental evaluation; coordinating with local, state, and federal agencies for review or approvals; and determining potential impacts.

Some of the proposed projects and future potential projects described in this study involving federal lands, funding, and programs would be subject to the National Environmental Policy Act (NEPA) and other federal regulations. The federal regulations are administered primarily by the BLM, USACE, EPA, NRCS, USFS, Farm Service Agency (FSA), and USFWS. State agencies with regulatory oversight and permitting approval that would require coordination on some of the proposed or potential projects include, but are not limited to, the Wyoming SEO, WDEQ, Wyoming SHPO, OSLI, and WGFD.

Additionally, various local zoning ordinances and permit requirements are associated with building, floodplain, and road or utility access that may be applicable within the city and county boundaries of the study area. Current zoning and permitting requirements are known to exist within the municipal boundaries of the cities of Gillette and Sundance and within Campbell and Weston Counties. Although Crook County does have a land-use plan, it does not currently include zoning except for municipalities [Lyons, 2015]. Zoning requirements may also exist within the towns of Hulett, Moorcroft, Pine Haven, and Wright that are applicable for constructing the proposed projects within the study area.

Permits or right-of-way access are required for the Wyoming Department of Transportation (WYDOT) and numerous utility and energy entities when project construction involves their properties. In the state of Wyoming, the state's "Wyoming Underground Facilities Notification Act" requires everyone who owns underground facilities in the state to be a member of One-Call of Wyoming. Before any excavation begins, the excavator is required to provide advance notice (at least 2 business days before intending to dig) to the One-Call of Wyoming Notification Center at 811 (or if calling from out-of-state, 1.800.849.2476) [Wyoming State Legislature, 2013].

5.2 NATIONAL ENVIRONMENTAL POLICY ACT COMPLIANCE AND DOCUMENTATION

Compliance with the NEPA applies whenever the proposed projects included in the watershed management plan would be located on federal lands, would need passage across federal lands, would be funded entirely or partially by federal agencies or programs, or would affect water quality that is regulated by federal law. The NEPA process is intended to help sponsors and agencies review the potential project effects and involve the public in making informed decisions about the environmental consequences of the proposed project.

For the proposed projects on federal lands or with federal cooperation, the BLM, USFS, or the NRCS would likely be considered the lead agencies in the NEPA process because some of the proposed projects' involved actions would occur on BLM and USFS lands or would be in conjunction with USDA Farmbill funding programs. Also, the USACE would presumably have a role in reviewing proposed projects that involve wetland enhancement or where wetlands might be impacted. Typically, these federal agencies have a Memorandum of Understanding (MOU) to outline responsibilities and roles of the agencies when a proposed project involves multiple agencies. The NEPA process can also facilitate in meeting other environmental review requirements, such as the Endangered Species Act; the National Historic Preservation Act; the Environmental Justice Executive Order; and other federal, state, and local laws and regulations.

5.2.1 National Environmental Policy Act Process for Reservoir Storage Projects

NEPA compliance efforts associated with any reservoir alternative would likely require preparing an EIS and associated efforts. The BLM or the USFS would likely be the lead agency for any water storage alternative project specified in the plan that is situated on federal land.

5.2.2 National Environmental Policy Act Process for Other Projects

To determine whether or not NEPA compliance is required for the proposed projects other than major (nonstock pond) reservoir storage, an individual, site-specific review is necessary to define factors, including the project's location, ownership, type, and funding. Because the majority of the proposed projects within the watershed management plan are mapped to occur on private lands, these projects would involve coordinating with the NRCS in completing the NEPA process and associated documentation. The NEPA process for the proposed projects on private lands is usually less rigorous and preparing an environmental assessment (EA) or EIS is probably unlikely because typically, impacts to the environment and resources from the types of these proposed projects is insignificant. However, if the proposed project involves federal land, the BLM, the USFS, and the NRCS have specific policies and procedures for completing and documenting the NEPA process for these other types of projects; these are explained in the following sections.

5.2.2.1 Bureau of Land Management

All of the BLM's actions, approvals, or authorizations have to conform to an existing land-use plan, which is typically a proposed and approved RMP and associated EIS documents. Three approved RMPs for the BLM's Field Offices cover portions of the watershed including the 2001 Buffalo RMP, the 2000 Newcastle RMP, and the 2003 Powder River Basin (PRB) RMP. The Buffalo Field Office is currently revising their existing RMP.

A proposed project or action that was identified and provided for in the RMP and associated EIS or EA would be considered to be in compliance; however, if the plan did not include the project or action, the activity is then reviewed to determine whether or not it is in conformance with the plan. If the project or action conforms to the plan, no modification is necessary; however, if the proposed activity is not in conformance, the proposal could then be modified to conform to the plan, or an amendment of the plan could be completed if necessary, or the proposal could be rejected and is not considered through a plan amendment. Presently, the BLM would be the lead agency for the previously described environmental review process and proposal consideration. These reviews are performed by BLM personnel and/or cooperating state and federal agency specialists and qualified private expert contractors reporting to the BLM. An example of an environmental review would be a proposed new wildlife/livestock watering development, which includes a water tank and delivery pipeline system that crosses or provides water to a watering facility on the BLM land and, therefore, would need to be reviewed to determine whether or not it conforms with the appropriate BLM RMP and complete the identified NEPA requirements.

5.2.2.2 Forest Service

All of USFS actions, approvals, or authorizations have to conform to an existing land-use plan, which typically includes the "Forest Plan" and amendments, as well as proposed and approved RMPs and associated EIS documents for the USFS Douglas and Bearlodge Ranger Districts. Grazing permits or leases for a particular allotment, however, are not included within a RMP, Forest Plan, or EIS.

A proposed project or action that was identified and provided for in the Forest Plan and associated EIS or EA would be considered to be in compliance; however, if the plan did not include the project or action, the activity is then reviewed to determine whether or not it is in conformance with the plan. If the project or action conforms to the plan, no modification is necessary; however, if the proposed activity is not in conformance, the proposal could then be modified to conform to the plan, or an amendment of the plan could be completed if necessary, or the proposal could be rejected and is not considered through a plan amendment. Presently, the USFS would be the lead agency for the previously described environmental review process and proposal consideration. These reviews are performed by USFS personnel and/or cooperating state and federal agency specialists and qualified private expert contractors reporting to the USFS. An example of an environmental review would be a proposed new wildlife/livestock watering development, which includes a water tank and delivery pipeline system that crosses or provides water to a watering facility on the USFS land and, therefore, would need to be reviewed to determine whether or not it conforms with the appropriate USFS Forest Plan, amendment, EIS, or EA, and the identified NEPA requirements would need to be completed.

5.2.2.3 Natural Resource Conservation Service

An example of an environmental review for a project would be a proposed new wildlife/livestock watering development, which includes a water tank and delivery pipeline system that crosses or provides water to a watering facility on federal or state land and, thus, would need to follow and document an appropriate NEPA process. Another example would be a proposed wildlife/livestock water development, which includes NRCS Environmental Quality Incentives Program (EQIP) funding, and engineering design assistance for a water well, solar pump, stock tank, and pipeline located entirely on private land. This would still require that the NRCS conduct an Environmental Evaluation and complete their Environmental Evaluation Worksheet (Form NRCS-CPA-52) to determine if an EA or EIS is required and to document the results of the evaluation and show compliance with NEPA.

5.3 PERMITS, CLEARANCES, AND APPROVALS

5.3.1 Dam and Reservoir Construction

In addition to the USACE Section 404 Permit, there are numerous other permits and/or approvals are required for new dam and reservoir construction. The primary additional permits and/or approvals that would be required for any of the alternative projects under consideration are provided below.

Section 404 Permit. Like all water development projects, any dam and reservoir storage project in the study area will have environmental permitting issues. Typically the most significant environmental permit to be secured is a Section 404 Dredge and Fill permit from the USACE, Omaha District. Even when impacts are anticipated to be modest, the process of obtaining a Section 404 permit for storage projects may take several years from initiation of the NEPA process.

The primary guidance in embarking on the permitting process for a new dam and reservoir storage project is developing a defensible purpose and need for the project. The NEPA process dictates that the least environmentally damaging practicable alternative that addresses the purpose and need be pursued. This is the alternative most likely to be successfully permitted.

Endangered Species Act (Section 7 Consultation). The lead agency would prepare a biological assessment to determine project effects on threatened and endangered plant and animal species listed or proposed for listing (candidate species) under the Endangered Species Act (16 U.S.C. § 1531 et seq.). USFWS would then issue an opinion on whether or not federal actions are likely to jeopardize the continued existence of a threatened or endangered species, or destroy 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 preferred alternative would jeopardize the continued existence of a species, it may offer a reasonable and prudent alternative that would preclude jeopardy.

Fish and Wildlife Coordination Act. 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 steps to protect the fish and wildlife resources that 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.

Laws and Regulations Addressing Cultural Resources. Because federal approvals are likely involved with any of the identified alternatives, a consideration of effects on cultural resources must be undertaken (Section 106 consultation), as required under the following laws and regulations: the National Historic Preservation Act (NHPA) of 1966 (16 U.S.C. § 470 et seq.); the NEPA of 1969 (42 U.S.C., § 4321); the Archaeological Resources Protection Act (ARPA) of 1979 (16 U.S.C. § 470aa et seq.); the National Park Services (NPS) procedures concerning the National Register of Historic Places (NR) (36 CFR Part 60); the Advisory Council on Historic Preservation's Procedures for the Protection of Cultural Properties (36 CFR Part 800); the Treatment of Archaeological Properties of 1980: Determination of Eligibility for Inclusion in the NR (36 CFR 63); the Secretary of Interior's Standards and Guidelines for Archaeological Historical Preservation of 1983; Reservoir Salvage Act of 1960; and the l974 Amendment to the Reservoir Salvage Act of 1960. The SHPO coordinates with federal agencies in determining the significance of cultural resources potentially affected by ground-disturbing activities.

In addition, consultation with relevant Native American groups concerning traditional cultural properties is required under the American Indian Religious Freedom Act of 1978 (AIRFA, P.L. 95-341.42 U.S.C. § 1996) and Section 4 of ARPA of 1979. Guidelines for evaluating traditional cultural properties are contained in Bulletin 38 issued by the NPS.

Wyoming Board of Land Commissioners. The Wyoming Board of Land Commissioners, through the State Lands and Investments Board (SLIB) is responsible for regulating all activities on state lands, including granting rights-of-way (ROW). Any facility, utility, road, railroad, ditch, or reservoir to be constructed on state or school lands must have a right-of-way, as required in the *Rules and Regulations Governing the Issuance of Rights of Way* (W.S. 36-20 and W.S. 36-202).

Wyoming State Engineer's Office Surface Water Storage Permit. The SEO administers the water rights system of appropriation within the state. The applicant must obtain the necessary water rights permits from the state of Wyoming for diverting and storing the state's surface water.

