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FINAL BEAVER CREEK LEVEL I WATERSHED STUDY

PREPARED FOR:

WYOMING WATER DEVELOPMENT COMMISSION
WESTON COUNTY NATURAL RESOURCE DISTRICT

PREPARED BY:

OLSSON ASSOCIATES

IN ASSOCIATION WITH:

STEADY STREAM HYDROLOGY,
RON E. VORE, PH.D.
AND KEITH CULVER

NOVEMBER 1, 2018

OLSSON® ASSOCIATES

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Final
Beaver Creek
Level I Watershed Study

WWDC Contract for Services
Number 05SC0296974
Olsson Project Number 017-1618

November 1, 2018

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.

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Appendices

Appendix A – Data Summaries
Appendix B – Benefits of Watershed Improvement Practices
Appendix C – Improvement Project Maps

1. INTRODUCTION

This Level I watershed study was prepared under contract to the Wyoming Water Development Commission (WWDC). The Weston County Natural Resource District (WCNRD) in Newcastle, Wyoming, is the project sponsor, and the plan was prepared on behalf of the landowners, land managers, stewards, and visitors of the Beaver Creek watershed. Olsson Associates (Olsson) completed the study in collaboration with Steady Stream Hydrology Inc. of Sheridan, Wyoming, Ron E. Vore, Ph.D. of Sundance, Wyoming and Keith Culver of Newcastle, Wyoming.

1.1. Watershed Study Overview

1.1.1. What is a Watershed Study?

A watershed study is holistic evaluation of an area that is interconnected by water. A Level I watershed study evaluates the current condition of an area and looks at opportunities for water improvement projects that will restore, maintain, and enhance healthy watershed function. Specifically, a Level I watershed study looks for projects, programs, or activities that support sustainable, beneficial water use for current and future watershed residents – be they human, animal, or plant. The study is comprehensive in that it evaluates many aspects of the natural setting to ensure that any proposed projects that are beneficial to one water user, are indeed beneficial to the watershed as a whole. A holistic approach to watershed management was made a keystone by the WWDC when the watershed program was developed.

Photo 1 Irrigation ditch and hay fields in Weston County.

Since the program was initiated, the Wyoming Legislature has authorized watershed studies across the state of Wyoming as illustrated in Figure 1.1.1. The studies are initiated to assist project sponsors, prioritize watershed management improvements, and ensure that any proposed projects are feasible, cost effective, and will indeed provide a positive benefit to the area.

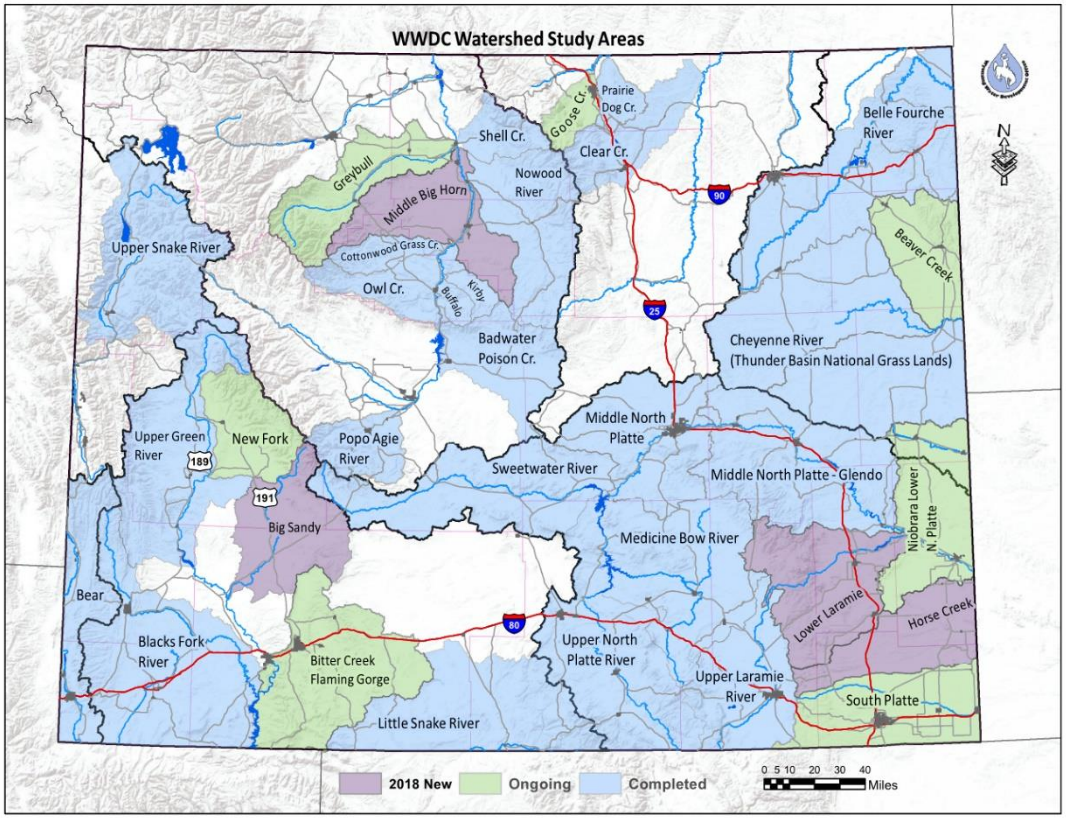

Figure 1.1.1 Wyoming Water Development Commission Watershed Study Areas.

In a WWDC newsletter, the four key issues for consideration in a watershed information and review study included water storage, irrigation infrastructure, upland water development, and stream channel condition. As stated in the newsletter, “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” (WWDC 2009).

1.1.2. The Beaver Creek Watershed Study Area

The Beaver Creek watershed is located primarily in Weston County, with a small tip on the north end in Crook County and on the southern end of the watershed in Niobrara County. The watershed covers over 884,000 acres and is defined by the interconnected stream drainage area of Beaver Creek and its numerous tributaries, including Skull, Oil, West Plum, Sweetwater, Salt, Stockade Beaver, and Sheep Creek and numerous other drainages. As illustrated in Figure 1.1.2, the watershed is connected by the surface water drainages of Beaver Creek, where any raindrop or snowflake that falls within this geographic area, will flow out of the study area into South Dakota just south of the Weston and Niobrara County line.

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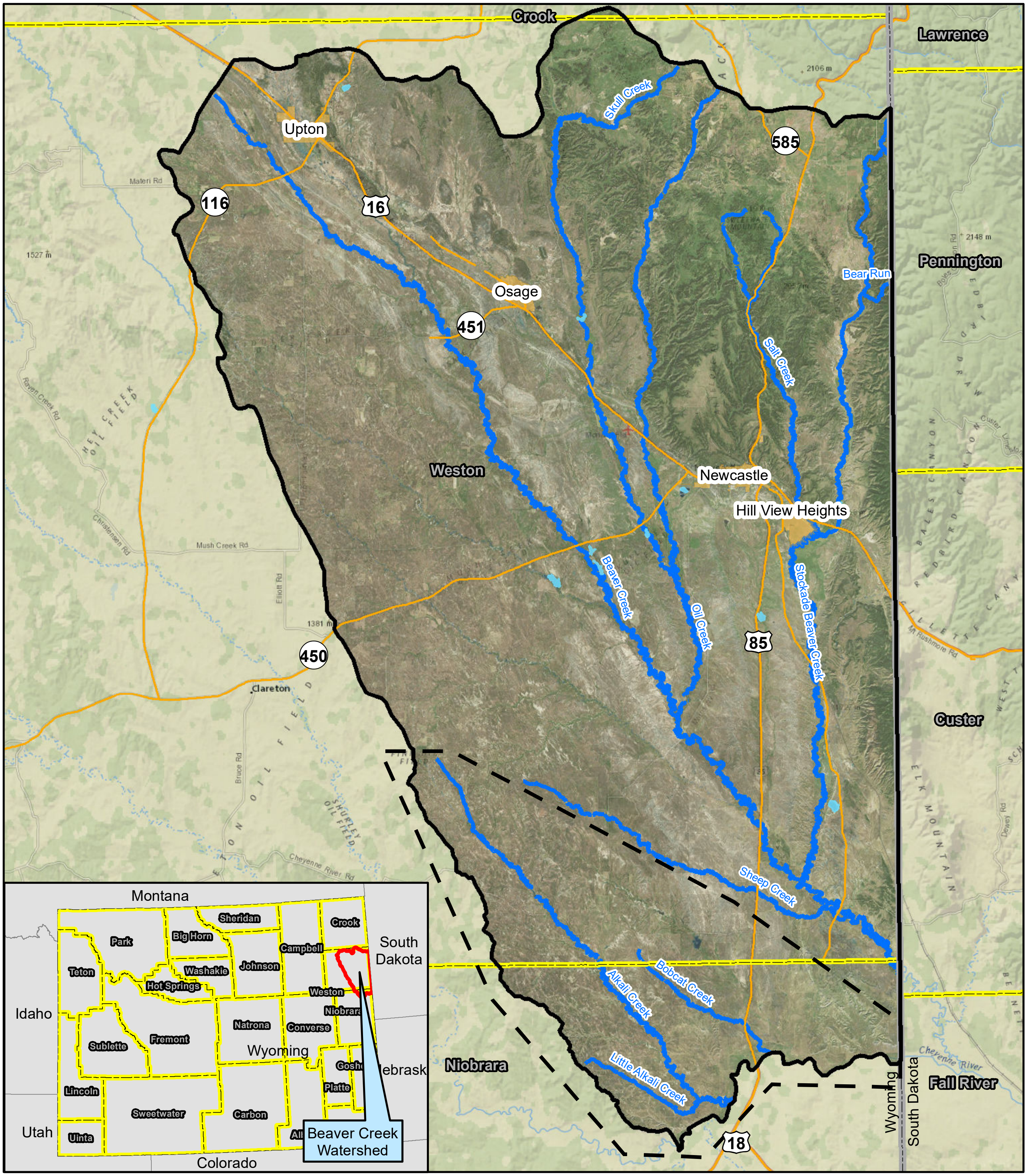

Major Rivers and Streams
Major Road
Municipal Area
Major Body of Water
Area Added to Watershed Study
State Border
County Border
Beaver Creek Watershed

Sources:
USCB Tiger Roads (2016), Places (2016),
County Boundary (2014), State Boundaries (2016)
USGS NHD Flowlines (2016)
ESRI World Imagery (2018)

OLSSON ASSOCIATES

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1 " = 35,000 '
Original Published Resolution
NAD 1983 UTM Zone 12N
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WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Location Map

FIGURE
1.1.2

As described, the watershed study area is not defined by political subdivisions or boundaries such as counties or roads but by the water system that sustains it.

At the beginning of this project, the project sponsor, WCNRD and the WWDC, decided to expand the study area to the south to include Bobcat, Alkali, and Little Alkali creeks. These three creeks drain into the Cheyenne River, but they were not included in the adjacent Thunder Basin watershed study. By including this small area of the Cheyenne watershed in the Beaver Creek study area, this project contains drainages that may otherwise have been missed in additional watershed studies. Furthermore, the area that encompasses Bobcat, Alkali, and Little Alkali creeks has issues in common with the Beaver Creek watershed that can be addressed as part of this study. Therefore, for the purposes of this study and this report, the Beaver Creek watershed includes the entire Beaver Creek watershed in the state of Wyoming and the three creeks (Bobcat, Alkali, and Little Alkali) that are adjacent to the south in the Cheyenne watershed (Figure 1.1.2, Location Map).

1.2. Key Issues in the Watershed

The WCNRD requested this Level I watershed be conducted to address specific issues that are affecting the area. Initially, the WCNRD board of directors was asked to identify its top concerns. The issues were summed up in the watershed study application as follows:

> *We have minimal precipitation in our area, we do not have much surface water available for crops or livestock/wildlife. Water development is crucial to our communities, ranches, and wildlife.*

Throughout development of this watershed study, public meetings were held at the Natural Resources Conservation Service (NRCS) office in Newcastle, Wyoming, where landowners, ranchers, and interested citizens were invited to identify potential water development projects that would benefit their properties, their operations, and/or the area. The following list summarizes the recurring themes and issues identified by the attendees at the public meetings.

- There is a lack of adequate water for livestock and wildlife across most of the watershed
- Pipelines are needed to provide water to tanks across several pastures for rotational grazing
- Spring developments would benefit livestock and wildlife across dry areas
- Stock dams are silted in or washed out and no longer provide water for livestock/wildlife
- Irrigation diversion structures require replacement where damage has occurred
- Irrigation system improvements would provide optimization and conservation
- Converting windmills to solar power would provide a reliable energy source for stock wells

1.3. Purpose and Scope

The purpose of this Level I watershed study and management plan is to describe the Beaver Creek watershed in its current condition, to suggest resolutions for water-related issues, and to provide insight into opportunities for improvements.

1.3.1. Review of Existing Data and Digital Library

The first step of every watershed study is to collect and review existing scientific and engineering data on the watershed as a whole. Since the scope includes a description and inventory of scientific information on geology, hydrology, soils, climate, land use, plant communities, wildlife habitat, infrastructure, and the geomorphic characteristics of the watershed stream system, to name a few, this first step in the watershed evaluation can be very wide-ranging. Specifically, for the Beaver Creek watershed, the area has been studied because of its unique geologic, environmental, and ecological aspects. The primary sources of information used in this study were published scientific reports and datasets from the following federal and state agencies and local organizations:

- U.S. Environmental Protection Agency (EPA)
- U.S. Department of the Interior
    - Bureau of Land Management (BLM)
    - U.S. Geological Survey (USGS)
    - U.S. Fish and Wildlife Service (USFWS)
    - U.S. Bureau of Reclamation
- U.S. Department of Agriculture (USDA)
    - Farm Service Agency (FSA)
    - Forest Service (USFS)
    - Natural Resources Conservation Service (NRCS)
- Wyoming Department of Environmental Quality (WDEQ)
- Wyoming Game and Fish Department (WGFD)
- Wyoming Geographic Information Science Center (WyGISC)
- Wyoming Oil and Gas Conservation Commission
- Wyoming State Engineer's Office (WSEO)
- Wyoming State Geological Survey (WSGS)
- Wyoming Water Development Commission (WWDC)
- Wyoming Wildlife and Natural Resources Trust

The information gathered is presented in sections 2 and 3 – Watershed Inventory and Descriptions, and Streamflow Hydrology respectively. Electronic copies of the references, maps, images, spreadsheets, and datasets were assembled into a digital library that was provided to the project sponsor upon completion of the project.

1.3.2. Geographic Information System (GIS)

Much of the information gathered as part of the Level I watershed study is compiled into a GIS dataset. The GIS dataset is an electronic repository of the information gathered during the inventory and description phase of the project. The information includes mapped datasets on soil, geology, vegetation, wildlife, and infrastructure that is represented in a series of layers that can be evaluated spatially. With the GIS datasets, the WCNRD and the agencies that manage the public lands in the Beaver Creek watershed will have the opportunity to overlay a series of maps to discern patterns, site proposed projects, and/or refine project plans based on the information presented in the digital map sets. A list of the GIS layers developed for this project is provided in Data Summary 1.3 (in Appendix A).

As specified in the contract, the GIS data is provided in electronic format using Esri's ArcGIS version 10.4, which is the current industry standard for GIS datasets. Each map in this report contains a list of the data sources; the sources of information are also listed electronically in the metadata files. The two-dimensional maps represent three-dimensional features and; therefore, the datasets were transformed using the Universal Transverse Mercator System (UTM), Zone 13 North.

The Beaver Creek Level I Watershed Study differs from previous watershed studies because a new online watershed planning resource has been developed by the University of Wyoming in collaboration with the Wyoming Association of Conservation Districts. The new watershed planning tool is called SuiteWater and it is a web-based GIS interface that integrates spatial datasets for review and reference during watershed planning studies. With SuiteWater fully operational, the scope of GIS datasets compiled for this study was reduced relative to previous studies. Instead of downloading and compiling a comprehensive list of GIS datasets, the most current datasets related to watershed planning and evaluation were viewed and analyzed online using SuiteWater (Figure 1.3.2). This resource proved very useful for quick analysis of proposed watershed improvement planning. Because of the limited map making capabilities of SuiteWater, the maps generated for this report used the GIS datasets compiled for this project as listed in Data Summary 1.3 (in Appendix A).

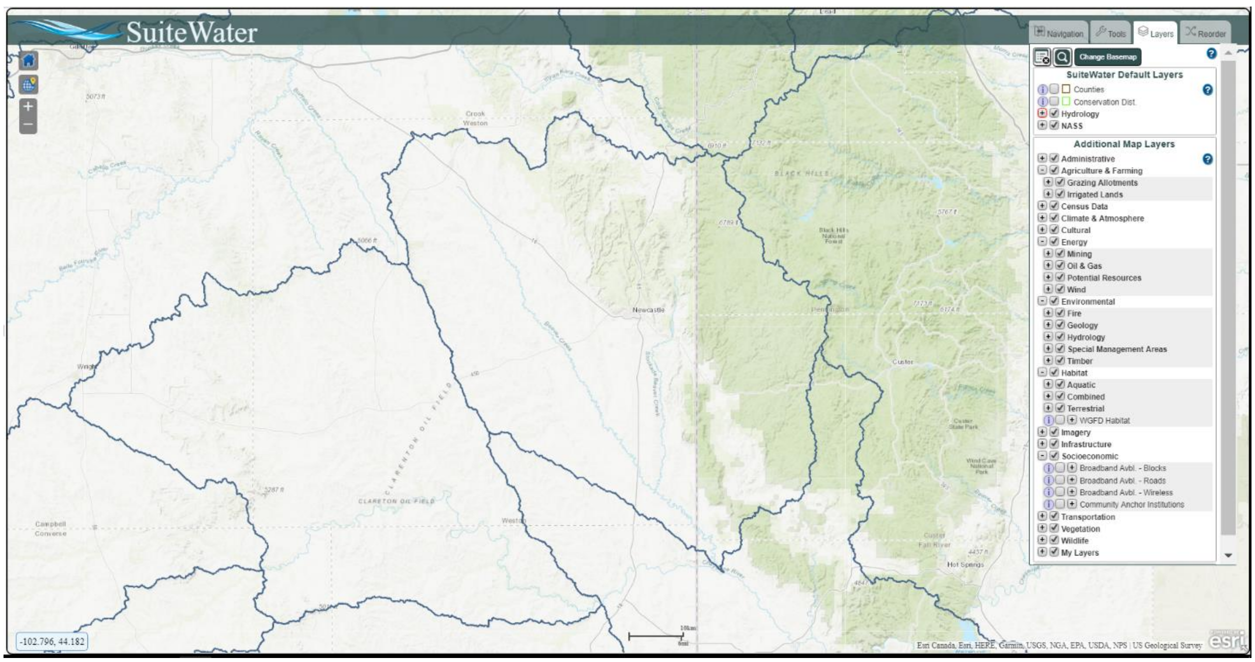


Figure 1.3.2 SuiteWater Online GIS System for Watershed Planning.

1.3.3. Watershed Management Plans and More

Ultimately, the final objective of this Level I watershed study is to provide plans for watershed management and rehabilitation that are practical, technically sound, feasible, and cost effective. Section 4 presents the watershed management plans for the Beaver Creek watershed that incorporate a wide variety of project types including the following:

- Livestock/Wildlife Watering Improvements
- Water Supply and Storage Improvements

- Irrigation System Improvements
- Other Management Project Improvements
- Stream Channel Condition and Stability Improvements

The conceptual plans for the improvements were developed by the Olsson project team of scientists and engineers in collaboration with local agencies and partners described throughout this document. Collaboration was important to ensure that the proposed projects were practical and feasible in the unique ecological setting and regulatory environment of the Beaver Creek watershed. Since the projects cannot be completed without adequate funding, opportunities for project financing through local, state, and federal agencies are presented in Section 6. Certain project improvements will require permitting; therefore, Section 7 describes many of the permits that will be required to complete specific enhancements.

Photo 2 Cattle grazing in Weston County.

2. WATERSHED INVENTORY AND DESCRIPTIONS

The first part of a Level I watershed study is to provide a description of the natural environmental features and resources of the area. To systematically describe this complex system, this section is divided into three main parts: the physical systems, the biological systems, and the anthropogenic systems. The following sections provide these descriptions as gathered from the cited sources and accompanying maps.

2.1. Physical Systems

2.1.1. Topography

The Beaver Creek watershed is unique because it straddles two well-known physiographic areas in Wyoming. To the west, the watershed is dominated by grasslands and much of the area is federally protected within the Thunder Basin National Grasslands. To the east, the watershed lies within the western flank of the Black Hills and instead of rolling grassland, the watershed has forested hills and high meadows with significant topographic relief.

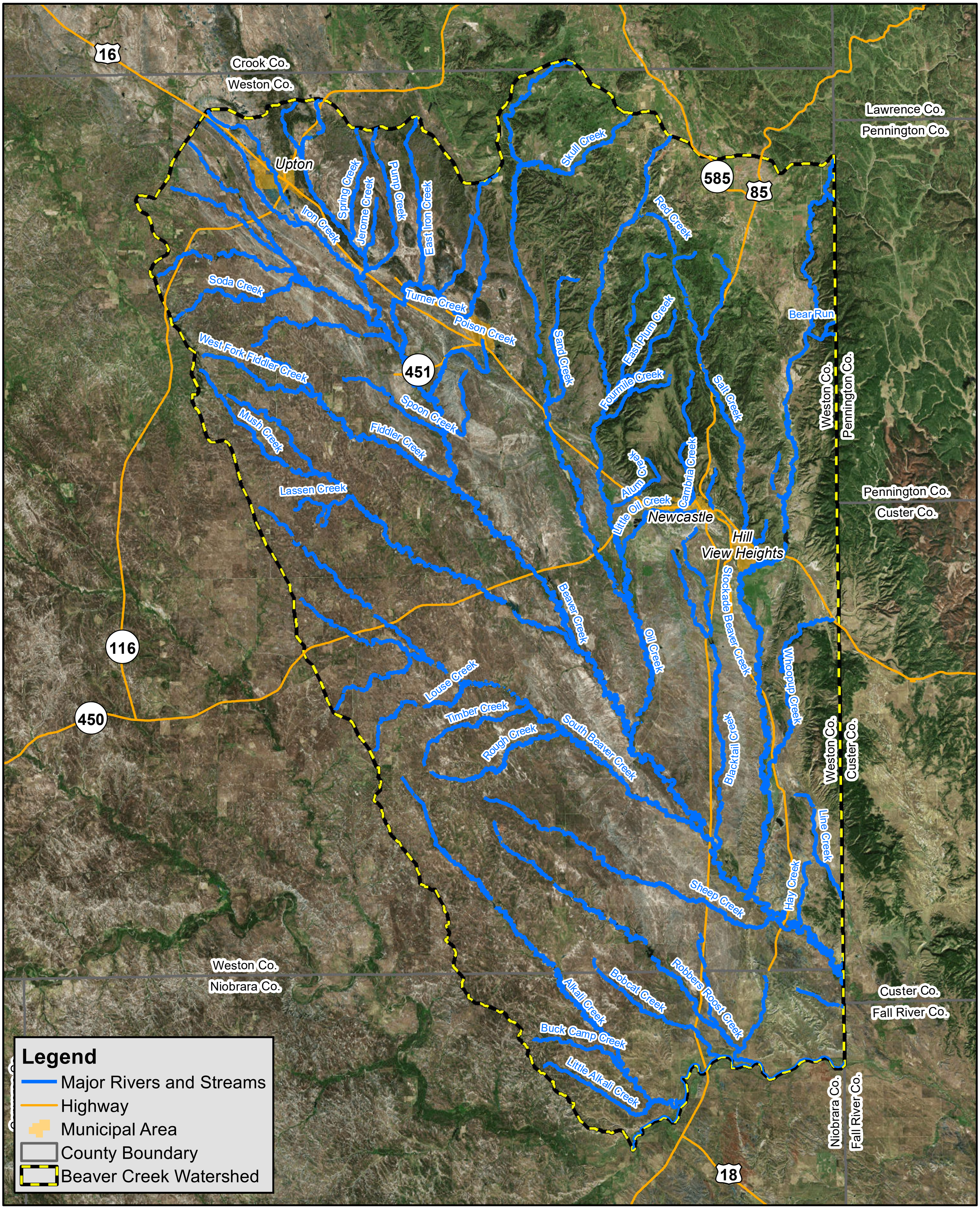
The Beaver Creek watershed covers approximately 1,382 square miles, or nearly 1.5 percent of Wyoming's surface area (Figure 1.1.2, Location Map). The watershed is located in northeastern Wyoming, stretching across the western Black Hills and the Thunder Basin National Grassland. The watershed covers 53.1 percent of Weston County and 4.1 percent of Niobrara County. The northern tip of the watershed covers less than 0.1 percent of the area of Crook County. Newcastle is the largest municipality in the watershed with a current population of 3,389 (U.S. Census Bureau 2017).

The Beaver Creek watershed falls within the Great Plains physiographic province and is divided into four primary land categories; The Pierre Shale Plains, Badlands, Black Hills, and Northern Rolling High Plains. The Pierre Shale Plains and Badlands is characterized by clay soil and gently rolling divides and hills around creeks and river valleys. Much of the basin consists of rolling prairie that is locally dissected into small areas of badlands. The Black Hills consists of steep-sided ridges, rocky hills, and plateaus. This mountainous country, in the form of a dissected plateau that slopes gently to the southwest and consists of broad even-topped divides separated by steep-sided canyons, can be found in the northeastern portion of the watershed. The Northern Rolling High Plains is characterized by flat lands and sandy soils.

Elevations in the watershed range from approximately 6,500 feet within the Black Hills region to 3,500 feet at the outlet point of the watershed in the southeast. The average elevation across the watershed is 4,200 feet above mean sea level.

2.1.2. Surface Water

Beaver Creek originates approximately 33 miles west of the Wyoming state line and flows from the northwest to the southeast across the watershed study area into South Dakota. Major drainageways and tributaries to Beaver Creek within the study area include Stockade Beaver Creek, Sweetwater Creek, Salt Creek, West Plum Creek, Oil Creek, Skull Creek, and Sheep Creek. As described in Section 1.1.2, the study area was expanded to include Bobcat Creek, Alkali Creek, and Little Alkali Creek, which all drain into the Cheyenne River. Major streams are shown in Figure 2.1.2-1. Additional hydrography information is shown in maps as described in subsequent sections.



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Niobrara and Weston Counties, Wyoming

Major Streams

FIGURE

2.1.2-1

2.1.2.1. *Hydrology*

The USGS uses a system of hydrologic map units to divide and subdivide the United States into successively smaller watersheds. The hydrologic map units are denoted by numeric hydrologic unit codes (HUC). The HUCs extend to 12 digits, which would be referred to as a twelfth order HUC. The Beaver Creek watershed lies within the following hydrologic map units:

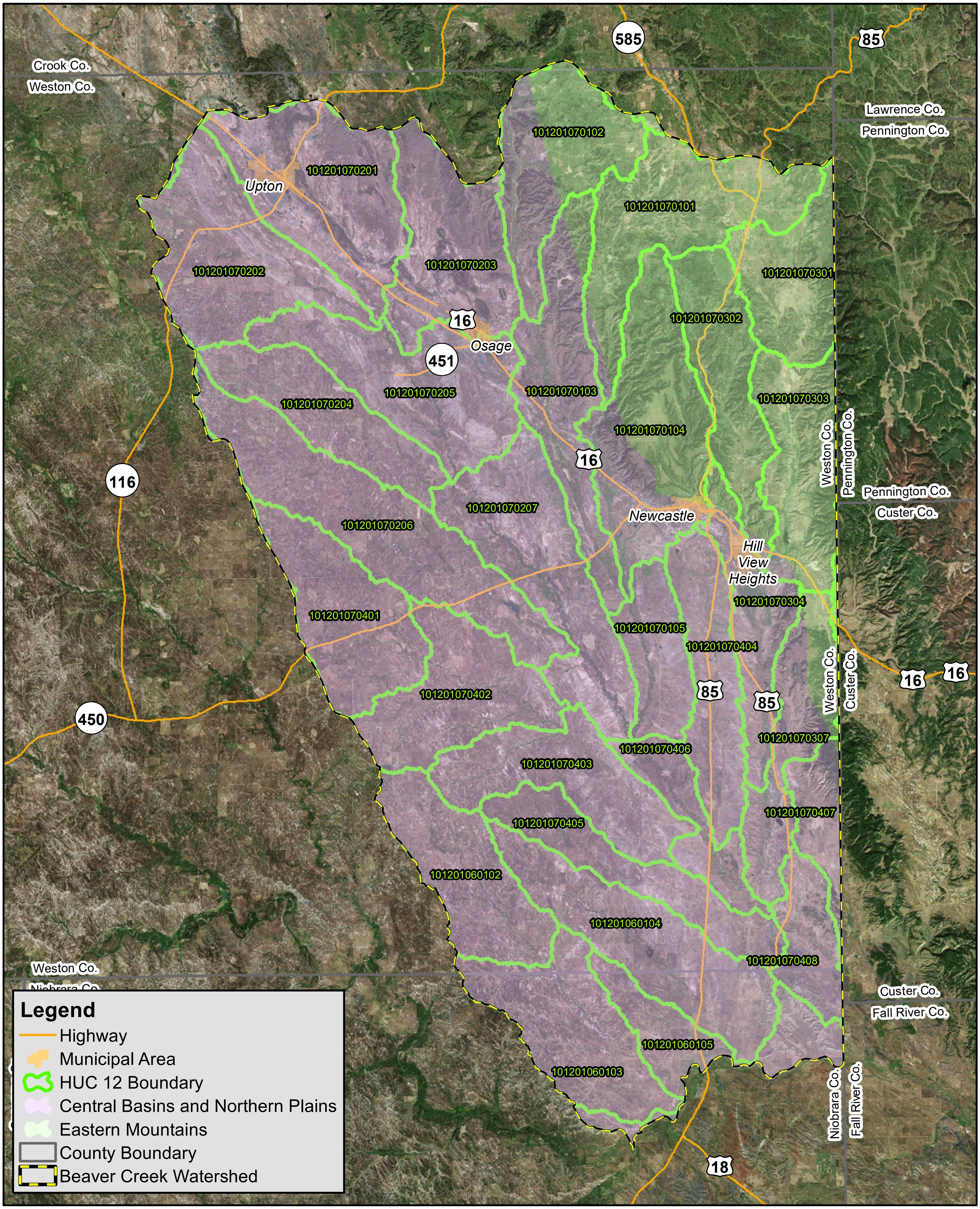
Region (Second order HUC):	10	Missouri Region
Subregion (Fourth order HUC):	1012	Cheyenne River Basin
Accounting Unit (Sixth order HUC):	101201	Cheyenne River Basin
Cataloging Unit (Eighth order HUC):	10120107	Beaver, South Dakota and Wyoming
Sub-basin (Tenth order HUC):	1012010701	Oil Creek
	1012010702	Upper Beaver Creek
	1012010703	Stockade Beaver Creek
	1012010704	Lower Beaver Creek
Sub-basin (Twelfth order HUC):		See Data Summary 2.1.2-1 in Appendix A

Figure 2.1.2-2 shows the HUCs for the study area to the twelfth order. Within the state of Wyoming, the majority of the study area lies within the Central Basins and Northern Plains region, with a portion of the eastern watershed identified to be in the Eastern Mountains region, as designated by Miller (2003). The Central Basins and Northern Plains region are semiarid to arid and with grasslands, shrublands, and some open woodlands. Measured annual peak flows show large variability year-to-year since the annual peaks are generally caused by moderate to very intense localized convective rainstorms. Most of the precipitation in the Eastern Mountains region occurs in March and April due to regional climate patterns. Many annual peak flows are the result of combined snowmelt and rainfall runoff or rainfall runoff alone. These regions are shown in Figure 2.1.2-2. The USGS developed regression equations for estimating peak flows (Miller 2003) within each of these regions.

The U.S. Army Corps of Engineers (USACE) (2017) defines different stream regimes as follows:

- A **perennial stream** has flowing water year-round during a typical year. The water table is located above the streambed for most of the year. Groundwater is the primary source of water for stream flow. Runoff from rainfall is a supplemental source of water for stream flow.
- An **intermittent stream** has flowing water during certain times of the year, when groundwater provides water for stream flow. During dry periods, intermittent streams may not have flowing water. Runoff from rainfall is a supplemental source of water for stream flow.
- An **ephemeral stream** has flowing water only during, and for a short duration after, precipitation events in a typical year. Ephemeral streambeds are located above the water table year-round. Groundwater is not a source of water for the stream. Runoff from rainfall is the primary source of water for stream flow.

Based on the National Hydrography Dataset (NHD) flowline layer, most of Beaver Creek, Skull Creek, and Stockade Beaver Creek within the study area are considered to be perennial for the majority of the stream length. Oil Creek upstream of the confluence with West Plum Creek and a small upstream portion of Skull Creek are also considered to be perennial. Alkali Creek, Bobcat Creek, Sheep Creek, the majority of Skull Creek, and West Plum Creek are considered to be intermittent. Only a very short reach of Stockade Beaver Creek at its upstream limit is identified as ephemeral (see Data Summary 2.1.2-2 in Appendix A). The stream types are shown in Figure 2.1.2-3.



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Niobrara and Weston Counties, Wyoming
HUC 12 Watersheds and Peak Flow Regions

FIGURE
2.1.2-2

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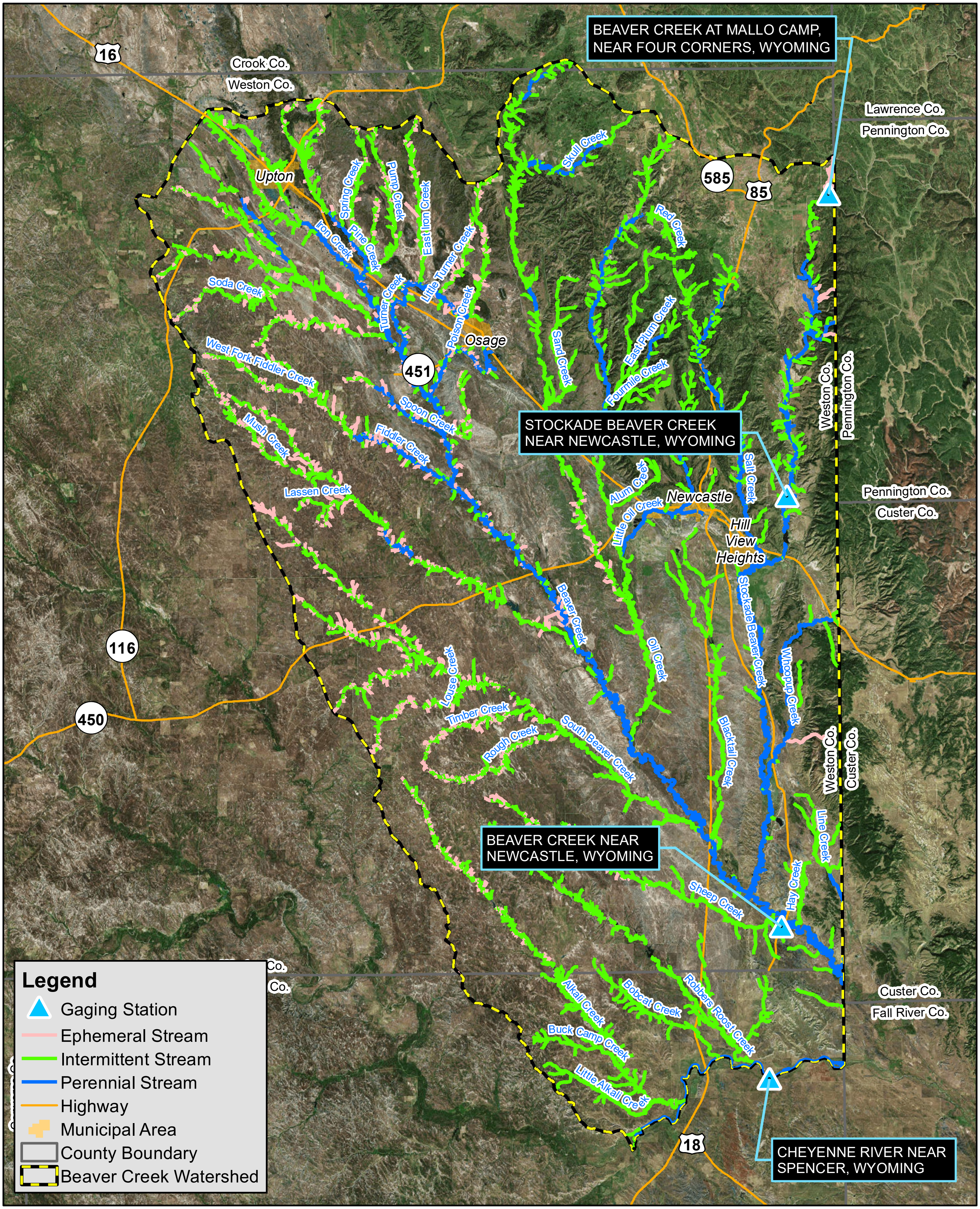

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WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Gaging Stations

FIGURE
2.1.2-3

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2.1.2.2. *Water Quality*

Many of the streams in the Beaver Creek study area have been classified for protection of one or more uses by the WDEQ. Streams within the study area have been classified as Class 2ABWW and Class 3B (WDEQ 2018). The Water Quality Rules and Regulations, Chapter 1, Wyoming Surface Water Quality Standards defines these two classifications as follows:

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

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

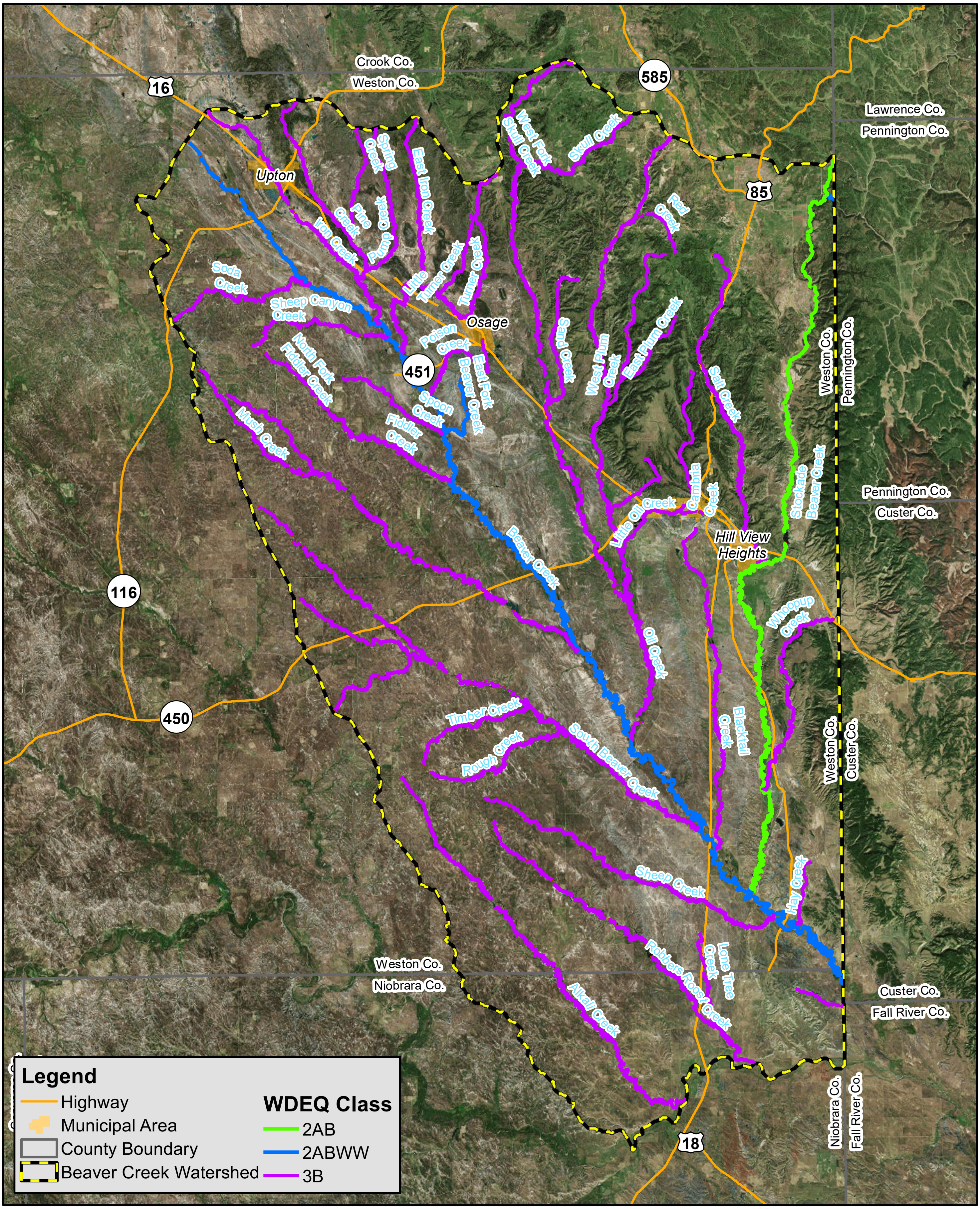
Table 2.1.2-1 defines the uses that are protected for all the WDEQ surface water classifications. Table 2.1.2-2 lists the streams in the Beaver Creek study area and their classifications. They are shown in Figure 2.1.2-4, WDEQ Stream Classifications.

Table 2.1.2-1 WDEQ Surface Water Classes and Use Designations.

Class	Drinking Water	Game Fish	Non-game Fish	Fish Consump-tion	Other Aquatic Life	Recre-ation	Wild-life	Agri-culture	Industry	Scenic Value
1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2AB	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2A	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
2B	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2C	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3A	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3B	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3C	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
4A	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4B	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4C	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes

Table 2.1.2-2 Surface Water Classifications in Study Area.

Stream	WDEQ Classification
Alkali Creek	3B
Alum Creek	3B
Beaver Creek	2ABWW
Blacktail Creek	3B
Cambria Creek	3B
East Fork Beaver Creek	2ABWW
East Iron Creek	3B
East Plum Creek	3B
Fiddler Creek	3B
Hay Creek	3B
Iron Creek	3B
Little Oil Creek	3B
Little Turner Creek	3B
Lone Tree Creek	3B
Mush Creek	3B
North Fork Fiddler Creek	3B
North Fork Lone Tree Creek	3B
North Fork Mush Creek	3B
Oil Creek	3B
Pine Creek	3B
Poison Creek	3B
Pump Creek	3B
Red Creek	3B
Robbers Roost Creek	3B
Rough Creek	3B
Salt Creek	3B
Sand Creek	3B
Sheep Canyon Creek	3B
Sheep Creek	3B
Skull Creek	3B
Soda Creek	3B
South Beaver Creek	3B
South Fork Lone Tree Creek	3B
Spoon Creek	3B
Spring Creek	3B
Stockade Beaver Creek	2AB
Timber Creek	3B
Turner Creek	3B
West Fork Skull Creek	3B
West Plum Creek	3B
Whoopup Creek	3B
Wildcat Creek	3B



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Niobrara and Weston Counties, Wyoming

Stream Classifications

FIGURE

2.1.2-4

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Water quality samples have been collected at two USGS gaging stations, 06394000 Beaver Creek near Newcastle, Wyoming and 06386500 Cheyenne River near Spencer, Wyoming, which is downstream of the confluences with Alkali Creek, Bobcat Creek, and Robbers Roost Creek. Table 2.1.2-3 lists the gaging stations, their periods of record, and the number of samples. The gages are shown in Figure 2.1.2-3, USGS Gaging Stations.

Table 2.1.2-3 USGS Gaging Stations with Water Quality Samples.

Station Number	Station Name	Water Quality Data Period of Record	Water Quality Data Samples
06386500	Cheyenne River near Spencer, Wyoming	5/14/1969 to 9/1/2015	300
06394000	Beaver Creek near Newcastle, Wyoming	10/30/1946 to 5/12/1986	260

Waters Requiring Total Maximum Daily Loads (TMDLs)

A TMDL is a “pollution budget and includes a calculation of the maximum amount of a pollution that can occur in a waterbody and allocates the necessary reductions to one or more pollutant sources” (EPA website 2016). A TMDL is a planning tool that considers restoration and protection activities with the goal of maintaining water quality standards. For each pollutant source of impairment, a TMDL must be established.

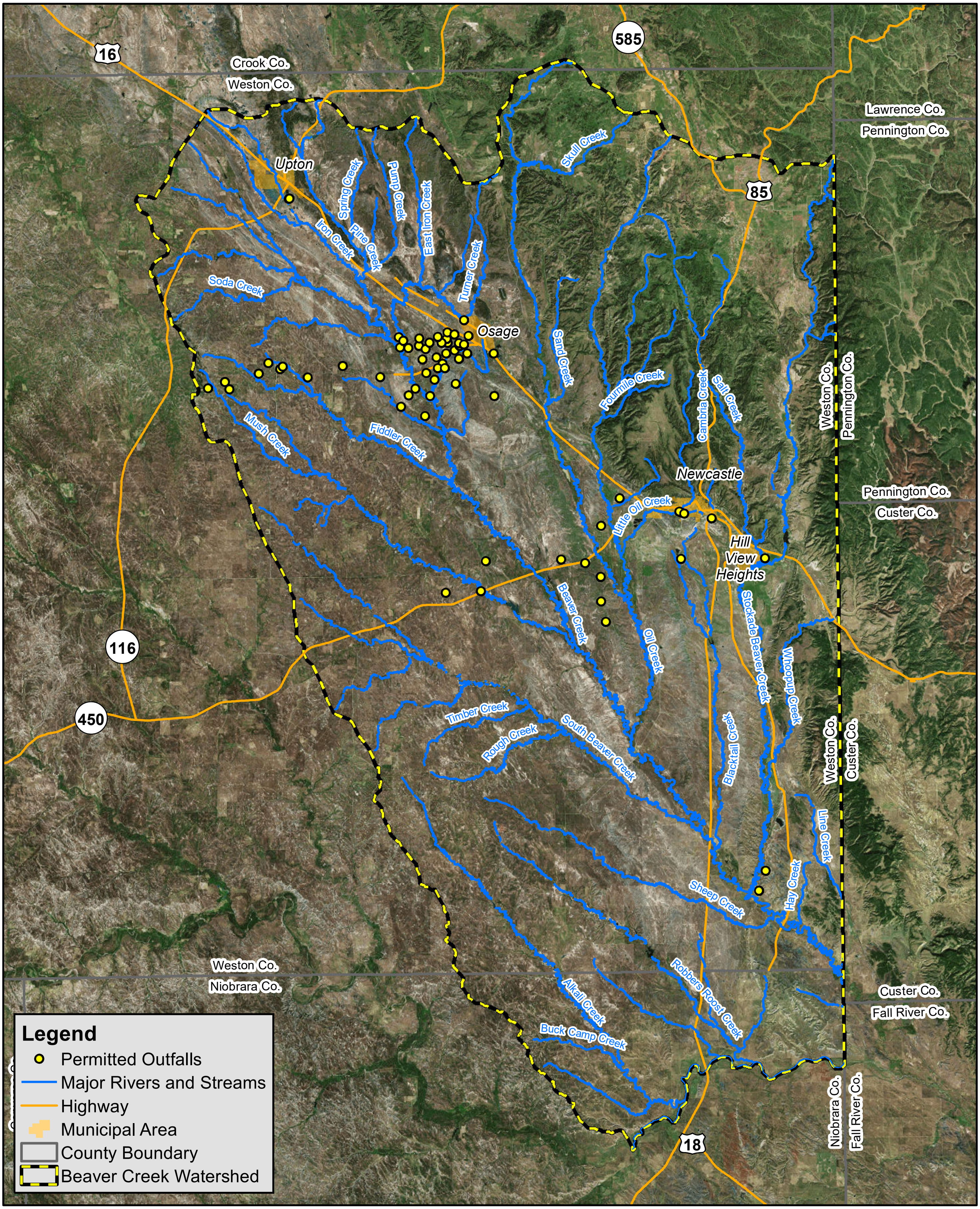
Under the Clean Water Act, the EPA requires all states to prepare and submit a "303(d) list," which is a term for the list of impaired and threatened waters (stream/river segments and lakes) in the state. States are required to submit the list for approval every two years during even numbered years.

Wyoming’s Draft 2016/2018 Integrated 305(b) and 303(d) Report (WDEQ 2018) shows that no streams are currently listed as impaired in the Beaver Creek watershed and adjoining study area. Poison Creek (WYCR101201070103_01) between the confluence with Beaver Creek to a point 7.3 miles upstream was added to the 303(d) List in 2002 because of the presence of small oil seeps known to reach Poison Creek. After cleanup efforts were conducted by the Wyoming Oil and Gas Conservation Commission, Poison Creek was removed from the 303(d) List in 2008.

A TMDL is in effect for Beaver Creek in South Dakota, downstream of the project area (Larson 2010). The TMDL is for fecal coliform bacteria from livestock, humans (septic systems), and wildlife. None of the five water samples taken in Wyoming exceeded South Dakota standards. Modeling of the watershed showed that uses in Wyoming were not a significant contributor of pollutants. Recommendations for improving the water quality in South Dakota include livestock exclusion and grazing management.

Wyoming Pollutant Discharge Elimination System (WYPDES) Permitted Discharges

Information obtained from the WDEQ/Water Quality Division (WQD) shows that there are 13 WYPDES industrial stormwater permitted outfalls and 68 additional permitted discharges in the study area. These permits consist of oil treaters, sanitary wastewater, and a couple of additional industrial uses. The locations of all the outfalls are shown in Figure 2.1.2-5, WYPDES Permitted Discharges. The industrial stormwater permitted outfalls are listed in Table 2.1.2-4, and the permitted outfalls are included in Data Summary 2.1.2-3, Permitted Outfalls in Appendix A.



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WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Permitted Outfalls

FIGURE
2.1.2-5

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Table 2.1.2-4 Wyoming Permitted Industrial Stormwater Outfalls.

Permit Number	Outfall Number	Facility Name	Permit Type	Permit Status
WYR001235	SW1	Upton #4 Landfill	Industrial Stormwater	In Effect
WYR000172	SW1	Dixon Brothers Newcastle Facility	Industrial Stormwater	In Effect
WYR000336	SW1	Mondell Field	Industrial Stormwater	In Effect
WYR000789	SW1	Newcastle Redi-Mix Plant	Industrial Stormwater	In Effect
WYR000837	SW1	Newcastle Yard	Industrial Stormwater	In Effect
WYR320251	SW1	Newcastle Quarry	Industrial Stormwater	In Effect
WYR320386	SW1	True Ranch Quarry	Industrial Stormwater	In Effect
WYR320037	SW1	Government Limestone Quarry	Industrial Stormwater	In Effect
WYR001270	SW1	Red Giant Oil Company (Newcastle Facility)	Industrial Stormwater	In Effect
WYR001302	SW1	City of Newcastle – Landfill #2	Industrial Stormwater	In Effect
WYR001344	SW1	Upton Regional Business Park – Warehouse Building	Industrial Stormwater	In Effect
WYR320801	SW1	Four Corners Pit	Industrial Stormwater	In Effect
WYR320802	SW1	Buckhorn Quarry	Industrial Stormwater	In Effect

2.1.2.3. *Flooding and Runoff*

The watershed does not contain any Federal Emergency Management Agency (FEMA) floodplains. Flooding concerns were not expressed during the project, including at meetings or at any site visits.

Photo 3 Burned area in the Oil Creek watershed.

In contrast, areas of the watershed have experienced damaging fires. Several landowners identified water improvement projects related to the Oil Creek fire of 2012 (see photo 3). Recently burned areas are highly susceptible to runoff and erosion. Best management practices to reduce potential sedimentation include seeding, mulching, weed control, contour log terraces where trees are available, straw wattles, and silt fences. The first four best management practices reduce runoff and erosion from burned areas, while the latter three reduce migration of sediment from the burned areas into drainageways. Additional information on the project requested in the Oil Creek fire burned area are presented in Section 4 – Watershed Management and Rehabilitation Plan.

2.1.3. Stream Geomorphology

The following section provides information on the stream geomorphology of the Beaver Creek watershed. Stream, or more precisely, fluvial geomorphology, is the study of how land is formed under the processes associated with running water. Over time, a natural stream channel at a given location establishes a cross section and planiform that reflect the quantity of water and the quantity and characteristics of sediment delivered to it from the drainage basin, as well as the imposed topography and local geologic conditions. Neither the water supplied (discharge) nor the quantity and distribution of sizes of the sediment load are delivered to the channel at a constant rate. All are subject to the variations of weather and climate, which dictate the magnitude, timing, and frequency of the range of flows and sediment delivered to a given channel reach. Thus, the channel experiences varying sequences of low and high flows, depending on runoff from the drainage basin. Largely because of the varying runoff, the amount of sediment supplied from the landscape and from sediments stored in, and adjacent to, the channel, varies as well (Emmett et al. 1983).

Alluvial channels, like the ones in the Beaver Creek watershed, composed of sediments deposited by the river, are free to adjust their form, and to a lesser extent, their gradient. Because of this, over time, an alluvial river develops a cross section and shape reflecting the quantities of water and sediment and the sizes of sediment brought to it. A variety of terms have been used to characterize streams and rivers flowing in alluvium, encompassing the concepts of adjustability and the tendency of a channel to develop a size and shape reflecting the range of flows and the quantity and characteristics of the sediment to which the channel is subjected. While erosion and deposition may take place, the channel neither aggrades (raises) nor degrades (lowers) its mean bed over time.

A variety of observations support the generalization that alluvial channels are adjustable and, over time, establish channel sizes and forms that are consonant with the flow and sediments available to them. In a given river reach, or length of stream, repeated measurements of cross sections of a channel reveal maintenance of the channel form as the river migrates across the valley floor (Leopold and Wolman 1960). In this section, measurements and descriptions of the fluvial geomorphology of the Beaver Creek watershed are described to better understand the erosional and depositional environment of the stream systems.

2.1.3.1. *Rosgen Stream Classification System*

The Rosgen Stream Classification System is a way of classifying and evaluating a stream system. The Rosgen system is widely accepted as the classification system of choice for watershed management activities. It is comprised of four levels, each being more detailed and site specific. Figure 2.1.3-1 shows the four inventory or assessment levels. Rosgen (2006) describes the following five objectives of this stream classification system:

- To predict a river's behavior from its appearance, based on documentation of similar responses from similar types for imposed conditions
- To stratify empirical hydraulic and sediment relations by stream type by state (condition) to minimize variance
- To provide a mechanism to extrapolate site-specific morphological data
- To describe physical stream relations to complement biological inventory and assist in establishing potential and departure states (conditions)
- To provide a consistent frame of reference for communicating stream morphology and condition among a variety of disciplines

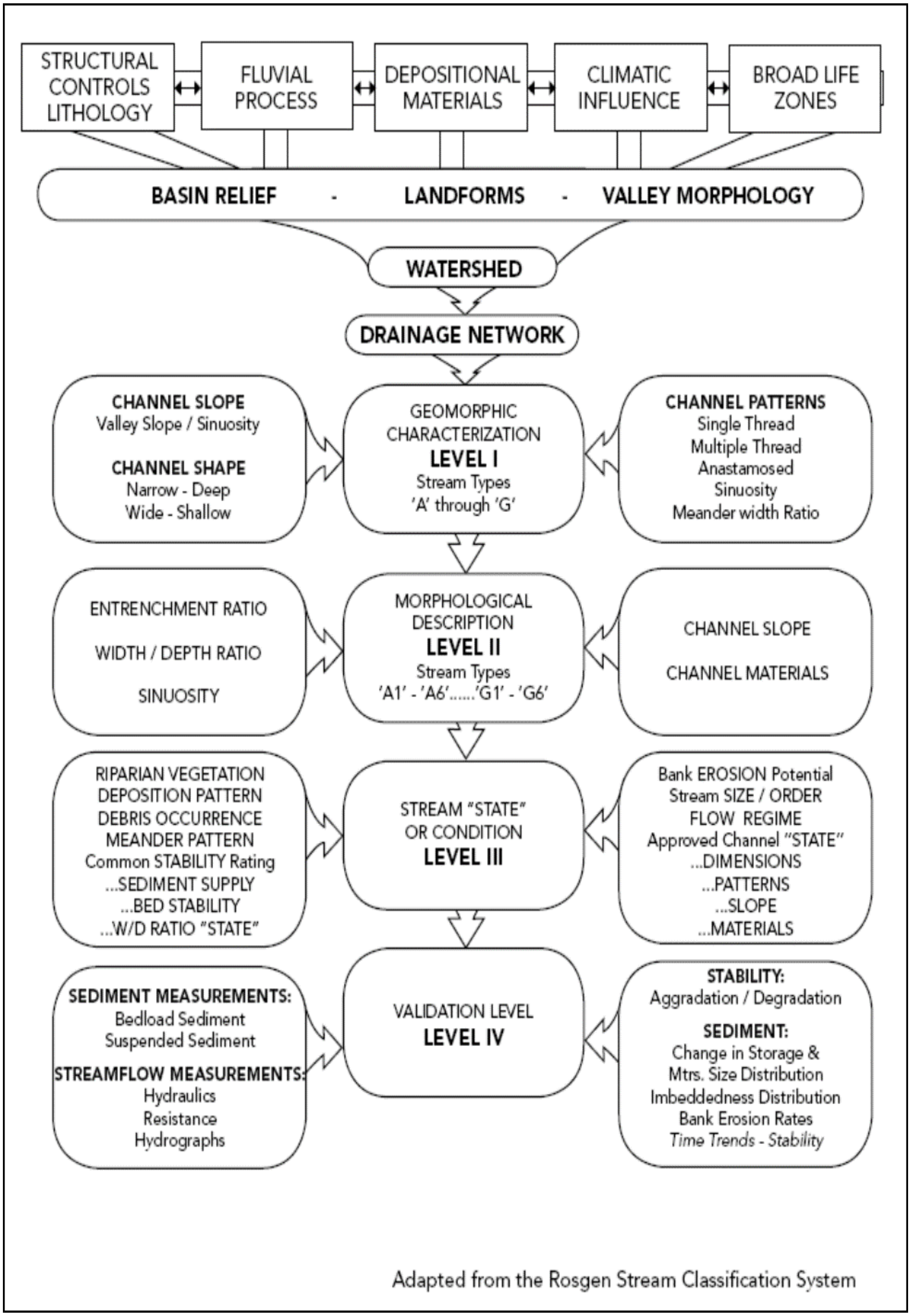


Figure 2.1.3-1 Rosgen's Four Inventory Assessment Levels.

As part of the Beaver Creek Level 1 watershed study, a Level 1 Rosgen channel classification was completed. This basic level of stream classification is based on morphological characteristics that result from the integration of basin relief, landform, and valley morphology. This coarse-scale level uses dimension, pattern, and profile to make determinations. Level I criteria is typically determined from topographic maps, landform maps, and/or aerial topography. Table 2.1.3-1 shows the general stream type descriptions and delineative criteria for a Level I classification. Disturbances to the channel, such as accelerated bank erosion or sediment supplies, can lead to channel changes and eventually stream type changes, as well. For example, there were evolutionary channel changes observed where an E-type channel originally was functioning at a higher base level that, over time, converted to a C, Gc, F, and now is back to a C-type channel at a lower base level.

2.1.3.2. *Level 1 Classification Methods*

For the Beaver Creek Level I Watershed Study, a Level I Rosgen channel classification was completed for the entire watershed. This Level I classification is intended to provide a general summary of the channel types (A through G) present within the watershed. The classification was completed using topographic maps and aerial photography (Google Earth) and limited field visits.

Level I stream classification is a general characterization of the stream within the watershed and is intended to be preliminary in nature. This level of classification makes use of readily available published information and relies on the experience of the observer. The first four delineative criteria for classification levels I and II are the same but vary greatly in the intensity of required data. Level II stream classification requires field measurements of the entrenchment ratio, width-to-depth ratio, slope, and sinuosity by establishment of a cross section and longitudinal profile.

To complete the Level I stream channel classification, an initial assessment of the streams included completing the following tasks:

- Map and identify the origin and character of landforms
- Overlay the drainage systems of interest
- Locate the terrace elevations to differentiate Pleistocene, Holocene, and modern depositional features

After the initial assessment is complete, the following sequence of analysis is used in the Level I stream channel classification:

1) Overlay the river system on the fluvial landscape to get the following:
    - General channel slope (steep/flat)
    - Channel bed features (step/pool or riffle/pool)
    - Estimate of channel shape (general width/depth ratio categories – less than 12; 12 to 40; and more than 40)
    - Pattern and profile to show floodplain extent
    - Plan view pattern (single or multiple channels)
    - Confinement (entrenchment slight, moderate, entrenched) or lateral containment (yes or no)
2) Delineation of Valley Types and Landforms
    - Landforms (alluvial fans, glacial and/or fluvial terraces, floodplains, hanging valleys)
    - Valley Types I through X (see Rosgen 1994)

Table 2.1.3-1 General Stream Type Descriptions.

Stream Type	General Description	Entrenchment Ratio	Width to Depth Ratio	Sinuosity	Slope	Landform/Soils/Features
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.	<1.4	<12	1.0 to 1.1	>.10	Very high relief. Erosional, bedrock or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with deep scour pools; waterfalls.
A	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.	<1.4	<12	1.0 to 1.2	.04 to .10	High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step/pool bed morphology.
B	Moderately entrenched, moderate gradient, riffle dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks.	1.4 to 2.2	>12	>1.2	.02 to .039	Moderate relief, colluvial deposition, and/or structural. Moderate entrenchment and width/depth ratio. Narrow, gently sloping valleys. Rapids predominate with scour pools.
C	Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well defined floodplains.	>2.2	>12	>1.2	<.02	Broad valleys with terraces, in association with floodplains, alluvial soils. Slightly entrenched with well-defined meandering channels. Riffle/pool bed morphology.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks.	N/A	>40	N/A	<.04	Broad valleys with alluvium, steeper fans. Glacial debris and depositional features. Active lateral adjustment, with abundance of sediment supply. Convergent/divergent bed features, aggradational processes, high bedload and bank erosion.
DA	Anastomosing (multiple channels) narrow and deep with extensive, well-vegetated floodplains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable streambanks.	>2.2	Highly variable	Highly variable	<.005	Broad, low-gradient valleys with fine alluvium and/or lacustrine soils Anastomosed (multiple channel) geologic control creating fine deposition with well-vegetated bars that are laterally stable with broad wetland floodplains. Very low bedload, high wash load sediment.
E	Low gradient, meandering riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander width ratio.	>2.2	<12	>1.5	<.02	Broad valley/meadows. Alluvial materials with floodplains. Highly sinuous with stable, well-vegetated banks. Riffle/pool morphology with very low width/depth ratios.
F	Entrenched meandering riffle/pool channel on low gradients with high width/depth ratio.	<1.4	>12	>1.2	<.02	Entrenched in highly weathered material. Gentle gradients, with a high width/depth ratio. Meandering, laterally unstable with high bank erosion rates. Riffle/pool morphology.
G	Entrenched "gully" step/pool and low width/depth ratio on moderate gradients.	<1.4	<12	>1.2	.02 to .039	Gullies, step/pool morphology with moderate slopes and low width/depth ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials, i.e., fans or deltas. Unstable, with grade control problems and high bank erosion rates.

2.1.3.3. *Level 1 Classification Results*

The results of the Level 1 Rosgen Stream Classification are graphically displayed on Figure 2.1.3-2, Major Streams with Rosgen Classification, and summarized on Data Summary 2.1.3 in Appendix A. The 14 classified streams in the Beaver Creek watershed are also represented graphically in Figures 2.1.3-3 and 2.1.3-4. Throughout the Beaver Creek watershed there were 14 streams classified into a total of 96 separate stream reaches. Below are the number of classified stream reaches per stream.

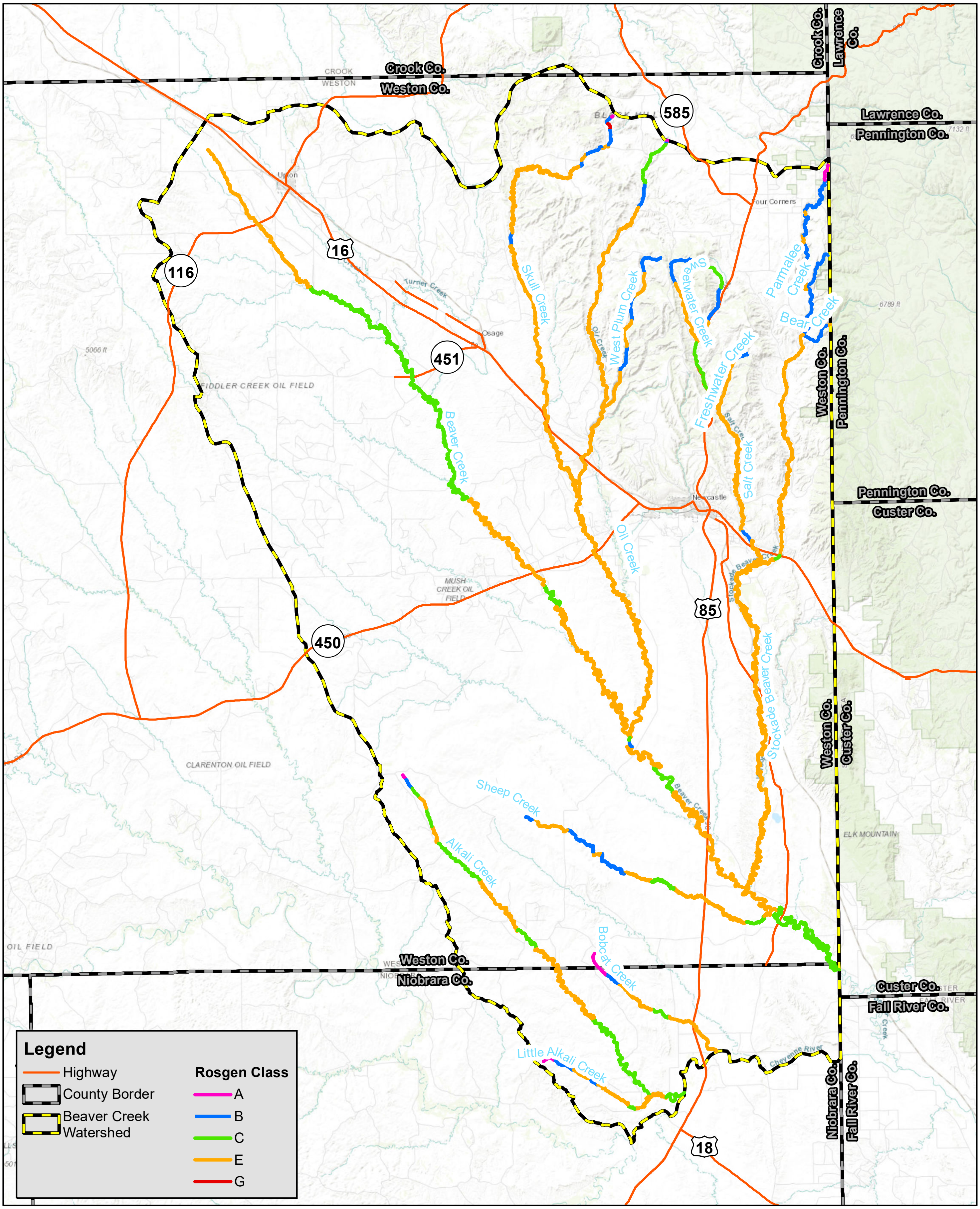
- Beaver Creek - 11
- Stockade Beaver Creek - 9
- Parmalee Creek - 2
- Bear Creek - 2
- Salt Creek - 8
- Sweetwater Creek - 3
- Freshwater Creek - 2
- Oil Creek - 7
- West Plum Creek - 6
- Skull Creek - 11
- Sheep Creek - 10
- Alkali Creek - 13
- Little Alkali Creek - 7
- Bobcat Creek - 5

Results showing percentages and lengths of stream types for the entire Beaver Creek watershed are listed in Table 2.1.3-2.

Table 2.1.3-2 Beaver Creek Watershed Stream Type Percentage and Length.

Watershed	Channel Type	Percent	Reach Length (Miles)
Beaver Creek	A	0.84	3.33
	B	10.17	40.22
	C	23.41	92.60
	D	0.00	0.00
	E	65.50	259.14
	F	0.00	0.00
	G	0.09	0.34
Beaver Creek Total		100.00	395.63

The results represent the fact that the Beaver Creek watershed streams are driven by spring runoff and from higher elevation snow. Runoff events occur typically from late April through June. Flows taper and vary, depending on spring rain storms, into the middle/end of June. As previously described, the landscape within the Beaver Creek watershed includes both grasslands to the west and south as well as the western flank of the Black Hills where the streams are often found in more confined valleys. However, even in the upper reaches the valley bottoms are sometimes very wide and flat with predominantly E type channels. In the highest stream reaches of the watershed, (north, northeast, and northwest) the streams are naturally very small to convey melting snow in spring and are nearly nonexistent later in the season because of a lack of water. Lower reaches tend to classify as E type channels (where slope decreased and sinuosity increased) and C type channels (where point bars and prominent floodplains formed).



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NAD 1983 StatePlane Wyoming East FIPS 4901 Feet

ESRI World Topo

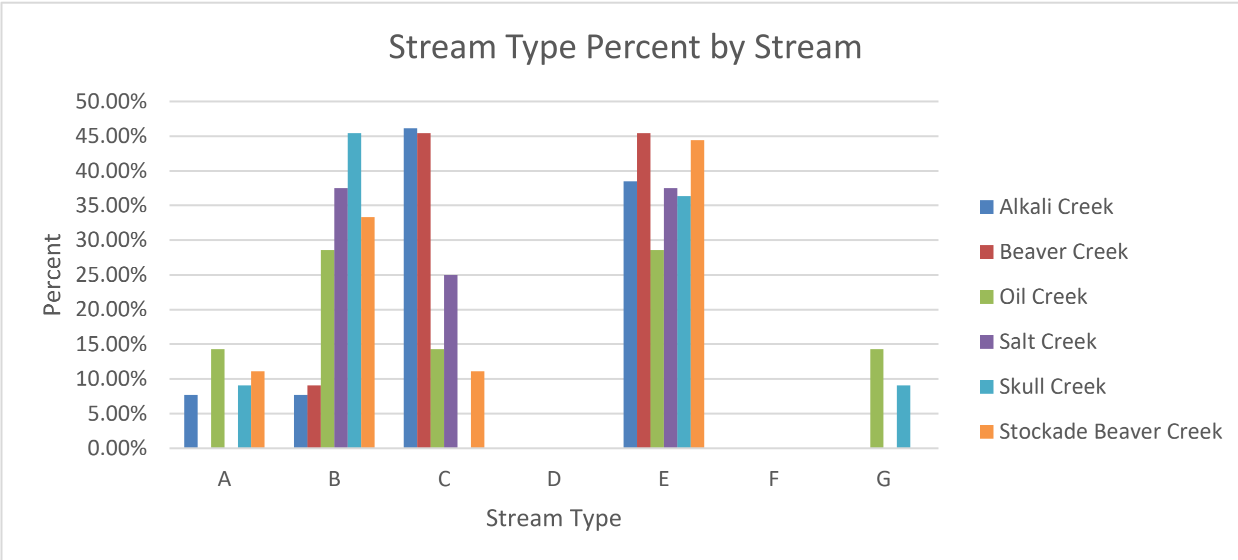
Beaver Creek Watershed Study

Niobrara and Weston Counties, Wyoming

Major Streams With Rosgen Classification

FIGURE

2.1.3-2



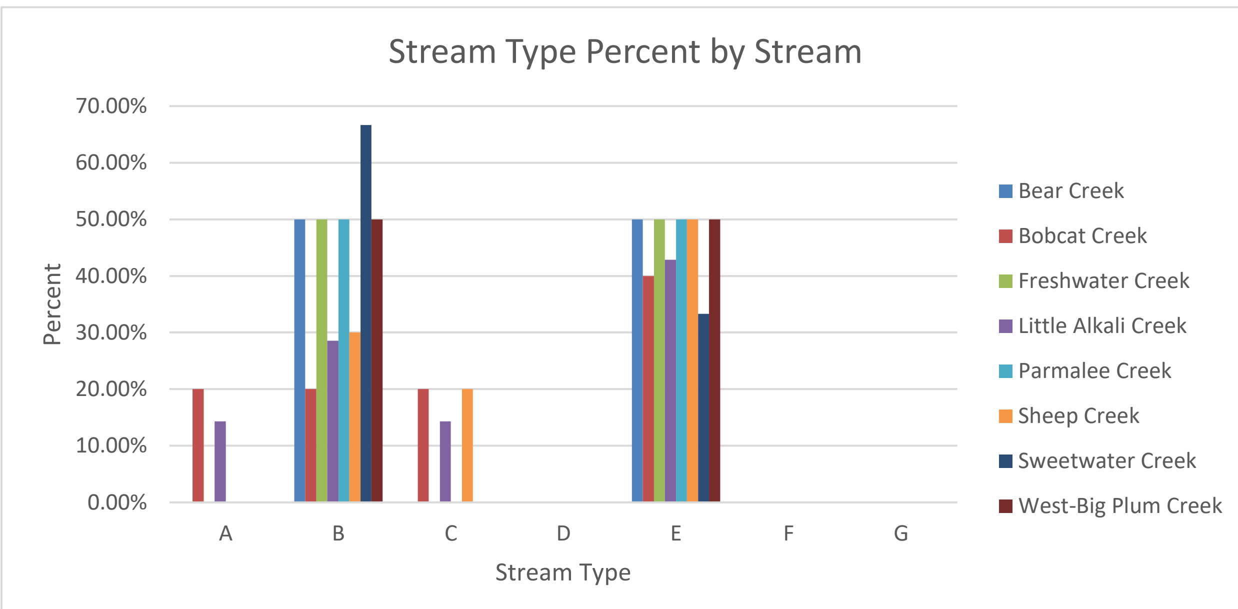
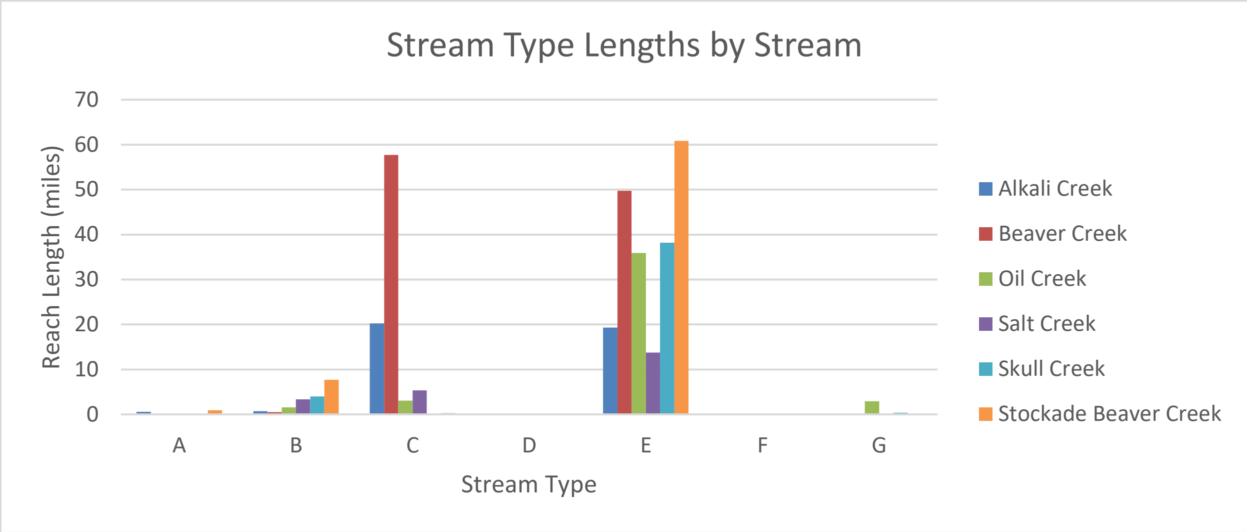


Figure 2.1.3-3 Stream Type Percent by Stream.



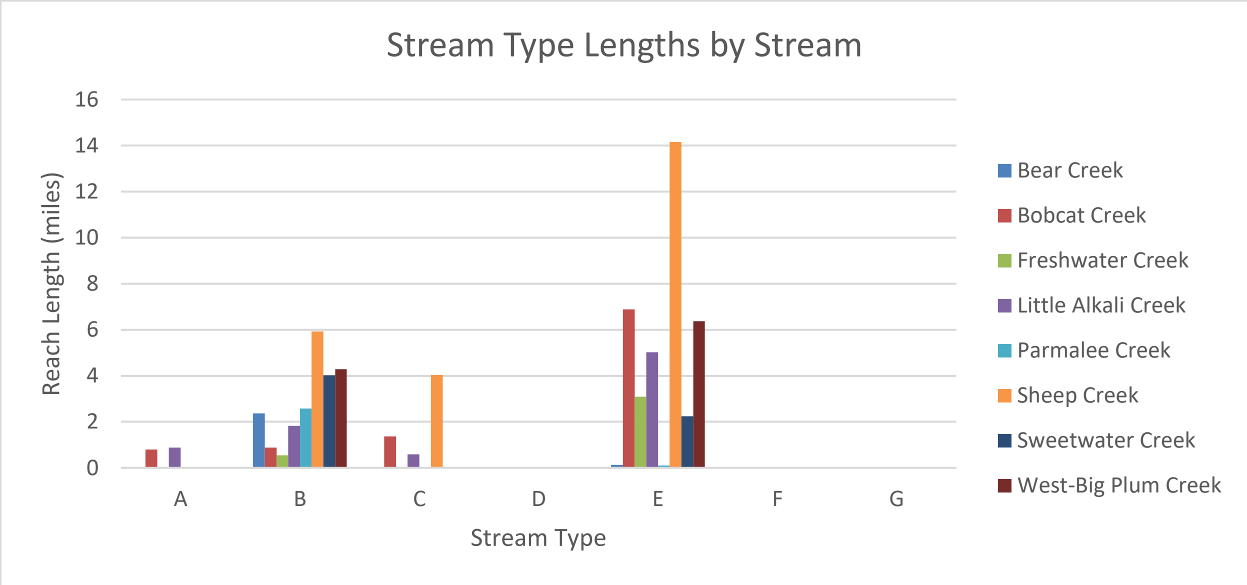


Figure 2.1.3-4 Stream Type Length by Stream.

The northern portion of the Beaver Creek watershed consists of its truest headwaters that arise in the north and west part of the watershed. In the most northern portions of these tributaries the channels were observed as types A, B, and E. The channels begin steeper, mostly as Bs, and then flatten into narrow, winding E channels and then C channels as the valleys become less confined.

The Level 1 stream classification is a high-level generalized classification. Various sites were field verified as possible to validate the Level 1 classification. Details that are not apparent from the aerial photos were observed in the field. Each location contains associated photos and stream type percent tables. Following the verified stream classification sites are the remaining streams and stream type percent tables.

Stockade Beaver Creek – The photos below were taken approximately 3.5 miles north of U.S. Highway 16 on the dirt road paralleling Stockade Beaver Creek. Near the gage station, the stream was thought to be possible G- or even F-type channels because of slight entrenchment, however the channel here was classified as C (see photos 4 and 5). It was given a C-type classification because of its aerial meander pattern, entrenchment ratio, and flood plain access. In photo 6, upstream of the gage station, the stream was verified as an E-type channel.

Photo 4 Stockade Beaver Creek and Gage Station.

Photo 5 Stockade Beaver Creek near the Gage Station.

Photo 6 Stockade Beaver Creek upstream of the Gage Station.

Table 2.1.3-3 Stockade Beaver Creek Percentage of Length by Stream Type.

Reach Name	Channel Type	Percent of Length	Stream Length (Miles)
Stockade Beaver Creek	A	1.32	0.92
	B	11.01	7.68
	C	0.43	0.3
	D	0.00	0
	E	87.24	60.87
	F	0.00	0
	G	0.00	0
Stockade Beaver Creek Total		100.00	69.77

Salt Creek – Salt Creek photos 7 and 8 below were taken approximately 1.4 miles north of U.S. Highway 16 on the dirt road paralleling Salt Creek. The photos verified Salt Creek's classification as a C-type stream because of the healthy floodplain and terrace features. Some reaches of Salt Creek were identified as E-type channels where there was increased confinement and sinuosity.

Photo 7 Salt Creek looking downstream 1.4 miles north of U.S. Highway 16.

Photo 8 Salt Creek looking upstream 1.4 miles north of U.S. Highway 16.

Table 2.1.3-4 Salt Creek Percentage of Length by Stream Type.

Reach Name	Channel Type	Percent of Length	Stream Length (Miles)
Salt Creek	A	0.00	0
	B	15.05	3.38
	C	23.78	5.34
	D	0.00	0
	E	61.18	13.74
	F	0.00	0
	G	0.00	0
Salt Creek Total		100.00	22.46

Oil Creek – The Oil Creek photos below were a very good verification for both the stream types and the valley types during the assessment process. For the first 2-3 miles north of U.S. Highway 16 on the dirt road paralleling Oil Creek, it is very apparent there was a historic fire to the east of the stream, yet the channel is very stable.

Photo 9 indicates Valley Type verification as an Alluvial Valley type VIII – Alluvial valleys fill with well-developed floodplains. Photos 10 and 11 were taken 2.7 miles north of U.S. Highway 16 on the dirt road paralleling Oil Creek and verified the stream as being an E-type channel. Photo 12 was taken nearly 1 mile further north and field verification classed the stream as mainly a G-type channel otherwise known as a gully. Although some small sections of Oil Creek are entrenched, the channel features indicate an E-type channel.

Photo 9 Oil Creek with valley type verification.

Photo 10 Oil Creek looking downstream 2.7 miles north of U.S. Highway 16.

Photo 11 Oil Creek looking upstream 2.7 miles north of U.S. Highway 16.

Photo 12 Oil Creek looking upstream 3.7 miles north of U.S. Highway 16.

Table 2.1.3-5 Oil Creek Percentage of Length by Stream Type.

Reach Name	Channel Type	Percent of Length	Stream Length (Miles)
Oil Creek	A	0.18	0.08
	B	3.56	1.55
	C	7.05	3.07
	D	0.00	0
	E	82.51	35.94
	F	0.00	0
	G	6.70	2.92
Oil Creek Total		100.00	43.56

West Plum Creek – West Plum Creek is very thick with vegetation and stable throughout most of its lengths. Field verification photos were helpful in the classification process. The following photos were taken north of U.S. Highway 16, approximately 3.3 miles paralleling Oil Creek, and then about 1.3 miles to the northeast along West Plum Creek. There were very small sections of G-type stream channel, but it was all classified and documented as E-type in this location. Photo 13 is looking back down the valley at the thick cover and photo 14 is looking upstream indicating very similar landscape characteristics.

Photo 13 Looking downstream 1.3 miles northeast along West Plum Creek.

Photo 14 Looking upstream 1.3 miles northeast along West Plum Creek.

Table 2.1.3-6 West Plum Creek Percentage of Length by Stream Type.

Reach Name	Channel Type	Percent of Length	Stream Length (Miles)
West Plum Creek	A	0.00	0
	B	40.24	4.29
	C	0.00	0
	D	0.00	0
	E	59.76	6.37
	F	0.00	0
	G	0.00	0
West Plum Creek Total		100.00	10.66

Skull Creek – The following photos for stream classification field verification on Skull Creek were taken 5.3 miles north of U.S. Highway 16 (4.5 miles northeast of the town of Osage) on a dirt road paralleling Skull Creek. Skull Creek was verified in field as a very stable E-type channel with wide hayfield floodplains. Photo 15 was taken from the top of a terrace as the road down to the stream was muddy and inaccessible during the field visit.

Photo 15 Skull Creek 5.3 miles north of U.S. Highway 16.

Table 2.1.3-7 Skull Creek Percentage of Length by Stream Type.

Reach Name	Channel Type	Percent of Length	Stream Length (Miles)
Skull Creek	A	0.23	0.1
	B	9.30	3.96
	C	0.00	0
	D	0.00	0
	E	89.67	38.19
	F	0.00	0
	G	0.80	0.34
Skull Creek Total		100.00	42.59

The results of stream classifications for the remaining Beaver Creek watershed streams are presented in tables 2.1.3-8 through 2.1.3-15.

Table 2.1.3-8 Alkali Creek Percentage of Length by Stream Type.

Reach Name	Channel Type	Percent of Length	Stream Length (Miles)
Alkali Creek	A	1.37	0.56
	B	1.69	0.69
	C	49.55	20.21
	D	0.00	0
	E	47.39	19.33
	F	0.00	0
	G	0.80	0
Alkali Creek Total		100.00	40.79

Table 2.1.3-9 Bear Creek Percentage of Length by Stream Type.

Reach Name	Channel Type	Percent of Length	Stream Length (Miles)
Bear Creek	A	0.00	0
	B	94.80	2.37
	C	0.00	0
	D	0.00	0
	E	5.20	0.13
	F	0.00	0
	G	0.00	0
Bear Creek Total		100.00	2.5

Table 2.1.3-10 Bobcat Creek Percentage of Length by Stream Type.

Reach Name	Channel Type	Percent of Length	Stream Length (Miles)
Bobcat Creek	A	7.96	0.79
	B	8.87	0.88
	C	13.81	1.37
	D	0.00	0
	E	69.35	6.88
	F	0.00	0
	G	0.00	0
Bobcat Creek Total		100.00	9.92

Table 2.1.3-11 Freshwater Creek Percentage of Length by Stream Type.

Reach Name	Channel Type	Percent of Length	Stream Length (Miles)
Freshwater Creek	A	0.00	0
	B	15.11	0.55
	C	0.00	0
	D	0.00	0
	E	84.89	3.09
	F	0.00	0
	G	0.00	0
Freshwater Creek Total		100.00	3.64

Table 2.1.3-12 Little Alkali Creek Percentage of Length by Stream Type.