Wyoming State Engineer's Office Permit to Construct/Dam Safety Review. The Wyoming Dam Safety Law [Wyoming State Legislature, 2014] requires that any persons, public company, government entity or private company who proposes to construct a dam that is greater than 20 feet high or that will impound more than 50 acre-feet of water, or a diversion system that will carry more than 50 cubic feet of water per second, must obtain approval for construction of the dam or ditch from the SEO. The approval by the SEO of a dam's construction is contingent upon the Office's review and approval of all dam plans and specifications, which must be prepared by a registered professional engineer licensed in Wyoming. Design, construction, and operation of jurisdictional dams must also comply with dam safety regulations pursuant to the Act.

Wyoming State Engineer's Office Ditch Enlargement Permit. In addition to the permits and clearances that will be required for reservoir construction, existing irrigation ditches may be required to convey water to off-channel reservoirs. If so, this effort would require an enlargement filing with the SEO. Even if physical enlargement of the existing ditch was found to not be required, the enlargement filing would be a legal formality as a water right requirement.

Wyoming Department of Environmental Quality—NPDES Permit and Section 401 Certification. The federal Clean Water Act is administered in Wyoming by the WDEQ, Water Quality Division (WQD) consistent with the Wyoming Environmental Quality Act. The Section 401 Certification is the state's approval to ensure that the activities authorized under Section 404 meet state water quality standards and do not degrade water quality. Any discharge of pollutants into the broadly defined "waters of the state" requires application to and permit issuance by the WQD in accordance with WQD's Rules and Regulations. This body of regulations sets forth classification of surface and groundwater uses and establishes water quality standards. The WQD administers the NPDES permit system including stormwater permits and construction-related, short-term discharge permits.

Implementation of any of the action alternatives would require application for and compliance with the provisions of the statewide general NPDES Construction Storm Water Discharge Permit (WYR10-000). Construction activities associated with dam construction or enlargement often result in the requirement to temporarily discharge pumped water. These discharges are provided for in a general permit. Upon acceptance of the application by the WDEQ, the temporary discharge must be in compliance with the terms of the general permit and any stipulations applied as a result of the application's review. The EPA has oversight responsibility for federal Clean Water Act programs delegated to and administered by the WDEQ WQD. The EPA also may intervene to resolve interstate disputes where discharges of pollutants in an upstream state may affect water quality in a downstream state.

Mining Permit. A Wyoming mining permit is not required for developing an aggregate and/or borrow material source solely for use in constructing one of the various reservoir alternatives and whose product is not for commercial sale. Commercial sources of aggregate, rock, or other mined materials are responsible for obtaining and maintaining all required permits and clearances for their operations.

Special Use Permits/Rights-of-Way/Easements. Special use permits, ROW, or easements will be required wherever access across the lands of others (private, state, or federal) is needed for construction and/or operation of the project facilities. These may be temporary (e.g., access to a temporary borrow area or quarry site to be closed and reclaimed, and construction of a new haul road) or permanent (e.g., construction of a wildlife/livestock pipeline alignment). Usually, privately owned lands that will be rendered permanently unavailable (such as the dam and reservoir footprint of a storage project) would be purchased unless the owner preferred (and the sponsoring entity agreed) to a permanent easement. Permanent use of BLM lands would most likely be administered under a grant with an appropriate term issued under their ROW process; the USFS would use their equivalent special use process. An easement or ROW from the WYDOT or Campbell, Crook, or Weston Counties may also be required. The specific requirements for ROW, special use permits, and easements vary widely and should be determined as part of the early stages of planning for a specific proposed project. This will help to avoid the potential for significant project delay, higher costs, or required changes in location/alignment or design during project development and implementation.

Other. In addition to the above, there may be other permits and clearances may be required for a given dam and reservoir project. These might include permits typically required to be provided by the construction contractor (e.g., air quality permit and trash/slash burning permit).

5.3.2 Other Project Types

Permit and clearance approvals for the proposed projects would depend on the site-specific project and its location. The permits and clearances discussed in Sections 5.1 and 5.3.1 could also be applicable for proposed projects. Permitting and clearance requirements for a specific project should be identified in the initial planning to achieve regulatory compliance, lower project costs, and avoid construction interruptions or design modifications. The following list includes permits and entities that may need to be obtained or involved in some of the watershed development projects. The extent of involvement and the nature of coordination would be determined on a project-by-project basis.

- USACE Section 404 permits
- WDEQ Discharge Permits for Construction Activities and Section 401 Certification
- Endangered Species Act (Section 7 Consultation)
- Fish and Wildlife Coordination Act
- OSLI and Wyoming Board of Land Commissioners Permits and/or Clearances
- SHPO Reviews and Consultations

- SEO Water Well Permits
- BLM and USFS Special Use Permits
- Campbell, Crook, and Weston Counties Permits
- Gillette, Sundance, Wright, and other towns' Permits.

5.4 ENVIRONMENTAL CONSIDERATIONS

5.4.1 Proposed, Threatened, and Endangered Species

The following species have the potential to occur within the proposed project areas within the watershed study area [Wyoming Natural Diversity Database, 2014]:

- **Endangered:** Black-footed ferret (*Mustela nigripes*)
- **Threatened:** Piping Plover (*Charadrius melodus*)
  Grizzly Bear (*Ursus arctos arctos*)

5.4.2 Other Species of Concern

The WYNDD records and maintains a list of species in Wyoming that are thought to be rare or sensitive, as discussed in Section 3.4.8.2. Table 3.15 lists the tracked or watched status of other species of concern potentially occurring within the study area, including 3 amphibians, 78 birds, 14 fern and fern allies, 4 fish, 4 insects, 28 mammals, 9 mollusks, and 6 reptiles [Wyoming Natural Diversity Database, 2014]. The sage-grouse is listed as a "candidate species; warranted but precluded" because existing information supports a proposal to list them as endangered or threatened; however, developing a proposed listing is precluded by higher priority listing activities.

5.4.2.1 Sage-Grouse

In March 2010, the USFWS published its listing decision for the Greater Sage-Grouse *(Centrocercus urophasianus)* as "warranted but precluded" and deficiencies in land use plan regulatory procedures was identified as a major threat in the USFWS' decision. In 2011, the Governor of Wyoming issued an executive order that requires state agencies to focus management to the greatest extent possible to prevent the sage-grouse from being listed as a threatened or endangered species. The core areas for sage-grouse cover approximately 229,000 acres (9 percent) of the study area, and are shown in Figure 3.16.

Also in response to the USFWS' decision, the BLM and the USFS prepared draft amendments with conservation measures for sage-grouse to their existing RMPs and Forest Plans within the BLM's Newcastle Field Office and the USFS' Thunder Basin National Grasslands. These measures included restrictions on land uses and actions to reduce the impacts of BLM/Forest Service programs or authorized uses. These amendments addressed core/priority, general, and connectivity habitat types for the sage-grouse in eastern, western, and southern Wyoming. In December 2013, the BLM and USFS released the following document and published a notice of availability in the Federal Register and opened a 90-day public comment period that closed March 24, 2014 [Sonneman, 2013]:

> *Wyoming Greater Sage-Grouse Draft Land Use Plan Amendment and Draft Environmental Impact Statement for the Casper, Kemmerer, Newcastle, Pinedale, Rawlins, and Rock Springs Field Offices and Bridger-Teton and Medicine Bow National Forests and Thunder Basin National Grassland for Public Lands Administered by the Bureau of Land Management Wyoming State Office and National Forest System Lands Administered by the Medicine Bow and Bridger-Teton National Forests and Thunder Basin National Grassland, December 2013.*

Although the proposed and draft EIS for the Wyoming sage-grouse plan have been released and reviewed as part of this watershed study, coordinating with the BLM and the WGFD is recommended for any proposed or future project that has the potential to impact sage-grouse habitat.

5.4.2.2 Rare Plant Species

The WYNDD, which was discussed in Section 3.5.4.1 and listed in Table 3.21, has 55 known rare plant species that are being watched and tracked along with wildlife species within the study area. Although some of these plant species could occur on a proposed project area, none of the plant species are currently protected by state or federal regulation but still deserve appropriate planning and implementation conservation efforts.

5.4.2.3 Big Game Species

The watershed contains portions of crucial big game habitat for elk, mule deer, and whitetail deer managed by the WGFD and seasonal ranges for several big game species. Three terrestrial Crucial Habitat Priority Areas exist within the watershed that contains big game crucial winter ranges and year-long ranges. Crucial habitats have biological important features that need protected or managed to maintain viable healthy wildlife populations and are areas where the WGFD concentrates their habitat protection and management activities. Proposed projects within this plan are typically implemented in a manner that improves or maintain these habitat features.

5.4.2.4 Fish Species

The study area contains waters with productive sport fisheries, including Belle Fourche River, Cold Springs Creek, Cook Lake, Gillette Lake, Keyhole Reservoir, and Sand Creek. The alternatives for rehabilitating reservoirs, dam embankments, and inlet/outlet ditches may have impacts to the streams and reservoirs and associated fishery resources, and initial review and coordinating with the WGFD is recommended before moving forward with any of the proposed alternatives. Other proposed projects such as livestock/wildlife water are expected to have no direct effect on fishery resources.

5.4.2.5 Wetlands

Site-specific wetland delineation and inventories were not part of the scope of the watershed study. Geospatial data for the mapped NWI areas are shown in Figure 3.25 and was included to identify where wetlands are located within the watershed. This mapping was used in preparing conceptual proposed projects areas that would avoid impacts to wetland resources. The alternatives for rehabilitating reservoirs, dam embankments, and inlet/outlet ditches may affect wetland resources depending on the specific provisions of the plans, designs, and construction specifications. Wetland creation and water development proposals within the study area should consult the USACE about any jurisdictional determinations and potential impacts on wetlands before implementing any proposed project.

5.5 MITIGATION

Mitigation requirements may be necessary for the alternative dam and reservoir sites presented in this plan to address impacts to wetlands, riparian vegetation, stream channel habitat, cultural resources, wildlife resources, and possibly threatened or endangered species. Preferably, an approach would include evaluating and considering these resources as part of any feasibility planning, which would adjust the designs accordingly and avoid the need for mitigation of significant impacts by potential designs and construction plans. Specific mitigation measures would need to be formulated to compensate for wetland losses determined by certified wetland delineations. Avoiding potential impacts to species of concern and associated habitat could usually be accomplished by scheduling construction activities outside of the relevant nesting, parturition, breeding, or migration seasons. Activities involving sage-grouse and sage-grouse habitat, as mentioned previously, should be coordinated with the BLM, USFS, NRCS, and WGFD.