Reach Name	Channel Type	Percent of Length	Stream Length (Miles)
Little Alkali Creek	A	10.59	0.88
	B	21.90	1.82
	C	7.10	0.59
	D	0.00	0
	E	60.41	5.02
	F	0.00	0
	G	0.00	0
Little Alkali Creek Total		100.00	8.31

Table 2.1.3-13 Parmalee Creek Percentage of Length by Stream Type.

Reach Name	Channel Type	Percent of Length	Stream Length (Miles)
Parmalee Creek	A	0.00	0
	B	96.25	2.57
	C	0.00	0
	D	0.00	0
	E	3.75	0.1
	F	0.00	0
	G	0.00	0
Parmalee Creek Total		100.00	2.67

Table 2.1.3-14 Sheep Creek Percentage of Length by Stream Type.

Reach Name	Channel Type	Percent of Length	Stream Length (Miles)
Sheep Creek	A	0.00	0
	B	24.60	5.93
	C	16.72	4.03
	D	0.00	0
	E	58.69	14.15
	F	0.00	0
	G	0.00	0
Sheep Creek Total		100.00	24.11

Table 2.1.3-15 Sweetwater Creek Percentage of Length by Stream Type.

Reach Name	Channel Type	Percent of Length	Stream Length (Miles)
Sweetwater Creek	A	0.00	0
	B	64.22	4.02
	C	0.00	0
	D	0.00	0
	E	35.78	2.24
	F	0.00	0
	G	0.00	0
Sweetwater Creek Total		100.00	6.26

2.1.3.4. *Sediment Transport*

A significant aspect of fluvial geomorphology includes the understanding of sediment transport by river systems. Catastrophic sediment erosion and deposition can be the result of floods. Equally important is the consistent entrainment of sedimentary particles during normal and low-flow conditions. For example, floodplains are formed by lateral movement of the erosional channels and deposition of sediment by vertical accretion. Sediment transport in river systems is an important component of landform development and habitat development for fish and other organisms. Sediment and bedload issues were not identified directly during field visits or landowner interviews except in areas that were recently burned.

2.1.3.5. *Channel Structure and Stream Stability*

Stream stability is defined as the ability of the stream to maintain its dimension, pattern, and profile, in such a manner that over time, it is neither aggrading nor degrading and can transport sediment and flows without adverse consequence to the watershed. Stable streams are desirable because they do not have heavy eroding stream beds or banks that entrain significant sediment loads. The Rosgen classification for the Beaver Creek watershed indicated primarily stable streams as indicated by the predominant classification of the streams as E channels that are highly sinuous with stable, well-vegetated river banks.

One exception to the stable stream systems of Beaver Creek was identified by landowners at the March 2018 project meeting. At the meeting, landowners indicated it is difficult and even impossible during high water for their cattle to cross Beaver Creek where it is entrenched. The entrenched sections have very steep high banks where landowners stated that cattle have attempted to cross and been lost. In a highly entrenched system, such as these reaches of Beaver Creek, the flows during spring runoff or during flood events rise out of the smaller channel in the bottom, quickly use the limited floodplain area, and fill the larger channel which has high, very steep banks. Because the stream is in this entrenched condition for many miles, bridges may be one of the only viable solutions. In specific locations, there may be opportunities to slope banks and create cattle trails into and out of the steep banks. Stream restoration options to convert the entrenched channel into pond features and create a new stream channel at a higher elevation would be an extremely large-scale and costly undertaking. This type of base level conversion has been occasionally used in similar situations and would require a watershed-wide approach.

2.1.4. Geology

Both of Beaver Creek watershed's most prominent geologic features are the result of the mountain building event called the Laramide Orogeny. During the Laramide, approximately 65 million years ago, the Black Hills were uplifted while the Powder River Basin to the west was warped downward. The result of these tectonic events is that geologic units of the watershed are tilted, down-warped, and faulted. Specifically, the rocks of Paleozoic and Early Cretaceous age are exposed on or near the flanks of the Black Hills but are deeply buried a short distance away. Progressively younger formations crop out farther from the Black Hills when moving into the Powder River Basin.

Figure 2.1.4-1 illustrates a generalized cross-section from USGS (2002) of the area north of the watershed. The cross-section location is approximately 15 miles outside the watershed, yet it remains relevant. A west to east cross-section through the Beaver Creek watershed would also demonstrate Precambrian metamorphic and igneous rocks have pushed upward in the Black Hills region, while layers of sedimentary rock dip to the southwest in the western region of the study area.

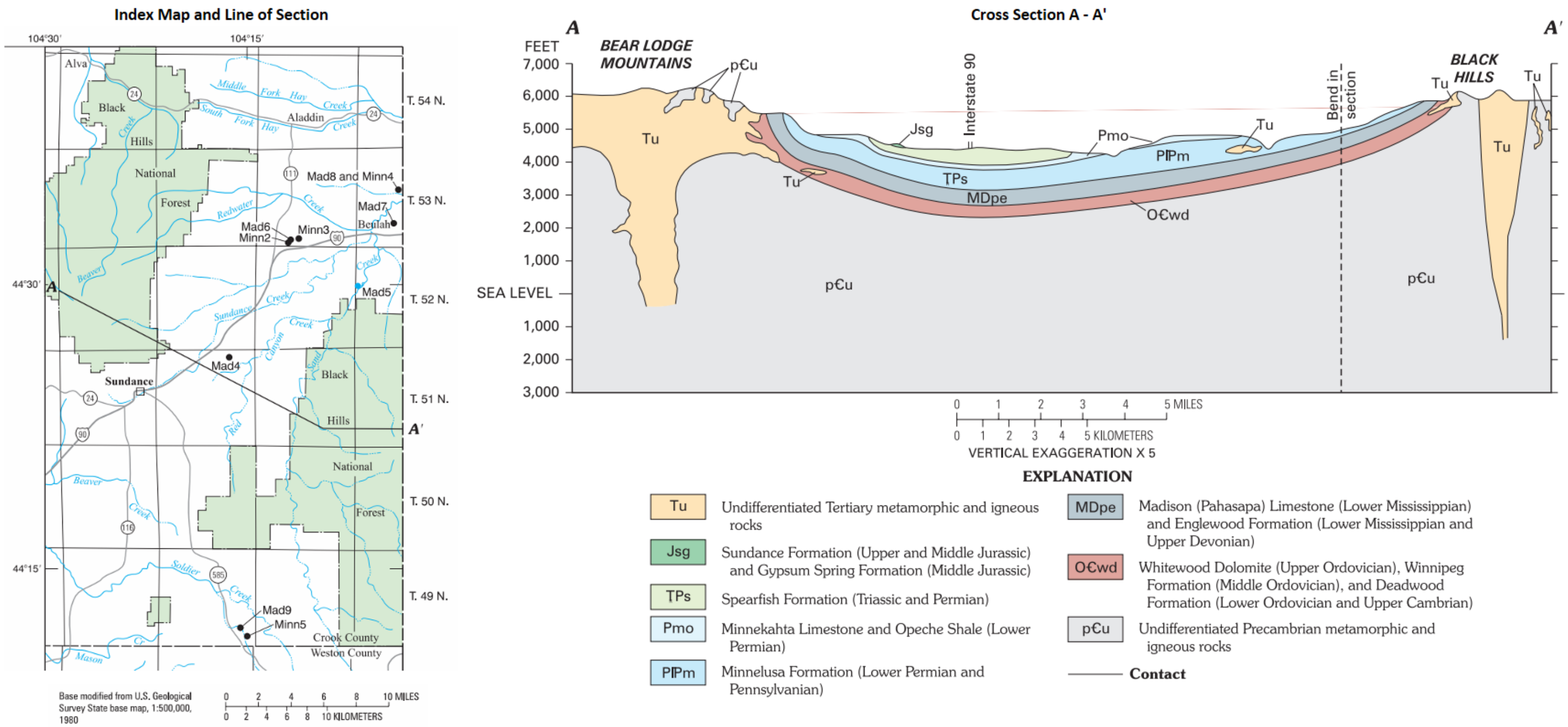


Figure 2.1.4-1 Generalized Cross-Section North of the Beaver Creek Watershed.

2.1.4.1. *Soils*

Soil surveys have been completed throughout the Beaver Creek watershed and are available online through the USDA NRCS (NRCS 2018). The distribution of the predominant soil types of the Beaver Creek watershed can be seen in Figure 2.1.4-2, STATSGO (STATe Soil GeOgraphic Soil Survey). Additionally, SSURGO (Soil SURvey GeOgraphic Soil Survey) data is available across most of the watershed.

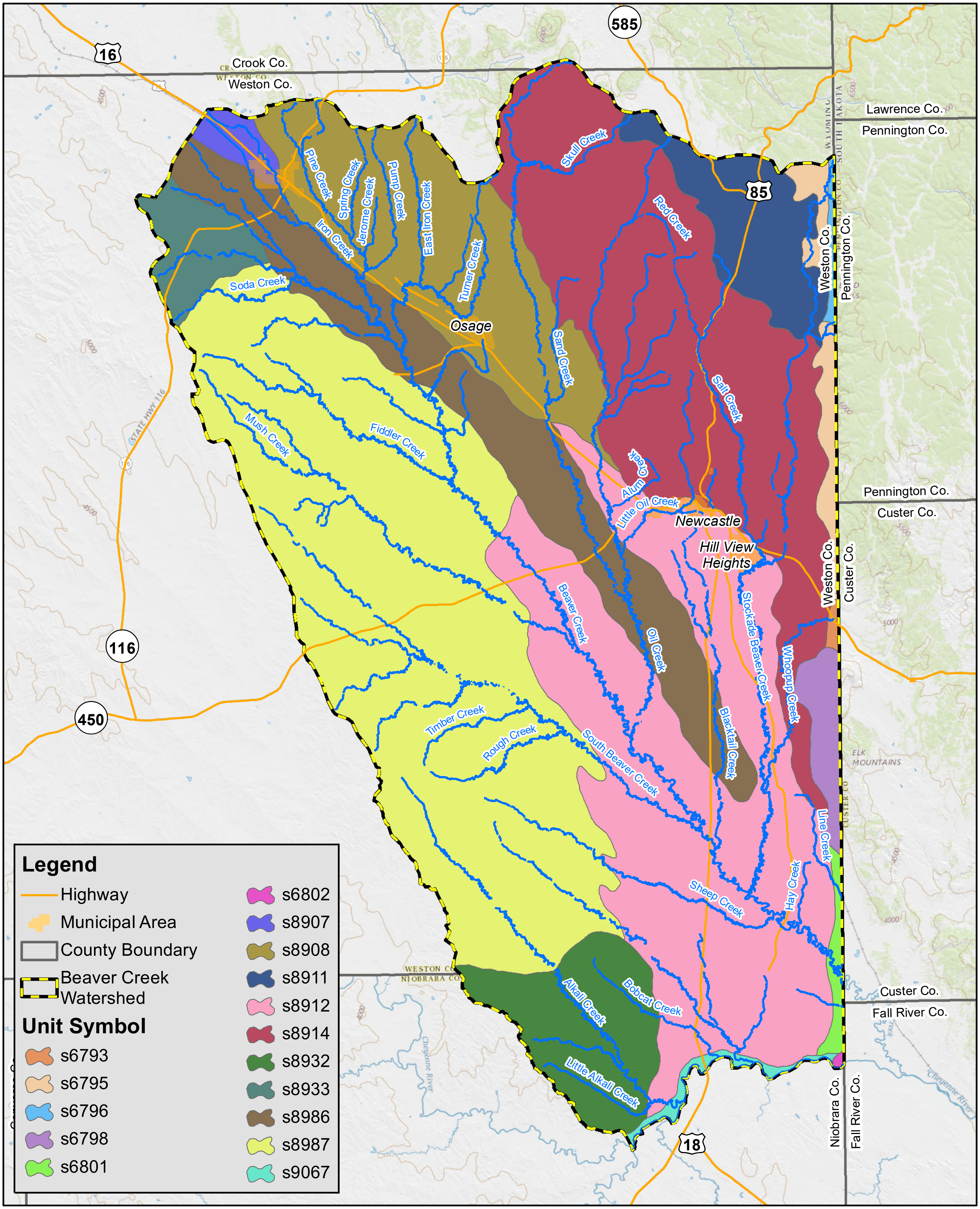
As stated in the data description for the NRCS STATSGO Soil Survey map, the dataset is a digital soil survey and generally is the most geographically detailed level of soil data developed by the National Cooperative Soil Survey. The information was prepared by digitizing maps, by compiling information onto a planimetric-correct base and digitizing, or by revising digitized maps using remotely sensed data and other information. The dataset consists of a detailed, field-verified inventory of soils and miscellaneous areas that normally occur in a repeatable pattern on the landscape and that can be cartographically shown at the scale mapped. The SSURGO Soil Survey map depicts information about the kinds and distribution of soils on the landscape. The soil map and data used in the SSURGO product were prepared by soil scientists as part of the National Cooperative Soil Survey.

Both the STATSGO and SSURGO Soil Survey interpretations predict soil behavior for specified soil uses and under specified soil management practices. For the purposes of this study, they assist in land use planning of broad categories such as cropland, rangeland, and pastureland. Soil survey interpretations also help plan specific management practices that are applied to specific soils, such as equipment use or irrigation of cropland. Soil interpretations use soil properties and qualities that directly influence a specified use of the soil. These properties and qualities include: (1) site features, such as slope gradient; (2) individual horizon features, such as particle size; and (3) characteristics that pertain to soil as a whole, such as depth to a restrictive layer.

Much of the watershed is overlain by Turnercrest-Terro-Tassel series. The Turnercrest series is described as deep, well drained, moderately rapidly permeable soils on uplands. These soils were formed in moderately coarse textured, calcareous residuum derived from sedimentary rock. The Terro series consists of moderately deep, well drained, moderately rapidly permeable soils on uplands and pediments. These soils were formed in residuum derived from soft sandstone. The Tassel series consist of shallow, well drained, moderately rapidly permeable soils on ridges and hills. These soils were formed in residuum derived from sandstone. All three series are found on hillsides and mountainsides with slopes ranging from two to 30 percent.

Photo 16 The Vanocker-Tilford-Rock outcrop-Paunsaugunt soil series exposed in a breached dam west of U.S. Highway 585 near its intersection with U.S. Highway 85.

The descriptions of the remaining soil types found within the Beaver Creek watershed can be found in Table 2.1.4-1. Table 2.1.4-1 summarizes the extent of the STATSGO Soil deposits by square miles and percentage of the Beaver Creek watershed.



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1 " = 35,000 '

Original Published Resolution

NAD 1983 UTM Zone 13N

USGS Topographic Map

WWDC Beaver Creek Watershed Study

Niobrara and Weston Counties, Wyoming

Soils

FIGURE

2.1.4-2

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Table 2.1.4-1 Soil Types Found in the Beaver Creek Watershed.

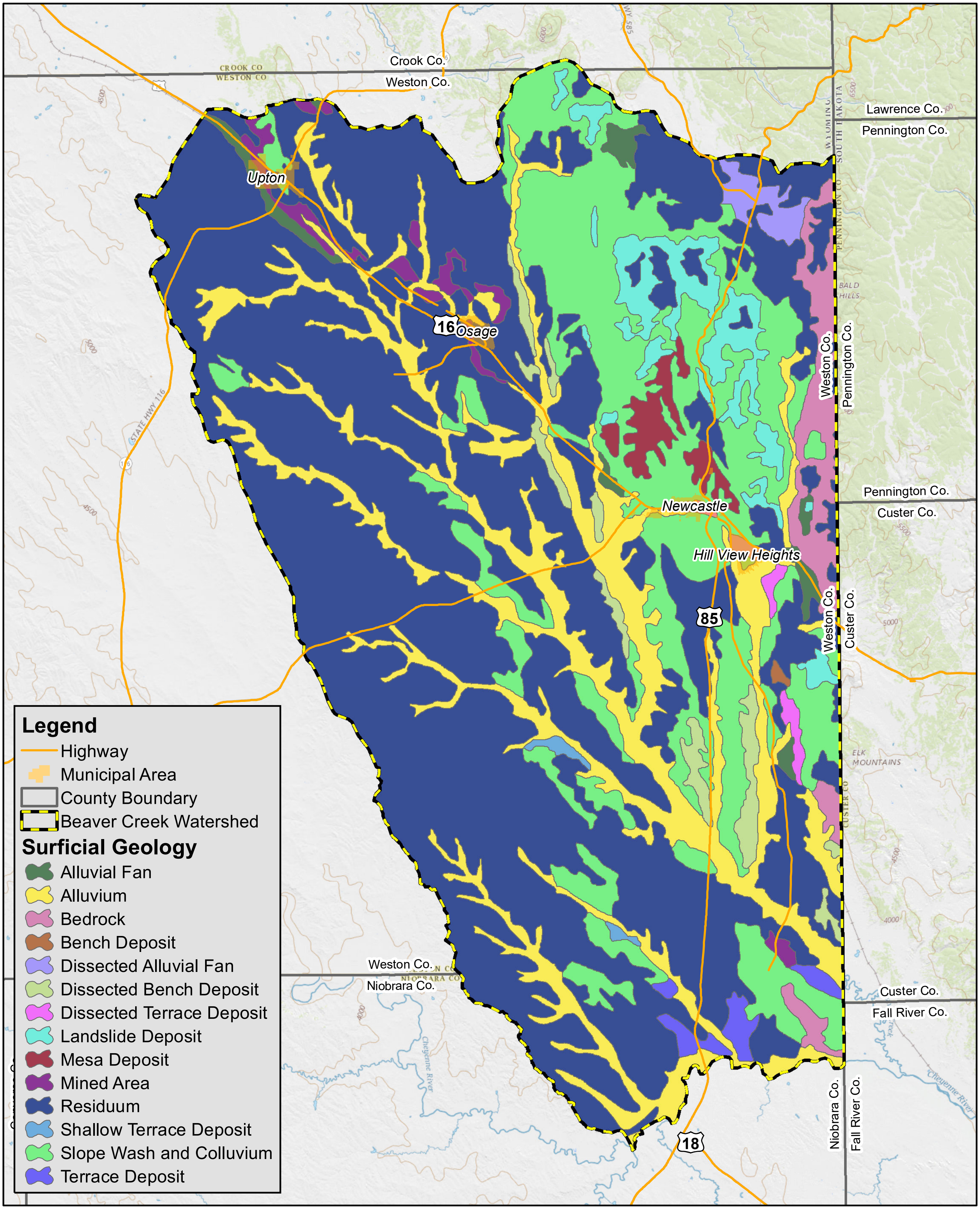
Unit Symbol	Soil Description	Area (acres)	Study Area (%)
s8987	Trunercrest-Terro-Tassel	248,561	28.09
s8912	Shingle-Sameday-Rock outcrop-Minnequa-Grummit-Bahl-Arvada	186,513	21.08
s8914	Crownest-Colhil	158,969	17.96
s8908	Ulm-Rock outcrop-Grummit-Demar-Bone	86,727	9.80
s8986	Theedle-Shingle-Savageton-Sameday-Rock outcrop	78,357	8.85
s8932	Taluce-Shingle-Cushman	39,593	4.47
s8911	Vanocker-Tilford-Rock outcrop-Paunsaugunt	31,936	3.61
s8933	Turnercrest-Forkwood-Cushman	16,292	1.84
s6798	Rockoa-Mathias-Lakoa-Canyon-Butche	9,728	1.10
s6795	Vanocker-Rock outcrop-Paunsaugunt-Citadel	6,701	0.76
s8907	Samday-Rock outcrop-Razor-Midway-Bone	6,163	0.70
s6801	Shingle-Pierre-Minnequa-Grummit	4,288	0.48
s6795	Vanocker-Rock outcrop-Paunsaugunt-Citadel	4,164	0.47
s9067	Draknab-Clarkelen	3,753	0.42
s6796	Trebor-Stovhol	2,063	0.23
s6793	Tilford-Nevee	901	0.10
s6802	Riverwash-Haverson-Glenberg-Bankard	265	0.03

2.1.4.2. Surficial Units

Figure 2.1.4-3 illustrates the surficial geology of the Beaver Creek watershed. Over half of the watershed is covered in residuum, because of extensive weathering of the carbonate rocks below. Other dominant units are slope wash and colluvium (19 percent) and alluvium (14 percent). See Table 2.1.4-2 for a full listing of the percent covered per acre across the watershed.

Table 2.1.4-2 Surficial Geology Units in the Beaver Creek Watershed.

Unit Symbol	Unit Name	Area (acres)	Study Area (%)
ri	Residuum	484,751	54.79
sci	Slope wash and colluvium	167,472	18.93
ai	Alluvium	123,914	14.01
li	Landslide deposits	25,840	2.92
Ri	Bedrock	22,264	2.52
bdi	Dissected bench deposits	14,380	1.63
mi	Mesa deposits	9,771	1.10
Mi	Mined areas	9,753	1.10
fi	Alluvial fan	8,874	1.00
ti	Terrace deposits	6,384	0.72
fdi	Dissected alluvial fan	5,973	0.68
tdi	Dissected terrace deposits	3,234	0.37
tre	Shallow terrace deposits	1,696	0.19
bi	Bench deposits	471	0.05



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OLSSON ASSOCIATES

Original Published Resolution
NAD 1983 UTM Zone 13N
USGS Topographic Map

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Surficial Geology Map

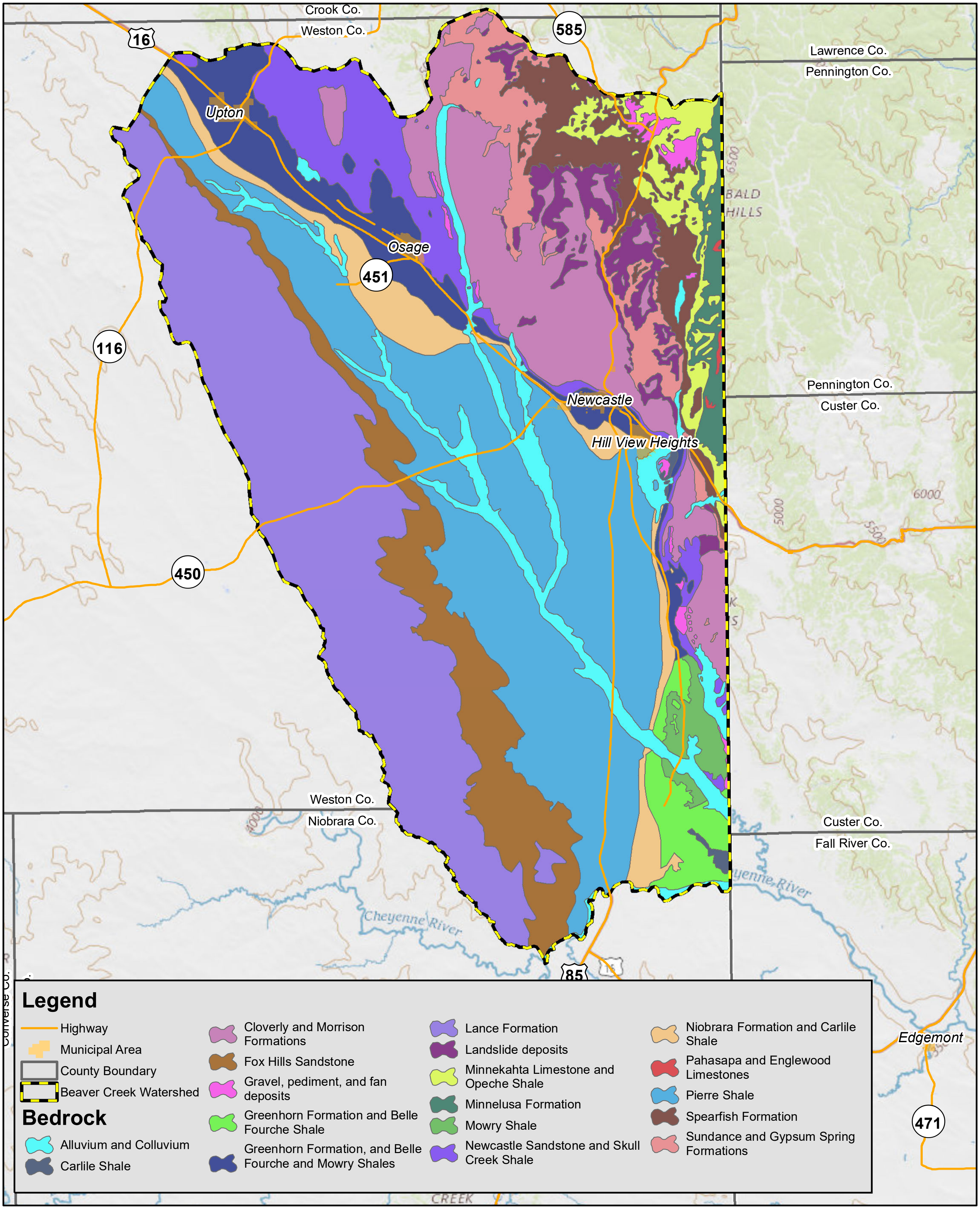
FIGURE
2.1.4-3

2.1.4.3. *Bedrock*

Table 2.1.4-3 indicates the bedrock geology units organized by geologic age with subsequent coverage area and the percentage of study area. Figure 2.1.4-4, Bedrock Geology, illustrates the bedrock geology mapped across the Beaver Creek watershed. Most of the youngest deposits (Quaternary in age) consist of clay, silt, sand, and gravel in floodplains, fans, terraces, and slopes, as well as locally derived clast and intermixed landslide deposits. Mesozoic rock types reflect significant sea level changes that occurred during this era. These Mesozoic deposits are comprised of sandstones, shales, limestones, and variegated terrestrial claystone-siltstones. Paleozoic deposits in the area consist of mostly carbonate and other shallow marine deposits. Please note that the acres covered by each unit as indicated in Table 2.1.4-3 do not include acres of the watershed that are covered by surface water including lakes, rivers, and streams.

Table 2.1.4-3 Bedrock Geology Units in the Beaver Creek Watershed.

Unit Symbol	Geologic Unit Name	Area (acres)	Study Area (%)
Cenozoic			
Quaternary			
Qa	Alluvium and colluvium	44,325	4.99
Qt	Gravel, pediment, and fan deposits	6,258	0.71
Qls	Landslide deposits	22,700	2.56
Mesozoic			
Cretaceous			
Kl	Lance Formation	190,742	21.50
Kfh	Fox Hills Sandstone	66,064	7.44
Kp	Pierre Shale	202,037	22.77
Knc	Niobrara Formation and Carlile Shale	33,860	3.81
Kcl	Carlile Shale	1,532	0.17
Kgb	Greenhorn Formation and Belle Fourche Shale	17,561	1.98
Kgbm	Greenhorn Formation, Belle Fourche, and Mowry Shales	50,758	5.72
Kns	Newcastle Sandstone and Skull Creek Shale	46,669	5.26
Kmr	Mowry Shale	9,632	1.09
Cretaceous – Jurassic			
KJ	Cloverly and Morrison Formations (N, S) or Cloverly Formation (Hartville uplift), or Inyan Kara Group (Black Hills), and Morrison Formation (NE)	88,916	10.02
Jurassic – Triassic			
Jsg	Sundance and Gypsum Springs Formations	32,265	3.64
Paleozoic			
Permian – Mississippian			
TrPs	Spearfish Formation	35,130	3.96
Pmo	Minnekahta Limestone and Opeche Shale	24,040	2.71
PPm	Minnelusa Formation	14,183	1.60
Mississippian – Devonian			
MDe	Pahasapa and Englewood Limestones	740	0.08



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1 " = 40,000 '
Original Published Resolution
NAD 1983 UTM Zone 13N
USGS Topographic Map

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Bedrock Geology Map

FIGURE
2.1.4-4

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2.1.4.4. *Geologic Hazards*

Landslides are one of the most common geologic hazards in the Beaver Creek watershed. There are five basic types of landslides that occur in three types of material. Falls, topples, slides (rotational and translational), lateral spreads, and flows can occur in bedrock, debris, or earth. Local geology, geologic structures, hydrology, and precipitation are the primary contributors to landslides. Landslides can cause significant damage; however, most occur in remote areas and do not typically cause damage.

The WSGS has mapped more than 30,000 landslides across Wyoming, and it maintains a database of these locations. Most reported landslides in the watershed have occurred to the north and northwest of the Newcastle area (Larsen and Wittke 2013). Landslide areas are shown in Figure 2.1.4-5.

2.1.5. Groundwater

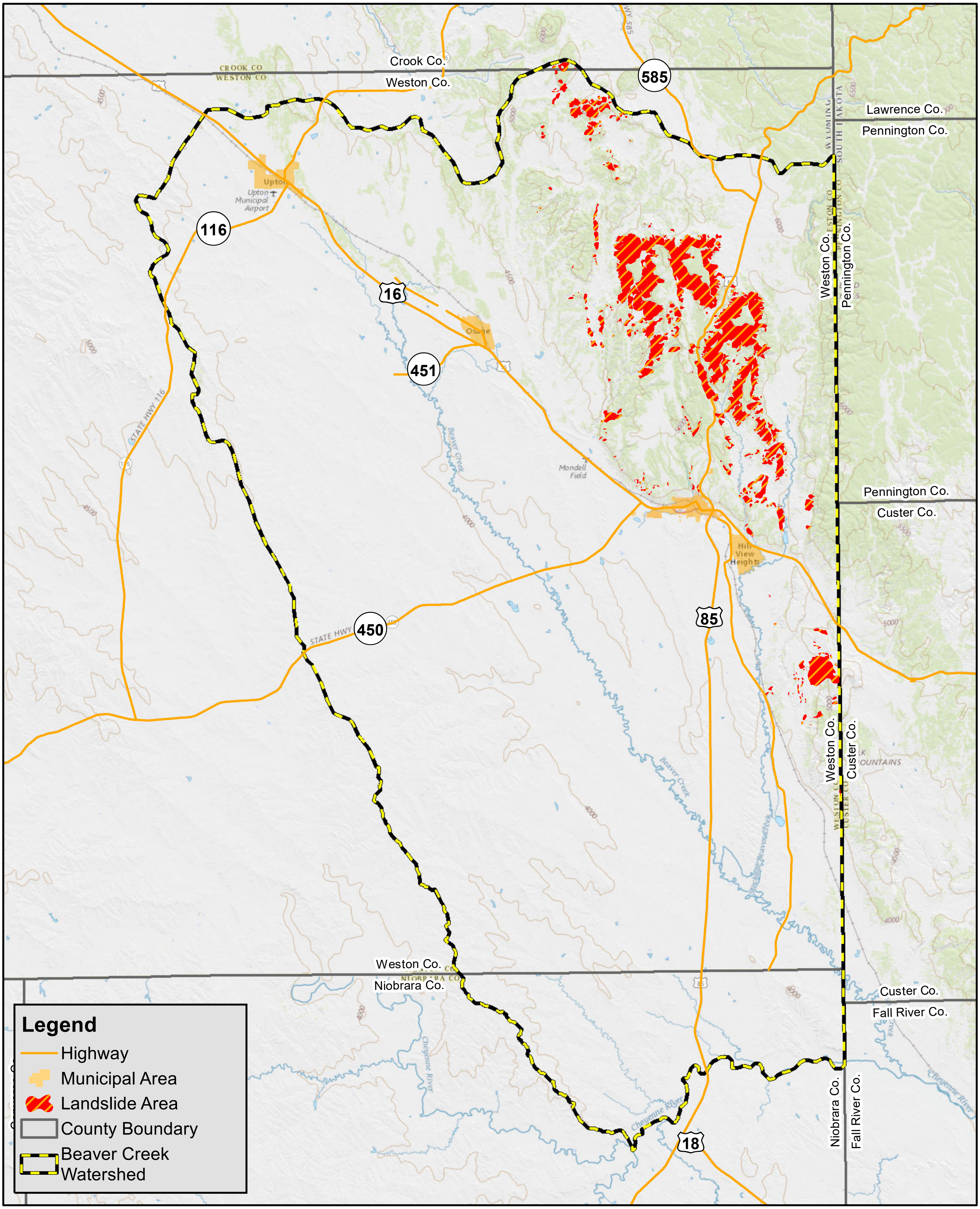
For most residents of the Beaver Creek watershed, groundwater is the most reliable source of water and of all the aquifers, the Madison Formation limestone (see photo 17) is the most prolific. A summary of the groundwater resources of the basin are presented herein.

2.1.5.1. *Hydrogeology*

Hydrogeology is the study of the movement of groundwater through geologic units, typically water that can be accessed and used as drinking water, for agriculture and for industry. Groundwater moves through the interconnected voids in host rocks. These voids consist of intergranular spaces, fractures, faults, vesicles, or some combination of these. Aquifers can be confined from above or below by confining units consisting of clay or shale. These units act as barriers to groundwater flow. Alluvial aquifers and shallow bedrock aquifers are the two primary sources of groundwater in the Beaver Creek watershed.

Alluvial aquifers are highly permeable, unconsolidated sand and gravel deposits that lie along active rivers and streams. Bedrock aquifers are described as consolidated formations that consist of coarse-grained lithologies such as sandstone, conglomerates, limestone, and dolomite (WWC Engineering 2007).

Photo 17 The Madison Formation limestone exposed in Spearfish Canyon, South Dakota.



OLSSON ASSOCIATES

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1 " = 35,000 '
Original Published Resolution
NAD 1983 UTM Zone 13N
USGS Topographic Map

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Landslide Areas Map

FIGURE
2.1.4-5

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Groundwater flow through sandstone and conglomerate aquifers occurs mostly through the primary porosity. However, enhanced groundwater flow through limestone and dolomite aquifers takes place through enhanced secondary permeability such as solution-enlarged fractures that can be caused by structural deformation. Recharge for these aquifers occurs primarily from rain and snowmelt. The following subsections provide more information on the groundwater available in the two specific aquifer types and from the springs that discharge groundwater to the surface.

2.1.5.2. *Aquifers and Springs*

Alluvial aquifers occur within the sediment deposits of Quaternary age. They are found along most of the alluvial valleys and consist of saturated silt, clay, and fine-grained sand. Local occurrences of sand and gravel are known throughout the basin with the most notable deposits present along the Cheyenne River along the southern border of the watershed study area. Alluvium is generally less than 50 feet thick and has low permeability, resulting in relatively small yields.

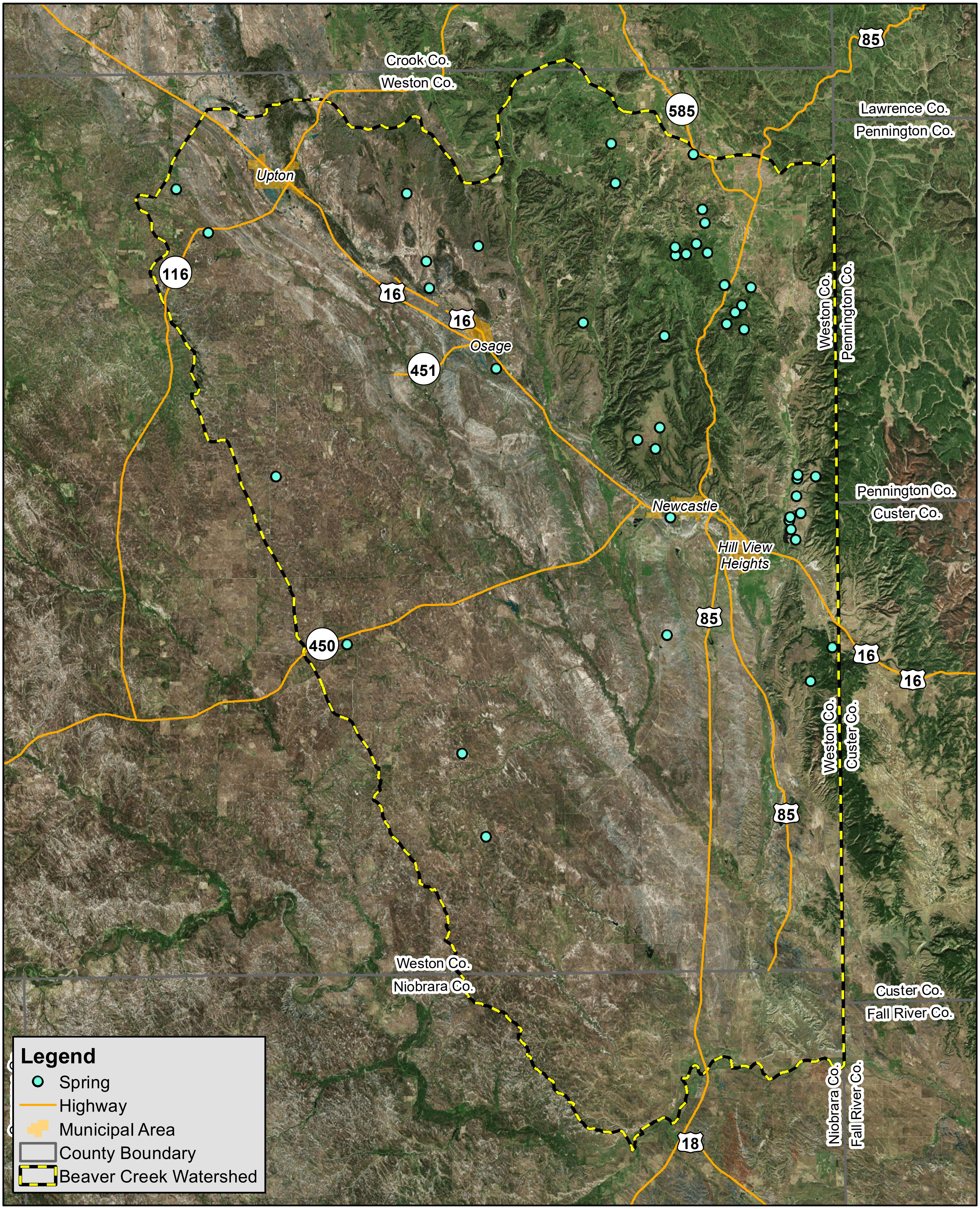
The three principal bedrock aquifers that exist within the Beaver Creek watershed are the Upper Paleozoic Madison, the Lower Cretaceous Dakota, and the Uppermost Cretaceous Fox Hills/Lance aquifer systems (WWDC 1985). The Madison aquifer is the most productive and reliable source of water and therefore is tapped for communities like Newcastle and Osage for their municipal water supply. Most high-capacity irrigation wells also tap into the Madison Formation; however, for most, the cost to drill a Madison well is prohibitive because the formation is very deep. Other isolated sandstones within shale sequences are locally exploited as aquifers, although their areal importance is limited.

Natural groundwater discharges occur through baseflow into lakes, rivers, and wetlands; leakage between geologic units; and springs. As of 2015, 47 springs have been mapped by the USGS within the Beaver Creek watershed (Figure 2.1.5, Springs and Seeps). It is important to note that many more likely occur within the watershed that currently remain unmapped. Springs in the area are frequently exploited as a water source for livestock. Discharge from these springs is often unreliable and sensitive to recharge variability and aquifer depletion.

2.1.5.3. *Groundwater Use, Base Flow, and Recharge*

Historically, major groundwater uses in the watershed have been for domestic use, agriculture (stock and irrigation), and municipal/public water systems. Groundwater is also used for industrial purposes, mostly related to mining. More information on anthropogenic water use is presented in Section 2.3.

Recharge in the area is estimated to range between less than an inch to about four inches per year, with the highest rates in the area flanking the Black Hills (Taboga and Stafford 2016). Recharge rates cannot be estimated directly across broad areas, so scientists must estimate recharge rates using indirect approaches. Taboga and Stafford used a water model and geospatial software to estimate the groundwater recharge rate. The calculations considered several parameters including precipitation runoff, slope, soil permeability, flowpaths, watershed area, and rock conductivity to name a few. Taboga and Stafford compared their recharge and baseflow estimates with net river outflows and recharge estimates from previous studies and concluded their computed rates of less than an inch to about four inches per year compared favorably with the other estimates. Compared to other areas of the county, this is a low rate of recharge, yet it is expectedly low because of the low precipitation rates typical of the Beaver Creek watershed.



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1 " = 35,000 '

Original Published Resolution

NAD 1983 UTM Zone 13N

ESRI World Imagery

WWDC Beaver Creek Watershed Study

Niobrara and Weston Counties, Wyoming

USGS Mapped Springs

FIGURE

2.1.5

2.1.6. Climate

The climate of the Beaver Creek watershed can be classified as semiarid, steppe in the Kőppen-Geiger climate classification system (Peel et. al 2007). The climate of the watershed is influenced by several nearby and distant mountain ranges including the Absaroka and Wind River mountains approximately 250 miles to the west, the Bighorn Mountains approximately 100 miles to the west-northwest and the Laramie Mountains approximately 90 miles to the southwest. The Black Hills, located along eastern boundary of the Beaver Creek watershed in western South Dakota, also influence the watershed. Moisture from the Pacific Ocean transported by westerly winds is primarily blocked by the Absaroka and Wind River mountains through autumn, winter, and spring.

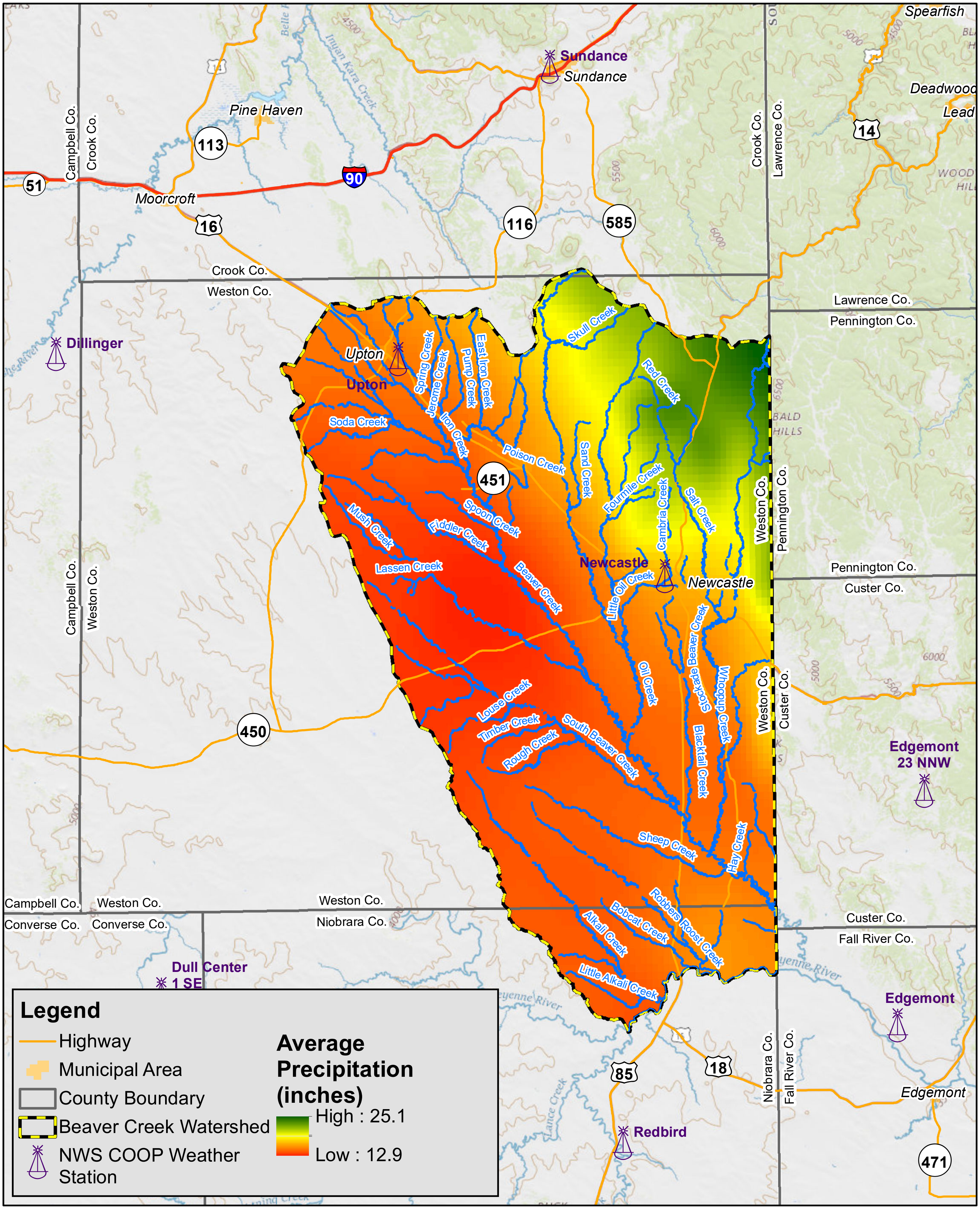
During the winter, upslope flow conditions (air moving from lower to higher elevation caused by easterly winds), provide moisture typically in the form of snow. During the summer months, thunderstorms that develop on the eastern slope of the Bighorn and Laramie mountains can impact the watershed. The Beaver Creek watershed is exposed to cold air masses that migrate down during the winter months from western and central Canada. Periods of extreme cold air can persist for several days in the watershed. Downslope flow conditions, air moving from higher elevation to lower elevation, from the Bighorn Mountains, Laramie Mountains, and Black Hills can warm the air and reduce humidity levels.

2.1.6.1. *Precipitation, Temperature, Climate Zones*

Several National Weather Service (NWS) Cooperative (COOP) Weather Stations are located in or near the Beaver Creek watershed study area. Eight of these stations had adequate historical data (greater than 30 years) available. Historical climate data for these eight stations was obtained from the Western Regional Climate Center website (http://www.wrcc.dri.edu/). Table 2.1.6 shows the average maximum temperature, average minimum temperature, and average precipitation on a monthly and annual basis for each station (Western Regional Climate Center 2016).

Figure 2.1.6-1 shows the average annual precipitation within the Beaver Creek watershed for the years 1981-2010. These data represent the results of Parameter Elevation Regression on Independent Slopes Model (PRISM) spatial climate data generated at the Oregon Climate Center, Oregon State University (PRISM Climate Group 2018). Mean annual precipitation varies from a minimum of less than 13 inches up to 25 inches per year. The highest precipitation rates are along the flanks of the Black Hills or the northeastern corner of the watershed and the lowest are in the grasslands to the west. Figure 2.1.6-2 shows average monthly precipitation by weather station.

Annual temperature patterns across the eight weather station locations is consistent. Figures 2.1.6-3 and 2.1.6-4 show maximum and minimum monthly temperatures at these locations. For all stations except Edgemont 23 NNW, the monthly mean maximum temperature occurs in July. Mean high temperatures in July at these stations range from about 83 degrees Fahrenheit (F) to about 90 F. The lowest monthly mean minimum temperature for all stations except Edgemont occurs in January. Mean low temperatures in January at these stations range from about 5 F to 12 F.



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1 " = 50,000 '
Original Published Resolution
NAD 1983 UTM Zone 13N
USGS Topographic Map

OLSSON ASSOCIATES

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Average Annual Precipitation (1981-2010)

FIGURE
2.1.6-1

Table 2.1.6 Summary of Monthly Climatic Data: Beaver Creek Watershed.

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Upton, Wyoming 489205: 9/1/1908 to 5/31/2016													
Average Max. Temp. (F)	30.9	35.1	45	56.5	67.2	78.1	86.9	85.6	74.5	60.3	43.4	32.4	58
Average Min. Temp. (F)	5.6	10.3	19.7	29.3	39.5	48.7	55.4	53.5	42.4	31	18.8	8.1	30.2
Average Total Precipitation (in.)	0.46	0.46	0.66	1.5	2.48	2.59	1.89	1.38	1.19	1.1	0.6	0.6	14.92
Newcastle, Wyoming 486660: 7/1/1906 to 6/10/2016													
Average Max. Temp. (F)	34.1	37.9	46.4	57.5	68	78.4	87.7	85.7	74.5	60.8	45.2	35.9	59.3
Average Min. Temp. (F)	11.4	14.5	22.4	32.2	42.2	51.6	59	57	46.6	35.1	22.8	14.2	34.1
Average Total Precipitation (in.)	0.45	0.51	0.73	1.5	2.51	2.52	2.01	1.61	1.16	1.03	0.6	0.5	15.13
Redbird, Wyoming 487555: 8/1/1948 to 6/4/2016													
Average Max. Temp. (F)	35.7	41.1	49.9	60.9	70.5	81.2	90.3	89	78.3	64.7	47.7	37.6	62.2
Average Min. Temp. (F)	7.9	13.3	21.5	31	41.1	50.1	56.7	54.2	42.8	31.1	19.1	9.7	31.5
Average Total Precipitation (in.)	0.28	0.38	0.76	1.68	2.47	2.49	1.88	1.33	1.21	0.91	0.49	0.29	14.16
Edgemont 23 NNW, South Dakota 392565: 10/1/1989 to 5/31/2016													
Average Max. Temp. (F)	35	37.9	46.3	55.1	64.8	74.6	83.6	83.8	73.6	59.3	44.9	35.5	57.9
Average Min. Temp. (F)	10.8	14.1	22.5	30.8	40.7	50.4	56.7	55.4	45.4	32.5	21.2	11.3	32.7
Average Total Precipitation (in.)	0.5	0.64	0.81	1.72	2.73	3.07	2.3	2.05	1.18	1.33	0.58	0.38	17.29
Edgemont, South Dakota 392557: 8/1/1948 to 6/10/2016													
Average Max. Temp. (F)	35.1	39	50.4	60.4	69.9	80.4	89.5	88.2	77.8	62.9	46.6	35.5	61.3
Average Min. Temp. (F)	9.5	13.1	23.3	32.3	42.8	52.3	59.3	56.9	45.7	32.6	19.8	9.2	33.1
Average Total Precipitation (in.)	0.36	0.46	0.99	1.77	2.53	2.47	2.11	1.55	1.21	1.23	0.61	0.4	15.68
Sundance, Wyoming 488705: 1/1/1893 to 6/9/2016													
Average Max. Temp. (F)	31.5	34.9	42.3	54	64.3	74.3	83.4	82.1	71.9	58.8	42.7	33.8	56.2
Average Min. Temp. (F)	9.3	12.1	18.9	29.2	38.9	47.8	54.6	52.8	43	32.6	20.8	12.8	31.1
Average Total Precipitation (in.)	0.76	0.77	1.07	1.87	2.8	3.17	1.97	1.47	1.38	1.32	0.9	0.77	18.24
Dillinger, Wyoming 482580: 7/1/1945 to 5/31/2016													
Average Max. Temp. (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 Min. Temp. (F)	7.3	12.1	19.7	28.7	38.7	47.3	53.8	52	41.2	30.4	18	9.3	29.9
Average Total Precipitation (in.)	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
Dull Ctr 1 SE, Wyoming 482725: 5/20/1926 to 4/30/2016													
Average Max. Temp. (F)	36.2	40.4	48.3	59	69.1	79.9	90	88.2	77.4	64	48	38	61.5
Average Min. Temp. (F)	10.8	14.1	21.5	30.6	40.3	48.9	55.9	53.7	43.3	32.8	21.8	13.5	32.3
Average Total Precipitation (in.)	0.24	0.37	0.65	1.44	2.35	2.21	1.65	1.28	1.03	0.87	0.46	0.3	12.86

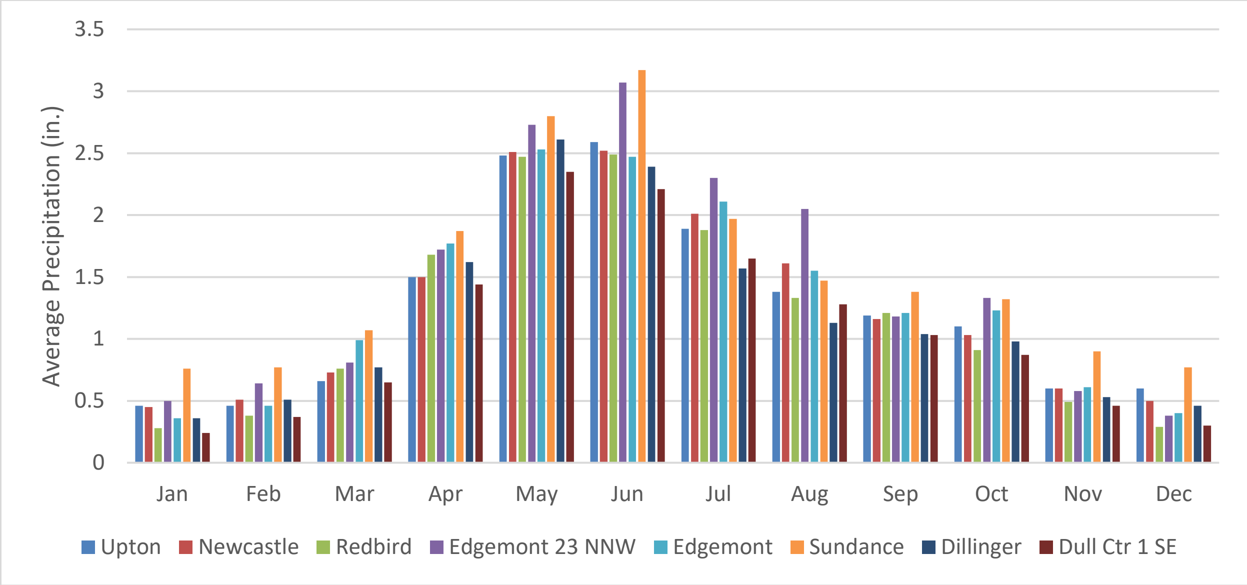


Figure 2.1.6-2 Average Monthly Precipitation.

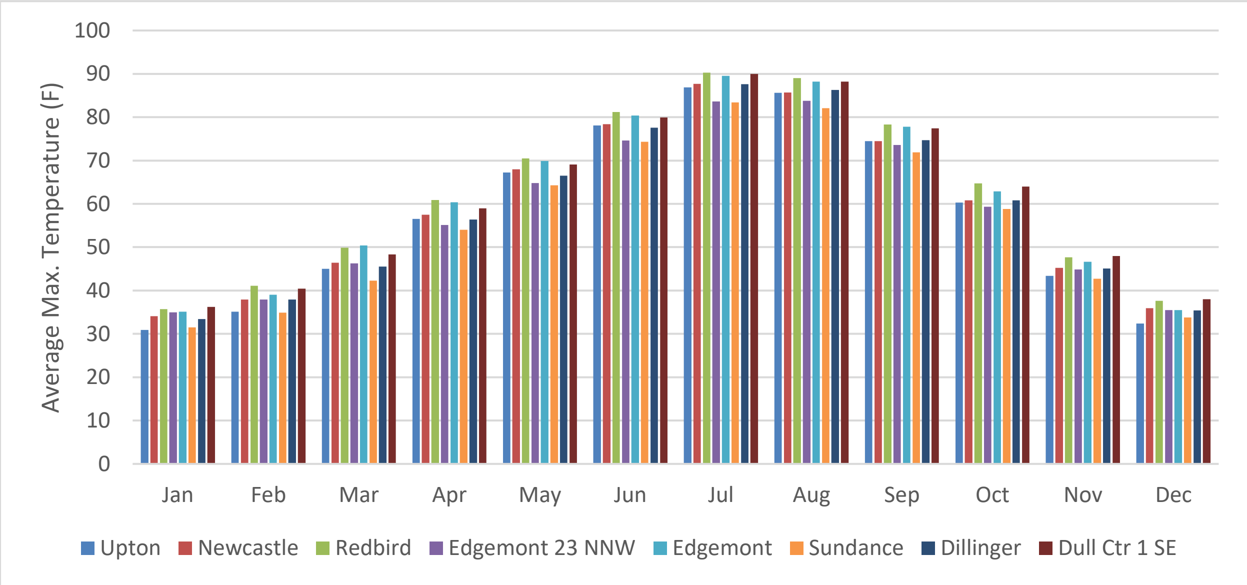


Figure 2.1.6-3 Average Maximum Temperature.

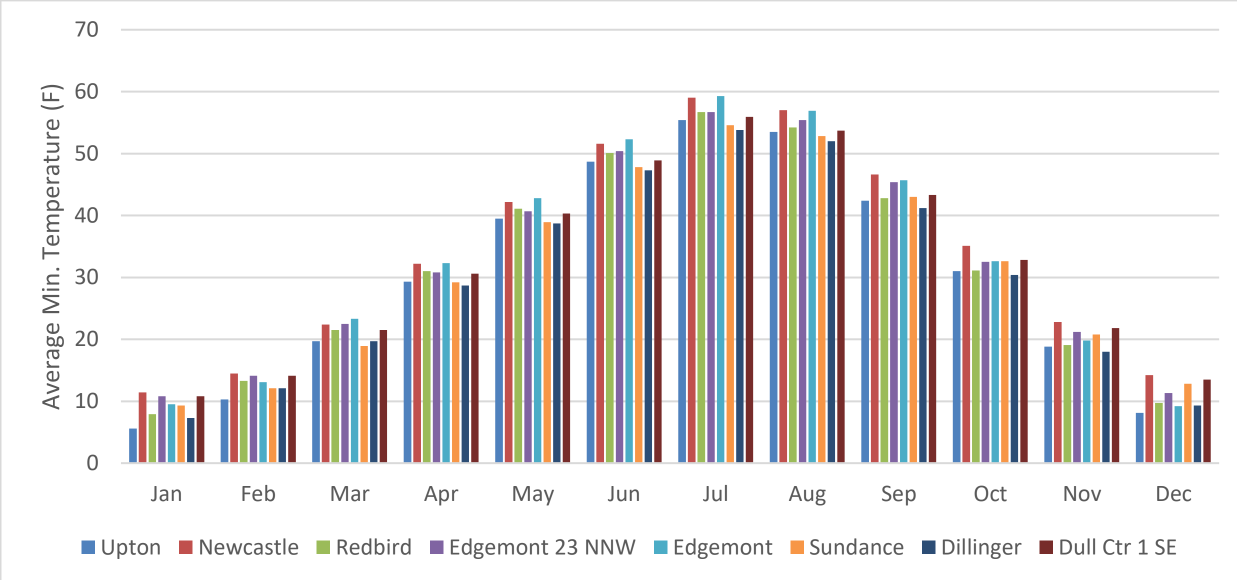


Figure 2.1.6-4 Average Minimum Temperature.

2.1.6.2. *Drought Conditions*

At the time of this writing, the Beaver Creek watershed lies within an area that is not experiencing drought conditions as defined by the U.S. Drought Monitor map for Wyoming (Figure 2.1.6-5). The U.S Drought Monitor uses a scale referred to as the U.S. Monitor Intensity Scale and is based on the combination of individual drought indices. The definition for each level of the scale, ranging from D0 to D4, is identified on the U.S. Drought Monitor map. The map identifies the watershed as not being affected by drought conditions; however, interpreting drought conditions for specific points based solely on the U.S. Drought Monitor map should be done with caution.

This climate analysis is based on approximately the last 50 to 100 years of historical data. It should be noted that climate conditions in this study area are not static. Climate change is occurring and will continue to occur in the future. Most of the state of Wyoming has experienced overall warming by 1 to 3 degrees F in the past century (EPA 2016). This change will have a significant impact on the climate and water supply of Wyoming:

> *Heat waves are becoming more common, and snow is melting earlier in spring. Rising temperatures and recent droughts have killed many trees by drying out soils, increasing the risk of forest fires, or enabling outbreaks of forest insects. In the coming decades, the changing climate is likely to decrease the availability of water in Wyoming, affect agricultural yields, and further increase the risk of wildfires. (EPA 2016)*

For further information on how these changes might affect the state, an informational fact sheet has been published by the EPA. There are many other resources that describe climate change and climate outlook in the United States. An interactive tool that presents risk factors for each state along with informative charts and graphs can be found here: http://statesatrisk.org/wyoming/ (States at Risk 2018). This report includes information on climate change and uses the Drought Monitor to aid the state in its future planning.

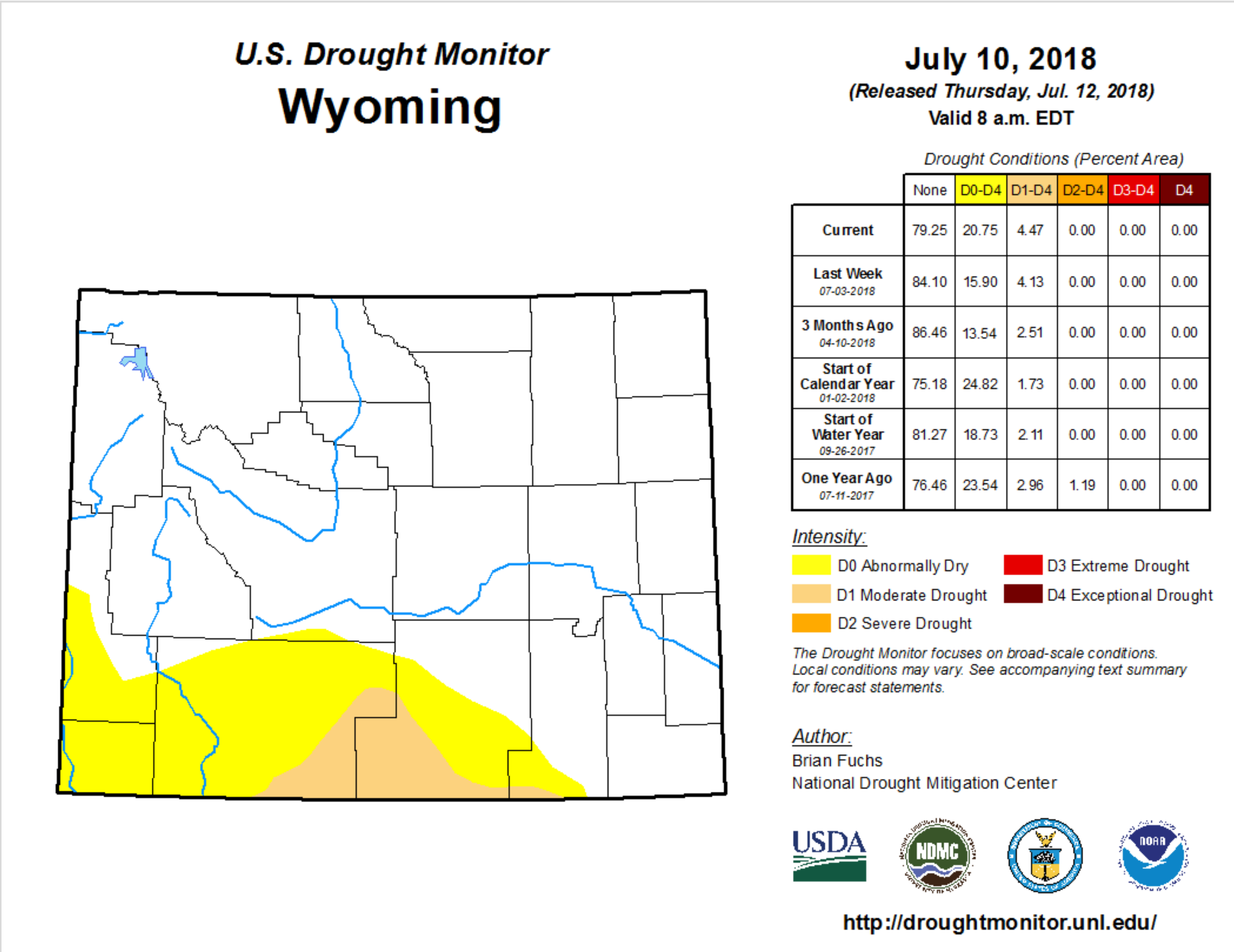


Figure 2.1.6-5 U.S. Drought Monitor for Wyoming – July 10,2018.

Although the study area is not experiencing drought conditions in July 2018, drought has affected the Beaver Creek watershed in recent history and will again in the future. Niobrara and Weston counties have both experienced some level of drought as recently as the beginning of 2018. Figures 2.1.6-6 and 2.1.6-7 show a timeline of recent drought events in Niobrara and Weston counties, respectively. Major drought events in 2002, 2004 and 2012 saw much of the study area in the extreme or exceptional drought categories (National Drought Mitigation Center 2018). Severe drought in the early 2000's prompted state of Wyoming officials to develop a task force and drought response plan. Within the drought response plan, triggers are outlined for precipitation forecast, snowpack levels, and reservoir levels (University of Wyoming 2003). Triggers help the state implement appropriate drought response actions and prepare for possible upcoming water shortages.

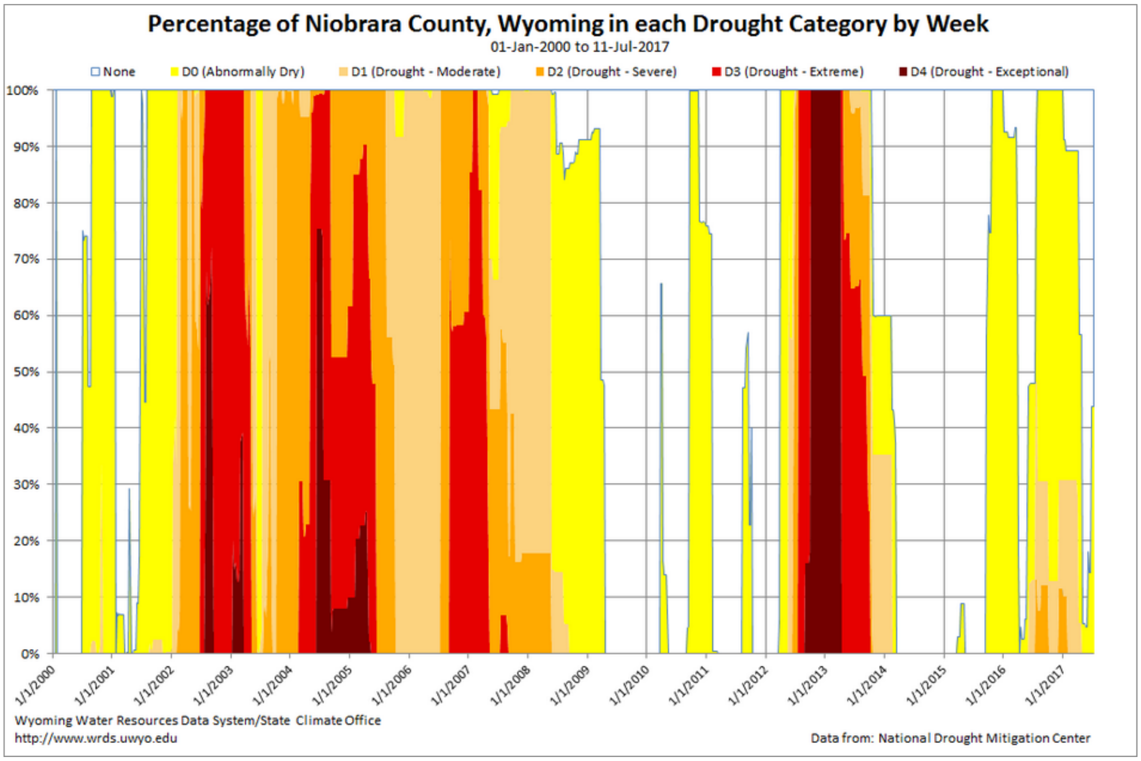


Figure 2.1.6-6 Timeline of Drought Conditions in Niobrara County.

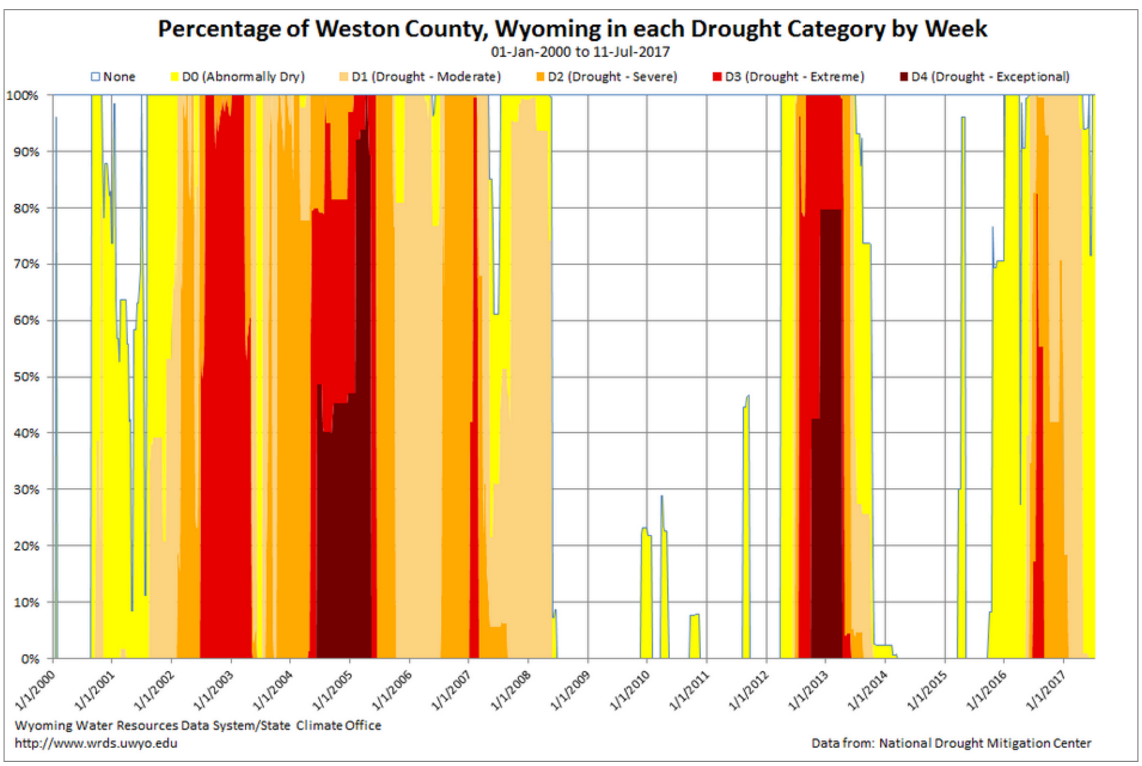


Figure 2.1.6-7 Timeline of Drought Conditions in Weston County.

2.2. Biological Systems

2.2.1. Fish and Wildlife

The Beaver Creek watershed contains an abundance of fish and wildlife species and habitat. Included in these populations are species of concern and crucial aquatic habitat areas. In particular, the conservation of the greater sage-grouse (*Centrocercus urophasianus*) is a top priority for the state of Wyoming.

2.2.1.1. *Fisheries*

There is a wide variety of streams that provide fish habitat throughout the Beaver Creek watershed. Sport fish designation streams within the watershed include but are not limited to: East Iron, Iron, Beaver, South Beaver, Turner, Skull, Fiddler, Mush, Oil, Blacktail, Stockade Beaver, Rough, Sheep, Alkali, Robbers Roost, and Salt creeks. These streams include Yellow Ribbon, Green Ribbon, Orange Ribbon, and unclassified waters (SuiteWater 2018). Yellow Ribbon waters are estimated to have between 50 and 300 pounds of sport fish per mile; Green Ribbon waters are estimated to have between 1 and 50 pounds of sport fish per mile; and Orange Ribbon waters do not have an estimated amount of sport fish per mile (WGFD 2006).

The National Fish Passage Program (NFPP) was created in 1999 as a part of the USFWS, which offers funding and field support to remove or renovate fish passage barriers to allow fish and water flow to be unobstructed (USFWS 2018a). There has not been a comprehensive study on fish barriers in this the Mountain-Prairie Region. However, more than 28,000 fish barriers are estimated to exist within the Mountain-Prairie Region (USFWS 2018a).

The Beaver Creek watershed contains areas identified by the Wyoming Natural Diversity Database (WYNDD) as aquatic crucial habitat priorities and aquatic enhancement habitat priorities (SuiteWater 2018). Crucial habitat priority areas are WYNDD designated areas that require protection and management to maintain a healthy habitat and wildlife population (WYNDD 2018a). Enhancement habitat priority areas are WYNDD designated areas that have the potential to improve and restore wildlife habitats. These areas are identified based on previously identified habitat issues (WYNDD 2018a).

Instream flow water rights were established in Wyoming in 1986, when the Instream Flow law was enacted (WWDC 2018). This law allows the state of Wyoming to have water rights without diverting water from a stream channel and while keeping the water protected for fisheries' purposes. There are no existing state-held instream flow water rights within the Beaver Creek watershed (WWDC 2018).

2.2.1.2. *Wildlife Habitat, Game, Sensitive Species*

The Beaver Creek watershed supports a variety of wildlife and habitats. Four species of big game (antelope [*Antilocapra Americana*], elk [*Cervus canadensis*], mule deer [*Odocoileus hemionus*], and white-tailed deer [*Odocoileus virginianus*]) have seasonal range within the watershed and two species of big game (mule deer and white-tailed deer) have crucial range within the watershed (SuiteWater 2018). Additionally, a herd of bighorn sheep inhabit Elk Mountain in the southeast portion of the watershed (K. Culver, personal communication, August 3, 2018). No identified migration corridors, critical habitat, or birthing areas are identified within the watershed for any big game species (SuiteWater 2018). Common predators present in the area include fox (*Vulpes Vulpes*), coyote (*Canis latrans*), bobcat (*Lynx rufus*), and mountain lion (*Puma concolor*). The WGFD, along with federal agencies, regulates hunting and fishing in Wyoming, enforces timing restrictions, and provides hunting and fishing licenses. Hunting and fishing are a large part of the culture and economy in Wyoming and maintaining healthy habitat for wildlife is key to the state's economic stability.

The WCNRD's Long Range Natural Resource Management Plan assists landowners with wildlife habitat improvement projects and provides information on endangered species listings (WCNRD 2016). The plan's objectives are to support wildlife management strategies, provide education regarding endangered species, support conservation plan initiatives, increase public hunting and fishing access, and boost predator control efforts. Essentially, this plan was developed by Weston County to maintain and promote a diverse wildlife population within the county.

The WYNDD, USFS, and BLM have each developed a species of concern or sensitive species list for Wyoming. These species are primarily chosen based on their rarity, vulnerability, and/or threatened status (WYNDD 2018b). Tables 2.2.1-1 through 2.2.1-3 list, by agency, the species of concern or sensitive species that have the potential to occur within the Beaver Creek watershed.

Table 2.2.1-1 WYNDD Species of Concern.

Species	Scientific Name
Northern Goshawk	*Accipiter gentilis*
Clark's Grebe	*Aechmophorus clarkia*
Baird's Sparrow	*Ammodramus bairdii*
Short-eared Owl	*Asio flammeus*
Burrowing Owl	*Athene cunicularia*
Ferruginous Hawk	*Buteo regalis*
Chestnut-collared Longspur	*Calcarius ornatus*
Greater Sage-grouse	*Centrocercus urophasianus*
Mountain Plover	*Charadrius montanus*
Black Tern	*Chlidonias niger*
Yellow-billed Cuckoo	*Coccyzus americanus*
Black-billed Cuckoo	*Coccyzus erythropthalmus*
Townsend's Big-eared Bat	*Corynorhinus townsendii*
Black-tailed Prairie Dog	*Cynomys ludovicianus*
Bobolink	*Dolichonyx oryzivorus*
Peregrine Falcon	*Falco peregrinus*
Common Loon	*Gavia immer*
Northern Pygmy-owl	*Glaucidium gnoma*
Bald Eagle	*Haliaeetus leucocephalus*
Loggerhead Shrike	*Lanius ludovicianus*
Northern Leopard Frog	*Lithobates pipiens*
Lewis's Woodpecker	*Melanerpes lewis*
Northern Long-eared Myotis	*Myotis septentrionalis*
Fringed Myotis	*Myotis thysanodes*
Long-billed Curlew	*Numenius americanus*
Smooth Greensnake	*Opheodrys vernalis*
Virginia's Warbler	*Leiothlypis virginiae*

Species	Scientific Name
American White Pelican	*Pelecanus erythrorhynchos*
Black-backed Woodpecker	*Picoides arcticus*
American Three-toed Woodpecker	*Picoides dorsalis*
White-faced Ibis	*Plegadis chihi*
McCown's Longspur	*Rhynchophanes mccownii*
Pygmy Nuthatch	*Sitta pygmaea*
Hayden's Shrew	*Sorex haydeni*
Plains Spadefoot	*Spea bombifrons*
Forster's Tern	*Sterna forsteri*
Red-bellied Snake	*Storeria occipitomaculata*
Swift Fox	*Volpes velox*
Meadow Jumping Mouse	*Zapus hudsonius*
Bear Lodge Meadow Jumping Mouse	*Zapus hudsonius campestris*
Source: NREX 2018	

Table 2.2.1-2 USFS Sensitive Species.

Species	Scientific Name
Northern Goshawk	*Accipiter gentilis*
Grasshopper Sparrow	*Ammodramus savannarum*
Burrowing Owl	*Athene cunicularia*
Ferruginous Hawk	*Buteo regalis*
Chestnut-collared Longspur	*Calcarius ornatus*
Greater Sage-grouse	*Centrocercus urophasianus*
Mountain Plover	*Charadrius montanus*
Black Tern	*Chlidonias niger*
Yellow-billed Cuckoo	*Coccyzus americanus*
Townsend's Big-eared Bat	*Corynorhinus townsendii*
Black-tailed Prairie Dog	*Cynomys ludovicianus*
Peregrine Falcon	*Falco peregrinus*
Common Loon	*Gavia immer*
Bald Eagle	*Haliaeetus leucocephalus*
Loggerhead Shrike	*Lanius ludovicianus*
Hoary Bat	*Lasiurus cinereus*
Northern Leopard Frog	*Lithobates pipiens*
Pacific Marten	*Martes caurina*
Lewis's Woodpecker	*Melanerpes lewis*
Fringed Myotis	*Myotis thysanodes*
Long-billed Curlew	*Numenius americanus*
Bighorn Sheep	*Ovis canadensis*
Black-backed Woodpecker	*Picoides arcticus*
American Three-toed Woodpecker	*Picoides dorsalis*

Species	Scientific Name
McCown's Longspur	*Rhynchophanes mccownii*
Brewer's Sparrow	*Spizella breweri*
Red-bellied Snake	*Storeria occipitomaculata*
Swift Fox	*Volpes velox*
Source: NREX 2018	

Table 2.2.1-3 BLM Sensitive Species.

Species	Scientific Name
Spotted Bat	*Euderma maculatum*
Townsend's Big-eared Bat	*Corynorhinus townsendii*
White-tailed Prairie Dog	*Cynomys leucurus*
Black-tailed Prairie Dog	*Cynomys ludovicianus*
Swift Fox	*Vulpes velox*
Long-eared Myotis	*Myotis evotis*
Fringed Myotis	*Myotis thysanodes*
Trumpeter Swan	*Cygnus buccinator*
White-faced Ibis	*Plegadis chichi*
Northern Goshawk	*Accipter gentilis*
Ferruginous Hawk	*Buteo regalis*
Peregrine Falcon	*Falco peregrinus*
Greater Sage-grouse	*Centrocercus urophasianus*
Long-billed Curlew	*Numenius americanus*
Burrowing Owl	*Athene cunicularia*
Columbian Sharp-tailed Grouse	*Tympanuchus phasianellus columbianus*
Bald Eagle	*Haliaeetus leucocephalus*
Mountain Plover	*Charadris montanus*
Loggerhead Shrike	*Lanius ludovicianus*
Brewer's Sparrow	*Spizella breweri*
Baird's Sparrow	*Ammodramus bairdii*
Sage Sparrow	*Amphispiza belli*
Sage Thrasher	*Oreoscoptes montanus*
Northern Leopard Frog	*Rana pipiens*
Limber Pine	*Pinus flexilis*
Sidesaddle Bladderpod	*Lesquerella arenosa var. argillosa*
Slender Moonwort	*Botrychium lineare*
Source: BLM 2010	

The bald eagle is listed as a species of concern or sensitive species by the WYNDD, USFS, and BLM. The bald eagle had a prevalent population throughout the United States in the early 19th century and experienced a drastic decline due to hunting and loss of habitat (USFWS 2018i). The decline of bald eagles did not go unnoticed. The Bald Eagle Protection Act was established in 1940, later becoming the Bald and

Golden Eagle Protection Act (BGEPA) in 1962. The population of bald eagles continued to decline due to the use of Dichlorodiphenyltrichloro (commonly known as DDT) after World War II. The Endangered Species Act (ESA) was enacted in 1973 and the bald eagle was listed as an endangered species in 1978. The BGEPA as well as the ESA resulted in the protection of bald eagle habitat and population to reestablish the species; the bald eagle was taken off the threatened and endangered species list in 2007 (USFWS 2018i). The bald eagle is still listed as a species of concern or sensitive species in many areas in an effort to maintain the healthy population of bald eagles that now exists throughout the United States.

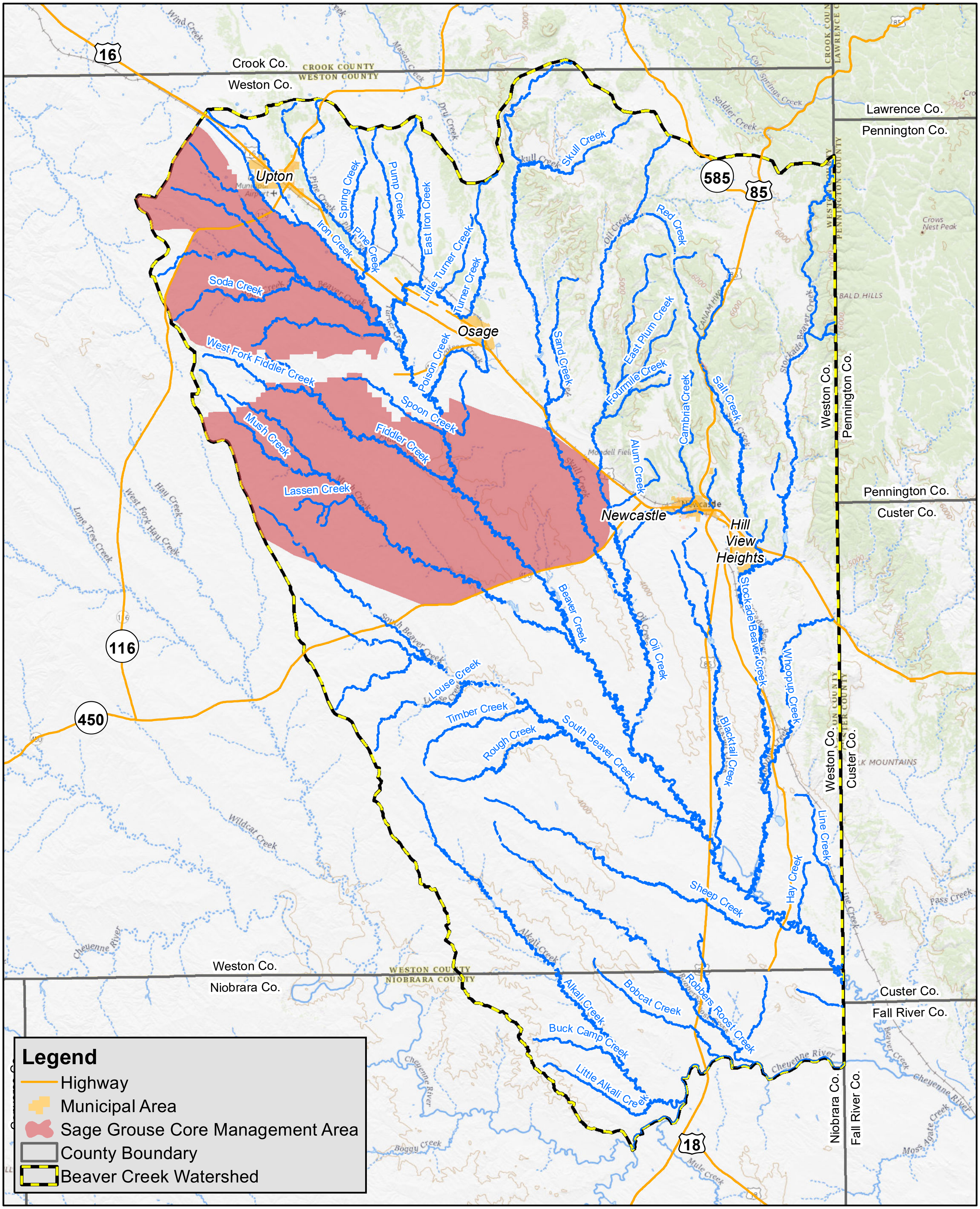
The burrowing owl is another species that is listed as a species of concern or sensitive species by the WYNDD, USFS, and BLM. Burrowing owls occupy burrows dug by small mammals, such as prairie dogs or ground squirrels, in open areas. The main threat to burrowing owl populations is land development as well as prairie dog and ground squirrel control measures. The Migratory Bird Treaty Act (MBTA) protects burrowing owls during the nesting season. However, with land development increasing across the United States, the loss of burrowing owl habitat is a concern (Burrowing Owl Conservation Network 2018).

The swift fox is a mammal that is listed as a species of concern or sensitive species by the WYNDD, USFS, and BLM. The swift fox is a small fox that feeds on prairie dogs, ground squirrels, mice, rabbits, birds, berries, and seeds. The swift fox has lost 60 percent of its historic population. The main threat to swift fox is loss of habitat due to conversion of grassland to agricultural land. Like the burrowing owl, the swift fox has also experienced a decline because of prairie dog and ground squirrel control measures as swift fox rely on those species as a stable source of food (Defenders of Wildlife 2018).

2.2.1.3. *Greater Sage-Grouse*

Photo 18 Greater Sage Grouse (USFWS 2016).

The greater sage-grouse is listed as a WYNDD species of concern and a BLM sensitive species (WYNDD 2018b; BLM 2010). Greater sage-grouse are largely reliant on sagebrush habitat, relying on sagebrush for food and shelter (USFWS 2018b). Although the greater sage-grouse has avoided federal listing as a threatened or endangered species, conservation measures have been implemented, with Wyoming as a national leader, to ensure that greater sage-grouse habitat is conserved, and the species remains abundant. Wyoming contains an estimated 37 percent of the existing greater-sage-grouse population; therefore, greater sage-grouse are at the forefront of conservation concerns in the state (USFWS 2018c). In 2015, the state of Wyoming put forth Executive Order 2015-4, Greater Sage-Grouse Core Area Protection (State of Wyoming 2015). The established greater sage-grouse core areas are essential for the preservation of sagebrush habitat and greater sage-grouse populations. The Beaver Creek watershed contains sage-grouse core areas as well as sections with occupied leks (SuiteWater 2018). Figure 2.2.1 shows the greater sage-grouse core area within the Beaver Creek watershed.