5.6 LAND OWNERSHIP AND PROPERTY OWNERS

Permission should be negotiated for easements, ROW, and right-of-access for all construction activities associated with the project. **Note that the WWDC has stated that lands will NOT be "taken" or condemned to construct projects recommended within the watershed management plan. WWDC representatives stated that the state is not interested in condemning lands for the purpose of constructing a reservoir built with an objective of benefitting those whose lands would be used. Participation must be voluntary.**

6.0 COST ESTIMATES

Costs were estimated for each of the conceptual proposed projects and alternatives described in Chapter 4.0. These estimated costs, representing 2014 dollars, are explained for each of the proposed project categories in the following subsections. However, cost estimates for surface water storage sites and alternatives were not adjusted for this study and represent values reported in the final reports.

6.1 IRRIGATION SYSTEM COMPONENTS

The costs of irrigation system components of the watershed management plan were estimated by using current unit costs for individual projects. The NRCS EQIP cost docket data were used when possible for typical design concepts. The irrigation system costs are estimated in Table 6.1.

6.2 UPLAND WILDLIFE/LIVESTOCK WATER COMPONENTS

The costs of upland wildlife/livestock water projects and components from the watershed management plan were estimated by using recent unit costs for similar projects, the 2014 NRCS EQIP cost docket data, and manufacturers' and vendors' advertised product prices. An itemized list of accompanying costs for each upland wildlife/livestock water project component is provided in Table 6.2. A typical upland water project normally includes the following general cost assumptions:

- Water Wells – costs range from $10,000 to $30,000 each, depending on total depth.
- Water Tanks – costs range from $2,000 to $3,000 each, depending on stock and storage tank volume.
- Pipelines – costs range from $8,000 to $11,000 per mile of piping and trenching.
- Spring Developments – costs range from $1,000 to $2,000, depending on storage tank volume and infiltration design capacity.
- Solar Pump, Panels, and Controls – costs range from $6,000 to $10,000, depending on pumping depth and number of panels.
- Conventional Windmills – costs range from $5,000 to $10,000, depending on fan wheel and stroke size.

Table 6.1. Irrigation Cost Estimates

Rehabilitation Item Number	Priority	Pipeline Less Than or Equal to 12-Inch Diameter	Pipeline Greater Than 12-Inch Diameter	Structure for Water Control Medium	Structure for Water Control Large	Regulating Reservoir	Pumping Plant	Calculated Costs ($)	Construction Costs ($)	Engineering Costs (10%) ($)	Construction and Engineering Subtotal ($)	Contingency (15%) ($)	Total Construction Costs ($)	Final Plans and Specifications ($)	Permits, Fees, Access ($)	Total Project Costs ($)
I-01	1	5,610		1	1	1		128,955	128,955	12,896	141,851	21,278	163,128	2,000	2,000	167,128
I-02	1	2,620		1				44,476	44,476	4,448	48,924	7,339	56,262	3,500	3,500	63,262
I-03	1	4,880	7,040	1	1	1	1	278,856	278,856	27,886	306,742	46,011	352,753	3,500	3,500	359,753
I-03A/B	3	1,300		1			2	50,320	50,320	5,032	55,352	8,303	63,655	3,500	3,500	70,655
I-04	3	6,740			1	1		130,604	130,604	13,060	143,664	21,550	165,214	2,000	2,000	169,214
I-04A	3	5,890			1			91,274	91,274	9,127	100,401	15,060	115,462	2,000	2,000	119,462
I-05	3							TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
I-06	3	7,670			1			113,168	113,168	11,317	124,485	18,673	143,158	2,000	2,000	147,158
I-07	2							TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
I-08	2	4,510		1				67,723	67,723	6,772	74,495	11,174	85,670	2,000	2,000	89,670
I-09	3	2,470			1			49,208	49,208	4,921	54,129	8,119	62,248	3,500	3,500	69,248
I-10	3	4,760		3			1	106,338	106,338	10,634	116,972	17,546	134,518	2,000	2,000	138,518
I-11	3	4,540			1			74,669	74,669	7,467	82,136	12,320	94,456	2,000	2,000	98,456
I-12	3	1,820			1		1	52,253	52,253	5,225	57,478	8,622	66,100	2,000	2,000	70,100
I-13	3							TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
I-14	3	8,920		1	1			140,793	140,793	14,079	154,872	23,231	178,103	2,000	2,000	182,103
I-15	2	6,800		2				108,140	108,140	10,814	118,954	17,843	136,797	3,500	3,500	143,797

Table 6.2. Estimated Costs Associated With Each of the Upland Livestock/Wildlife Water Source/Supply Proposed Projects and Components of the Watershed Management Plan (Page 1 of 2)

Item Number	Plan Component	Description	Priority	Construction Costs ($)	Engineering Costs (10%) ($)	Construction and Engineering Subtotal ($)	Contingency (15%) ($)	Total Construction Costs ($)	Final Plans and Specifications ($)	Permits, Fees, Access ($)	Total Project Costs ($)
1	LW-01	Coyote Draw Pipeline and Tank	1	77,150	7,715	84,865	12,730	97,595	2,000	2,000	101,595
2	LW-02	Coyote Stock Reservoir	1	25,000	2,500	27,500	4,125	31,625	3,500	3,500	38,625
3	LW-03	Coyote Draw Stock Reservoir	1	25,000	2,500	27,500	4,125	31,625	3,500	3,500	38,625
4	LW-04	Gold Mine Draw Pipeline and Tank	2	35,900	3,590	39,490	5,924	45,414	2,000	2,000	49,414
5	LW-05	Hallie Draw Well, Solar Pump, and Tank	2	70,350	7,035	77,385	11,608	88,993	2,000	2,000	92,993
6	LW-06	Spring/East Bluff Pipeline and Tank	1	29,150	2,915	32,065	4,810	36,875	2,000	2,000	40,875
7	LW-07	Strips/West Bluff Pipeline and Tank	2	12,500	1,250	13,750	2,063	15,813	2,000	2,000	19,813
8	LW-08	East Dry Creek Well, Pipeline, and Tank	2	32,400	3,240	35,640	5,346	40,986	2,000	2,000	44,986
9	LW-09	Vore Draw Pipeline and Tank	3	15,250	1,525	16,775	2,516	19,291	3,500	3,500	26,291
10	LW-10	Whitelaw Solar Pump and Storage Tank	1	13,300	1,330	14,630	2,195	16,825	2,000	2,000	20,825
11	LW-10A	Divide Allotment Pipeline and Tank	2	29,850	2,985	32,835	4,925	37,760	2,000	2,000	41,760
12	LW-11	Eagle Ridge 1 Spring Development and Tank	1	24,130	2,413	26,543	3,981	30,524	2,000	2,000	34,524
13	LW-12	Eagle Ridge 2 Spring Development and Tank	2	17,400	1,740	19,140	2,871	22,011	2,000	2,000	26,011
14	LW-12A	Marr Stock Reservoir	2	25,000	2,500	27,500	4,125	31,625	2,000	2,000	35,625
15	LW-13	Porcupine Stock Reservoir	3	25,000	2,500	27,500	4,125	31,625	3,500	3,500	38,625
16	LW-14	Johnson Draw Well, Solar Pump, and Tank	1	59,660	5,966	65,626	9,844	75,470	2,000	2,000	79,470
17	LW-15	Shenandoah #4 Well, Solar Pump, and Tank	2	51,950	5,195	57,145	8,572	65,717	2,000	2,000	69,717
18	LW-16	Dry Creek #2 Well, Solar Pump, and Tank	1	59,150	5,915	65,065	9,760	74,825	2,000	2,000	78,825
19	LW-17	Miller Creek #1 Well, Solar Pump, and Tank	1	41,200	4,120	45,320	6,798	52,118	2,000	2,000	56,118
20	LW-18	Dry Creek #4 Well, Solar Pump, and Tank	2	41,200	4,120	45,320	6,798	52,118	2,000	2,000	56,118
21	LW-19	Dry Creek #3 Well, Solar Pump, and Tank	2	41,200	4,120	45,320	6,798	52,118	2,000	2,000	56,118
22	LW-20	Hay Creek #1 and #2 Well, Solar Pump, and Tank	3	41,200	4,120	45,320	6,798	52,118	2,000	2,000	56,118
23	LW-21	Miller Creek #2 Well, Solar Pump, and Tank	3	41,200	4,120	45,320	6,798	52,118	2,000	2,000	56,118
24	LW-22	Dry Creek #5 Well, Solar Pump, and Tank	3	41,200	4,120	45,320	6,798	52,118	2,000	2,000	56,118
25	LW-23	Corral Creek #1 Well, Pipeline, and Tank	1	87,400	8,740	96,140	14,421	110,561	2,000	2,000	114,561
26	LW-24	Alvin Creek Pipeline and Tank	2	15,200	1,520	16,720	2,508	19,228	2,000	2,000	23,228
27	LW-25	Corral Creek #2 Well, Pipeline, and Tank	2	51,950	5,195	57,145	8,572	65,717	2,000	2,000	69,717
28	LW-26	Corral Creek #3 Spring Development, Pipeline, Tank	3	36,250	3,625	39,875	5,981	45,856	2,000	2,000	49,856
29	LW-27	Eggie Basin Pipeline and Tank	1	31,850	3,185	35,035	5,255	40,290	2,000	2,000	44,290
30	LW-28	Pine Ridge Well, Pipeline, and Tank	3	62,300	6,230	68,530	10,280	78,810	2,000	2,000	82,810
31	LW-29	Little Draw #1 Well, Pipeline, and Tank	3	41,200	4,120	45,320	6,798	52,118	2,000	2,000	56,118
32	LW-30	Alma Stock Reservoir	2	25,000	2,500	27,500	4,125	31,625	3,500	3,500	38,625
33	LW-31	Lower Alma Stock Reservoir	2	25,000	2,500	27,500	4,125	31,625	3,500	3,500	38,625
34	LW-32	Mikel Creek Well, Pipeline, and Tank	3	41,200	4,120	45,320	6,798	52,118	2,000	2,000	56,118

Table 6.2. Estimated Costs Associated With Each of the Upland Livestock/Wildlife Water Source/Supply Proposed Projects and Components of the Watershed Management Plan (Page 2 of 2)

Item Number	Plan Component	Description	Priority	Construction Costs ($)	Engineering Costs (10%) ($)	Construction and Engineering Subtotal ($)	Contingency (15%) ($)	Total Construction Costs ($)	Final Plans and Specifications ($)	Permits, Fees, Access ($)	Total Project Costs ($)
35	LW-33	Little Draw #2 Well, Pipeline, and Tank	1	59,150	5,915	65,065	9,760	74,825	2,000	2,000	78,825
36	LW-34	Sage Draw Well, Pipeline, and Tank	3	44,300	4,430	48,730	7,310	56,040	2,000	2,000	60,040
37	LW-35	Tobey Draw Pipeline, Tank, and Stock Reservoir	1	27,350	2,735	30,085	4,513	34,598	2,000	2,000	38,598
38	LW-35A	Noecker Stock Reservoir	3	52,350	5,235	57,585	8,638	66,223	2,000	2,000	70,223
39	LW-35B	Dinky Stock Reservoir	3	52,350	5,235	57,585	8,638	66,223	2,000	2,000	70,223
40	LW-36	Line Creek Spring Development, Pipeline, Tank	2	27,250	2,725	29,975	4,496	34,471	2,000	2,000	38,471
41	LW-37	Little Wright Draw Well, Pipeline, and Tank	1	78,000	7,800	85,800	12,870	98,670	2,000	2,000	102,670
42	LW-38	Busby Draw Well, Pipeline, and Tank	2	41,200	4,120	45,320	6,798	52,118	2,000	2,000	56,118
43	LW-39	Wolfe Draw Pipeline and Tank	2	23,300	2,330	25,630	3,845	29,475	2,000	2,000	33,475
44	LW-40	Kruger #1 Well and Pipeline	1	36,050	3,605	39,655	5,948	45,603	2,000	2,000	49,603
45	LW-41	Kruger #2 Pipeline and Tank	2	63,700	6,370	70,070	10,511	80,581	2,000	2,000	84,581
46	LW-42	Kruger #3 Pipeline and Tank	2	76,750	7,675	84,425	12,664	97,089	2,000	2,000	101,089
47	LW-42A	Oak Creek Well, Pipeline, and Tank	2	73,500	7,350	80,850	12,128	92,978	2,000	2,000	96,978
48	LW-43	Kilpatrick Creek Pipeline and Tank	3	70,450	7,045	77,495	11,624	89,119	2,000	2,000	93,119
49	LW-44	Newland #4 Stock Reservoir	1	25,000	2,500	27,500	4,125	31,625	3,500	3,500	38,625
50	LW-44A	Iron Creek Well, Pipeline, and Tank	3	41,200	4,120	45,320	6,798	52,118	2,000	2,000	56,118
51	LW-45	Sawmill Well, Tank, and Stock Pond	1	66,200	6,620	72,820	10,923	83,743	2,000	2,000	87,743
52	LW-46	Bear Gulch Well, Pipeline, and Tank	2	66,200	6,620	72,820	10,923	83,743	2,000	2,000	87,743
53	LW-46A	Bear Stock Reservoir	3	25,000	2,500	27,500	4,125	31,625	3,500	3,500	38,625
54	LW-46B	Bear Gulch Stock Reservoir	3	25,000	2,500	27,500	4,125	31,625	3,500	3,500	38,625
55	LW-47	Shield Stock Reservoir	3	25,000	2,500	27,500	4,125	31,625	3,500	3,500	38,625
56	LW-47A	Left Creek Stock Reservoirs	3	25,000	2,500	27,500	4,125	31,625	3,500	3,500	38,625
57	LW-48	Left Creek Spring Development, Pipeline, Tank	2	12,650	1,265	13,915	2,087	16,002	2,000	2,000	20,002
58	LW-49	Vines Draw Well, Pipeline, and Tank	3	66,200	6,620	72,820	10,923	83,743	2,000	2,000	87,743
59	LW-50	Grubb #3 Stock Reservoir	3	25,000	2,500	27,500	4,125	31,625	3,500	3,500	38,625
60	LW-50A	Brimmer Stock Reservoir	3	25,000	2,500	27,500	4,125	31,625	3,500	3,500	38,625
61	LW-51	Arkansas Creek Wildlife Guzzler and Pond	3	28,100	2,810	30,910	4,637	35,547	2,000	2,000	39,547
62	LW-52	Upper Sundance Well, Pipeline, and Tank	3	41,200	4,120	45,320	6,798	52,118	2,000	2,000	56,118
63	LW-53	East Rupe Spring Development, Pipeline, Tank	2	35,400	3,540	38,940	5,841	44,781	3,500	3,500	51,781
64	LW-54	Bennor #2 Well, Pipeline, and Tank	1	90,250	9,025	99,275	14,891	114,166	2,000	2,000	118,166
65	LW-55	Donkey Creek Well, Pipeline, and Tank	2	82,950	8,295	91,245	13,687	104,932	2,000	2,000	108,932
66	LW-56	Kester #1 Spring Development, Pipeline, Tank	1	46,060	4,606	50,666	7,600	58,266	2,000	2,000	62,266
67	LW-57	Kester #2 Spring Development, Pipeline, Tank	2	56,050	5,605	61,655	9,248	70,903	2,000	2,000	74,903

6.3 OTHER MANAGEMENT PRACTICES AND IMPROVEMENTS

The costs of other potential practices and improvements from the watershed management plan, such as stream channel restoration, rangeland and grazing management, noxious weed control, prescribed burning, and wetland enhancement, were not estimated because these types of projects and associated components are highly variable and depend on site location and accessibility, available material sources, hauling and mileage, specialized equipment and operator availability, and permitting and design requirements. Staff with local organizations listed in Chapter 7.0 should be consulted regarding the estimated costs for these types of practices and improvement projects.

6.4 SURFACE WATER STORAGE

For each site, a conceptual layout of the reservoir pool was prepared in the study's GIS from previous study reports and using USGS topographic mapping. The reservoir pool layouts were primarily used to determine areas of attributes affected at the site and were used in the initial screening of the potential sites. Design cost estimates were estimated and extrapolated using the values previously stated for these alternatives and reported in the *Final Report, Crook County Reservoir Project Level I* [ESA Consultants Inc., 1999]; and the *Final Report Crook County Reservoirs and Water Management Study – Level I* [Short Elliot Hendrickson Inc., 2006]. The previously reported estimated costs represent 2006 dollars and were not adjusted for the purposes of this study.

7.0 FUNDING OPPORTUNITIES

7.1 OVERVIEW

Sources of funding and financing for proposed projects within the watershed and the associated technical support and assistance are available from various local, private, state, and federal entities. The widespread opportunities described in this Level I watershed study, watershed management plan, and resulting proposed projects and alternatives make identifying and obtaining potential project funding dependent on local coordination and voluntary cooperation.

Local coordination is crucial in developing viable financing approaches that could be developed in implementing proposed projects and realizing beneficial watershed improvements. Voluntary cooperation between landowners, managers, irrigators, residents, organizations, and agencies is essential in addressing the identified land and water resource concerns within the Belle Fourche River Watershed. Land and water users and managers interested in voluntarily implementing conservation projects and programs should be aware of the partnership opportunities and program incentives available in successfully achieving their watershed improvement goals and objectives.

Local, state, and federal agencies, along with private organizations, provide technical assistance for watershed and conservation projects with a smaller amount of these entities also providing financial assistance. Private contributions, such as in-kind provisions, are vital in developing and accomplishing a successful watershed or conservation project. Agencies and organizations with technical and financial assistance programs, which could potentially assist with proposed projects and alternatives, are provided in the subsequent sections. Funding and program information for potential conservation and watershed project and program assistance was obtained primarily from the following sources:

- **Water Management and Conservation Assistance Programs Directory**, is an overview of local, state, and federal programs with associated contact information (*http://wwdc.state.wy.us/wconsprog/2014WtrMgntConsDirectory.html*)
- **Catalog of Federal Funding Sources for Watershed Protection** is a searchable database of financial assistance sources (grants, loans, and cost-sharing) available to fund a variety of watershed projects (*http://www.epa.gov/watershedfunding*)

Additional information about potential funding sources were reviewed and incorporated from previous watershed studies completed on behalf of the WWDC and specifically included excerpts from the *Sweetwater River Watershed Study Basinwide Watershed Management Plan* [Anderson Consulting Engineers, 2012] and the *Thunder Basin Watershed Management Plan, Level I Watershed Study* [Olsson Associates, 2009]. These potential sources described in this chapter are certainly not an all-inclusive listing of the available opportunities for water management and conservation projects. Also, the available funding levels for these programs vary annually because they are subject to budget appropriations; spending authorizations; and in some instances, donation amounts for private organizations. Additionally, the contact information for these sources can and does change occasionally. Important contact information for local conservation organizations include, but are certainly not limited to, the following contacts:

- Campbell County Conservation District (307.682.1824)
- Crook County Natural Resource District (307.283.2870)
- Weston County Natural Resource District (307.746.3264)
- NRCS Casper State Office (307.233.6750)
- NRCS Douglas Area Office (307.358.3050)
- NRCS Newcastle Field Office (307.746.3264)
- NRCS Sundance Field Office (307.283.2870)
- NRCS Gillette Field Office (307.682.8843)
- BLM Cheyenne State Office (307.775.6256)
- BLM Buffalo Field Office (307.684.1100)
- BLM Newcastle Field Office (307.746.6600)
- USFS Douglas Ranger District (307.358.4690)
- USFS Bearlodge Ranger District (307.283.1361)
- WGFD Casper Regional Office (307.473.3400)
- WGFD Sheridan Regional Office (307.672.7418).

7.2 LOCAL AGENCIES

7.2.1 Conservation Districts

Three conservation districts cover portions of the watershed, including Crook County Natural Resource District (56 percent), Campbell County Conservation District (34 percent), and Weston County Natural Resource District (10 percent). Conservation districts are locally led, locally elected county government entities. They function as representatives of local people with responsibility to natural resource issues. Local conservation district boards perform as a liaison between local landowners and resource users and state and federal government agencies. Conservation districts are providers of information and education at the local level. Districts also provide technical assistance as local resources, capacity, and expertise allow. They can also assist in developing and implementing program and project design and funding through assistance in proposal preparation, presentation, and pursuit of grant assistance. Conservation districts can also provide funding assistance, often through in-kind contributions such as staff time and technical aid. They can administer programs, projects, and grants on behalf of recipients of state and federal natural resource programs. Districts can assist with developing leveraged, partnered programs and projects. Additional information can be found on their website (*http://www.conservewy.com*).

7.2.2 County Weed and Pest Districts

County Weed and Pest Districts in Campbell, Crook, and Weston Counties also provide technical and financial assistance to landowners within the study area. These special-purpose districts deliver a wide range of support, including weed information, treatment education, field mapping, infestation control and eradication, early detection and response, and cost-share or discounted product incentives. Local contact information for the Weed and Pest Control Districts within the study area includes the following:

- Campbell County Weed and Pest (307.682.4369)
- Crook County Weed and Pest (307.283.2375)
- Weston County Weed and Pest (307.746.4555).

7.3 STATE PROGRAMS

7.3.1 Wyoming Department of Environmental Quality

The WDEQ WQD administers the Nonpoint Source Program, which solicits funding proposals under Section 319(h) of the Clean Water Act that address nonpoint sources of pollution within the state of Wyoming. Funded proposals usually address multiple program objectives such as BMP installation, agriculture and urban, information and education, and BMP effectiveness or water quality monitoring. Program funding depends upon federal budget appropriations and the annual fund allocation from the EPA to the state of Wyoming. Section 319 grant funds are available to local, state, and federal agencies; nongovernmental organizations; and private individuals who implement projects that reduce nonpoint source pollution and improve the quality of surface water and groundwater. Information regarding program eligibility, priorities, and applications is available at the Wyoming NPS Program website (*http://deq.state.wy.us/wqd/watershed/nps/NPS.htm*).