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NAD 1983 UTM Zone 13N
USGS Topographic Map

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Sage Grouse Core Management Areas

FIGURE 2.2.1

2.2.2. Land Cover

The Beaver Creek watershed is within the Great Plains-Palouse Dry Steppe Province terrestrial-based ecoregion (USFS 2018a). The most dominant land cover in the watershed area consists of cool semidesert scrub and grassland dominated by sagebrush steppe (Figure 2.2.2, Land Cover). Sagebrush steppe are habitats of mixed grassland and scattered shrubs with 10-25 percent cover. Native *bunchgrasses* that form dense clumps and other native grasses comprise another 25 percent of cover. The other dominant land cover is temperate and boreal grassland and shrubland dominated by mesomorphic grasses and shrubs with some scattered trees. The northeastern portion of the study area is home to thousands of acres of temperate and boreal forest and woodland, also known as the Black Hills. Dominant plant species in this area include ponderosa pine (*Pinus ponderosa*) trees and prairie grasses such as bluestem (*Schizachyrium scoparium*) (USGS 2018).

2.2.2.1. Riparian Areas

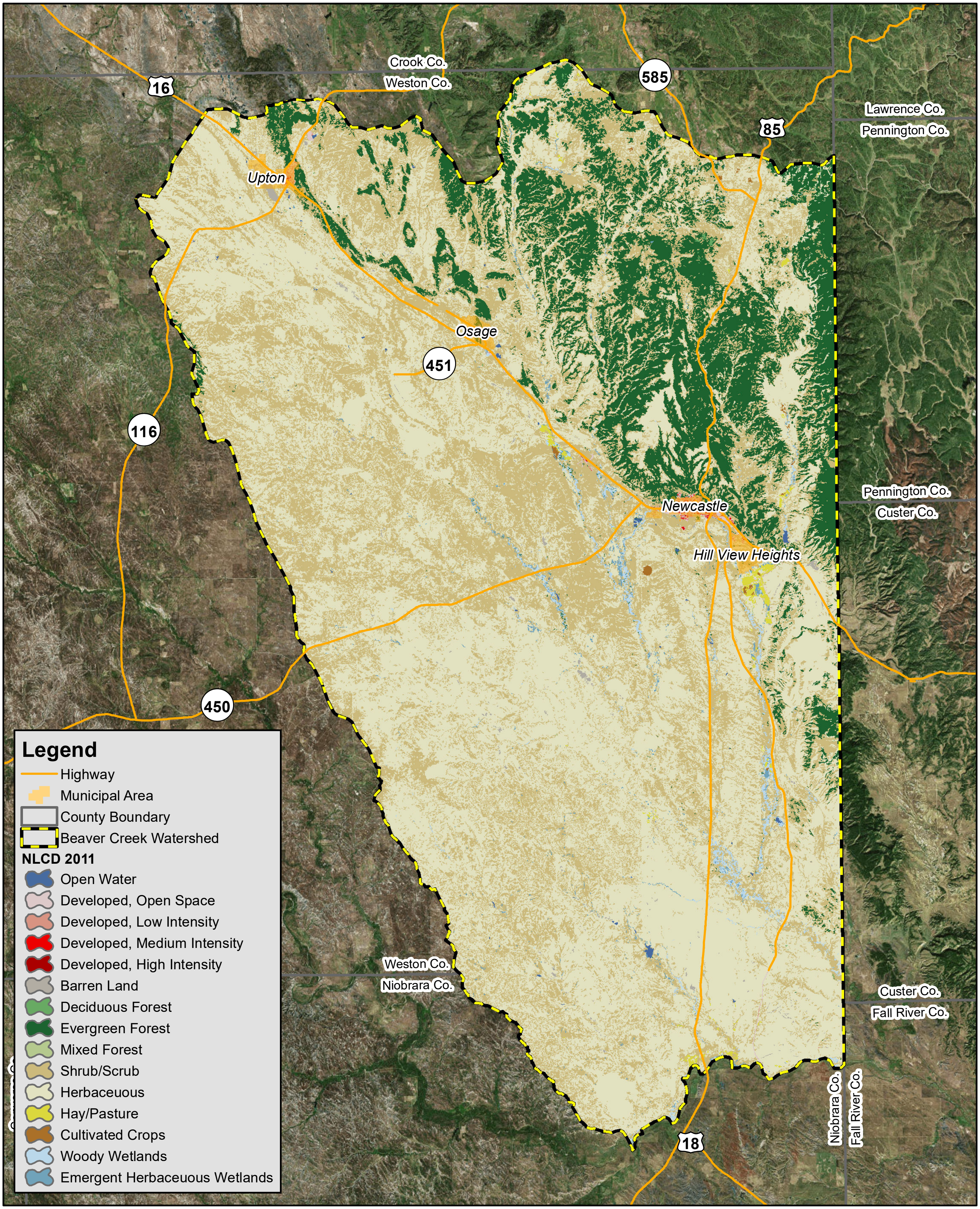
Riparian areas are described as lands occurring along waterways that are defined by a presence of water (USDA 2018a). The watershed consists mainly of shrub/scrub, grasslands/herbaceous, and evergreen forest vegetation that make up a predominantly dry environment that is not supportive of extensive riparian habitats. For this reason, the Beaver Creek watershed does not contain any mapped riparian areas identified by the National Wetlands Inventory (NWI). Unmapped, narrow, discontinuous riparian areas do exist primarily in the eastern and northern portions of the watershed. The isolated riparian areas are critical habitat for many plant and animal species in the area. Protection of these fragile habitats is an important part of the grazing management practices for ranchers in the area. Developing sources of water in the uplands will be described in Section 4, Watershed Management and Rehabilitation. These proposed upland water sources are designed to ensure that riparian areas are protected by providing alternative water sources away from the riparian areas.

2.2.2.2. Wetlands

Wetlands provide habitat for a diverse set of wildlife and are protected under the jurisdiction of the USACE. The USACE has jurisdiction over wetlands in order to protect and maintain the unique habitat wetlands create for aquatic wildlife. Along with providing habitat for a wide range of plants and animal species, wetlands also passively treat water, increase groundwater availability, and reduce flood damage (Know Your Watershed 2018). Freshwater emergent wetlands, freshwater ponds, lakes, and riverines are dispersed throughout the Beaver Creek watershed and are mapped by the NWI.

2.2.2.3. Vegetation and Plant Communities

Vegetation type in the Beaver Creek watershed is summarized in Table 2.2.2. The dominant vegetation cover type within the study area is herbaceous, accounting for 55.7 percent of the land cover in the watershed. This is followed by scrub/shrub at 24.5 percent and tree cover at 14.8 percent. Within these respective vegetation covers, Northwestern Great Plains Mixed Grass Prairie is the predominant cover and accounts for 40 percent of the watershed, followed by Inter-Mountain Basins Big Sagebrush Steppe at 20 percent and Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna at 12 percent. Remaining vegetation covers range from five percent to less than one percent within their respective cover groups and are consistent with vegetation types listed in Table 2.2.2.



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ESRI World Imagery

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Land Cover

FIGURE
2.2.2

Table 2.2.2 Vegetation Cover in the Beaver Creek Watershed.

Vegetation Type	Acres	Percentage of Total Watershed Area
Barren	1,833	0.2
Developed	8,167	0.9
Herb Cover	492,751	55.7
Cropland	28,861	3.3
Open Water	811	0.1
Quarries	1,093	0.1
Shrub Cover	216,793	24.5
Sparse Vegetation Canopy	3,684	0.4
Tree Cover	130,978	14.8

2.3. Anthropogenic Systems

2.3.1. Agricultural Water Use

The agricultural sector is one of the major consumers of water in this area of Wyoming. In fact, over 80 percent of water consumed by man's activities is used for irrigation in the northeastern area of the state (HKM Engineering 2002a). The majority of agricultural products in Wyoming are processed into feed for the livestock industry. In the Beaver Creek watershed, most of the water used in irrigation comes from surface water supplies via diversions. A relatively smaller portion of irrigation water comes from groundwater. Storage facilities throughout the watershed are important resources for staging irrigation water to meet demand. By examining agricultural water use in Beaver Creek watershed, it is clear that surface water availability is crucial to the economic success of the area.

2.3.1.1. *Irrigated Lands*

Only one percent, or approximately 12,300 acres, of the Beaver Creek watershed is irrigated. This statement is based on an inventory of irrigated lands in northeast Wyoming identified on 2017 aerial photography compiled for the WWDC by RESPEC. The following description is a subset of the inventory that only includes land within the Beaver Creek watershed. Irrigated land can be divided into the following categories:

- Class A: Full service irrigation
- Class AB/ABC: A mix between full service, partial service, and man-induced subirrigation
- Class B/BC: Partial service irrigation
- Class BD: Class B lands that are undergoing residential development
- Class C: Man-induced subirrigation
- Class E: Idle irrigation
- Class H: Minor beneficial use
- Class S: Spreader dike irrigation

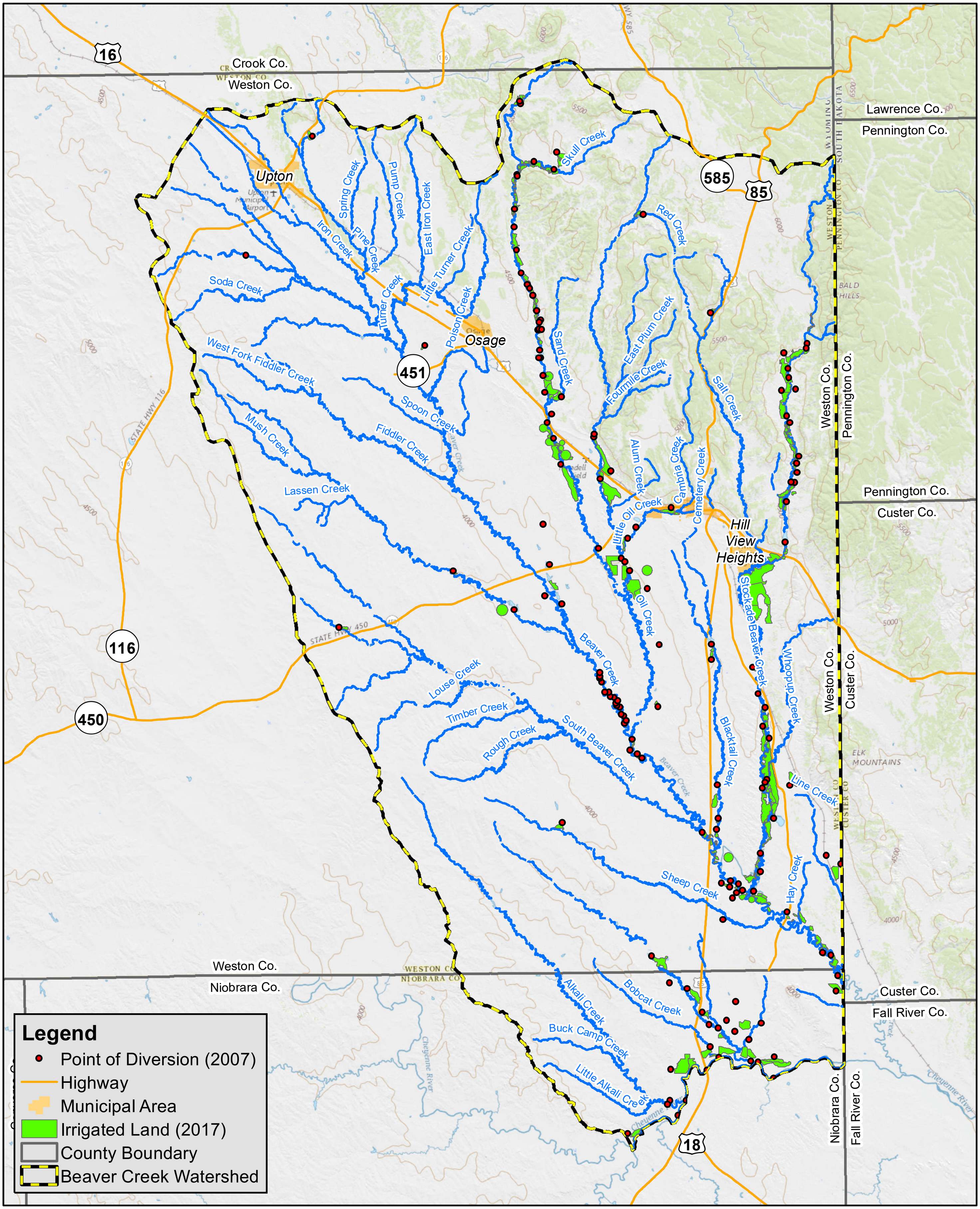
Figure 2.3.1 shows the locations of irrigated land throughout the study area as mapped in 2017 for the Northeast Wyoming River Basin Plan Update (WWDC, in progress). Points of diversion for these irrigated lands in 2017 have not been updated at the time of this report. Instead, shown on the map are points of diversion for irrigated land parcels in 2007. Because most of the cropland in the study area is surface water irrigated, the irrigated land parcels follow the river valleys of Beaver Creek, Stockade Beaver Creek, and their tributaries. There are approximately 675 acres within the Beaver Creek watershed that have been developed for irrigation since 2007. Most of these acres have been developed in the upper reaches of Beaver Creek and Stockade Beaver Creek in and around the Black Hills.

A small portion of the irrigated land in the watershed uses groundwater as a primary water source. Of the active irrigated acres in the study area, only about 2 percent are groundwater irrigated (HKM Engineering 2002). Table 2.3.1 shows the distribution of irrigated land by irrigation class in the study area. Partial service irrigation is used by almost half of landowners in the area. This means that these lands receive a reduced supply when surface water availability is limited. Full-service irrigated lands typically receive a full water supply during the growing season. Classes E and H make up a combined 13 percent of the distribution. Idle irrigated lands are lands that are not currently receiving water, perhaps because of nonfunctional delivery systems. Class H lands are usually situated near ephemeral streams, and only receive water on occasion via “kick-out” ditches.

The ranching industry in Wyoming provides one of the state’s largest exports—cattle. Much of the agriculture in Wyoming is associated with providing forage for livestock. Alfalfa, grass hay, and pasture grass are the major crops grown in the study area. Small grains and corn are also grown on a relatively smaller scale. According to the most recent Wyoming Census of Agriculture, irrigated forage including hay, grass silage, and greenchop comprises 83 percent of irrigated crops grown in Weston County. The other 17 percent comes from irrigated oats for grain. In Niobrara County, 95 percent of irrigated crops are irrigated forage, and 5 percent are irrigated corn (USDA 2012).

Table 2.3.1 Irrigated Land Class Distribution of Beaver Creek Watershed.

Irrigation Capability	Acres	Percentage of Total Irrigated Area
Class A	1,594	13.0
Class AB/ABC	1,514	12.3
Class B/BC	5,843	47.5
Class BD	852	6.9
Class C	0	0
Class E	306	2.5
Class H	1,280	10.4
Class S	907	7.4
Total	**12,296**	**100**
Source: RESPEC, unpublished data, 2018		



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WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Irrigated Lands and Points of Diversion

FIGURE
2.3.1

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2.3.1.2. *Irrigation Systems*

According to the 2017 Wyoming Irrigation Systems Report by the WWDC, there are no irrigation districts or companies that operate in the study area (WWDC 2017). Active irrigation systems in the Beaver Creek watershed are privately owned and operated by landowners. Points of diversion used by landowners in the study area are shown in Figure 2.3.1.

The absence of irrigation districts and the widespread use of partial service irrigation results in a scarcity of information about how the irrigation systems operate in the Beaver Creek watershed. The annual hydrographer's report by the WSEO yields little additional information. Diversion records indicate only one diversion is tracked in the study area. This diversion is located on Stockade Beaver Creek and supplies the LAK ditch. Records from 2016 and 2017 show up to four cubic feet per second (cfs) of water is diverted from May to August (WSEO 2016, 2017). Information about specific irrigation systems within the watershed and recommendations for improvements are contained in the Water Management and Rehabilitation Plan section of this report.

2.3.2. Domestic, Municipal and Industrial Water Use

In addition to irrigation, other water uses throughout the Beaver Creek watershed are highly diversified due to Wyoming's unique geology that allows for oil and gas production, mineral mining, and industrial water uses. There is also substantial domestic and municipal use in communities and rural households.

2.3.2.1. *Potable Water Systems*

Domestic water uses in this report are defined as uses satisfied by individual wells or small water systems. Municipal water uses are met by a public water supply entity. Domestic use in the study area includes water used for rural homes, subdivisions, parks, campgrounds, rural schools, commercial establishments, and other small water uses that are not supplied from a central public water system (HKM Engineering 2002a). Domestic demand is met with groundwater, except for rural homes with access to a surface water source.

According to the Wyoming SEO e-Permit database, there are 213 identified domestic wells in the study area that supply water for residents (Figure 2.3.2-1, Domestic Water Users). Table 2.3.2-1 shows the self-supplied domestic water use in Niobrara and Weston counties. Although the counties extend beyond the Beaver Creek watershed area, this is a useful metric for showing the importance of domestic wells in the area. To adjust these numbers based on size of the study area, it is assumed that half of the consumption in Weston County and one-twentieth of the consumption in Niobrara County occur within the Beaver Creek watershed. With these assumptions, the domestic water consumption in the study area is 264,718,000 gallons per year.

Table 2.3.2-1 2015 Domestic Water Use.

Domestic Water Supply Area	Population Served	Per Capita Use (gal/person/day)	Total Annual Consumption (gal)
Niobrara County	843	71	218,460,000
Weston County	1,905	73	507,590,000
Source: USGS Water Use Data for Wyoming (https://waterdata.usgs.gov/wy/nwis/water_use)			

There are 11 public water entities that supply municipal water in the study area. Two include the incorporated municipalities of Newcastle and Upton. The rest are districts and joint powers boards:

- Cambria Improvement and Service District (I&SD)
- Canyon Improvement and Service District
- Force Road Joint Powers Board (JPB)
- Heritage Village Water and Sewer District (W&SD)
- Osage Water District (WD)
- Salt Creek Water District
- Sunset Ranch Water District
- Water Unlimited Inc.
- West End Water District

All of these entities meet their demand with groundwater (HKM Engineering 2002). Table 2.3.2-2 shows the peak daily consumption and annual consumption of these entities. Survey responses including system capacity show that most of these entities have adequate infrastructure to meet their existing needs (WWDC 2016).

Table 2.3.2-2 2016 Municipal Water Use.

Water Supply Entity	Population Served	Peak Daily Consumption (gal)	Total Annual Consumption (gal)
Cambria I&SD	170	51,000	8,657,000
Canyon I&SD	100	13,000	3,700,000
Force Road JPB*	185	184,000	14,519,000
Heritage Village W&SD*	700	391,300	34,011,900
City of Newcastle	4000	1,840,000	60,745,000
Osage WD	278	57,000	17,241,000
Salt Creek WD	480	130,000	36,756
Sunset Ranch WD	60	13,000	11,000,000
Town of Upton	1100	693,000	73,749,000
Water Unlimited Inc	80	No data	No data
West End WD*	300	No data	No data
Source: WWDC 2016			

*Entity did not respond to 2016 survey, data of last survey completed given.

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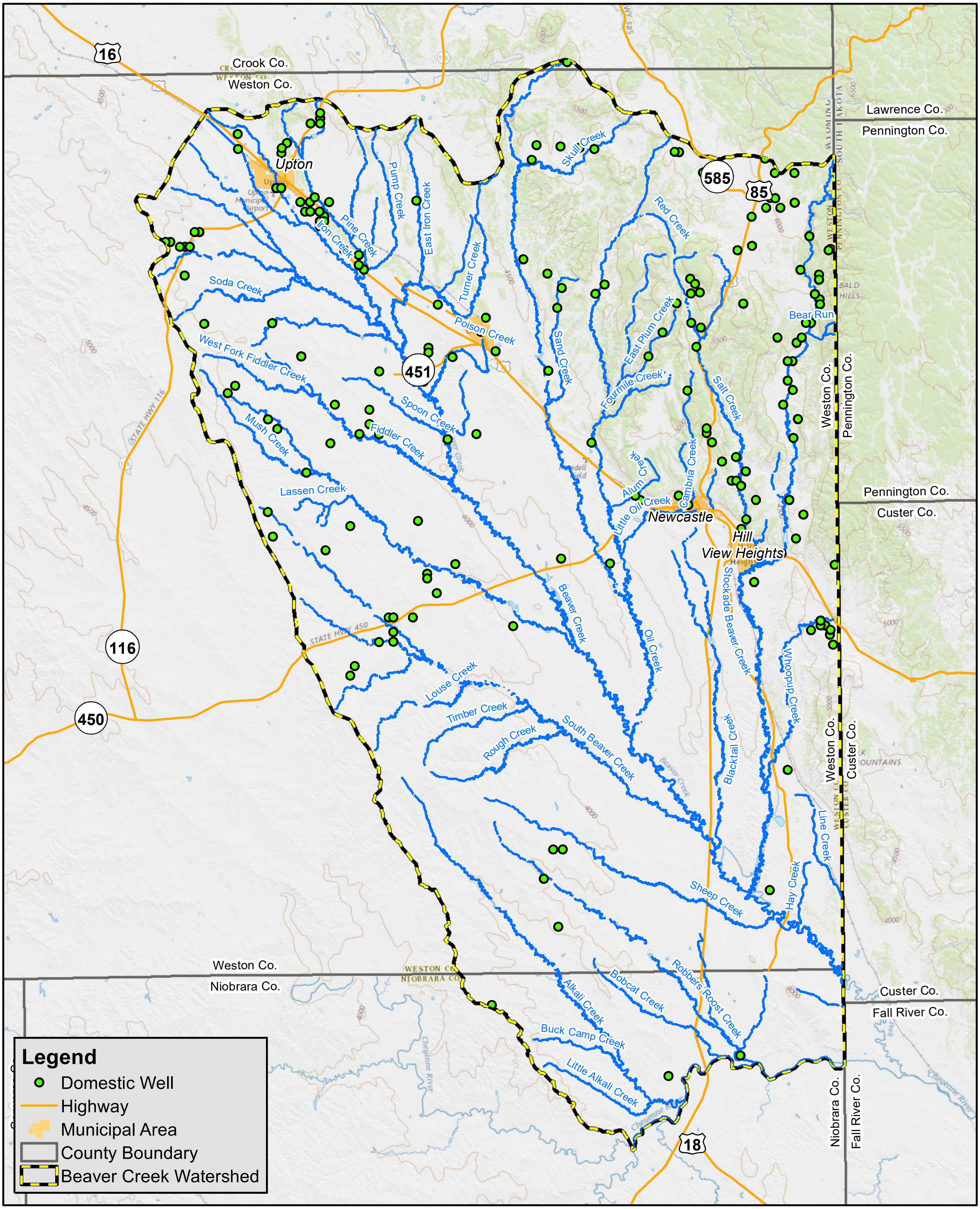

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USGS Topographic Map

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Domestic Water Users

FIGURE
2.3.2-1

2.3.2.2. *Industrial and Mining*

Industrial water uses in the Beaver Creek watershed include conventional oil and gas production, oil refining, and mineral mining. The majority of water used for industrial purposes comes from groundwater (HKM Engineering 2002a).

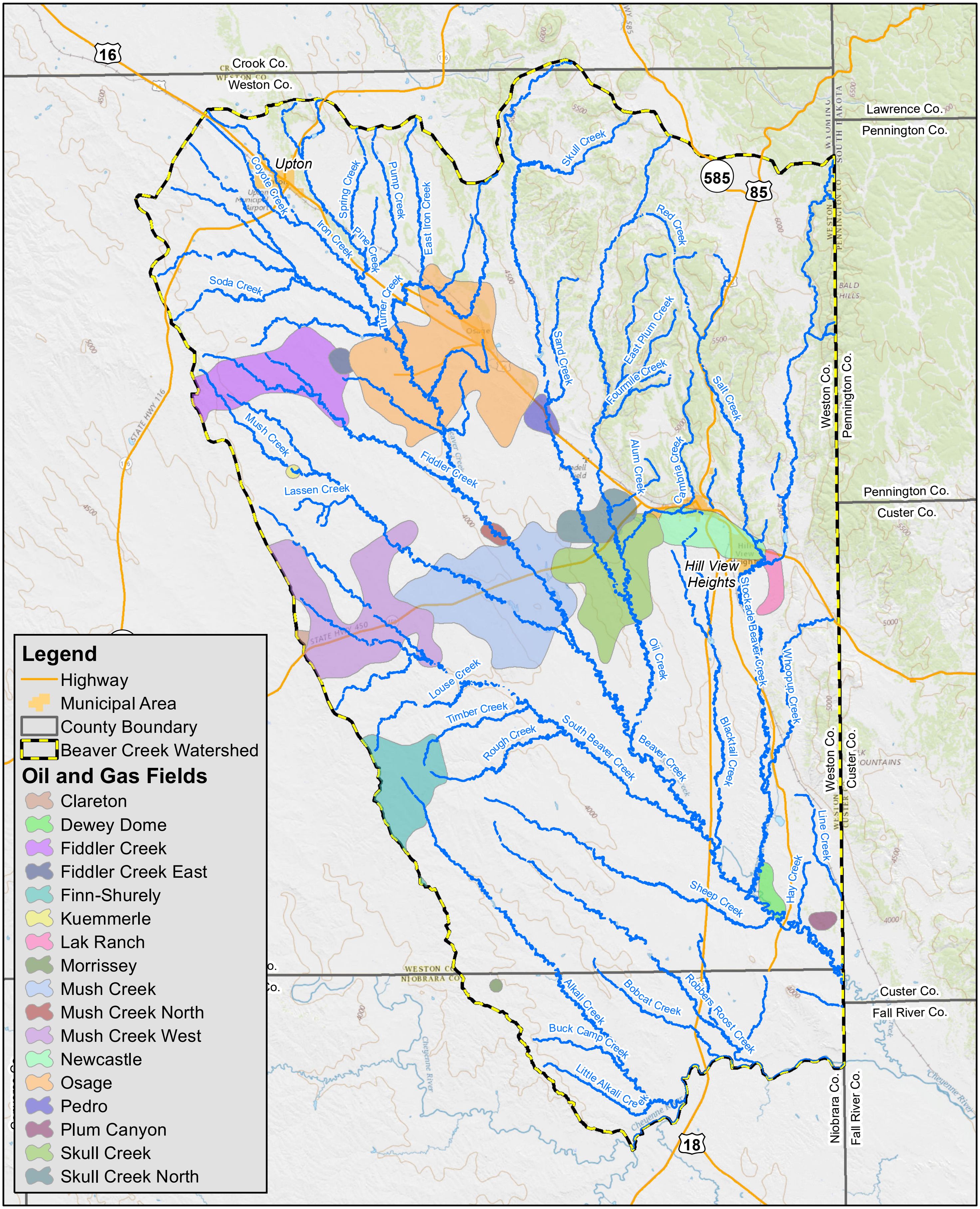
Wyoming has large reserves of oil and natural gas that lie under fault-bounded Laramide basins. In fact, Wyoming ranks sixth nationwide in natural gas production and eighth in oil production (WSGS 2018). The oil and gas industry experiences pricing highs and lows which affect the production, employment, and statewide economy. To boost oil production, Wyoming continues to expand horizontal drilling and hydraulic fracturing in certain basins; especially in the Powder River Basin (Lynds and Toner 2015). The Powder River Basin encompasses much of the northeastern area of the state, including the western portion of the Beaver Creek watershed. Within the Beaver Creek watershed study area, there is active oil and gas production near the city of Newcastle. The oil refinery located in Newcastle consumes approximately 400 acre-feet of groundwater per year (HKM Engineering 2002a). There are 17 total active oil and gas wellfields in the study area (Figure 2.3.2-2, 2017 Oil and Gas Production).

Table 2.3.2-3 lists the amount of oil, gas, and water produced during oil and gas production in Wyoming with the counties located within the basin (Niobrara and Weston) highlighted for emphasis. Niobrara and Weston counties account for less than 2 percent of the state's oil production and less than 1 percent of the state's natural gas production in 2017. Although Niobrara and Weston counties extend well beyond the boundary of the Beaver Creek watershed, the data in Table 2.3.2-3 is useful for comparing orders of magnitude of oil, gas, and water production in the state. While oil and gas wells can produce groundwater, they can also consume it. Water is consumed via injection into the oil and gas aquifers. Injection wells are used to stimulate production. The net amount of water consumed by oil and gas wells is not monitored, and therefore cannot be quantified (HKM Engineering 2002a).

Rock exposures through Wyoming make it an excellent place to collect minerals including gemstones, industrial minerals, and metals. Wyoming is the most prolific coal-producing state in the union, supplying 41 percent of the U.S. domestic supply of coal in 2017 (WSGS 2018). In fact, Wyoming produces more coal than the next six coal-producing states combined, including West Virginia, Pennsylvania, Illinois, Kentucky, Texas, and Montana (WSGS 2018). More detailed information on Wyoming coal production can be found online at http://www.wsgs.wyo.gov/energy/coal.

The nearest active coal mine to the study area is the Coal Creek Mine about 54 miles west of Newcastle in Campbell County. Although no active coal mines exist in the study area, four coal field districts are in operation: Skull Creek, Sundance, Cambrian, and Gillette (WSGS 2018). The Osage power plant was a coal-fired plant that produced electricity and was located a half mile south of Osage. (Figure 2.3.2-3, Coal Fields). When the plant was operational, water was used for cooling purposes. About 870 acre-feet of groundwater was consumed annually at the plant (HKM Engineering 2002a). Since publication of the HKM Engineering report in 2002, the Osage power plant was closed and has been removed.

In addition to energy minerals, Wyoming's resources include metals and industrial minerals. Industrial minerals such as bentonite, gypsum, aggregate, limestone, decorative stone, and trona are important to the state's economy. Wyoming's bentonite supply makes up about 70 percent of the world's known supply (Wyoming Mining Association 2018). A major source of bentonite is located within the Beaver Creek watershed along the Southern Black Hills. Gypsum and limestone can also be found in the study area (WSGS 2018).



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Original Published Resolution
NAD 1983 UTM Zone 13N
USGS Topographic Map

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Oil and Gas Production (2018)

FIGURE
2.3.2-2

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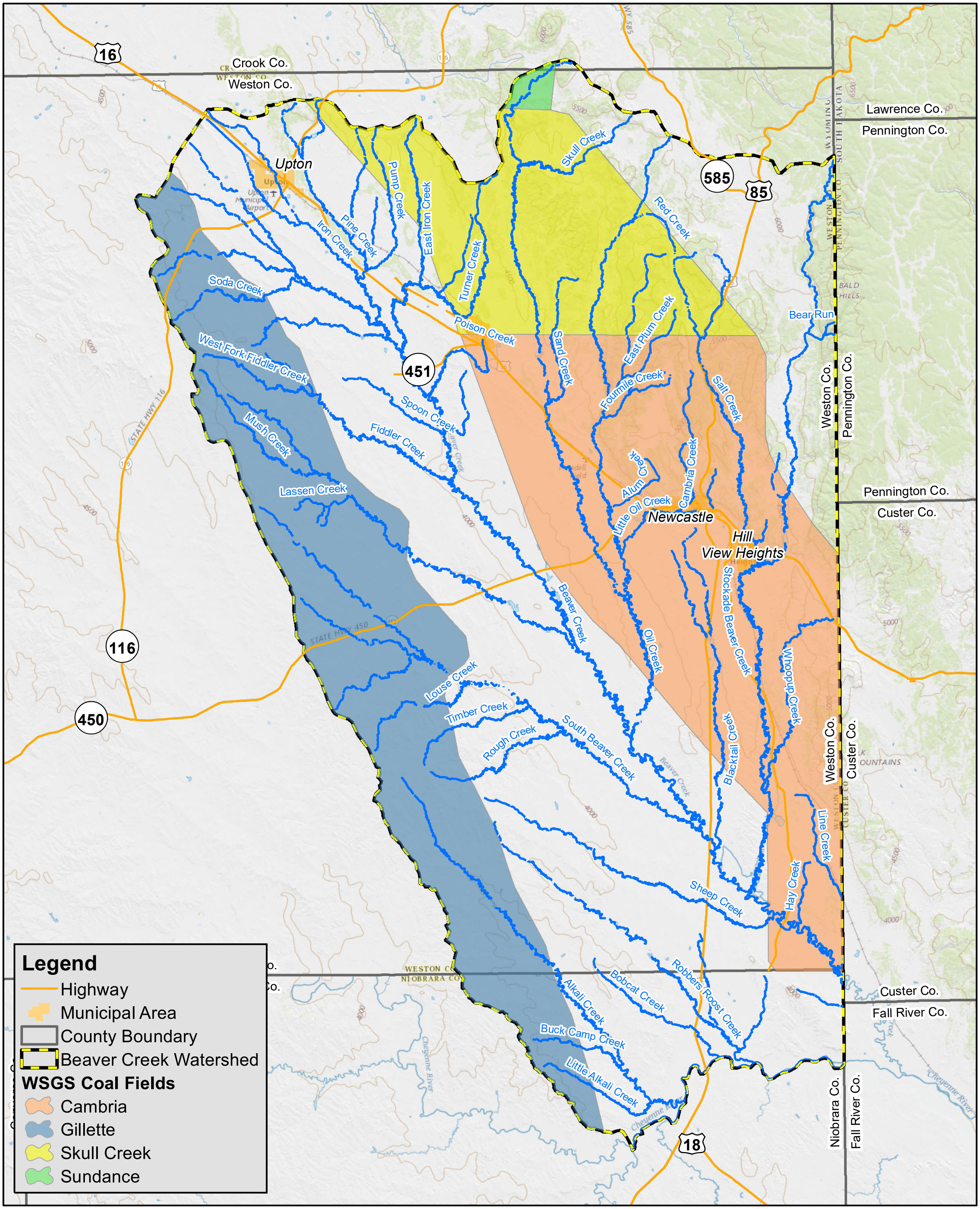

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Original Published Resolution
NAD 1983 UTM Zone 13N
USGS Topographic Map

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Coal Fields

FIGURE
2.3.2-3

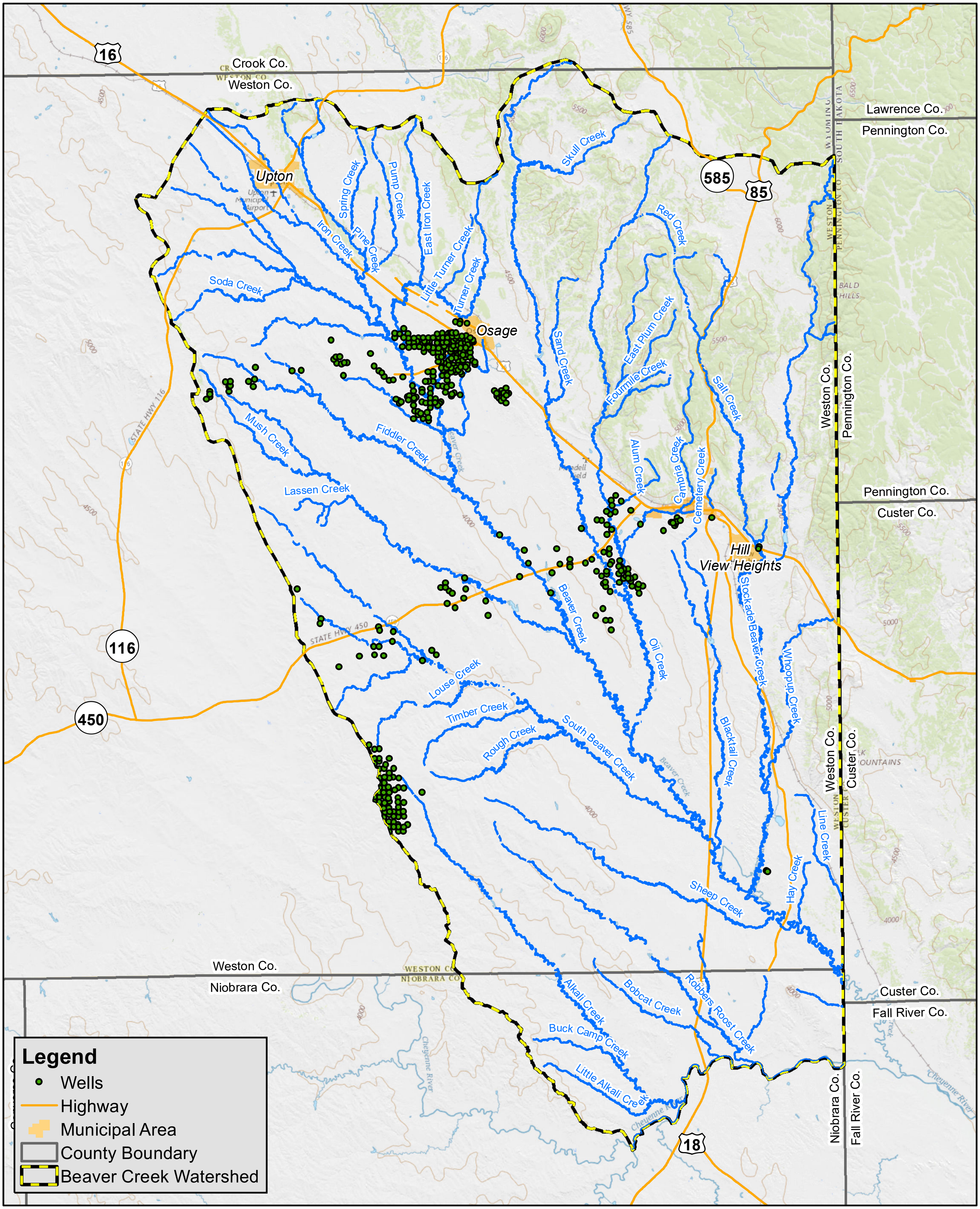
Table 2.3.2-3 2017 Oil and Gas Production Summary.

County	Producing Wells	Total Year Oil/BBLS*	% State Oil Total	Total Year Gas/MCF**	% State Gas Total	Total Year Water/BBLS	% State Water Total
Albany	31	37,614	0.05	998	0.00	1,809,436	0.11
Big Horn	399	1,358,482	1.80	1,329,242	0.07	147,734,427	8.67
Campbell	4,346	17,335,896	22.91	79,114,899	4.38	155,553,451	9.13
Carbon	1,792	1,391,711	1.84	88,774,465	4.92	81,799,039	4.80
Converse	1,235	14,063,644	18.59	50,986,300	2.83	11,762,385	0.69
Crook	344	1,001,950	1.32	22,840	0.00	25,608,364	1.50
Fremont	1,185	3,638,040	4.81	138,673,055	4.68	180,427,428	10.59
Goshen	2	6,840	0.01	0	0.00	840	0.00
Hot Springs	587	2,113,163	2.79	416,659	0.02	205,075,464	12.04
Johnson	3,704	1,035,668	1.37	96,667,656	5.36	105,279,728	6.18
Laramie	320	7,265,951	9.60	6,493,530	0.36	8,018,014	0.47
Lincoln	1,325	361,543	0.48	41,184,131	2.28	597,715	0.04
Natrona	1,653	4,962,918	6.56	10,334,601	0.57	138,718,986	8.14
Niobrara	226	925,465	1.22	1,194,409	0.07	11,501,346	0.68
Park	1,167	6,037,065	7.98	9,271,765	0.51	526,386,591	30.89
Platte	0	0	0.00	0	0.00	0	0.00
Sheridan	199	16,796	0.02	1,104,357	0.06	3,709,575	0.22
Sublette	6,648	6,142,586	8.12	972,050,382	53.86	29,172,698	1.71
Sweetwater	3,588	5,851,375	7.73	216,145,253	11.98	48,168,074	2.83
Uinta	425	764,885	1.01	87,830,340	4.87	1,129,459	0.07
Washakie	275	525,010	0.69	1,460,140	0.08	9,606,306	0.56
Weston	1,056	832,351	1.10	1,626,103	0.09	12,002,115	0.70
County Totals	**30,307**	**75,668,953**		**1,804,681,305**		**1,704,061,441**	
Source: Wyoming Oil and Gas Conservation Commission 2018							

*BBLS = barrels
**MCF = one thousand cubic feet

2.3.2.3. *Produced Water*

Produced water is the term used to describe the water pumped from oil and gas wells during operation. It is the largest byproduct associated with oil and gas exploration and production. Table 2.3.2-3 shows the barrels of water produced as a result of oil and gas operations in 2017. Figure 2.3.2-4 shows the locations of water produced as a result of oil and gas production in 2000. Contaminants present in produced water can include salt, oil and grease, chemical additives introduced by drilling operations, and naturally occurring radioactive materials (Clark and Veil 2009).



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USGS Topographic Map

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Produced Water (2000)

FIGURE
2.3.2-4

In the United States, on-land produced water is usually disposed of through injection back into the ground, discharged through National Pollutant Discharge Elimination System (NPDES) permits, through beneficial reuse, or publicly owned treatment works (Clark and Veil 2009). Data from 2012 indicates over 1,160,000,000 barrels (bbl) of produced water was injected back into the ground statewide via 2,759 injection wells. The following passage describes produced water management in the nearby Powder River Basin of Wyoming:

> *Information on historic trends that was provided for produced water management in the Powder River Basin indicate that since 1987, 4.784 billion bbl have been produced from coal beds. Approximately 54% has been discharged to ephemeral and perennial streams, 35% has been managed using off-channel pits, 5% has been reused for irrigation projects, 3% has been managed through injection, and 3% has been treated and then discharged into streams. Much of the produced water from conventional gas activities in the Big Horn Basin was also managed through agricultural reuse, although the actual volume is unknown. (Veil 2015)*

2.3.3. Water Storage

The Beaver Creek watershed does not contain any water storage sites of significant size. The majority of water storage occurs in numerous small stock ponds and impoundments used by land owners. The study area does include a variety of small, low hazard structures and the largest dam in the area is Spencer Reservoir located near Newcastle shown in photo 19.

2.3.3.1. *Reservoirs*

No natural lakes of significant size exist within the Beaver Creek watershed. According to the National Inventory of Dams (NID), 42 dams are located within the study area. Figure 2.3.3-1, National Inventory of Dams, shows the locations of the dams. The combined storage behind the identified dams is 15,503 acre-feet. The reservoirs range in storage from 43 to 2,847 acre-feet, with dam heights ranging from 9 to 45 feet. The purposes of the reservoirs include irrigation, fish and wildlife, fire protection, stock, flood control, debris control, recreation, and water supply. Dams that do not fall under the jurisdiction of the State Engineer's Office are not included in the database. Data Summary 2.3.3 in Appendix A lists the dams included in the database, along with select relevant information.

Photo 19 Spencer Reservoir, also called LAK Reservoir near Newcastle, Wyoming.

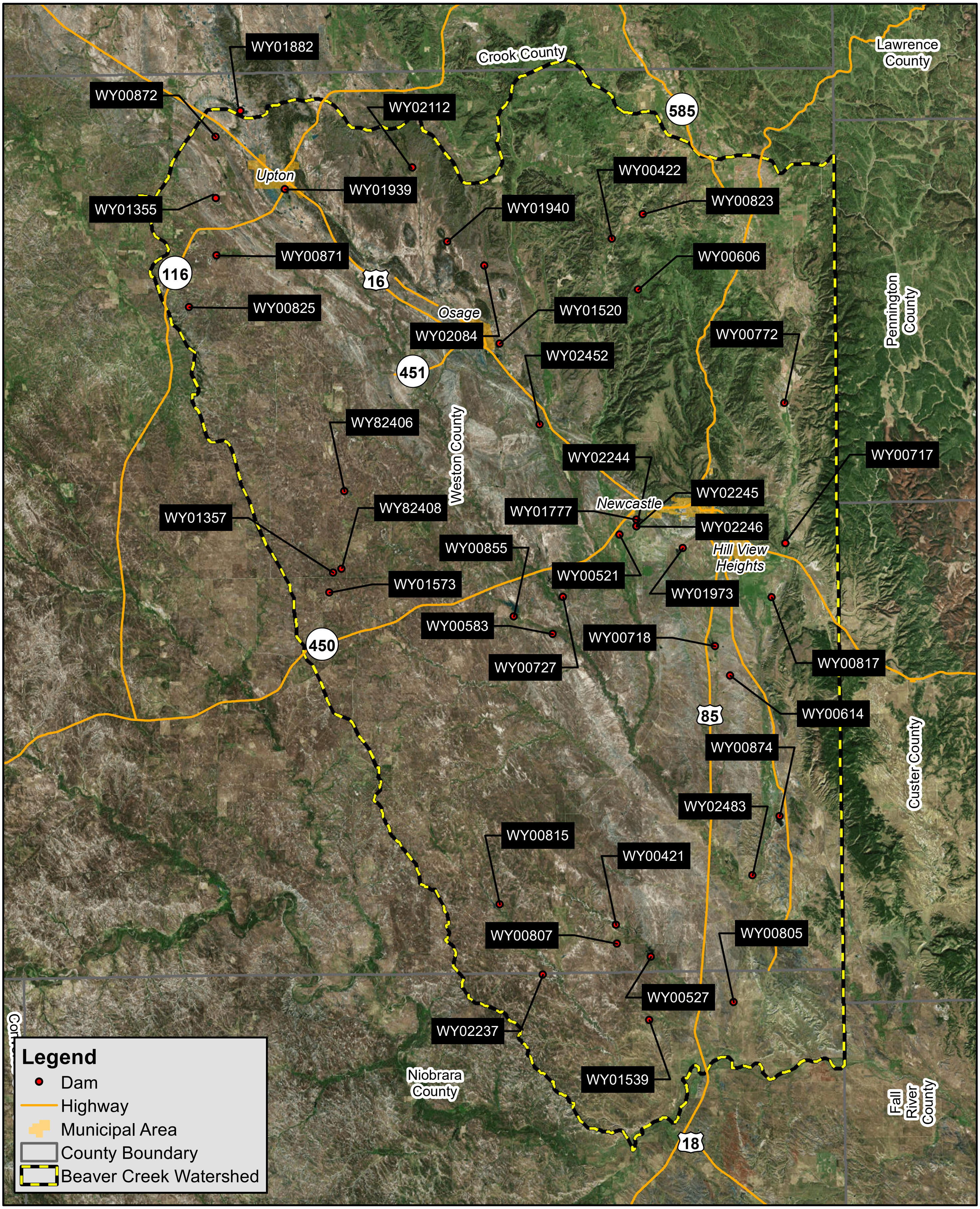
Seven of the structures are listed as having storage of 500 acre-feet or more, as shown in Table 2.3.3-1. The largest reservoir is Spencer, commonly referred to as Spencer-LAK, listed to have over 2,800 acre-feet of storage. The seven largest reservoirs are all located in Weston County and serve the primary purpose of irrigation, except for Upton Reservoir, which has a primary purpose of water supply. A review of the locations in Google Earth showed that all of the dams are holding water but are not at the maximum pool. Sedimentation was observed in the upper reaches of Robbers Roost and Klodt reservoirs. Klodt and Upton reservoirs appear to have shallow water that contains sediment. Aerial photographs from previous years show that Robbers Roost Reservoir was essentially dry in 2006, Klodt Reservoir has had lower water since 2006, and Upton Reservoir had essentially no water in 2006. Geier Irrigation Reservoir was constructed in 2008 and is filled by a Madison Formation well.

Table 2.3.3-1 National Inventory of Dams with Minimum Storage of 500 acre-feet.

NID ID	Dam Name	Stream	Height (feet)	Storage (acre-ft)	Primary Purpose
WY00717	Spencer	Stockade Beaver Creek	45	2,847	Irrigation
WY00874	M. W. Reservoir	Stockade Beaver Creek	35	2,410	Irrigation
WY00527	Robbers Roost	Robbers Roost Creek	22	1,989	Irrigation
WY00855	Klodt	Mush Creek	26	1,708	Irrigation
WY00718	Howell	Black Tail Creek	25	840	Irrigation
WY02452	Geier Irrigation Reservoir	Oil Field Draw Offstream	42	587	Irrigation
WY00872	Upton	Pine Creek	30	500	Water Supply

Previous Studies

The 2002 Northeast Wyoming River Basins Plan (HKM Engineering 2002a) identified three storage site/reservoir projects in the long and short lists of future water use opportunities: Beaver Creek Reservoir (south), Beaver Creek Reservoir (north), and Stockade Beaver Creek Reservoir. The three sites were the focus of Level I and Level II studies by the WWDC. Relevant information about the reservoirs is shown in Table 2.3.3-2. Beaver Creek (north), as it was called in the Northeast Wyoming River Basins Report, was the proposed opportunity that seemed the most feasible. The project was carried through an analysis of hydrology and design but stopped because of funding considerations. Beaver Creek (north) was discussed at the April 24, 2018, public meeting to gauge potential interest in the project. The topic was raised by a property owner in the watershed and the current cost to construct was estimated to be $30-$40 million (J. Mead, personal communication, April 24, 2018). This estimate was based on a similar sized WWDC reservoir project currently underway. To most of the residents at the meeting, this cost was prohibitive.



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ESRI World Imagery

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
National Inventory of Dams

FIGURE
2.3.3-1

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Table 2.3.3-2 Previously Identified Storage Opportunities.

Storage Opportunity	Purpose	Storage (acre-feet)	Relevant Study
Beaver Creek (north)	Recreation	8,000	Beaver Creek Dam and Reservoir Project – Final Report Level II (Bearlodge Ltd. 1991)
Beaver Creek (south)	Recreation	5,026	Beaver Creek Dam and Reservoir – Level I (Bearlodge Ltd. 1989)
Stockade Beaver Creek	Recreation	208/520 (two sites)	Stockade Beaver Creek Reservoir – Final Report Level I (Bearlodge Ltd. 1986)

2.3.3.2. *Upland Water Storage*

The study area contains numerous small impoundments and stock watering ponds, which are shown in Figure 2.3.3-3, Estimated Stock and Wildlife Pond Locations. The estimated stock pond locations were mapped using a dataset created by HKM Engineering for the 2002 Northeast River Basin Plan (HKM Engineering 2002a). To build the dataset, HKM Engineering used the permitted stock pond database maintained by the WSEO. The permitted stock ponds database was narrowed down to only include ponds with a capacity of 20 acre-feet or less. The Belle Fourche River Compact permits unlimited use of stock water reservoirs not exceeding 20 acre-feet in capacity; therefore, the assumption was made in the analysis that stock ponds in the area are less than 20 acre-feet in capacity. This revised stock pond geodatabase was further refined to only include ponds in areas where USGS 7 ½ minute quadrangle maps are available. The resulting map shows 1,215 stock and wildlife ponds in the study area. Upon review of the map, it is the opinion of the WCNRD and local NRCS, that this is a significant over estimate of the number of stock ponds that currently exist in the watershed (personal communication, Lacey Sloan, October 17, 2018).

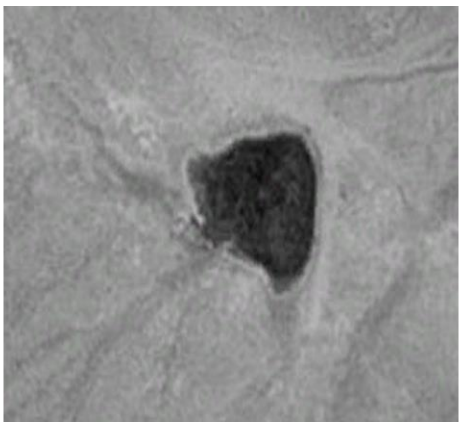
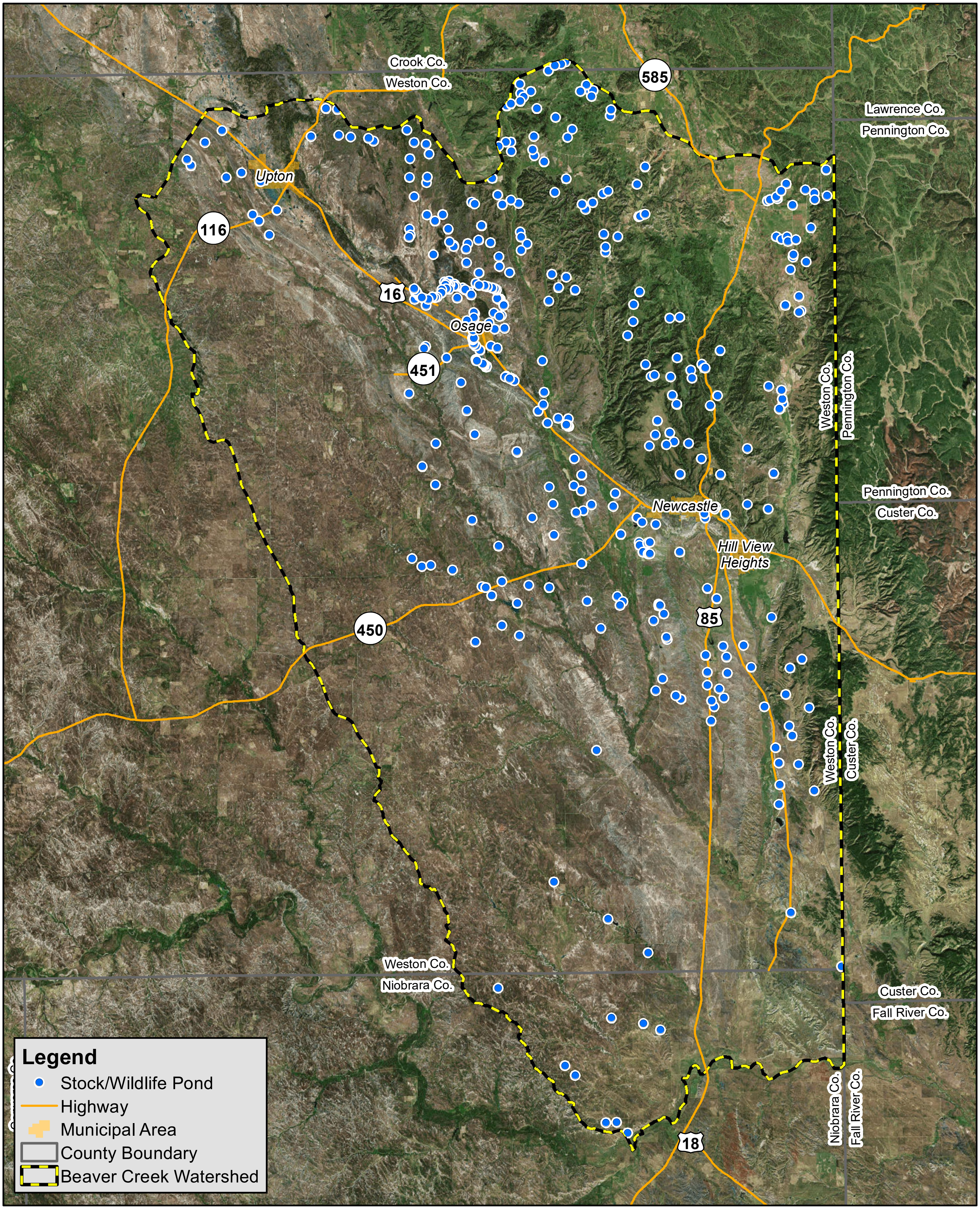


Figure 2.3.3-2 An Example of a Breached Dam Identification.

A reconnaissance-level survey of the entire study area was conducted using aerial photography, topographic maps, and GIS surface water layers to identify locations where potential breached dams appeared to exist. Some of the dams are breached and the reservoirs are empty, while others are apparently partially breached and still hold some water. Figure 2.3.3-2 shows an example of an identified breached dam location. Figure 2.3.3-4 shows the locations of the identified breached dams compared to other identified water sources. A total of 47 potential breached dams were identified. These structures could be repaired to provide additional livestock / wildlife watering in areas not served by other water sources. Permitting can be easier for repairing an existing structure as compared to constructing a new one.



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Original Published Resolution
NAD 1983 UTM Zone 13N
ESRI World Imagery

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Estimated Stock and Wildlife Pond Locations

FIGURE
2.3.3-3

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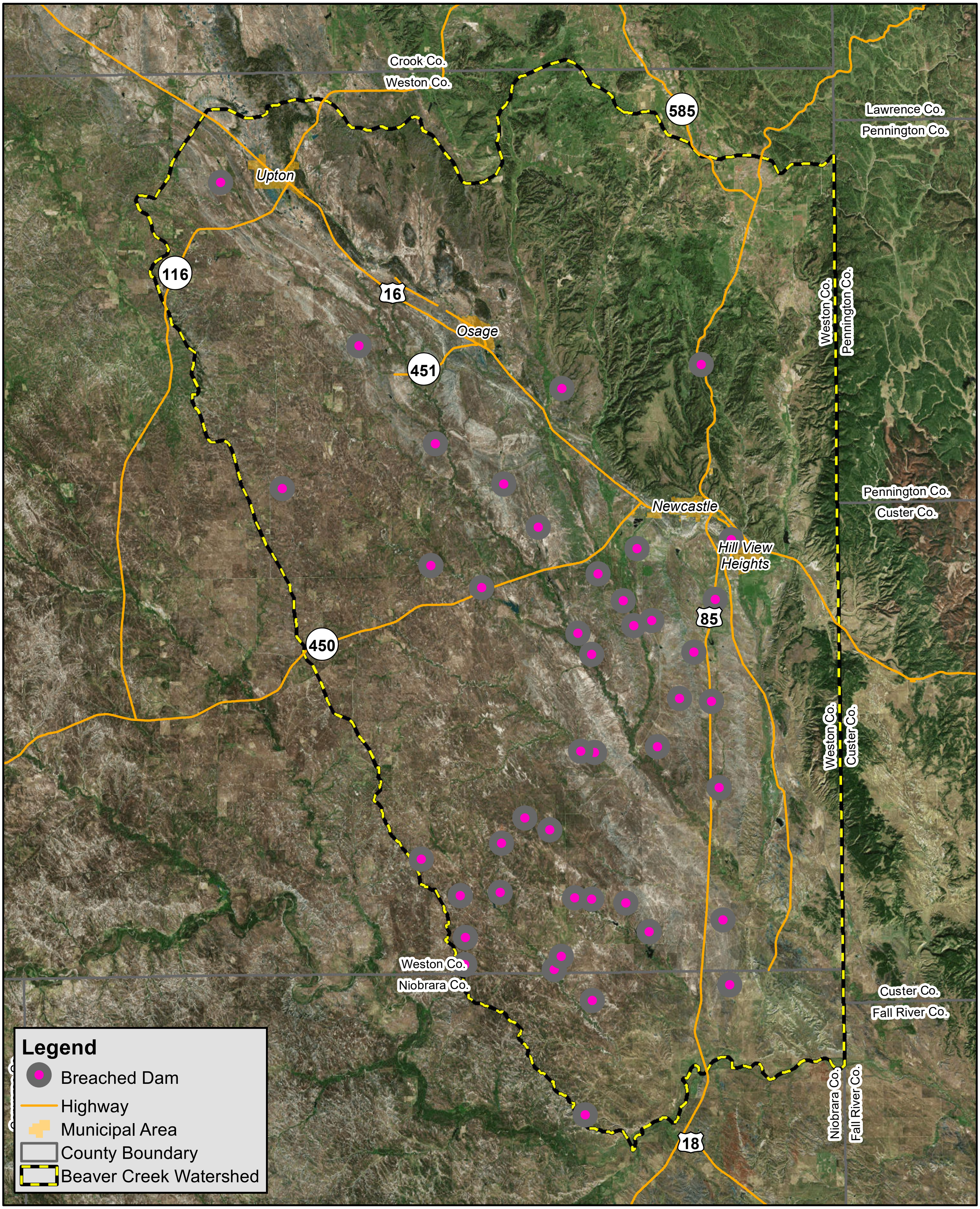

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1 " = 35,000 '

Original Published Resolution

NAD 1983 UTM Zone 13N

ESRI World Imagery

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WWDC Beaver Creek Watershed Study

Niobrara and Weston Counties, Wyoming

Breached Dams

FIGURE

2.3.3-4

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2.3.4. Land

Land use throughout the Beaver Creek watershed is dependent on many factors including elevation, precipitation, and land ownership. The following section summarizes the current land use, ownership, and key land management associations.

2.3.4.1. *Land Use*

Table 2.3.4-1 lists the land use across the watershed by acre and by percentage as reported by the USDA. The summary indicates that the predominant land uses are grassland and shrubland which are primarily for agricultural/grazing. Water use for the agricultural pastures is low relative to cropland, industrial and to some extent urban water use. The following discussion focuses on the potential for future expansion of these specific land uses and how this relates to future water use.

Table 2.3.4-1 Land Use within the Watershed.

Land Use Type	Acres	Percentage of Total Watershed Area
Barren	1,294	0.1
Conservation Easement	2,443	0.3
Cropland	37,999	4.3
Urban/Developed	8,499	1.0
Forested	115,314	13.0
Grassland	346,119	39.1
Shrubland	370,124	41.9
Open Water	521	0.1
Wetlands	1,995	0.2
Source: USDA 2017		

Urban areas currently represent approximately one percent of the watershed. The largest town located within the watershed is Newcastle with a stable population of approximately 3,500 for the past 25 years. With this said, urban growth in the watershed is not predicted to be significant. The watershed contains approximately 2,718 miles of roadway, 66 miles of railroads, and 150 miles of electrical power lines.

Cropland areas within the watershed, which occupy less than five percent of the watershed, have the highest demands on water. Cropland includes areas that are fallow, irrigated, and non-irrigated. There is the potential for future expansion of cropland within the watershed, although only as development of stable water sources continue.

2.3.4.2. *Land Ownership*

The Beaver Creek watershed consists of approximately 884,000 acres within Weston, Crook, and Niobrara counties. Land ownership within the watershed is predominantly private (1,073 square miles, or 74.6 percent of the watershed). The state of Wyoming owns approximately 115 square miles (8.3 percent) of the watershed, and approximately 232 square miles (16.8 percent) are federal lands (BLM and USFS). Categories of land ownership/land management are shown in Table 2.3.4-2. Public lands are managed the BLM, USFS, and the state of Wyoming. The USFS also manages areas of the National Grasslands located within the watershed, including the Thunder Basin National Grassland and Black Hills National Forest. There are two municipalities within the watershed – the City of Newcastle and the Town of Upton.

The Thunder Basin National Grassland is located in the Powder River Basin of Wyoming between the Big Horn Mountains and the Black Hills and ranges in elevation from 3,600 to 5,200 feet. Wildlife abound year-round in the Thunder Basin National Grasslands and the area provides forage for livestock. The Thunder Basin National Grassland has highly intermingled ownership within the grassland boundary, including federal, state, and private lands. The Grasslands are located in parts of Weston, Niobrara, and Crook counties in the study area for this report. The Thunder Basin National Grassland is managed by the Douglas Ranger District, with the Supervisor's office located in Laramie.

Table 2.3.4-2 Listing of Land Owners.

Land Owner	Acres	Percent of Watershed
Bureau of Land Management	63,655	7.2
U.S. Forest Service	85,080	9.6
Other	2,314	0.3
Private	659,043	74.6
State	73,789	8.3

2.3.4.3. *Land Management and Upland Water Resources*

The USFS grazing allotments make up 27 percent (approximately 239,628 acres) and the BLM grazing allotments make up 7 percent (approximately 62,974 acres) of land within the study area. The USFS and BLM grazing allotments for the Beaver Creek watershed are listed in Tables 2.3.4-3 and 2.3.4-4, respectively. As noted in Section 2.3.4.2 on land ownership, there are complex land patterns in the Thunder Basin National Grasslands because of federal, state, and private land ownership which accounts for the differences between the percentages listed for land management and land ownership.

The USFS Rangeland Management Program for the National Forest System lands is responsible for the management and promotion of range vegetation, the protection of soil and water resources, ecological diversity, and habitat quality (USFS 2002). In recent years, the USFS and BLM have become more conservative in their management of federal grazing allotments in an effort to improve range quality and provide adequate forage for wildlife. Conservation of rangeland has become a collaborative effort between landowners, managers, agencies, and the public to address public concern regarding habitat quality and the effects of livestock grazing (USFS 2018b).

In collaboration with the BLM, USFS, USFWS, and NRCS, the Thunder Basin Grasslands Prairie Ecosystem Association was founded to conserve the sagebrush steppe and shortgrass prairie environments located in Campbell, Converse, Crook, Niobrara, and Weston counties in Wyoming. The Thunder Basin Grasslands Prairie Ecosystem Association focuses on maintaining healthy habitat for black-tailed prairie dogs, mountain plover, burrowing owl, ferruginous hawk, greater sage-grouse, sage sparrow, Brewer's sparrow, and sage thrasher.

In addition, the WCNRD has implemented a Long-Range Natural Resource Management Plan for 2016-2021. The objective of the management plan regarding rangeland is to monitor rangeland conditions, promote conservation practices to improve range conditions, promote education on natural resources, and to support local, state, and federal agencies in their collaboration with the public to develop management plans (WCNRD 2016).

Table 2.3.4-3 Listing of USFS Grazing Allotments.

USFS Allotment Name	USFS Allotment Number	Approximate Acres
Adkins	09301	612
Alkali	09312	14,535
Arledge	09356	11,126
AU7	09365	55
Borgialli	09310	7,998
Brown Community	09002	2,089
Bruce	09313	4,431
Butcher Road	09315	7,156
Childs	09361	727
Christensen	09317	1,144
Coordingly	09321	1,993
Cossart	09337	4,148
Cowger	09358	1,311
Cranston	09325	214
Crows Nest Upper Beaver	00404	542
D&W Livestock	09329	29,123
Dry Beaver	00406	256
East Upton-Osage	09004	5,505
Elk Mountain	00407	5,716
Elliott	09340	1,010
Foltz Community	09003	1,652
Fordyce	09343	1,951
Fulton	09346	2,844
Grieves	09352	4,695
Hagerman	09345	1,617
Hanson	09353	802
Harkness Draw	09309	0.006
Huckins	09397	635
Kraft	09328	571
Kuemmerle	09362	1,843
Lower Beaver	00412	824
M D Ranch	09349	2,557
Martens	09368	3,352
Materi	09370	869
McGee	09305	646
Mendenhall	09348	3,528
Middle Upton-Osage	09005	10,115
Mush Creek	09374	4,913
Norris	09378	398
North Fork	09344	4,072
Oliver	09380	3,629
Patton	09327	2,155
Peterson	09383	377
Pine Ridge	09307	7,382
Pipeline	09308	3,258
Rankin	09388	395
Rawhouser	09363	1,259

USFS Allotment Name	USFS Allotment Number	Approximate Acres
Shannon	09376	1,313
Shaw	09395	9,552
Sixmile Basin	09364	26,747
Soldier Creek	00416	247
Stanton	09314	122
Stellwagon	09371	2,554
Sweet	09335	2,047
Sweet Ranch	09324	2,595
Townsend Co.	09354	13,125
Turner Creek	09341	2,122
Webster	09357	1,824
West Upton-Osage	09006	4,640
Whisler	09311	407
Whitney	09360	445
X-Ring	09369	5,858
Total		**239,628**

Note: Total may not sum exactly due to rounding.

Table 2.3.4-4 Listing of BLM Grazing Allotments.

BLM Allotment Name	BLM Allotment Number	Approximate Acres
Oil Creek I	4370	860
Little Alkali Creek I	4104	450
Seven-Mile Creek	4120	86
Sweetwater Mountain	4341	113
Mule Creek Junction	4269	37
Robbers Roost	14020	201
Blacktail Creek	4369	676
Lucky Strike Min	4062	934
Sherwood Canyon I	4126	316
Hutt Road	14019	120
Skull Creek Road	4300	319
Fatal Hollow	4266	8
Burlington Northern RR	4281	770
Lone Tree I	4119	6,043
Cheyenne River	4056	880
Rats Valley	4227	232
Red Butte	4231	45
Hay Creek I	4391	245
Bald Hills	4386	407
Bobcat Creek	4333	522
Rock Corral Draw	4051	1,808
Rattlesnake Range	4038	445
Clifton Canyon	4135	1,034
Stockade Beaver Creek	4256	39
Butcher Road	4030	163
Powerline	4382	39
YT Reservoir	4297	80
Hilton Draw	4342	40
Alkali Creek	14136	558

BLM Allotment Name	BLM Allotment Number	Approximate Acres
Lance Creek IV	4118	334
Benhart Draw	4087	8,101
Gypsum Draw	4190	79
Little Alkali Creek II	4052	586
State Line Stars	4219	142
East Branch	4278	579
Boles Canyon II	4279	156
Canyon	4255	40
Bear Run II	4137	256
Dewey Junction	4201	560
Frannie Peak	4292	2,114
Beaver Creek II	4305	244
Rock Canyon	4337	7,043
MW	14011	3,577
Twenty-One Draw	4254	1,423
Mondell Field	4086	955
Blacktail Canyon	4323	232
Turner Creek	14133	3,000
Horsethief Canyon	4235	40
West Skull Creek	4287	41
Oil Creek II	4234	82
Beaver Creek I	4336	359
Boles Canyon I	4183	601
Rats Valley Creek	4156	560
Stockade Beaver	14005	303
West Fork	4140	80
South Beaver Creek	4061	3,782
Bear Run I	14021	414
Robbers Roost II	4363	79
Four-Mile Draw	4177	965
Seeley Road	4071	355
Kinney Canyon	4066	1,452
U Blacktail	4390	640
Sheldon Canyon	4321	161
Home Ranch Spring	4325	341
Elk Mountain	4399	1642
Lone Tree II	4088	577
Cave Spring	4364	480
Rock Pile	4165	372
Cheyenne Deadwood	4389	150
Sheep Creek	4048	691
Sherwood Canyon II	4046	1,008
Plum Creek Road	4354	40
Plum Canyon	7279	1
Twentyone Divide	2492	12
Skull Creek	4146	78
Black Canyon	4296	778
	Total	**62,974**

Note: Total may not sum exactly due to rounding.

The potential capabilities of grazing resources are best understood when landscape with homogenous growing conditions – such as precipitation, soils, slope, and geomorphic nature – are identified and separated from each other. These units (known as ecological sites) are included in the NRCS Electronic Field Office Technical Guides (eFOTGs) for Niobrara and Weston counties. These eFOTGs are available online at the following website: https://efotg.sc.egov.usda.gov/

Ecological Site Descriptions (ESDs) are grouped by precipitation zones and a total of 15 ecological sites are applicable for the Beaver Creek watershed. The ESD addresses the full range of physiographic and climatic features that influence water features, representative soil features, plant communities, wildlife interpretations, grazing interpretations, hydrology functions, recreational uses, and other factors relevant to the site type. Due to the size of the documents, ESDs are not included in this report, however, the ESDs can be easily downloaded in PDF format from the previously cited website.

Table 2.3.4-5 lists the 15 ecological sites occurring within the study area and the sites are summarized by acreage. Most of the Beaver Creek watershed has the detailed soil mapping needed to complete the associated ecological site assessments, however, as noted, nearly 60,000 areas do not have assigned ESDs.

Table 2.3.4-5 Ecological Sites within the Study Area.

Ecological Site Name	Approximate Acreage
Clayey	81,903
Clayey Overflow	9,249
Dense Clay	4,433
Loamy	194,020
Lowland	2,765
Overflow	7,511
Saline Lowland	28,927
Saline Upland	76,516
Sandy	57,298
Shale	1,903
Shallow Clayey	105,843
Shallow Loamy	154,838
Shallow Sandy	47,456
Thin Upland	47,404
Very Shallow	5,030
Ecological Classification Not Defined	59,213

2.3.4.4. *Cultural Resources*

Cultural resources are sites and remains associated with human activities. Such resources include historic trails, historic buildings and archaeological sites, and areas or elements of the natural human landscape that have traditional cultural significance. Wyoming has an abundance of these historical sites located throughout the state, and a detailed plan in place to continue to protect them. Wyoming's Comprehensive Statewide Historic Preservation Plan for 2016-2026 shows how important the preservation of these cultural resources are to the people of Wyoming. The top priority of this comprehensive plan is to increase public education and outreach efforts (Wyoming SHPO 2016). Further outlined in the plan are actions and priorities for historic preservation activities across the state.

Two historic trails cross the study area with a north-south orientation—the Cheyenne-Deadwood Stage Road and the Texas Trail (NREX 2018). The Cheyenne-Deadwood Stage Road served as a stagecoach route between Cheyenne, Wyoming and Deadwood, South Dakota. The road was in operation during the Black Hills Gold Rush period, until it was replaced by a railroad in the late 1800s. The Texas Trail was a 19th century cattle trail used by ranchers to drive cattle from Texas to Canada. The trail helped foster the early development of the cattle industry in the western Great Plains (Wyoming SHPO 2018).

Photo 20 Weston County Courthouse.

Within the study area, seven sites are included in the National Register of Historic Places:

- Weston County Courthouse
- Cambria Casino/Flying V Guest Ranch
- Newcastle Commercial District
- U.S. Post Office in Newcastle
- Wyoming Army National Guard Cavalry Stable
- Jenney Stockade Site
- DSD Bridge over the Cheyenne River

The following six sites are located within the study area in Weston County. The Cambria Casino, or Flying V Guest Ranch as it is modernly called, is a resort in the foothills of the Black Hills originally erected as a memorial to the miners of Cambria, Wyoming. The Weston County Courthouse, Newcastle Commercial District, and U. S. Post Office in Newcastle are in operation and continue to serve the residents of Newcastle. The Wyoming Army National Guard Cavalry Stable is now open as a museum located in Newcastle. It is the only remaining National Guard cavalry stable known to exist in Wyoming. The Jenney Stockade Site served as a stage station on the historic Cheyenne-Deadwood Stage Road as a place for travelers to stop and have a meal (Wyoming SHPO 2018). Additional historic structures that are not on the National Register of Historic Places can be seen throughout the watershed, such as those shown in photo 21.

There is one site listed in the National Register of Historic Places in the study area in Niobrara County. The DSD Bridge over the Cheyenne River is a single-span truss bridge on Niobrara County road CN14-46. It is still in use today. There are no sites on the National Register of Historic Places within the study area in Crook County (Wyoming SHPO 2018).

Wyoming contains a large number of paleontological resources (or fossil specimens) and sites throughout the state and Beaver Creek watershed where fossiliferous sedimentary rock is exposed at the surface. As part of the environmental assessment process prior to energy development, many sites within the Beaver Creek watershed underwent a cultural resource inventory conducted by various archaeological consultants and the Office of the Wyoming State Archeologist.

Photo 21 Historic structures along Stockade Beaver Creek.

3. STREAMFLOW HYDROLOGY

3.1. Northeast Basins Model

Water availability and shortages in the Beaver Creek and Cheyenne River watersheds were evaluated as part of the Northeast Wyoming River Basins Plan update, which was underway at the time this document was finalized. The August 2018 draft results were made available for inclusion with this report. The 2018 update used information developed for the 2002 Northeast Wyoming River Basins Plan Final Report (HKM Engineering 2002a) as a basis for the analysis. The 2002 study used the period of 1970 to 1999 and represented dry, normal, and wet year hydrologic conditions. The 2018 study used the study period of 1975 through 2014. The wet and dry years were selected as the wettest and driest 20 percent of the years. In the 2002 study, the remaining 60 percent of years were considered to be normal years. For the 2018 update, the normal years were represented by the median condition of all years.

The following paragraphs summarize additional model development. They were taken from the technical memorandum documenting the Northeast Wyoming River Basins Plan Spreadsheet Model Development and Calibration (HKM Engineering 2002b). Schematics of the model networks are included in the technical memorandum. The majority of the study area was included in the Beaver Creek model and schematic, while Robbers' Roost Creek was represented by its own reach and nodes in the Cheyenne River watershed and model. The model nodes did not change with the 2018 update.

> "The models do not explicitly account for water rights, appropriations, or compact allocations nor is the model operated based on these legal constraints. Further, the model does not associate supplemental reservoir releases to the appropriate water users. However, by calibrating the models to historical streamflows at gaged locations, the models can be used to generally represent existing operations. Theoretical maximum diversion requirements were calculated using the mapped acreage of irrigated lands and consumptive irrigation requirements (CIR) were provided by the Consumptive Use and Consumptive Irrigation Requirements – Wyoming (Pochop et al., 1992)."

The models were calibrated by adjusting the estimated actual diversions and diversion demands as well as irrigation efficiencies, duration of irrigation, and irrigation return flows.

> "At each node, a water budget computation was completed to determine the amount of water that bypasses the node. At non-storage nodes, the difference between inflow, including upstream inflows, return flow, imports and basin gains, and outflows, including diversions, basin losses and exports, is the amount of flow available for the next node downstream. For storage nodes, an additional loss calculation for evaporation and the change in storage was evaluated. Also at storage nodes, any uncontrolled spill that occurs is added to the scheduled release to determine total outflow. Diverted amounts at diversion nodes are the minimum of demand (the full supply diversion at the structure) and physically available streamflow. The mass balance, or water budget calculations, is performed for all nodes in a reach.
>
> "Available water" at a given reach terminus was defined as the minimum of the physically available flow at that point and the available flow at all downstream reaches (HKM Engineering 2002c). Available flow was defined first at the most downstream point and then upstream availability was calculated in stream order. The calculations were made on a monthly basis, and annual water

availability was computed as the sum of monthly values. Calculating the annual availability in this way yields a different result than applying the same logic to annual flows for each reach. The summation of monthly values is more accurate, since it reflects the constraints of downstream use on a monthly basis.

The model has limitations, which should be considered when reviewing the model and its results. The most significant limitation is that the model does not account for diversions in accordance with Wyoming water law. Downstream senior rights are not given priority, which should result in an upstream junior right incurring a shortage. Though the model does not account for this occurrence, historical diversion data would reflect these actual operational conditions. If a Level II study of a particular storage project is to be undertaken, it is suggested that StateMod or similar model be developed so that water rights can be appropriately exercised, and potential water availability can be more accurately estimated."

Table 3.1-1 summarizes the modeling conditions for the Beaver Creek watershed. The designation of dry, normal, and wet years was determined from this information.

Table 3.1-1 Beaver Creek Model Condition Summary

Beaver Creek							
Station Name	Beaver Creek at Mallo Camp, near Four Corners, WY		Stockade Beaver Creek near Newcastle, WY		Beaver Creek near Newcastle, WY		Model Condition
Station Number	6392900		6392950		6394000		
Year	acre-ft/yr	% Rank	acre-ft/yr	% Rank	acre-ft/yr	% Rank	
1992	943	23.3	6,968	3.3	5,952	3.3	Dry
1977	832	10	9,012	43.3	11,806	16.6	Dry
1980	1,815	76.6	8,153	26.6	7,032	6.6	Dry
1981	1,456	56.6	7,187	6.6	9,736	10	Dry
2006	937	20	7,658	16.6	13,070	23.3	Dry
2007	813	6.6	7,419	10	15,275	36.6	Dry
1975	1,375	46.6	9,402	56.6	27,518	80	Normal
1976	776	3.3	9,259	53.3	20,947	63.3	Normal
1979	1,868	83.3	9,146	46.6	14,231	30	Normal
1993	956	26.6	7,479	13.3	26,516	76.6	Normal
1994	1,261	43.3	7,726	20	29,080	86.6	Normal
1995	1,433	53.3	8,764	40	13,567	26.6	Normal
1996	1,470	60	10,079	63.3	38,587	93.3	Normal
1997	1,642	70	10,893	73.3	40,289	96.6	Normal
1998	1,681	73.3	11,835	80	27,931	83.3	Normal
2000	1,818	80	12,504	90	15,674	43.3	Normal
2001	1,555	63.3	11,355	76.6	18,851	56.6	Normal
2002	1,090	40	10,819	70	17,600	50	Normal
2003	965	33.3	10,230	66.6	18,657	53.3	Normal
2004	982	36.6	8,412	33.3	21,811	66.6	Normal
2005	878	13.3	8,507	36.6	15,393	40	Normal
2008	960	30	8,198	30	15,724	46.6	Normal

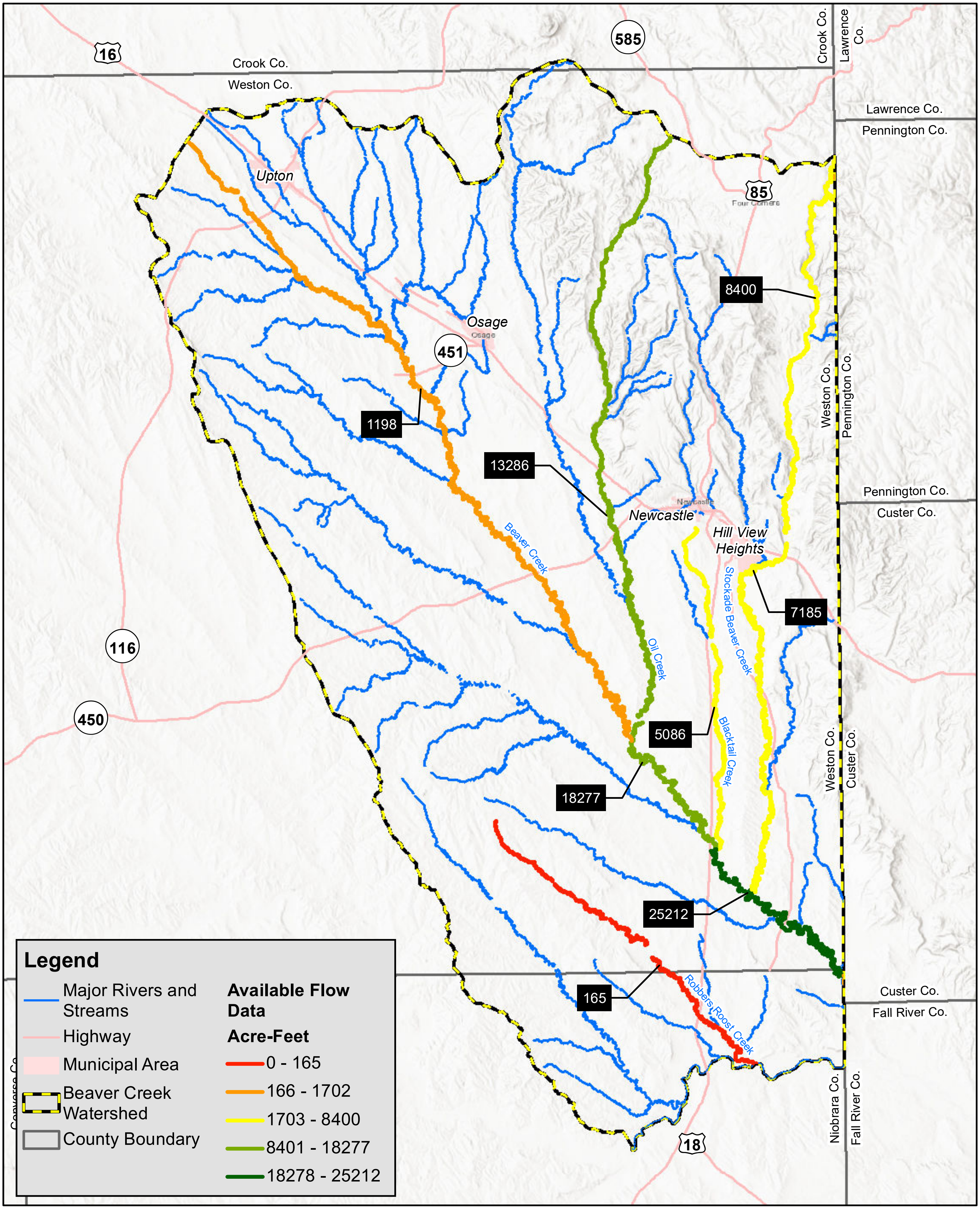
Beaver Creek							
Station Name	Beaver Creek at Mallo Camp, near Four Corners, WY		Stockade Beaver Creek near Newcastle, WY		Beaver Creek near Newcastle, WY		Model Condition
Station Number	6392900		6392950		6394000		
Year	acre-ft/yr	% Rank	acre-ft/yr	% Rank	acre-ft/yr	% Rank	
2009	894	16.6	8,015	23.3	21,949	70	Normal
2010	1,429	50	9,604	60	19,290	60	Normal
1978	1,618	66.6	9,153	50	42,333	100	Wet
1999	2,391	96.6	12,704	93.3	25,020	73.3	Wet
2011	2,589	100	12,496	86.6	32,022	90	Wet
2012	2,008	86.6	12,470	83.3	14,885	33.3	Wet
2013	2,094	90	12,805	96.6	11,542	13.3	Wet
2014	2,296	93.3	14,497	100	11,957	20	Wet

Table 3.1-2 shows a summary of the total annual available flow for the dry, normal, and wet years. Data Summary 3.1 in Appendix A provides monthly water availability for the dry, normal, and wet years. Figure 3.1-1 shows the water availability in a normal year for the tributaries identified in the model. The models indicate shortages in certain reaches when comparing diversions to available water. The reaches in which shortages were noted are highlighted.

Table 3.1-2 Annual Available Flow[1] Data (in acre-feet) as included in the Northeast Wyoming River Basins Models (RESPEC, 2018)

Reach[2]	Reach Name	Dry Year	Normal Year	Wet Year
1	Beaver Creek above Oil Creek	98	1,198	5,482
2	Oil Creek	8,046	13,286	11,715
3	Beaver Creek above Blacktail Creek	11,238	18,277	21,565
4	Blacktail Creek	4,010	5,086	4,669
5	Beaver Creek above Stockade Beaver Creek	17,027	25,212	28,103
6	Dry Beaver Creek	1,170	1,702	2,020
7	Beaver Creek in South Dakota	1,159	1,686	2,000
8	Stockade Beaver Creek Tributaries above Gage 06392950	5,375	5,353	6,019
9	Stockade Beaver Creek above Gage 06392950	7,879	8,400	9,827
10	Stockade Beaver Creek above Beaver Creek	4,787	7,185	10,495
11	Stockade Beaver Creek Tributaries above Mouth	39	599	3,285
12	Beaver Creek Tributaries above Gage 0634000	25	389	2,163
13	Beaver Creek above Stateline	14,674	21,439	30,731
14	Beaver Creek above Gage 06394001	14,439	21,199	30,489
26	Robbers' Roost Creek	17	165	392

[1]Annual available flow is the sum of the monthly available flows.
[2]Reaches 1-14 are from the Beaver Creek model. Reach 26 is from the Cheyenne River Model.
Shaded cells denote that the models indicate shortages in the reach.