7.3.2 Wyoming Game and Fish Department

The WGFD may offer technical and funding assistance to help landowners, conservation groups, institutions, land managers, government agencies, industry, and nonprofit organizations develop or maintain water sources for fish and wildlife. Assistance may also be provided for protecting or improving riparian areas/wetlands, restoring streams, and upgrading irrigation infrastructure in a manner that provides improved fish passage or diversion screening.

Habitat Trust Fund: Funds can be used for acquisitioning, maintaining, or improving wildlife habitat; or for promoting human understanding and enjoyment of the fish and wildlife resource (habitat or information and education projects). Funds can be used for internal projects or paid as grants to an outside entity. All proposals must have a department sponsor and be entered into a department proposal database by early January or early August annually. Project proposals will be prioritized for funding by department staff during January through March and the Wyoming Game and Fish Commission grants preliminary approval in March and final approval in July for funds available in July. No cost share is required but is strongly recommended. Projects should occur in priority habitats or watersheds (*http://wgfd.wyo.gov/web2011/wildlife-1000426.aspx*). Approximately $600,000 to $1,200,000 is allocated annually to projects across Wyoming.

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. Project proposals will be prioritized for funding by department staff during January through March and the Wyoming Game and Fish Commission grants preliminary approval in March and final approval in July for funds available in July. No cost share is required but is strongly recommended. Projects should occur in priority habitats or watersheds (*http://wgfd.wyo.gov/web2011/wildlife-1000426.aspx*). Approximately $25,000 to $90,000 is allocated annually to projects across Wyoming.

7.3.3 Wyoming Office of State Lands and Investments

The OSLI is the administrative arm of the Board of Land Commissioners and the State Loan and Investment Board. It is the statutory responsibility of the OSLI to carry out the policy directives and decisions of these two boards. The organizational structure of OSLI consists of the Office of the Director and four divisions: Administrative Services Division, Trust Land Management Division, Field Service Division, and Wyoming State Forestry. Collectively, these divisions serve the trust beneficiaries–Wyoming's school children and state institutions; numerous clients in agriculture, mineral, timber, transportation, communication, public utility, recreation, tourism and other Wyoming industries; local government entities; state and federal agencies; and the resident and nonresident general public.

The Farm Loan Program, established in 1921, provides long-term real estate loans to Wyoming's agricultural operators. The use of this program has been expanded over the years to also include loans for the purchase of livestock and to assist beginning agricultural producers.

The Irrigation Loans Program, established in 1955, is designed to support small and large agricultural water development projects. The Legislature has allocated a total of $275 million for loans under the Farm Loan Program, and $20 million for the Irrigation Loan Program. Both programs are funded from the Wyoming Permanent Mineral Trust Fund. Joint Powers Act Loan Program was established in 1974 and the Legislature authorized the Joint Powers Act Loan Program to benefit local communities for infrastructure needs. These loans are approved from funds within the state's Permanent Mineral Trust Fund. These programs are an aid to cities, counties and special districts in providing needed government services and public facilities.

7.3.4 Wyoming Water Development Commission

The WWDC is responsible for coordinating, developing, and planning Wyoming's water and related land resources. The commission, which consists of ten members who are appointed by the governor with approval of the Senate, represents the four-state water divisions and the Wind River Reservation. Appointments are for a term of 4 years and a political split on the commission is required. Clients served by the commission include irrigation districts, conservancy districts, municipalities, water and sewer districts, joint powers boards, improvement and service districts, counties, and state agencies.

The WWDC administers and develops financing recommendations for the Wyoming Water Development Program, which was defined as the following by W.S. 41-2-112(a):

> *Established to foster, promote and encourage the optimal development of the state's human, industrial, mineral, agricultural, water and recreational resources. The program shall 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 reduction of flood damage, for abatement of pollution, for preservation and development of fish and wildlife resources and for protection and improvement of public lands and shall help make available the waters of this state for all beneficial uses, including but not limited to municipal, domestic, agricultural, industrial, instream flows, hydroelectric power and recreational purposes, conservation of land resources and protection of the health, safety and general welfare of the people of the state of Wyoming.*

7.3.5 Wyoming Water Development Program

The main Wyoming Water Development Program encompasses new development, dams and reservoirs, rehabilitation, water resources planning, and master planning. Information described below was abstracted from the Operating Criteria of the Wyoming Water

Development Program (*http://wwdc.state.wy.us/opcrit/final_opcrit.pdf*) and from a form titled *Information for New Applicants* (*http://wwdc.state.wy.us/projappl/New_Ap_Info.pdf*).

The most current information on funding is important to review before submitting an application because 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 websites and contact with the WWDC staff is recommended before beginning the application process.

- **New Development Program** – The New Development Program develops presently unused and/or unappropriated waters of Wyoming.
- **Rehabilitation Program** – The Rehabilitation Program provides funding assistance for the improvement of water projects completed and in use for at least 15 years.
- **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.
- **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 the following assistance to project sponsors:
  - **Basin-Wide Plans** – The program serves to develop basin-wide plans for each of the state's major drainage basins.
  - **Master Plans** – The program provides a service to municipalities, districts, and other entities to assist in preparing planning documents that serve as master plans for future water supply systems and improvements. The plans are 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 percent of the total project costs will be paid by local matching funds.

7.3.5.1 New Development Program

This program provides technical assistance and funding to develop waters of the state that are currently unused and/or unappropriated. The program encompasses a wide range of projects, including the following types:

- Multiple Purpose (including among other uses, two or more of the following: agriculture, recreation, environmental, and erosion control)
- New Storage (e.g., dams and reservoirs less than 2,000 acre-feet)
- New Supply (e.g., deep wells, alluvial wells, diversion dams)
- Watershed Improvement (for components whose primary function or benefit is water development)
- Recreation.

These project types are listed above in the order of preference assigned by the WWDC when determining what projects to pursue among all of the applications received for funding.

7.3.5.2 Rehabilitation Program

The Rehabilitation Program addresses the improvement of water projects completed and in use for at least 15 years to assist in keeping existing water supplies effective and viable for the future. The Rehabilitation Program can improve existing agricultural storage facilities or conveyance systems to ensure safety, decrease operation and maintenance 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.

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

7.3.5.3 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. The source of revenue for the program is Water Development Account No. Ill [W.S. 41-2-124(a)(iii)], which has received Water Development Account No. I appropriations and budget reserve account appropriations on occasion, as approved by the legislature; the interest earnings that have accrued to the Water Development Account No. Ill; and a percentage (0.5 percent) of the revenues which accrue to the state's severance tax distribution account. Legislative approval must be granted before 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 developing reservoir operating plans, recreation, environmental enhancement, flood control, erosion control and hydropower uses should be explored as secondary purposes.

7.3.5.4 Key Criteria and Procedures

An application for funding under the New Development and Rehabilitation Programs must meet the following key criteria most applicable to potential projects as identified in Chapter 4.0:

- *The project sponsor shall be a public entity that can legally receive state funds, incur debt, generate revenues to repay a 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… 2,000 or more acres of irrigated cropland, or must rehabilitate watershed infrastructure, which will develop or preserve the beneficial use of water in a watershed. The watershed rehabilitation projects must possess an estimated minimum useful life span of twenty-five (25) years and demonstrate that sufficient public benefits will accrue to justify construction of the anticipated improvements…*

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 the initial project applications; the fee does not apply to projects advanced to the next level of study or to construction.
- 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 project applications is August 15 of each year; the due date for applications for advancing to the next study level or construction funding is October 1 of each year.

Two important criteria that apply specifically to dam and reservoir projects include the following:

- *For projects that enlarge existing storage projects by 1,000 acre-feet or greater or for proposed new dam and reservoirs with a capacity of 2,000 acre-feet or greater, expenses associated with final engineering design and required National Environmental Policy Act reviews, including but not limited to environmental assessments and environmental Impact statements, are eligible components of a Water Development Program Level II, Phase III Study Project.*

- *For dam and reservoir projects, the Commission may waive sponsor eligibility requirements through Level II, Phase II. However, the eligible entity requirements shall be met prior to initiation of Level II, Phase III activities described herein.*

7.3.5.5 Financial Plan

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

- A 67 percent grant to 33 percent loan mix.
- Minimum 4 percent loan interest rate (current rate is 4 percent, but legislature may increase the rate).
- Maximum 50-year term of loans; term shall not exceed the 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.

In the document titled *Information for New Applicants*, the following additional relevant information is provided regarding financial terms:

- *The best available project financial terms include a grant for Level I and Level II expenses, a grand of 75% of the Level III costs, a loan of 25% of the Level III costs with an interest rate of four percent (4%) and a term equal to the economic life of the project/improvements or fifty (50) years, whichever is less. Principal and interest payments may be deferred for five (5) years after project completion. However, these favorable terms will be granted when a project is essential and the project sponsor has a very limited ability to pay.*
- *Those sponsors who feel more favorable terms are warranted due to a limited ability to pay must make a formal presentation to the Commission documenting their case. Sponsors electing to pursue this option should be aware that the Commission is reluctant to deviate from this standard and such requests will be denied unless they are clearly documented and justified.*

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 because of 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 the 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 believes is relevant to the commission's final decision.

The project sponsor shall be a public entity that can legally receive state funds, incur debt, generate revenues to repay a state loan, hold title, and grant a minimum of a parity position mortgage on the existing water system and improvements appurtenant to the project or provide other adequate security for the anticipated state construction loan. 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. Applicant may then know if there is a viable project before 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 2-year duration with the study being completed the first year and the sponsor forming the 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. Because evaluating the feasibility of new dams is complex, the applicant will know if the proposed reservoir is feasible before becoming a public entity. However, the applicant must be a public entity before applying for Level II, Phase III funding.

7.3.6 Small Water Project Program

The SWPP is intended to be compatible with the conventional WWDC program described above. Small water projects are defined as providing multiple benefits where the total estimated project costs (including construction, permitting, construction engineering, and land procurement) are less than $100,000 or where WWDC's maximum financial contribution is 50 percent of project costs or $25,000, whichever is less. SWPP funding is a "one-time" grant so that operation and maintenance costs are not included. Loans are not available under the SWPP.

7.3.6.1 Eligibility

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

- Small reservoirs and stock watering ponds (up to 20 feet high and 20 acre-feet capacity)
- Wells
- Pipelines and conveyance facilities
- Spring developments
- Windmills
- Wetland developments.

Irrigation works and projects may be eligible if they are already documented in a conservation district's existing watershed plan, a resource management plan, or an environmental evaluation prepared by a state or federal agency. These types of projects are only eligible if they cannot be addressed by the Water Development Program. Benefits associated with SWPP projects may include, but are not necessarily limited to, the following:

- 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.

7.3.6.2 Application, Evaluation, and Administration

Details of the application and evaluation process and program administrative procedures are provided in the Small Water Project Program Operating Criteria available online as noted previously. Some key aspects of the process and procedures applicable to the potential projects identified in Chapter 4.0 include the following:

1. Planning for small water projects will be generated by a WWDC watershed study or equivalent as determined by the WWDO. A watershed study will incorporate, at a minimum, available technical information that describes conditions and assessments of the watershed including hydrology, geology, geomorphology, geography, soils, vegetation, water conveyance, infrastructure, and stream system data. A plan outlining the site-specific activities that may remediate existing impairments or address opportunities beneficial to the watershed shall also be included. A watershed study may identify one or more projects that may qualify for SWPP funding. A professional engineer and/or geologist (as appropriate) shall certify any analysis submitted unless generated by a federal agency.
2. Applications shall be received by January 1 of each calendar year. Applications meeting criteria requirements will be considered during the regularly scheduled WWDC meeting in March. Applications shall include a project application, sponsor project referral, project location map, project cost estimates, and any letters of authorization or commitment of participation that may be available from other funding sources.

3. Projects that improve watershed condition and function, provide multiple benefits, and meet the funding criteria specified in W.S. 99-3-703(j)(vii) or W.S. 99-3-704(g)(vii), as described in B.4 herein, are eligible for consideration.

4. The sponsoring entity will be required to address the WWDC and provide testimony and other additional supporting evidence that justifies SWPP funding whenever the public benefit documentation, submitted with the application, is deemed to be insufficient by the WWDC.

7.3.7 Wyoming Wildlife and Natural Resource Trust

The Wildlife and Natural Resource Trust, created in 2005, is an independent state agency governed by a nine-member citizen board appointed by the Governor. Funded by interest earned on a permanent account, donations, and legislative appropriation, the purpose of the program is to enhance and conserve wildlife habitat and natural resource values throughout the state. Any project designed to improve wildlife habitat or natural resource values is eligible for funding. The office is centrally located in Riverton, Wyoming.

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 minimal amounts, and acquisition presents the necessary factor in attaining or preserving preferred 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.

The goal of the Board is to assist all applicants in the process of enhancing wildlife and natural resources in Wyoming.

7.4 FEDERAL AGENCIES

7.4.1 Bureau of Land Management

- **The BLM's Riparian Habitat Management Program** offers the opportunity to coordinate with outside interests on riparian improvement projects. The goal of the 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, and 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 complete for the funds available in the riparian program.

- **Range Improvement Planning and Development** 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 BLM require the execution of a permit. Although there are a couple of methods for authorizing range improvements on public lands, Cooperative Agreement for Range Improvements form 4120-6 is the method most commonly used. 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 BLM's share is from the range improvement fund, which is generated from the grazing fees collected. A limited amount of funding is from the general rangeland management appropriations. If the cooperator is a livestock operator, their contributions are generally in the form of labor; at times, they may also provide some of the material costs. Contributions from the conservation/environmental interest are monetary and often are in the form of grants. They also contribute labor occasionally.

BLM's Watershed and Water Quality Improvement 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 implementing several Section 319 watershed plans statewide.

- It is anticipated that as the WDEQ continues the inventory of waters of the state and identifying impaired and/or threatened waterbodies, the BLM will be partnering with the WDEQ to improve water quality in waterbodies on public lands. In the course of developing watershed plans or TMDLs for these watersheds, the BLM will be routinely involved in watershed health assessments, planning, project implementation and 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 BMPs; e.g., prescribed burns, vegetation treatments, instream structures to enhance vegetation cover, controlled accelerated soil erosion, increased water infiltration, and enhanced stream flows and water quality.

Currently, in response to the Clean Water and Watershed Restoration initiative and associated funding increases, the BLM is expanding its efforts to address water quality and environmental concerns associated with abandoned mines. This work will also be accomplished, in cooperation with the State Abandoned Mine Lands Division, on a priority watershed basis, and will employ appropriate BMPs to address identified acid mine drainage and runoff problems from mine tailings and waste rock piles.

7.4.2 Bureau of Reclamation

The USBR mission is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the public. The USBR has a major responsibility, in partnership with states, water users, and other interested parties, to help improve water resources and the water use efficiency in the western United States. After more than 100 years, USBR's primary role has evolved from one of water resource development to one of water resource management. More efficient water use is a key component of USBR's water resource management strategy.

The Sustain and Manage America's Resources for Tomorrow (WaterSMART) Program establishes a framework to provide federal leadership and assistance on the efficient use of water, integrating water and energy policies to support the sustainable use of all natural resources, and coordinating the water conservation activities of various department bureaus and offices. Through the WaterSMART Program, the department is working to achieve a sustainable water management strategy to meet the nation's water needs through projects that conserve and use water more efficiently, increase the use of renewable energy and improve energy efficiency, protect endangered and threatened species, facilitate water markets, or carry out other activities to address climate-related impacts on water or prevent any water-related crisis or conflict.

A major component of WaterSMART is the Water and Energy Efficiency Grant Program, through which USBR provides funding in two funding groups. In Funding Group I, up to $300,000 in federal funding is available per project, for smaller on-the-ground projects that can be completed within 2 years. In Funding Group II, up to $1 million in funding is available for larger, phased, on-the-ground projects that may take up to 3 years to complete. Water and Energy Efficiency Grants are awarded through a west-wide competitive process that requires a minimum 50 percent cost share by the recipient.

The Water Conservation Field Services Program (WCFSP), by contrast, provides smaller amounts of funding ($100,000 per project maximum) through local competitions within a region or area. The projects funded are generally smaller in scope than Water and Energy Efficiency Grant projects and are focused on fundamental conservation improvements as identified in water conservation plans developed by water users. Financial assistance provided through the WCFSP also requires a minimum 50 percent cost share by the recipient. Funding opportunity announcements for WaterSMART grants and the WCFSP can be found on *grants.gov* website.

7.4.3 Environmental Protection Agency

The Targeted Watershed Grants Program administered by the EPA "encourages watershed practitioners to examine local water related problems in the context of the larger watershed in which they exist, to develop solutions to those problems by creatively applying the full array of available tools, including general, state and local programs, to restore and preserve water resources through strategic planning and coordinated project management that draw in public and private sector partners..." as described in the program website (*http://www.epa.gov/twg/2006/2006faq.html#intro*). Organizations eligible for funding include nonprofits, tribes, and local governments. The assistance provided consists of grants for up to 75 percent of the total project costs. A match of at least 25 percent is required. The typical median amount awarded is $700,000 with a typical range of $300,000 to $900,000. The application must be made by the governor and the competition for these grants is keen.

7.4.4 Farm Service Agency

The FSA administers three different programs that may be applicable to some of the alternative projects identified in Chapter 4.0. Each of these three programs is briefly discussed below. The FSA is a member agency of the USDA. Programs administered through the FSA are offered through local county committees. Technical assistance needed for implementing FSA programs is provided through the NRCS. FSA programs available are the Conservation Reserve Program, the Continuous Sign-up for High Priority Conservation Practices, and the Emergency Conservation Program.

Conservation Reserve Program (CRP) offers agricultural producers annual rental payments to remove highly erodible cropland from production. Farmers and ranchers establish long-term conservation practices on erodible and environmentally sensitive land. In exchange, they receive 10–15 years of annual rental payments and cost-share assistance. CRP is a voluntary program specifically for highly erodible lands currently in active production planted two of the five most recent crop years. Land offered for CRP is ranked according to environmental benefit for wildlife habitat, erosion control, water quality, and air quality.

Continuous Sign-Up for High Priority Conservation Practices provides management flexibility to farmers and ranchers to implement certain high priority conservation practices on eligible land. Land must meet the requirements of CRP and be determined by the NRCS to be eligible and suitable for the following:

- Riparian buffers
- Filter strips
- Grass waterways
- Shelter belts
- Field windbreaks
- Living snow fences
- Contour grass strips
- Salt tolerant vegetation
- Shallow water areas for wildlife.

This is a cost-share program that offers rental rates based on the average value of dryland cash rent with an additional financial incentive of up to 20 percent of the soil rental rate for field windbreaks, grass waterways, filterstrips and riparian buffers. An additional 10 percent may be added if the land is located in an EPA-designated wellhead protection area. A provision for cost share of up to 50 percent of the cost of establishing permanent cover is available.

Emergency Conservation Program (ECP) provides emergency funding and technical assistance for farmers and ranchers to rehabilitate farmland damaged by natural disasters and for carrying out emergency water conservation measures for livestock during periods of severe drought. Participants receive cost-share assistance of up to 75 percent of the cost to implement approved emergency conservation practices, as determined by county FSA committees. Some of the conservation practices are includes the following:

- Removing debris
- Restoring fences and conservation structures
- Providing water for livestock in drought situations.

7.4.5 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). Although not all inclusive, some of these programs are identified in the following text.

The **Partners for Fish and Wildlife Program** serves as the primary tool for conservation delivery on privately owned land for the USFWS. The program provides technical and financial assistance to private landowners and tribes on a voluntary basis to help meet the habitat needs of federal trust species and conservation partner-designated species of interest. The program targets habitats that are in need of restoration or enhancement such as riparian areas, streams, wetlands, and grassland. Field biologists work one-on-one with landowners and partners to plan and implement a variety of projects, including grazing lands management, sage steppe enhancement, stream habitat improvement and fish passage, invasive species removal, and wetland establishment.

The **Wildlife and Sport Fish Restoration (WSFR) Program** works with states, insular areas, and the District of Columbia to conserve, protect, and enhance fish, wildlife, their habitats, and the hunting, sport fishing, and recreational boating opportunities they provide. The WSFR Program provides oversight and/or administrative support for the following grant programs: Wildlife Restoration Grant Program, Sport Fish Restoration Grant Program, Boating Infrastructure Grant Program, State Wildlife Grant Program, Tribal Wildlife Grant Program, and Tribal Landowner Incentive Grant Program.

The **Conservation Planning Assistance Program** works directly with other federal agencies and programs, as well as the public, on infrastructure development projects to protect the environment and preserve our nation's biological, terrestrial, and aquatic natural resources. Field biologists in all 50 states assist project proponents, planners, and agency personnel in developing plans that conserve, restore, or enhance fish and wildlife while at the same time, accomplishing the objectives of proposed development. This program provides grants to state fish and wildlife agencies to fund projects that bring together USFWS, state agencies and private organizations and individuals. Projects include identifying significant problems that can adversely affect fish and wildlife and their habitats, actions to conserve species and their habitats, actions that will provide opportunities for the public to use and enjoy fish and wildlife through nonconsumptive activities, and monitoring species and identifying significant habitats.

The **Cooperative Endangered Species Conservation Fund** (Section 6 of the ESA) provides grants to states and territories to participate in a wide array of voluntary conservation projects for candidate, proposed, and listed species. The program provides funding to states and territories for species and habitat conservation actions on nonfederal lands. States and territories must contribute a minimum nonfederal match of 25 percent of the estimated program costs of approved projects, or 10 percent when two or more states or territories implement a joint project.