OLSSON ASSOCIATES

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1 " = 35,000 '
Original Published Resolution
NAD 1983 UTM Zone 13N
ESRI World Hillshade

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Available Surface Water

FIGURE
3.1-1

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Shortages were most notable for Stockade Beaver Creek and Robbers' Roost Creek. At the state line, Beaver Creek showed annual availability to range from approximately 14,000 acre-feet to 30,000 acre-feet.

3.2. Gage Data

The study area contains two active USGS gages and one historical gage that is no longer in use. The Cheyenne River near Spencer, Wyoming gage is located outside of the study area downstream of the confluences with Alkali Creek, Bobcat Creek, and Robbers Roost Creek. The gages are shown in Figure 2.1.2-3, USGS Gaging Stations. Water quality samples have been collected at two of the gage locations, 06394000 Beaver Creek near Newcastle, Wyoming, and 06386500 Cheyenne River near Spencer, Wyoming. Table 3.2 below lists the gages and their periods of record. Detailed information regarding these sites is available through the links listed in the table and at http://waterdata.usgs.gov/wy/nwis/si.

Table 3.2 USGS Gaging Stations.

Station Number	Station Name	Flow Measurement Period of Record, Water Years*	Daily/ Monthly Flow Data	Number of Recorded Annual Peak Flows
06386500	Cheyenne River near Spencer, Wyoming	10/1/1948 to 10/12/2017	Yes	37
06392900	Beaver Creek near Mallo Camp, near Four Corners, Wyoming	10/10/1974 to present	Yes	35
06392950	Stockade Beaver Creek near Newcastle, Wyoming	10/1/1974 to present	Yes	35
06394000	Beaver Creek near Newcastle, Wyoming	10/1/1944 to 12/30/1997	Yes	55

*Daily flows are not available for the entire date range. They are available for at least portions of the date range.

Figure 3.2 shows the average monthly discharge for the four gages. Stockade Beaver Creek near Newcastle and Beaver Creek near Mallo Camp show relatively steady flow throughout the year. Beaver Creek near Newcastle shows two discharge peaks, the first due to snowmelt and the second due to runoff. The Cheyenne River, downstream of the added tributaries, shows that most flow occurs between April and August.

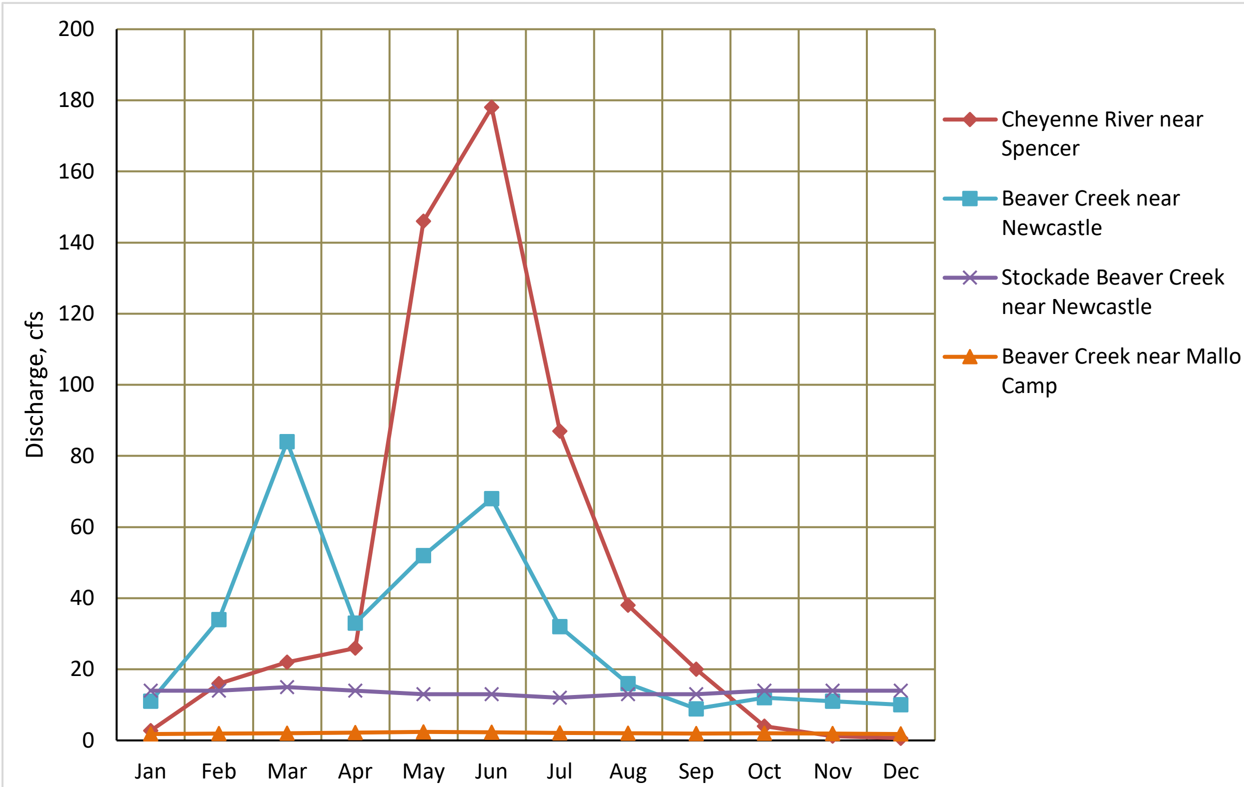


Figure 3.2 Mean Monthly Discharge for Period of Record (Varies).

4. WATERSHED MANAGEMENT AND REHABILITATION PLAN

The purpose of this Level I watershed study is to describe Beaver Creek watershed in its current condition, to suggest resolutions for any water-related issues, and to provide insight into opportunities for improvements. At this point in the study report, the current condition of the watershed has been described in sections 2 and 3. The following subsections provide details on the proposed watershed improvement projects that constitute the watershed management and rehabilitation plan.

As described briefly in Section 1.2 Key Issues in the Watershed, in order to identify the water issues and improvement opportunities in the district, public meetings were held in Newcastle at the NRCS office building (located at 1225 Washington Boulevard, Newcastle, Wyoming). The meetings were intended to introduce public and private landowners, managers, and stewards of the Beaver Creek watershed to the Level I watershed study and request information on potential water improvement projects. The project meetings were announced in the local newspaper, the Newsletter Journal — a weekly newspaper published in Newcastle, Wyoming since 1890. Other announcements were made through advertising on Facebook and through publishing meeting announcements on the WCNRD website. Additionally, letters introducing the project and postcard invitations to the project meetings were mailed to over 400 residents and agencies in the Beaver Creek watershed area two weeks before each meeting. Table 4.0 lists the meeting dates, topics, and locations.

Table 4.0 Project Meeting Dates and Topics.

Date	Topic/Description
June 27, 2017	Project Introduction and Public Input Requests
August 29, 2017	Project Status and Water Storage Opportunities
October 3, 2017	Project Status and Geomorphological Evaluations
March 6, 2018	Project Status and Geomorphological Results
April 24, 2018	Project Status, Water Storage, and Water Quality Opportunities
October 16, 2018	Watershed Study Results and Recommendations

The meetings were well attended with over 25 residents and agency representatives in attendance at each meeting. The public interactions developed into evaluations with 40 individual landowners on their private or leased property. For nearly every project identified, a site visit was scheduled, and the appropriate team members visited the proposed project location. For example, for projects that involved irrigation improvements, a professional engineer on the project team examined the proposed improvements and developed conceptual designs and cost estimates. Additionally, since the intent was to provide a holistic approach to watershed management, additional team members such as stream geomorphologists and geologists were included in the project review team to ensure that any conceptual design was developed in recognition of the need to ensure that all proposed projects in the watershed study are evaluated holistically. Over 75 individual water improvement projects were identified by the team during the site visits.

Each of the proposed projects is described in more detail in the following subsections. To provide a systematic approach to project improvements consistent with the objectives of the WWDC Level I project scope, projects were subdivided into wildlife/livestock watering opportunities, irrigation improvements, surface water flood and water supply/storage improvements, and other management practice improvements. Please note that the numbers in each subsection are not sequential. For example, at the Cammack ranch there were five individual project improvements identified during the site visit. The Livestock/Wildlife Watering projects (LWW-1.1, LWW-1.2, LWW-1.3, and LWW-1.5) are described in Section 4.1 and the Other Management Practice project (OMP-1.4) is described in Section 4.4. There were no stream channel condition and stability improvement projects identified in this study. In Appendix B, a description of the benefits to these types of projects is listed for use in preparing the applications for funding through the WWDC Small Water Project Program and other funding sources. And finally, information on landownership is provided at the end of each project description. This information is provided to help assess the types of permits that will be required to complete the project. Please note that landownership information was documented using data available at the time of the study. For each project, landownership should be verified to confirm permitting requirements.

4.1. Livestock/Wildlife Watering (LWW) Improvements

By far, the greatest need in the Beaver Creek watershed is for reliable sources of water for livestock and wildlife. As described in Section 2, Inventory and Descriptions, the primary use for water in the area is for agriculture, with livestock as the primary product. Additionally, this area is a destination for hunters especially late season when water supplies are low. Providing watering improvements for both livestock and wildlife will help drive the economy of the watershed while at the same time provide benefits for better watershed function. For example, by locating a new source of water in the upland areas of the watershed, both livestock and wildlife will be able to access water away from sensitive riparian habitats.

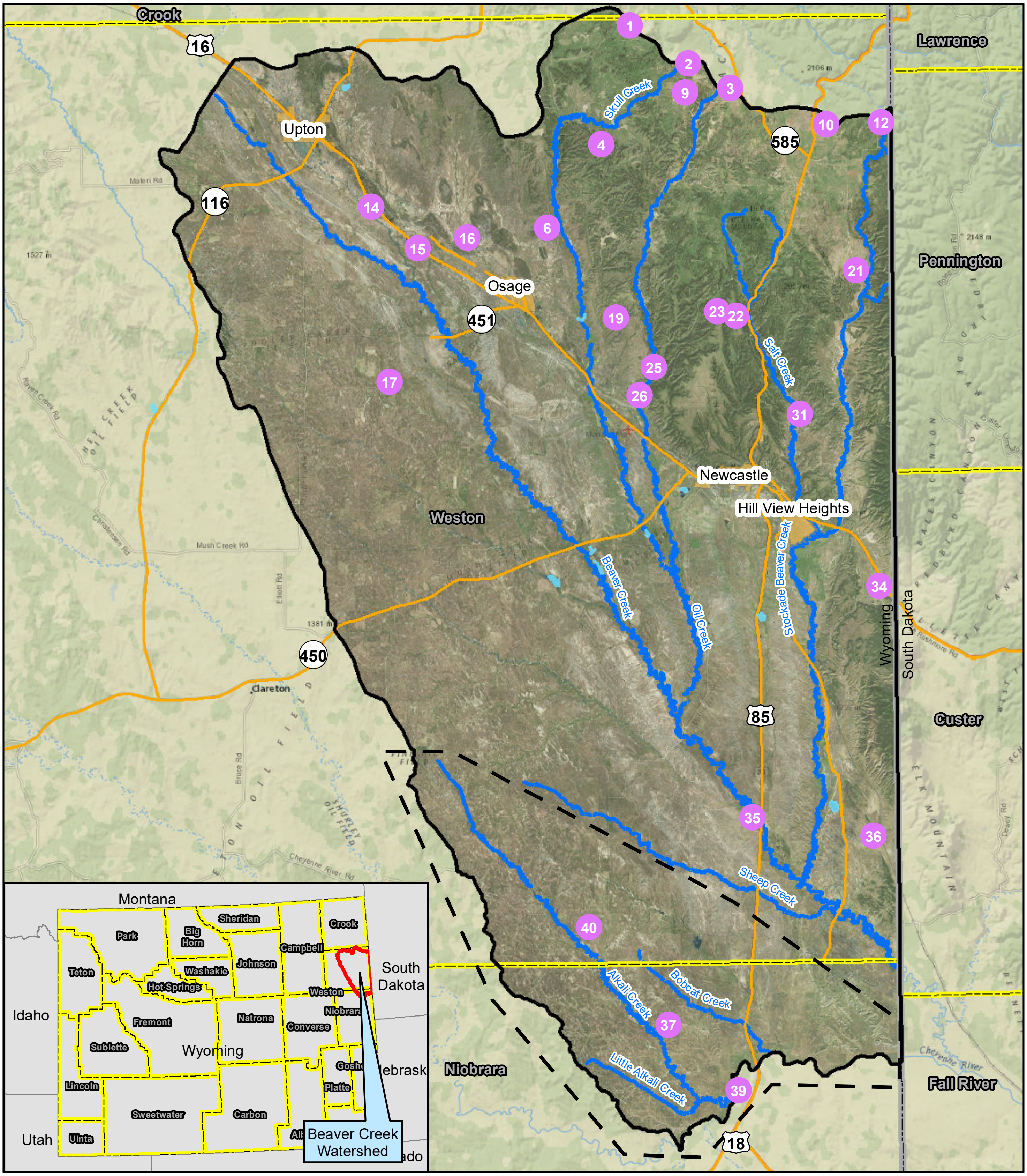
To ensure that the new sources of water are safe for both livestock and wildlife, the WCNRD has a program to provide wildlife escape ramps to producers in the area. The escape ramps make the stock tanks more usable and safer for wildlife while protecting water quality. For each project with a stock tank proposed in this watershed study, escape ramps will be provided by WCNRD.

Table 4.1 lists the proposed improvement projects and Figure 4.1 illustrates the general location of the projects. Appendix C includes a map of each proposed improvement. The following sub-sections describe the conceptual plan for rehabilitation or replacement developed for each project.

Table 4.1 Livestock/Wildlife Water Improvement Projects.

Project Number	Landowner or Leasee	Project Description
LWW-1.1	Cammack	Pipeline extension and stock tank
LWW-1.3	Cammack	Pipeline extension and stock tanks
LWW-1.4	Cammack	Pipeline extension and stock tanks
LWW-1.5	Cammack	Spring development
LWW-2.1	Peterson	Pipeline extension and stock tank
LWW-3.1	Burleson	New pipeline and stock tanks
LWW-4.1	Lewis, J	Well and pipeline project
LWW-6.1	Tavegia/Geier	New well, pipeline and stock tank
LWW-9.1	Lewis, BJ	Pond and pipeline development
LWW-10.1	Neal	Spring development
LWW-12.1	Calmus	Spring rehabilitation

Project Number	Landowner or Leasee	Project Description
LWW-14.1	Mills	Pipeline and stock tanks
LWW-14.2	Mills	Pipeline and stock tanks
LWW-14.3	Mills	Pipeline and stock tanks
LWW-14.4	Mills	Pipeline and stock tank
LWW-14.5	Mills	Middle Cordingly pasture project
LWW-14.6	Mills	Mills Reservoir solar pumps
LWW-15.1	Inyan Kara	Inyan Kara pipeline and stock tanks
LWW-16.1	Bau	Surface repair of abandoned oil well
LWW-16.2	Bau	Surface repair of abandoned oil well
LWW-17.1	Branscom	Well conversion to solar power
LWW-17.2	Branscom	New solar well pump and stock tank
LWW-19.1	Larsen	Pipeline rehabilitation
LWW-21.2	Rawhouser	Pipeline and stock tanks
LWW-22.1	Rossman	Pipeline and stock tank
LWW-22.2	Rossman	Pipeline and stock tank
LWW-22.4	Rossman	Well conversion to solar pump
LWW-23.1	Merrill	Proposed livestock water supply well
LWW-23.2	Merrill	Proposed pipeline and stock tanks
LWW-25.3	Sandrini	Proposed new well and pipeline rehabilitation
LWW-26.1	Culver	New well and stock tank
LWW-31.1	Vore	Pipeline, storage, and stock tanks
LWW-34.1	Sudbrink	Proposed expansion of pipeline and stock tanks
LWW-34.2	Sudbrink	Proposed spring rehabilitation
LWW-35.2	Tidyman	Proposed pipeline and stock tank
LWW-36.1	Hollenbeck	Proposed pipeline and stock tanks
LWW-37.1	Simon	Conversions to solar pumps
LWW-39.1	Tysdal	Mule Creek Junction pipeline project
LWW-40.1	Harris	Proposed windmill conversions
LWW-40.2	Harris	Proposed oil well conversions



Watering Improvement Project
Major Rivers and Streams
Major Road
Municipal Area
Major Body of Water
Area Added to Watershed Study
State Border
County Border
Beaver Creek Watershed

Sources:
USCB Tiger Roads (2016), Places (2016),
County Boundary (2014), State Boundaries (2016)
USGS NHD Flowlines (2016)
ESRI World Imagery (2018)

OLSSON ASSOCIATES

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0 1.5 3 6 Miles

1 " = 35,000 '
Original Published Resolution
NAD 1983 UTM Zone 12N
ESRI World Imagery

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Proposed Livestock/Wildlife
Watering Improvement Projects

FIGURE 4.1

F:\2017\1501-2000\017-1637\40-Design\GIS\2018-07-19_BeaverCreekWatershedLocationMap.mxd PUBLISHED BY: gmalek-madani DATE: October 11, 2018

4.1.1. LWW-1.1 Cammack Pipeline Extension and Stock Tank Project

The Cammacks have been working with the NRCS on several watershed improvements projects on their property on Green Mountain Road to supply water to a portion of their property that lacks adequate livestock/wildlife water sources. There is an existing well and pipeline across a portion of the property. By connecting to the existing infrastructure, the proposed pipeline extension and stock tank will provide a water source to the north pasture. Funding has been secured for this project through EQIP.

The conceptual plan for project LWW-1.1 is illustrated in Appendix C, Map 1.1 and includes the following elements:

- Install a 1.5-inch High Density Polyethylene (HDPE) pipeline below the frost line from the existing pipeline to the new stock tank
- Install a 1,200-gallon stock tank in the north pasture
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tank.
- The proposed project is located entirely on private land.

4.1.2. LWW-1.3 Cammack Pipeline and Stock Tank Project

The conceptual plan for project LWW-1.3 is illustrated in Appendix C, Map 1.3 and includes the following elements:

- Install a 1.5-inch HDPE pipeline below the frost line from the existing pipeline to the new stock tanks
- Install two 1,200-gallon stock tanks to the southeast of the ranch headquarters
- Install the necessary fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tanks.
- The proposed project is located entirely on private land.

4.1.3. LWW-1.4 Cammack Pipeline and Stock Tank Project

The conceptual plan for project LWW-1.4 is illustrated in Appendix C, Map 1.4 and includes the following elements:

- Install a 1.5-inch HDPE pipeline below the frost line from the existing pipeline to the new stock tank
- Install two 1,200-gallon stock tanks to the west of the ranch headquarters
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tanks
- The proposed project is located entirely on private land.

4.1.4. LWW-1.5 Cammack Spring Development Project

In the southwestern portion of Cammack Ranch there is an active spring where water flows nearly year-round. Access to the water is in a muddy pit (see photo 22) and by developing the spring with a pipe and stock tank, access to the water will be easier for cattle and wildlife. An application for funding of this project through EQIP was submitted, however, funding was not received.

Photo 22 Proposed spring Development (LWW-1.5).

The conceptual plan for project LWW-1.5 is illustrated in Appendix C, Map 1.5 and includes the following elements:

- Develop the existing spring with a spring box and install fence around the spring box
- Install a 1.5-inch HDPE pipeline below the frost line from the spring box to the stock tank
- Install a 1,200-gallon stock tank
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tank
- The proposed project is located entirely on private land.

4.1.5. LWW-2.1 Peterson Pipeline Extension and Stock Tank Project

A new well and two stock tanks were recently installed on the Peterson Ranch. An extension of the pipeline and an additional stock tank is proposed to provide a new livestock/wildlife water source to an area southwest of the ranch headquarters. The site contractor confirmed that the new well and pump have the needed capacity to pressurize the proposed pipeline extension.

The conceptual plan for project LWW-2.1 is illustrated in Appendix C, Map 2.1 and includes the following elements:

- Install a 1.5-inch HDPE pipeline below the frost line from the existing pipeline to the new stock tank
- Install a 1,200-gallon stock tank to the southwest of the ranch headquarters
- Install the necessary fittings, valves, and appurtenances to manage water flow, pressure and water level in the stock tank.
- The proposed project is located entirely on private land.

4.1.6. LWW-3.1 Burleson Pipeline Extension and Stock Tanks Project

On the western flank of the Burleson Ranch, a stock pond dam breached resulting in inadequate water for livestock and wildlife (see photo 16). A new well was recently installed west of the ranch headquarters and this project includes installing a pipeline and six stock tanks to provide new livestock/wildlife water sources across the property.

The conceptual plan for project LWW-3.1 is illustrated in Appendix C, Map 3.1 and includes the following elements:

- Install a 1.5-inch HDPE pipeline below the frost line from the existing well to connect three new tanks to the north and to connect three more new tanks to the south
- Install six rubber tire stock tanks
- Install the necessary fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tanks.
- The proposed project is located entirely on private land.

4.1.7. LWW-4.1 J. Lewis Well and Pipeline Project

The Lewis property lies along a steep timbered ridge. The northern portion of the property lies on the flat above Skull Creek. The southern portion of the property lies on top of the ridge and consists of relatively flat grassland with a few scattered trees. The remote southern ridgetop is prime habitat for big game and other wildlife species. Currently there is a small dam located on state of Wyoming property southwest of Mr. Lewis' property. The state property is currently leased by the Tlustos who indicated a willingness to work with Mr. Lewis to develop water in the area. The proposed project would consist of a well, pump, and stock tank. A buried pipeline would carry overflow water from the tank to the dry pond on state property (see photo 23).

The conceptual plan for project LWW-4.1 is illustrated in Appendix C, Map 4.1 and includes the following elements:

- Install a well with a total depth of approximately 500 feet, a solar pump, and a 1,200-gallon stock tank
- Install the necessary fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tank.
- Install approximately 2,400 feet of 1.5-inch HDPE pipeline below the frost line from the new well to the dry pond
- The new well would be installed on private property and the pipeline would be installed on state land.
- The proposed project is located on state and private land.

Photo 23 Dry pond on state property that would benefit from a new well and pipeline (Project LWW-4.1).

4.1.8. LWW-6.1 Tavegia/Geier Well, Pipeline, and Stock Tanks Project

The Inyan Kara Grazing Association issued a grazing permit to H. Tavegia and M. Geier on the East Upton-Osage Community Pasture. Tavegia and Geier would like to install a well and stock tanks to supply water to a portion of the property that lacks adequate livestock/wildlife water sources.

The conceptual plan for project LWW-6.1 is illustrated in Appendix C, Map 6.1 and includes the following elements:

- Install a well to a total depth of approximately 300 feet fitted with a solar pump
- Install one storage and four stock tanks
- Install the necessary fittings, valves, and appurtenances to manage water flow, pressure and water level in the storage and stock tanks
- Install approximately 13,200 feet of 2.0-inch HDPE pipeline below the frost line
- The new well and tanks would be installed on the Upton-Osage Community Pasture and a portion of the pipeline would be installed on land managed by the BLM and USFS.
- The proposed project is located on federal land managed by the BLM and USFS and private land.

4.1.9. LWW-9.1 BJ Lewis Pond and Pipeline Project

There is a developed spring on the eastern edge of the Lewis property which flows approximately 500 feet via a PVC pipeline to a stock tank. The property is currently leased for grazing approximately 60 cow/calf pairs during the late summer into the fall. The water supply to the property is not always adequate. The landowner would like to develop a pond to catch overflow water from the spring. This would provide another source of livestock water as well as provide wildlife water and habitat. Because of the soil type in this area, the pond will likely need to be lined to prevent excessive seepage. Approximately 550 feet of pipeline will be needed to connect the existing stock tank to the proposed pond.

The conceptual plan for project LWW-9.1 is illustrated in Appendix C, Map 9.1 and includes the following elements:

- Install approximately 550 feet of 1.5-inch HDPE pipeline below the frost line
- Grade an earthen embankment approximately 130 feet in length to establish a pond fill height of 20 feet with 4 feet of freeboard
- Install an Agri-Drain or equivalent spillway structure with the approximate dimensions of 14 by 16 inches with a 10- to 12-inch HDPE outlet pipe
- Install a 6-inch bentonite liner across the base of the pond
- The proposed project is located entirely on private land.

4.1.10. LWW-10.1 Neal Spring Development Project

The Neal property currently has no source of water. A well was drilled to 400 feet but the well was dry. A preliminary geologic assessment based on existing wells in the area indicates that water bearing formations are extremely variable in the area. The project is to develop an intermittent spring to supply water to a portion of the property that is leased for grazing and lacks adequate livestock/wildlife water sources.

The conceptual plan for project LWW-10.1 is illustrated in Appendix C, Map 10.1 and includes the following elements:

- Develop the existing spring with a spring box
- Install a 1.5-inch HDPE pipeline below the frost line from the spring box to the stock tank
- Install a 1,200-gallon stock tank

- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tank
- The proposed project is located entirely on private land.

4.1.11. LWW-12.1 Calmus Spring Rehabilitation Project

This project includes rehabilitating a spring to provide a more consistent source of water for livestock/wildlife watering (see photo 24).

The conceptual plan for project LWW-12.1 is illustrated in Appendix C, Map 12.1 and includes the following elements:

- Develop the existing spring with a spring box
- Install a 1.5-inch HDPE pipeline below the frost line
- Install fittings, valves, and appurtenances to manage water flow
- The proposed project is located entirely on private land.

Photo 24 Spring rehabilitation proposed to enhance water supply to a spring-fed pond (LWW-12.1).

4.1.12. LWW-14.1 Mills Pipeline and Stock Tanks Project

Mr. Mills is implementing a high-intensity, short-duration grazing management plan that will result in improved soil health and a more productive plant community. He is using existing barbed wire fences combined with permanent and temporary electric fences to accomplish this. The proposed pipeline and stock tanks project would supply water to a portion of the property that lacks adequate livestock/wildlife water sources. There are four Mills livestock/wildlife watering projects that consist of installing pipelines and tanks in four different areas of the ranch. These pipelines will be fed from existing wells, hydrants, and pipelines on the ranch. The projects will be implemented in four phases and are described here as four different projects (LWW-14.1 through LWW-14.4). Funding for this project was secured through EQIP.

The conceptual plan for project LWW-14.1 is illustrated in Appendix C, Map 14.1 and includes the following elements:

- Install 12,700 linear feet of 1.5-inch HDPE pipeline below the frost line from the existing pipeline to the new stock tanks
- Install four 1,200-gallon stock tanks
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tanks.
- The proposed project is located entirely on private land.

4.1.13. LWW-14.2 Mills Pipeline and Stock Tanks Project

The conceptual plan for project LWW-14.2 is illustrated in Appendix C, Map 14.2 and includes the following elements:

- Install 8,860 linear feet of 1.5-inch HDPE pipeline below the frost line from the existing pipeline to the new stock tanks
- Install four 1,200-gallon stock tanks
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tanks.
- The proposed project is located entirely on private land.

4.1.14. LWW-14.3 Mills Pipeline and Stock Tanks Project

The conceptual plan for project LWW-14.3 is illustrated in Appendix C, Map 14.3 and includes the following elements:

- Install 3,920 linear feet of 1.5-inch HDPE pipeline below the frost line from the existing pipeline to the new stock tanks
- Install four 1,200-gallon stock tanks
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tanks.
- The proposed project is located entirely on private land.

4.1.15. LWW-14.4 Mills Pipeline and Stock Tank Project

The conceptual plan for project LWW-14.4 is illustrated in Appendix C, Map 14.4 and includes the following elements:

- Install 5,500 linear feet of 1.5-inch HDPE pipeline below the frost line from the existing pipeline to the new stock tank
- Install one 1,200-gallon stock tank
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tank.
- The proposed project is located entirely on private land.

4.1.16. LWW-14.5 Mills Cordingly Pasture Project

In the northwestern portion of the Mills ranch – the Middle Cordingly pasture – is approximately 1,078 acres. There are multiple wells in the pasture suitable for livestock/wildlife watering; however, the wells do not have pumps and there is no electricity in the pasture. The Middle Cordingly pasture project would consist of two portable solar pumping systems and a portable storage and stock tank (see photo 25) to supply water to a portion of the watershed that lacks adequate livestock/wildlife water sources and to facilitate rotational grazing. Mr. Mills proposes to cross fence the pasture into smaller paddocks and move the solar pumps and portable storage and stock tank as needed.

The conceptual plan for project LWW-14.5 includes the following elements (note: a map was not developed for this project):

- Install 1,000 feet of four-strand barbed wire fencing
- Purchase two portable solar pumping systems
- Purchase one portable storage and stock tank
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the portable tank
- The proposed project is located entirely on private land.

Photo 25 Portable storage and stock tank.

4.1.17. LWW-14.6 Mills Reservoir Pumps Project

The Mills reservoir pumps project consists of using a portable solar water pump and portable stock tank to pump water from existing stock reservoirs for livestock use. The primary purpose of this is to improve water quality and improve wildlife and waterfowl habitat. Mr. Mills is also interested in fencing some of these reservoirs along with some upland to provide waterfowl nesting habitat. It is estimated that this portable solar pump would be used throughout the ranch on at least four different reservoirs. The fenced in areas would be viable candidates for the CRP. An application for funding of this project through EQIP was submitted, however, funding was not received.

The conceptual plan for project LWW-14.6 includes the following elements (note: a map was not developed for this project):

- Install 1,000 feet of four-strand barbed wire fencing
- Purchase two portable solar pumping systems
- Purchase one portable storage and stock tank
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the portable tank
- The proposed project is located entirely on private land.

4.1.18. LWW-15.1 Inyan Kara Pipeline and Stock Tanks Project

The Inyan Kara Grazing Association proposed this project at the outset of the watershed study. The project components include installing a new well, 12 stock tanks, and a pipeline to connect the water delivery system. At the time of this writing, the well, solar pump, and 15,000-gallon storage tank had been installed. Applications for the project elements described below were submitted for funding through the Small Water Project Program (SWPP).

The conceptual plan for project LWW-15.1 is illustrated in Appendix C, Map 15.1 and includes the following elements:

- Install approximately 40,000 linear feet of 1.5-inch HDPE pipeline below the frost line from the new well to the proposed stock tanks
- Install 12 1,200-gallon stock tanks and two hydrants
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the storage and stock tanks.
- The proposed project is located on federal land managed by the USFS and private land.

4.1.19. LWW-16.1 Bau Well Repair and Stock Tank Project

There is an old oil well on the Bau property that was not adequately abandoned. At the well casing, water seeps to the surface causing boggy areas that are a hazard to cattle and are a mosquito breeding ground. The well is completed in the Dakota Formation and may have quality and quantity that is adequate to develop as a water source for livestock/wildlife and wildlife.

The conceptual plan for project LWW-16.1 is illustrated in Appendix C, Map 16.1 and includes the following elements:

- Repair surface completion of well
- Install approximately 50 linear feet of 1.5-inch HDPE pipeline below the frost line from the well to the proposed stock tank
- Install a 1,200-gallon stock tank
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tank.
- The proposed project is located on federal land managed by the USFS and private land.

4.1.20. LWW-16.2 Bau Well Repair and Stock Tank Project

There is an additional old oil well on the Forest Service land adjacent to the Bau property that was not adequately abandoned.

The conceptual plan for project LWW-16.2 is illustrated in Appendix C, Map 16.2 and includes the following elements:

- Repair surface completion of well
- Install approximately 100 linear feet of 1.5-inch HDPE pipeline below the frost line from the well to the proposed stock tank
- Install a 1,200-gallon stock tank
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tank.
- The proposed project is located entirely on private land.

4.1.21. LWW-17.1 Branscom Well Conversion

There is an old windmill on the Branscom property that has not functioned since the property was purchased by the current owner (see photo 26). Based on the depth and yield of nearby wells, the existing well may be completed to a depth of approximately 150-200 feet below ground surface. This project would involve rehabilitating an existing well and installing a solar pump and stock tank to supply water to a portion of the property that lacks adequate livestock/wildlife water sources.

Photo 26 Windmill proposed for conversion to solar power (LWW-17.1).

The conceptual plan for project LWW-17.1 is illustrated in Appendix C, Map 17.1 and includes the following elements:

- Perform a well test and rehabilitate through development, as needed
- Install a solar powered pump on the existing well
- Install a 1,200-gallon stock tank
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tank.
- The proposed project is located entirely on private land.

4.1.22. LWW-17.2 Branscom New Solar Well Pump and Tank

This project would involve drilling a new well and installing a solar pump and stock tank on an existing well to supply water to a portion of the watershed that lacks adequate livestock/wildlife water sources. Based on the depth and yield of nearby wells, the new well would be completed to a depth of approximately 150-200 feet below ground surface.

The conceptual plan for project LWW-17.2 is illustrated in Appendix C, Map 17.2 and includes the following elements:

- Drill a new alluvial well approximately 150-200 feet below ground surface
- Install a solar powered pump
- Install a 1,200-gallon stock tank
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tank.
- The proposed project is located entirely on private land.

4.1.23. LWW-19.1 Larsen Pipeline Rehabilitation Project

A well, pipeline, and stock tank system has not been used on a portion of the Larsen property since the property was purchased in 2004. In 2012, wildfire damaged most of the water supply system. Two of the existing tanks are galvanized metal and are no longer usable. The third tank was fiberglass and was destroyed in the fire. The well pump and electrical leads were also destroyed in the fire. This project would provide a source of water for livestock/wildlife in an area that lacks a functioning water supply after the wildfire.

The conceptual plan for project LWW-19.1 is illustrated in Appendix C, Map 19.1 and includes the following elements:

- Install a solar powered pump on the existing well
- Install three new 1,200-gallon stock tanks
- Install new fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tanks.
- The proposed project is located entirely on private land.

4.1.24. LWW-21.2 Rawhouser Pipeline and Stock Tanks Project

The Rawhouser pipeline and stock tanks project would involve installing a new pipeline and associated stock tanks to supply water to a portion of the watershed in the Stockade Beaver Creek drainage that lacks adequate livestock/wildlife water sources. An existing well would be upgraded to supply the pipeline that will provide water up to the top of the ridgeline.

The conceptual plan for project LWW-21.2 is illustrated in Appendix C, Map 21.2 and includes the following elements:

- Install approximately 8,000 linear feet of 1.5-inch HDPE pipeline below the frost line from the existing well (see photo 27) to the new stock tanks
- Install two 1,200-gallon stock tanks
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tanks.
- The proposed project is located entirely on private land.

Photo 27 Existing wellhouse (LWW-21.2).

4.1.25. LWW-22.1 Rossman Pipeline and Stock Tank Project

The Rossman pipeline and stock tank project would involve extending an existing pipeline and adding an associated stock tank. This project would provide a source of water for livestock/wildlife in an area that lacks an adequate water supply.

The conceptual plan for project LWW-22.1 is illustrated in Appendix C, Map 22.1 and includes the following elements:

- Install approximately 2,700 linear feet of 1.5-inch HDPE pipeline below the frost line from the existing pipeline to the new stock tank
- Install one 1,200-gallon stock tank
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tank.
- The proposed project is located entirely on private land.

4.1.26. LWW-22.2 Rossman Pipeline and Stock Tank Project

The Rossman pipeline and stock tanks project would involve extending an existing pipeline and adding an associated stock tank. This project would provide a source of water for livestock/wildlife in an area that lacks an adequate water supply.

The conceptual plan for project LWW-22.2 is illustrated in Appendix C, Map 22.2 and includes the following elements:

- Install approximately 8,000 linear feet of 1.5-inch HDPE pipeline below the frost line from the existing pipeline to the new stock tank
- Install one 1,200-gallon stock tank
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tank.
- The proposed project is located entirely on private land.

4.1.27. LWW-22.4. Rossman Well Conversion to Solar Pump Project

There is an old windmill on the Rossman property. This project would involve converting the windmill to a solar pump to supply water to a portion of the watershed that lacks adequate livestock/wildlife water sources.

The conceptual plan for project LWW-22.4 is illustrated in Appendix C, Map 22.4 and includes the following elements:

- Install a solar powered pump on the existing well
- The proposed project is located entirely on private land.

4.1.28. LWW-23.1. Merrill Proposed Livestock Water Supply Well Project

This project would involve installing a new Madison Formation water supply well to provide water to a portion of the watershed that lacks adequate livestock/wildlife water sources. This will be the first phase of the well and proposed pipeline and tanks projects.

The conceptual plan for project LWW-23.1 is illustrated in Appendix C, Map 23.1 and includes the following elements:

- Install a Madison Formation well
- The proposed project is located entirely on private land.

4.1.29. LWW-23.2 Merrill Pipeline and Stock Tanks Project

This project would be an enlargement of an existing pipeline system with the addition of five stock tanks. The project would provide additional wildlife water as well as allowing the landowners to implement an improved rotational grazing system.

The conceptual plan for project LWW-23.2 is illustrated in Appendix C, Map 23.2 and includes the following elements:

- Install approximately 21,750 linear feet of 1.5-inch HDPE pipeline below the frost line from the existing pipeline to the new stock tanks
- Install five 1,200-gallon stock tanks
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tanks.
- The proposed project is located entirely on private land.

4.1.30. LWW-25.3 Sandrini New Well and Pipeline Rehabilitation Project

In 2012, the Oil Creek fire damaged most of the water supply system. This project would provide a source of water for livestock/wildlife in an area that lacks a functioning water supply ever since the fire.

The conceptual plan for project LWW-25.3 is illustrated in Appendix C, Map 25.3 and includes the following elements:

- Drill a new alluvial well on private property
- Install a solar powered pump on the new well
- Install approximately 14,300 linear feet of 1.5-inch HDPE pipeline below the frost lie from the new well to the four existing tanks
- Install new fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tanks.
- The proposed project is located on state and private land.

4.1.31. LWW-26.1 Culver New Solar Well Pump

This property lies along Oil Creek and is used as a yearling operation. The creek waters the majority of the pastures and the remaining pastures are watered by shallow (60 to 80 feet deep) wells (see photo 28). There is a spring on the property that supplies the corrals and house, but the quantity is not sufficient for livestock needs.

During wet years, the creek and wells supply adequate water for livestock. However, during normal and dry years, the creek will dry up in spots and the high sulphur content of the creek and well water causes sulphate toxicity in the calves and yearlings. In the past, this has led to the loss of several head of livestock. The landowners must haul water from Newcastle during the hotter months of summer.

This project would involve drilling a new well and installing a solar pump to supply water to a portion of the watershed that lacks adequate livestock/wildlife water sources. Based on the depth and yield of nearby wells, the new well would be completed in the Sundance Formation to a depth of approximately 350 feet below ground surface.

Photo 28 Existing well proposed for replacement (LWW-26.1).

The conceptual plan for project LWW-26.1 is illustrated in Appendix C, Map 26.1 and includes the following elements:

- Drill a new well to approximately 350 feet below ground surface
- Install a solar powered pump on the new well
- Install approximately 1,700 linear feet of 1.5-inch HDPE pipeline below the frost lie from the new well to the new and existing tanks
- Install one new 1,200-gallon stock tank
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level from the well to the stock tanks
- The proposed project is located entirely on private land.

4.1.32. LWW-31.1 Vore Pipeline and Stock Tanks Project

The Vore Ranch lays northeast of Newcastle along Stockade Beaver and Salt creeks. It is a cow/calf operation and the project would enlarge an existing pipeline system to provide water for livestock and wildlife and improve grazing distribution. There is an existing artesian well on the property which flows approximately 16 gallons per minute. The well provides water to two tanks near the well and another tank approximately 5,550 feet to the south. The proposed system upgrade would provide water for approximately 250 cow/calf pairs as well as wildlife. It would also allow the Vores to better rotate and distribute grazing pressure.

The conceptual plan for project LWW-31.1 is illustrated in Appendix C, Map 31.1 and includes the following elements:

- Install approximately 10,050 linear feet of 1.5-inch HDPE pipeline above the frost line from the existing pipeline to a new pump station
- Install a solar powered pump and pump station
- Install three 1,200-gallon stock tanks
- Install one 5,000 storage tank
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tanks.
- The proposed project is located entirely on private land.

4.1.33. LWW-34.1 Sudbrink Proposed Expanded Pipeline and Stock Tanks Project

The Sudbrink property consists of approximately 60 acres and is currently fenced into four pastures for horses and cattle. The Sudbrinks have water rights on a well on the neighbor's property. There is a flow restrictor that limits flow to 3 gallons per minute. There is an existing pipeline on the southern portion of the property that has two frost-free hydrants installed for future tank sites. They would like to install an additional 925 feet of pipeline and two more tanks to water the three pastures on the northern portion of the property.

The conceptual plan for project LWW-34.1 is illustrated in Appendix C, Map 34.1 and includes the following elements:

- Install approximately 925 linear feet of 1.5-inch HDPE pipeline below the frost line from the existing pipeline to the two new tanks
- Install two 1,200-gallon stock tanks
- Install new fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tanks
- The proposed project is located entirely on private land.

4.1.34. LWW-34.2 Sudbrink Proposed Spring Rehabilitation Project

This project includes rehabilitating a spring to provide a more consistent source of water for livestock/wildlife watering.

The conceptual plan for project LWW-34.2 is illustrated in Appendix C, Map 34.2 and includes the following elements:

- Develop the existing spring with a spring box
- Install fittings, valves, and appurtenances to manage water flow to the stock tank
- The proposed project is located entirely on private land.

4.1.35. LWW-35.2 Tidyman Proposed Pipeline and Stock Tank Project

The Tidyman proposed pipeline and stock tank project would expand an existing pipeline to an area in the south end of the Beaver Creek watershed where there is inadequate water for livestock/wildlife.

The conceptual plan for project LWW-35.2 is illustrated in Appendix C, Map 35.2 and includes the following elements:

- Install approximately 1,500 linear feet of 1.5-inch HDPE pipeline below the frost line from the existing pipeline to a new stock tank
- Install a new 1,200-gallon stock tank
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tank.
- The proposed project is located on private land except for the corridor along Highway 85.

4.1.36. LWW-36.1 Hollenbeck Proposed Pipeline and Stock Tank Project

The Hollenbeck pasture consists of a little over 1,000 acres of native rangeland. Currently, it has a stock tank in the southeastern portion (see photo 29) and a pond that contains water during the wetter years. Most years, these two sources of water are inadequate and Mr. Hollenbeck hauls water to temporary tanks. The proposed pipeline and stock tank project would expand an existing pipeline to an area in the Beaver Creek watershed where there is inadequate water for livestock and wildlife.

Photo 29 Existing solar well to supply an expanded pipeline and stock tanks (LWW-36.1).

The conceptual plan for project LWW-36.1 is illustrated in Appendix C, Map 36.1 and includes the following elements:

- Install approximately 14,650 linear feet of 1.5-inch HDPE pipeline below the frost line from the existing pipeline to the new stock tanks
- Install two new 1,200-gallon stock tanks
- Install one new 5,000-gallon storage tank
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the storage and stock tanks
- The proposed project is located entirely on private land.

4.1.37. LWW-37.1 Simon Conversions to Solar Pumps Project

The Simon Ranch covers a large area in the southern portion of the Beaver Creek watershed. This project would involve converting six windmills to solar pumps to provide a more reliable source of water to an area with an inadequate rainfed water supply.

The conceptual plan for project LWW-37.1 is illustrated in Appendix C, Map 37.1 and includes the following elements:

- Install solar powered pumps on six existing wells
- Install fittings, valves, and appurtenances to manage water flow and water level in storage and stock tanks
- The proposed project is located entirely on private land.

4.1.38. LWW-39.1 Tysdal Mule Creek Junction Pipeline Project

Early in the development of this watershed management plan, the Tysdals proposed an innovative project to take advantage of an unused existing well at the Mule Creek Junction rest stop. The well was installed as the only water supply at the rest stop. The water was not used because, due to unique geologic conditions, the produced water is 160 degrees Fahrenheit and therefore too hot for use at the rest stop. The Tysdals' proposal was to pipe the heated water to their ranch and distribute the water for use to the Tysdals and their neighbors. The idea was that the water would passively cool as it flowed north to the Tysdal property. The project has several complicating aspects including:

- Crossing the Cheyenne River and U.S. Highway 85
- A significant distance needed to pipe from the rest stop to the Tsydal property
- The cooling potential of the native soil is unknown

In 2001, a study was conducted for the Wyoming Department of Transportation to evaluate the feasibility, interest, and costs associated with development of a rural water system (Wester Wetstein, 2001). At that time, the project was not pursued. The Tysdals requested a current cost estimate for their proposed project.

The conceptual plan for project LWW-39.1 is illustrated in Appendix C, Map 39.1 and includes the following elements:

- Install approximately 16,000 linear feet of CPVC pipeline
- Install approximately 8,000 linear feet of 4-inch SDR pipeline
- Install approximately 24,000 linear feet of 1.5-inch SDR pipeline
- Install a heat-tolerant booster pump, vault, and well variable frequency drive
- Install five 4,500-gallon storage tanks
- Install fittings, valves, and appurtenances to manage water flow, pressure, and water level in the stock tank.
- The proposed project is located on private and state-owned land.

4.1.39. LWW-40.1 Harris Windmill Conversion Project

The Harris Ranch covers a large area in the southern portion of the Beaver Creek watershed. This project would involve converting two windmills (see photo 30) to solar powered pumps and adding stock tanks to provide a more reliable source of water to an area with an inadequate water supply. This project could be completed in phases where the wells are converted separately, as needed.

Photo 30 Windmill proposed for conversion to solar power (LWW-40.1).

The conceptual plan for project LWW-40.1 is illustrated in Appendix C, Map 40.1 and includes the following elements:

- Install two solar powered pumps on existing wells
- Install two 1,200-gallon stock tanks (one at each well)
- Install fittings, valves, and appurtenances to manage water flow and water level in the stock tanks
- The proposed project is located entirely on private land.

4.1.40. LWW-40.2 Harris Oil Well Conversion Project

There are several oil wells on the Harris Ranch that are not currently being used and are cased through water bearing formations. Mr. Harris would like to drill out the wells, log and perforate these casing across the water bearing units. After the wells are converted from oil to water production, solar pumps and tanks would be installed. This project could provide a more reliable source of water to a large area with an inadequate water supply.

Although this is a good idea for reuse of existing infrastructure, the WWDC has found that these projects are not easy to complete for several reasons. Often information on the old oil wells is not adequate for drillers to identify the water bearing units and/or the well construction information is not complete for perforation and therefore drillers are reluctant to bid on the work. Therefore, off-setting and re-drilling a new water well at this location may be a preferred alternative. A conceptual design has not been laid out for this project as the water distribution requirements for the area need to be evaluated.

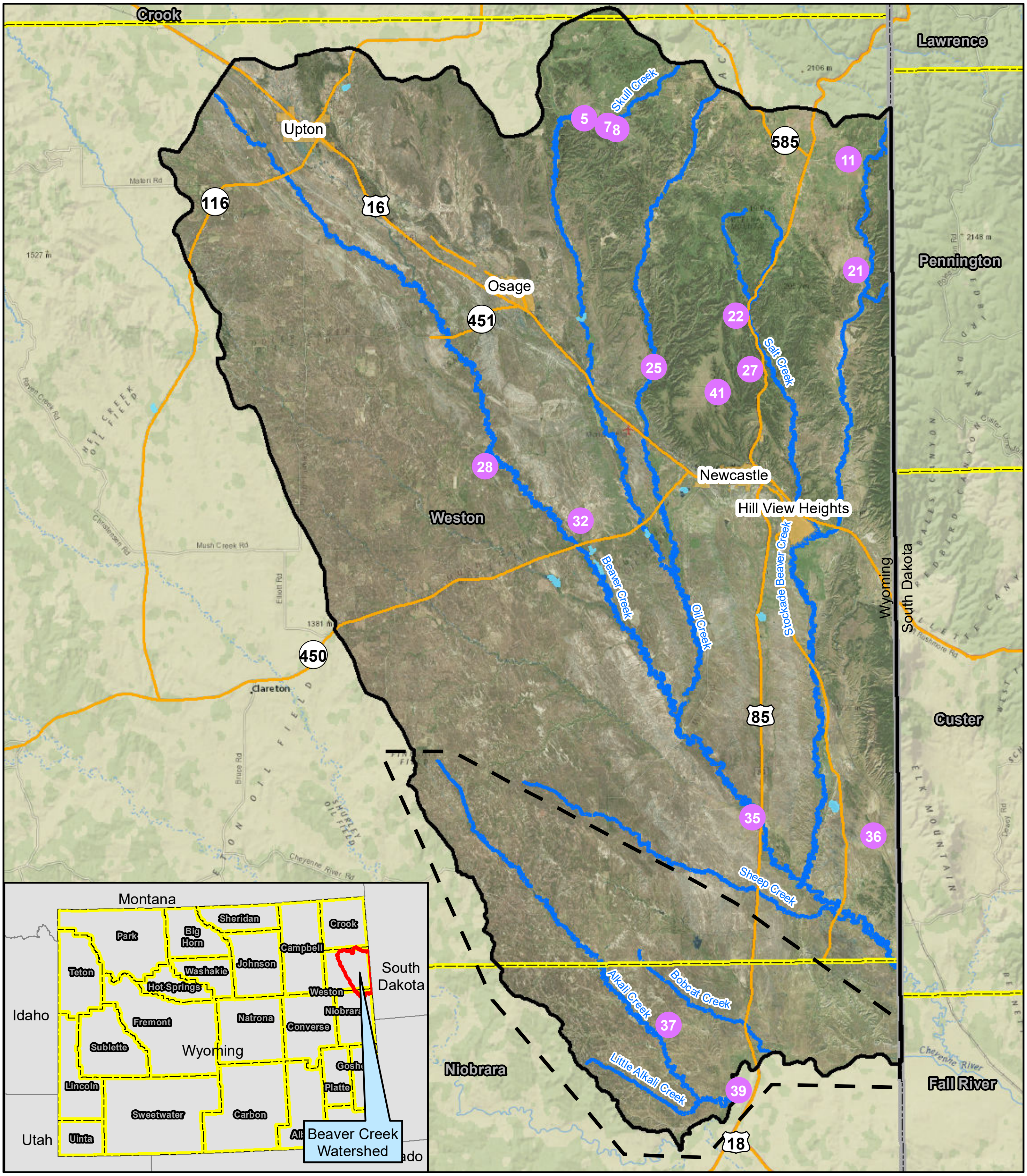
4.2. Water Supply/Storage (WSS) Improvement Projects

Water supply and storage improvement projects can also help provide reliable sources of water for livestock and wildlife. An investigation of breached dams in the watershed was conducted by the project team and is described in section 2.3.3. Many of the proposed water supply and storage improvements described in the following sub-sections address the repair of breached dams in the watershed, and have dual benefits to the economy and to overall watershed function.

Table 4.2 lists the proposed improvement projects and Figure 4.2 illustrates the general location of the projects. Appendix C includes a map of each proposed improvement. The following sub-sections describe the conceptual plan for rehabilitation or replacement developed for each project.

Table 4.2 Water Supply/Storage Improvement Projects.

Project Number	Landowner or Leasee	Project Description
WSS-5.1	Tlustos	Proposed new pond
WSS-7.1	Braun	New dam with spillway
WSS-8.1	Schaeffer	Dam rehabilitation
WSS-11.1	Cruzen	Pond rehabilitation
WSS-21.1	Rawhouser	Proposed spring-fed pond
WSS-22.3	Rossman	Reservoir rehabilitation
WSS-22.5	Rossman	Small reservoir rehabilitation
WSS-25.1	Sandrini	Proposed new dam
WSS-25.2	Sandrini	Pond Rehabilitation
WSS-27.1	Field	Proposed pond rehabilitations
WSS-28.1	Hiser	Proposed new stock pond
WSS-32.1	Millett	Proposed breached dam rehabilitation
WSS-35.3	Tidyman	Proposed new headgate and pond
WSS-36.2	Hollenbeck	Proposed pond rehabilitation
WSS-36.3	Hollenbeck	Proposed new stock pond
WSS-37.2	Simon	Proposed pit excavations
WSS-37.3	Simon	Proposed pond rehabilitations
WSS-39.2	Tysdal	Breached dam rehabilitation
WSS-41.1	Thares	Proposed pond rehabilitations



Water Supply/Storage Improvement Project
Major Rivers and Streams
Major Road
Municipal Area
Major Body of Water
Area Added to Watershed Study
State Border
County Border
Beaver Creek Watershed

Sources:
USCB Tiger Roads (2016), Places (2016), County Boundary (2014), State Boundaries (2016)
USGS NHD Flowlines (2016)
ESRI World Imagery (2018)

OLSSON ASSOCIATES

N

0 1.5 3 6 Miles

1 " = 35,000 '
Original Published Resolution
NAD 1983 UTM Zone 12N
ESRI World Imagery

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Proposed Water Supply/Storage Improvement Projects

FIGURE
4.2

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4.2.1. WSS-5.1 Tlustos Proposed New Pond Project

The Tlustos Ranch lies on the upper portion of Skull Creek. They lease the ranch for both grazing and hay production. Skull Creek meanders through a wide valley and is lined with woody and riparian vegetation. The wildlife value of the valley is somewhat limited by the lack of open water. The area would benefit from additional water sources for livestock and wildlife. Two pond sites are proposed; the second site is a backup location in case the first site is not deemed suitable. The first site would consist of excavating in an oxbow of the creek, installing a spillway around the pond site for flood flows and a pipeline to deliver water to the excavated pond site. A small berm would be constructed to separate floodwaters from the pond and an outlet structure would allow for normal water flow from the pond back into the channel. The potential pond area would be about 1.5 acres. The backup site is similar, is also on Skull Creek, and is at a breached dam site. The alternative site would be larger in quantities and surface area.

The conceptual plan for project WSS-5.1 is illustrated in Appendix C, Map 5.1 and includes the following elements:

- Construct earthen embankment approximately 10 feet tall and 240 feet in length
- Install approximately 185 feet of 8-inch HDPE pipeline as an inlet pipe
- Install an Agri-Drain or equivalent spillway structure with 30 linear feet of 12-inch HDPE outlet pipe
- The proposed project is located entirely on private land.

4.2.2. WSS-7.1 Braun Proposed New Pond Project

The property consists of approximately 427 acres of rangeland and hayland. Skull Creek runs through the property and is spring fed. The creek flows year-round and provides adequate stock water. The grazing is leased for 75 cow/calf pairs during the summer. The area would benefit from an additional water source for livestock and wildlife. Additionally, a pond on Skull Creek could provide habitat for wildlife and waterfowl by fencing off the riparian area below the pond to improve the riparian area for wildlife. There are two potential pond sites. The first proposed site provides the best emergency spillway location into a drainage that runs parallel and eventually into Skull Creek. The second potential site is located about 250 feet downstream. The project would consist of an earth fill with a spillway. In addition, the riparian fence would be approximately 1,900 feet in length and would enclose about 4 acres of riparian area. This area would be an excellent candidate for the CCRP program.

The conceptual plan for project WSS-7.1 is illustrated in Appendix C, Map 7.1 and includes the following elements:

- Construct earthen embankment approximately 10 feet tall and 240 feet in length
- Install an Agri-Drain or equivalent spillway structure with 30 linear feet of 12-inch HDPE outlet pipe
- Install a four-strand barbed wire fence, approximately 1,900 linear feet around riparian area
- The proposed project is located entirely on private land.

4.2.3. WSS-8.1 Schaeffer Dam Rehabilitation Project

Several years ago, a reservoir was constructed on the property. The reservoir was located in a spring-fed draw, a tributary to Skull Creek. The dam filled but failed soon after it was constructed (see photo 31). A reconstructed dam would provide wildlife and waterfowl habitat as well as supplementing livestock water. A geologic and engineering investigation would need to be completed to ensure the existing dam can be rehabilitated, re-cored and rebuilt. A new principle spillway structure would need to be added and the emergency spillway site possibly lowered below the original design.

Photo 31 Breached dam for rehabilitation (WSS-8.1).

The conceptual plan for project WSS-8.1 is illustrated in Appendix C, Map 8.1 and includes the following elements:

- Complete a geotechnical and engineering assessment for site suitability
- Construct earthen embankment
- Install an Agri-Drain or equivalent outlet structure and 160 linear feet of 12-inch HDPE outlet pipe
- The proposed project is located entirely on private land.

4.2.4. WSS-11.1 Cruzen Pond Rehabilitation Project

In dry years, the wildlife watering pond on the Cruzen property is dry. This project includes rehabilitating the pond by installing a liner and cleaning out the ditch that feeds the pond. The rehabilitation would supply water to a portion of the property that lacks a consistent wildlife water source.

The conceptual plan for project LWW-11.1 is illustrated in Appendix C, Map 11.1 and includes the following elements:

- Regrade the dam embankment to allow for surface runoff from surrounding agricultural field
- Install a bentonite liner in the base of the pond
- Clean out brush and debris from the small ditch that feeds the pond
- The proposed project is located entirely on private land.

4.2.5. WSS-21.1 Rawhouser Proposed Spring-fed Pond Project

The Rawhouser spring-fed pond project would involve building an earthen embankment to supply water to a portion of the watershed in the Stockade Beaver Creek drainage that lacks adequate livestock/wildlife water sources.

The conceptual plan for project WSS-21.1 is illustrated in Appendix C, Map 21.1 and includes the following elements:

- Construct earthen embankment approximately 8 feet tall and 100 feet in length
- Install an Agri-Drain or equivalent spillway structure with 58 linear feet of 12-inch HDPE outlet pipe
- The proposed project is located entirely on private land.

4.2.6. WSS-22.3 Rossman Reservoir Rehabilitation Project

This project would involve lining an existing reservoir to supply water to a portion of the watershed that lacks adequate livestock/wildlife water sources. There is a porous sandstone outcrop at the eastern and western catchment area. Lining the reservoir with bentonite will reduce infiltration.

The conceptual plan for project WSS-22.3 is illustrated in Appendix C, Map 22.3 and includes the following elements:

- Place a 6-inch thick bentonite treatment across the base of the reservoir catchment area
- The proposed project is located entirely on private land.

4.2.7. WSS-22.5 Rossman Small Reservoir Rehabilitation Project

This project would involve dredging an existing small reservoir to supply water to a portion of the watershed that lacks adequate livestock/wildlife water sources. Currently the reservoir is filled with silt.

The conceptual plan for project WSS-22.5 is illustrated in Appendix C, Map 22.5 and includes the following elements:

- Dredge approximately 1,500 cy of silt from existing reservoir
- The proposed project is located entirely on state land.

4.2.8. WSS-25.1 Sandrini Dam Rehabilitation Project

An existing pond east of the farmstead has washed out and needs repair (see photo 32). A reconstructed dam would provide wildlife and waterfowl habitat as well as supplementing stock water. A geologic and engineering investigation would need to be completed to site the new structure, possibly slightly downstream of the former structure.

The conceptual plan for project WSS-25.1 is illustrated in Appendix C, Map 25.1 and includes the following elements:

- Complete a geotechnical and engineering assessment for site suitability
- Construct earthen embankment approximately 8 feet high and 215 feet long
- Install an Agri-Drain or equivalent outlet structure
- Excavate and protect a small spillway structure
- The proposed project is located entirely on private land.

Photo 32 Sandrini dam rehabilitation site (WSS-25.1).

4.2.9. WSS-25.2 Sandrini Proposed Pond Rehabilitation Project

This project would involve dredging and lining an existing small reservoir to supply water to a portion of the watershed that lacks adequate livestock/wildlife water sources. Currently the reservoir is leaking and does not retain water through the late season when it is needed.

The conceptual plan for project WSS-25.2 is illustrated in Appendix C, Map 25.2 and includes the following elements:

- Dredge silt from existing reservoir
- Place a 6-inch thick bentonite treatment across the base of the reservoir catchment area
- Excavate and place riprap on a small spillway
- The proposed project is located on state and private land.

4.2.10. WSS-27.1 Field Proposed Pond Rehabilitations Project

The majority of the 1,200-acre property located north of Newcastle is timbered. The owner leases the property for grazing during the summer months. Water for livestock is currently provided by three stock dams, but these ponds will not supply adequate water during dry years. The owner is interested in developing a more dependable water source for both livestock and wildlife. No known springs exist on the property. The project will require a site investigation to determine if the ponds can be enlarged, sealed or otherwise improved. The landowner does not live in Wyoming and a site visit could not be arranged in time for the investigation to be completed. No conceptual map was prepared for this project since a site visit for location verification was not completed.

The conceptual plan for project WSS-27.1 and includes the following elements:

- Dredge silt from existing reservoirs
- Place a 6-inch thick bentonite treatment across the base of the reservoir catchment area
- The proposed project is located entirely on private land.

4.2.11. WSS-28.1 Hiser Proposed New Stock Pond Project

The proposed project would involve building a new stock pond to supply water to a portion of the watershed that lacks adequate livestock/wildlife water sources. The Hisers operate a cow/calf operation approximately 12 miles west of Newcastle. They would like to construct a pond to help alleviate pressure on their only well. The proposed site is well defined, fairly narrow and varies in height from about 20 to 30 feet. Surface soils are clay and clay loam. The drainage area above the project site is approximately 200 acres. Soils within the drainage area are primarily clay. This should provide adequate runoff to supply a small pond. The proposed site is one of several possibilities, but this particular site provides a fairly good emergency spillway into a small drainage immediately downstream of the left abutment. The Hisers recently leveled a site for an arena and have a fairly large (perhaps 1,500 cy) stockpile of soil that could be used for dam construction. The soil lies close enough to the project site that it could be moved with a frontend loader. The stockpiled soil appears to have fairly high clay content.

The conceptual plan for project WSS-28.1 is illustrated in Appendix C, Map 28.1 and includes the following elements:

- Construct earthen embankment approximately 10 feet tall and 150 feet in length
- Install an Agri-Drain or equivalent outlet structure with 70 linear feet of 12-inch HDPE outlet pipe
- Construct a 10-foot wide by 65-foot long spillway
- The proposed project is located entirely on private land.

4.2.12. WSS-32.1 Millett Proposed Breach Dam Rehabilitation Project

Approximately 10 years ago “Eliza’s” dam was breached (see photo 33). This project would include repairing the breached dam and installing a spillway and outlet structure. The project would provide livestock and wildlife a water source in an area of the watershed that doesn’t have an adequate water supply.

The conceptual plan for project WSS-32.1 is illustrated in Appendix C, Map 32.1 and includes the following elements:

- Construct earthen embankment along breach approximately 120 feet in length and 15 feet tall
- Install an Agri-Drain or equivalent outlet structure with a 12-inch HDPE pipe approximately 100 feet long
- Construct a spillway approximately 10 feet wide and 60 feet long
- The proposed project is located entirely on federal land managed by the USFS.

4.2.13. WSS-35.3 Tidyman Proposed New Headgate and Pond Project

The Tidyman Ranch lies between Beaver and Blacktail creeks. This project would replace an existing headgate on Blacktail Creek and construct a new pond east of the ranch headquarters. The pond would provide a more stable water supply to livestock/wildlife in the area.

Photo 33 Breached dam proposed for repair (WSS-32.1).

The conceptual plan for project WSS-35.3 is illustrated in Appendix C, Map 35.3 and includes the following elements:

- Install new headgate at the diversion point off Blacktail Creek to regulate flow
- Construct 8-foot high earthen embankment 200 feet long
- Install an Agri-Drain or equivalent outlet structure with a 12-inch HDPE pipe approximately 60 feet long
- Excavate for pond storage
- The proposed project is located entirely on private land.

4.2.14. WSS-36.2 Hollenbeck Proposed Pond Rehabilitation Project

This project would involve dredging and fencing an existing reservoir to supply water to a portion of the watershed that lacks adequate livestock/wildlife water sources (see photo 34). Fencing will facilitate rotational grazing.

The conceptual plan for project WSS-36.2 is illustrated in Appendix C, Map 36.2 and includes the following elements:

- Dredge silt from existing reservoir
- Install a four-strand barbed wire fence around pond
- The proposed project is located entirely on private land.

Photo 34 Pond proposed for dredging and fencing (WSS-36.2).

4.2.15. WSS-36.3 Hollenbeck Proposed New Stock Pond Project

The proposed project would involve building a new stock pond to supply water to a portion of the watershed that lacks adequate livestock/wildlife water sources. This project is a low priority if the other two Hollenbeck projects (LWW-36.1 and WSS-36.2) are completed. Therefore, the exact location and dimensions of the proposed new pond will need to be established if the project goes forward.

The conceptual plan for project WSS-36.3 is illustrated in Appendix C, Map 36.3 and includes the following elements:

- Excavate approximately 2,500 cubic yards of material for a stock pit
- The proposed project is located entirely on private land.

4.2.16. WSS-37.2 Simon Proposed Pit Excavations Project

The proposed project would involve building two new stock pits to supply water to a portion of the watershed that lacks adequate livestock/wildlife water sources.

The conceptual plan for project WSS-37.2 is illustrated in Appendix C, Map 37.2 and includes the following elements:

- Excavate two deep pits to allow for surface and groundwater infiltration. Estimated quantities are 2,600 cubic yards each.
- The proposed project is located entirely on private land.

4.2.17. WSS-37.3 Simon Proposed Pond Rehabilitation Project

This project would involve dredging 12 reservoirs to supply water to a portion of the watershed that lacks adequate livestock/wildlife water sources.

The conceptual plan for project WSS-37.3 is illustrated in Appendix C, Map 37.3 and includes the following elements:

- Dredge silt from 12 existing reservoirs. Each location is estimated to require 3,000 cubic yards of earthwork for each.
- The proposed project is located on federal land managed by the BLM and private land.

4.2.18. WSS-39.2 Tysdal Proposed Breach Dam Rehabilitation Project

This project would include repairing the breached dam (see photo 35) and installing an outlet structure. The project would provide livestock and wildlife a water source in an area of the watershed without adequate water supply.

The conceptual plan for project WSS-39.2 is illustrated in Appendix C, Map 39.2 and includes the following elements:

- Repair earthen embankment along breached dam
- Install an Agri-Drain or equivalent outlet structure with a 12-inch HDPE pipe approximately 60 feet long
- Construct a 10-foot wide by 60-foot long spillway
- The proposed project is located entirely on private land.

Photo 35 Breached dam (WSS-39.2)

4.2.19. WSS-41.1 Thares Proposed Pond Rehabilitation Projects

The proposed projects would consist of excavation/earth moving to create additional storage in ponds #1-#3 and lining all the ponds to reduce infiltration and maintain more water in the ponds. The project would provide livestock and wildlife additional water sources in areas of the watershed without adequate water supply.

The conceptual plan for project WSS-41.1 is illustrated in Appendix C, Map 41.1 and includes the following elements:

- Excavation/earthwork to deepen or reshape Ponds #1, #2, and #3, Quantities are estimated to be 1,445, 705, and 610 cubic yards, respectively. Earthwork was recently completed for Ponds #4, #5, and #6.
- Install a bentonite liner in the base of each pond.
- The proposed projects are located entirely on private land.

Photo 36 Existing Pond #2 (WSS-41.1)

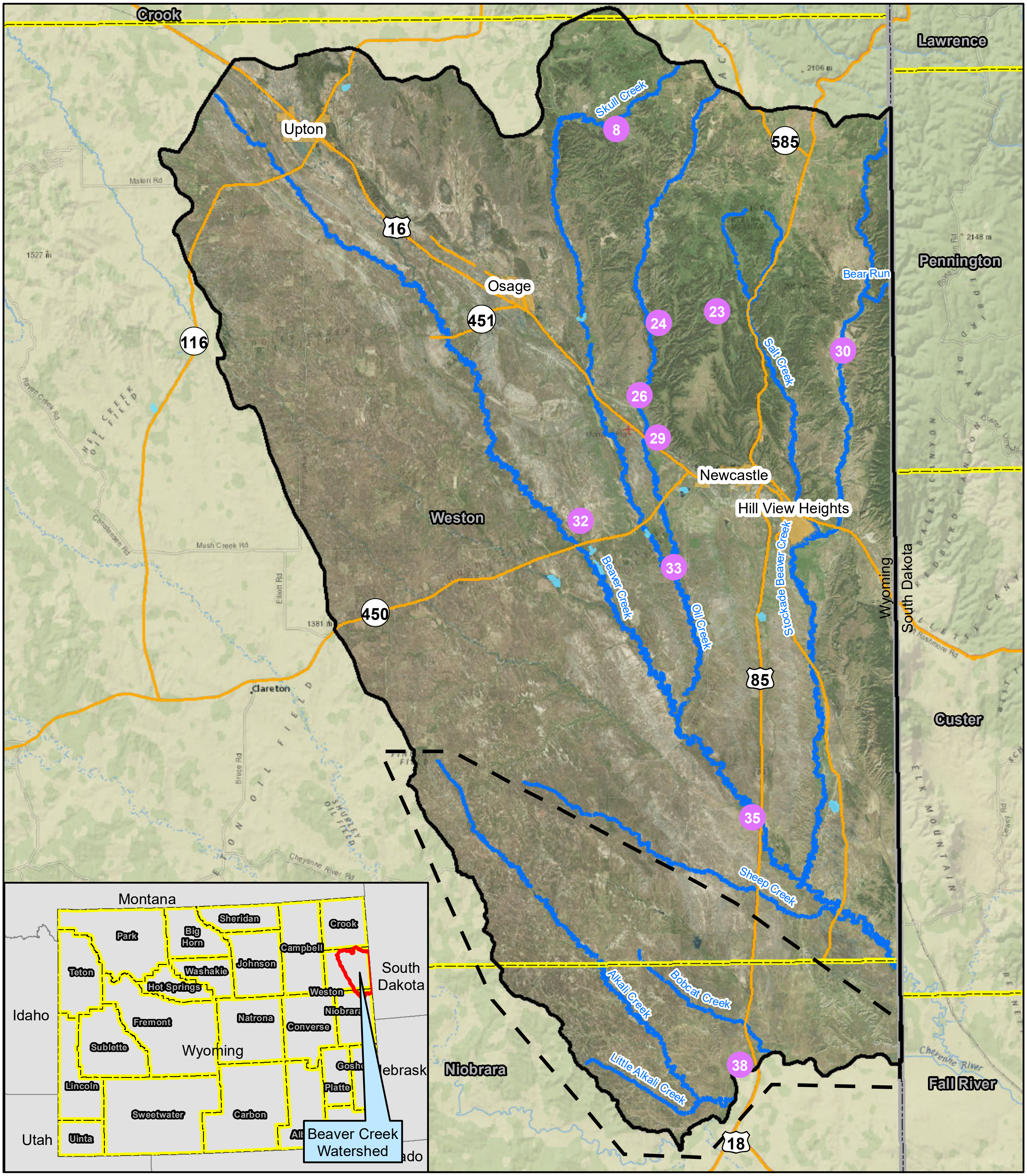
4.3. Irrigation Systems Improvement (ISI) Projects

As described in Section 2.3.1, less than 1 percent of the Beaver Creek watershed is currently irrigated according to a 2017 irrigation inventory (RESPEC, unpublished data, 2018). Because of the scarcity of irrigation systems in the watershed, there were only 10 irrigation projects that were identified for improvement or rehabilitation. For each of the proposed project improvements, an assessment of the current conditions of the system was completed by the Olsson project team with input from the landowners. The project team evaluated current delivery systems, diversions, and ditch conditions, as appropriate. For many of the projects in the Beaver Creek watershed, improvements included rehabilitating or installing new spreader dikes in order to better distribute runoff across pasture and hay fields. Additionally, new irrigation systems such as side-roll or sprinkler systems were proposed in areas where an adequate water source was available to pressurize the system. Finally, there were several diversions that needed rehabilitation to increase efficiency of the system and to eliminate erosion in some older diversions.

Table 4.3 lists the proposed improvement projects and Figure 4.3 illustrates the general location of each project. Appendix C includes a map of each proposed improvement. The following sub-sections describe the conceptual plan for rehabilitation or replacement developed for each project.

Table 4.3 Irrigation System Improvement Projects.

Project Number	Landowner or Leasee	Project Description
ISI-8.2	Schaeffer	Rehabilitate spreader dikes
ISI-23.3	Merrill	Proposed irrigation system
ISI-24.1	Perino	New irrigation system
ISI-26.2	Culver	Irrigation diversion rehabilitation
ISI-29.1	Engle	Rehabilitate irrigation
ISI-30.1	Popma	New irrigation system
ISI-32.2	Millett	Rehabilitate spreader dikes
ISI-33.1	Livingston	Replace diversion structure
ISI-35.1	Tidyman	New irrigation system
ISI-38.1	Bayne	Irrigation system rehabilitation



Irrigation System Improvement Project
Major Rivers and Streams
Major Road
Municipal Area
Major Body of Water
Area Added to Watershed Study
State Border
County Border
Beaver Creek Watershed

Sources:
USCB Tiger Roads (2016), Places (2016), County Boundary (2014), State Boundaries (2016)
USGS NHD Flowlines (2016)
ESRI World Imagery (2018)

OLSSON ASSOCIATES

N

0 1.5 3 6 Miles
1 " = 35,000 '
Original Published Resolution
NAD 1983 UTM Zone 12N
ESRI World Imagery

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Proposed Irrigation System Improvement Projects

FIGURE 4.3

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4.3.1. ISI-8.2 Schaeffer Rehabilitate Spreader Dikes Project

In 2012, the Oil Creek fire burned much of the property including a steep, rocky timbered ridge on the southern edge of the Schaeffer property. Years ago, a series of spreader dikes and catchment ponds had been constructed to reduce runoff and erosion to some of the farmland below. As a result of the fire, the spreader dikes and catchment ponds have failed and the farmland below has sustained erosion and deposition to the point where some of the land is unsuitable for cultivation or haying. The landowner would like to rehabilitate the spreader dikes. This would require both cleaning the existing structures and rebuilding areas that have breached.

The conceptual plan for project ISI-8.2 is illustrated in Appendix C, Map 8.2 and includes the following elements:

- Repair breaches in spreader dikes
- Remove debris from dikes

4.3.2. ISI-23.3 Merrill Proposed Irrigation System Project

This project would involve installing a new irrigation system that would provide water to a 29-acre hayfield that lacks adequate water resources for hay production. Because of the irregular boundary and uneven terrain in the field, using a Big- Gun irrigation system or equivalent is proposed.

The conceptual plan for project ISI-23.3 is illustrated in Appendix C, Map 23.3 and includes the following elements:

- Purchase and install a Big-Gun or equivalent irrigation system
- Install fittings, valves, and appurtenances to manage water flow and pressure from the new Madison well (LWW-23.1) to the irrigation system
- The proposed project is located entirely on private land.

4.3.3. ISI-24.1 Perino Proposed Irrigation System Project

This project would involve installing a new irrigation system that would provide water to a hayfield along West Plum Creek that lacks adequate water resources for hay production. A side-roll irrigation system is proposed for the project.

The conceptual plan for project ISI-24.1 is illustrated in Appendix C, Map 24.1 and includes the following elements:

- Purchase and install a side-roll or equivalent irrigation system
- Purchase and install irrigation pump
- Install fittings, valves, and appurtenances to manage water flow and pressure from the pond on West Plum Creek to the irrigation system
- The proposed project is located entirely on private land.

4.3.4. ISI-26.2 Culver Proposed Diversion Rehabilitation Project

This project would involve installing a new pipe in an existing irrigation diversion to provide water to an area along Oil Creek that lacks adequate water resources for hay production.

The conceptual plan for project ISI-26.2 is illustrated in Appendix C, Map 26.2 and includes the following elements:

- Install a new HPDE pipe (24-inch diameter by 20 feet long)
- The proposed project is located entirely on private land.

4.3.5. ISI-29.1 Engle Rehabilitate Spreader Dikes Project

The landowner would like to rehabilitate a small dam and expand the existing spreader dike system to improve water distribution across a pasture.

The conceptual plan for project ISI-29.1 is illustrated in Appendix C, Map 29.1 and includes the following elements:

- Rehabilitation of a small dam by removing debris and silt
- Rehabilitate and expand existing spreader dikes
- The proposed project is located on state and private land.

4.3.6. ISI-30.1 Popma Proposed Irrigation System Project

This project would involve installing a new well and irrigation system to provide water to a hayfield along Stockade Beaver Creek that lacks adequate water resources for hay production. A wheel-line irrigation system is proposed for the project.

The conceptual plan for project ISI-30.1 is illustrated in Appendix C, Map 30.1 and includes the following elements:

- Drill a new alluvial well to a depth of approximately 200 feet below ground surface
- Purchase and install a wheel-line irrigation system
- Install fittings, valves, and appurtenances to manage water flow and pressure from the new well to the irrigation system
- The proposed project is located entirely on private land.

4.3.7. ISI-32.2 Millett Rehabilitate Spreader Dikes Project

The landowner would like to rehabilitate and expand the existing spreader dike system to improve water distribution across a pasture.

The conceptual plan for project ISI-32.2 is illustrated in Appendix C, Map 32.2 and includes the following elements:

- Expand and rehabilitate existing spreader dikes
- The proposed project is located entirely on federal land managed by the USFS.

4.3.8. ISI-33.1 Livingston Proposed Diversion Rehabilitation Project

The Livingstons divert water off Oil Creek into a field on the east and west of the creek for hay production. A new diversion structure could improve control of irrigation water.

The conceptual plan for project ISI-33.1 is illustrated in Appendix C, Map 33.1 and includes the following elements:

- Install a new diversion structure
- Regrade the area around the diversion
- Install rip rap or other best management practices to reduce erosion
- The proposed project is located entirely on private land.

4.3.9. ISI-35.1 Tidyman Proposed New Irrigation System Project

This project would involve installing a new irrigation system that would provide water to a hayfield along the east bank of Beaver Creek that lacks an efficient watering system for hay production (see photo 37). A center-pivot irrigation system is proposed for the project.

The conceptual plan for project ISI-35.1 is illustrated in Appendix C, Map 35.1 and includes the following elements:

Photo 37 Existing pump from Beaver Creek to hay fields (ISI-35.1).

- Level existing hay field ditches
- Purchase and install a center-pivot irrigation system
- Install fittings, valves, and appurtenances to manage water flow and pressure from the pump out of Beaver Creek to the irrigation system
- The proposed project is located on state and private land.

4.3.10. ISI-38.1 Bayne Irrigation System Rehabilitation Project

This property lies approximately 30 miles south of Newcastle along the Cheyenne River in Niobrara County. This is a cow/calf operation and Mr. Bayne uses water from the Cheyenne River to irrigate his alfalfa/grass hay meadows. Because of excessive salt in the water during low flows, he can only irrigate when the water is high. Because of the limited irrigation time, it is important for him to maximize the amount of water he can pump on his fields. This is difficult to do with only one pumping location. Mr. Bayne would like to add another pump station and approximately 1 mile of ditch to increase water application efficiency and increase hay production.

The conceptual plan for project ISI-38.1 is illustrated in Appendix C, Map 38.1 and includes the following elements:

- Grade a new irrigation ditch to deliver up to 2 cfs
- Install a small check dam with a 60-foot length
- Place rip rap, as needed
- The proposed project is located entirely on private land.

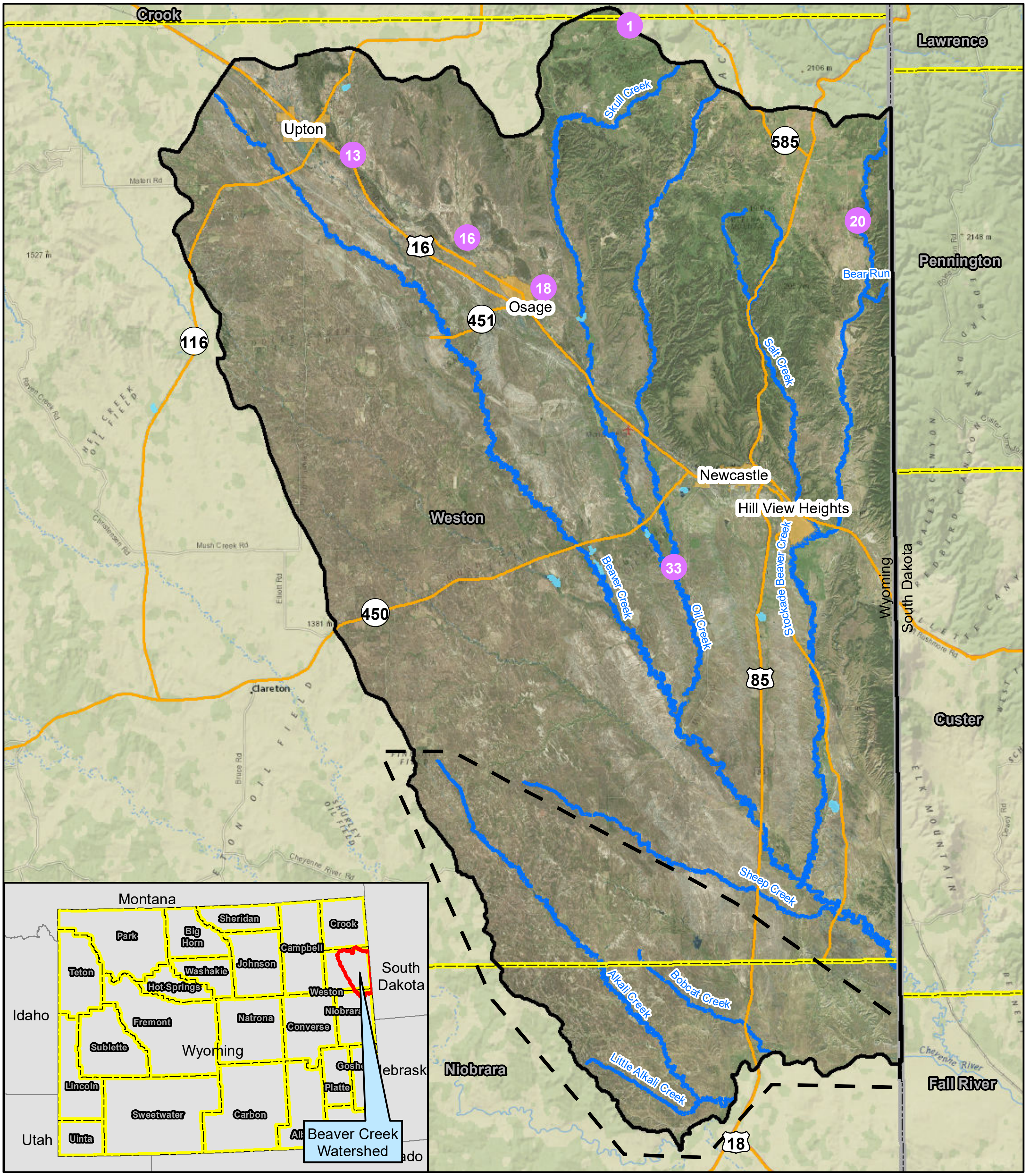
4.4. Other Management Practice (OMP) Improvement Projects

Several projects have been identified that do not fall into the previously described categories. These projects address habitat restoration, erosion control and repair, oil well abandonment, and revegetation issues.

Table 4.4 lists the proposed improvement projects and Figure 4.4 illustrates the general location of each project. Appendix C includes a map of each proposed improvement. The following sub-sections describe the conceptual plan developed for each project.

Table 4.4 Other Management Practice Improvement Projects.

Project Number	Landowner or Leasee	Project Description
OMP-1.2	Cammack	Vegetation restoration
OMP-13.1	Frederick	Sediment basin construction
OMP-16.3	Bau	Plug abandoned oil well
OMP-18.1	Hennessey	Sediment reduction
OMP-20.1	Weyrich	Wildlife and vegetation restoration
OMP-33.2	Livingston	Headcuts at confluence of Oil and Skull creeks
OMP-33.3	Livingston	Revegetation
OMP-42.1	Weston Co FSA	Weather Station



Other Improvement Project
Major Rivers and Streams
Major Road
Municipal Area
Major Body of Water
Area Added to Watershed Study
State Border
County Border
Beaver Creek Watershed

Sources:
USCB Tiger Roads (2016), Places (2016), County Boundary (2014), State Boundaries (2016)
USGS NHD Flowlines (2016)
ESRI World Imagery (2018)

OLSSON ASSOCIATES

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0 1.5 3 6 Miles

1 " = 35,000 '
Original Published Resolution
NAD 1983 UTM Zone 12N
ESRI World Imagery

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Proposed Other Management Practice Improvement Projects

FIGURE
4.4

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4.4.1. OMP-1.2 Cammack Vegetation Restoration Project

Approximately 15 acres surrounding the old farmstead has poor vegetative cover. Revegetation would reduce weed infestation, reduce sediment runoff in barren areas and provide better forage for livestock/wildlife. Funding for this project has been secured through EQIP.

The conceptual plan for project OMP-1.2 is illustrated in Appendix C, Map 1.2 and includes the following elements:

- Revegetate approximately 15 acres with a mix of western wheat grass and alfalfa using a no-till drill
- The proposed project is located entirely on private land.

4.4.2. OMP-13.1 Frederick Sediment Basin Construction

The Frederick property is east of Upton on Pine Creek. The Mr. Frederick has been working with the NRCS High Plains Area Office on a sediment basin to reduce sedimentation of a pond to the west of the ranch headquarters. The NRCS office prepared conceptual plans for the sediment basin. The notes indicated the drainage area is 13.5 square miles. The estimated sediment yield from the drainage area is 4,802 cubic yards per year. An estimate of the material excavation requirement is 26,000 cubic yards (cy). Some of the excavated material could be placed on the banks if it is in compliance with USACE Section 404. If the material is placed onsite, the cost to construct would be reduced.

The conceptual plan for project OMP-13.1 is illustrated in Appendix C, Map 13.1 and includes the following elements:

- Excavation of approximately 26,000 cy of material to build a sediment basin
- Haul excavated material to a disposal/reuse site
- The proposed project is located entirely on private land.