The **North American Wetlands Conservation Act (NAWCA) 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 acquisitioning, enhancing, and restoring wetlands and wetlands-associated habitat. This program encourages voluntary, public-private partnerships. Public or private, profit or nonprofit entities, or individuals establishing public/private sector partnerships are eligible. Cost-share partners must at least match grant funds with nonfederal monies.

The **Fish and Wildlife Service's (FWS) Challenge Cost Share Program** started in 1988 as a way to enhance partnerships with state and local governments, individuals, and public and private groups. The program enables the FWS to manage cooperatively its natural and cultural resources and fulfill stewardship responsibilities to fish and wildlife management. Under this program, projects must occur on a refuge or directly benefit a refuge. The program encourages refuge managers to form partnerships and leverage allocated funds to complete the projects. Appropriated funds may be used to pay for no more than 50 percent of the cost of a project. Nonfederal sources, including state/local governments, private individuals/ organizations, business enterprises, and philanthropic and charitable groups provide the matching 50 percent cost share. The cooperator share may be a nonmonetary contribution. Cooperative agreements are signed with the cost-share partners

7.4.6 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. The policy of the Forest Service is 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 that will provide a classification of watersheds and stream reach conditions. Forest service water quality programs are coordinated with the WDEQ and other appropriate agencies. The Forest Service also has a water rights program that is coordinated with the Wyoming SEO. 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 waterbody conditions. The NRCS administers a number of funding and technical assistance programs applicable to

7.4.7 Natural Resources Conservation Service

The NRCS administers a number of funding and technical assistance programs applicable to many of the alternative projects. These programs are briefly described below. The NRCS provides leadership in a partnership effort to help people voluntarily conserve, improve, and sustain natural resources on private lands. The purpose and mission of the agency is to help landowners treat every acre of their private property according to its needs and within its capability. The treatment includes a balance between the land use for economic return and protecting its ability to be productive from generation to generation.

Conservation planning is key to successful land stewardship as NRCS employees and landowners work together to tailor-make voluntary conservation plans that meet the specific needs of individual customers. The NRCS workforce has the technical expertise and field experience to help land users solve their natural resource challenges and maintain and improve their ability to thrive economically. They are highly skilled in many scientific and technical specialties, including soil science, soil conservation, range conservation, engineering, agronomy, biology, geology, hydrology, forestry, cultural resources, GIS, and economics. The NRCS conducts natural resource inventories and assessments to indicate status, conditions and trends of natural resources on private lands. This resource information and technology include science-based technical tools, technical guides, and performance specifications and standards that ensure quality and consistency of conservation planning and application across the nation.

Technical and cost-share assistance is available through the NRCS. This assistance includes designs, specifications, construction, and management and financial help for practice and system installation. Local people, individually and collectively, decide how to use NRCS capabilities in the natural resource conservation planning and application process. The role of NRCS is to support and facilitate these individual and local decisions based on good resource information, whether that is a grazing management plan or layout for an irrigation system.

The NRCS provides technical assistance for the following programs in Wyoming:

- **Grazing Lands Conservation Initiative (GLCI):** Accelerated range management technical assistance is available to producers in every county to support this initiative.
- **Small Watershed Program (PL-566):** NRCS works through local government sponsors to help solve natural resource and related economic problems on specific watersheds.

- **Snow, Water and Climate Services:** Snow survey crews collect information on snowpack conditions to provide Wyoming water users with forecasts of seasonal water supplies. This helps determine available water to meet agricultural, industrial, recreational, and urban area needs.
- **Soil Surveys:** Soil surveys provide a field-based scientific inventory of soil resources and information on the potentials and limitations of each soil. This information assists in determining the best uses of the land based on soil type.
- **Plant Materials:** Wyoming NRCS is serviced by the Plant Materials Center (PMC) at Bridger, Montana. The Plant Materials Program identifies, selects, and releases superior performing plant collections for a variety of conservation uses.

NRCS administers the following Landscape Planning Programs:

- **Emergency Watershed Protection (EWP) Program** assists in implementing emergency measures, including the purchase of flood plain easements, for runoff retardation and soil erosion prevention to safeguard lives and property from floods, drought, and the products of erosion on any watershed whenever fire, flood or any other natural occurrence is causing or has caused a sudden impairment of the watershed.
- **Watershed Protection and Flood Prevention Operations (WFPO) Program** provides technical and financial assistance to entities of state and local governments and tribes (project sponsors) for planning and installing watershed projects.
- **Watershed Surveys and Planning (WSP)** authorizes the NRCS to cooperate with federal, state, and local agencies and tribal governments to protect watersheds from damage caused by erosion, floodwater, sediment and to conserve and develop water and land resources.

NRCS administers the following 2014 Farm Bill programs:

- **EQIP:** Through EQIP, technical assistance, cost share, and incentive payments are available to agricultural producers to implement conservation practices that improve water quality, enhance grazing lands, and/or increase water conservation.
- The **Sage-Grouse Working Lands for Wildlife Initiative** is offered under the EQIP with the purpose of providing assistance to agricultural producers to implement practices that will alleviate or reduce threats to sage-grouse habitat.
- **Conservation Stewardship Program (CSP)** encourages land stewards to improve their conservation performance by installing and adopting additional activities, and improving, maintaining, and managing existing activities on agricultural land and nonindustrial private forest land.
- The **Regional Conservation Partnership Program (RCPP)** promotes coordination between the NRCS and its partners to deliver conservation assistance to producers and landowners. The NRCS provides assistance to producers through partnership agreements

and through program contracts or easement agreements. Assistance is delivered in accordance with the rules of EQIP, CSP, Agricultural Conservation Easement Program (ACEP) and HFRP, and in certain areas the Watershed Operations and Flood Prevention Program.

- The **Agricultural Management Assistance (AMA)** provides financial assistance to agricultural producers to address resource issues such as water management, water quality, invasive species control, and erosion control by incorporating conservation into their farming or ranching operations. The purpose of the AMA is to assist producers in reducing risk to their operation.

- **Conservation Innovation Grants (CIG) Program** is intended to stimulate the development and adoption of innovative conservation approaches and technologies while leveraging federal investment in environmental enhancement and protection, in conjunction with agricultural production. Under CIG, EQIP funds are used to award competitive grants to nonfederal governmental or nongovernmental organizations, tribes, or individuals.

- The **ACEP** provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits. Under the Agricultural Land Easements (ALE) component, NRCS helps tribes, state and local governments and nongovernmental organizations protect working agricultural lands and limit nonagricultural uses of the land. Under the Wetlands Reserve Easements (WRE) component, the NRCS helps to restore, protect and enhance enrolled wetlands.

- **Partners** NRCS collaborates with many local, state, and federal agency partners to provide the maximum technical assistance to people who work the land and to leverage the federal contributions to natural resource conservation on private lands. The state's 34 conservation districts take a special place in the partnership and the natural resource conservation delivery system. Units of local government, conservation districts operate on the premise that local people know the most about local natural resource needs. Conservation districts link the NRCS to local communities and to local priorities for natural resource conservation.

7.4.8 U.S. Army Corps of Engineers

The USACE 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 USACE is responsible for a worldwide military construction program, an extensive environmental program, and a broad national civil works program. The USACE 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-related projects and respond to water resource needs.

- **Planning Assistance to States.** This program provides for assistance in preparing plans for developing, using, and conserving water and related land resources. The USACE provides 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 $500,000 per state and studies are cost shared on a 50-50 basis with a nonfederal sponsor such as a state, public entity, or a tribe.
- **Flood Plain Management Services.** This program provides technical services and planning guidance for supporting and promoting 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 free to local, regional, state, or nonfederal public agencies. Federal agencies and private entities have to cover 100 percent of costs.
- **Flood Damage Reduction Projects.** This program provides structural and nonstructural projects to reduce damages caused by flooding and focuses on solving local flood problems in urban areas, towns, and villages. The USACE 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 funded by federal sources. Any cost above this amount is cost shared 50-50 with the sponsor in the form of cash and in-kind services. Construction lands, easements, ROW, relocations, and disposal and 5 percent of the projects costs are the sponsor's responsibility. Operation and maintenance and a maximum of 50 percent of total project cost are the sponsor's responsibility.
- **Project Modification for Improvement of Environment.** The purpose of this program is to modify structures or operation of previously constructed water resources projects to improve environmental quality, especially fish and wildlife values. A study, at federal expense, is initiated followed by a feasibility plan that is cost shared 25 percent by the sponsor.
- **Aquatic Ecosystem Restoration.** This effort is for restoring historic habitat conditions to benefit fish and wildlife resources primarily to provide structural or operational changes to improve the environment such as river channel reconnection, wetland creation, or improving water quality. The conditions are similar to the Project Modification Program with sponsor cost share being 35 percent.
- **Water Resources Projects.** The purpose of this program is to construct larger projects for flood damage reduction and to provide technical assistance in resolving more complex water resource problems. The program is used to evaluate projects costing more than $10 million that include purposes of flood control, water supplies, water quality, environmental protection and restoration, sedimentation, or recreation. Reservoirs,

diversions, levees, channels, or flood plain parks are examples. The USACE works with a nonfederal sponsor to define the flood- or water resource-related problem or opportunity, evaluate flood control or solutions, select a plan, develop a design, and construct a project. Special authorization and funding from Congress is required with a reconnaissance study being federal cost. A feasibility study to establish solutions is cost shared 50 percent by the nonfederal sponsor with 35–50 percent of the construction cost the responsibility of the sponsor.

- **Support for Others Program.** This program provides for environmental protection and restoration or facilities and infrastructure and includes Environmental Planning and Compliance, Economic and Financial Analyses, Flood Plain Management, Cultural Resources, and General Planning. All costs for these programs are provided by the customer agency.
- **Regulatory Authority/Responsibility.** The USACE 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 USACE to regulate the discharge of dredged or fill material into waters, which would include dams and dikes, levees, riprap, bank stabilization, and development fill. Three kinds of permits are issued by the USACE: individual, nationwide, and regional general.

7.4.9 Rural Utilities Service

The USDA Rural Development's utilities program is authorized to provide financial assistance for water and waste disposal facilities in rural areas in towns of up to 10,000 people. This program is intended for nonprofit corporation 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, pledge security for loans, and 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 ROW 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.

The USDA Rural Development also guarantees loans to eligible commercial lenders to improve, develop, or finance water or waste disposal facilities in rural areas. This guarantee is a warrant to protect the lender and may cover up to 90 percent of the principal advanced. The guarantee fee is 1 percent of the loan amount multiplied by the percent of the guarantee. Interest rates will be negotiated between the lender and the borrower.

7.5 NONPROFIT AND OTHER ORGANIZATIONS

7.5.1 Ducks Unlimited

Ducks Unlimited, Inc. (DU) is a funding source for wetlands and waterfowl restoration. DU conducts program development through a partner agency in providing short-term project funding assistance. Money availability is limited to what is within the organizational system. Generally, $20,000 to $30,000 is available annually statewide with additional funding support from project specific donations.

DU offers a waterfowl habitat development and protection program called Matching Aid to Restore States Habitat (MARSH). This is a reimbursement program that provides matching funds for restoring, protecting, or enhancing wetlands. The financial extent of this program is dependent on DU's income within the state. MARSH projects must significantly benefit waterfowl. Projects receiving funding support must be on lands that can demonstrate at least a 30-year project life at a minimum. Groups requesting assistance must be able to demonstrate capacity to execute long-term habitat agreements, deliver and manage projects, and be willing to assume project liability. DU's goal is to match MARSH funds equally with private, state, or federal sources. Their objective is to obtain maximum leverage possible to maximize benefit to waterfowl. Therefore, leveraged projects have a greater likelihood of being approved. Specifics for proposal submission, budget preparation, project development, and receipt of funding can be further explained by the DU local coordinator. The local coordinator can provide additional information relating to the program and provide partner contact opportunities at a local level.

7.5.2 National Fish and Wildlife Foundation

The National Fish and Wildlife Foundation (NFWF) is a private, nonprofit, tax-exempt organization chartered by Congress in 1984 to sustain, restore, and enhance the nation's fish, wildlife, plants, and habitats. The NFWF provides grant funding on a competitive basis through their Keystone Initiative Grants and Special Grant Program. Some of the grants/programs available include, but are not limited to, the following:

- **Pulling Together Initiative** – provides support on a competitive basis for forming local weed management area 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 nonfederal match is required.
- **Native Plant Conservation Initiative** – funding preference for "on-the-ground" projects that involve local communities and citizen volunteers in restoring native plant communities.
- **Bring Back the Natives Grant Program** – funds to restore damaged or degraded riverine habitats and their native aquatic species provided by the BLM, USBR, USFWS, USFS, and NFWF; minimum 2:1 nonfederal match required.
- **Five-Star Restoration 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.

Information about these and other NFWF grants/programs is available at their website (*http://nfwf.org/*).

7.5.3 Trout Unlimited

The mission of the Wyoming Council of Trout Unlimited is to conserve, protect, and restore Wyoming's cold-water (trout) fisheries and their watersheds. The Council is made up of 16 chapters located throughout the state. While a majority of Trout Unlimited members are indeed enthusiastic anglers, their focus is not only on maintaining fisheries for the purpose of angling. Healthy trout fisheries are indicative of well-functioning, sound ecosystems and that the work we do toward restoring good trout habitat will ultimately benefit the overall environment.

Of special concern are Wyoming's four subspecies of native cutthroat trout that currently inhabit a tiny fraction of their historic range. Working with federal and state agencies, local officials and landowners, Wyoming Trout Unlimited is actively engaged in a battle to keep these fish from being listed under the Endangered Species Act. 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. Partnerships are encouraged and can include local conservation districts and state and federal agencies. Those interested should contact the Council office.

8.0 CONCLUSIONS AND RECOMMENDATIONS

A comprehensive, interdisciplinary study including inventory and description of the Belle Fourche River Watershed was completed to identify and evaluate land and water resource issues and concerns in the study area. An extensive GIS and digital library were also incorporated as part of this Level I watershed study. The GIS includes information collected and generated during the study from many sources and serves as a valuable reference for potential projects and future efforts within the watershed.

8.1 CONCLUSIONS

Following the information gathering and watershed inventory efforts of the study, several proposed projects and associated components along with identified opportunities, initial recommendations, and potential resource effects were developed as part of the watershed management plan. The plan's projects, opportunities, and recommendations were formulated based upon field inventory findings; GIS mapping and analysis; landowner feedback during scoping meetings and field visits; and planning conceptual projects with participants, partners, and sponsors during the study. Resource issues and concerns within the watershed were identified and evaluated to outline proposed improvements and alternatives associated with the following study areas:

- Irrigation System Conservation and Rehabilitation
- Livestock/Wildlife Upland Watering Opportunities
- Grazing Management Opportunities
- Surface Water Storage Opportunities
- Stream Channel Condition and Stability
- Wetlands Enhancement Opportunities
- Other Watershed Management Opportunities.

8.1.1 Irrigation System Components

- Proposed projects and associated components for issues identified during field inventories for irrigation system infrastructure were completed for 15 irrigation systems.
- Irrigation water storage and regulating reservoirs are vital components and are needed in close proximity to irrigated lands, which are fairly dispersed throughout the study area, especially along the Belle Fourche River below Keyhole Reservoir.

- Most of the structures inventoried and evaluated require rehabilitation efforts to reduce seepage and conserve water; however, common infrastructure needs are more individual in nature and unique within the watershed.
- Recommended improvements to existing irrigation systems mainly involve replacement and/or rehabilitation of existing but weakened diversion structures, headgates, and pumps along with replacement of ditches with pipelines to reduce conveyance losses.
- Irrigation system improvements could be implemented individually or entirely at once, depending on the goals of the landowner or manager.
- The proposed irrigation system projects would require minor involvement or permitting from regulatory agencies to be completed. However, work involving stream channels would require consultation with the USACE.

8.1.2 Livestock/Wildlife Upland Watering Opportunities

- Livestock grazing and ranching commonly occurs throughout the watershed with other land uses including timber production, mining, oil and gas production, wildlife habitat, and recreation.
- Opportunities to improve range and riparian conditions require installing and operating well-distributed, reliable upland water sources and watering facilities for wildlife and livestock. Installing pipelines and stock tanks is the foundation of effective grazing management and can be an economical way to improve rangeland conditions.
- Grazing on both rangelands and forestlands is an essential part of a typical livestock operation within the study area and often requries more reliable, plentiful water sources.
- The study area contains 159 BLM grazing allotments encompassing 309,100 acres of rangeland and another 26 USFS grazing allotments encompassing 54,210 rangeland acres consisting of private, state, and federal lands.
- The USFS administers those federal forest lands in 31 grazing allotments, which encompass approximately 179,850 acres of federal, state, and private lands within the Black Hills National Forest (BHNF).
- Coordination with the BLM and the USFS regarding grazing allotment management is necessary and requires more involvement in developing proposed livestock/wildlife water supply projects beyond the conceptual level projects included within the study.
- Because of the existing regulatory environment and involvement of third-party interests, the proposed projects with portions of federal lands could be difficult and require additional review and planning efforts.
- Several proposed projects and pipeline components could be rerouted or redesigned to involve only private or state lands, these might result in increased materials and construction costs but could avoid project delays and permitting issues.

- There were 67 potential livestock/wildlife water projects identified for development resulting from an effort that evaluated available water sources in coordination with participating landowners and allotment permittees.
- Conceptual project plans and component designs along with associated cost estimates were calculated for each of the proposed projects. The primary components included water wells, solar pumps, buried pipelines, and stock tanks, which would require additional final planning, design, and permitting completed before construction.
- The proposed projects and components would need to be installed, operated, and maintained by the landowner or manager in accordance with current standards and specifications realize the expected benefits to the project area and watershed.
- Opportunities exist within the watershed for developing CBM wells and distribution systems into livestock/wildlife water supplies; however, specific projects are largely dependent on surface use agreements, well, landowner liability acceptance, livestock drinking water suitability, water rights and permitting, proximity of power sources and transmission lines, and possible groundwater and/or surface water contamination.

8.1.3 Surface Water Storage Opportunities

- Water storage development within the watershed has been impacted by the Belle Fourche River Compact of 1943, which divides the water in northeast Wyoming between Wyoming and South Dakota.
- Landowners and study participants identified problems with several existing reservoirs that limited the ability to store water and also identified potential opportunities for water storage within the study area.
- A "long list" of ten potential surface water storage sites and alternatives involving mostly rehabilitation of existing facilities in need of update or repair, along with enlargement of existing facilities, and construction of new facilities was developed during the study.
- A "short list" of five potential sites was selected from the long list that may provide substantial storage opportunities and alternatives were screened initially based on environmental, hydrologic, geologic, potential benefits, costs, and other data.

8.1.4 Grazing Management Opportunities

- Constructing and operating reliable water supply projects must be developed and implemented in areas with inadequate water sources before adjustments or alternatives in grazing management could be made on a particular area or allotment.
- Developing reliable water sources and associated watering facilities can aid in distribution, timing, and frequency of grazing animals. However, additional measures such as cross fencing, low-stress herding, mineral/salting, and grazing density should be evaluated as part of the site-specific, grazing management inventory and plan.

- Available tools such as the ESD and the STM can be used by landowners and managers so that they can be aware of the growth potential of desirable vegetation and predicted responses on a particular range site.
- These tools could be used in developing appropriate rangeland treatments and grazing practices to begin the transition from an undesirable to a desirable plant community.

8.1.5 Stream Channel Condition and Stability

- Some impaired channel reaches were identified during the geomorphic assessment and classification within the study area.
- Categories of impairments were identified and included, but not limited to, degradation of riparian vegetation and degradation of riparian condition in the form of stream bank erosion and channel degradation.
- Site-specific improvements should be developed to alleviate the channel impairments and restore riparian/wetland function as part of the watershed management plan.

8.1.6 Other Upland Management Opportunities

- Potential wetland creation and enhancement opportunities exist on hydric soils in the Subbasin above Keyhole Reservoir.
- Potential hydrologic effects resulting from bark beetle mitigation and timber management should be evaluated in areas of the Redwater Subbasin and Subbasin below Keyhole Reservoir.
- Noxious weed and invasive species control used to assist range and forest management according to the state and transition models.

8.2 RECOMMENDATIONS

Several proposed conceptual projects, identified opportunities, suggested alternatives, and initial conclusions have been presented and discussed within this report and watershed management plan. The summary recommendations listed below are included for consideration:

- Several irrigation system rehabilitation projects and livestock/wildlife upland water projects could be eligible to apply for funding through the WWDC SWPP.
- Surface water opportunities exist within the watershed but would require a partnership of local organizations, including but certainly not limited to, the Crook County Irrigation District and the Crook County Natural Resource District in order to pursue additional investigations, feasibility studies, and financing to implement potential projects.

- Priority projects should be reviewed and selected, and components should be implemented when the necessary technical and financial requirements are determined.
- Landowners or managers seeking to participate in the SWPP should consult and coordinate with their local conservation districts, which are eligible sponsors of SWPP applications and project agreements.
- The study's GIS and digital library should be used as a tool in planning and developing projects and should be updated as necessary from available information sources.
- Potential funding opportunities exist for proposed and future improvement projects within the watershed, including ranch and farm improvements, irrigation system rehabilitation, riparian/wetland enhancements, river corridor and stream channel restoration, and surface water storage projects.
- Innovative strategies for coordinated project funding and financing involving private, local, state, and federal sources will need to be pursued because many of the opportunities are unique in this watershed and do not conform to traditional programs and guidelines.
- Basing this approach on local, collaborative endeavors that integrate more than one watershed issue that could result in achievement of multiple benefits is essential.

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