4.4.3. OMP-16.3 Bau Well Abandonment Project

There is an old water supply well associated with a historic mining facility adjacent to the Bau property that was not adequately abandoned. At the well casing, water seeps to the surface causing boggy areas that are a hazard to cattle and a mosquito breeding ground. Since this old well was associated with the mining industry, funding for reclamation may be available through the Abandoned Mine Land Division of the WDEQ (see section 6.2.1).

The conceptual plan for project OMP-16.3 is illustrated in Appendix C, Map 16.3 and includes the following elements:

- Properly abandon well to stop artesian flow at the surface
- The proposed project is located entirely on state land.

4.4.4. OMP-18.1 Hennessey Sediment Reduction Project

There are two small ponds on the Hennessey property east of Osage. The two ponds receive a significant fine sediment load and the first pond is full of silt and cattails (see photo 38). This project would involve dredging the first pond and installing sediment control measures. The improvements would increase water quality and supply water to a portion of the watershed that lacks adequate livestock/wildlife water sources.

The conceptual plan for project OMP-18.1 is illustrated in Appendix C, Map 18.1 and includes the following elements:

- Dredge 2,000 cubic yards the first pond to remove excess sediment
- Excavate 2,000 cubic yards from the second pond to provide storage
- Install a 160-foot 12-inch HDPE pipe from the upstream to the downstream pond
- The proposed project is located entirely on private land.

Photo 38 Fine soil in the foreground and pond/wetland with cattails in background (Project OMP-18.1).

4.4.5. OMP-20.1 Weyrich Wildlife and Vegetation Restoration Project

Photo 39 Abandoned beaver dam (OMP-20.1).

This property lies along Stockade Beaver Creek in the northeastern portion of Weston County. It consists of approximately 80 acres. The creek flows consistently throughout the northern portion of the property, but in the southern portion the creek is intermittent and absent in dry years. Historically, there have been active beaver in this area creating numerous ponds of various sizes. For an unknown reason, the beaver have disappeared over the last three years (see photo 39) and most of the ponds have vanished. Beaver habitat seems excellent with at least two willow species, chokecherry, aspen, and dogwood abundant near the stream. The Weyrichs would very much like to see the return of the beaver and this would be a likely candidate site for reintroduction of problem beaver from another area. The improvements would increase terrestrial and aquatic habitat, water quality and supply water to a portion of the watershed that lacks adequate wildlife water sources.

There is a small flowing spring in the northeastern corner of the property. The site may be suitable for excavating a small pond for waterfowl habitat. There is a grass meadow about 9 acres in size just west of the creek. Vegetation is primarily Kentucky bluegrass and Smooth brome grass. The recommendation is to use the Conservation District's no-till drill to introduce alfalfa, clover, or another legume into the meadow. This would provide forage for wildlife and help supply nitrogen for existing vegetation. This property contains some marketable timber and much of the area is overstocked with younger Ponderosa pine. The Weyrichs want to be good stewards of this timber and it is a prime candidate for a timber management plan.

The conceptual plan for project OMP-20.1 is illustrated in Appendix C, Map 20.1 and includes the following elements:

- Excavate a small pond (spring-fed)
- Reintroduce beaver (rescue/relocation)
- Revegetate nine acres with alfalfa and clover using a no-till drill
- The proposed project is located entirely on private land.

4.4.6. OMP-33.2 Headcuts at Confluence of Oil and Skull Creeks Project

The Livingstons divert water off Oil Creek into a field on the east and west of the creek for hay production. Overland flows during high water events are of concern to the landowner at points where the water reenters Oil Creek. This project would reduce the sediment load on Oil Creek and reduce erosion of the hay field.

The conceptual plan for project OMP-33.2 is illustrated in Appendix C, Map 33.2 and includes the following elements:

- Install rip rap or other best management practices to reduce erosion
- The proposed project is located entirely on private land.

4.4.7. OMP-33.3 Livingston Revegetation Project

One of the Livingstons' pastures off Oil Creek is infested with weeds (kochia). This project would increase hay production and reduce invasive species.

The conceptual plan for project OMP-33.3 is illustrated in Appendix C, Map 33.3 and includes the following elements:

- Revegetate approximately six acres with wheat grass and alfalfa using a no-till drill
- The proposed project is located entirely on private land.

4.4.8. OMP-42.1 Weston County FSA Weather Station

USDA offers a variety of disaster assistance programs to help communities, farmers, ranchers, and businesses that have been hard hit by natural disasters. For example, the USDA Farm Service Agency (FSA) Disaster Assistance Programs provide producers with assistance when eligible weather events result in losses of crops and livestock. These programs are dependent on accurate weather data, for eligibility purposes. Unfortunately, often the closest automated weather station that is available to provide the weather information is in Rapid City, South Dakota. The weather station is on the east side of the Black Hills and experiences quite different weather patterns. For this reason, the Weston County FSA is requesting an automated weather station be located within the Beaver Creek watershed to better document climate conditions. The proposed station will provide the local weather data needed to document drought and other natural disasters so that communities, farmers, ranchers and businesses can access the funds made available through the disaster assistance programs.

5. COST ESTIMATES

In this section, conceptual cost estimates are presented for many of the proposed watershed improvement projects described in Section 4. To be consistent with the objectives of the watershed study and with other watershed reports prepared for WWDC across Wyoming, the projects are grouped into the following categories and their general locations are illustrated in Figure 5.0-1:

- Livestock/Wildlife Watering Improvements (LWW)
- Water Supply/Storage Improvements (WSS)
- Irrigation System Improvements (ISI)
- Other Management Practice Improvements (OMP)

Cost estimates are based on the NRCS Environmental Quality Incentives Program (EQIP) costs, as presented in the Fiscal Year 2018 Practice Payment Rate Table for the state of Wyoming (NRCS 2018). The values in the NRCS rate table represent the amount of money typically paid to the applicant for the EQIP project and not the actual cost of the project. To better represent actual construction costs, the EQIP payment rates for livestock projects were inflated by 25 percent. This cost-estimating protocol, using inflated EQIP rate table pricing, is consistent with other WWDC watershed reports and is used here so that project costs are comparable. Additionally, the cost estimate tables include an additional 15 percent for engineering cost and another 15 percent for contingency. There is an additional five percent added to the total construction cost for permitting and fees.

5.1. Livestock/Wildlife Watering Improvements Cost Estimates

Table 5.1 lists the cost estimates for each livestock/wildlife improvement project. EQIP pricing was used except where there were no prices available on the EQIP rate table or as noted here. Pricing for the Mule Creek Junction pipeline project (LWW-39.1) was obtained from various sources including EQIP, local contractor historical pricing, supplier pricing, and past project price referencing.

5.2. Water Supply/Storage Improvements Cost Estimates

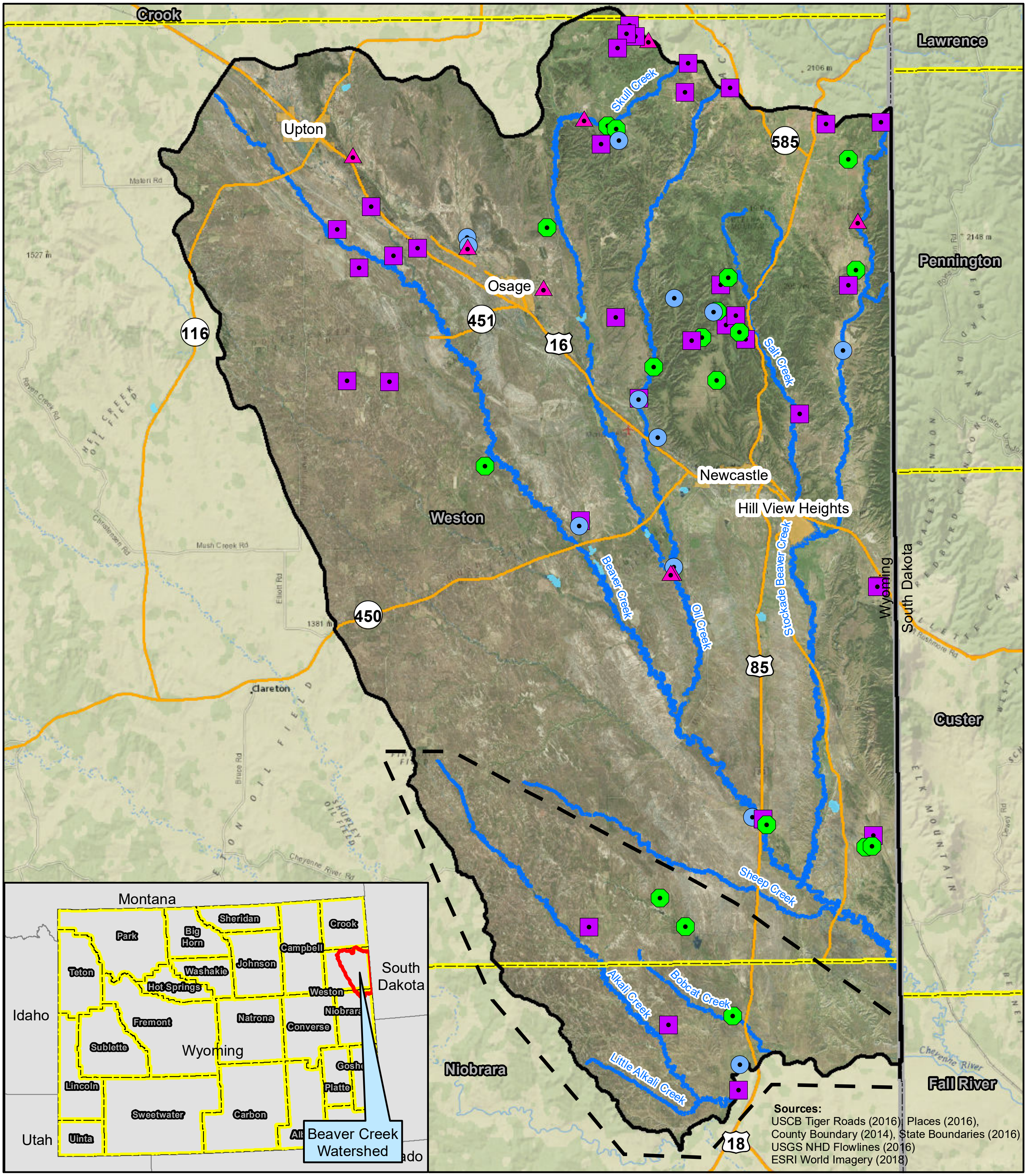
Table 5.2 lists the cost estimates for each water supply/storage improvement project. EQIP pricing was used except where there were no prices available on the EQIP rate table with no exceptions. Quantities of earthwork for embankments or liners for reservoir rehabilitations were estimated based on site visits. For most dam or reservoir rehabilitation projects, an engineering and/or geotechnical assessment will be required prior to construction.

5.3. Irrigation System Improvements Cost Estimates

Table 5.3 lists the cost estimates for each irrigation system improvement project. EQIP pricing was used except where there were no prices available on the EQIP rate table or as noted here. Diversion structure costs were derived from final costs of recent projects similar in size and scope to the projects in this report.

5.4. Other Management Practice Improvements Cost Estimates

Table 5.4 lists the cost estimates for other management practice improvement projects. EQIP pricing was used except where there were no prices available on the EQIP rate table with no exceptions.



Irrigation System Improvement
Livestock/Wildlife Watering Improvement
Other Management Practice Improvement
Water Supply/Storage Improvement
Major Rivers and Streams
Major Road
Municipal Area
Major Body of Water
Area Added to Watershed Study
State Border
County Border
Beaver Creek Watershed

OLSSON ASSOCIATES

N

0 1.5 3 6 Miles

1 " = 35,000 '
Original Published Resolution
NAD 1983 UTM Zone 12N
ESRI World Imagery

WWDC Beaver Creek Watershed Study
Niobrara and Weston Counties, Wyoming
Proposed Project Locations

FIGURE
5.0-1

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Table 5.1 Livestock/Wildlife Water Improvements Cost Estimates

Project Number	Landowner or Leasee	Project Description	Estimated Construction Cost ($)	Estimated Engineering Cost ($)	Contingency ($)	Total Construction Cost ($)	Estimated Cost for Permits, Fee ($)	Estimated Total Project Cost ($)
LWW-1.1	Cammack	Pipeline extension and stock tank	7,451	1,118	1,285	9,854	$493	10,347
LWW-1.3	Cammack	Pipeline extension and stock tanks	6,716	1,007	1,159	8,882	$444	9,326
LWW-1.4	Cammack	Pipeline extension and stock tanks	6,716	1,007	1,159	8,882	$444	9,326
LWW-1.5	Cammack	Spring development	6,723	1,008	1,160	8,891	$445	9,336
LWW-2.1	Peterson	Pipeline extension and stock tank	7,451	1,118	1,285	9,854	$493	10,347
LWW-3.1	Burleson	New pipeline and stock tanks	23,231	3,485	4,007	30,723	$1,536	32,259
LWW-4.1	Lewis, J	Well and Pipeline Project	39,665	5,950	6,842	52,456	$2,623	55,079
LWW-6.1	Tavegia/Geier	New well, pipeline and stock tank	69,399	10,410	11,971	91,780	$4,589	96,369
LWW-9.1	Lewis, BJ	Pond and pipeline development	164,690	24,704	28,409	217,803	$10,890	228,693
LWW-10.1	Neal	Spring development	3,237	486	558	4,281	$214	4,495
LWW-12.1	Calmus	Spring Rehabilitation	3,790	568	654	5,012	$251	5,263
LWW-14.1	Mills	Pipeline and stock tanks	39,319	5,898	6,782	51,999	$2,600	54,599
LWW-14.2	Mills	Pipeline and stock tanks	30,823	4,623	5,317	40,763	$2,038	42,801
LWW-14.3	Mills	Pipeline and stock tanks	19,893	2,984	3,432	26,308	$1,315	27,624
LWW-14.4	Mills	Pipeline and stock tank	14,974	2,246	2,583	19,803	$990	20,793
LWW-14.5	Mills	Middle Cordingly Pasture Project	22,080	3,312	3,809	29,200	$1,460	30,660
LWW-14.6	Mills	Mills Reservoir Solar Pumps	22,080	3,312	3,809	29,200	$1,460	30,660
LWW-15.1	Inyan Kara	Inyan Kara pipeline and stock tanks	122,160	18,324	21,073	161,557	$8,078	169,634
LWW-16.1	Bau	Surface repair of abandoned oil well	9,471	1,421	1,634	12,526	$626	13,152
LWW-16.2	Bau	Surface repair of abandoned oil well	9,471	1,421	1,634	12,526	$626	13,152
LWW-17.1	Branscom	Well conversion to solar power	12,602	1,890	2,174	16,666	$833	17,499
LWW-17.2	Branscom	New solar well pump and tank	18,005	2,701	3,106	23,811	$1,191	25,002
LWW-19.1	Larsen	Pipeline rehabilitation	16,902	2,535	2,916	22,353	$1,118	23,471
LWW-21.2	Rawhouser	Pipeline and stock tanks	23,310	3,497	4,021	30,827	$1,541	32,369
LWW-22.1	Rossman	Pipeline and stock tank	8,779	1,317	1,514	11,610	$580	12,190
LWW-22.2	Rossman	Pipeline and stock tank	20,505	3,076	3,537	27,118	$1,356	28,474
LWW-22.4	Rossman	Well conversion to solar pump	8,487	1,273	1,464	11,225	$561	11,786
LWW-23.1	Merrill	Proposed livestock water supply well	65,906	9,886	11,369	87,161	$4,358	91,519
LWW-23.2	Merrill	Proposed pipeline and tanks	62,147	9,322	10,720	82,189	$4,109	86,299
LWW-25.3	Sandrini	Proposed new well and pipeline rehabilitation	44,660	6,699	7,704	59,063	$2,953	62,016
LWW-26.1	Culver	New well and stock tank	28,192	4,229	4,863	37,284	$1,864	39,148
LWW-31.1	Vore	Pipeline, storage and stock tanks	33,627	5,044	5,801	44,472	$2,224	46,696
LWW-34.1	Sudbrink	Proposed expansion of pipeline and tanks	7,657	1,148	1,321	10,126	$506	10,632
LWW-34.2	Sudbrink	Proposed spring rehabilitation	3,237	486	558	4,281	$214	4,495
LWW-35.2	Tidyman	Proposed pipeline and stock tank	10,624	1,594	1,833	14,050	$702	14,752
LWW-36.1	Hollenbeck	Proposed pipeline and stock tank project	43,461	6,519	7,497	57,477	$2,874	60,351
LWW-37.1	Simon	Conversions to solar pumps	50,924	7,639	8,784	67,347	$3,367	70,714
LWW-39.1	Tysdal	Proposed pipeline and storage tank project	509,000	76,350	87,803	673,153	$33,658	706,810
LWW-40.1	Harris	Proposed windmill conversions	30,827	4,624	5,318	40,769	$2,038	42,807

Table 5.2 Water Supply/Storage Improvements Cost Estimates

Project Number	Landowner or Leasee	Project Description	Estimated Construction Cost ($)	Estimated Engineering Cost ($)	Contingency ($)	Total Construction Cost ($)	Estimated Cost for Permits, Fee ($)	Estimated Total Project Cost ($)
WSS-5.1	Tlustos	Proposed new pond	38,198	5,730	6,589	50,516	$2,526	53,042
WSS-7.1	Braun	New dam with spillway	39,868	5,980	6,877	52,725	$2,636	55,361
WSS-8.1	Schaeffer	Dam rehabilitation	53,250	7,988	9,186	70,423	$3,521	73,944
WSS-11.1	Cruzen	Pond rehabilitation	13,244	1,987	2,285	17,515	$876	18,391
WSS-21.1	Rawhouser	Proposed spring-fed pond	10,380	1,557	1,790	13,727	$686	14,413
WSS-22.3	Rossman	Reservoir rehabilitation	56,043	8,406	9,667	74,117	$3,706	77,823
WSS-22.5	Rossman	Small reservoir rehabilitation	10,778	1,617	1,859	14,254	$713	14,966
WSS-25.1	Sandrini	Proposed new dam	24,238	3,636	4,181	32,054	$1,603	33,657
WSS-25.2	Sandrini	Pond rehabilitation	31,755	4,763	5,478	41,996	$2,100	44,096
WSS-28.1	Hiser	Proposed new stock pond	27,418	4,113	4,730	36,260	$1,813	38,073
WSS-32.1	Millett	Proposed breach dam rehabilitation	48,779	7,317	8,414	64,510	$3,226	67,736
WSS-35.3	Tidyman	Proposed new headgate and pond	38,479	5,772	6,638	50,888	$2,544	53,432
WSS-36.2	Hollenbeck	Proposed pond rehabilitation	20,070	3,011	3,462	26,543	$1,327	27,870
WSS-36.3	Hollenbeck	Proposed new stock pond	9,875	1,481	1,703	13,060	$653	13,713
WSS-37.2	Simon	Proposed pit excavations	20,540	3,081	3,543	27,164	$1,358	28,522
WSS-37.3	Simon	Proposed pond rehabilitations	269,175	40,376	46,433	355,984	$17,799	373,783
WSS-39.2	Tysdal	Breached dam repair	14,996	2,249	2,587	19,833	$992	20,824
WSS-41.1	Thares	Proposed pond rehabilitations	55,644	8,347	9,599	73,589	$3,679	77,269

Table 5.3 Irrigation System Improvements Cost Estimates

Project Number	Landowner or Leasee	Project Description	Estimated Construction Cost ($)	Estimated Engineering Cost ($)	Contingency ($)	Total Construction Cost ($)	Estimated Cost for Permits, Fee ($)	Estimated Total Project Cost ($)
ISI-8.2	Schaeffer	Rehabilitate spreader dikes	1,187	178	205	1,570	$78	1,648
ISI-23.3	Merrill	Proposed irrigation system	18,028	2,704	3,110	23,842	$1,192	25,034
ISI-24.1	Perino	New irrigation system	88,287	13,243	15,229	116,759	$5,838	122,597
ISI-26.2	Culver	Irrigation diversion rehabilitation	810	122	140	1,071	$54	1,125
ISI-29.1	Engle	Rehabilitate irrigation	7,275	1,091	1,255	9,621	$481	10,102
ISI-30.1	Popma	New irrigation system	56,531	8,480	9,752	74,762	$3,738	78,500
ISI-32.2	Millett	Rehabilitate spreader dikes	7,300	1,095	1,259	9,654	$483	10,137
ISI-33.1	Livingston	Replace diversion structure	6,239	936	1,076	8,251	$413	8,663
ISI-35.1	Tidyman	Proposed new irrigation system	70,113	10,517	12,094	92,724	$4,636	97,360
ISI-38.1	Bayne	Irrigation system rehabilitation	18,584	2,788	3,206	24,578	$1,229	25,807

Table 5.4 Other Management Practice Improvements Cost Estimates

Project Number	Landowner or Leasee	Project Description	Estimated Construction Cost ($)	Estimated Engineering Cost ($)	Contingency ($)	Total Construction Cost ($)	Estimated Cost for Permits, Fee ($)	Estimated Total Project Cost ($)
OMP-1.2	Cammack	Vegetaton restoration	2,096	314	362	2,772	$139	2,910
OMP-13.1	Frederick	Sediment basin construction	112,000	16,800	19,320	148,120	$7,406	155,526
OMP-16.3	Bau	Plug abandoned oil well	6,556	983	1,131	8,670	$433	9,103
OMP-18.1	Hennessey	Sediment reduction	25,690	3,854	4,432	33,975	$1,699	35,674
OMP-20.1	Weyrich	Wildlife and vegetation restoration	5,207	781	898	6,887	$344	7,231
OMP-33.2	Livingston	Headcuts at confluence of Oil and Skull Creek	10,449	1,567	1,803	13,819	$691	14,510
OMP-33.3	Livingston	Revegetation	922	138	159	1,219	$61	1,280
OMP-42.1	Weston Co FSA	Weather station	7,078	1,062	1,221	9,360	$468	9,829

6. PROJECT FINANCING

__A multitude of funding opportunities are available to help with conservation project development and implementation.__ Many local, state, and federal programs are designed to provide both technical and funding assistance. In addition, many local and regional organizations aid in getting conservation on the ground. Matching these sources of assistance can be a challenge since they have different application requirements, design and construction protocols, and varying trigger or batching dates. The conservation district is a great local resource for help in getting through the hurdles associated with applications, permitting, reporting, and administration of conservation projects. The staff is committed to assisting local partnerships in conservation.

A variety of sources may be available to offer funding for various portions of the project. The general criteria and applicability of each of the funding sources are discussed in this section and are categorized by project type. A summary of the funding sources can be found in Appendix A, Data Summary 6.0. Funding sources presented here are not necessarily inclusive of all funding options available. Information presented here is also subject to change since funding sources may change their terms and criteria. The contacts listed for the various funding sources may also change.

The primary local resources for the project are the local conservation districts, the NRCS, and the BLM. These entities offer local expertise relative to the area as well as intimate knowledge of potential funding programs that may apply to the projects outlined in this report. These key local resources include, but are not limited to the following:

Local Conservation Districts:

- Weston County Natural Resource District (phone: 307.746.3264 extension 4)
- Niobrara Conservation District (phone: 307.334.9957)

Bureau of Land Management (BLM):

- Newcastle Field Office - Newcastle, Wyoming (phone: 307.746.6600)

Natural Resources Conservation Service Offices (NRCS):

- Weston County – Newcastle, Wyoming (phone: 307.746.3264)

Weston County Board of County Commissioners

- Weston County (phone: 307.746.4744)

Additionally, two online resources outline a variety of funding sources for grant, loan, and in-kind support for watershed-related projects. These two resources were used extensively for researching available funding sources for this project. The first is the Water Management & Conservation Assistance Programs Directory, which was last updated in 2014 and is available from the WWDC. The directory is available online (http://wwdc.state.wy.us/wconsprog/2014-WMCAP-Directory.pdf).

The second site, developed and maintained by the EPA, is an online Catalog of Federal Funding Sources for Watershed Protection and can be accessed online (https://www.cfda.gov/downloads/CFDA_2015.pdf).

The WGFD has published "Habitat Extension Bulletin No. 50 – Fisheries and Wildlife Habitat Cost-Share Programs and Grants." This bulletin provides a listing of potential funding sources for fisheries and wildlife habitat projects and may be viewed online here:

https://wgfd.wyo.gov/WGFD/media/content/PDF/Habitat/Extension%20Bulletins/B50-Fisheries-and-Wildlife-Habitat-Cost-Sharing-Programs-and-Grants.pdf

6.1. Local Agencies

6.1.1. Weston County Natural Resource District (WCNRD)

Wyoming conservation districts are locally elected and lead government entities. Wyoming conservation districts act to promote best management practices and conservation of the natural resources of the county. These districts also provide funding assistance through cost-share programs and in-kind contributions. A complete list of WCNRD cost-share programs is available at http://www.westoncountynrd.org/.

One of the primary cost-share programs that would be applicable to projects described in this watershed study is the Rural Cost Share Program, which was created to help fund projects that make a positive difference on the land. The types of projects that are funded through the program include the following:

- Soil erosion mitigation including streambank stabilization
- Resource damage such as field loss, stream bank stabilization, and rangeland improvements that are caused by acts of nature
- Solar stock pumps to improve livestock distribution in remote areas
- Spring developments to enhance wildlife and/or improve livestock distribution
- Fencing for implementing a rotational grazing system
- Riparian fencing to manage livestock and reduce grazing impacts
- Practices that federal farm bill programs do not fund such as electrical costs

The rural cost-share program funds are open to all applicants and require a 50 percent match from the applicant, which may include direct dollars and/or in-kind contribution.

6.1.2. Other Local Agencies

The Beaver Creek watershed also extends across portions of the Niobrara Conservation District to the south and the Crook County Natural Resource District to the north. Additional programs may be available to the portions of the Beaver Creek watershed that fall within these districts.

6.2. State Agencies

6.2.1. Wyoming Department of Environmental Quality (WDEQ)

The WDEQ provides financial assistance for best management practices to address non-point sources of pollution under Section 319 of the CWA. Grant funding requires a 40 percent match from the applicant. The match may come from the local landowner, a conservation or irrigation district, or a nonprofit organization.

A Request for Proposals is typically issued in spring or early summer of each year. Additional information about the program and the application process can be obtained from the program's website (http://deq.wyoming.gov/wqd/non-point- source./).

The WDEQ administers the Abandoned Mine Land (AML) Program that provides grants to perform a variety of services including reclaiming unproductive mine lands, closing mine openings, reducing dangerous highwalls, abating underground coal mine fires, and removing dilapidated buildings. The ALM Division is located at 200 West 17th Street, Suite 400 in Cheyenne and can be contacted by phone at 307-777-6145. For more information on the programs, more information is available at the AML website: (http://deq.wyoming.gov/aml/).

6.2.2. Wyoming Game and Fish Department (WGFD)

The WGFD offers a variety of funding options that are best summarized from the Water Management & Conservation Assistance Program Directory (http://wwdc.state.wy.us/wconsprog/2014-WMCAP-Directory.pdf).

The WGFD may offer technical and funding assistance to help landowners, conservation groups, institutions, land managers, government agencies, industries, 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 acquisition, maintenance, or improvement of wildlife habitat or for the promotion of human understanding and enjoyment of the fish and wildlife resource (habitat or information and education projects). Funds can be used for interval projects or paid as grants to an outside entity. All proposals must have a WGFD sponsor and be entered into a department proposal database by early January or early August annually. Project proposals will be prioritized for funding by WGFD staff during January through March; the preliminary approval for WGFD grants is March, and final approval is in July for funds available in July. No cost-share is required, but it is strongly recommended. Projects should occur in priority habitats or wetlands. 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 WGFD sponsor and be entered into a department proposal database by early January annually. Project proposals will be prioritized for funding by WGFD staff during January through March; the preliminary approval for WGFD grants is March, and final approval is in July for funds available in July. No cost-share is required, but it is strongly recommended. Projects should occur in priority habitats or watersheds. Approximately $25,000 to $90,000 is allocated annually to projects across Wyoming.

6.2.3. Wyoming Office of State Lands and Investments

The Wyoming Office of State Lands and Investments offers a variety of funding options that are best summarized from the Water Management & Conservation Assistance Program Directory available online here: (http://wwdc.state.wy.us/wconsprog/2014-WMCAP-Directory.pdf).

The Office of State Lands and Investments is the administrative arm of the Board of Land Commissioners and the State Loan and Investment Board. It is the statutory responsibility of the Office of State Lands and Investments to carry out the policy directives and decisions of these two boards.

The organizational structure of the Office of State Lands and Investments consists of the Office of the Director and five divisions: Financial Programs and Management Services, Real Estate Management and Farm Loans, Mineral Leasing and Royalty Compliance, Wyoming State Forestry, and Information Technology. Collectively, these divisions serve the trust's 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 non-resident general public.

The Farm Loan Program, which was 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, which was established in 1955, is designed to support small and large agricultural water development projects. The Wyoming Legislature has allocated a total of $275 million for loans under the Farm Loan Program and $20 million for the Irrigation Loans Program. Both programs are funded from the Wyoming Permanent Mineral Trust Fund.

Joint Powers Act Loan Program was established in 1974. The Wyoming Legislature authorized the Joint Powers Act Loan Program to benefit local communities with infrastructure needs. These loans are approved from funds within the Wyoming Permanent Mineral Trust Fund. These programs aid cities, counties, and special districts by providing needed government services and public facilities.

6.2.4. Wyoming Oil and Gas Conservation Commission

The Wyoming Oil and Gas Conservation Commission (WOGCC) regulates oil and gas activities in the state of Wyoming. According to the WOGCC website, when an oil and gas well on state or fee land is no longer economically productive, the owner of that well is required by state regulations to plug and abandon the well. Over the years, there have been times when wells were orphaned by their owners mostly through bankruptcy and the responsibility to safely plug and reclaim the wells becomes the responsibility of the WOGCC. Since 2014, the WOGCC has removed approximately 2,214 orphaned wells on state and private lands with 140 of those were converted to water wells for nearby ranchers. For more information on the Orphan Well Program, contact the Sr. Public Affairs Specialist, 307-315-2969 or visit the website:
https://sites.google.com/a/wyo.gov/oil-and-gas/orphan-well-program

6.2.5. Wyoming Water Development Commission (WWDC)

The WWDC provides grant and loan funding for water supply reconnaissance and feasibility studies and construction projects. Funding for studies and construction projects comes from mineral taxes. All planning studies and construction projects must be approved for funding by the Wyoming Legislature. Applicants must be public entities such as municipalities, irrigation districts, service and improvement districts, or joint powers boards. Projects must address water supply, transmission, or storage.

Project Planning: The WWDC funds and manages both Level I reconnaissance studies and Level II feasibility studies. Level I studies carry out necessary reconnaissance work, while Level II studies determine a project's feasibility. Levels I and II are 100 percent grant-funded. Project construction is covered in Level III. Project applications originate with sponsoring entities. New applications must be received by the WWDC by March 1 of each year. The Wyoming Legislature must authorize each project and approve funding before a project is initiated and before it advances to the next level.

Construction: Once a project receives a Level III authorization, the staff of the WWDC's Construction Division works with project sponsors to establish the legal documentation, making state funds available and ensuring that the project constructed complies with the description, intent, and budget as specified in the enabling legislation. One of the professional staff is assigned to each construction project from design through construction and warranty acceptance. The Construction Division assists the sponsor with design engineer selection, plan and specification review, and award of the construction contract, and then it reviews and approves all project payments. WWDC policy allows for grants of 67 percent of the eligible portions of new development and rehabilitation projects. The remainder of funding for eligible portions can be loaned at a 4 percent interest rate for new development and rehabilitation projects. Sponsors may choose to fund the loan portion from other sources.

River Basin Planning: The purpose of river basin planning is to gather and make available accurate, contemporary water information. This would include such information as hydrology for the wet, dry, and average years; GIS format coverage maps of irrigated land masses, well locations, and headgate locations; estimates of consumptive water use; and projection of future water demands. WWDC's River Basin Planning Division will assist the WWDC, the Legislature, and the governor in developing effective state water policies to protect Wyoming's water and to promote responsible development. The Planning Division will also quantify Wyoming's water resource allocations available under the state's compacts and decrees and will give Wyoming citizens access to the water information they need to deal with water issues at the grassroots level. The completion of each river basin plan is achieved with the help of the public, private consultants, and state and federal agencies.

Groundwater Grant Program: The 1981 and 1984 Wyoming Legislatures addressed W.S. 41-2-119, which authorized the WWDC to grant up to $4 million to incorporated cities and towns for exploration programs to evaluate the potential use of underground water for municipal purposes. During the 2002 session, the Legislature appropriated an additional $1,500,000 for the groundwater grant program and included water and sewer districts and improvement and service districts in addition to cities and towns, which were already eligible to receive groundwater grants, as eligible grant recipients. Authorized entities are eligible to receive up to $400,000 in grant funds and are required to provide 25 percent of the total project costs in local matching funds. The primary purpose of the program is to inventory the available groundwater resources in the state where data on aquifer resources are scarce. The program also serves to assist communities in the development of efficient water supplies. The program is not a well rehabilitation program that, for instance, replaces failed wells or repairs deficient wells. Unlike other projects within the water development program, funding for projects that meet the criteria of the Groundwater Grant Program can be allocated directly by the WWDC without legislative action.

Small Water Project Program (SWPP): The SWPP is intended to be compatible with the WWDC conventional program and criteria and to parallel and partner with other local, state, and federal programs that perform water resource planning and water development in Wyoming. Small water projects are defined as those projects that provide multiple benefits to livestock, wildlife, irrigation, recreation, and/or the environment. Pre-2018, a cap of $135,000 was imposed on projects eligible for funding. W.S. 99-3-1903 was introduced and passed in the Wyoming Legislature to remove this cap. With this change, there is no limit on total project cost for a project to be eligible for SWPP funding. The commission will provide a maximum financial contribution of 50 percent of project costs or $35,000, whichever is less. SWPP funding is a "one-time" grant so ongoing Operation & Maintenance (O&M) costs are not included. Loans are not available under SWPP. The kinds of projects eligible for SWPP funding include, but are not necessarily limited to the following:

- Environmental projects (stream bank stability, water quality improvements, or erosion protection)
- Irrigation infrastructure
- Pipelines
- Small reservoirs
- Spring developments
- Solar platforms
- Tanks
- Wells
- Wetland development
- Windmills

*As stated in Governor Mead's Wyoming Water Strategy, 2015, "**Aging infrastructure for irrigation and diversion can negatively affect stream systems.** Rebuilding old infrastructure provides opportunities to use new technologies and improve efficiencies in water and in time spent on management. Irrigation practices can be more efficient and precise that ever imagined in earlier generations."*

These projects may address environmental concerns by providing water supplies to support plant and animal species, and they 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.

6.2.6. Wyoming Department of Agriculture

Rangeland Health Assessment Program

The Wyoming Department of Agriculture has developed the Rangeland Health and Assessment Program to assure the development and use of credible data in the assessment of Wyoming rangelands. It does this by providing a structured approach that fosters and assists in collaborative efforts to monitor rangelands involving, as applicable, landowners, lessees, permittees, and federal and state land agencies.

The Wyoming Department of Agriculture has several goals for the program. The short-term goal of the program is to sustain viable levels of federal grazing land by providing credible data to assist federal land agencies in completing required National Environmental Policy Act (NEPA) analysis and to enable agencies and permittees to defend against challenges to grazing permit renewals and management plans.

The long-term goal of the program is to assess trends in the health of all rangelands and assure the use of credible data in adjusting management where indicated. Monitoring will help maintain or improve the economic viability of the livestock grazing industry and its contribution to the Wyoming economy.

The Rangeland Health and Assessment Program grants, valued from $16,000 to $20,000, provides for professional contractors and equipment to monitor vegetation and soils on grazing allotments. Data collection includes locating historic transects and collecting data using the same method used during the previous data collection event. This allows for trend determination. Plants are identified to the species level, involving keying out many plants. Soil pits are also dug to determine chemistry, structure, texture, and layers. The USFS will incorporate data into allotment files and will use them in future management decisions, such as permit renewal processes.

Wyoming Department of Agriculture's Rangeland Health and Assessment Program information is located on the website at http://wyagric.state.wy.us/divisions/nrp/rangeland-health.

6.2.7. Wyoming Wildlife and Natural Resources Trust

The Wyoming Wildlife and Natural Resources Trust offers a variety of funding options that are best summarized from the Water Management & Conservation Assistance Program Directory available online here: (http://wwdc.state.wy.us/wconsprog/2014-WMCAP-Directory.pdf).

The Wyoming Wildlife and Natural Resources Trust was created in 2005 and is funded by interest earned on a permanent account and by donations and legislative appropriations. 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 resources values is eligible for funding.

Wyoming Wildlife and Natural Resources Trust funding is available for a wide variety of projects throughout the state, including the natural resource programs of other agencies. Examples of projects eligible for funding include, but are not limited to, the following:

- Projects that improve or maintain existing terrestrial habitat necessary to maintain optimum wildlife populations and 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
- Improvements 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 when acquisition presents the necessary factors in attaining or preserving desired wildlife or fish population levels
- Mitigation of impacts detrimental to wildlife habitat, the environment, and the multiple use of renewable natural resources, or mitigation of conflicts and reduction of potential disease transmission between domestic wildlife and domestic livestock

6.3. Federal Agencies

6.3.1. Bureau of Land Management (BLM)

The BLM offers three distinct programs for funding, which are best summarized in the Water Management & Conservation Assistance Program Directory, which is available online (http://wwdc.state.wy.us/wconsprog/2014-WMCAP-Directory.pdf).

Riparian Habitat Management Program – The program offers the opportunity to coordinate with outside interests in riparian improvement projects. The goal of BLM's riparian-wetland management is to maintain, restore, improve, protect, and expand these areas so they are in proper functioning condition for their productivity, biological diversity, and sustainability. The overall objective is to achieve an advanced ecological status, except where resource management objectives, including proper functioning condition, would require an earlier successional stage. The goal includes aggressive riparian-wetland information inventorying, training, and research programs as well as improving the partnerships and cooperative management processes. Funding is available on an annual basis and is subject to budget allocations from Congress. All submitted cooperative projects compete for the funds available in the riparian program.

Range Improvement Planning and Development – The program is a cooperative effort with the livestock operator and 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. 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 form 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 comes from the range improvement fund, which is generated from grazing fees collected. There is also a limited amount of funding from general rangeland management appropriations. Contributions come either in the form of labor or may provide some material costs as well and are typically in the form of a grant.

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 implementation of several Section 319 watershed plans statewide. This program is a cooperative effort between the BLM and the WDEQ. Goals of the program for watershed projects will typically be the restoration and maintenance of healthy watershed function and are typically accomplished through best management practices, prescribed burns, vegetation treatment, and instream structures to enhance vegetation cover, control accelerated soil erosion, increase water infiltration, and enhance stream flows and water quality.

6.3.2. Bureau of Reclamation

The Bureau of Reclamation offers two programs for funding, which are best summarized in the Water Management & Conservation Assistance Program Directory online (http://wwdc.state.wy.us/wconsprog/2014-WMCAP-Directory.pdf).

The Bureau of Reclamation's mission is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. The Bureau of Reclamation has a major responsibility, in partnership with states, water users, and other interested parties, to help improve water resources and the efficiency of water use in the western United States. After more than 100 years, the bureau'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 the bureau's water resource management strategy.

WaterSMART (Sustain and Manage America's Resources for Tomorrow) – This program established 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 Bureau of Reclamation bureaus and offices. Through the WaterSMART program, the bureau 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 the bureau provides funding in two funding groups. In Funding Group I, up to $300,000 in federal funding is available per project and is for smaller on-the-ground projects that can be completed within two 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 three years to complete. Water and energy efficiency grants are awarded through a competitive process that requires a minimum 50 percent cost share by the recipient. More information can be found online here: http://www.usbr.gov/WaterSMART.

Water Conservation Field Services Program (WCFSP) – This program 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 they are focused on fundamental conservation improvements as identified in water conservation plans developed by water users. Financial assistance provided through the program also requires a minimum 50 percent cost share by the recipient. More information can be found online here: http://www.usbr.gov/waterconservation.

6.3.3. Environmental Protection Agency (EPA)

The EPA administers the Targeted Watersheds Grant Program. Established in 2003, the Targeted Watersheds Grant Program is designed to encourage successful community-based approaches and management techniques to protect and restore the nation's watersheds. The Targeted Watersheds Grant Program is competitive and based on the fundamental principles of environmental improvement: collaboration, new technologies, market incentives, and results-oriented strategies. The Targeted Watersheds Grant Program focuses on multifaceted plans for protecting and restoring water resources that are developed using partnership efforts of diverse stakeholders. The program's implementation grants are focused on individual watershed organizations. Successful watershed organizations are chosen because they best demonstrate the ability to achieve on-the-ground, measurable environmental results relatively quickly, having already completed the necessary watershed assessments and developed a technically sound watershed plan. Each of the watershed organizations exhibits strong partnerships with a wide variety of support; creative, socio-economic approaches to water restoration and protection; and explicit monitoring and environmentally based performance measures. Proposals must be nominated by either a governor or a by a tribal leader from the state in which the project resides. More information can be found here: https://www3.epa.gov/region9/water/watershed/grants.html.

6.3.4. Farm Service Agency (FSA)

The FSA is a member agency of the USDA. Programs administered through the FSA are offered through local county committees. Technical assistance needed for implementation of FSA programs is provided through the NRCS. The FSA programs available include the following:

Conservation Reserve Program – This program 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 to 15 years of annual rental payments and cost-share assistance. This 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 the program is ranked according to environmental benefit for wildlife habitat, erosion control, water quality, and air quality.

Continuous Sign-Up for High-Priority Conservation Practices – Continuous sign-up provides management flexibility to farmers and ranchers to implement certain high-priority conservation practices on eligible land. Land must meet the requirements of the Conservation Reserve Program and must be determined by NRCS to be eligible and suitable for riparian buffers, filter strips, grass waterways, shelter belts, field windbreaks, living snow fences, contour grass strips, salt-tolerant vegetation, or 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, filter strips, and riparian buffers. An additional 10 percent may be added if the land is in an EPA-designated wellhead protection area. There is also a provision for cost share of up to 50 percent of the cost of establishing permanent cover.

Emergency Conservation Program – The program 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 conservation practices are removing debris, restoring fences and conservation structures, and providing water for livestock in drought situations.

More information for each of the programs can be found online here:
http://www.fsa.usda.gov/FSA/webapp?area=home&subject=landing&topic=landing.

6.3.5. U.S. Fish and Wildlife Service (USFWS)

The USFWS offers technical and financial assistance to a variety of entities and offers six programs addressing the management, conservation, restoration, or enhancement of wildlife and aquatic habitat. These six programs are best summarized in the Water Management & Conservation Assistance Program Directory available online here: http://wwdc.state.wy.us/wconsprog/2014-WMCAP-Directory.pdf.

Partners for Fish and Wildlife Program – 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 in need of restoration or enhancement such as riparian areas, streams, wetlands, and grasslands. 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 construction, invasive species removal, and wetland establishment.

Wildlife and Sport Fish Restoration – The USFWS's Wildlife and Sport Fish Restoration Program works with states, insular areas, and the District of Columbia to conserve, protect, and enhance fish and their wildlife and habitats, and the hunting, sport fishing, and recreational boating opportunities they provide. The 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.

Conservation Planning and Assistance Program – The Conservation Planning and Assistance Program works directly with other federal agencies and programs, as well as with the American 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 identification of 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, monitoring of species, and identification of significant habitats.

Cooperative Endangered Species Conservation Fund / Section 6 Grants – 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.

North American Wetlands Conservation Act Grant Program – This grant program promotes long-term conservation of wetlands ecosystems and the waterfowl, migratory birds, fish, and wildlife that depend upon such habitat. Conservation sections supported are acquisition, enhancement, and restoration of wetlands and wetlands-associated habitat. This program encourages voluntary, public, and 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.

National Wildlife Refuge Challenge Cost-Share Program – The USFWS Challenge Cost-Share Program started in 1988 to enhance partnerships with state and local governments, individuals, and public and private groups. The program enables the USFWS to manage cooperatively its natural and cultural resources and fulfill stewardship responsibilities to fish and wildlife management. Under this program, projects must either 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 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 non-monetary contribution. Cooperative agreements are signed with the cost-share partners.

6.3.6. Natural Resources Conservation Service (NRCS)

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 properties according to the lands' needs and within the lands' capabilities. The treatment includes a balance between the land use for economic return and protecting its ability to be productive from generation to generation. Technical and cost-share assistance is available through NRCS. The NRCS administers the following Farm Bill programs, which are best summarized in the Water Management & Conservation Assistance Program Directory available online here:
http://wwdc.state.wy.us/wconsprog/2014-WMCAP-Directory.pdf.

Environmental Quality Incentives Program (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 helping agricultural producers implement practices that will alleviate or reduce threats to sage-grouse habitat.

Conservation Stewardship Program (CSP) – This program encourages land stewards to improve their conservation performance by installing and adopting additional activities and by improving, maintaining, and managing existing activities on agricultural land and nonindustrial private forest land.

The Regional Conservation Partnership Program – This program promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners. NRCS helps producers through partnership agreements and through program contracts or easement agreements. Assistance is delivered in accordance with the rules of EQIP, CSP, and the Agricultural Conservation Easement Program (ACEP), and in certain areas, the Watershed Operations and Flood Prevention Program.

The Agricultural Management Assistance Program – This program 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 farming or ranching operations. The purpose of the program is to assist producers in reducing risk to their operations.

Conservation Innovation Grants – This 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 this grant program, EQIP funds are used to award competitive grants to nonfederal governmental or nongovernmental organizations, tribes, or individuals.

The Agricultural Conservation Easement Program (ACEP) – This program provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits. Under the Agricultural Land Easements component, NRCS helps Indian tribes, state and local governments, and nongovernmental organizations protect working agricultural lands and limit nonagricultural uses of the land. Under the Wetlands Reserve Easements component, NRCS helps to restore, protect, and enhance enrolled wetlands.

6.4. Nonprofit and Other Organizations

In this section, several national nonprofit organizations that promote conservation and fund restoration projects are described.

6.4.1. Ducks Unlimited

Ducks Unlimited Inc. is a funding source for wetlands and waterfowl restoration. Ducks Unlimited 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.

Ducks Unlimited offers a waterfowl habitat development and protection program called MARSH, which stands for Matching Aid to Restore State Habitat. This is a reimbursement program that provides matching funds for restoration, protection, or enhancement of wetlands. The financial extent of this program is dependent on Ducks Unlimited's income within the state. Projects receiving funding support must demonstrate at least 30 years of beneficial life at a minimum.

6.4.2. National Fish and Wildlife Foundation (NFWF)

The NFWF provides several charter grant programs for regions across the nation. The most applicable programs for the projects in this watershed study include the following:

Five-Star Restoration Program – This program provides modest financial assistance on a competitive basis to support community-based wetland, riparian, and coastal habitat restoration projects that build diverse partnerships and foster local natural resources stewardship through education, outreach, and training activities.

Bring Back the Natives – The NFWF, in cooperation with the USFWS, BLM, USDA, USFS, and Trout Unlimited (TU), requests pre-proposals from nonprofit organizations; universities; Native American tribes; and local, state, and federal agencies interested in restoring, protecting, and enhancing native populations of sensitive or listed aquatic species, especially on lands on or adjacent to federal agency lands. Funding for the program is administered through NFWF from federal agencies cooperating to support this program. This funding requires a $2 nonfederal match for each federal dollar requested by applicants. Since 1991, this program has supported 279 projects and has benefited over 120 species, 29 of which are federally listed as threatened or endangered.

Native Plant Conservation Initiative – The NFWF solicits proposals for the Native Plant Conservation Initiative grants cycle. This grant program is conducted in cooperation with the Plant Conservation Alliance (PCA), a partnership between the NFWF, 10 federal agencies, and more than 270 nongovernmental organizations. The PCA provides a framework and strategy for linking resources and expertise in developing a coordinated national approach to the conservation of native plants. Since 1995, the Native Plant Conservation Initiative grant program has funded multiple-stakeholder projects that focus on the conservation of native plants and pollinators under any of the following six focal areas: conservation, education, restoration, research, sustainability, and data linkages.

Pulling Together Initiative – The Pulling Together Initiative seeks proposals that will help control invasive plant species, mostly through the work of public/private partnerships such as Cooperative Weed Management Areas. Applications are accepted from private nonprofit 501(c) organizations; federally recognized tribal governments; local, county, and state government agencies; and from field staff of federal government agencies. Individuals and for-profit businesses are not eligible to receive these grant funds, but they are encouraged to work with eligible applicants to develop and submit applications to the initiative. Applicants must provide a 1:1 nonfederal match for their grant request.

More information for each of these funding options and others can be found at NFWF's website here: http://www.nfwf.org.

6.4.3. Trout Unlimited (TU)

TU was founded in 1959 with a mission to conserve, protect, and restore North America's trout and salmon fisheries and their watersheds. TU works to achieve this mission on local, state, and national levels through an extensive volunteer network and dedicated staff. Since 2007, TU's Wyoming Water and Habitat Program has developed innovative and pragmatic partnerships with landowners, ranchers, and agencies in an effort to conserve our cold-water fisheries. To date, TU has raised over $10 million to reconnect and restore over 1,000 miles of streams for wild and native trout through the implementation of over 100 projects with numerous partners in Wyoming. Landowners and agencies who partner with TU have enjoyed the benefits of maintenance-free irrigation diversion structures, irrigation efficiency upgrades, riparian fencing, river channel restoration, stream habitat enhancements, and new road crossing infrastructure while at the same time benefiting fisheries. TU does not have a local chapter in the Newcastle area; however, the Wyoming Council of TU is a group of volunteers from throughout the state who work to enhance cold-water fisheries in Wyoming. To reach the Wyoming Council of TU, contact the Green River office at 307.321.1476 or www.tu.org.

6.5. Funding for Sage-Grouse Conservation Efforts

In the state of Wyoming, there are several funding sources whose mission is to benefit the habitat and success of the sage-grouse. There are also organizations who will have special requirements for any construction or modification to the local habitat. The WGFD has compiled a list of funding opportunities for Wyoming sage-grouse conservation efforts. The funding opportunities are best summarized in the WGFD's web site here:
https://wgfd.wyo.gov/WGFD/media/content/PDF/Habitat/Sage%20Grouse/SGC_FUNDINGOPPS_REVISED0414.pdf.

6.5.1. State of Wyoming Sources for Sage-Grouse Conservation Efforts

Wyoming Wildlife and Natural Resource Trust Account – This account was created by legislative action in 2005 for the purposes of preserving and enhancing Wyoming's wildlife and natural resources. Income from the trust account funds a wide variety of conservation programs (http://wwnrt.state.wy.us).

Wyoming Game and Fish Department (WGFD) Trust Fund – This is a matching grants program for riparian or upland habitat improvement, water development, and industrial water projects (http://wgfd.wyo.gov).

WGFD / Wyoming State General Fund – Wyoming Sage-Grouse Conservation Fund – This funding was approved by the Legislature via the governor's budget request and was designed to implement projects identified in local sage-grouse conservation plans (http://wgfd.wyo.gov).

Wyoming Animal Damage Management Board – This board provides funding for the purposes of mitigating damage caused to livestock, wildlife, and crops by predatory animals, predacious birds, and depredating animals or for the protection of human health and safety (http://www.wyadmb.com).

6.5.2. Federal Sources for Sage-Grouse Conservation Efforts

U.S. Department of the Interior, U.S. Fish and Wildlife Service (USFWS) (http://www.fws.gov)

- **Partners for Fish and Wildlife Program –** Aids private landowners who want to restore or improve habitat on their properties. The landowner is reimbursed after project completion, based on the cost-sharing formula in the agreement.
- **Private Stewardship Program –** Provides grants or other assistance to individuals and groups engaged in private conservation efforts that benefit species listed or proposed as endangered or threatened under the ESA, candidate species, or other at-risk species on private lands. Maximum federal share is 90 percent.
- **Cooperative Conservation Initiative –** Supports efforts to restore natural resources and establish or expand wildlife habitat. Maximum federal share is 50 percent.
- **Multistate Conservation Grant Program –** Supports sport fish and wildlife restoration projects identified by the International Association of Fish and Wildlife Agencies. Maximum federal share is 100 percent.
- **Conservation Grants –** Provides financial assistance to states to implement wildlife conservation projects such as habitat restoration, species status surveys, public education and outreach, captive propagation and reintroduction, nesting surveys, genetic studies, and development of management plans. Maximum federal share is 75 percent for a single state or 90 percent for two or more states implementing a joint project.

USDA Farm Service Agency (FSA) (http://www.fsa.usda.gov/pas/)

- **Conservation Reserve Program –** A voluntary program for agricultural landowners. Through this program, an individual can receive annual rental payments and cost-share assistance to establish long-term, resource-conserving covers and to enhance wildlife habitat on eligible agricultural land.

USDA Natural Resource Conservation Service (NRCS) (http://www.wy.nrcs.usda.gov)

- **Conservation Technical Assistance –** Provides voluntary conservation technical assistance to land users, communities, units of state and local government, and other federal agencies in planning and implementing conservation systems. This assistance is for planning and implementing conservation practices that address natural resources issues.

- **Environmental Quality Incentives Program (EQIP) –** Provides a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible goals. EQIP offers financial and technical help to assist eligible participants install or implement a broad variety of structural and management practices on eligible agricultural land.
- **Conservation Innovation Grants –** A voluntary program that enables the NRCS to work with public and private entities to accelerate the development and adoption of innovative conservation approaches and technologies in conjunction with agricultural production.
- **Working Lands for Wildlife –** A partnership between NRCS and the USFWS to combat the decline of seven specific wildlife species whose decline could be reversed and could benefit other species with similar habitat needs. The greater sage-grouse is one of the seven.
- **Conservation Stewardship Program (CSP) –** Helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resources concerns. Participants earn CSP payments for conservation performance – the higher the performance, the higher the payment.
- **Agricultural Conservation Easement Program (ACEP) –** Provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits. Under the Agricultural Land Easements component, NRCS helps Indian tribes, state and local governments, and nongovernmental organizations protect working agricultural lands and limit nonagricultural uses of the land through conservation easements. Under the Wetlands Reserve Easements component, NRCS helps to restore, protect, and enhance enrolled wetlands. ACEP is a new program that consolidates three former programs – the Wetlands Reserve Program, Grasslands Reserve Program, and Farm and Ranch Land Protection Program.
- **Regional Conservation Partnership Program –** Promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners. NRCS provides assistance to producers through partnership agreements and through program contracts or easement agreements. This program combines the authorities of four former conservation programs – the Agricultural Water Enhancement Program, the Chesapeake Bay Watershed Program, the Cooperative Conservation Partnership Initiative, and the Great Lakes Basin Program – and delivers assistance through covered programs, including EQIP, CSP, ACEP, Healthy Forest Reserve Program, and Watershed and Flood Prevention Operations in Critical Conservation Areas.

U.S. Department of Interior, Bureau of Land Management (BLM) (http://www.blm.gov)

- **Challenge Cost Share –** This program is designed to leverage funds with partners to monitor and inventory resources; implement habitat improvement projects; develop recovery plans; protect or document cultural resources; provide enhanced recreational experiences; and to better manage wild horse and burro populations. Matching funds, goods, or services are required.

USDA U.S. Forest Service (USFS) (http://www.fs.fed.us)

- **Cooperative Project Funding –** Contact local USFS staff for information about opportunities to develop partnerships in projects involving national forests or national grasslands.
- **Partnership Resource Center –** The Partnership Resource Center of the National Forest Foundation and the USFS provides partnering organizations and USFS staff with the information to enhance working relationships. Partnerships expand opportunities for obtaining grants. Many funding sources prefer or require them because projects involving partnerships have an increased potential for success (http://www.partnershipresourcecenter.org).

6.5.3. Other Potential Sources for Sage-Grouse Conservation Efforts

Wyoming Wildlife – The Foundation – This foundation (now a component fund of the Wyoming Community Foundation) is a charitable, non-advocacy organization dedicated to conservation education and the funding and management of projects that benefit Wyoming wildlife (http://www.wyomingwildlifefoundation.org).

Wyoming Governor's Big Game License Coalition – Funding generated from the sale of governor's licenses are placed in five accounts: bighorn sheep, moose, elk, mule deer, and general wildlife. Funds administered by the Wyoming Wildlife – The Foundation. (http://www.wyomingwildlifefoundation.org/index.aspx)

National Fish and Wildlife Foundation (NFWF) – Conservation Partners Program – Grants funded through this program provide staff and technical assistance to private landowners in regions where some of the nation's most crucial conservation issues can be addressed through Farm Bill programs (http://www.nfwf.org/conservationpartners/Pages/home.aspx).

National Fish and Wildlife Foundation (NFWF) – Pulling Together Initiative – Provides support for the formation of local Weed Management Area partnerships. These partnerships engage federal resource agencies, state and local governments, private landowners, and others in developing weed management projects within an integrated pest management strategy. Nonfederal matching funds, goods, or services are required (http://www.nfwf.org/pti/Pages/home.aspx).

Intermountain West Joint Venture – Capacity Grants Program – Habitats within the program area support nearly 100 percent of the range of all high-priority sagebrush steppe land bird species, such as sage sparrow, sage thrasher, sage-grouse, and Brewer's sparrow. This grants program is designed to build capacity and catalyze partnerships that measurably contribute to the protection, restoration, or enhancement of priority bird habitats to support sustainable populations of birds in the Intermountain West. Successful capacity grants are meant to join conservation partners together—around priority areas, habitats, or bird species—to improve conservation program effectiveness (http://iwjv.org/funding-opportunity/iwjv-capacity-grantsprogram).

The Nature Conservancy (TNC) – This organization works with conservation supporters and partner organizations to create funding for conservation worldwide using a variety of creative methods (http://nature.org).

Rocky Mountain Elk Foundation – This wildlife conservation organization has an emphasis on elk. It advocates sustainable, ethical use of resources and seeks common ground among stakeholders. It funds habitat restoration and improvement projects and acquires land or conservation easements (http://www.rmef.org).

Mule Deer Foundation – This foundation's goals center on restoring, improving, and protecting mule deer habitat. The Mule Deer Foundation achieves its goals through partnering with state and federal wildlife agencies, conservation groups, businesses, and individuals to fund and implement habitat enhancement projects on both public and private lands (http://www.muledeer.org).

Muley Fanatic Foundation – The mission of this organization is to ensure the conservation of mule deer and their habitat and to provide such supporting services to further the sport of hunting and sound wildlife management (http://www.muleyfanatic.com).

One Shot Antelope Foundation – Water for Wildlife – Water for Wildlife is a conservation program designed to benefit wildlife and the environment in arid regions of the western United States. Emphasis focuses on the development of supplemental water resources in areas where both the habitat and wildlife are being impaired by lack of this vital resource (http://www.waterforwildlife.com).

North American Grouse Partnership – This organization promotes the conservation of prairie grouse and the habitats necessary for their survival and reproduction (http://www.grousepartners.org).

Pheasants Forever – Some sage-grouse populations in Wyoming occur within areas that have a local Pheasants Forever chapter. Local chapters determine how their funds are spent. Projects that benefit game birds other than pheasants may be eligible for funding (http://www.pheasantsforever.org/chapters/).

Bow Hunters of Wyoming – This organization assists with wildlife studies, habitat improvement, and other conservation efforts.

7. PERMITS

The following sections present the potential federal, state, and local regulatory permits that could be required for the watershed management plan and rehabilitation activities proposed in Section 4. This section is intended to characterize the potential environmental permitting requirements for the proposed activities and to summarize the environmental documentation, permits, agency clearances and approvals, and other agency requirements that may be necessary to implement the proposed activities, depending on the final planning and design. The applicability of the federal, state, and local permits, clearances, and approvals will depend upon the project sites selected and the potential permitting implications of each of those sites.

Irrigation and livestock/water activities on private lands are generally not subject to federal, state, and local agency review and/or approval; however, the projects proposed in Section 4 are likely to require some amount of review and/or approval from the appropriate agency(ies) depending on the locations and features of the proposed projects.

7.1. National Environmental Policy Act (NEPA) Compliance and Documentation

The 1969 NEPA requires federal agencies to assess potential environmental effects of projects an agency proposes to undertake, fund, or approve. NEPA is triggered when an action occurs on federal land, federal funds may be used for the undertaking, and/or when federal agency action is necessary for a project to move forward. The NEPA process is intended to avoid, minimize, and mitigate adverse environmental effects of federal actions, and requires analysis and documentation of potential effects (adverse and beneficial) of a proposed action and any alternative actions. NEPA mandates an open public involvement process throughout the NEPA timeline.

If the watershed management plan and rehabilitation activities proposed in Section 4 occur on federal lands or federal funds will be used for the undertaking, NEPA will be triggered, and the respective federal agency will be the lead agency charged with providing compliance with NEPA and related environmental statutes. Federal regulations dictate the permitting requirements and review process of water-related projects. The timeframes for securing the necessary permits from federal agencies for such projects vary, and in some cases, could take multiple years depending on the location and complexity of the proposed activities.

7.1.1. U.S. Forest Service (USFS)

The USFS also has NEPA procedures that include its regulations at 36 Code of Federal Regulations (CFR) Part 220, Forest Service Manual 1950, and Forest Service Handbook 1909.15. The NEPA documentation (i.e., categorical exclusion, EA, or environmental impact statement [EIS]) may be prepared in-house by USFS staff or by a third-party expert (for USFS review). The USFS, under the USDA, conducts an environmental analysis using the best available science and makes decisions that will increase the health, resilience, diversity, and productivity of national forests and grasslands. Development of any projects located on the Medicine Bow-Routt National Forest-Thunder Basin Grasslands will be guided by the Thunder Basin National Grassland Revised Land and Resource Management Plan (RMP) and Record of Decision (USFS 2002). The RMP contains management standards and guidelines, availability and sustainability of lands, and people-carrying capacities for resource management to address or prevent issues associated with existing natural resources and people's continued use of them.

7.1.2. U.S. Fish and Wildlife Service (USFWS)

The National Wildlife Refuge System Improvement Act of 1997 was established to fulfill the mission of the refuge system and requires that the USFWS develop a 15-year conservation plan for each national wildlife refuge (National Wildlife Refuge System Improvement Act of 1997). Projects conducted within national wildlife refuges need to correspond with the coinciding conservation plans. No national refuges are located within the Beaver Creek watershed (USFWS 2018d).

7.1.3. Bureau of Land Management (BLM)

NEPA evaluations and processes for projects that are proposed where BLM is the lead federal agency are performed by BLM staff or independent third-party experts responsible to BLM. BLM has responsibility under the Federal Land Policy and Management Act (FLPMA) to manage public lands for multiple use and sustained yield, except where otherwise provided by law. BLM's NEPA Handbook H-1790-1 (2008), Mitigation Handbook H-1794-1 (2016), and Land Use Planning Handbook H-1601-1 (2005) provide guidance for activities proposed to occur on BLM-managed lands. Like other federal agencies, the scope of BLM's environmental analyses includes categorical exclusions, EAs, and EISs depending on the anticipated effects of the proposed activities. Chapter 11 of the Department of the Interior's (DOI) NEPA policy found in Departmental Manual (DM) Part 516 (BLM 2009) is specific to the BLM's management of the NEPA process.

7.1.4. U.S. Army Corps of Engineers (USACE)

USACE NEPA regulations are contained at 33 CFR Part 230. Appendix B to Part 325 sets forth implementing procedures for the USACE regulatory program. The USACE, through requirements contained in Section 404 of the CWA, regulates activities involving the discharge of dredged or fill material into waters of the United States. As such, any project that has the potential to affect wetlands or waters of the United States must address Section 404 permitting requirements (unless it is an exempt activity). Executive Order 11990, Protection of Wetlands, requires federal agencies to avoid to the extent possible, long- and short-term adverse impacts associated with the destruction and modification of wetlands, and to avoid direct and indirect new construction in wetlands wherever there is a practicable alternative.

7.1.5. Other State/Federal Agencies

The Wyoming Game and Fish Commission serves as the policy making board of the WGFD and is responsible for the direction of the WGFD. The WGFD provides the state of Wyoming a system of control, propagation, management, and protection and regulation of all wildlife in Wyoming (W.S. 23-1-301-303, W.S. 23-1-401). The WGFD issues various permits and licenses for game and fish.

7.1.6. Watershed-Wide Environmental Analysis

Because of the large number of potential water development and habitat restoration projects within the Beaver Creek watershed, a "watershed-wide" environmental analysis is recommended as an overall assessment. This assessment will streamline the environmental analysis process and create a single baseline characterization and impacts assessment of relevant environmental issues across the watershed. This single baseline characterization can be used as a starting point for individual projects and can be altered or supplemented as needed.

7.2. Permitting/Clearances/Approvals

Environmental resources are protected by a variety of federal, state, and local regulations. Permits, authorization considerations, and agency contacts are discussed in the sections below.

7.2.1. Wild and Scenic Rivers Act

The Wild and Scenic Rivers Act, enacted in 1968, protects selected rivers and their surrounding environments for the purpose of protecting the water quality and the free-flowing conditions of the rivers. The selected rivers are administered by federal or state agencies and are classified as wild, scenic, or recreational. Any project that proposes the installation of dams or other similar construction within a protected river requires a complementary policy that preserves the water quality and natural flow of the river. Under the Wild and Scenic Rivers Act, federal support for the construction of dams or other instream activities that have the potential to alter streamflow is prohibited within protected rivers (Wild and Scenic Rivers 2018). There are no wild and scenic designated rivers in the Beaver Creek watershed.

7.2.2. Wilderness Act of 1964

The Wilderness Act of 1964 was enacted to designate certain wilderness areas and protect them from being impaired by human habitation. The Wilderness Act of 1964 defines wilderness as an area that has not been substantially altered by man and remains generally untouched except by the forces of nature. Wilderness areas are designated by Congress and signed off by the President. Congress also directed federal agencies to evaluate lands for suitability as wilderness in addition to designated wilderness areas (The Wilderness Act 1964). Lands being evaluated for suitability as wilderness are categorized as *designated*, *recommended*, *proposed*, *suitable*, or *study area*. These areas are managed so that their suitability as wilderness is not diminished. There are no congressionally designated wilderness areas in the Beaver Creek watershed (USDA 2018b).

7.2.3. Fish and Wildlife Coordination Act (FWCA)

The FWCA requires federal agencies involved in actions that will result in the control or structural modification of any natural stream or body of water for any purpose to take action to protect the fish and wildlife resources that may be affected by the action. The FWCA requires federal agencies or applicants to consult with state and federal wildlife agencies to prevent, mitigate, and compensate for project-induced losses of wildlife resources, as well as to enhance those resources.

7.2.4. Migratory Bird Treaty Act (MBTA)

The MBTA requires avoiding construction activities in grassland, wetland, stream, and woodland habitats and on bridges that may result in the take of migratory birds, eggs, young, and/or active nests. In Wyoming, most migratory bird activity occurs during the period of April 1 to July 15.The USFWS has indicated that if a proposed construction period is planned to occur during the primary nesting season, or at any other time that may result in the take of the nests of migratory birds, a survey should be performed. A qualified biologist must conduct the field survey of the affected habitats and structures to assess the presence of nesting migratory birds during nesting season. The survey results need to be maintained with the project files and made available to the USFWS upon request. The USFWS should be contacted immediately if active nests are identified within the construction area and within a 0.5-mile line of sight that cannot be avoided. If active nests are observed that cannot be avoided until after the birds have left the nest and no practicable or reasonable avoidance measure is identified, including delay of construction, a Federal Fish and Wildlife License/Permit must be obtained from the USFWS for the work to proceed.

7.2.5. Bald and Golden Eagle Protection Act (BGEPA)

Bald and golden eagles are federally protected under the BGEPA of 1940. The BGEPA prohibits anyone, without a permit issued by the Secretary of the Interior, from the take, possession, and commerce of bald and/or golden eagles, including their parts, nests, and eggs. The definition of take includes pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb. Compliance with the BGEPA is part of the NEPA documentation. As with the MBTA, if construction activities fall within the primary eagle nesting season, a survey of eagle nesting sites should be conducted following the guidelines set forth by the USFWS.

7.2.6. U.S. Army Corps of Engineers (USACE) Section 404 Permit

The USACE's Wyoming Regulatory Office administers and enforces Section 404 of the CWA in Wyoming for the Omaha District. Under the CWA, a Section 404 permit is required for discharging dredged or fill material into waters of the United States. Constructing or rehabilitating a diversion structure (e.g., a headgate, weir, or diversion dam) and associated in-stream or streambank work would involve discharging dredged or fill material into waters of the United States and would require permitting under Section 404 of the CWA.

Because many waterbodies and wetlands are considered waters of the United States, they are subject to the USACE's regulatory authority. Depending on the nature and extent of activities proposed, a Nationwide Permit (NWP or Regional General Permit) or Individual Permit may be required. NWPs are a type of general permit issued by the USACE on a nationwide basis for activities having minimal impacts. The USACE's *2017 Nationwide Permits, General Conditions, District Engineer's, Decision, Further Information, and Definitions* document provides an index of the current list of NWPs based on the nature of the proposed activity. They are designed to provide timely authorization for certain activities in waters of the United States while protecting the nation's aquatic resources. Smaller projects with minor impacts typically qualify for general permits, while larger projects with greater impacts may require an individual permit (which requires more review, including an environmental analysis that documents efforts to avoid, minimize, and mitigate impacts—in that order). The USACE can only issue individual permits for the least environmentally damaging practicable alternative (LEDPA). Some agricultural exemptions from Section 404 permitting exist for constructing or maintaining irrigation ditches, including siphons, pumps, headgates, wingwalls, weirs, screens, or other facilities that are appurtenant and functionally related to irrigation ditches; the USACE should be contacted to discuss such exemptions.

Permit applications can be obtained by contacting the USACE's Wyoming Regulatory Office in Cheyenne at 307.772.2300 and by accessing http://www.nwo.usace.army.mil/Missions/Regulatory-Program/Wyoming.

7.2.7. Endangered Species Act (ESA)

The ESA Section 7 requires federal agencies to protect threatened and endangered species by avoiding impacts, including destruction or modification, to potential habitat. A project funded by a federal agency is required to consult with the USFWS, informally or formally, to discuss potential impacts to threatened and endangered species. The federal agency will typically request a biological assessment to determine whether the project is likely to adversely impact a threatened or endangered species or its habitat early on in the project planning. If there are no anticipated impacts, an informal consultation is typically conducted with the USFWS to determine whether the USFWS is in agreement that the project will not affect or is unlikely to adversely affect threatened or endangered species, and to confirm that no avoidance or mitigation measures need to be taken. If there are anticipated impacts, the federal agency typically requests a formal consultation with the USFWS to determine whether avoidance or mitigation measures need to be taken with respect to threatened and endangered species habitat impacts (USFWS 2013); the USFWS' decision is rendered in a biological opinion.

7.2.7.1. *Threatened and Endangered Species*

The federally proposed, threatened or endangered species in Table 7.2.7 have the potential to occur within the Beaver Creek watershed study area (USFWS 2018e). No critical habitat is present within the watershed.

Table 7.2.7 Federal Proposed, Threatened or Endangered Species in the Beaver Creek Watershed.

Species	Scientific Name	Status	Habitat
Northern Long-eared Bat	*Myotis septentrionalis*	Threatened	Forested areas, areas containing caves and mines
Least Tern	*Sterna antillarum*	Endangered	Sandbars and salt flats, near and around water
Red Knot	*Calidris canutus rufa*	Threatened	Coastal shores, migrate through North America
Whooping Crane	*Grus americana*	Endangered	Wetlands, marshes, ponds, wet meadows, rivers
Ute Ladies'-tresses orchid	*Spiranthes diluvialis*	Threatened	Moist meadows, stream terraces, floodplains at elevations between 4,300-6,850 feet

Sources: USFWS 2018e, USFWS 2018f, USFWS 2018g, USFWS 2018h, NatureServe Explorer 2018a, and NatureServe Explorer 2018b.

7.2.7.2. *Federal Agency Species of Concern*

The BLM and the USFS have developed a list of species of concern for specific areas. The USFWS has also developed a list of species of concern. The BLM/USFS species list is more extensive than the USFWS list, but both lists of species will need to be assessed for impacts before the commencement of any proposed activities in Section 4 occur on federal land. For example, the greater sage-grouse is not listed as a federally threatened or endangered species, but there are still conservation concerns that the USFS, in coordination with the BLM, has addressed. The USFS has identified priority habitat management areas, general habitat management areas, and sagebrush focal areas. Priority habitat management areas have the highest habitat value and highest conservation priority for maintaining sagebrush habitat for the greater sage-grouse. General habitat management areas require some habitat management to maintain greater sage-grouse populations within those areas. Sagebrush focal areas are areas with a large amount of sagebrush, creating ideal habitat for greater sage-grouse (USFS 2018b). Although the greater sage-grouse is not protected by the USFWS, the USFS and BLM have implemented measures to protect greater sage-grouse and their habitat.

7.2.7.3. *Wyoming State Species of Concern*

The WYNDD develops and maintains lists of plant and animal species in Wyoming that are biologically sensitive. Plants and animals are included on the species of concern list based on their rarity, inherent vulnerability, and threatened status (WYNDD 2018b). The WGFD has implemented a Wyoming State Wildlife Action Plan which is a strategy to maintain a diversity of wildlife throughout the state and to reduce the need for future listing under the ESA. This plan focuses on species that have not received much attention in the past, including species that have not been hunted or fished (WGFD 2018).

The state of Wyoming has implemented a statewide conservation strategy for the greater sage-grouse. Executive Order 2015-4 indicates core area protection measures for greater sage-grouse populations. The greater sage-grouse core areas have the highest conservation value and are of upmost importance to maintaining greater sage-grouse populations (State of Wyoming 2015).

Coordination with the WGFD is recommended for any project activities that have the potential to affect greater sage-grouse habitat. Providing or increasing water to areas where water is limited may create a beneficial impact for this species and should be considered when evaluating the net potential impacts to this species.

7.2.8. Other Federal and State Permits

Wyoming Board of Land Commissioners and Wyoming Office of State Lands and Investments

The Wyoming Board of Land Commissioners has responsibility for regulating all activities on state lands. The Office of State Lands and Investments grants rights-of-way (ROWs). Projects to be constructed on state or school lands require a ROW grant per the *Rules and Regulations Governing the Issuance of ROW* (W.S. 36-20 and W.S. 36-202).

Some of the projects proposed in Section 4 could occur on Wyoming state lands. For a project to occur on state land, a grazing and agricultural lessee must obtain permission from the Board of Land Commissioners prior to construction in accordance with W.S. 36-2-107. The lessee must submit an Application for Construction of Improvements on State Land to the Office of State Lands and Investments for review and approval. Information and applications are available by contacting the Office of State Lands and Investments at 307.777.7331 and by accessing http://lands.wyo.gov/lands/leasing/agricultural.

Wyoming State Engineer's Office (WSEO)

Surface Water Storage Permit

The Wyoming SEO administers the water rights system of appropriation within the state. For construction to occur on state lands, the required water rights permits for the diversion and storage of the state's surface water must be obtained. The majority of the projects proposed in Section 4 would require a permit from the SEO. A water right would have to be obtained or modified for proposed wells, livestock/wildlife water, irrigation rehabilitation, and water-storage projects in accordance with W.S. 41-3-101.

Permit to Construct/Dam Safety Review

The SEO also administers Wyoming's Safety of Dams Program. Wyoming Dam Safety Law (W.S. 41-3) requires any persons, public company, government entity, and private company proposing to construct a dam greater than 20 feet high or which will impound more than 50 acre-feet of water, or a diversion system which will carry more than 50 cfs to obtain approval for construction of the dam or ditch from the SEO. Proposed construction, enlargement, major repair, alteration, or removal of a dam or diversion system with headgates or diversion structures that carry more than 50 cfs require plans and specifications prepared by a Wyoming-licensed registered professional engineer to be submitted to the SEO for approval pursuant to W.S. 41-3-308.

Other Permits

Depending on the nature of work being performed, additional permits may have to be secured from the SEO, including the following (and others listed at http://seo.wyo.gov/applications-forms#Surface):

Ditches, Pipelines, Waterhauls: This permit authorizes new diversions from streams (including ditches, pipelines, and temporary water hauls), and for special application stock or domestic diversions from a stream not exceeding 25 gallons per minute.

Enlargement of Ditches, Pipelines: This permit is to enlarge an existing ditch, pipeline or waterhaul to allow the diversion of more water.

Reservoirs: This permit is used to allow new reservoirs or enlarge existing reservoirs.

Applications, regulatory information, and instructions for dam safety reviews can be accessed at https://sites.google.com/a/wyo.gov/seo/regulations-instructions. SEO permits can be accessed via the state's e-Permit website at http://seoweb.wyo.gov/e-Permit/ (a username and password are required).

Some of the proposed activities discussed in Section 4 for the Beaver Creek watershed would typically include drilling a water well or rehabilitating an existing water well to provide a source of livestock/wildlife water within the watershed. In such cases, the following permit may apply:

Appropriate Groundwater: This permit requires any person to obtain a water right appropriation prior to drilling a water well. Drilling and pump contactors and well owners must comply with W.S. 41-3-909. The water quality of a completed well must be suitable for livestock and cannot exceed certain suitability constituents for groundwater standards (W.S. 35-11-302).

Groundwater applications, regulatory information, and form instructions are available at
https://sites.google.com/a/wyo.gov/seo/regulations-instructions,
https://sites.google.com/a/wyo.gov/seo/ground-water/water-wellconstruction, and
http://deq.wyoming.gov/wqd/groundwater/resources/rules-regs/.

Wyoming Department of Environmental Quality (WDEQ)

Wyoming Pollutant Discharge Elimination System (WYPDES) Program

The EPA has oversight responsibility for the federal CWA delegated to and administered by the Wyoming Water Quality Division (WQD). Stormwater discharges are regulated under the CWA by the WDEQ's WYPDES Program. Project sponsors for proposed activities occurring within the watershed should contact the WDEQ to determine if a Construction General Permit (CGP) is required. Construction activities that disturb 5 or more acres must obtain a Large CGP, and those that disturb 1 or more acres (but less than 5 acres) must obtain a Small CGP. Large CGPs must be accompanied with a Storm Water Pollution Prevention Plan. Construction activities associated with the proposed activities in Section 4 can result in the requirement to temporarily discharge pumped water. Temporary discharges must comply with the terms of the CGP and any stipulations applied.

The WDEQ has the authority to authorize temporary increases in water turbidity above the numeric criteria of Section 23, Chapter 1, Wyoming Surface Water Quality Standards (W.S. 35-11-101) for some short-term, construction-related activities performed in live water. The proposed activities discussed in Section 4 that include irrigation diversions and/or streambank work would require a temporary turbidity waiver.

Section 401 Certification

A Section 401 certification is Wyoming's approval that activities authorized under Section 404 of the CWA meet state water quality standards and do not degrade water quality. For a proposed activity that requires a USACE Section 404 permit, preconstruction notification (PCN) must be submitted to the USACE. The PCN is then forwarded to the WDEQ for review under Section 401 of the CWA to determine compliance with the state's surface water quality standards (W.S. 35-11-101). Discharges of pollutants into waters of the United States must be authorized by permit issuance from the WQD in accordance with the WQD's rules and regulations. Those rules and regulations set forth the classification of surface water and groundwater uses and establish Wyoming's water quality standards. Any activity involving a discharge of fill to a Class 1 water or adjacent wetland require a 401 certification from WQD, regardless of the type of Section 404 permit used to authorize the activity. A 14-day public notice and comment period is also required. WDEQ may issue special conditions with a 401 certification to provide compliance with surface water quality standards or total maximum daily loads.

Additional information and forms are available by contacting the WDEQ at 307.777.7781 and by accessing http://deq.wyoming.gov/wqd/ and http://deq.wyoming.gov/wqd/401-certification/.

Wyoming State Historic Preservation Office (SHPO)

Proposed activities within the watershed that will be located on federal land, use federal funding, or require a federal permit should be reviewed by SHPO in accordance with Section 106 of the National Historic Preservation Act (NHPA) of 1966 and the Wyoming Antiquities Act of 1935 (W.S. 35-1-114 to -116). The SHPO reviews cultural resource reports, issues compliance letters for proposed activities, provides comments on activities that could potentially affect historic properties or cultural resources, and makes recommendations regarding additional investigations where necessary. Additional SHPO compliance and review information can be obtained by contacting the SHPO at 307.777.6311 and by accessing http://wyoshpo.state.wy.us/Section106/Index.aspx.

Wyoming Department of Fire Protection and Electrical Safety

For proposed activities within the Beaver Creek watershed that involve the installation of electrical equipment, the Wyoming Department of Fire Protection and Electrical Safety should be contacted to determine if a wiring permit is required before commencing construction. A wiring permit is required when electrical equipment is installed in new construction or the remodel of a building, mobile home, or premises. The electrical installation must be performed in accordance with W.S. 35-9-120 and -123. Certain exemptions apply. Additional information and an application for a wiring permit can be obtained by contacting the Wyoming Department of Fire Protection and Electrical Safety at 307.777.7288 and by accessing http://wsfm.wyo.gov/electrical-safety/wiring-permits.

Special Use Permits/Rights-of-Way (ROWs)/Easements

Special use permits, ROWs, and/or easements may be required where access across the lands of others is required for construction and/or operation of a project. These can be temporary or permanent. Typically, privately owned lands that will be rendered permanently unavailable will be purchased unless the owner and sponsoring entity concur on a permanent easement.

Bureau of Land Management (BLM)

Permanent use of BLM lands would likely be administered under a grant with an appropriate term issued under the BLM's ROW process.

U.S. Forest Service (USFS)

Permanent use of USFS lands would likely be administered under a special use authorization with an appropriate term issued under the USFS' special use process.

Wyoming Department of Transportation (WYDOT)

An easement or ROW from the WYDOT could be required for some of the projects proposed in Section 4.

Property Access and Ownership

Permission should always be obtained from a landowner, lessee, or management agency before any fieldwork is performed on a property for a proposed activity within the watershed. Verbal permission from landowners may be sufficient for some site visits; if project-specific field data needs to be collected, written permission should be acquired. The Enterprise Technology Services' Wyoming Statewide Parcel Viewer is available at http://gis.wyo.gov/parcels/. It can be used to determine parcel ownership of land that will be affected by a proposed undertaking. Information regarding state land parcels and surface leases is accessible from the Office of State Lands and Investments at:

http://gis.statelands.wyo.gov/GIS/OSLIGIS/StateLandAccess/
http://statelands.wyo.gov/surfaceplatbook/.

Other

In addition to the above, there may be other permits, authorizations, and clearances required for the proposed activities in Section 4, some of which may be covered or provided by the construction contractor (e.g., air quality permit, trash/slash burning permit, utility/One-Call of Wyoming, etc.).

County

Other local/county zoning ordinances and permits may be required (e.g., building construction, floodplain development, aquifer construction, wastewater, and road or utility access), within the study area for Weston, Crook, and Niobrara counties. County contact information is as follows:

--Weston County: https://westongov.com/, 307.746.2474
--Crook County: http://www.crookcounty.wy.gov/, 307.283.4548
--Niobrara County:, http://niobraracounty.org/, 307.334.2211

Special Districts

There are special districts (e.g., flood control, irrigation, road, and improvement districts) located within the Beaver Creek watershed. If a project involves the property and/or facility of a special district, permission or a permit should be obtained before commencing construction.

7.3. Environmental Considerations

7.3.1. Wetland Resources

A formal wetland delineation in accordance with the USACE's guidelines has not been conducted across the Beaver Creek watershed. GIS digital mapping from the NWI exists and is available for review. However, some areas identified as wetlands on the NWI map may not qualify as jurisdictional wetlands upon field investigation, and wetlands areas not mapped by the NWI may exist. This is because the methodology used to prepare the NWI maps changes and the nature of wetlands is to change and develop over time due to natural events. A formal wetland delineation should be conducted once project sites are selected to determine potential impacts to wetland areas and appropriate avoidance, minimization, and mitigation measures, as appropriate.

7.3.2. Fish and Wildlife Resources

There are a wide variety of opportunities for hunting and fishing within the Beaver Creek watershed. WGFD and federal agencies regulate the timing and location of permitted hunting and fishing. Hunting and fishing are both allowed within the watershed with the appropriate permits. Antelope, elk, mule deer, and white-tailed deer have migration populations within the Beaver Creek watershed. There are multiple sport fishing waters within the watershed, too, including Orange Ribbon, Yellow Ribbon, and Green Ribbon designated waters.

7.4. Cultural and Paleontological Resources

To protect and enhance Wyoming cultural resources as important links to the human history of the river corridors in the Beaver Creek watershed, including historical and archaeological sites, cultural landscapes, and ethnographic resources, additional cultural records searches and fieldwork would need to be completed prior to construction of any of the recommended projects to identify and record such resources that could be inundated or otherwise affected by the projects.

Federal approvals may be involved with the recommended watershed management and rehabilitation plan projects for the Beaver Creek watershed, and in such cases, potential impacts on cultural resources must be considered (i.e., Section 106 consultation). If the watershed management plan and rehabilitation activities proposed in Section 4 occur on federal lands, the NHPA and Native American Graves Protection and Repatriation Act (NAGPRA) may apply. The NHPA requires federal agencies to evaluate the impact of federally funded or permitted projects on historic properties. The NAGPRA requires federal agencies and institutions that receive federal funding to return Native American cultural items to lineal descendants and culturally affiliated Indian tribes. It also establishes procedures for the unanticipated discovery or planned excavation of such items on federal or tribal lands.

Collection of paleontological resources on public lands is not allowed unless special permits are obtained. Collection and preservation should only be performed by a trained paleontologist.

7.5. Mitigation

Mitigation may be required for impacts to resources, including wetland vegetation, stream channel habitat, cultural resources, fish and game resources, and threatened and endangered species. To address impacts, avoidance and minimization measures are preferred over mitigation. If mitigation is required for wetland or stream channel impacts, a mitigation plan will be required and will need to be approved by the USACE in order to obtain a Section 404 permit. Any potential mitigation for threatened and endangered species impacts will coincide with formal consultation with the USFWS.

A formal search of Wyoming cultural resources records for previous projects and known historic buildings and archaeological sites within the study area with the Wyoming SHPO should be performed prior to construction/rehabilitation activities occurring to determine if there are additional properties that need to be evaluated and/or areas that need to be surveyed to assess the likelihood of those activities having impacts on historically significant cultural resources. For activities on federal lands, consultation with the Wyoming SHPO will be required (and Class I cultural resources surveys may be needed prior to ground-disturbing activities). If a cultural resources mitigation plan needs to be developed, it would likely culminate in a Memorandum of Understanding or Agreement between the Wyoming SHPO and the lead federal agency, with concurrence by the project sponsor(s) and potentially affected Native American tribes.

Wyoming contains a large number of paleontological resources (or fossil specimens) and sites throughout the state and Beaver Creek watershed where fossiliferous sedimentary bedrock is exposed at the surface. Collection of fossils on public lands is not allowed unless special permits are obtained. While the collection of fossils on private land is not prohibited, collection and preservation should be performed by a trained paleontologist.

8. CONCLUSIONS AND RECOMMENDATIONS

This section provides the conclusions and recommendations of this Level I watershed study. The conclusions and recommendations pertain to the watershed improvements presented in the Watershed Management Plan (Section 4) and incorporate interpretations from the cost estimates, permitting and project financing (Sections 5, 6, and 7).

8.1. Conclusions

This watershed study provides a holistic evaluation of the Beaver Creek watershed, an area encompassing over 884,000 acres. This Level I watershed study evaluated the current condition of the Beaver Creek watershed and looked at opportunities for water improvement projects to restore, maintain, and enhance healthy watershed function. The current condition of the watershed was evaluated and summarized in the inventory, descriptions and streamflow hydrology of the watershed study, sections 2 and 3 of this report. The datasets and reports evaluated for the inventory and descriptions were incorporated into a GIS dataset and digital library provided electronically to the WCNRD and WWDC. The datasets and digital library will provide the WCNRD, WWDC, and cooperating agencies information for planning and implementation of the watershed improvements outlined in this report.

During the development of this watershed study, residents who live in the watershed, together with the agencies that manage public lands, attended project meetings to voice their concerns about what they viewed as watershed issues and opportunities. Table 8.1 provides a summary of these issues or opportunities identified and a summary of the resolution identified for each item.

Table 8.1 Issues, Opportunities, and Resolutions.

Landowner Identified Issue or Opportunity	Proposed Resolution
There is a lack of water in specific areas that could be resolved with pits, ponds, and/or solar wells.	Over 90 percent of the proposed rehabilitation projects include wells, tanks, and/or small stock dams to provide a water supply in specific areas.
The biggest issue in the Beaver Creek is the quantity and distribution of water.	Over 90 percent of the proposed projects involve developing new water sources in areas that currently do not have an adequate water supply.
The best water source is very deep, and the cost is prohibitive.	One solution is to build pipelines to supply water from these deep, expensive wells across many landowners to share the cost of well installation.
It is unknown whether rebuilding a breached dam or replacing the source with a well and pipeline is better.	What might work best in one area may not in another due to the depth to groundwater or other factors. In general, the best solution is typically to build pipelines and stock tanks to better distribute the supply water.
The Beaver Creek Reservoir study from 1991 can be updated to determine the feasibility and cost at present.	A fully revised engineering cost estimate and feasibility study was not within the scope of this project; however, a current cost for the project was estimated to be $30-$40 million.

Landowner Identified Issue or Opportunity	Proposed Resolution
Many of the windmills have leather that need to be replaced often. Converting them to solar power wells would be much more cost effective.	Ten windmill conversions to solar power pumps were proposed in the watershed management and rehabilitation plan (Section 4).
There are many small- and medium-size pits and ponds that are silted in and need to be cleaned out.	Twenty pond rehabilitations that include dredging were proposed in the watershed management and rehabilitation plan (Section 4).
Old springs can be developed as a water source to fill ponds.	Five projects were proposed to develop existing springs to supply water to new and existing ponds in the watershed management and rehabilitation plan (Section 4).
There are concerns about water quality and quantity during times of drought.	The water quality issue addressed through some of the projects was sedimentation due to excessive erosion. Quantity issues were addressed through many of the water supply and upland water projects.
Across the watershed there are breached dams because of disintegrating galvanized outlet pipes. These pipes should be replaced to avoid additional damage.	Twenty pond rehabilitations were proposed in the watershed management and rehabilitation plan (Section 4).
Cottonwood tree populations are declining, and trees are not regenerating.	This issue was not specifically addressed as part of this watershed study. It was discussed, but the issue may have to do with the changing flow regime of the Beaver Creek and Cheyenne River and other ecological factors.
The USDA Weston County Farm Service Agency representative noted that the area lacks adequate automated weather stations to document climate data for disaster relief.	The Director of the Water Resources Data System & State Climate Office was contacted of the need for an automated weather station. A funding request was included in the 2020 federal budget request.
Increased storage and decreased runoff should be balanced with habitat maintenance and enhancement of riparian areas.	To ensure there is a balance, the proposed watershed improvement projects include both small dams and upland well/pipeline projects.
Less reliance on shallow stock ponds to water livestock and more reliance on wells and pipelines will reduce evaporation and the creation of mud flats.	Numerous pipeline projects were proposed as part of the watershed management and rehabilitation plan (Section 4).
Water quality enhancements will increase livestock growth and health performances.	Overall, the projects proposed in this watershed study are designed to increase the health and function of the watershed for livestock production and wildlife habitat.
Most of the streams are already fully-appropriated and many areas that have irrigation water rights are seldom irrigated due to lack of adequate water.	One resolution proposed was to develop deeper wells that service multiple landowners and places less demand on alluvial water.

Many of the specific recommendations are presented below; however, it is important to note that not every possible project was identified during project development. Public outreach was completed and those who expressed interest in participating in the study were contacted. Individuals will inevitably come forward after this project is complete with issues that require resolution. The WCNRD and WWDC will be available to work with these individuals to let them know that projects **are still eligible** for funding through the SWPP if they are within the Beaver Creek watershed.

8.2. Recommendations

A Level I watershed study looks for projects, programs, or activities that support sustainable, beneficial water use for current and future watershed residents–human, animal, or plant. The following recommendations are made to help foster this goal.

8.2.1. Livestock/Wildlife Water (LWW) Improvements

- One of the best options to enhance rangeland is to ensure adequate watering opportunities for livestock and wildlife. With dispersal of livestock watering sources away from riparian zones, these zones are relieved of grazing and trampling pressure. Little used forage on upland areas have a greater chance of being accessed by foraging animals with these proposed water sources.
- The proposed livestock/wildlife projects include the combinations of the following elements: development of existing springs; modification of oil wells; windmill conversions; and installation of groundwater wells, solar powered pumps, stock tanks, piping and fencing to maximize water distribution for livestock and wildlife.
- The cost estimates for the projects range from less than $5,000 to rehabilitate an existing spring near Newcastle to a pipeline project at Mule Creek Junction that would cost over $700,000. Cost estimates varied greatly depending on the length and type of proposed pipeline.
- Additional livestock/wildlife water development improvements could be made, as needed, using the plans and cost estimates provided in this report as a guide for conceptual design, cost and financing opportunities.

8.2.2. Water Supply and Storage (WSS) Improvements

- There have been no requests for large surface-storage improvements. In contrast, the proposed water storage projects involve the construction and rehabilitation of small ponds. Existing ponds in the study area need to be dredged to increase storage capacity. In some cases, rehabilitation also includes lining the pond to prevent water loss to seepage.
- The cost estimates for the projects range from less than $15,000 for a small reservoir rehabilitation to over $350,000 to rehabilitate 12 ponds on one property.
- Surface water supply and storage improvement projects could be made in other parts of the watershed, as needed, using the plans and cost estimates provided in this report as a guide for conceptual design, cost and financing opportunities.

8.2.3. Irrigation System Improvements (ISI)

- Irrigation improvements are proposed as requested by ranchers/landowners in the Beaver Creek watershed. The irrigation improvements focus on rehabilitation/replacement of existing structures, enhanced delivery of water, and economic practicality and physical feasibility.
- The specific recommendations include repairs to spreader dike breaches, replacing diversion structures, regrading ditches, and several options for upgrading irrigation systems. The cost estimates for the projects range from just over $1,000 to install a new diversion pipeline to an option presented for a new irrigation system, if implemented, is estimated to cost over $120,000.
- Additional irrigation system improvements could be made across the watershed using the plans and cost estimates provided in this report as a guide for conceptual design, cost, and financing opportunities.

8.2.4. Other Management Practices (OMP) Improvements

- Other management practices and improvements are in various stages of implementation across the watershed. The specific improvements and/or best management practices recommended in this report include additional vegetation restoration projects, habitat enhancements for wildlife, repair of headcutting occurring at the confluence of Oil and Skull creeks, plugging an abandoned well and installing an automated weather station.
- Cost estimates for these other management improvements are very site-specific and range from just over $1,000 for revegetation to over $150,000 to construct a sediment basin.

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10. ACRONYMS AND ABBREVIATIONS

ACEP.............................Agricultural Conservation Easement Program
BGEPA..........................Bald and Golden Eagle Protection Act
BLM...............................Bureau of Land Management
CFR...............................Code of Federal Regulations
CGP...............................construction general permit
CMP..............................corrugated metal pipe
CPVC............................chlorinated polyvinyl chloride
CRP...............................Conservation Reserve Program
CSP...............................Conservation Stewardship Program
CWA..............................Clean Water Act
DM................................Departmental Manual
DOI...............................Department of Interior
EA.................................Environmental Assessment
eFOTG..........................electronic Field Office Technical Guide
EIS................................Environmental Impact Statement
EPA...............................U.S Environmental Protection Agency
EQIP.............................Environmental Quality Incentives Program
ESA...............................Endangered Species Act
ESD...............................ecological site description
FEMA............................Federal Emergency Management Agency
FLPMA..........................Federal Land Policy and Management Act
FSA...............................Farm Service Agency
FWCA...........................Fish and Wildlife Coordination Act
GIS................................Geographic Information System
HDPE............................high density polyethylene
HU................................historically underserved
HUC..............................Hydrologic Unit Code
LEDPA...........................least environmentally damaging practicable alternative
MBTA............................Migratory Bird Treaty Act
NAGPRA.......................Native American Graves Protection and Repatriation Act
NEPA.............................National Environmental Policy Act
NFWF............................National Fish and Wildlife Foundation
NHD..............................National Hydrography Dataset
NHPA............................National Historic Preservation Act
NID...............................National Inventory of Dams
NOAA…………………..National Oceanic and Atmospheric Administration
NPDES..........................National Pollutant Discharge Elimination System
NPS...............................National Park Service
NRCS............................U.S. Natural Resources Conservation Service
NWI..............................National Wetlands Inventory
NWP..............................Nationwide Permit
O&M.............................Operations and Maintenance

PCA ....Plant Conservation Alliance
PCN ....preconstruction notification
PRISM ....Parameter Elevation Regression on Independent Slopes Model
RMP ....Resource Management Plan
ROW..............................right-of-way
SDR ....standard dimension ratio
SHPO ....State Historic Preservation Office
SSURGO.......................Soil Survey Geographic Database
STATSGO ....State Soil Geographic Database
SWPP............................Small Water Project Program
TMDL.............................Total Maximum Daily Load
TNC ....The Nature Conservancy
TU.................................Trout Unlimited
USACE ..........................U.S. Army Corps of Engineers
USDA……………………U.S. Department of Agriculture
USFS.............................U.S. Forest Service
USFWS .........................U.S. Fish and Wildlife Service
USGS ............................U.S. Geological Survey
UTM..............................Universal Transverse Mercator System
WCD..............................Water Control Division
WCNRD.........................Weston County natural Resource District
WDEQ ....Wyoming Department of Environmental Quality
WGFD ....Wyoming Game and Fish Department
WQD.............................Water Quality Division
WSEO ....Wyoming State Engineer's Office
WSGS ....Wyoming State Geological Survey
WWDC ....Wyoming Water Development Commission
WYDOT ....Wyoming Department of Transportation
WyGISC ....Wyoming Geographic Information Science Center
WYNDD.........................Wyoming Natural Diversity Database
WYPDES.......................Wyoming Pollutant Discharge Elimination System

Units of Measure

BBL...............................barrel
CFS ....cubic feet per second
CY ....cubic yards
MCF...............................thousand cubic feet

Appendix A

Data Summaries

Data Summary 1.3 GIS Layer Information
Data Summary 2.1.2-1 HUC 12 IDs
Data Summary 2.1.2-2 NHD Hydrographic Categories
Data Summary 2.1.2-3 Permitted Outfalls
Data Summary 2.1.3 Rosgen Classifications
Data Summary 2.3.3 National Inventory of Dams
Data Summary 3.1 Available Flow Data in the Northeast Wyoming River Basins Models
Data Summary 6.0 Funding Sources

Data Summary 1.3 GIS Layer Information		
Data Name in Map	**Directory in Geodatabase**	**Filename in Geodatabase**
U.S. Army Corps of Engineers (USACE)		
National Inventory of Dams	Hydrology	Dams
U.S. Census Bureau (USCB)		
County Border	Infrastructure	TIGER_Counties
Major Road	Infrastructure	TIGER_SouthDakotaRoads; TIGER_WyomoingRoads
Municipal Area	Infrastructure	TIGER_Place_SouthDakota; TIGER_Place_Wyoming
State Border	Infrastructure	TIGER_US_States
U.S. Geological Survey (USGS)		
HUC 12 Boundary	Hydrology	HUC_12_Basin_Boundary
Major Rivers and Streams	Hydrology	MajorRiversAndStreams
Major Waterbody	Hydrology	MajorWaterbodies
Gaging Station	Hydrology	GuagingStations
Ephemeral Stream	Hydrology	MajorRiversAndStreamsFCode
Intermittent Stream	Hydrology	MajorRiversAndStreamsFCode
Perinneal Stream	Hydrology	MajorRiversAndStreamsFCode
Land Ownership	Administrative	LandOwnership_Weston; LandOwnership_Niobrara
Average Precipitation (inches)	Root directory	AveragePrecipitation.tif
National Land Cover Dataset	Root directory	NLCD_BeaverCreekWatershed_2011.tif
Wyoming Department of Environmental Quality (WDEQ)		
Permitted Outfalls	Environment	Permitted_Outfalls
WDEQ Stream Classification	Environment	Stream_Classification
Wyoming State Geological Survey (WSGS)		
Bedrock Geology	Geology	Bedrock
Surficial Geology	Geology	SurficialGeology
Springs and Seeps	Geology	SpringsAndSeeps
Landslides	Geology	LandslideAreas
Coal Fields	Infrastructure	CoalFields
Produced Water Wells	Infrastructure	ProducedWaterWellLocations
Oil and Gas Fields	Infrastructure	OilAndGasFields
Wyoming Water Development Commission (WWDC)		
Domestic Water Users	Hydrology	DomesticWells
Irrigated Lands	Hydrology	IrrigatedLand
Irrigation Points of Diversion	Hydrology	PointsOfDiversion
Stock/Wildlife Pond	Hydrology	Stock_WildlifePonds
Developed for Project (Olsson)		
Beaver Creek Watershed	Administrative	BeaverCreekWatershed
Osage Coal Plant	Infrastructure	OsageCoalPlant
Rosgen Class	Hydrology	RosgenLevel1_StreamClassification
Irrigation System Improvement Project	Hydrology	IrrigationSystemImprovementProjects
Livestock/Wildlife Watering Improvement Project	Hydrology	Livestock_WildlifewateringImprovementProjects
Water Supply/Storage Improvement Project	Hydrology	WaterSupply_StorageImprovementProjects
Other Management Practice Improvement Project	Hydrology	OtherManagementPracticeImprovementProjects
Access	Small Water Projects	SmallWaterProjects_BeaverCreek_PointFeatures
Pipe Feature	Small Water Projects	SmallWaterProjects_BeaverCreek_PointFeatures
Erosion	Small Water Projects	SmallWaterProjects_BeaverCreek_PointFeatures
Outlet Structure	Small Water Projects	SmallWaterProjects_BeaverCreek_PointFeatures
Point Feature	Small Water Projects	SmallWaterProjects_BeaverCreek_PointFeatures
Water Feature	Small Water Projects	SmallWaterProjects_BeaverCreek_PointFeatures
Vegetated Area	Small Water Projects	SmallWaterProjects_BeaverCreek_PointFeatures
Well	Small Water Projects	SmallWaterProjects_BeaverCreek_PointFeatures
Ranch Building/Access	Small Water Projects	SmallWaterProjects_BeaverCreek_PointFeatures
Hydrant	Small Water Projects	SmallWaterProjects_BeaverCreek_PointFeatures
Check Dam	Small Water Projects	SmallWaterProjects_BeaverCreek_PointFeatures
Dam/Berm	Small Water Projects	SmallWaterProjects_BeaverCreek_PointFeatures
Proposed Stock Tank	Small Water Projects	SmallWaterProjects_BeaverCreek_PointFeatures
Exisiting Stock Tank	Small Water Projects	SmallWaterProjects_BeaverCreek_PointFeatures
Existing Hydrant	Small Water Projects	SmallWaterProjects_BeaverCreek_PointFeatures
Storage Tank	Small Water Projects	SmallWaterProjects_BeaverCreek_PointFeatures
Diversion Structure	Small Water Projects	SmallWaterProjects_BeaverCreek_LineFeatures
Existing Pipeline	Small Water Projects	SmallWaterProjects_BeaverCreek_LineFeatures
Proposed Pipeline	Small Water Projects	SmallWaterProjects_BeaverCreek_LineFeatures
Fence	Small Water Projects	SmallWaterProjects_BeaverCreek_LineFeatures
Property Boundary	Small Water Projects	SmallWaterProjects_BeaverCreek_LineFeatures
Dike	Small Water Projects	SmallWaterProjects_BeaverCreek_LineFeatures
Dam	Small Water Projects	SmallWaterProjects_BeaverCreek_LineFeatures
Drainage	Small Water Projects	SmallWaterProjects_BeaverCreek_LineFeatures
Path	Small Water Projects	SmallWaterProjects_BeaverCreek_LineFeatures
Spillway	Small Water Projects	SmallWaterProjects_BeaverCreek_LineFeatures
Irrigation Ditch	Small Water Projects	SmallWaterProjects_BeaverCreek_LineFeatures
Earth Feature	Small Water Projects	SmallWaterProjects_BeaverCreek_AreaFeatures
Irrigated Land	Small Water Projects	SmallWaterProjects_BeaverCreek_AreaFeatures
Spillway	Small Water Projects	SmallWaterProjects_BeaverCreek_AreaFeatures
Pond	Small Water Projects	SmallWaterProjects_BeaverCreek_AreaFeatures
Propoerty Boundary	Small Water Projects	SmallWaterProjects_BeaverCreek_AreaFeatures
Vegetation	Small Water Projects	SmallWaterProjects_BeaverCreek_AreaFeatures
Western Regional Climate Center (WRCC)		
NOAA Weather Station	Infrastructure	NOAA_COOP_WeatherStations

Data Summary 2.1.2-1 HUC 12 IDs

HUC ID Number	Watershed Name
10120107	**Beaver Creek, South Dakota and Wyoming**
1012010701	**Oil Creek**
101201070101	Upper Oil Creek
101201070102	Upper Skull Creek
101201070103	Lower Skull Creek
101201070104	Middle Oil Creek
101201070105	Lower Oil Creek
1012010702	**Upper Beaver Creek**
101201070201	Iron Creek
101201070202	Soda Creek-Beaver Creek
101201070203	Turner Creek
101201070204	Fiddler Creek
101201070205	Sheep Canyon Creek-Beaver Creek
101201070206	Mush Creek
101201070207	Luce Draw-Beaver Creek
1012010703	**Stockade Breaver Creek**
101201070301	Beaver Run-Stockade Beaver Creek
101201070302	Salt Creek
101201070303	Rats Valley-Stockade Beaver Creek
101201070304	Cemetary Creek-Stockade Beaver Creek
101201070305	Gillette Canyon
101201070306	Roby Canyon
101201070307	Rock Canyon-Stockade Beaver Creek
1012010704	**Lower Beaver Creek**
101201070401	South Beaver Creek
101201070402	Middle South Beaver Creek
101201070403	Lower South Beaver Creek
101201070404	Blacktail Creek
101201070405	Sheep Creek
101201070406	Beaver Creek
101201070407	Line Creek
101201070408	Hay Creek-Beaver Creek
10120106	**Angostura Reservoir**
1012010601	**Robber Roost-Cheyenne River**
101201060102	Upper Alkali Creek
101201060103	Lower Alkali Creek
101201060104	Robbers Roost Creek
101201060105	Bobcat Creek-Cheyenne River
101201060106	Sage Creek-Cheyenne River

Data Summary 2.1.2-2 NHD Hydrographic Categories		
Alkali Creek	Horse Creek	Robbers Roost Creek
Alum Creek	Inyan Kara Creek	Rock Creek
Arch Creek	Iron Creek	Rough Creek
Bear Run	Jerome Creek	Rush Creek
Beaver Creek	Lance Creek	Sage Creek
Black Thunder Creek	Lassen Creek	Salt Creek
Blacktail Creek	Left Fork Blacktail Creek	Sand Creek
Bobcat Creek	Line Creek	Sevenmile Creek
Boggy Creek	Lion Creek	Sheep Canyon Creek
Bridge Creek	Little Alkali Creek	Sheep Creek
Buck Camp Creek	Little Bear Run	Sheldon Creek
Buffalo Creek	Little Oil Creek	Skull Creek
Bull Creek	Little Pine Ridge Creek	Snyder Creek
Cambria Creek	Little Piney Creek	Soap Creek
Cemetery Creek	Little Spearfish Creek	Soda Creek
Cheyenne River	Little Thunder Creek	Soldier Creek
Cleo Creek	Little Turner Creek	South Beaver Creek
Coal Mine Creek	Lodgepole Creek	South Branch Beaver Creek
Cold Creek	Lone Tree Creek	South Fork Lassen Creek
Cold Springs Creek	Lonetree Creek	South Fork Lone Tree Creek
Coon Creek	Louse Creek	South Fork Moss Agate Creek
Cottonwood Creek	Lower Willow Creek	South Greasewood Creek
Count Creek	Mason Creek	South Snyder Creek
Coyote Creek	Middle Fork Lassen Creek	Spearfish Creek
Crooked Creek	Middle Fork Wind Creek	Spoon Creek
Deep Creek	Moss Agate Creek	Spring Creek
Deer Creek	Mule Creek	Stockade Beaver Creek
Dogie Creek	Mush Creek	Sweetwater Creek
Dry Beaver Creek	North Fork Fiddler Creek	Timber Creek
Dry Creek	North Fork Lone Tree Creek	Tomcat Creek
Dugout Creek	North Fork Moss Agate Creek	Turner Creek
Dumbrill Creek	North Fork Mush Creek	Wagonhound Creek
Dupont Creek	North Greasewood Creek	West Bull Creek
East Branch Robbers Roost Creek	Oil Creek	West Fork Buffalo Creek
East Fork Beaver Creek	Owl Creek	West Fork Fiddler Creek
East Fork Hay Creek	Pass Creek	West Fork Fourmile Creek
East Iron Creek	Patrick Creek	West Fork Hay Creek
East Plum Creek	Paxton Creek	West Fork Skull Creek
Fiddler Creek	Pine Creek	West Fork Wind Creek
Fourmile Creek	Poddy Creek	West Plum Creek
Freda Creek	Poison Creek	Whoopup Creek
Frog Creek	Pump Creek	Wildcat Creek
Green River	Rats Valley Creek	Willow Creek
Hay Creek	Raven Creek	Wind Creek
Hon Creek	Red Creek	

Data Summary 2.1.2-3 Permitted Outfalls

Outfall ID	WY Permit Number	Outfall Number	Permittee	Facility Name	Permit Type	Permit Category	Permit Status	Latitude	Longitude	Permit Issued	Permit Expires	Is Major?
1107	WY0001163	1	Wyoming Refining Company	Newcastle Refinery	Industrial	Individual Permit	In Effect	43.81264	-104.21774	8/20/2013	7/31/2018	0
1141	WY0001163	2	Wyoming Refining Company	Newcastle Refinery	Industrial	Individual Permit	In Effect	43.84743	-104.21718	8/20/2013	7/31/2018	0
1142	WY0001163	3	Wyoming Refining Company	Newcastle Refinery	Industrial	Individual Permit	In Effect	43.84809	-104.21898	8/20/2013	7/31/2018	0
1161	WY0002593	1	M & K Oil Company Inc.	Fiddler Creek Field Lundberg	Oil Treaters	Individual Permit	In Effect	43.96188	-104.64526	5/31/2016	7/31/2021	0
1187	WY0003221	1	Osage Partners, LLC	Poison Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.965444	-104.470299	8/30/2016	8/31/2021	0
1227	WY0002500	1	Four Corners Petroleum, LLC	Underwood Fiddler Creek Field Discharges	Oil Treaters	Individual Permit	In Effect	43.94222	-104.68567	6/7/2016	8/31/2021	0
1253	WY0003298	1	Osage Partners, LLC	Osage Juniper Newcastle Sand Unit	Oil Treaters	Individual Permit	In Effect	43.942116	-104.492341	5/15/2017	6/30/2022	0
1254	WY0003301	1	Osage Partners, LLC	Osage Juniper Newcastle Sand Unit	Oil Treaters	Individual Permit	In Effect	43.92142	-104.4824	8/30/2016	8/31/2021	0
1313	WY0001414	1	POC-I, LLC	Winter Ridge Mush Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.78962	-104.42575	8/30/2016	8/31/2021	0
1358	WY0020605	1	Upton, Town of	Upton Wastewater Lagoon	Sanitary Wastewater	Individual Permit	In Effect	44.08534	-104.62293	12/8/2014	12/31/2019	0
1488	WY0003051	1	POC-I, LLC	Winter Ridge Skull Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.78109	-104.30129	8/30/2016	8/31/2021	0
1726	WY0026701	1	Osage Partners, LLC	Rock Well Beaver Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.95374	-104.48093	8/30/2016	8/31/2021	0
1727	WY0026719	1	Osage Partners, LLC	Rock Well Turner Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.97431	-104.48855	8/30/2016	8/31/2021	0
1732	WY0027081	1	Washburn, Lee	Government Olds #1	Oil Treaters	Individual Permit	In Effect	43.80994	-104.3175	6/7/2016	8/31/2021	0
2192	WY0032620	1	Osage Partners, LLC	Lambie Field, Strickling Lease, Townsend State Lease (aka Beaver Creek Discharges)	Oil Treaters	Individual Permit	In Effect	43.973229	-104.508016	5/15/2017	6/30/2022	0
2390	WY0034789	1	POC-I, LLC	Townsend Newcastle Sand Unit	Oil Treaters	Individual Permit	In Effect	43.95948	-104.56772	8/30/2016	8/31/2021	0
3850	WY0001163	4	Wyoming Refining Company	Newcastle Refinery	Industrial	Individual Permit	In Effect	43.8467	-104.214	8/20/2013	7/31/2018	0
7809	WY0045900	1	Maha Energy Inc.	LAK Ranch	Oil Treaters	Individual Permit	In Effect	43.812366	-104.130674	6/7/2016	8/31/2021	0
15073	WY0025127	1	Coronado Oil Company	Collins Lease	Oil Treaters	Individual Permit	In Effect	43.84291	-104.18571	12/5/2016	8/31/2021	0
28803	WY0094331	1	RBJ Ranch, LLC	RBJ No. 1 Tank Battery	Oil Treaters	Individual Permit	In Effect	43.56268	-104.14035	1/26/2015	3/31/2020	0
29652	WY0003051	2	POC-I, LLC	Winter Ridge Skull Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.76567	-104.29633	8/30/2016	8/31/2021	0
29653	WY0003051	3	POC-I, LLC	Winter Ridge Skull Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.83803	-104.3003	8/30/2016	8/31/2021	0
29654	WY0003051	4	POC-I, LLC	Winter Ridge Skull Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.85859	-104.28081	8/30/2016	8/31/2021	0
29655	WY0003051	5	POC-I, LLC	Winter Ridge Skull Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.79973	-104.30137	8/30/2016	8/31/2021	0
29656	WY0001414	2	POC-I, LLC	Winter Ridge Mush Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.78847	-104.46227	8/30/2016	8/31/2021	0
29657	WY0001414	3	POC-I, LLC	Winter Ridge Mush Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.81208	-104.42065	8/30/2016	8/31/2021	0
29713	WY0003221	2	Osage Partners, LLC	Poison Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.96057	-104.46391	8/30/2016	8/31/2021	0
29714	WY0003221	3	Osage Partners, LLC	Poison Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.95726	-104.46902	8/30/2016	8/31/2021	0
29715	WY0003221	4	Osage Partners, LLC	Poison Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.96839	-104.46018	8/30/2016	8/31/2021	0
29716	WY0003221	5	Osage Partners, LLC	Poison Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.97065	-104.45104	8/30/2016	8/31/2021	0
29717	WY0003221	6	Osage Partners, LLC	Poison Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.96429	-104.44695	8/30/2016	8/31/2021	0
29718	WY0003221	7	Osage Partners, LLC	Poison Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.97401	-104.44617	8/30/2016	8/31/2021	0
29719	WY0003221	8	Osage Partners, LLC	Poison Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.95732	-104.46162	8/30/2016	8/31/2021	0
29720	WY0003221	9	Osage Partners, LLC	Poison Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.94877	-104.4725	8/30/2016	8/31/2021	0
29721	WY0003221	10	Osage Partners, LLC	Poison Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.96815	-104.43819	8/30/2016	8/31/2021	0
29722	WY0003221	11	Osage Partners, LLC	Poison Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.97595	-104.44674	8/30/2016	8/31/2021	0
29723	WY0003221	12	Osage Partners, LLC	Poison Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.97636	-104.45833	8/30/2016	8/31/2021	0
29724	WY0003221	13	Osage Partners, LLC	Poison Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.97487	-104.44157	8/30/2016	8/31/2021	0
29725	WY0003221	14	Osage Partners, LLC	Poison Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.97943	-104.45931	8/30/2016	8/31/2021	0
29726	WY0003221	15	Osage Partners, LLC	Poison Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.98431	-104.45862	8/30/2016	8/31/2021	0
29727	WY0003221	16	Osage Partners, LLC	Poison Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.98283	-104.45153	8/30/2016	8/31/2021	0
29728	WY0003221	17	Osage Partners, LLC	Poison Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.96806	-104.41073	8/30/2016	8/31/2021	0
29729	WY0003301	2	Osage Partners, LLC	Osage Juniper Newcastle Sand Unit	Oil Treaters	Individual Permit	In Effect	43.95085	-104.52882	8/30/2016	8/31/2021	0
29730	WY0003301	3	Osage Partners, LLC	Osage Juniper Newcastle Sand Unit	Oil Treaters	Individual Permit	In Effect	43.92854	-104.50754	8/30/2016	8/31/2021	0
29732	WY0026701	2	Osage Partners, LLC	Rock Well Beaver Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.9717	-104.48131	8/30/2016	8/31/2021	0
29733	WY0026701	3	Osage Partners, LLC	Rock Well Beaver Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.97667	-104.47731	8/30/2016	8/31/2021	0
29734	WY0026701	4	Osage Partners, LLC	Rock Well Beaver Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.93711	-104.49923	8/30/2016	8/31/2021	0
29735	WY0026701	5	Osage Partners, LLC	Rock Well Beaver Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.97629	-104.46468	8/30/2016	8/31/2021	0
29736	WY0026701	6	Osage Partners, LLC	Rock Well Beaver Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.94544	-104.45056	8/30/2016	8/31/2021	0
29737	WY0026701	7	Osage Partners, LLC	Rock Well Beaver Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.98076	-104.46864	8/30/2016	8/31/2021	0
29738	WY0026701	8	Osage Partners, LLC	Rock Well Beaver Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.93622	-104.4104	8/30/2016	8/31/2021	0
29740	WY0026719	2	Osage Partners, LLC	Rock Well Turner Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.97971	-104.48789	8/30/2016	8/31/2021	0
29741	WY0026719	3	Osage Partners, LLC	Rock Well Turner Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.98135	-104.4367	8/30/2016	8/31/2021	0
29742	WY0026719	4	Osage Partners, LLC	Rock Well Turner Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.98088	-104.50926	8/30/2016	8/31/2021	0
29743	WY0026719	5	Osage Partners, LLC	Rock Well Turner Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.97258	-104.49929	8/30/2016	8/31/2021	0
29744	WY0026719	6	Osage Partners, LLC	Rock Well Turner Creek Discharges	Oil Treaters	Individual Permit	In Effect	43.99334	-104.44123	8/30/2016	8/31/2021	0

Data Summary 2.1.2-3 Permitted Outfalls

Outfall ID	WY Permit Number	Outfall Number	Permittee	Facility Name	Permit Type	Permit Category	Permit Status	Latitude	Longitude	Permit Issued	Permit Expires	Is Major?
29968	WY0002500	2	Four Corners Petroleum, LLC	Underwood Fiddler Creek Field Discharges	Oil Treaters	Individual Permit	In Effect	43.94306	-104.708	6/7/2016	8/31/2021	0
29969	WY0002500	3	Four Corners Petroleum, LLC	Underwood Fiddler Creek Field Discharges	Oil Treaters	Individual Permit	In Effect	43.954	-104.655	6/7/2016	8/31/2021	0
29970	WY0002500	4	Four Corners Petroleum, LLC	Underwood Fiddler Creek Field Discharges	Oil Treaters	Individual Permit	In Effect	43.95715	-104.633	6/7/2016	8/31/2021	0
33936	WY0032620	2	Osage Partners, LLC	Lambie Field, Strickling Lease, Townsend State Lease (aka Beaver Creek Discharges)	Oil Treaters	Individual Permit	In Effect	43.97817	-104.50462	5/15/2017	6/30/2022	0
33937	WY0032620	3	Osage Partners, LLC	Lambie Field, Strickling Lease, Townsend State Lease (aka Beaver Creek Discharges)	Oil Treaters	Individual Permit	In Effect	43.96383	-104.4847	5/15/2017	6/30/2022	0
33963	WY0003298	2	Osage Partners, LLC	Osage Juniper Newcastle Sand Unit	Oil Treaters	Individual Permit	In Effect	43.9364	-104.47697	5/15/2017	6/30/2022	0
51736	WY0002500	5	Four Corners Petroleum, LLC	Underwood Fiddler Creek Field Discharges	Oil Treaters	Individual Permit	In Effect	43.9478	-104.69056	6/7/2016	8/31/2021	0
51737	WY0002500	6	Four Corners Petroleum, LLC	Underwood Fiddler Creek Field Discharges	Oil Treaters	Individual Permit	In Effect	43.95926	-104.63008	6/7/2016	8/31/2021	0
62632	WY0020605	2	Upton, Town of	Upton Wastewater Lagoon	Sanitary Wastewater	Individual Permit	In Effect	44.08542	-104.62254	12/8/2014	12/31/2019	0
67226	WY0002500	7	Four Corners Petroleum, LLC	Underwood Fiddler Creek Field Discharges	Oil Treaters	Individual Permit	In Effect	43.950897	-104.60425	6/7/2016	8/31/2021	0
69490	WY0027081	2	Washburn, Lee	Government Olds #1	Oil Treaters	Individual Permit	In Effect	43.81273	-104.34226	6/7/2016	8/31/2021	0
74835	WY0096202	1	Park Oil Properties, LLC	Dewey Dome Lease	Oil Treaters	Individual Permit	In Effect	43.577622	-104.133442	4/13/2018	3/31/2023	0

Data Summary 2.1.3 Rosgen Classifications

Reach Name	Reach ID	Reach Length	Landform	Valley Type	Terrace Features	Channel Slope	Bed Features	Channel Shape	Floodplain	Pattern	Confinement	Lateral Containment	Channel Type
Alkali Creek	B-Alk-0-A	0.56	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A
Alkali Creek	B-Alk-1-B	0.69	glacial/fluvial terrace	II	multiple	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B
Alkali Creek	B-Alk-2-C	0.72	glacial/fluvial terrace	IV	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C
Alkali Creek	B-Alk-3-E	0.69	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	E
Alkali Creek	B-Alk-4-C	1.2	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C
Alkali Creek	B-Alk-5-E	1.38	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	E
Alkali Creek	B-Alk-6-C	4.84	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C
Alkali Creek	B-Alk-7-E	5.5	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	E
Alkali Creek	B-Alk-8-C	2.72	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C
Alkali Creek	B-Alk-9-E	9.82	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	E
Alkali Creek	B-Alk-10-C	8.91	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C
Alkali Creek	B-Alk-11-E	1.94	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	E
Alkali Creek	B-Alk-12-C	1.82	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C
Bear Creek	B-Bea-0-E	0.13	glacial/fluvial terrace	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	yes	E
Bear Creek	B-Bea-1-B	2.37	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B
Beaver Creek	B-Bea-0-E	12.85	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	<12 w:d	active apparent	single	slight	yes	E
Beaver Creek	B-Bea-1-C	26.02	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	C
Beaver Creek	B-Bea-2-E	11.52	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	<12 w:d	active apparent	single	slight	yes	E
Beaver Creek	B-Bea-3-C	2.9	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	C
Beaver Creek	B-Bea-4-E	4.34	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	<12 w:d	active apparent	single	slight	yes	E
Beaver Creek	B-Bea-5-C	11.5	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C
Beaver Creek	B-Bea-6-B	0.53	glacial/fluvial terrace	VIII	multiple	steep	step/pool	<12 w:d	active apparent	single	moderate	yes	B
Beaver Creek	B-Bea-7-E	5.04	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	E
Beaver Creek	B-Bea-8-C	4.31	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	moderate	no	C
Beaver Creek	B-Bea-9-E	15.95	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	E
Beaver Creek	B-Bea-10-C	12.96	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C
Bobcat Creek	B-Bob-0-A	0.79	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	<12 w:d	none apparent	single	entrenched	yes	A
Bobcat Creek	B-Bob-1-B	0.88	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	<12 w:d	none apparent	single	moderate	yes	B
Bobcat Creek	B-Bob-2-E	3.3	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	E
Bobcat Creek	B-Bob-3-C	1.37	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C
Bobcat Creek	B-Bob-4-E	3.58	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	E
Freshwater Creek	B-Fre-0-B	0.55	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	no	B
Freshwater Creek	B-Fre-1-E	3.09	glacial/fluvial terrace	V	multiple	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E
Little Alkali Creek	B-Lit-0-A	0.88	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	<12 w:d	none apparent	single	slight	yes	A
Little Alkali Creek	B-Lit-1-B	1.2	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	<12 w:d	none apparent	single	slight	yes	B
Little Alkali Creek	B-Lit-2-E	1	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	E

Reach Name	Reach ID	Reach Length	Landform	Valley Type	Terrace Features	Channel Slope	Bed Features	Channel Shape	Floodplain	Pattern	Confinement	Lateral Containment	Channel Type
Little Alkali Creek	B-Lit-3-B	0.62	glacial/fluvial terrace	VIII	multiple	flat	step/pool	12-40 w:d	active apparent	single	slight	no	B
Little Alkali Creek	B-Lit-4-E	2.1	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	E
Little Alkali Creek	B-Lit-5-C	0.59	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C
Little Alkali Creek	B-Lit-6-E	1.92	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E
Oil Creek	B-Oil-0-A	0.08	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A
Oil Creek	B-Oil-1-B	0.09	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B
Oil Creek	B-Oil-2-C	3.07	glacial/fluvial terrace	V	multiple	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	C
Oil Creek	B-Oil-3-B	1.46	glacial/fluvial terrace	V	multiple	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B
Oil Creek	B-Oil-4-E	39.33	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	E
Parmalee Creek	B-Par-0-B	2.57	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B
Parmalee Creek	B-Par-1-E	0.1	glacial/fluvial terrace	V	multiple	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E
Salt Creek	B-Sal-0-B	0.3	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B
Salt Creek	B-Sal-1-C	1.7	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	C
Salt Creek	B-Sal-2-B	2.25	glacial/fluvial terrace	VIII	multiple	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B
Salt Creek	B-Sal-3-E	1.59	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	<12 w:d	none apparent	single	slight	yes	E
Salt Creek	B-Sal-4-C	3.64	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C
Salt Creek	B-Sal-5-E	9.28	glacial/fluvial terrace	V	multiple	flat	riffle/pool	<12 w:d	none apparent	single	slight	yes	E
Salt Creek	B-Sal-6-B	0.83	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B
Salt Creek	B-Sal-7-E	2.87	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E
Sheep Creek	B-She-0-B	0.82	glacial/fluvial terrace	VIII	multiple	steep	step/pool	<12 w:d	active apparent	single	moderate	no	B
Sheep Creek	B-She-1-E	2.55	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	<12 w:d	active apparent	single	slight	yes	E
Sheep Creek	B-She-2-B	2.67	glacial/fluvial terrace	VIII	multiple	steep	step/pool	<12 w:d	active apparent	single	moderate	no	B
Sheep Creek	B-She-3-E	0.76	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E
Sheep Creek	B-She-4-B	2.44	glacial/fluvial terrace	VIII	multiple	steep	step/pool	12-40 w:d	active apparent	single	moderate	no	B
Sheep Creek	B-She-5-E	2.36	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	E
Sheep Creek	B-She-6-C	2.55	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C
Sheep Creek	B-She-7-E	7.49	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	E
Sheep Creek	B-She-8-C	1.48	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C
Sheep Creek	B-She-9-E	0.99	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	E
Skull Creek	B-Sku-0-A	0.1	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A
Skull Creek	B-Sku-1-B	0.55	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B
Skull Creek	B-Sku-2-G	0.34	glacial/fluvial terrace	I	none	flat	riffle/pool	<12 w:d	none apparent	single	entrenched	yes	G
Skull Creek	B-Sku-3-B	1.09	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B
Skull Creek	B-Sku-4-E	0.53	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	E
Skull Creek	B-Sku-5-B	1.1	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	active apparent	single	moderate	yes	B
Skull Creek	B-Sku-6-E	0.58	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	E
Skull Creek	B-Sku-7-B	0.49	glacial/fluvial terrace	VIII	multiple	steep	step/pool	12-40 w:d	active apparent	single	moderate	yes	B

Reach Name	Reach ID	Reach Length	Landform	Valley Type	Terrace Features	Channel Slope	Bed Features	Channel Shape	Floodplain	Pattern	Confinement	Lateral Containment	Channel Type
Skull Creek	B-Sku-8-E	10.85	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	E
Skull Creek	B-Sku-9-B	0.73	glacial/fluvial terrace	VIII	multiple	steep	step/pool	12-40 w:d	active apparent	single	moderate	yes	B
Skull Creek	B-Sku-10-E	26.23	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	E
Stockade Beaver Creek	B-Sto-0-A	0.92	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A
Stockade Beaver Creek	B-Sto-1-B	4.12	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B
Stockade Beaver Creek	B-Sto-2-E	0.19	glacial/fluvial terrace	II	none	flat	riffle/pool	<12 w:d	none apparent	single	slight	yes	E
Stockade Beaver Creek	B-Sto-3-B	1.94	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B
Stockade Beaver Creek	B-Sto-4-E	0.81	glacial/fluvial terrace	II	none	flat	riffle/pool	12-40 w:d	none apparent	single	slight	yes	E
Stockade Beaver Creek	B-Sto-5-B	1.62	glacial/fluvial terrace	II	multiple	steep	step/pool	12-40 w:d	active apparent	single	moderate	no	B
Stockade Beaver Creek	B-Sto-6-E	22.32	glacial/fluvial terrace	V	multiple	steep	step/pool	12-40 w:d	active apparent	single	slight	yes	E
Stockade Beaver Creek	B-Sto-7-C	0.3	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C
Stockade Beaver Creek	B-Sto-8-E	37.55	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	E
Sweetwater Creek	B-Swe-0-B	2.46	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B
Sweetwater Creek	B-Swe-1-E	2.24	glacial/fluvial terrace	V	multiple	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E
Sweetwater Creek	B-Swe-2-B	1.56	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B
West Plum Creek	B-Wes-0-B	1.43	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B
West Plum Creek	B-Wes-1-E	1.82	glacial/fluvial terrace	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E
West Plum Creek	B-Wes-2-B	1.48	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B
West Plum Creek	B-Wes-3-E	1.82	glacial/fluvial terrace	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E
West Plum Creek	B-Wes-4-B	1.38	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	active apparent	single	moderate	no	B
West Plum Creek	B-Wes-5-E	2.73	glacial/fluvial terrace	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E

Data Summary 2.3.3 Dams within the Study Area Included in the National Inventory of Dams

NID ID	Dam Name	River	Height (feet)	Storage (acre-ft)	Owner	Primary Purpose	Secondary Purpose(s)	County	Longitude	Latitude
WY00825	TWIN FORKS	NORTH FORK DEER DRAW	42	133	TURKEY TRACK RANCH	Fire Protection, Stock, Or Small Fish Pond	Fire Protection, Stock, Or Small Fish Pond	WESTON	-104.7275	44.0038
WY00871	LITTLE SODA	BOX ELDER OR LITTLE SODA CREEK	16	148	HOWARD & DIANA WHITE	Irrigation	Irrigation, Fire Protection, Stock, Or Small Fish Pond	WESTON	-104.6986	44.0427
WY00872	UPTON	PINE CREEK	30	500	TOWN OF UPTON	Water Supply	Water Supply	WESTON	-104.699	44.1319
WY01355	SCS BEAVER CREEK	BEAVER CREEK	21	70	USDA FS	Fish and Wildlife Pond	Recreation, Fire Protection, Stock, Or Small Fish Pond, Fish and Wildlife Pond	WESTON	-104.699	44.0858
WY01882	SR. NO. 22-14A	D22-1 DRAW TRIB EAST FORK WIND	13	177	MICHAEL C. GREEN	Fire Protection, Stock, Or Small Fish Pond	Recreation, Fire Protection, Stock, Or Small Fish Pond	WESTON	-104.673	44.1511
WY01939	UPTON WASTEWATER TREATMENT	IRON CREEK	9	147	TOWN OF UPTON	Debris Control	Debris Control, Other	WESTON	-104.6269	44.0922
WY00422	BIG DELANEY	WELL DRAW	25	45	MARK J. PIELOCH	Irrigation	Irrigation	WESTON	-104.2866	44.0533
WY00606	V. E. LISSOLO IRRIGATION	W PLUM OR BIG PLUM CREEK	30	89	ELIZEBETH MILLET & WYO. STATE LAND OFF.	Irrigation	Irrigation	WESTON	-104.2597	44.015
WY00823	PERINO	SPRING DRAW	45	73	BOB PERINO	Irrigation	Irrigation	WESTON	-104.2541	44.0716
WY01520	BLACK HILLS POWER & LIGHT	EAST BRANCH POISON CREEK	27	195	BLACK HILLS POWER AND LIGHT	Other	Other	WESTON	-104.4044	43.9752
WY01940	UPTON-OSAGE NO. F.S. 9-498-33	MOULTON DRAW	24	75	USDA FOREST SERVICE	Fish and Wildlife Pond	Fish and Wildlife Pond	WESTON	-104.458	44.0522
WY02084	TURNER RESERVOIR	TURNER CREEK	32	45	USDA FS	Fish and Wildlife Pond	Recreation, Fire Protection, Stock, Or Small Fish Pond, Fish and Wildlife Pond	WESTON	-104.4197	44.0339
WY02112	EAST IRON CREEK DAM	EAST IRON CREEK	24	67	USDA FS	Flood Control	Flood Control, Recreation, Fish and Wildlife Pond	WESTON	-104.4939	44.1081
WY00583	MICHAELS	MICHAELS DRAW	17	125	MELVIN PERINO	Fire Protection, Stock, Or Small Fish Pond	Fire Protection, Stock, Or Small Fish Pond	WESTON	-104.3516	43.7566
WY00727	STATE	SHOSTAK DRAW	17	390	D & W LIVESTOCK COMPANY, INC.	Fire Protection, Stock, Or Small Fish Pond	Fire Protection, Stock, Or Small Fish Pond	WESTON	-104.3405	43.7844
WY00855	KLODT	MUSH CREEK	26	1708	TOWNSEND CO.	Irrigation	Irrigation	WESTON	-104.3917	43.77
WY01357	CUMMINGS	SOUTH FORK BEAVER CREEK	16	83	USDA FOREST SERVICE	Fish and Wildlife Pond	Fire Protection, Stock, Or Small Fish Pond, Fish and Wildlife Pond	WESTON	-104.5788	43.8038
WY01573	BRUCE NO. F.S. 9-313-1	WILLIAMSON DRAW	22	73	USDA FOREST SERVICE	Fish and Wildlife Pond	Fire Protection, Stock, Or Small Fish Pond, Fish and Wildlife Pond	WESTON	-104.5828	43.7889
WY02452	GEIER IRRIGATION RESERVOIR	OIL FIELD DRAW OFFSTREAM	42	587	MARLIN GEIER	Irrigation	Irrigation	WESTON	-104.3635	43.9143
WY82406	MARTENS 9-368-1	MUSH CREEK	20	90	USDA FS	Fish and Wildlife Pond	Recreation, Fire Protection, Stock, Or Small Fish Pond, Fish and Wildlife Pond	WESTON	-104.5667	43.865
WY82408	CUMMINGS NO 9-328-2	SOUTH FORK BEAVER CREEK	21	83	USDA FS	Fish and Wildlife Pond	Recreation, Fire Protection, Stock, Or Small Fish Pond, Fish and Wildlife Pond	WESTON	-104.57	43.8067
WY00521	LEO	PETE DRAW	30	43	GENEVIEVE AIMONETTO	Irrigation	Irrigation, Fire Protection, Stock, Or Small Fish Pond	WESTON	-104.2812	43.831
WY00614	ROSEAN	ROSEAN DRAW	23	117	AGNES K. MORGAN	Fire Protection, Stock, Or Small Fish Pond	Fire Protection, Stock, Or Small Fish Pond	WESTON	-104.168	43.7242
WY00717	SPENCER	STOCKADE BEAVER CREEK	45	2847	TRUE RANCHES, INC. (TONY FERELLA)	Irrigation	Irrigation	WESTON	-104.1094	43.8233
WY00718	HOWELL	BLACK TAIL CREEK	25	840	CRAIG DEVENAUX	Irrigation	Irrigation, Fire Protection, Stock, Or Small Fish Pond	WESTON	-104.1833	43.7466
WY00806	SLIDE	STOCKADE BEAVER CREEK	27	113	TRUE RANCHES, INC. (TOBY WINGERT)	Fire Protection, Stock, Or Small Fish Pond	Fire Protection, Stock, Or Small Fish Pond	WESTON	-104.1277	43.1277
WY00817	SPENCER NO. 2	STOCKADE BEAVER CREEK	25	173	TRUE RANCHES, INC. (TOBY WINGERT)	Fire Protection, Stock, Or Small Fish Pond	Fire Protection, Stock, Or Small Fish Pond	WESTON	-104.1241	43.7827
WY01777	NEWCASTLE WASTEWATER TREATMENT (CELL 1)	PETE DRAW	15	70	CITY OF NEWCASTLE	Other	Other	WESTON	-104.2636	43.8422
WY01973	WYO. REFINING CONTAINMENT POND	WINDMILL DRAW	28	297	TOM & GERALD FARNSWORTH	Debris Control	Debris Control, Other	WESTON	-104.2158	43.8205
WY02244	NEWCASTLE WASTEWATER TREATMENT (CELL 2)	PETE DRAW	15	131	CITY OF NEWCASTLE	Other	Other	WESTON	-104.2636	43.8372
WY02245	NEWCASTLE WASTEWATER TREATMENT (CELL 3)	PETE DRAW	15	70	CITY OF NEWCASTLE	Other	Other	WESTON	-104.2636	43.8372
WY02246	NEWCASTLE WASTEWATER TREATMENT (CELL 4)	PETE DRAW	15	87	CITY OF NEWCASTLE	Other	Other	WESTON	-104.2636	43.8372
WY00421	HOUSE	ROBBERS ROOST CREEK	23	120	JOHN HUTT	Fire Protection, Stock, Or Small Fish Pond	Fire Protection, Stock, Or Small Fish Pond	WESTON	-104.2885	43.5378
WY00527	ROBBER'S ROOST	ROBBERS ROOST CREEK	22	1989	MICHAEL & ALICE HARRIS	Irrigation	Irrigation	WESTON	-104.2528	43.5136
WY00805	CAMPBELL NO. 2	MILLER DRAW	23	240	MARGARET HEINE CONSERVATORSHIP	Fire Protection, Stock, Or Small Fish Pond	Fire Protection, Stock, Or Small Fish Pond	NIOBRARA	-104.1677	43.4788
WY00807	THREE FORKS	THREEEFORKS DR, TR ROBBERS RST	31	64	DIANE M. SIMON	Fire Protection, Stock, Or Small Fish Pond	Fire Protection, Stock, Or Small Fish Pond	WESTON	-104.2877	43.5236
WY00815	SEDGWICK	ALKALI CREEK	25	169	STROH & SONS, INC.	Fire Protection, Stock, Or Small Fish Pond	Fire Protection, Stock, Or Small Fish Pond	WESTON	-104.4083	43.5538
WY00874	M. W. RESERVOIR	STOCKADE BEAVER CREEK	35	2410	BALDWIN RANCH, LLC, ATT: DONNA HUNT	Irrigation	Irrigation	WESTON	-104.1183	43.6183
WY01539	ANDERSON NO. 1	SOURS DRAW	26	48	CLAUDE D. SMITH, ETAL.	Fire Protection, Stock, Or Small Fish Pond	Fire Protection, Stock, Or Small Fish Pond	NIOBRARA	-104.255	43.4661
WY02237	HARRIS	BUM DRAW	35	281	MIKE HARRIS	Fish and Wildlife Pond	Fire Protection, Stock, Or Small Fish Pond, Fish and Wildlife Pond	NIOBRARA	-104.3644	43.5008
WY02483	ENL. BRUNNER	STOCKADE BEAVER CREEK	37	226	RONALD E. BRUNNER	Irrigation	Irrigation	WESTON	-104.1468	43.574
WY00772	MARTIN-THOMPSON	STOCKADE BEAVER CR	27	265	DOUBLE TRIANGLE RANCH	Fire Protection, Stock, Or Small Fish Pond	Fire Protection, Stock, Or Small Fish Pond	WESTON	-104.1086	43.9286

Data Summary 3.1. Available Flow Data (in acre-feet) for Beaver Creek Watershed and a Portion of Cheyenne River Basin as included in the Northeast Wyoming River Basins Models (RESPEC, 2018)

Dry Year														
Reach[1]	Reach Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total[2]
1	Beaver Creek above Oil Creek	3	42	17	0	0	0	2	12	8	6	5	4	98
2	Oil Creek	63	1,739	5,441	0	803	0	0	0	0	0	0	0	8,046
3	Beaver Creek above Blacktail Creek	132	1,816	5,471	48	1,416	482	435	423	317	334	267	98	11,238
4	Blacktail Creek	181	162	174	523	108	1,042	744	256	287	176	177	181	4,010
5	Beaver Creek above Stockade Beaver Creek	370	2,014	5,665	593	1,656	1,740	1,457	939	889	729	599	376	17,027
6	Dry Beaver Creek	76	87	100	93	96	119	136	109	117	77	83	76	1,170
7	Beaver Creek in South Dakota	75	86	99	93	95	118	135	108	116	76	82	75	1,159
8	Stockade Beaver Creek Tributaries above Gage 06392950	572	478	547	439	442	294	431	334	361	439	502	537	5,375
9	Stockade Beaver Creek above Gage 06392950	759	675	759	648	419	506	668	557	664	722	758	744	7,879
10	Stockade Beaver Creek above Beaver Creek	877	93	61	642	20	116	0	0	0	979	1,056	943	4,787
11	Stockade Beaver Creek Tributaries above Mouth	0	28	11	0	0	0	0	0	0	0	0	0	39
12	Beaver Creek Tributaries above Gage 0634000	0	18	7	0	0	0	0	0	0	0	0	0	25
13	Beaver Creek above Stateline	741	756	3,202	1,906	1,411	1,744	1,459	1,187	404	363	762	740	14,674
14	Beaver Creek above Gage 06394001	747	759	3,205	1,864	1,337	1,674	1,419	1,143	371	388	782	751	14,439
26	Robbers' Roost Creek	0	4	13	0	0	0	0	0	0	0	0	0	17

Normal Year														
Reach[1]	Reach Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total[2]
1	Beaver Creek above Oil Creek	18	303	528	0	193	0	28	33	25	44	17	10	1,198
2	Oil Creek	49	5,048	5,977	0	2,173	0	0	0	0	39	0	0	13,286
3	Beaver Creek above Blacktail Creek	224	5,465	6,527	40	2,871	414	409	688	496	546	384	212	18,277
4	Blacktail Creek	180	156	179	394	322	1,556	829	251	644	189	196	190	5,086
5	Beaver Creek above Stockade Beaver Creek	486	5,676	6,746	439	3,257	2,144	1,506	1,181	1,482	999	764	532	25,212
6	Dry Beaver Creek	112	121	152	160	155	163	161	182	161	115	103	118	1,702
7	Beaver Creek in South Dakota	111	120	150	159	154	161	160	181	159	114	102	117	1,686
8	Stockade Beaver Creek Tributaries above Gage 06392950	444	413	503	395	561	473	434	467	408	400	412	443	5,353
9	Stockade Beaver Creek above Gage 06392950	723	694	827	746	600	642	628	658	686	723	713	762	8,400
10	Stockade Beaver Creek above Beaver Creek	838	284	423	747	0	1,386	445	0	191	890	1,020	962	7,185
11	Stockade Beaver Creek Tributaries above Mouth	8	214	377	0	0	0	0	0	0	0	0	0	599
12	Beaver Creek Tributaries above Gage 0634000	5	138	242	0	0	0	0	0	0	4	0	0	389
13	Beaver Creek above Stateline	815	1,610	5,867	1,840	4,151	2,177	1,597	850	403	520	763	846	21,439
14	Beaver Creek above Gage 06394001	822	1,615	5,870	1,804	4,088	2,101	1,550	798	366	544	784	858	21,199
26	Robbers' Roost Creek	2	55	108	0	0	0	0	0	0	0	0	0	165

Data Summary 3.1. Available Flow Data (in acre-feet) for Beaver Creek Watershed and a Portion of Cheyenne River Basin as included in the Northeast Wyoming River Basins Models (RESPEC, 2018)

Wet Year														
Reach[1]	Reach Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total[2]
1	Beaver Creek above Oil Creek	28	629	3,020	0	1,196	5	398	48	36	84	23	16	5,482
2	Oil Creek	71	2,256	6,374	1,327	712	0	0	975	0	0	0	0	11,715
3	Beaver Creek above Blacktail Creek	266	3,008	9,407	1,529	2,495	477	819	1,788	590	579	384	223	21,565
4	Blacktail Creek	204	211	226	233	88	1,273	925	132	741	213	211	211	4,669
5	Beaver Creek above Stockade Beaver Creek	552	3,273	9,672	1,768	2,655	1,924	2,018	2,165	1,680	1,055	779	563	28,103
6	Dry Beaver Creek	129	137	202	199	151	184	222	226	204	127	124	116	2,020
7	Beaver Creek in South Dakota	128	136	200	197	149	182	220	224	202	126	122	115	2,000
8	Stockade Beaver Creek Tributaries above Gage 06392950	458	422	647	477	492	466	540	606	569	450	444	448	6,019
9	Stockade Beaver Creek above Gage 06392950	780	739	1,075	918	787	689	760	884	865	789	770	771	9,827
10	Stockade Beaver Creek above Beaver Creek	932	1,392	2,227	620	0	1,235	126	0	732	1,106	1,120	1,006	10,495
11	Stockade Beaver Creek Tributaries above Mouth	14	447	2,162	0	641	0	0	0	0	22	0	0	3,285
12	Beaver Creek Tributaries above Gage 0634000	9	287	1,390	0	357	0	98	0	0	21	0	0	2,163
13	Beaver Creek above Stateline	972	5,219	8,927	3,837	4,062	2,113	1,339	1,321	474	715	924	829	30,731
14	Beaver Creek above Gage 06394001	979	5,223	8,929	3,800	4,002	2,040	1,286	1,267	435	742	945	841	30,489
26	Robbers' Roost Creek	2	47	343	0	0	0	0	0	0	0	0	0	392

[1]Reaches 1-14 are from the Beaver Creek model. Reach 26 is from the Cheyenne River Model.

[2]"Total" available flow is the sum of the monthly available flows

Shaded cells denote that the models indicate shortages in the reach

Data Summary 6.0 Primary Potential Funding Sources

Agency/Entity	Program Name	Project Type(s)	Internet URL	Telephone
Local				
Niobrara Conservation District	N/A	Liaison, In-Kind administrative and technical assistance, program coordination/partnering	https://www.niobraracounty.org/departments/conservation/index.asp	(307) 334-9957
Weston County Natural Resource District	N/A	Liaison, In-Kind administrative and technical assistance, program coordination/partnering	http://www.westoncountynrd.org/	(307) 746-3264
Weston County Board of County Commissioners	N/A	Liaison, In-Kind administrative and technical assistance, program coordination/partnering	https://westongov.com/departments/county_commissioner/index.asp	(307) 746-4744
State				
Wyoming Department of Agriculture	Rangeland Health Assessment Program	Monitoring of rangeland	http://wyagric.state.wy.us/	(307) 777-7321
Wyoming Department of Environmental Quality	Nonpoint Source Implementation Grants (Section 319 Program)	Water Quality Best Management Practices	http://deq.wyoming.gov/	307-777-7937
	Abandoned Mine Land	Reclamation of abandoned mine lands	http://deq.wyoming.gov/aml/	307-777-6145
Wyoming Game and Fish Department	Habitat Trust Fund	Promotes Water Quality	https://wgfd.wyo.gov	307-777-4600
	Fish Passage Grants	Fish passage ladders or fish screens		
Wyoming Office of State Lands and Investments	Farm Loan Program	Agricultural and Livestock Assistance	http://lands.wyo.gov/	307-777-7331
	The Irrigation Loans Program	Small and large Agricultural Water Development Projects		
	Joint Powers Act Loan Program	Government Services and Public Facilities		
Wyoming Oil and Gas Conservation Commission	Orphan Well Program	The Wyoming Oil and Gas Conservation Comission is responsible for abandonment of orphaned oil and gas wells.	http://wogcc.wyo.gov/orphan-well-program	307-315-2969
Wyoming Water Development Commission	New Development Program	Water Supply Development	http://wwdc.state.wy.us/	307-777-7626
	Rehabilitation Program	Improvements of Existing Water Projects		
	Dam and Reservoir Program	New Dams and Dam expansion		
	Small Water Projects Program	Construction/Rehabilitation of Small Reservoirs, Wells, Pipelines, Springs, Solar Platforms, Irrigation Works, Windmills, and Wetland Development		
Wyoming Wildlife and Natural Resource Trust	N/A	Wildlife Habitat Improvements and Natural Resource Improvements/Preservation	http://wwnrt.state.wy.us/	307-777-8024
Federal				
Bureau of Land Management - Newcastle Field Office	Riparian Habitat Management Program	Improve/Restore/Protect Riparian Areas	https://www.blm.gov/office/newcastle-field-office	307-746-6600
	Range Improvement Planning and Development	Water Development for Livestock, Livestock Best Management Practices (BMPs)		
	Watershed and Water Quality Improvement	Restoration and Maintenance of Watershed Function		
Bureau of Reclamation	WaterSMART	Promotes Water Management	http://www.usbr.gov/gp/wyao/	307-261-5671
	Water Conservation Field Services Program	Conservation Improvements		
Environmental Protection Agency	Targeted Watersheds Grants Program	Riparian, Wetland, Aquatic and Upland Habit Protection and Improvement	https://www.epa.gov/wy	303-312-6692
Farm Service Agency	Conservation Reserve Program	Removal of Highly Erodible Cropland from Production	http://www.fsa.usda.gov/state-offices/Wyoming/index	307-261-5231
	Continuous Sign-Up for High Priority Conservation Practices	Riparian Buffers, Filter Strips, Grass Waterways, Shelter Belts, Field Windbreak, Living Snow Fences, Contour Grass Strips, Salt Tolerant Vegetation, and Shallow Water Areas		
	Emergency Conservation Program	Farmland Rehabilitation Damaged by Natural Disasters or Emergency Water Conservation for Livestock		
Fish and Wildlife Service	Partners for Fish and Wildlife Program (PFW)	Grazing lands management, sage steppe enhancement, stream habitat improvement and fish passage, invasive species removal, and wetland establishment	http://www.fws.gov/	307-332-7607
	Wildlife and Sport Fish Restoration (WSFR)	Multiple grant programs to conserve, protect, and enhance fish, wildlife and their habitats.		
	Conservation Planning and Assistance Program	Infrastructure development projects to protect the environment and preserve our nation's biological, terrestrial, and aquatic natural resources.		
	Cooperative Endangered Species Conservation Fund	Conservation projects for candidate, proposed, and listed species		
	North American Wetlands Conservation Act Grant Program	Conservation program supports acquisition, enhancement, and restoration of wetlands and wetlands-associated habitat		
	National Wildlife Refuge Challenge Cost Share Program	For USFWS refuges to manage cooperatively the natural and cultural resources and fulfill stewardship responsibilities to fish and wildlife management		
Natural Resource Conservation Service	Environmental Quality Incentives Program (EQIP)	Improve Water Quality, Enhance Grazing Lands, and Increase Water Conservation	http://www.wy.nrcs.usda.gov/	307-233-6750
	Conservation Stewardship Program (CSP)	The program encourages land stewards to improve their conservation performance		
	The Regional Conservation Partnership Program (RCPP)	Deliver conservation assistance to producers and landowners		
	The Agricultural Management Assistance (AMA)	Financial assistance to address water management, water quality, invasive species control, and erosion control issues		
	Conservation Innovation Grants (CIG)	Stimulates the development and adoption of innovative conservation approaches		
	The Agricultural Conservation Easement Program (ACEP)	Protects working agricultural lands and limits non-agricultural uses of the land		
Non-Profit and Other Organizations				
Ducks Unlimited	Matching Aid to Restore States Habitat	Wetlands and Waterfowl Restoration	http://www.ducks.org/wyoming	(307) 733-3567
National Fish and Wildlife Foundation	Five-Star Restoration Matching Grants Program	Wetland, Riparian, and Coastal Habitat Restoration	http://www.nfwf.org/	202-857-0166
	Bring Back the Natives	Preserve/Enhance Native Aquatic Species		
	Native Plant Conservation Initiative	Conservation of Native Plantlife		
	Pulling Together Initiative	Invasive Plant Species Control		
Trout Unlimited	N/A	Partnership and grant coordination, reconnecting and restoring trout habitat. Irrigation diversion and efficiency upgrades, culvert replacements, fish screens and ladders, channel and stream restoration	http://wyomingtu.org/	307-699-1022
Sage Grouse Initiatives (multiple)	Multiple	Habitat Improvements to Benefit Sage Grouse	Varies, See Section 6.5	

Appendix B

Benefits of Watershed Improvement Practices

NRCS Conservation Practice Effects – Network Diagrams included for reference:

Dam, number 402
Dike, number 356
Grade Stabilization Structure, number 410
Irrigation Field Ditch, number 383
Irrigation Land Leveling, number 464
Irrigation Pipeline, number 430
Livestock Pipeline, number 516
Pond, number 378
Pond Sealing or Lining – Geomembrane or Geosynthetic Clay Liner, number 521
Restoration and Management of Rare or Declining Natural Communities, number 643
Sediment Basin, number 350
Shallow Water Development and Management, number 646
Spring Development, number 574
Sprinkler System, number 442
Structure for Water Control, number 587
Water Well, number 642
Watering Facility, number 614
Well Decommissioning, number 351
Wetland Wildlife Habitat Management, number 644

Appendix B - Benefits of Watershed Improvement Practices

One of the goals of the watershed study is to identify specific watershed projects and practices that will improve the health and function of the Beaver Creek watershed. How does one identify the benefits to the watershed that the specific projects may provide? This question has been thoroughly researched and documented through U.S. Department of Agriculture (USDA) guidance documents compiled in the National Conservation Practices Standards (NRCS 2018b). Several tools and reference standards (available online at www.nrcs.usda.gov) were developed for use in planning conservation practices and to evaluate the net effect of specific practices. For planning purposes:

> *"The Conservation Practices Physical Effects (CPPE) matrix, and associated planning tools, describe how NRCS's conservation practices effect the Natural Resource and Human-Economic Environments. The Excel spreadsheets…can be used to describe the environmental and economic effects of each conservation practice. A qualitative statement describes the conservation practice's impact on Soil, Water, Air, Plants, Animals, Energy and Land, Labor, Capital and Risk. The tools also define the conservation practice, practice units, typical land use and a relative cost estimate" (NRCS 2018b).*

Additionally, the NRCS prepares Conservation Practice Effects – Network Diagrams to help identify the effects of specific practices. As stated on the NRCS website:

> *"NRCS prepares network diagrams of featured practices, or related sets of practices which act together to achieve desired purposes. Network diagrams 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. They show the potential positive and negative outcomes of practice installation, and are useful as a reference point for next steps, and as a communication tool with partners and the public" (NRCS 2018b).*

These network diagrams have been used in previous watershed studies to point out specific project effects and benefits. To maintain consistency with previous Level I studies, the same is true with the Beaver Creek watershed study. Table B-1 lists the NRCS Conservation Practice Effects – Network Diagrams included in this appendix along with an example of the potentially applicable projects as described in Section 4 of this report.

Table B-1. List of NRCS Network Effect Diagrams Included in this Appendix.

Best Management Practice Description or Title	NRCS Number	Publication Date	Example of Potentially Applicable Projects
Dam	402	2017	WSS-5.1
Dike	356	2014	ISI-8.2
Grade Stabilization Structure	410	2014	OMP-33.2
Irrigation Field Ditch	388	2014	ISI-38.1
Irrigation Land Leveling	464	2016	ISI-35.1
Irrigation Pipeline	430	2014	ISI-26.2
Livestock Pipeline	516	2014	LWW-3.1
Pond	378	2015	WSS-5.1
Pond Sealing or Lining – Geomembrane or Geosynthetic Clay Liner	521	2017	WSS-22.3
Restoration and Management of Rare or Declining Natural Communities	643	2017	OMP-1.2

Best Management Practice Description or Title	NRCS Number	Publication Date	Example of Potentially Applicable Projects
Sediment Basin	350	2016	LWW-13.1
Shallow Water Development and Management	646	2014	LWW-25.3
Spring Development	574	2014	LWW-10.1
Sprinkler System	442	2015	ISI-23.3
Structure for Water Control	587	2017	ISI-33.1
Water Well	642	2014	ISI-30.1
Watering Facility	614	2014	LWW-2.1
Well Decommissioning	351	2014	OMP-16.3
Wetland Wildlife Habitat Management	644	2014	OMP-20.1

To illustrate how the network diagrams can be used to identify the direct and indirect benefits of specific projects, we have developed a summary of the potential effects/benefits for each of the types of projects. By reviewing the specific conceptual project components and the appropriate network diagrams, similar lists of effects/benefits can be developed for the projects proposed in this watershed study. Examples of a potentially applicable project are listed above; however, the list is not all inclusive because several projects have more than one conservation practice that could apply.

Livestock/Wildlife Watering Improvement Projects

As described in NRCS Conservation Practice Effects – Network Diagram, Spring Development (574), the effects and benefits of improving a natural spring to provide water for livestock and wildlife include:

- Increased water quality and quantity for livestock and wildlife
  - Decreased livestock concentration in sensitive areas
  - Increased livestock condition and productivity
  - Increased upland wildlife habitat
  - Increased water quality

The cumulative effects of this management practice include:

- Positive income stability to individuals and communities
- Positive impacts to health for humans, habitats, and domestic and wild animals
- Potential for improved environmental quality and stream fauna
- Potential for increased recreational opportunities

Water Supply/Storage Improvement Projects

As described in NRCS Conservation Practice Effects – Network Diagram, Pond (378), the effects and benefits of constructing a pond where water is needed for livestock, fish, wildlife, recreation, fire control, and/or irrigation include:

- Increased water quality, quantity, and distribution for livestock and wildlife
  - Increased plant growth and productivity
  - Increased livestock condition and productivity
  - Potential for increased upland wildlife habitat

The cumulative effects of this management practice include:

- Positive income stability to individuals and communities
- Positive impacts to health for humans and for domestic and wild animals

Irrigation System Improvement Projects

As described in NRCS Conservation Practice Effects – Network Diagram, Irrigation Pipeline (430), the effects and benefits of rehabilitating and improving water conveyance for irrigation systems include:

- Increased water availability for irrigation
  - Increased plant growth and productivity
- Decreased infiltration and evaporation losses
  - Increased plant growth and productivity
  - Decreased leaching of nutrients
- Decreased erosion associated with practice
  - Decreased sediment delivery to surface waters

The cumulative effects of this management practice include:

- Positive income stability to individuals and communities
- Positive impacts to aquatic health for humans and for domestic and wild animals
- Improved environmental quality and stream fauna

Other Management Practice Improvement Projects

As described in NRCS Conservation Practice Effects – Network Diagram, Restoration and Management of Rare or Declining Natural Communities (643), the effects and benefits of enhancements to habitat include:

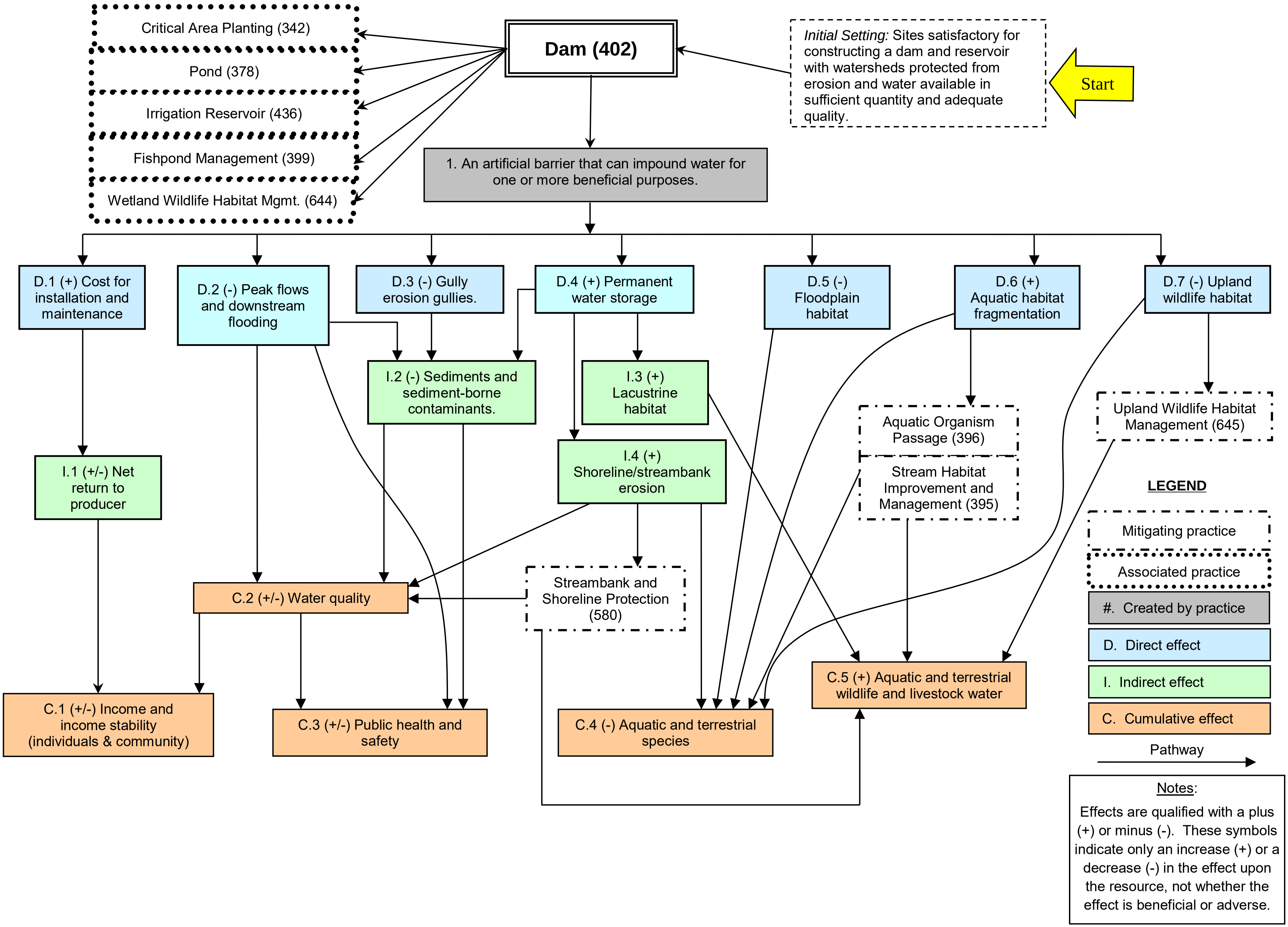
- Increased soil quality
- Increased production of desired vegetative species
- Increased use of habitat by target and non-target species

The cumulative effects of this management practice include:

- Potential positive income stability to individuals and communities
- Positive impacts to health and population of rare and declining species
- Potential for increased water and air quality
- Potential positive impacts to biodiversity

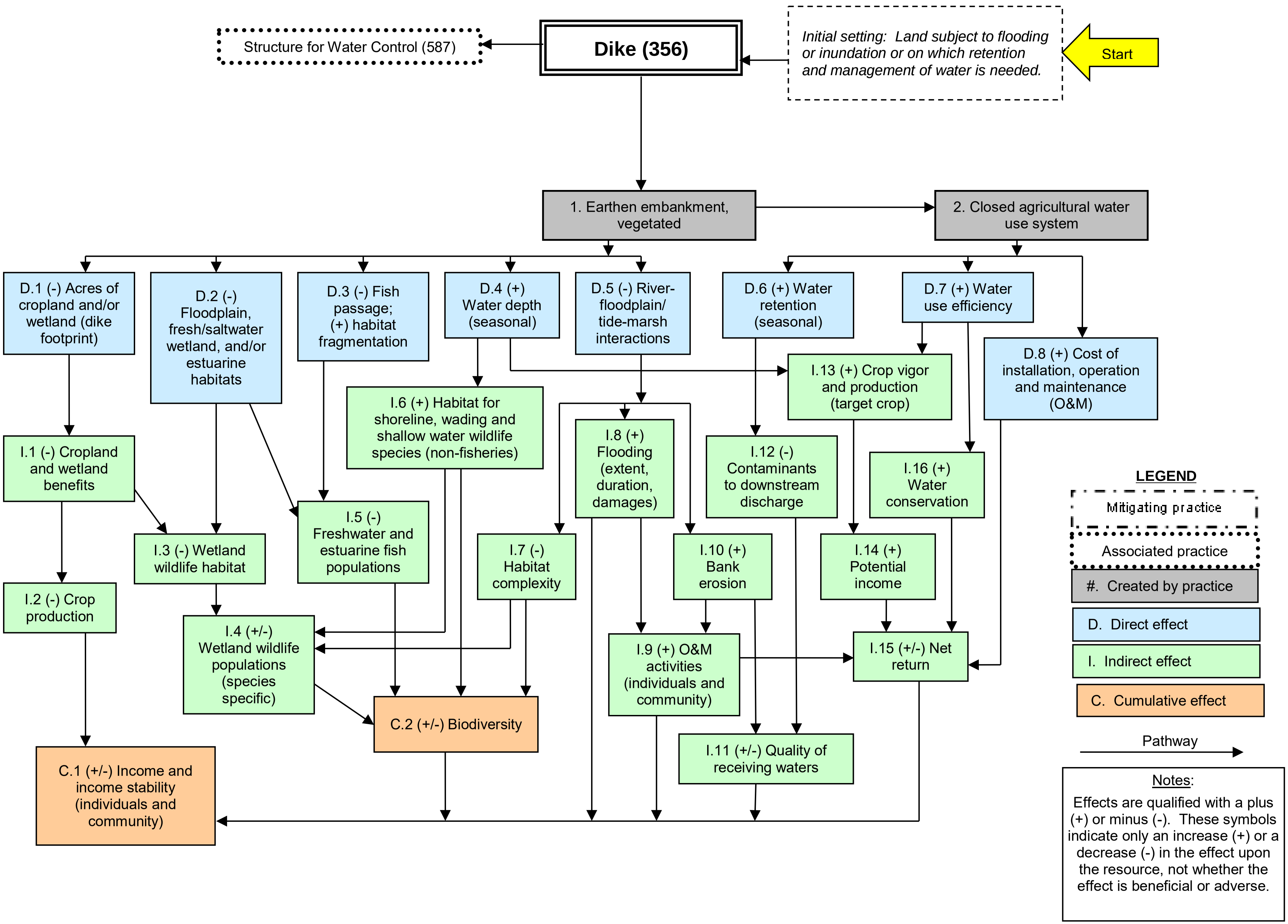
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

October 2017



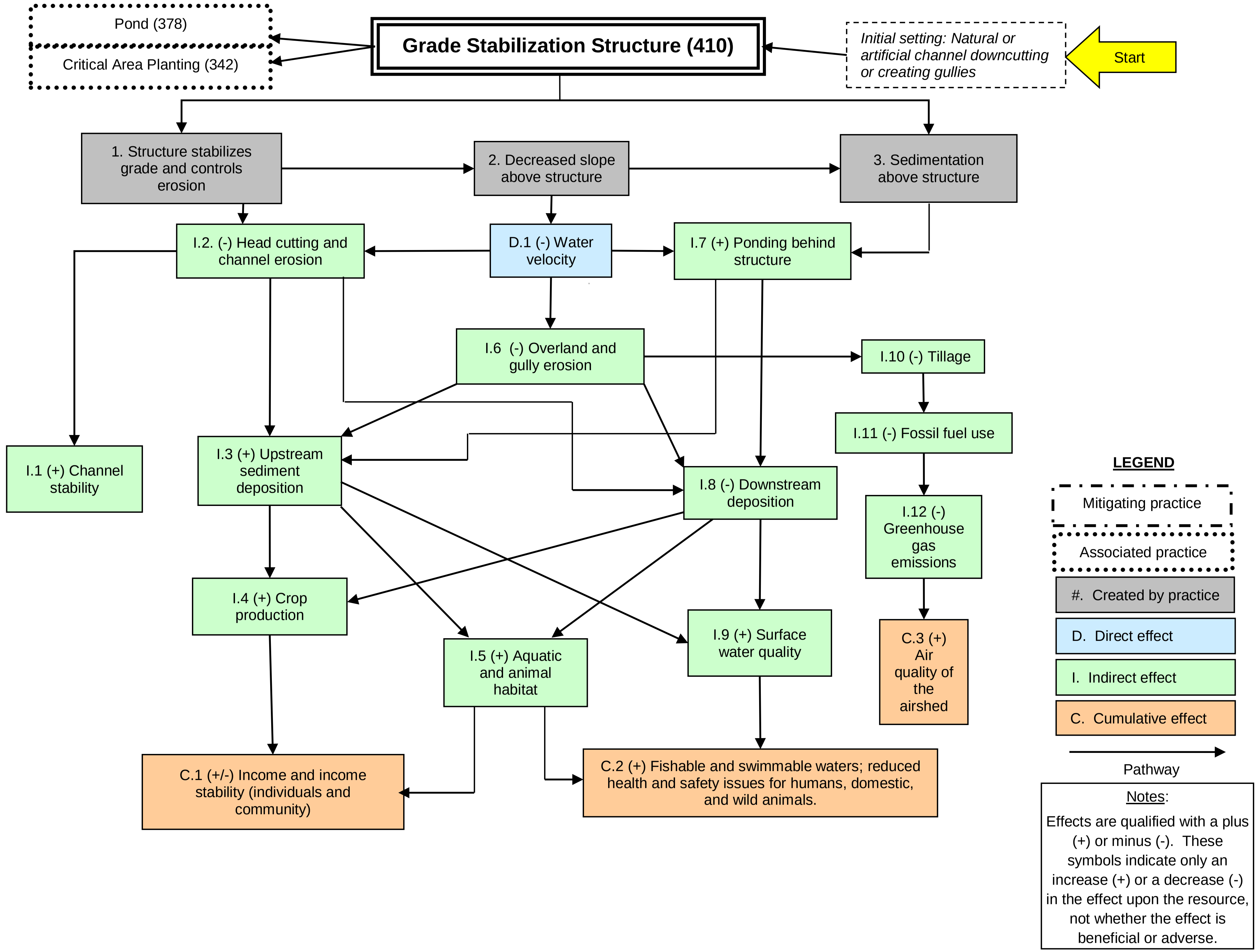
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

March 2014



NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

September 2014



NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

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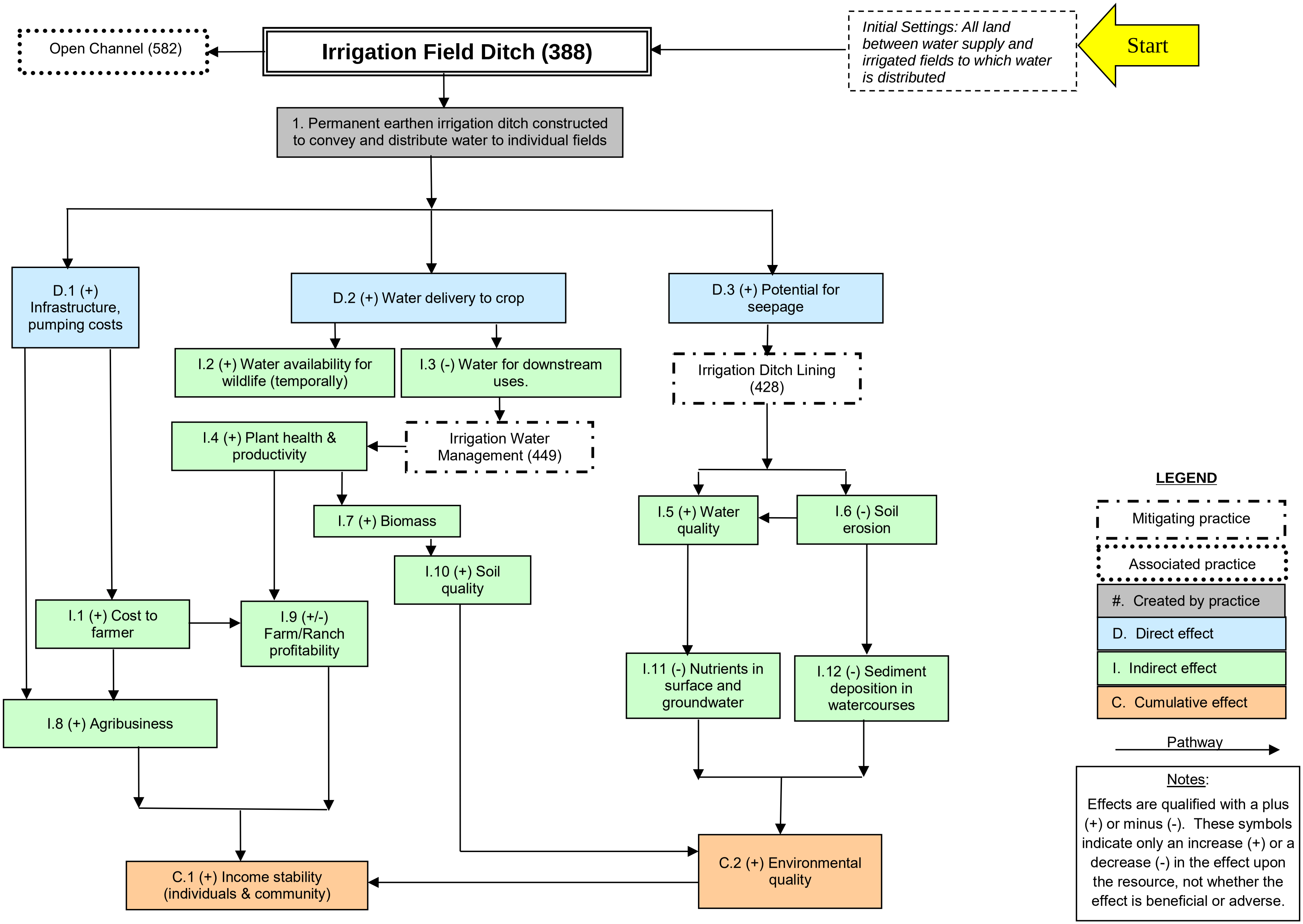
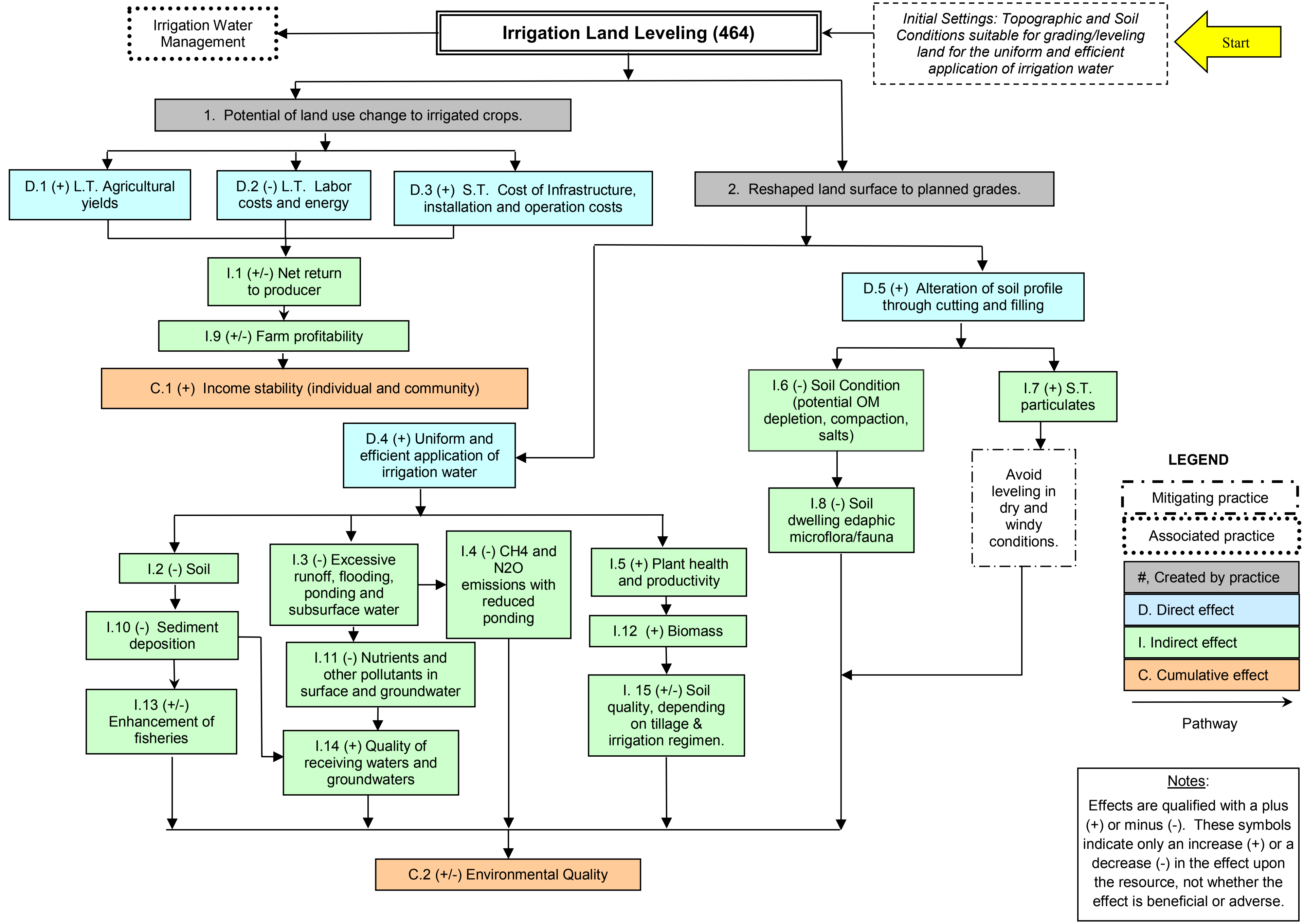


NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

September 2016

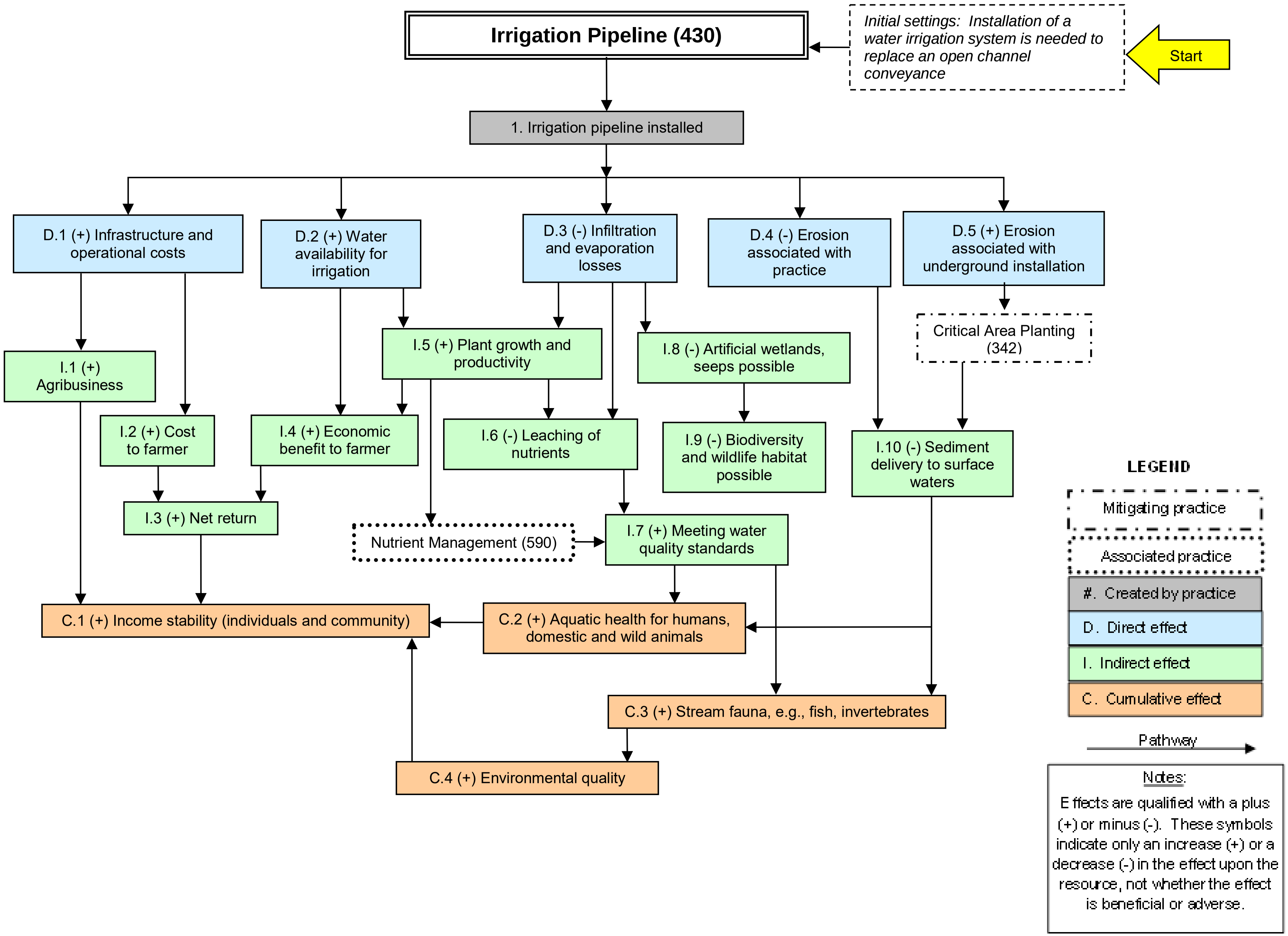


Notes:

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.

NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

March 2014



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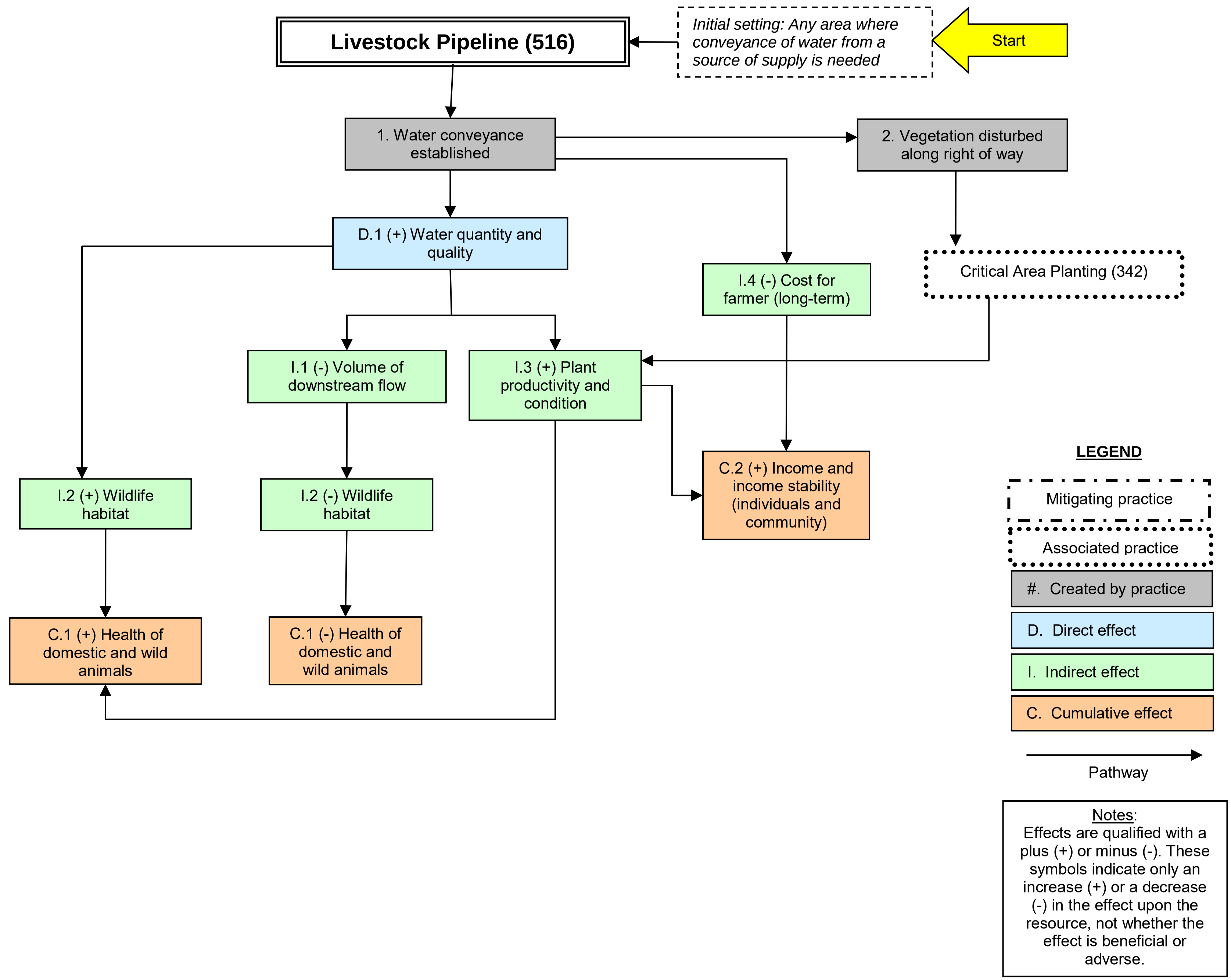

NRCS CONSERVATION PRACTICE EFFECTS- NETWORK DIAGRAM

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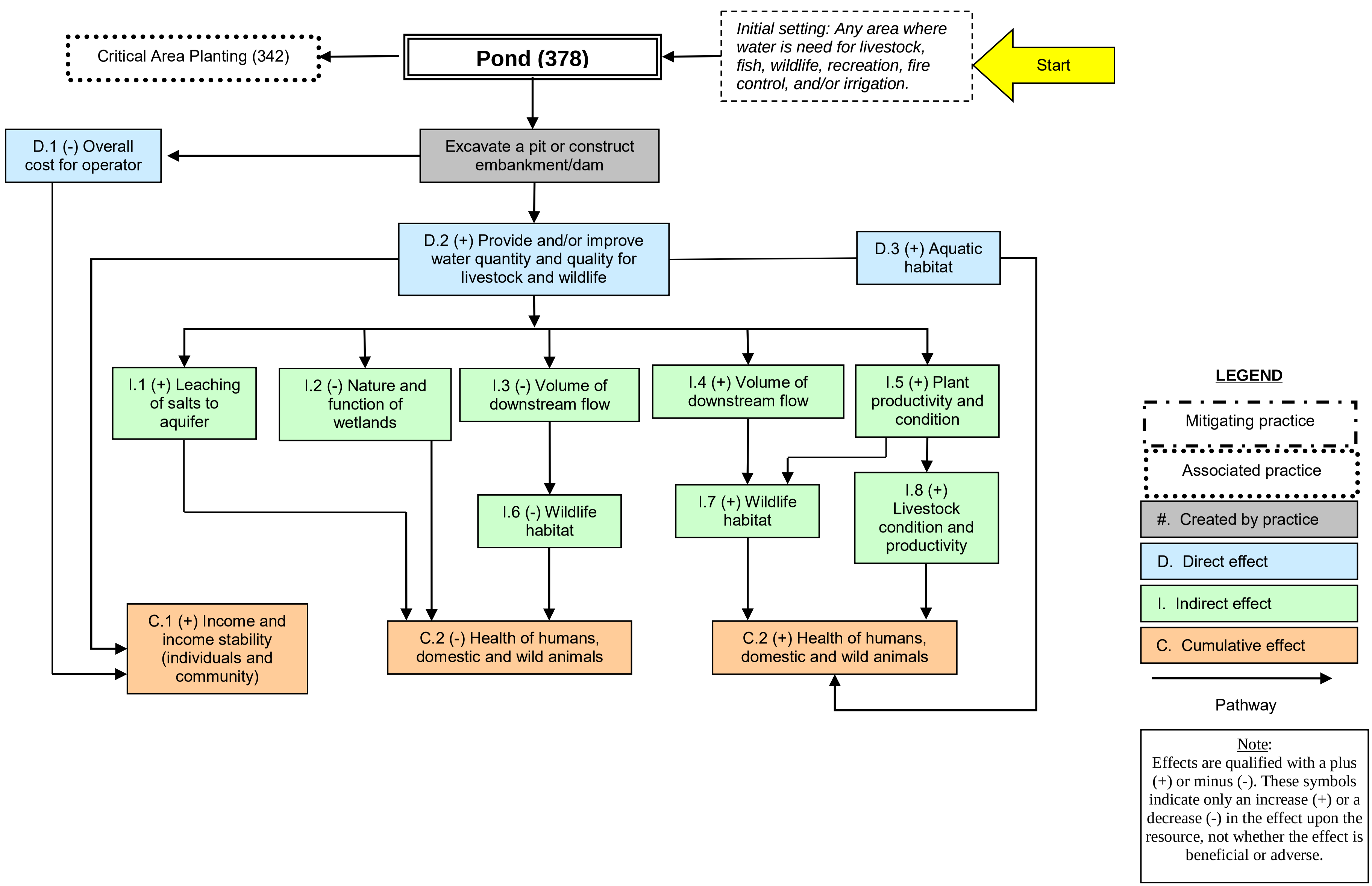

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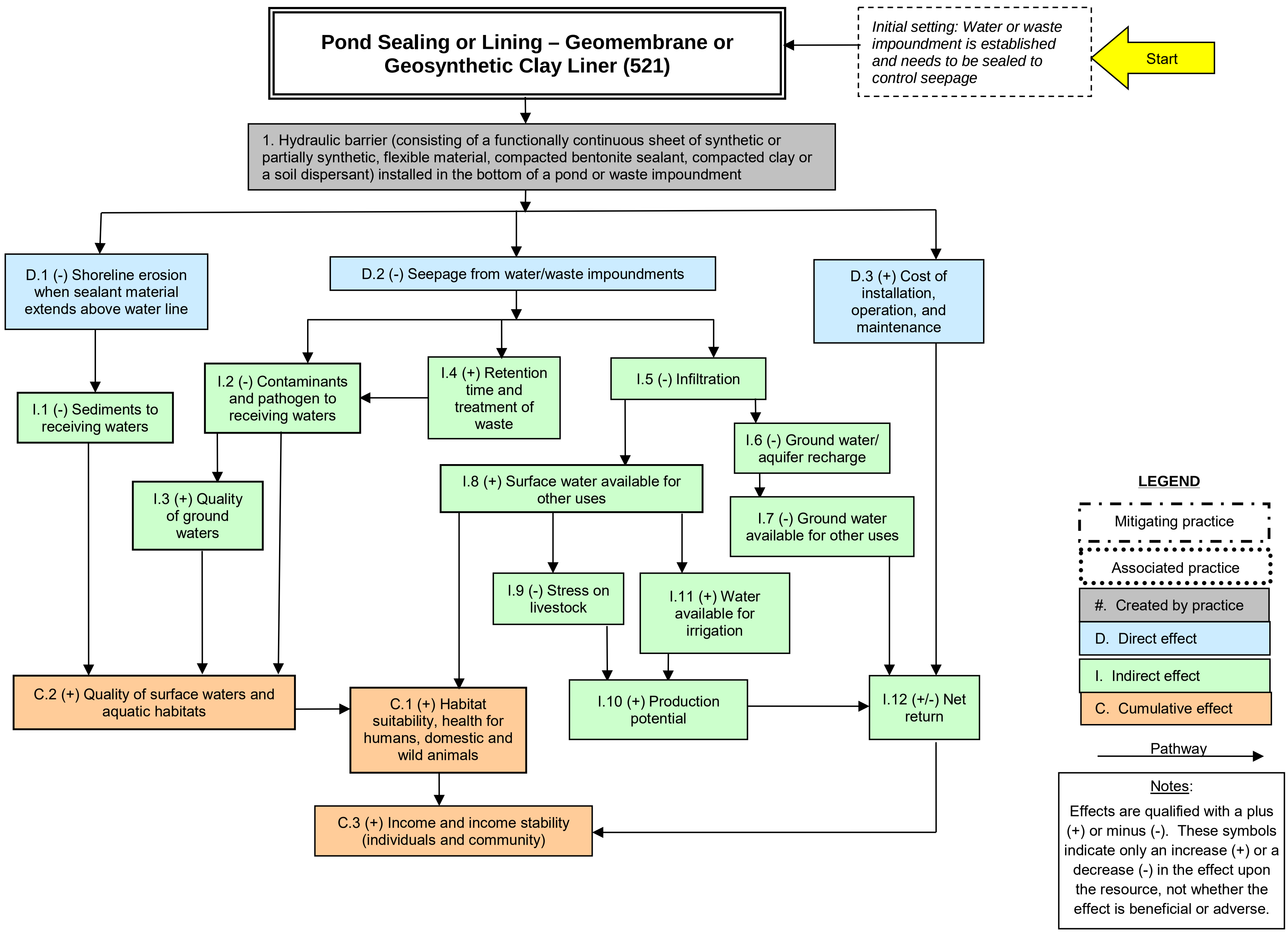
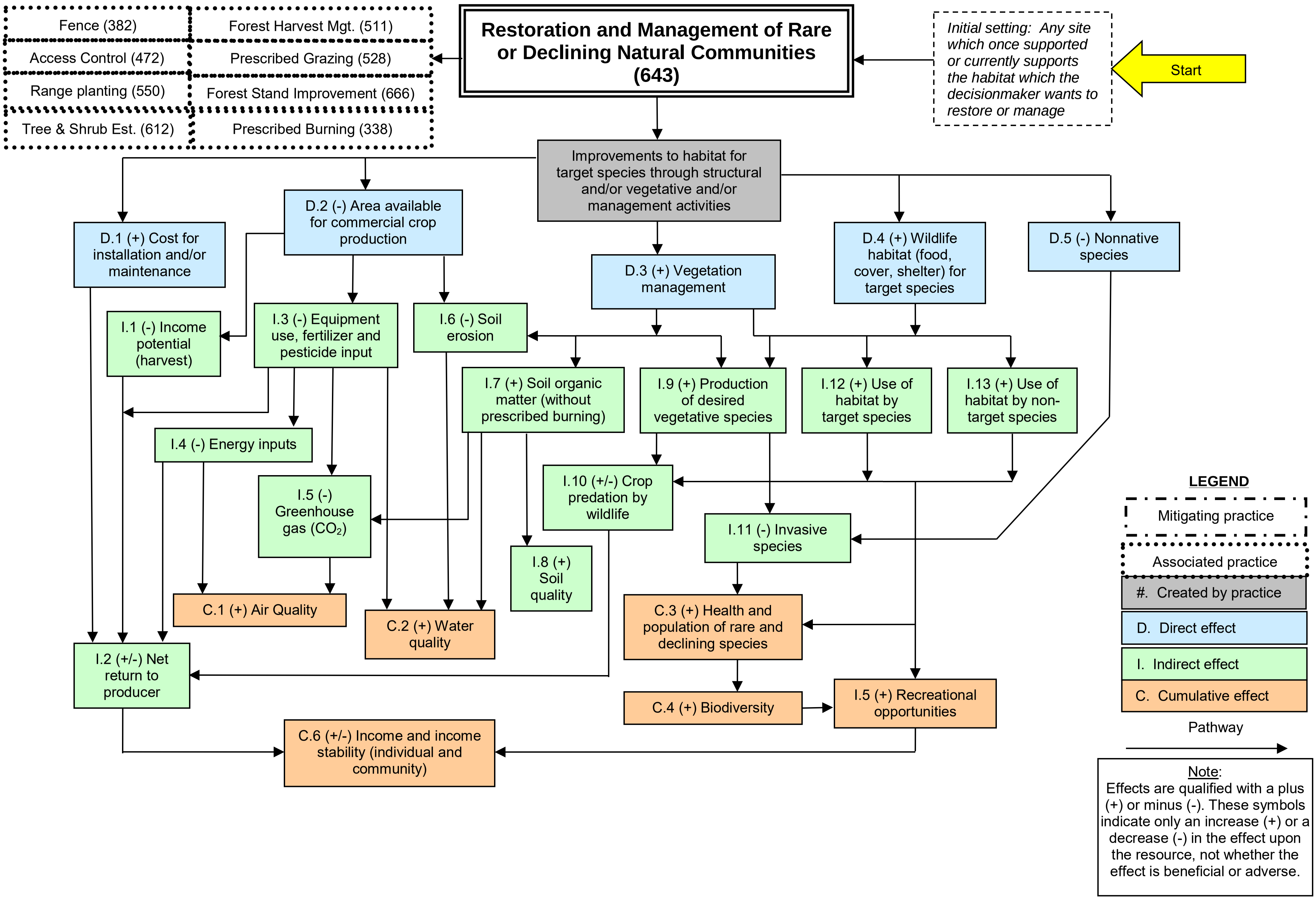


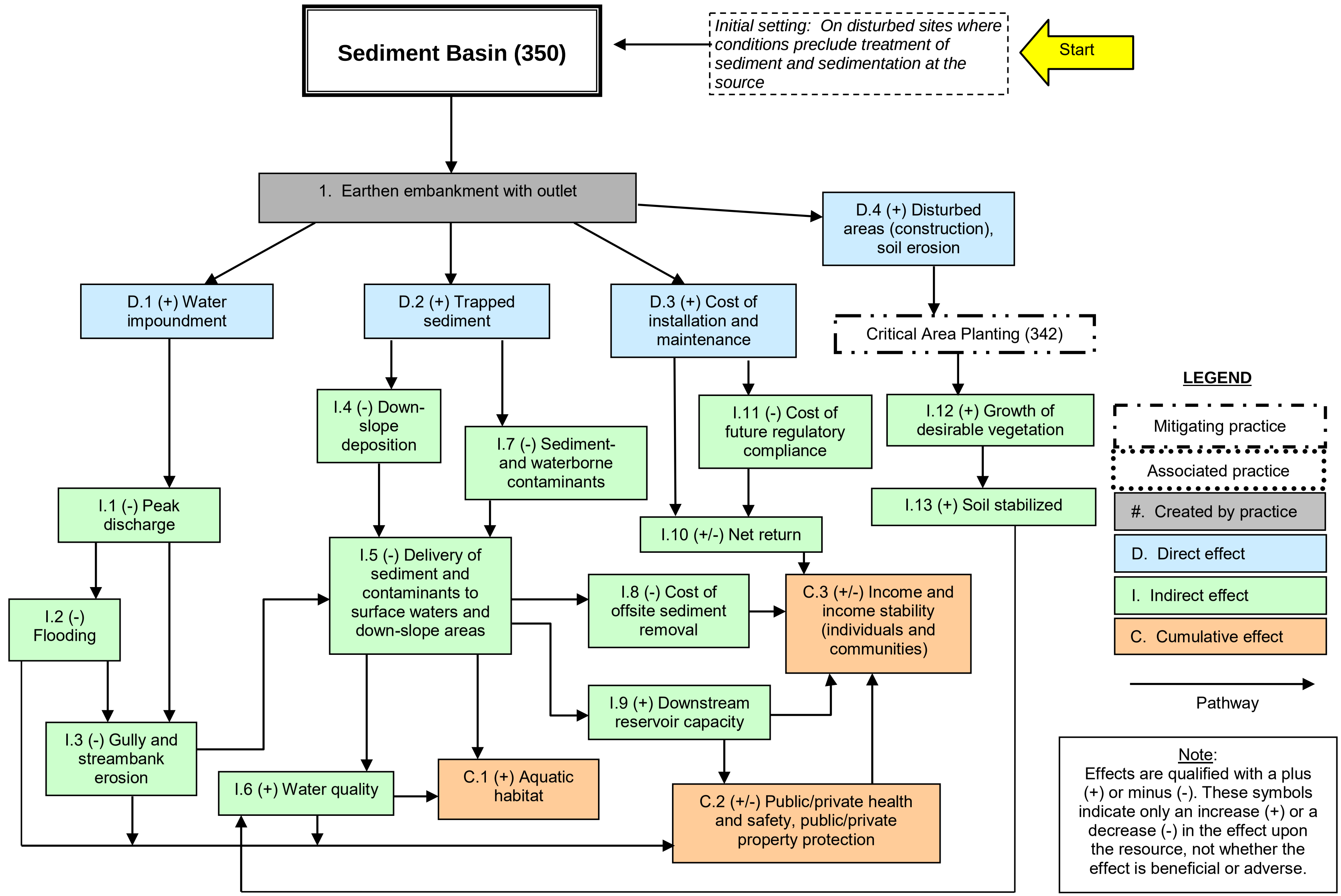
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

August 2017



NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

May 2016



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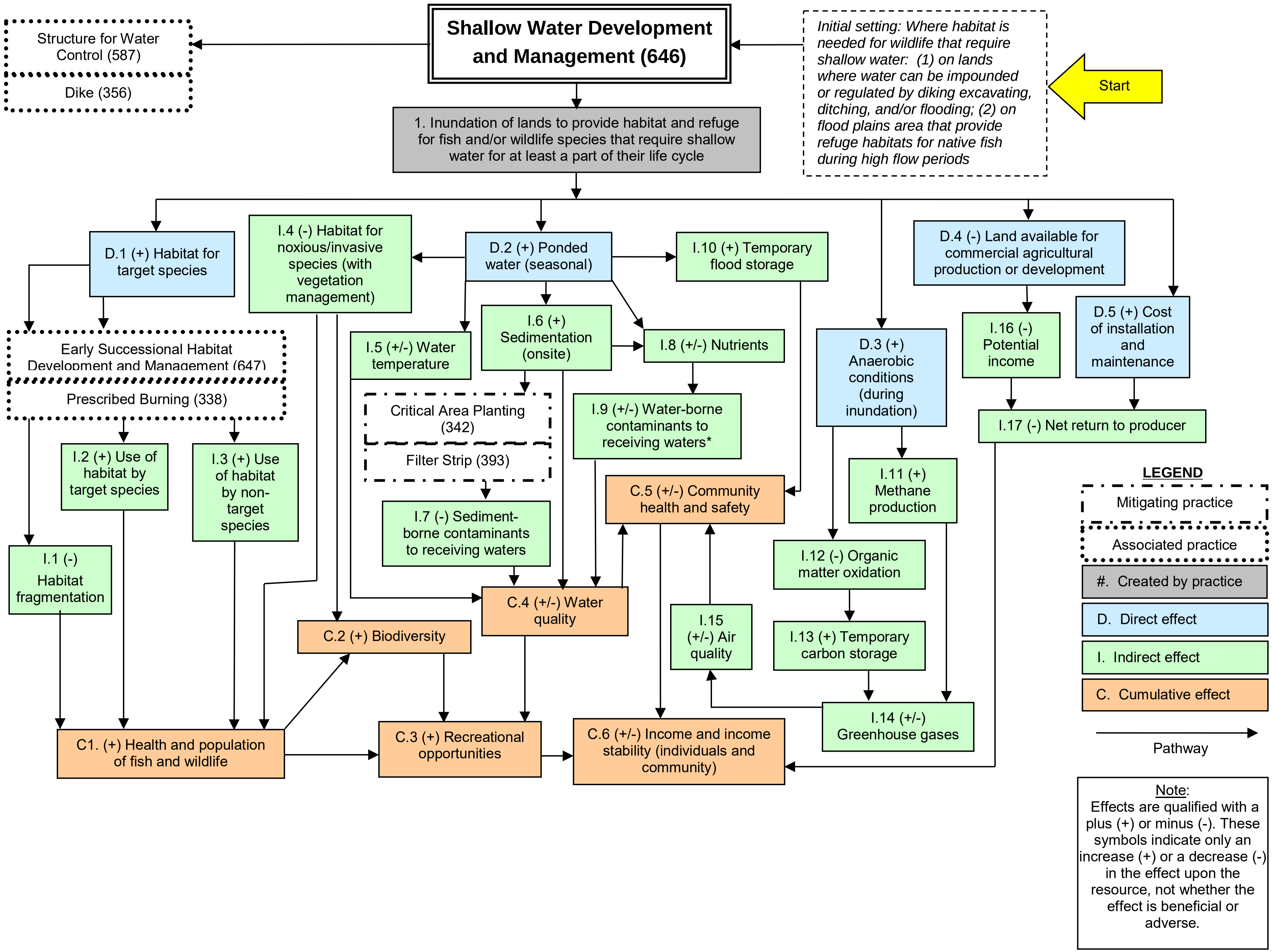

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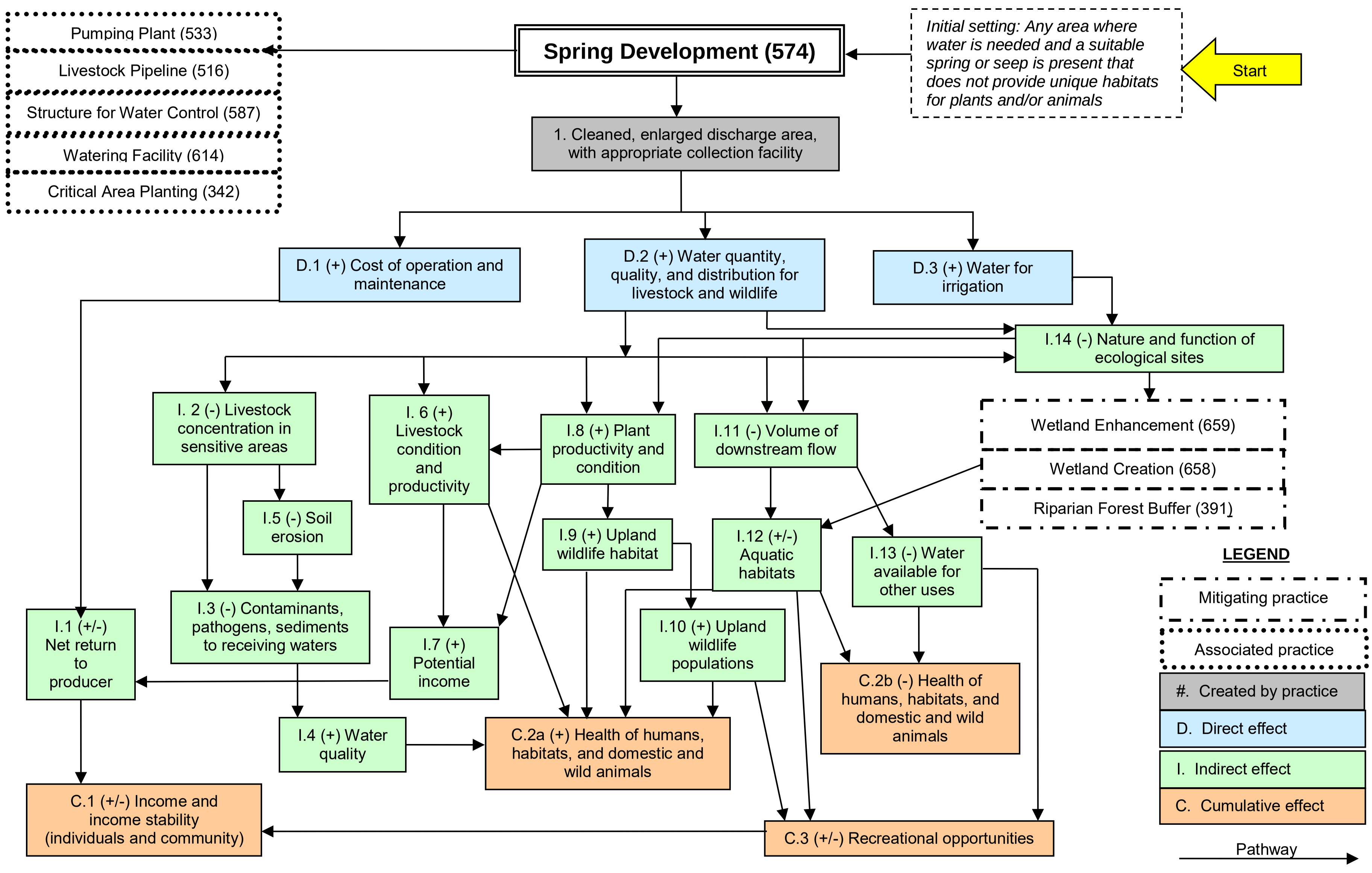

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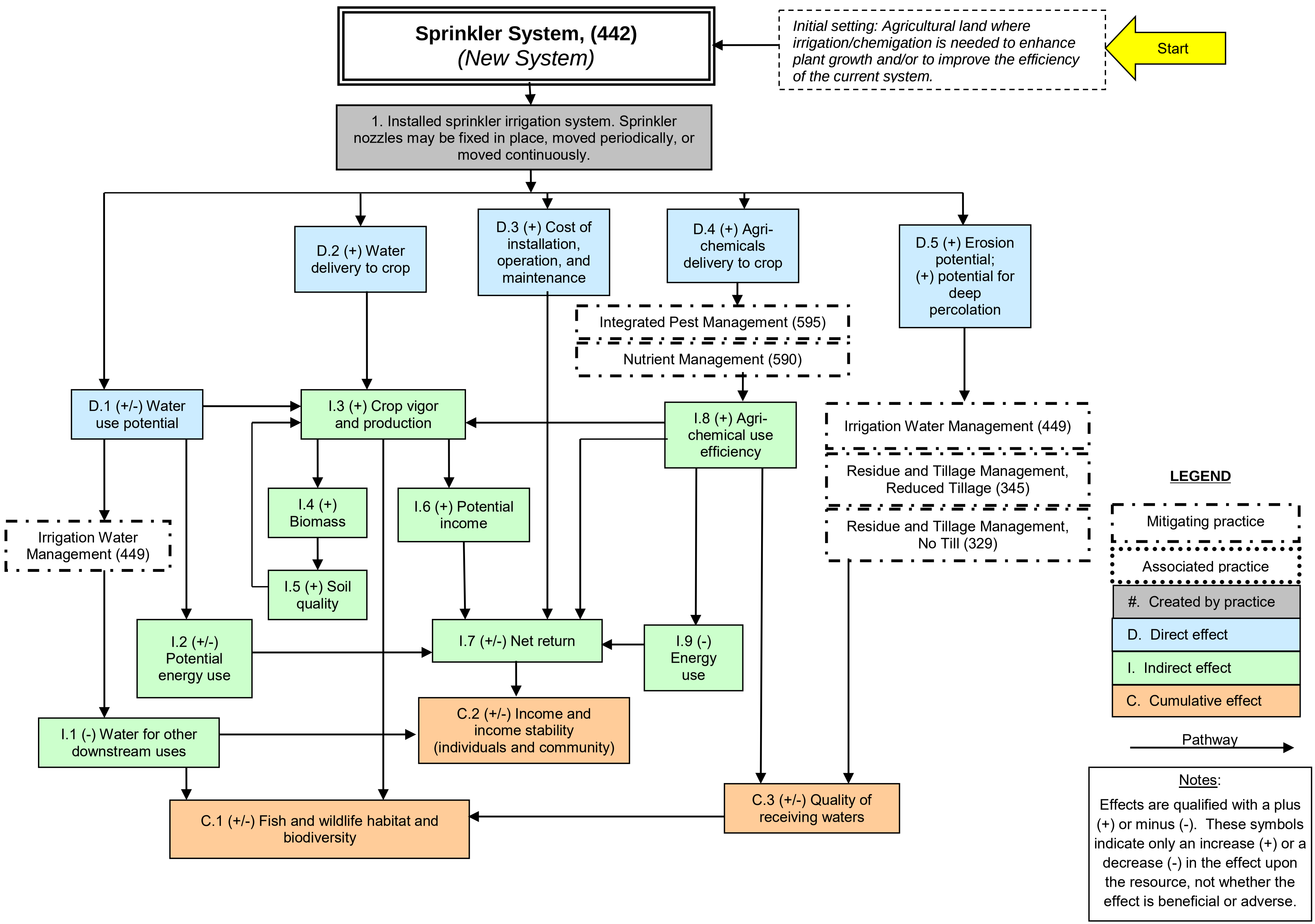
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

September 2015



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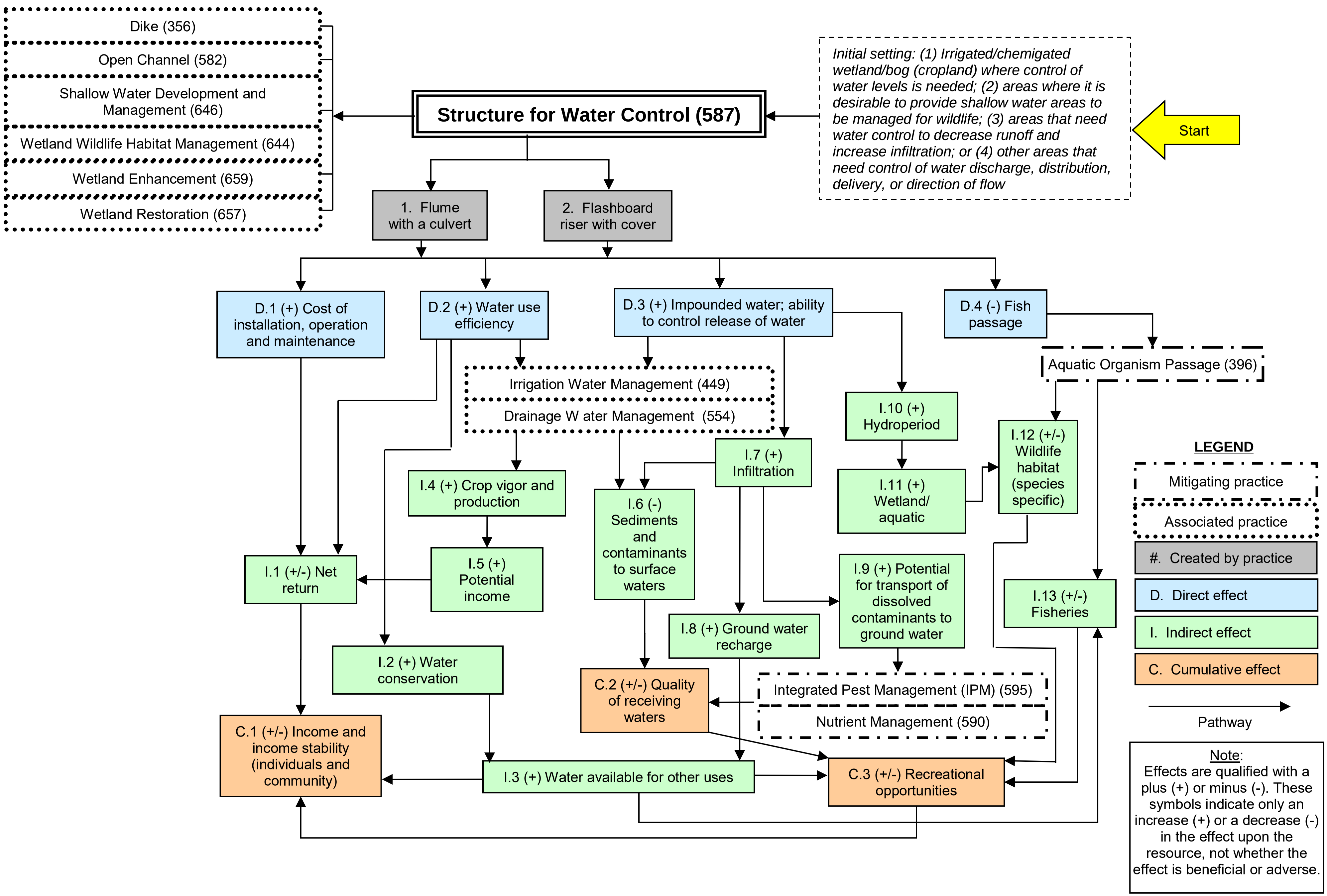

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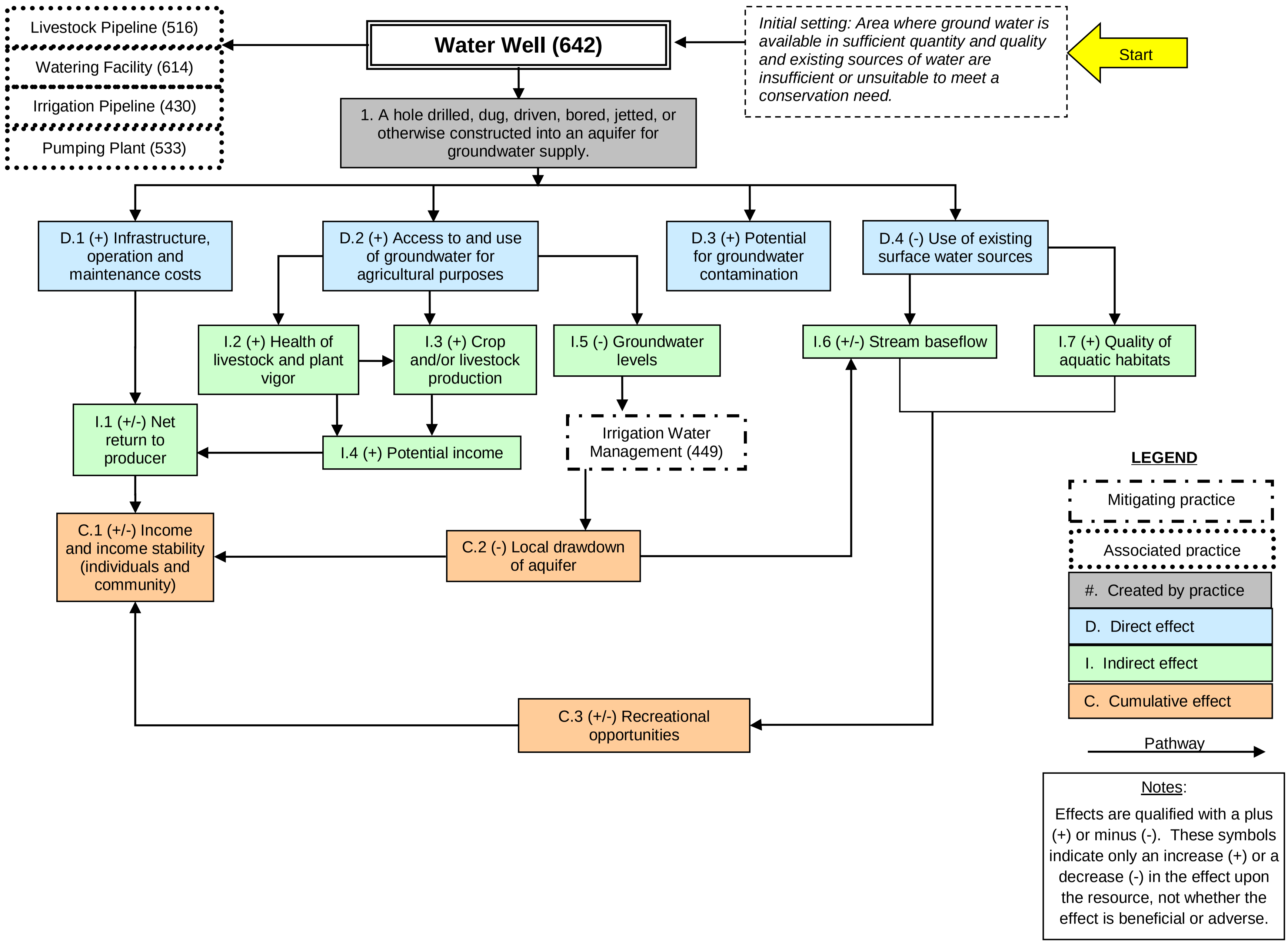

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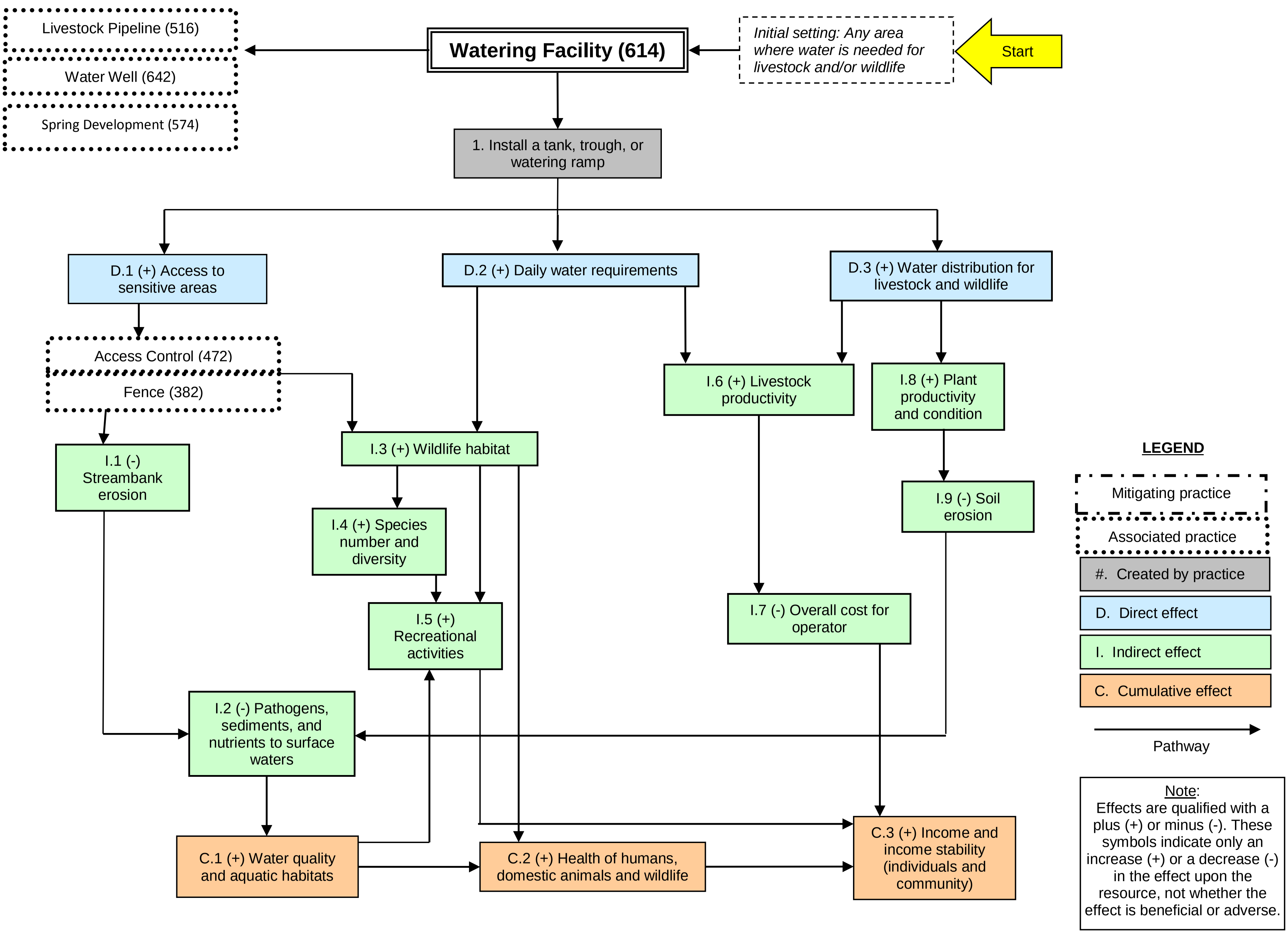
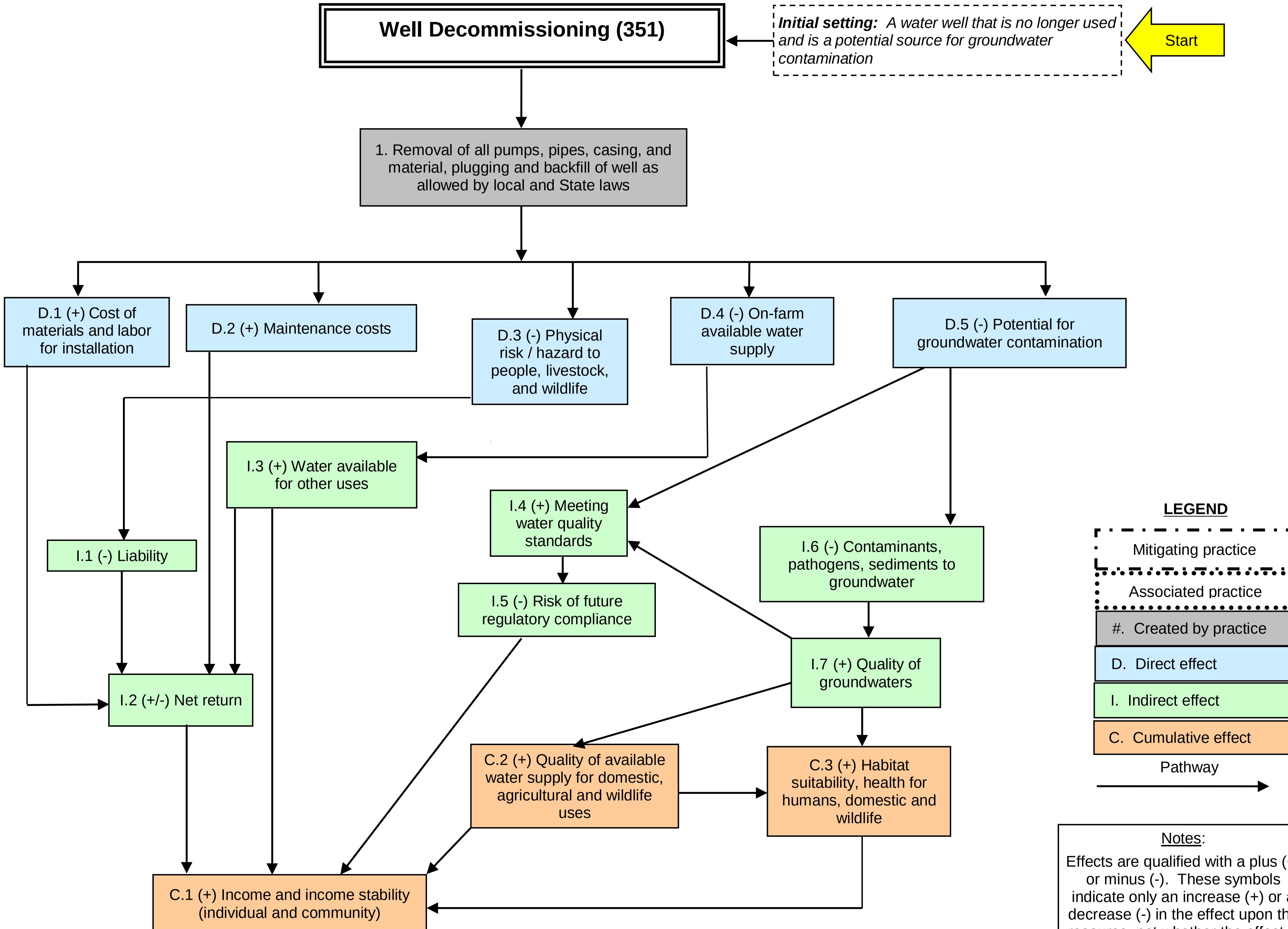


NRCS Conservation Practice Effects - Network Diagram

September 2014



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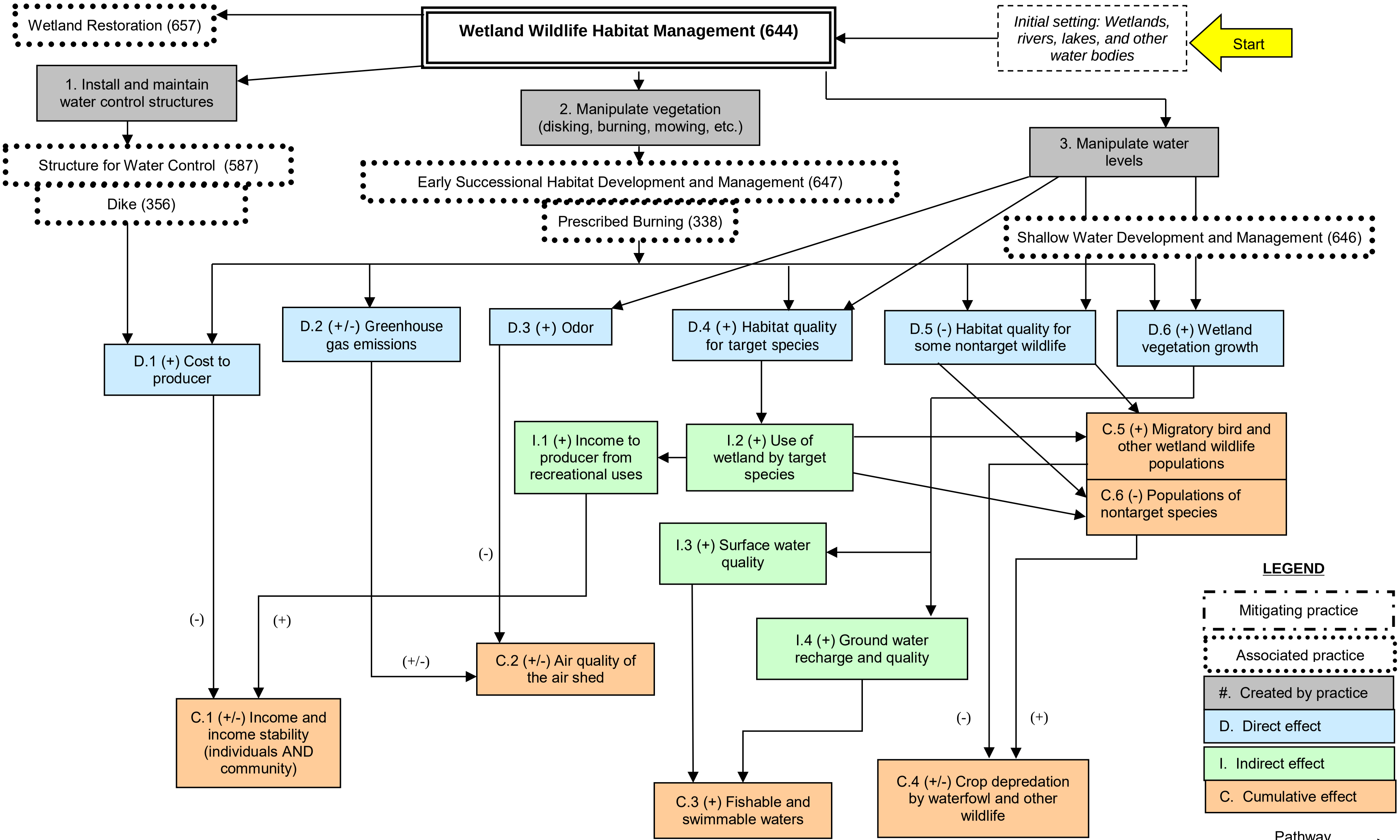
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

March 2014



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.

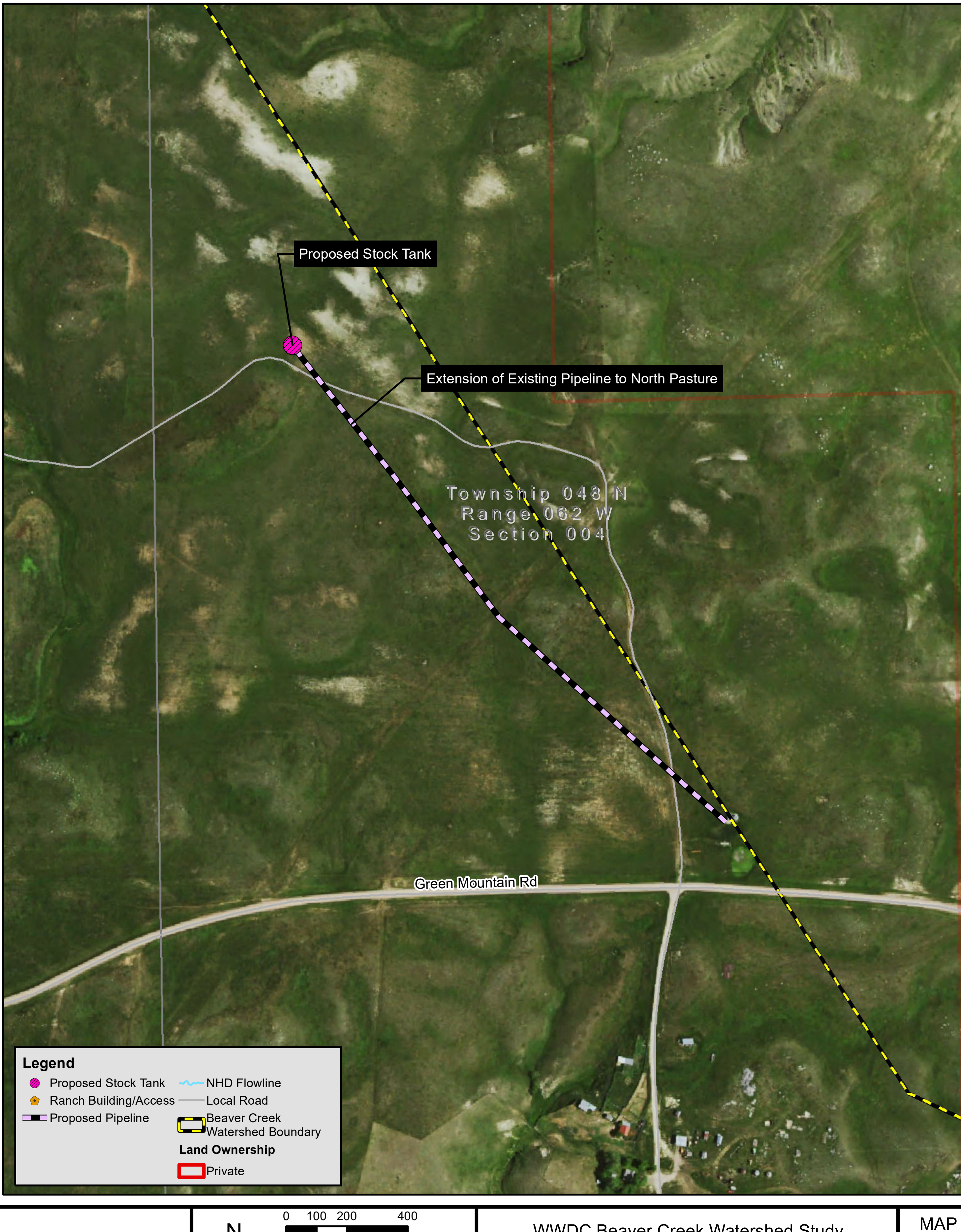
Appendix C

Improvement Project Maps

Appendix C Improvement Project Map List Sorted by Ranch Name

Landowner or Leasee	Project Number	Project Description
Bau	LWW-16.1	Surface repair of abandoned oil well
Bau	LWW-16.2	Surface repair of abandoned oil well
Bau	OMP-16.3	Plug abandoned oil well
Bayne	ISI-38.1	Irrigation system rehabilitation
Branscom	LWW-17.1	Well conversion to solar power
Branscom	LWW-17.2	New solar well pump and tank
Braun	WSS-7.1	New dam with spillway
Burleson	LWW-3.1	New pipeline and stock tanks
Calmus	LWW-12.1	Spring Rehabilitation
Cammack	LWW-1.1	Pipeline extension and stock tank
Cammack	OMP-1.2	Vegetaton restoration
Cammack	LWW-1.3	Pipeline extension and stock tanks
Cammack	LWW-1.4	Pipeline extension and stock tanks
Cammack	LWW-1.5	Spring development
Cruzen	WSS-11.1	Pond rehabilitation
Culver	LWW-26.1	New well and stock tank
Culver	ISI-26.2	Irrigation diversion rehabilitation
Engle	ISI-29.1	Rehabilitate irrigation
Frederick	OMP-13.1	Sediment basin construction
Harris	LWW-40.1	Proposed windmill conversions
Hennessey	OMP-18.1	Sedment reduction
Hiser	WSS-28.1	Proposed new stock pond
Hollenbeck	LWW-36.1	Proposed pipeline and stock tank project
Hollenbeck	WSS-36.2	Proposed pond rehabilitation
Hollenbeck	WSS-36.3	Proposed new stock pond
Inyan Kara	LWW-15.1	Inyan Kara pipeline and stock tanks
Larsen	LWW-19.1	Pipeline rehabilitation
Lewis, BJ	LWW-9.1	Pond and pipeline development
Lewis, J	LWW-4.1	Well and Pipeline Project
Livingston	ISI-33.1	Replace diversion structure
Livingston	OMP-33.2	Headcuts at Confluence of Oil and Skull Creek
Livingston	OMP-33.3	Revegetation
Merrill	LWW-23.1	Proposed livestock water supply well
Merrill	LWW-23.2	Proposed pipeline and tanks
Merrill	ISI-23.3	Proposed irrigation system
Millett	WSS-32.1	Proposed breach dam rehabilitation
Millett	WSS-32.2	Rehabilitate spreader dikes
Mills	LWW-14.1	Pipeline and stock tanks
Mills	LWW-14.2	Pipeline and stock tanks
Mills	LWW-14.3	Pipeline and stock tanks
Mills	LWW-14.4	Pipeline and stock tank
Neal	LWW-10.1	Spring development

Perino	ISI-24.1	New irrigation system
Peterson	LWW-2.1	Pipeline extension and stock tank
Popma	ISI-30.1	New irrigation system
Rawhouser	WSS-21.1	Proposed spring-fed pond
Rawhouser	LWW-21.2	Pipeline and stock tanks
Rossman	LWW-22.1	Pipeline and stock tank
Rossman	LWW-22.2	Pipeline and stock tank
Rossman	WSS-22.3	Reservoir rehabilitation
Rossman	LWW-22.4	Well conversion to solar pump
Rossman	WSS-22.5	Small reservoir rehabilitation
Sandrini	WSS-25.1	Proposed new dam
Sandrini	WSS-25.2	Pond Rehabilitation
Sandrini	LWW-25.3	Proposed new well and pipeline rehabilitation
Schaeffer	WSS-8.1	Dam rehabilitation
Schaeffer	ISI-8.2	Rehabilitate spreader dikes
Simon	LWW-37.1	Conversions to solar pumps
Simon	WSS-37.2	Proposed pit excavations
Simon	WSS-37.3	Proposed pond rehabilitations
Sudbrink	LWW-34.1	Proposed expansion of pipeline and tanks
Sudbrink	LWW-34.2	Proposed spring rehabilitation
Tavegia/Geier	LWW-6.1	New well, pipeline and stock tank
Thares	WSS-41.1	Pond rehabilitation
Tidyman	ISI-35.1	Proposed new irrigation system
Tidyman	LWW-35.2	Proposed pipeline and stock tank
Tidyman	WSS-35.3	Proposed new headgate and pond
Tlustos	WSS-5.1	Proposed new pond
Tysdal	LWW-39.1	Proposed pipeline and storage tank project
Tysdal	WSS-39.2	Breached Dam Repair
Vore	LWW-31.1	Pipeline, storage and stock tanks
Weyrich	OMP-20.1	Wildlife and vegetation restoration



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Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

OLSSON ASSOCIATES

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Cammack Ranch

MAP 1.1

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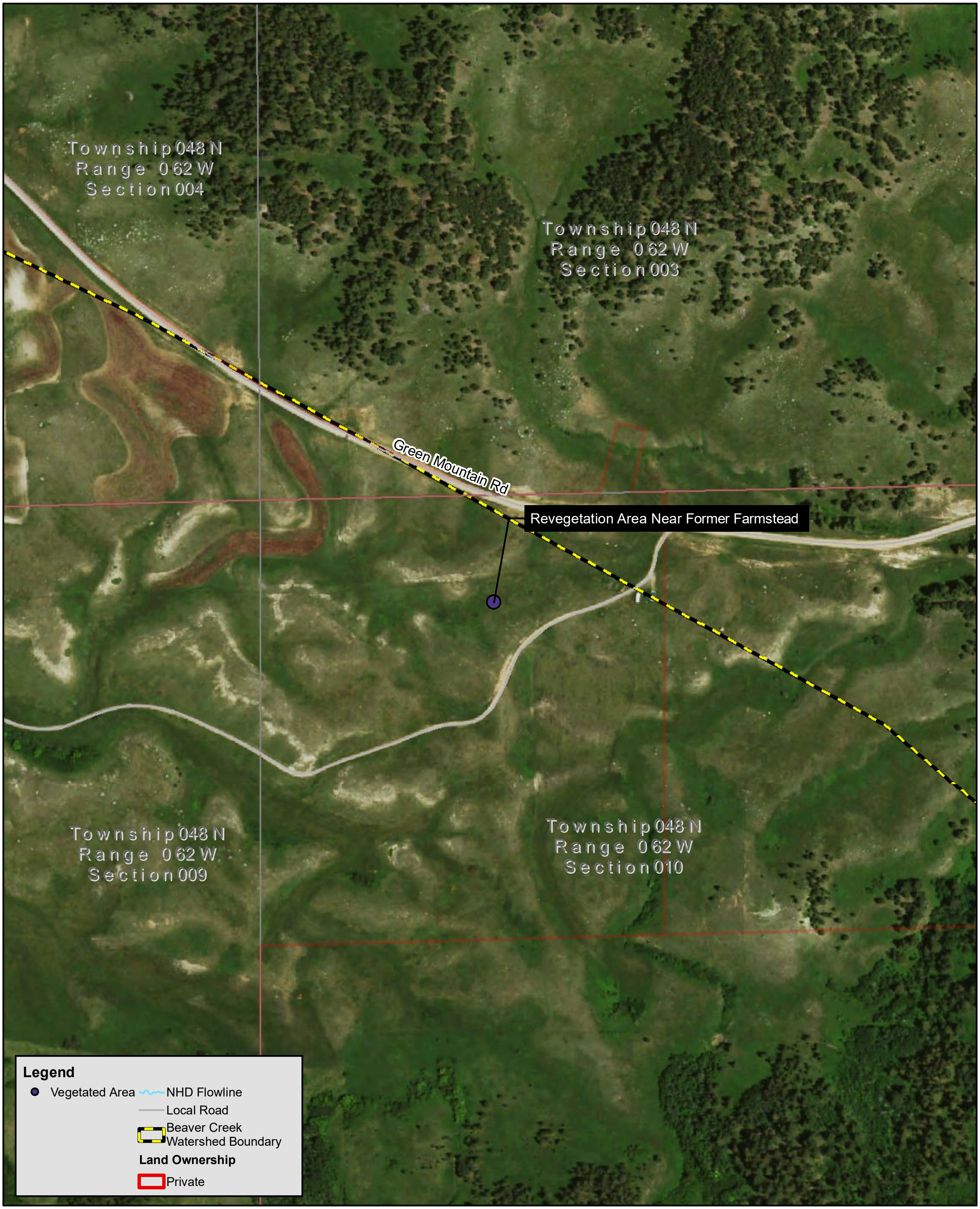

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USDA NAIP Wyoming 2016

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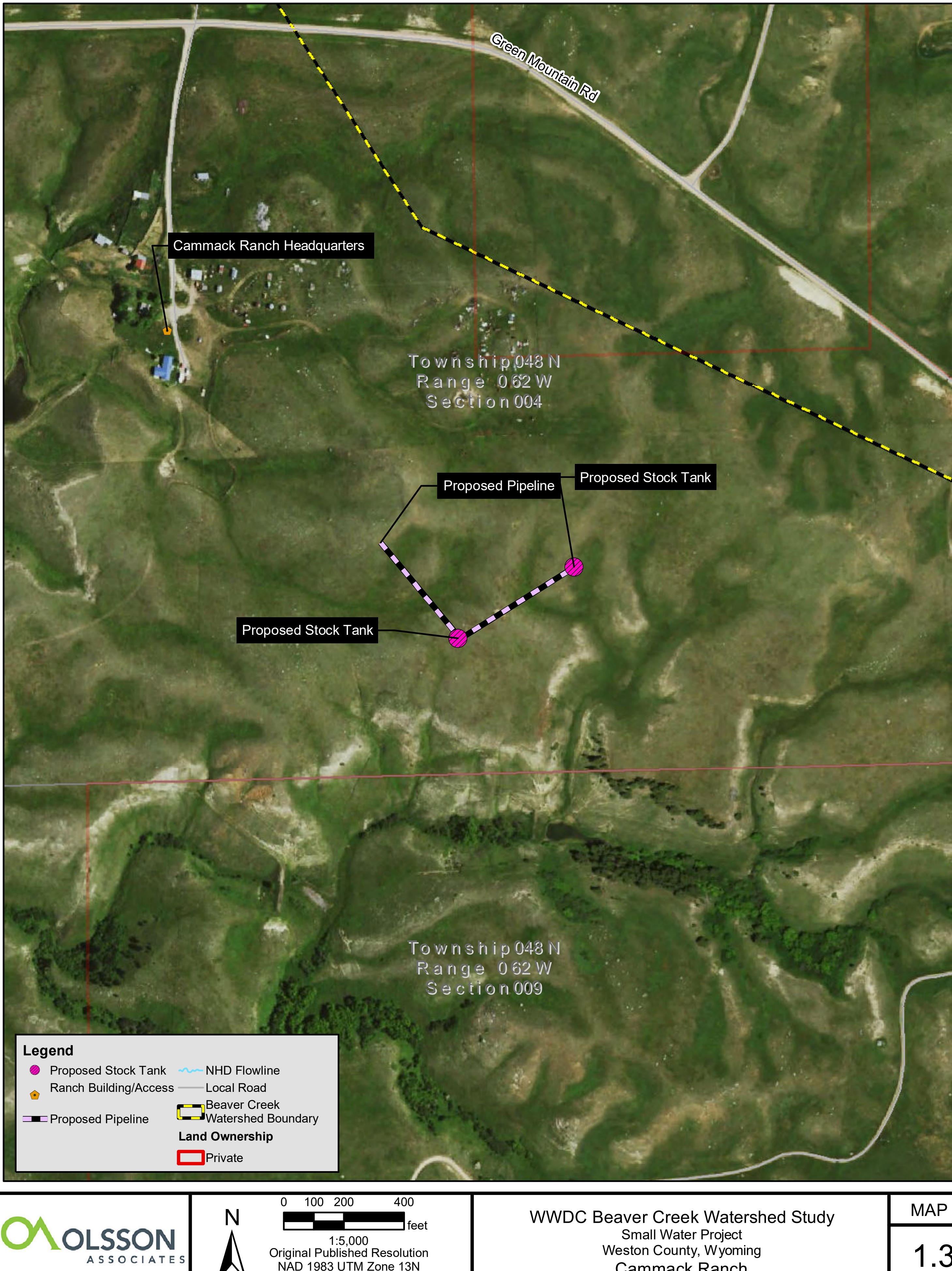
Small Water Project
Weston County, Wyoming
Cammack Ranch

MAP
1.2



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OLSSON ASSOCIATES

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Cammack Ranch

MAP
1.3

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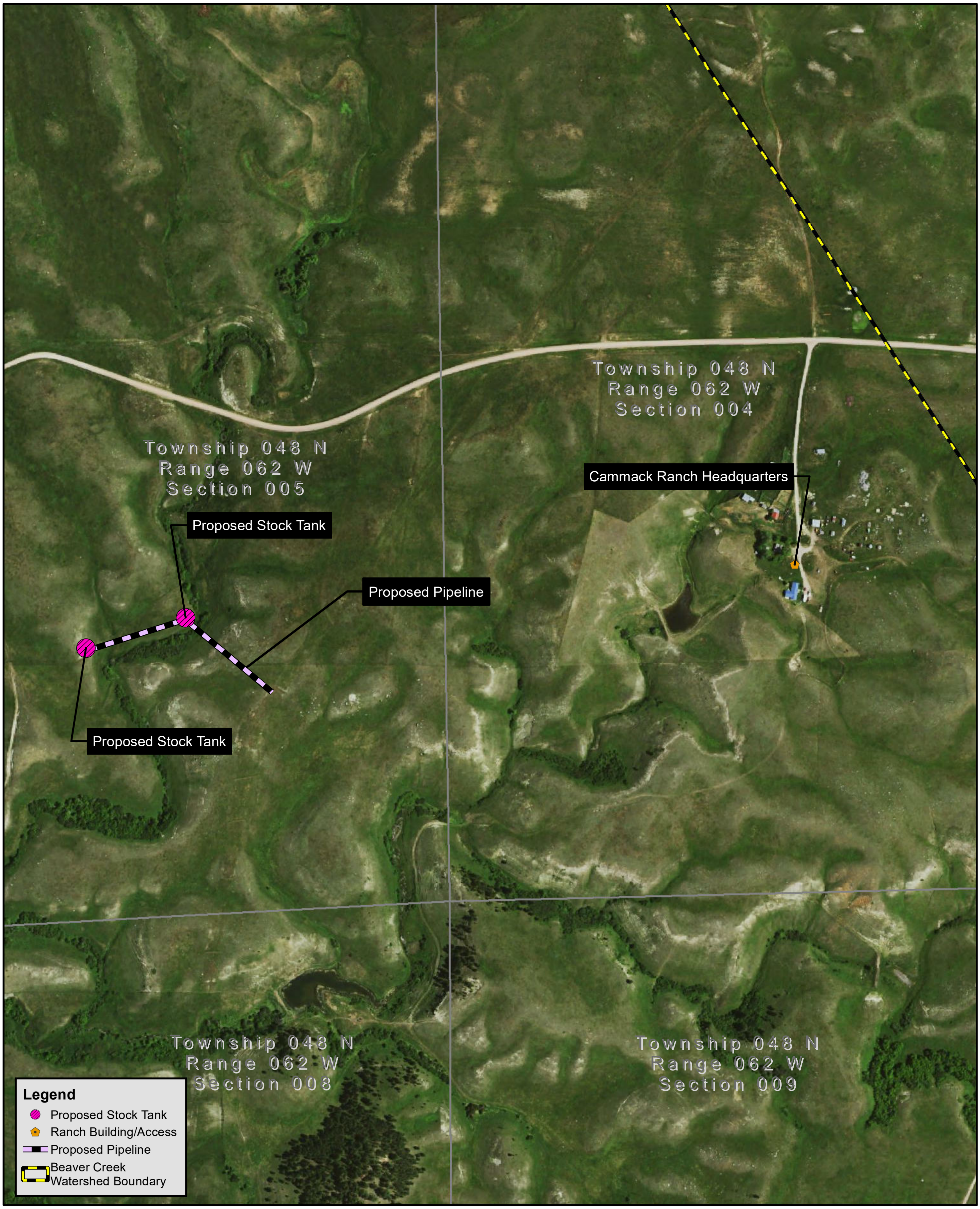

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OLSSON ASSOCIATES

N

0 100 200 400 feet

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NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Cammack Ranch

MAP 1.4

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1:5,000
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USDA NAIP Wyoming 2016

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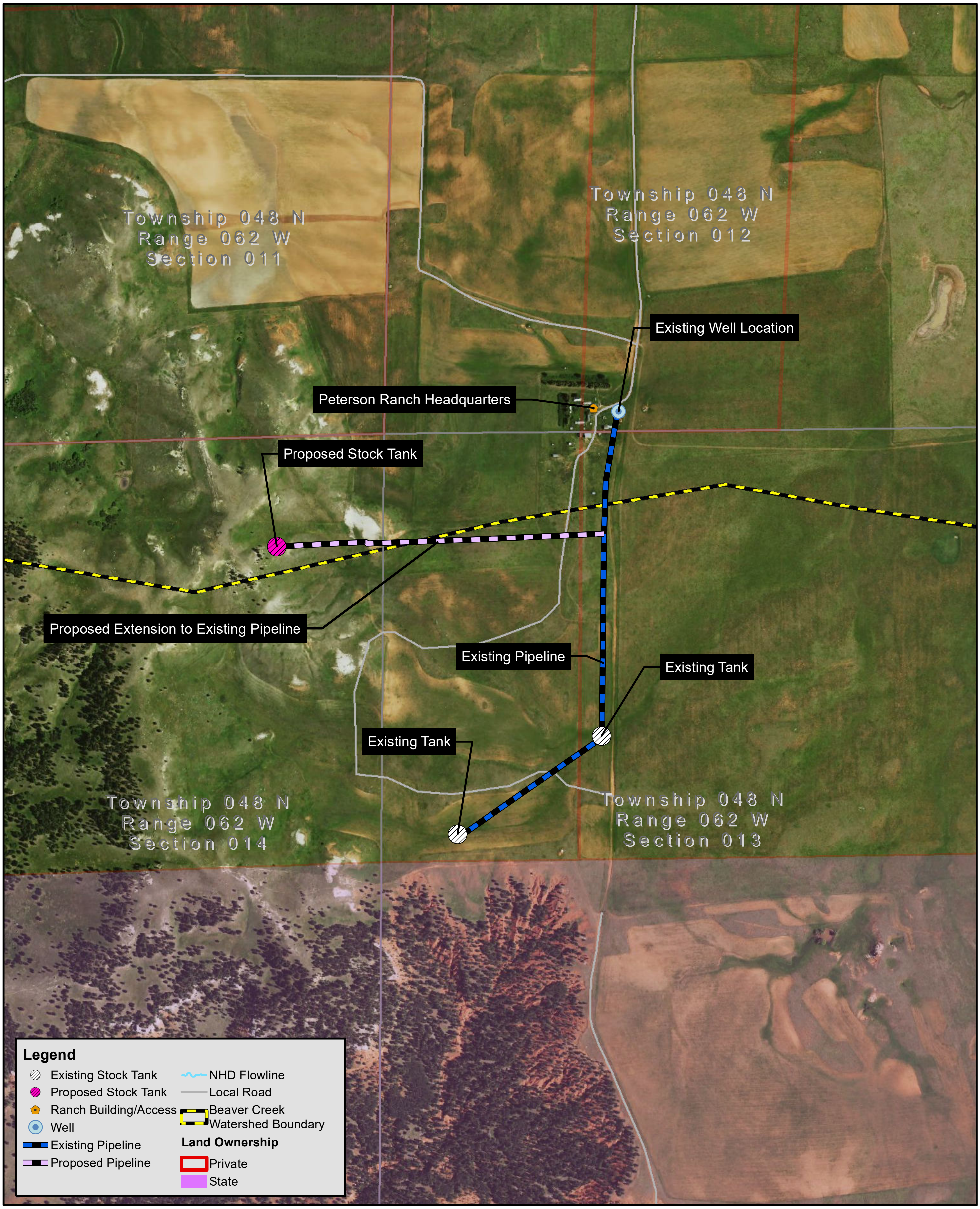
Small Water Project
Weston County, Wyoming
Cammack Ranch

MAP 1.5



OLSSON ASSOCIATES

N

0 200 400 800 feet

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USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Peterson Ranch

MAP
2.1

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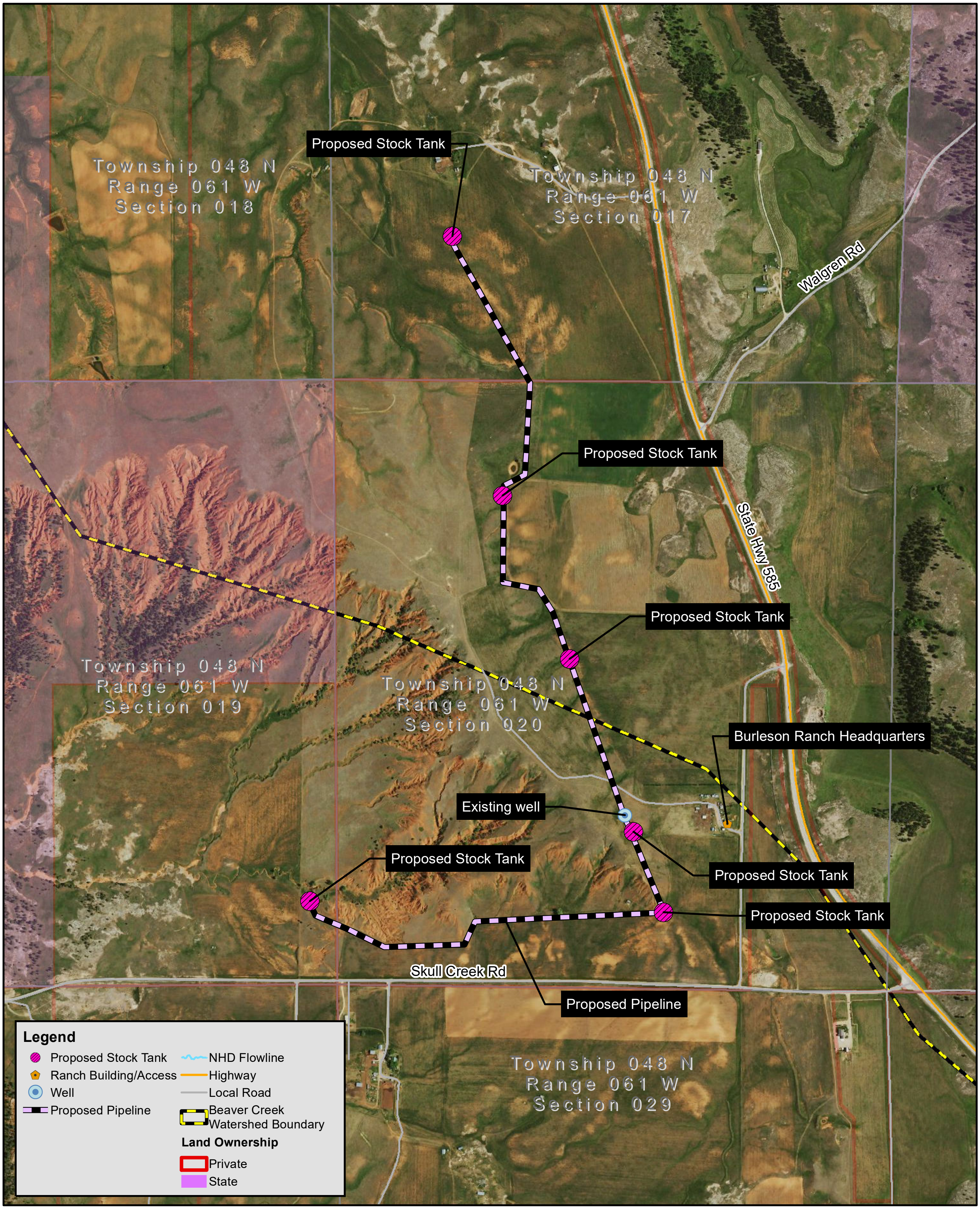

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OLSSON ASSOCIATES

N

0 200 400 800 feet

1:14,000
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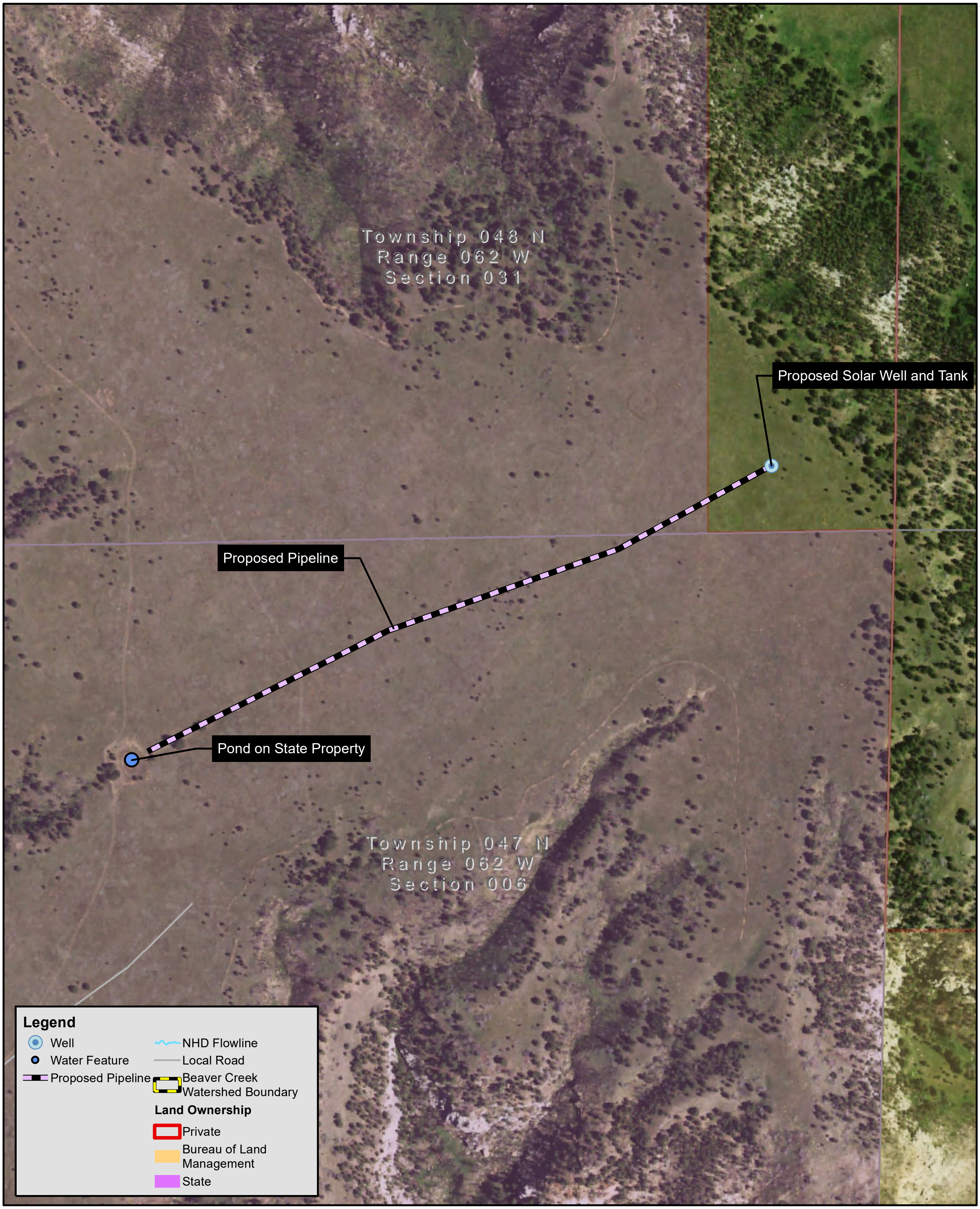
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Burleson Ranch

MAP
3.1



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OLSSON ASSOCIATES

N

0 100 200 400 feet

1:5,000
Original Published Resolution
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USDA NAIP Wyoming 2016

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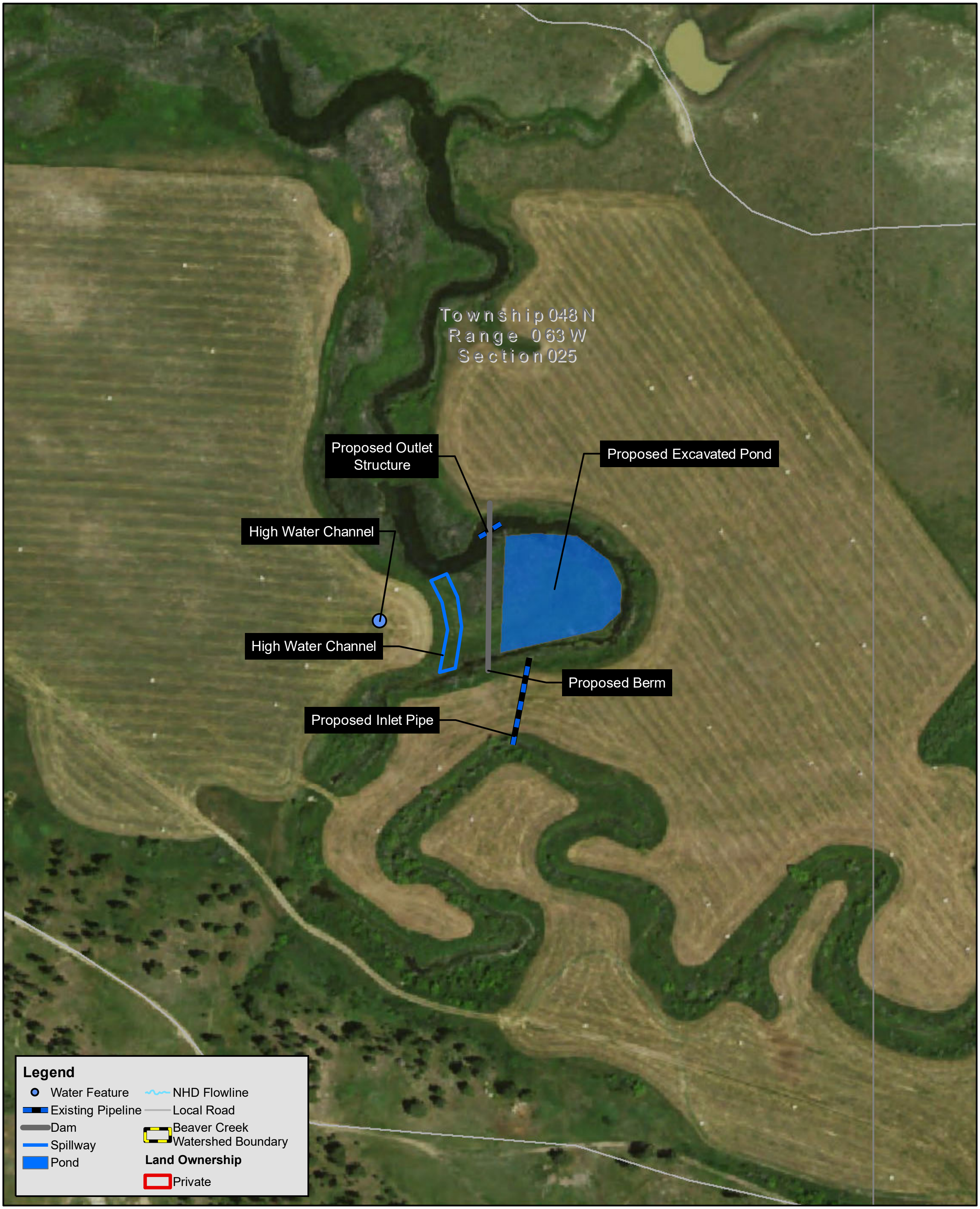
Small Water Project
Weston County, Wyoming
Lewis (James) Ranch

MAP
4.1



OLSSON ASSOCIATES

N

0 100 200 feet

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USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Tlustos Ranch

MAP 5.1

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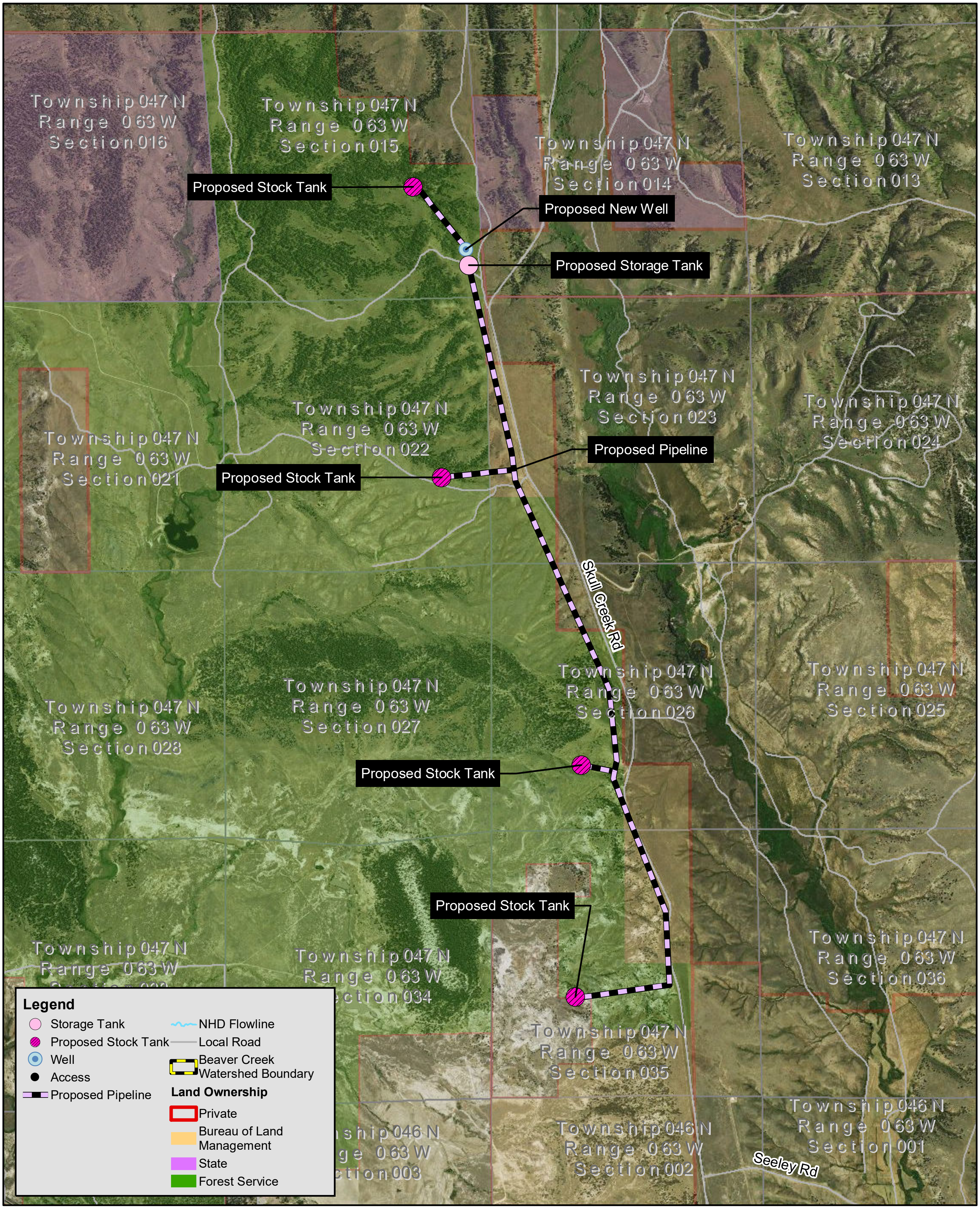

OLSSON ASSOCIATES

N

0 600 1,200 2,400 feet

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USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Tavegia Ranch

MAP
6.1

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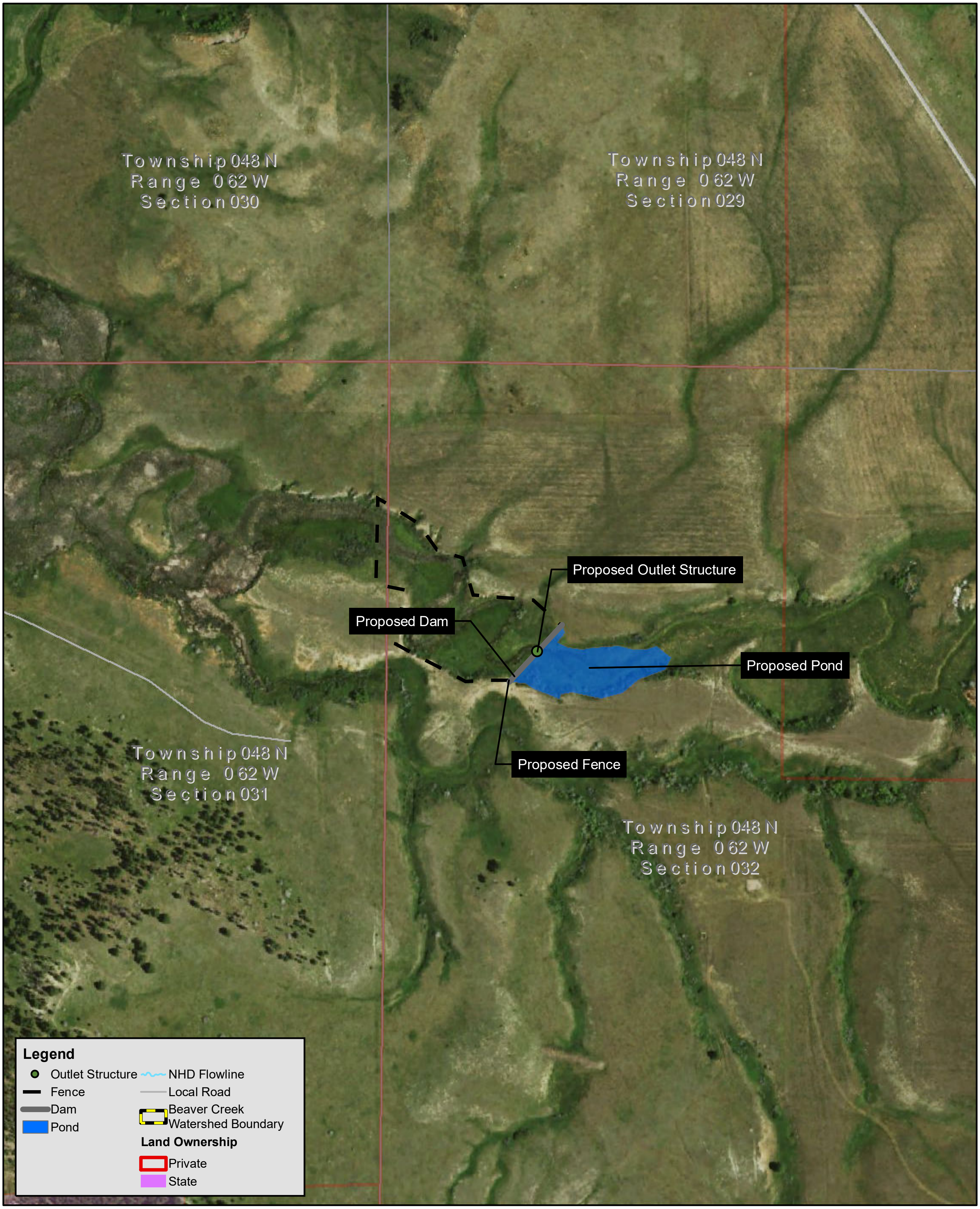

OLSSON ASSOCIATES

N

0 100 200 400 feet

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Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Braun Ranch

MAP 7.1

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OLSSON ASSOCIATES

N

0 45 90 feet

1:1,200
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

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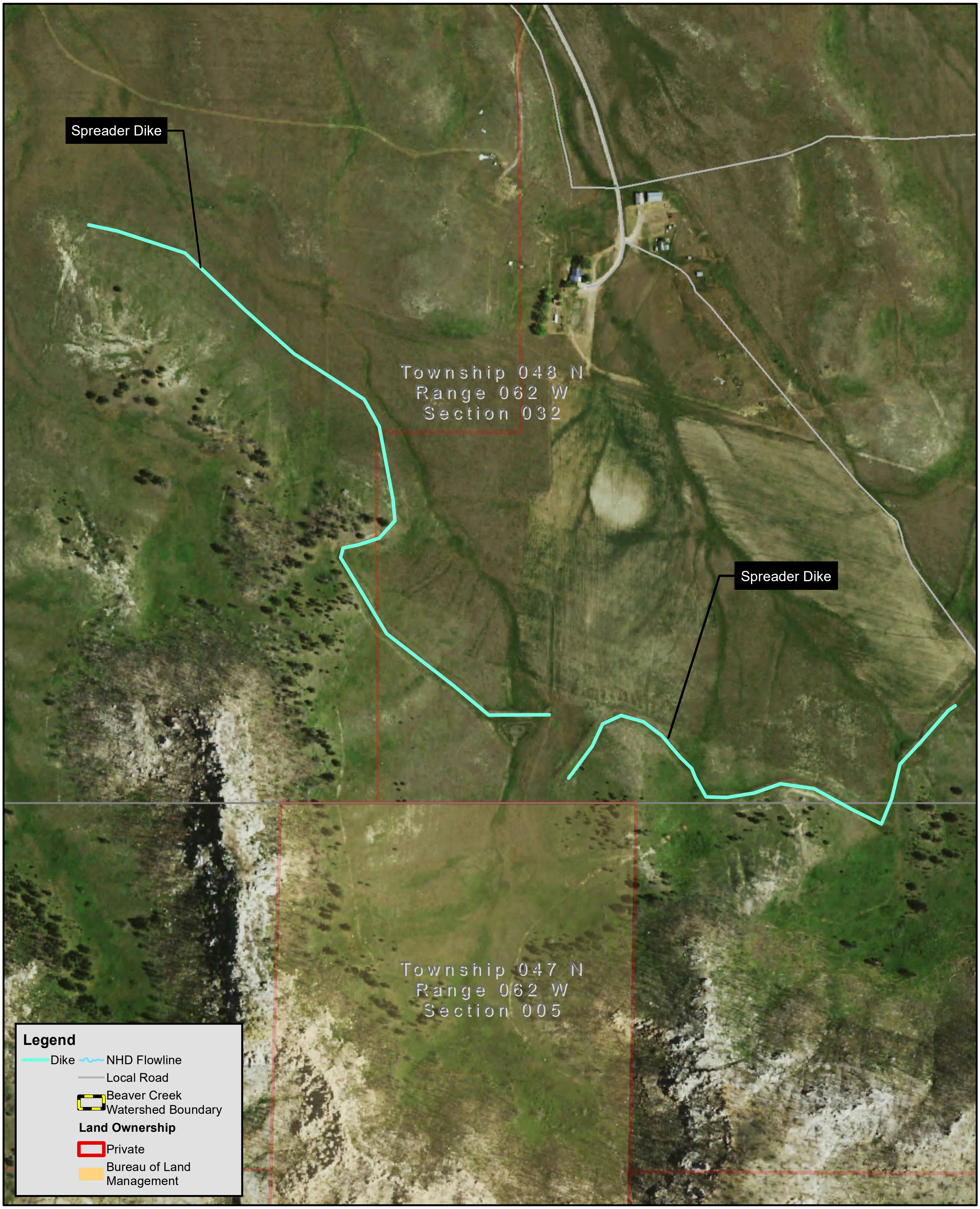
Small Water Project
Weston County, Wyoming
Schaeffer Ranch

MAP 8.1



OLSSON ASSOCIATES

N

0 100 200 400 feet

1:5,500
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USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Schaeffer Ranch

MAP
8.2

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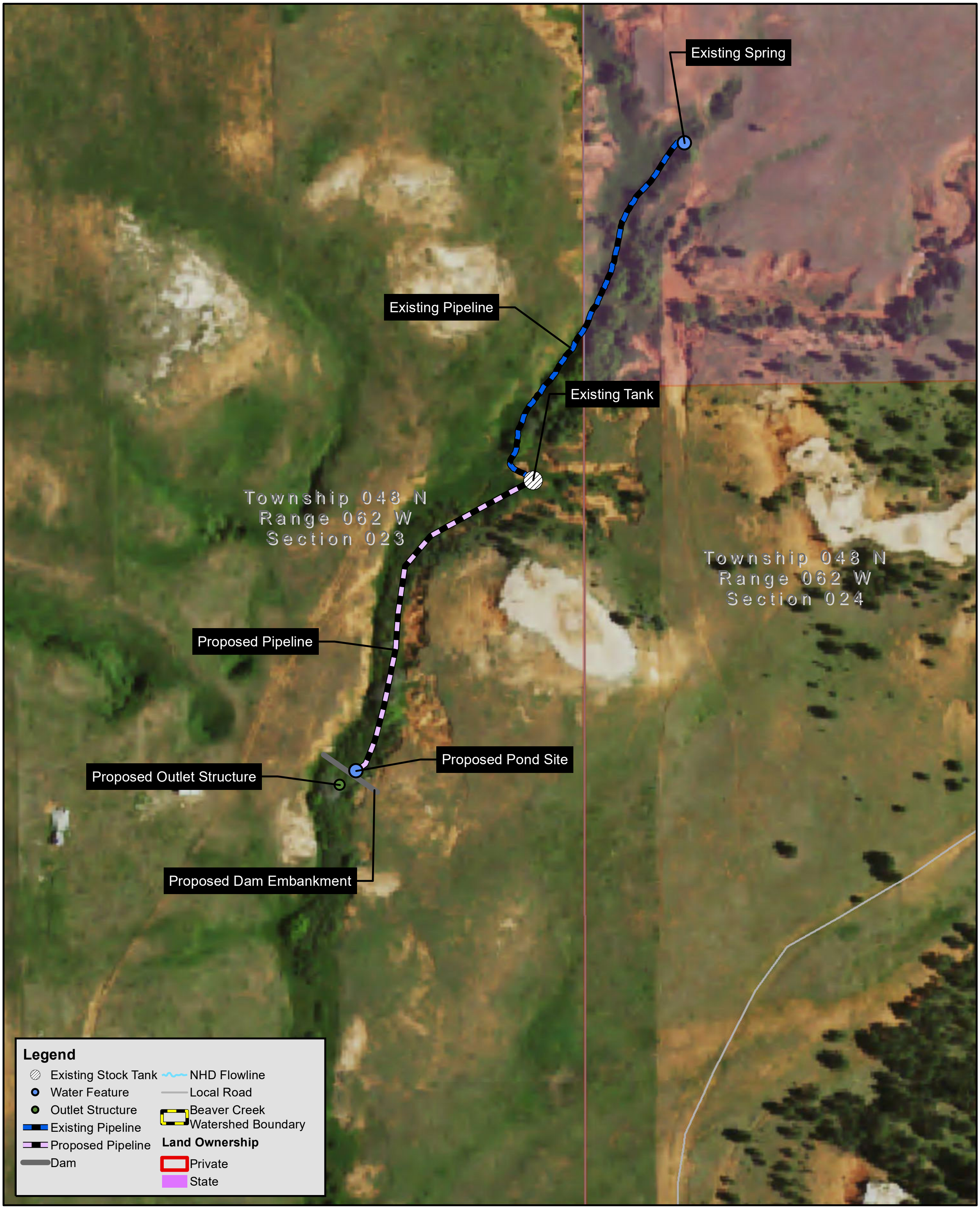

OLSSON ASSOCIATES

N

0 80 160 feet

1:2,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Lewis (Betty Jean) Ranch

MAP
9.1

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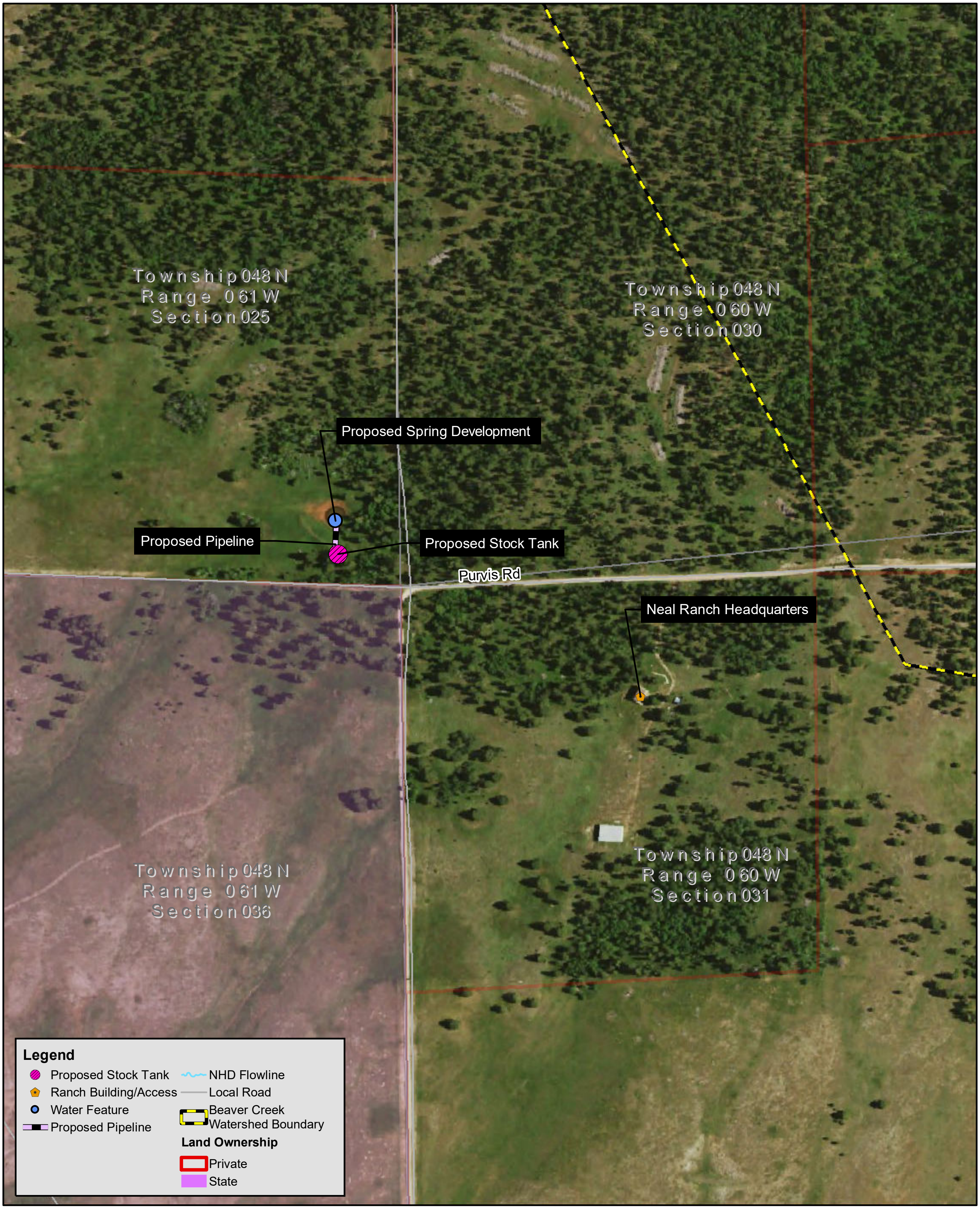

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OLSSON ASSOCIATES

N

0 100 200 400 feet

1:5,000
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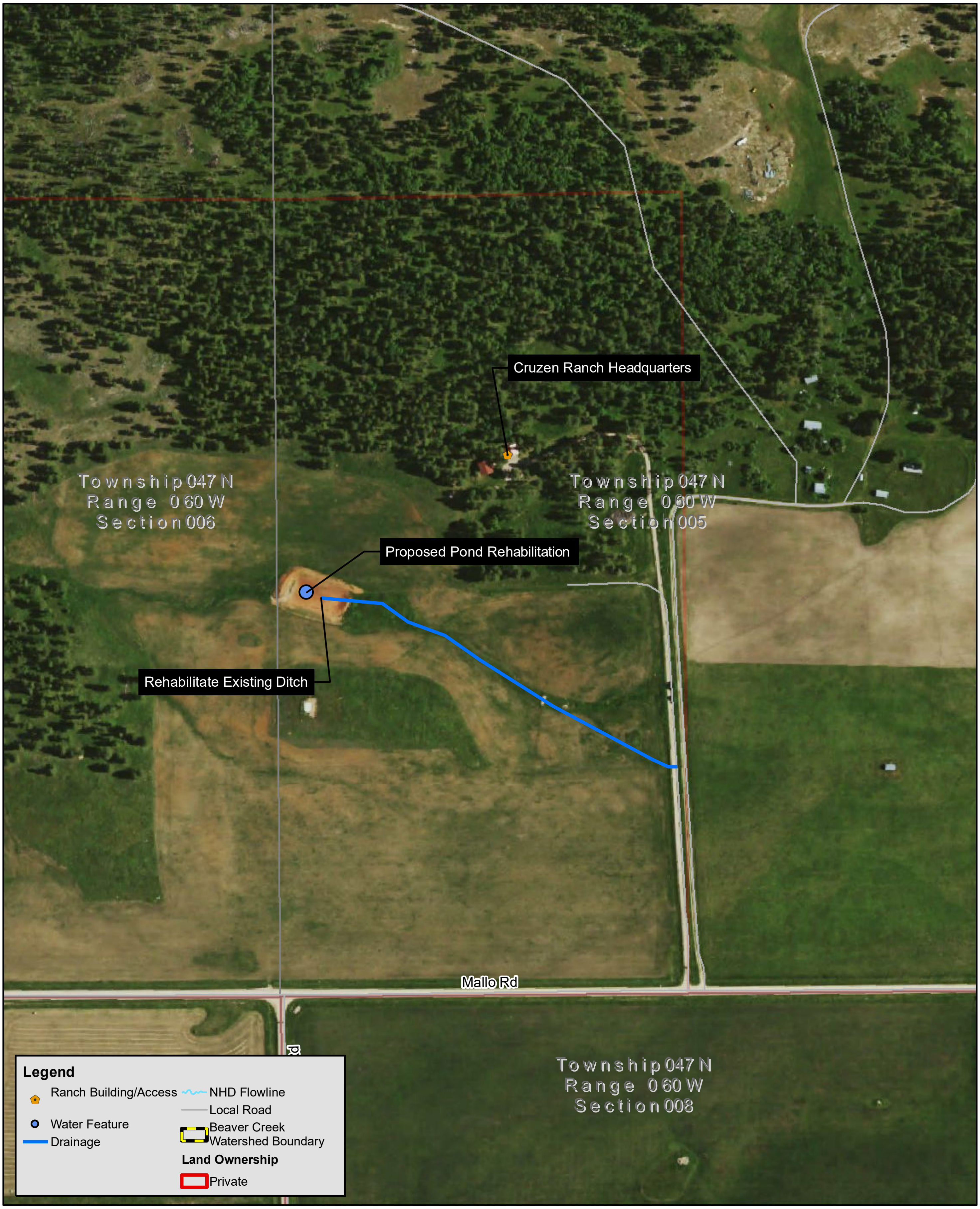
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Neal Ranch

MAP
10.1



OLSSON ASSOCIATES

N

0 100 200 400 feet

1:5,000
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NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Cruzen Ranch

MAP
11.1

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OLSSON ASSOCIATES

N

0 60 120 feet

1:1,500
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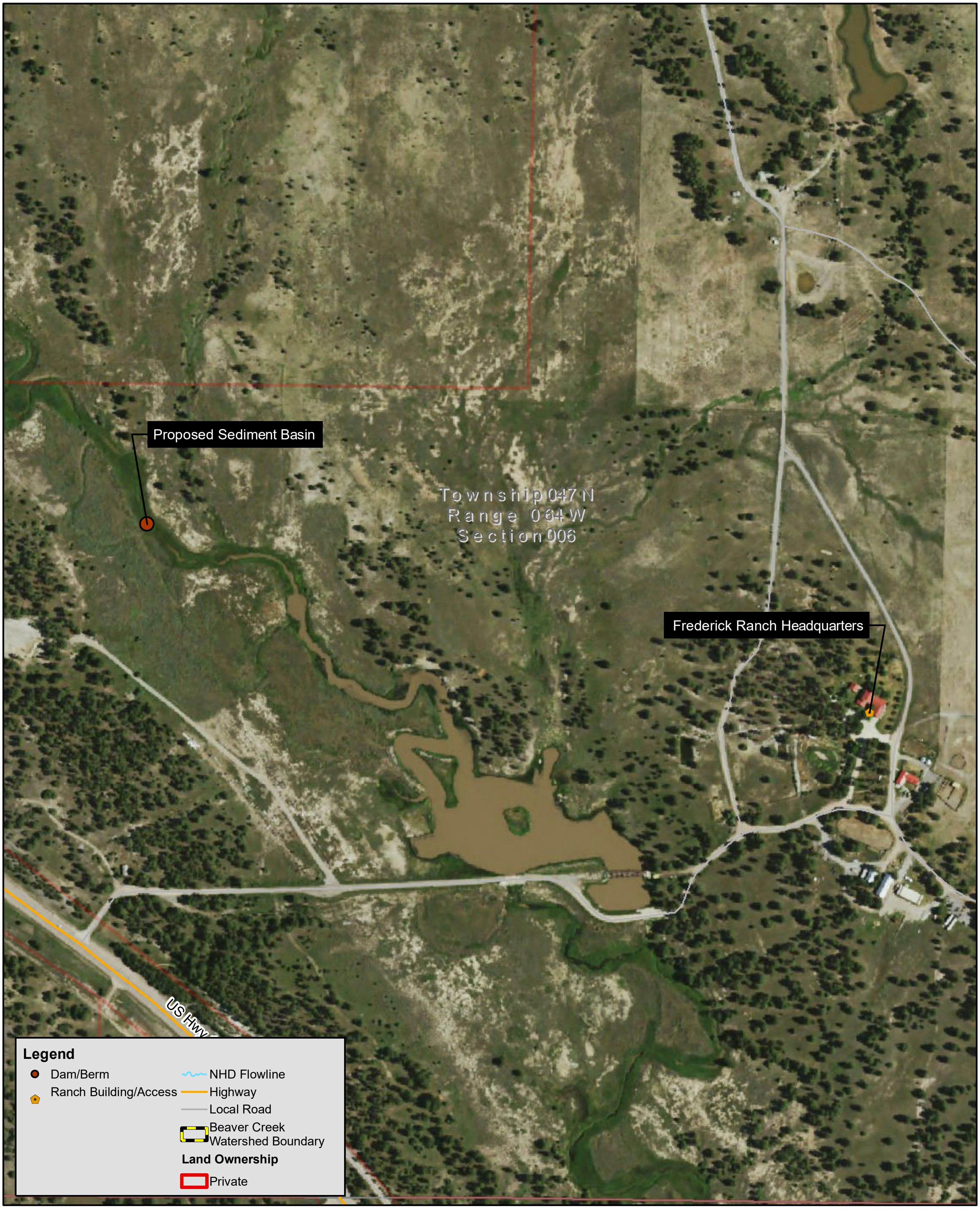
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Calmus Ranch

MAP
12.1



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OLSSON ASSOCIATES

N

0 100 200 400 feet

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USDA NAIP Wyoming 2016

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Small Water Project
Weston County, Wyoming
Frederick Ranch

MAP
13.1

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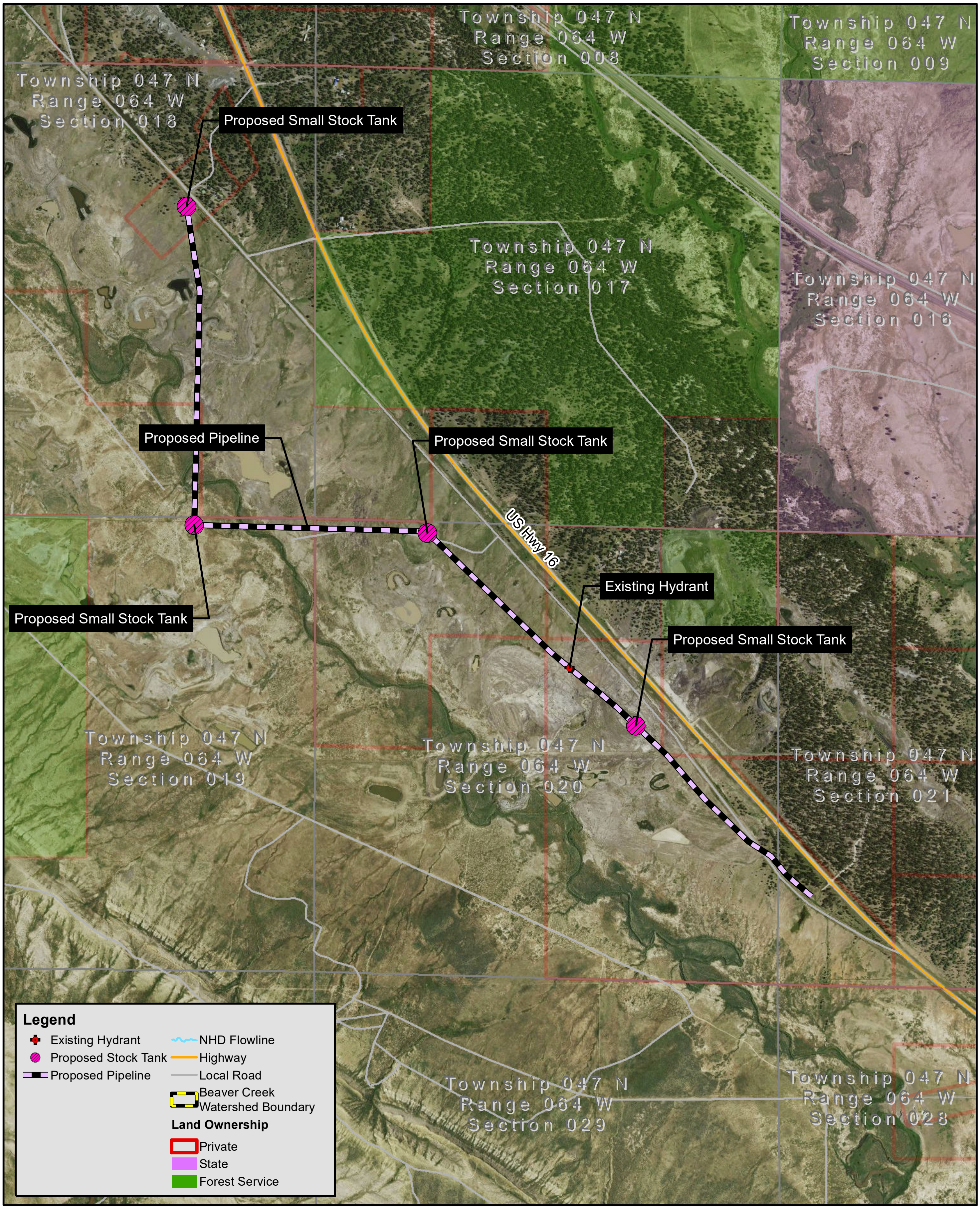

OLSSON ASSOCIATES

N

0 300 600 1,200 feet

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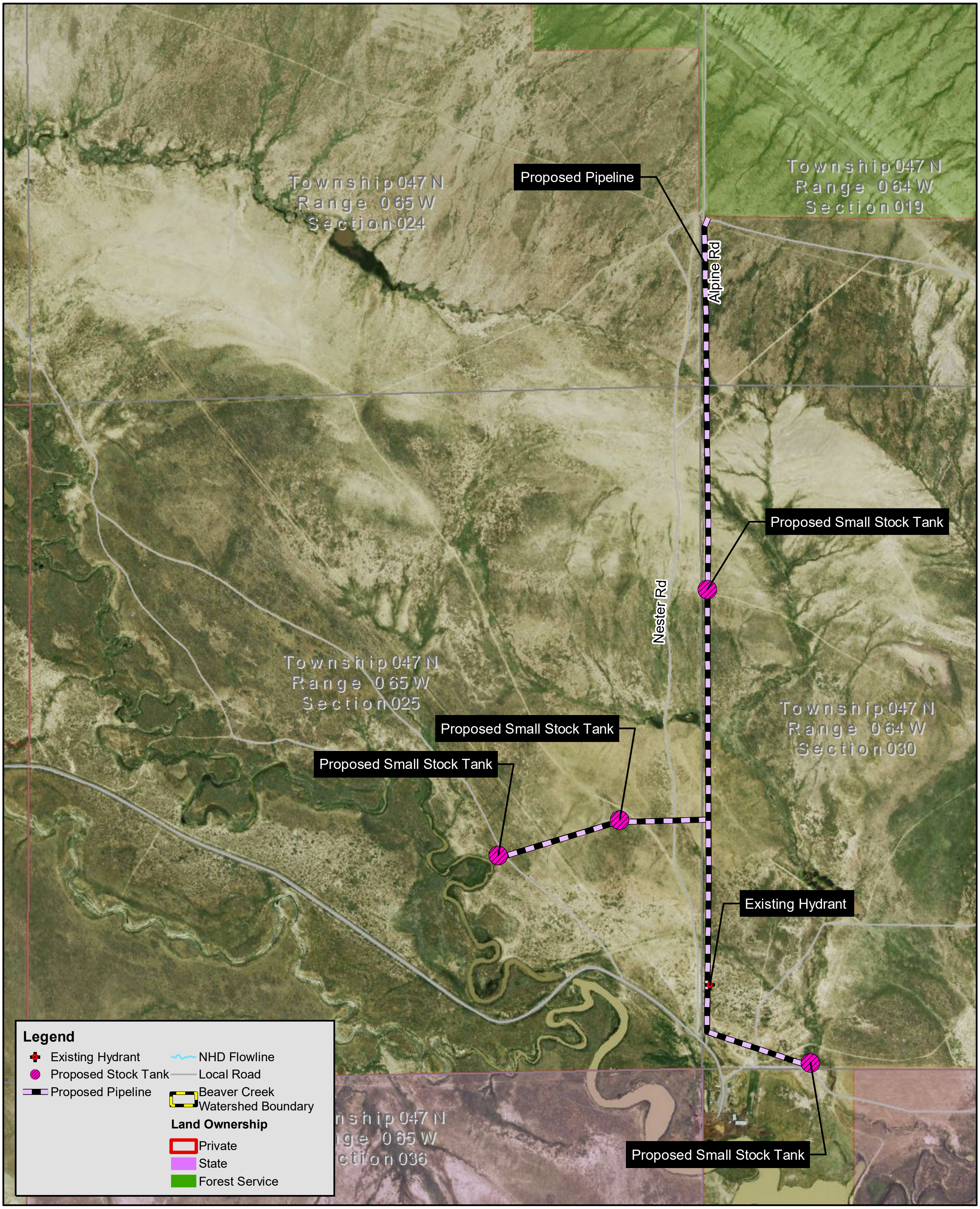
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Mills Ranch

MAP
14.1



N

0 200 400 800 feet

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WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Mills Ranch

MAP
14.2

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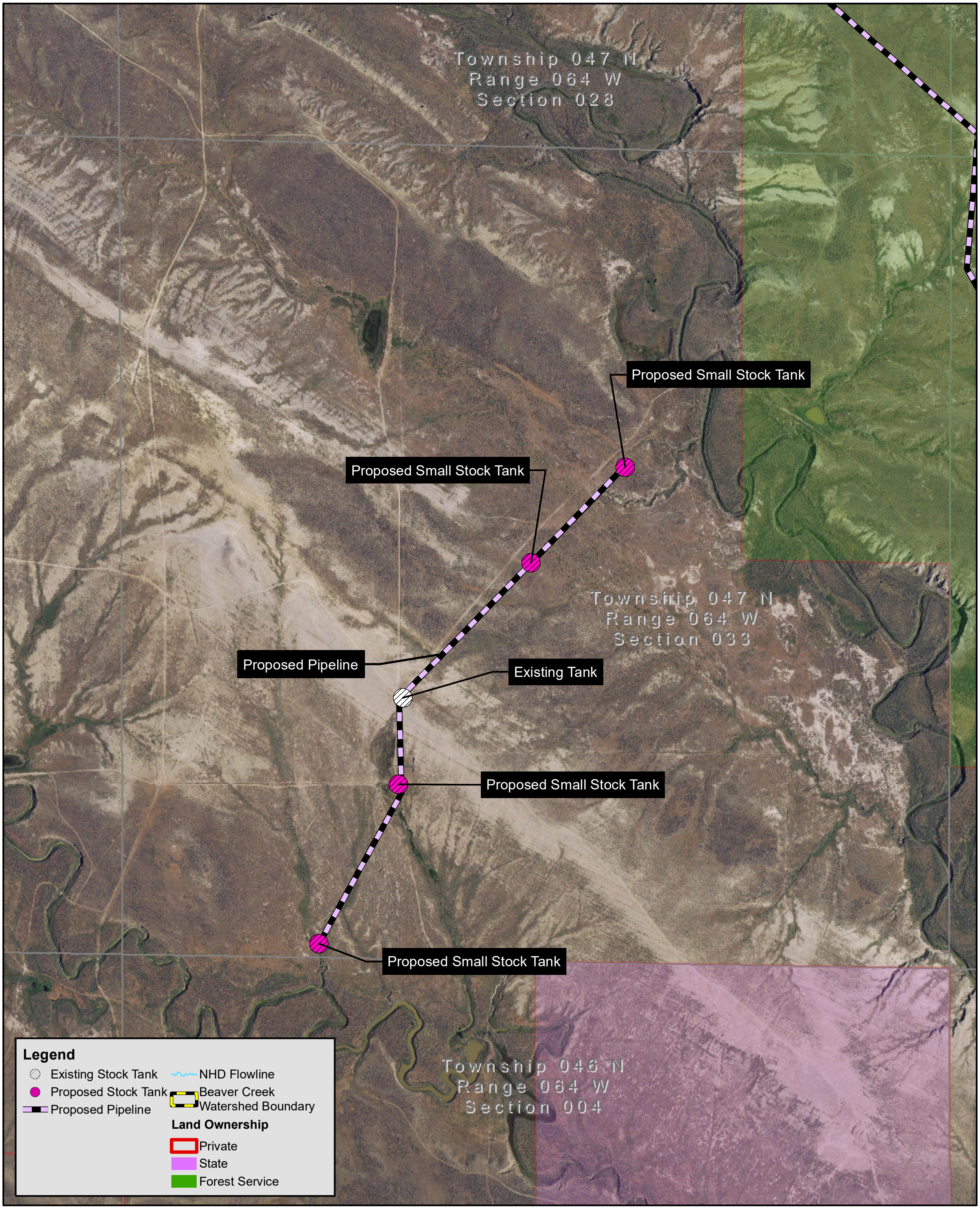

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OLSSON ASSOCIATES

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Mills Ranch

MAP
14.3

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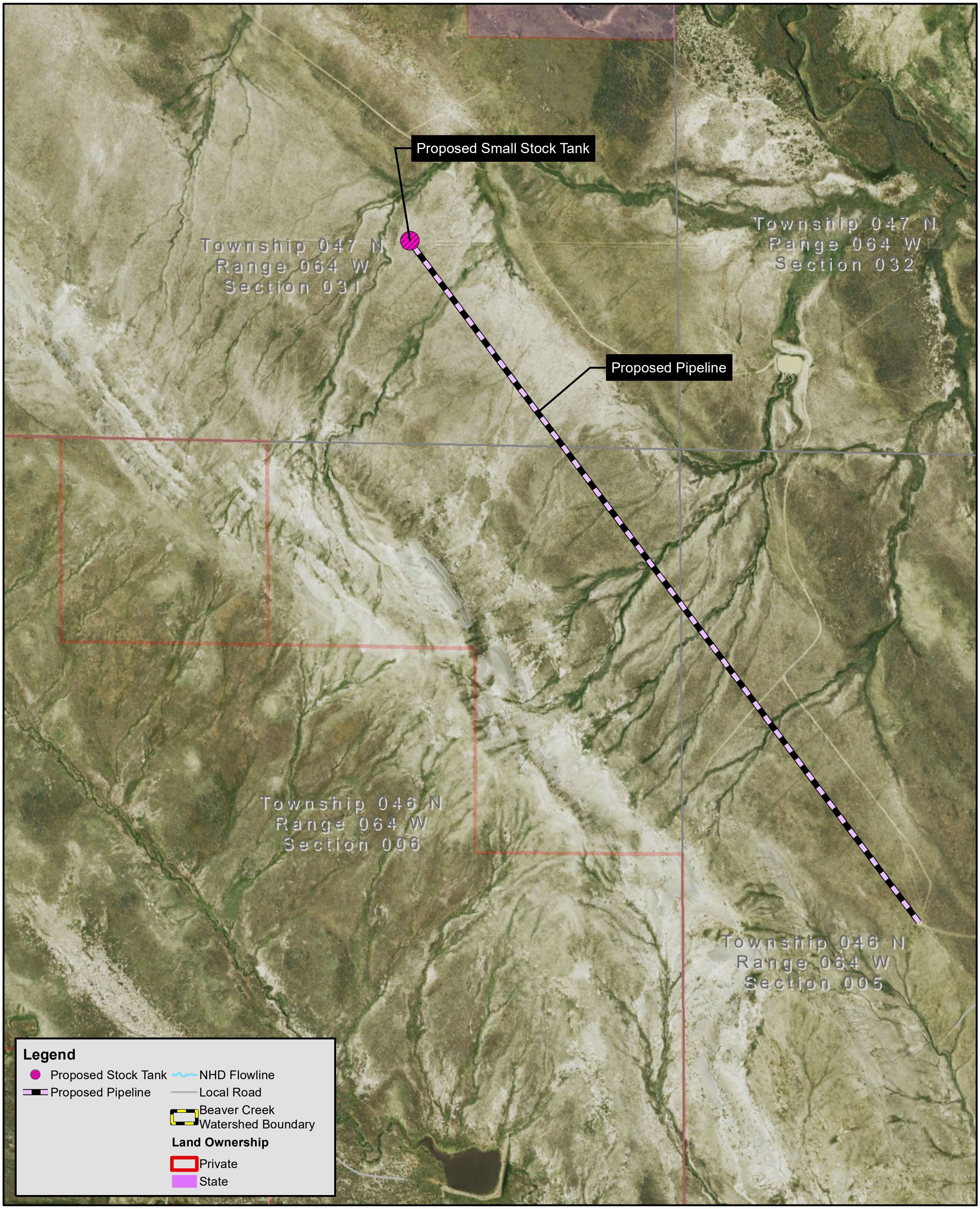

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WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Mills Ranch

MAP
14.4

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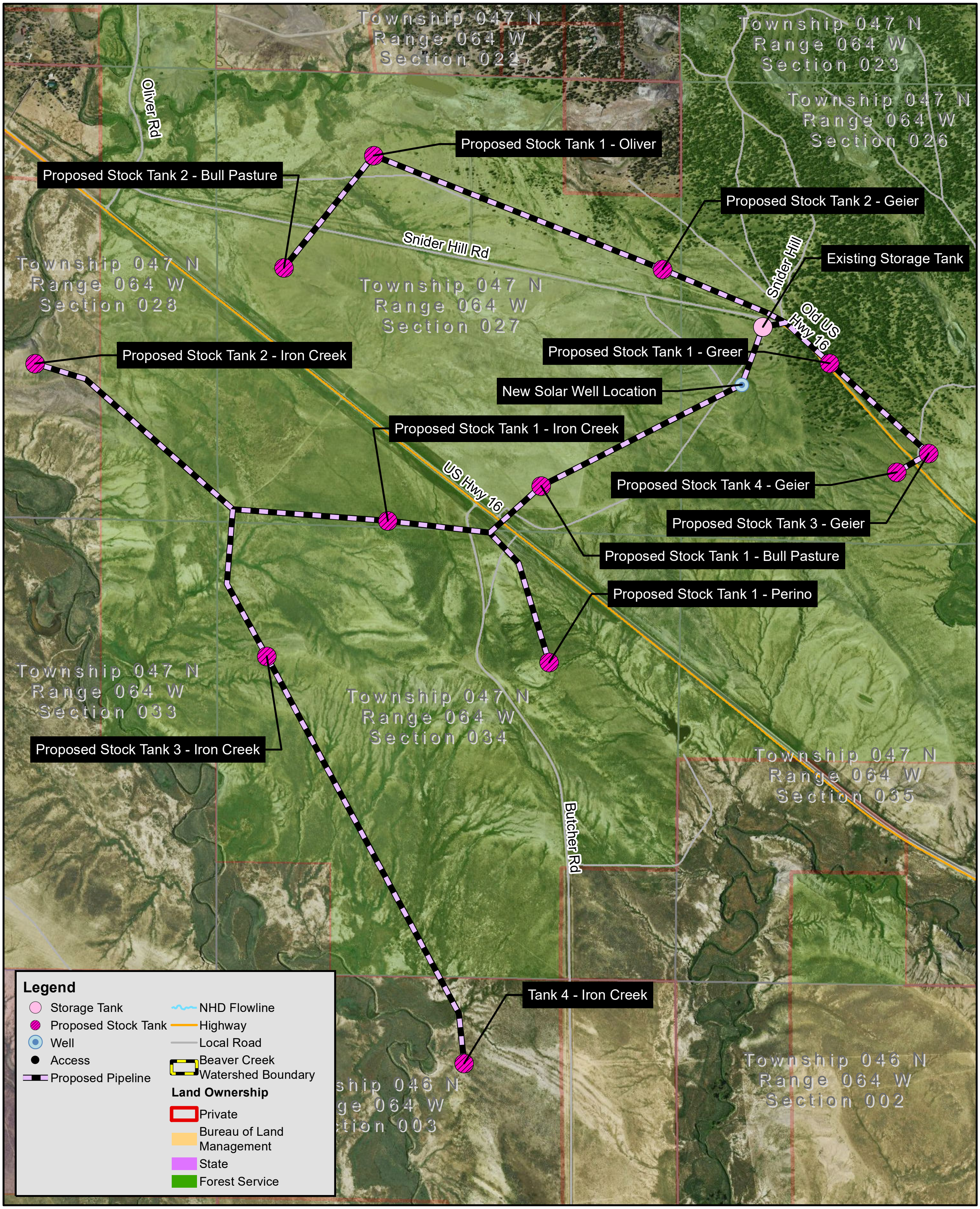

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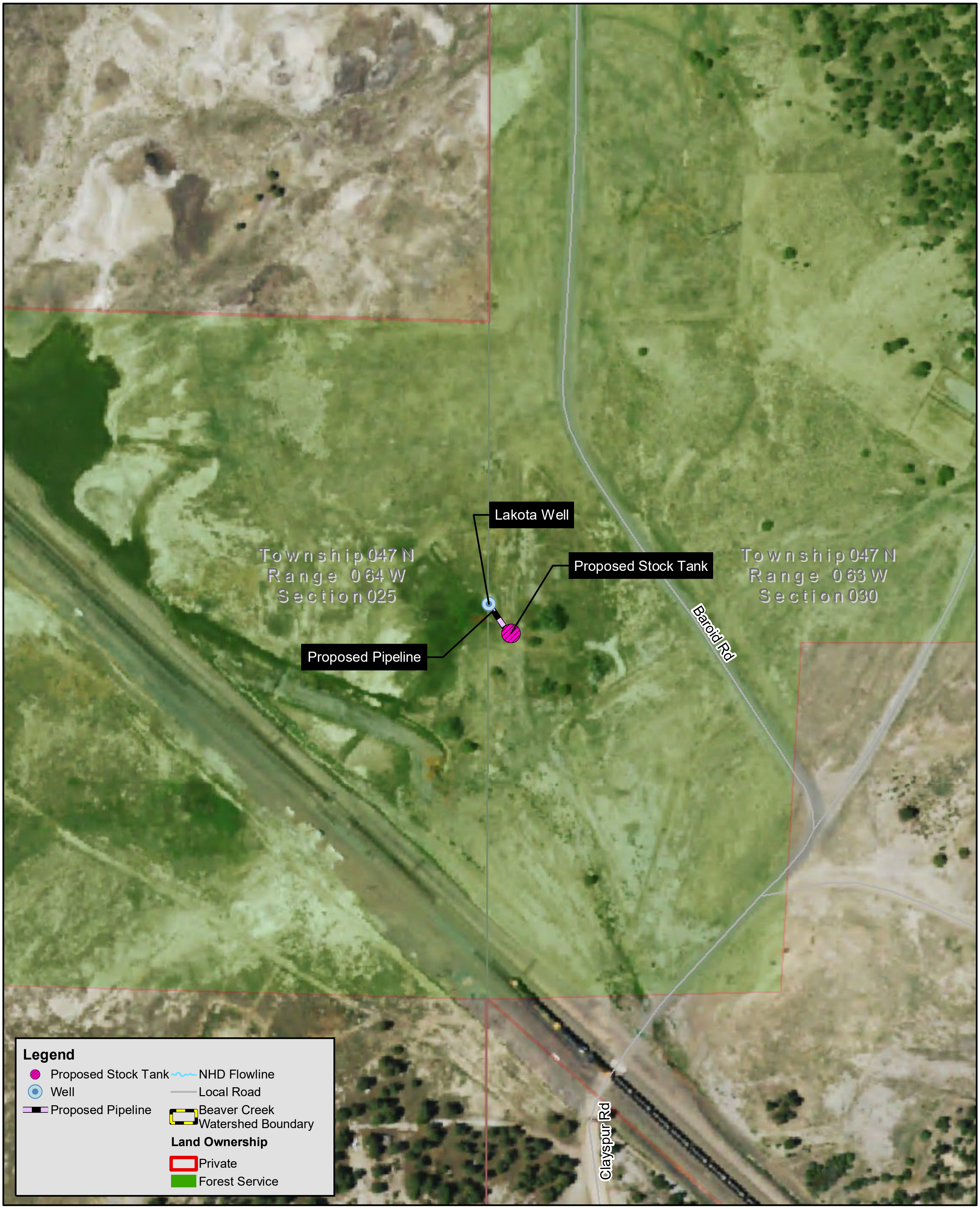
Small Water Project
Weston County, Wyoming
Inyan Ranch

MAP
15.1



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OLSSON ASSOCIATES

N

0 100 200 feet

1:3,000
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USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Bau Ranch

MAP 16.1

OLSSON ASSOCIATES

N

0 80 160 feet

1:2,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Bau Ranch

MAP
16.2

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OLSSON ASSOCIATES

N

0 80 160 feet

1:2,000
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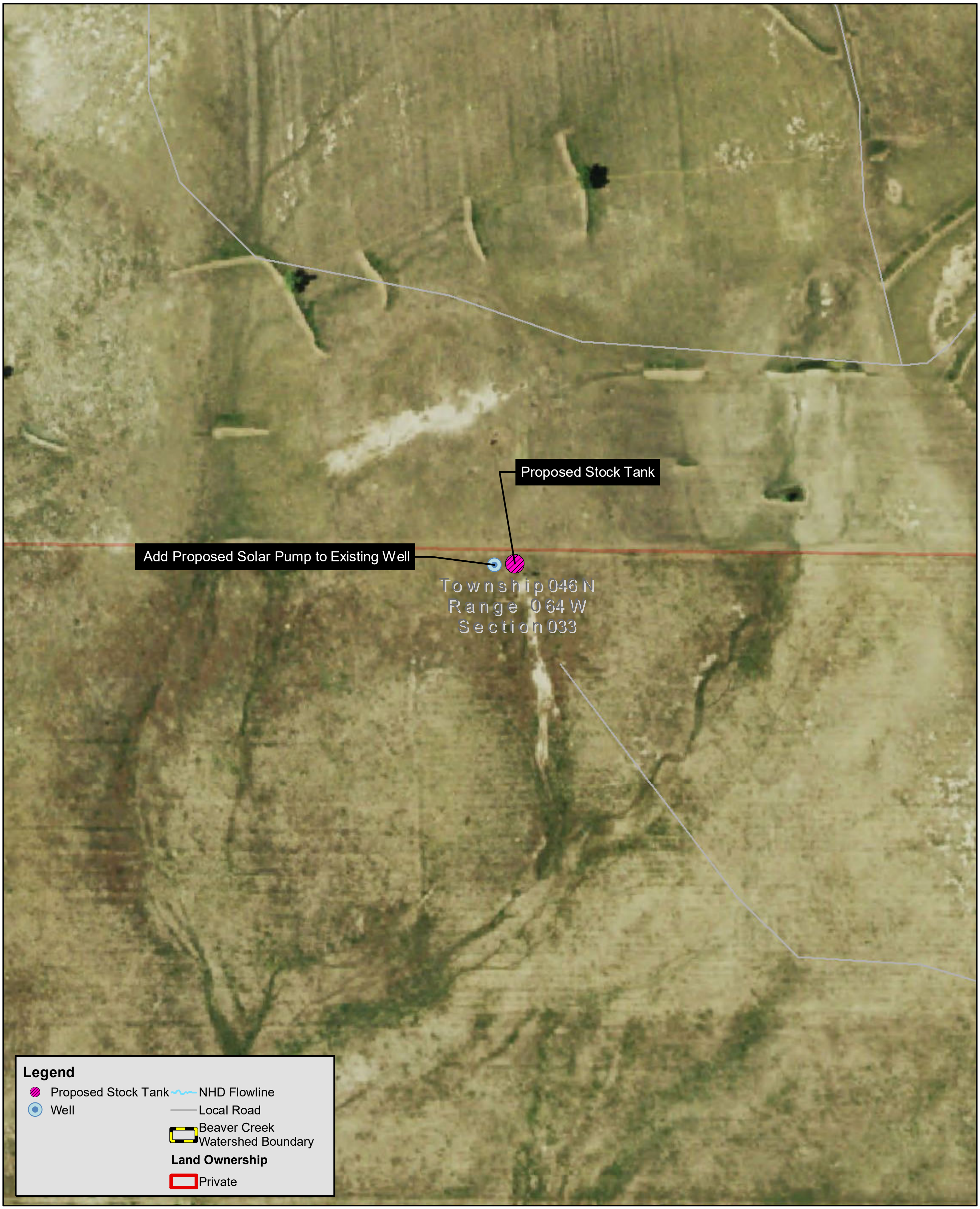
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Bau Ranch

MAP
16.3



OLSSON ASSOCIATES

N

0 100 200 feet

1:3,000
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USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Branscom Ranch

MAP
17.1

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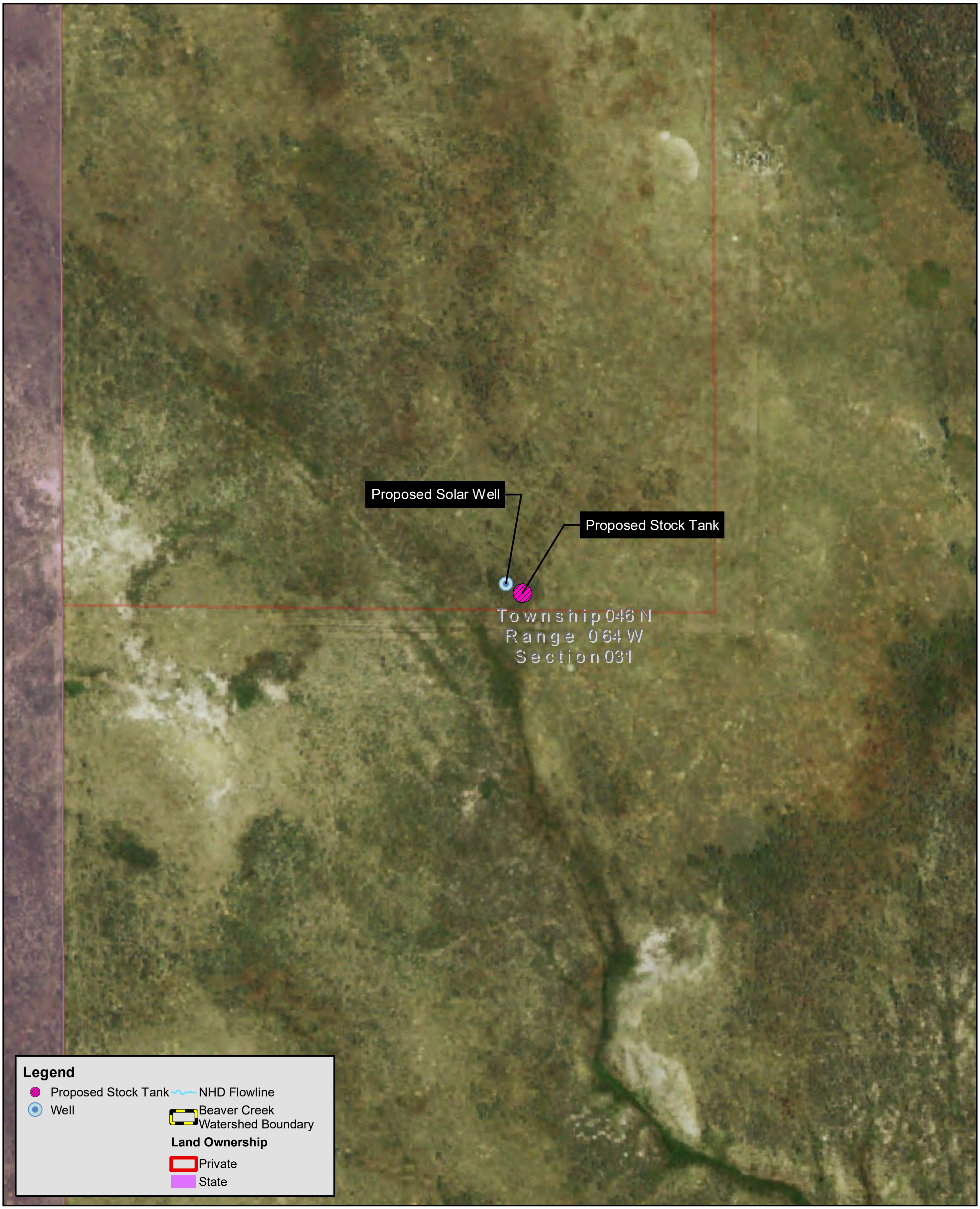

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OLSSON ASSOCIATES

N

0 100 200 feet

1:3,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Branscom Ranch

MAP
17.2

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OLSSON ASSOCIATES

N

0 100 200 feet

1:3,000
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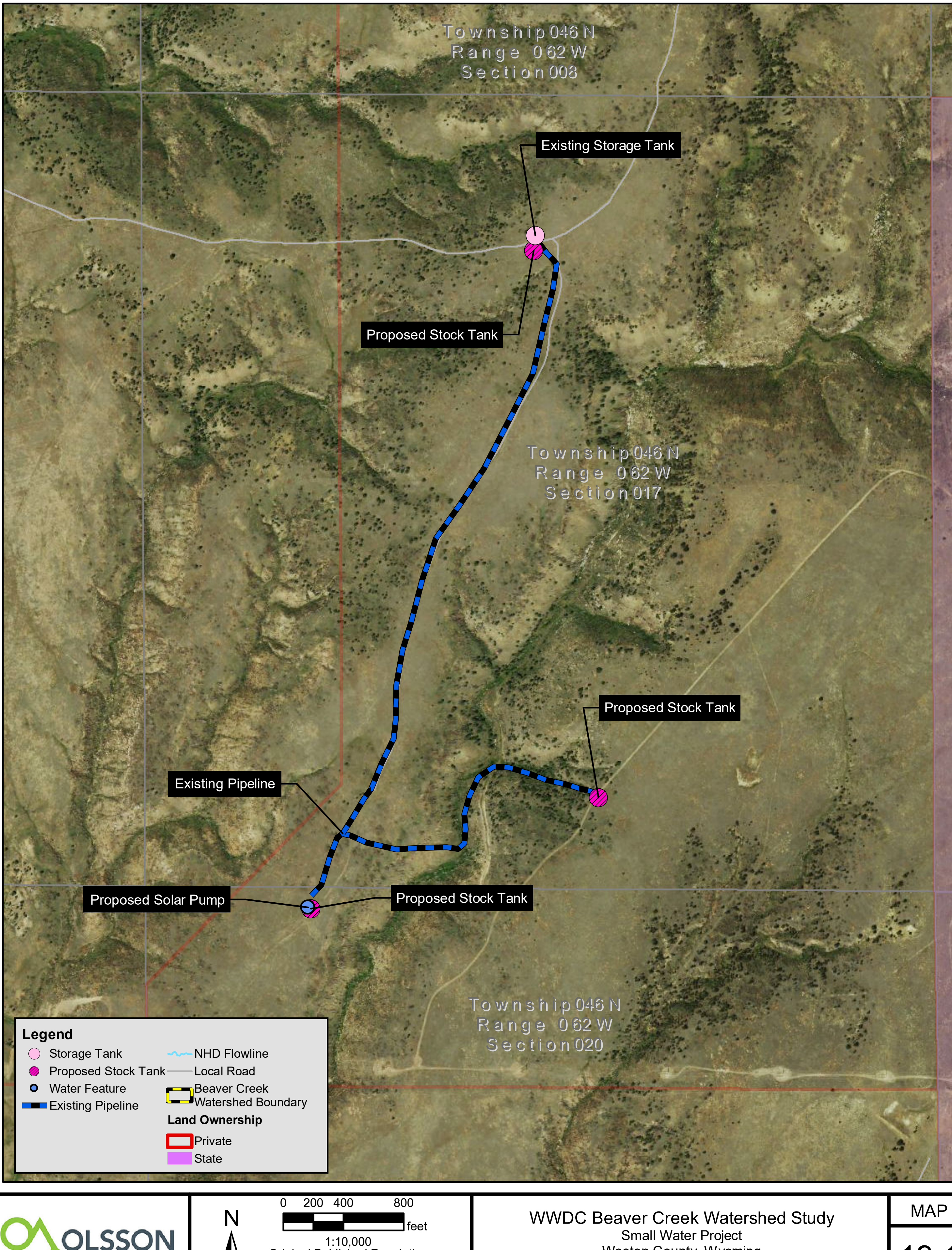
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Hennessey Ranch

MAP
18.1



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OLSSON ASSOCIATES

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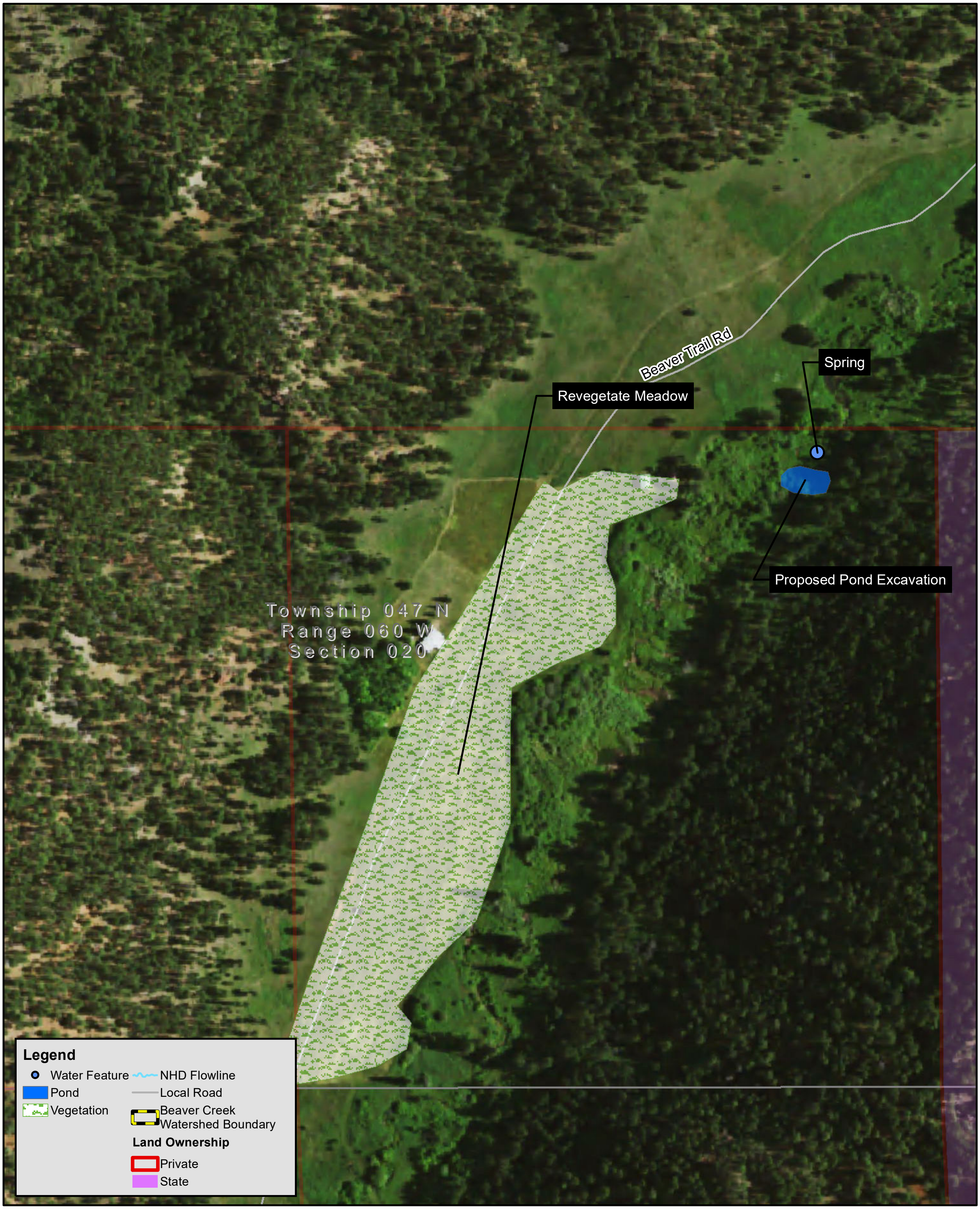
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Larsen Ranch

MAP
19.1



N
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feet
1:3,000
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USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Weyrich Ranch

MAP
20.1

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OLSSON ASSOCIATES

N

0 100 200 feet

1:3,000
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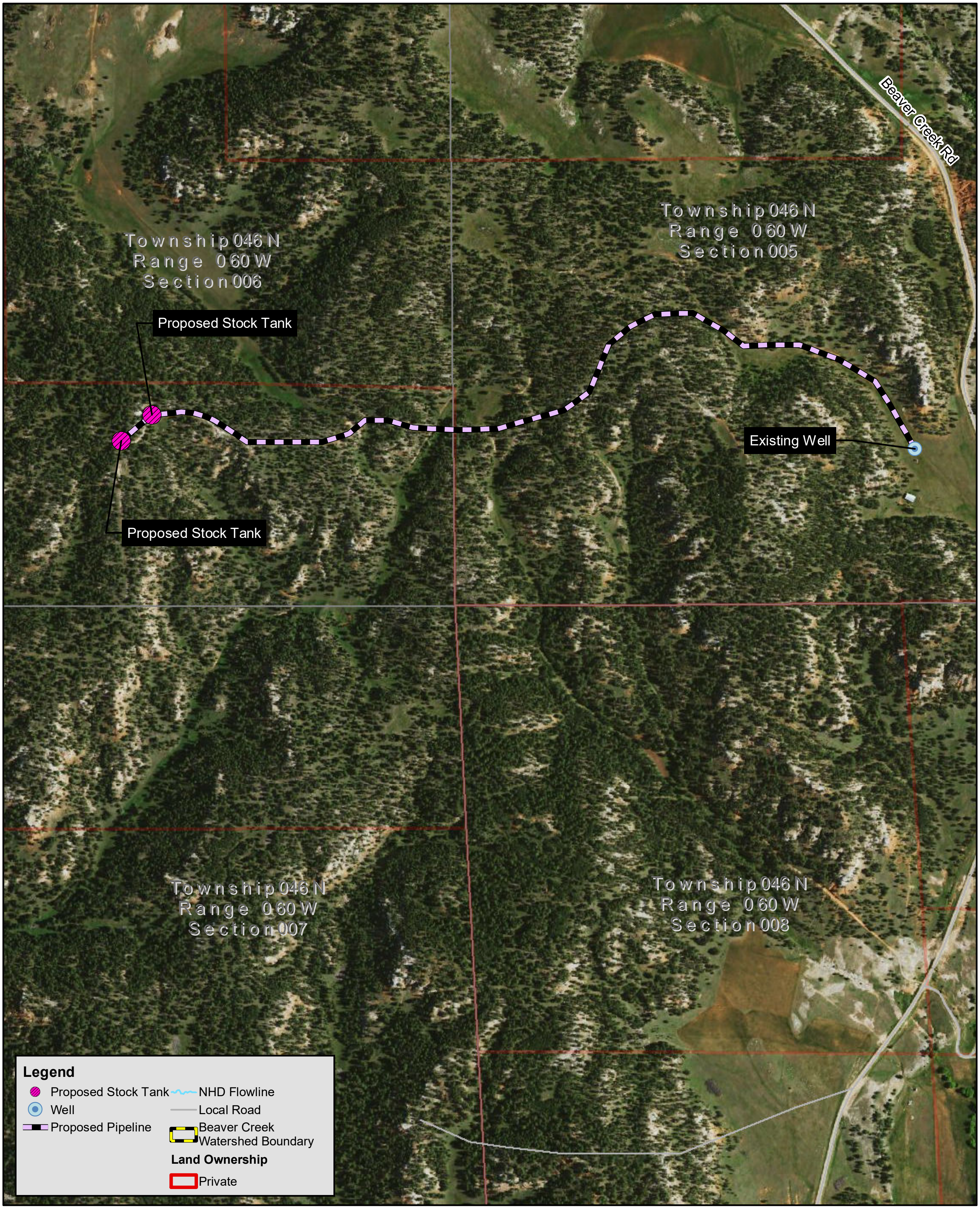
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Rawhouser Ranch

MAP
21.1



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OLSSON ASSOCIATES

N

0 100 200 400 feet

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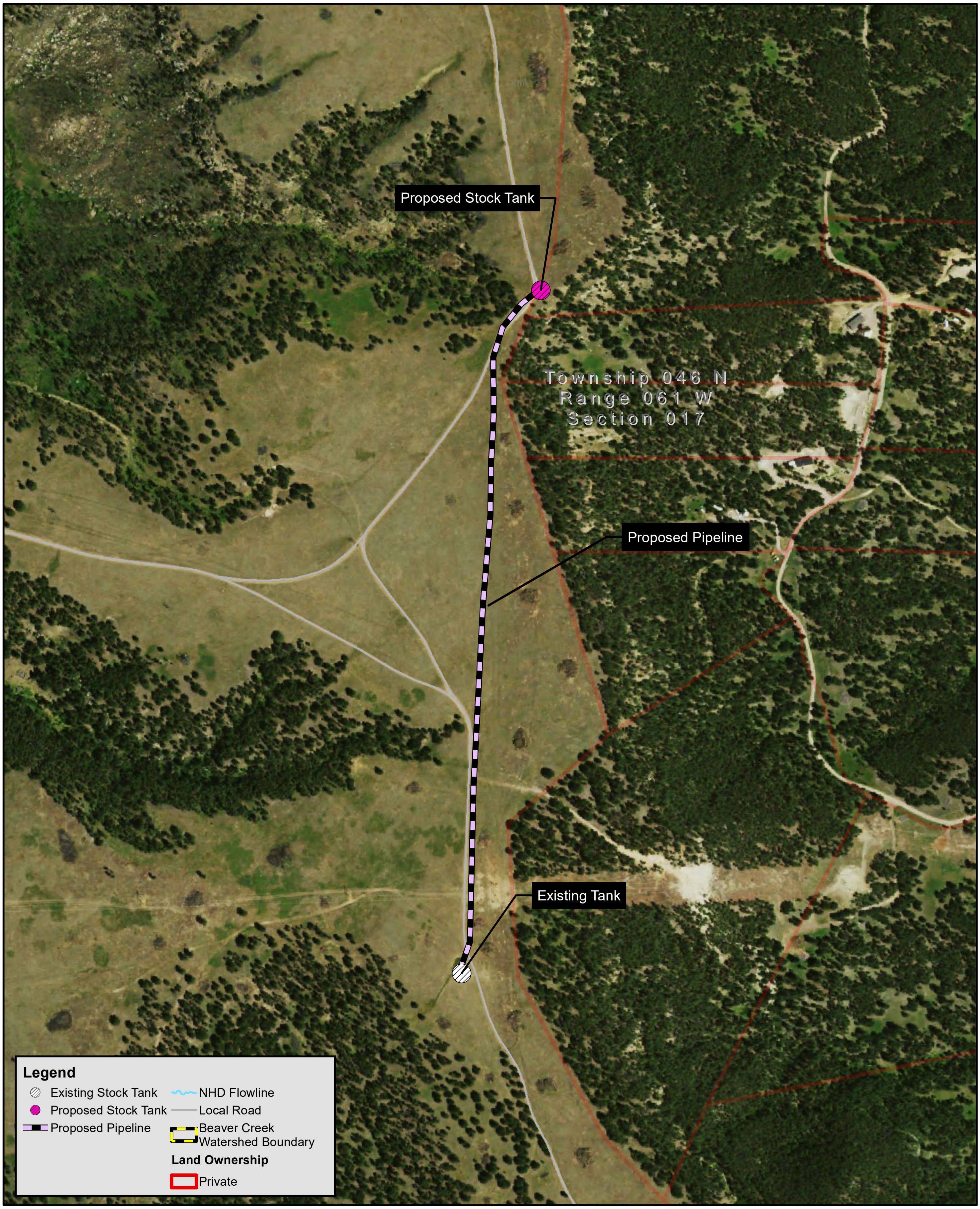
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Rawhouser Ranch

MAP
21.2



OLSSON ASSOCIATES

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Original Published Resolution
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USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Rossman Ranch

MAP
22.1

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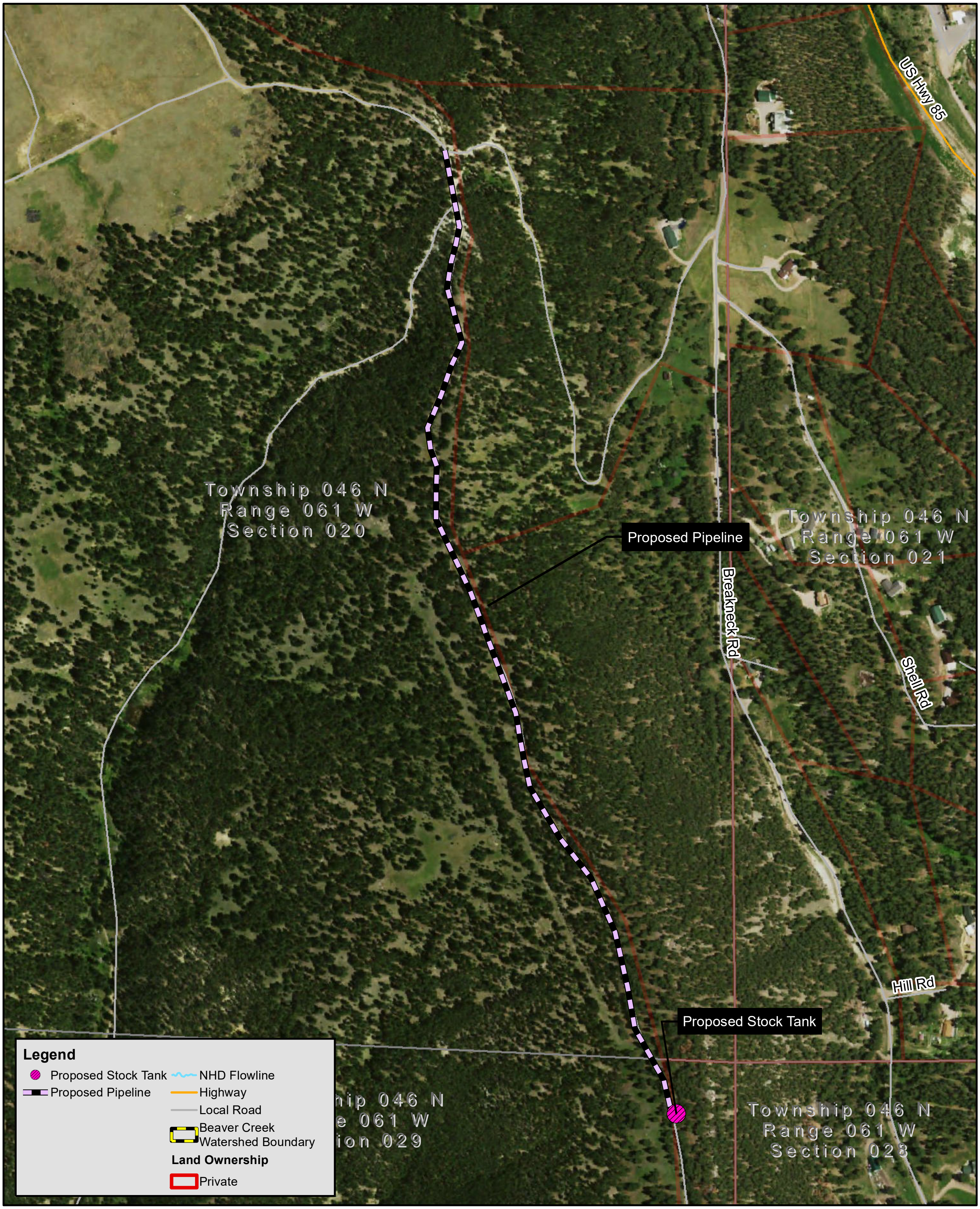

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OLSSON ASSOCIATES

N

0 100 200 400 feet

1:6,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Rossman Ranch

MAP
22.2

OLSSON ASSOCIATES

N

0 80 160 feet

1:2,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Rossman Ranch

MAP
22.3

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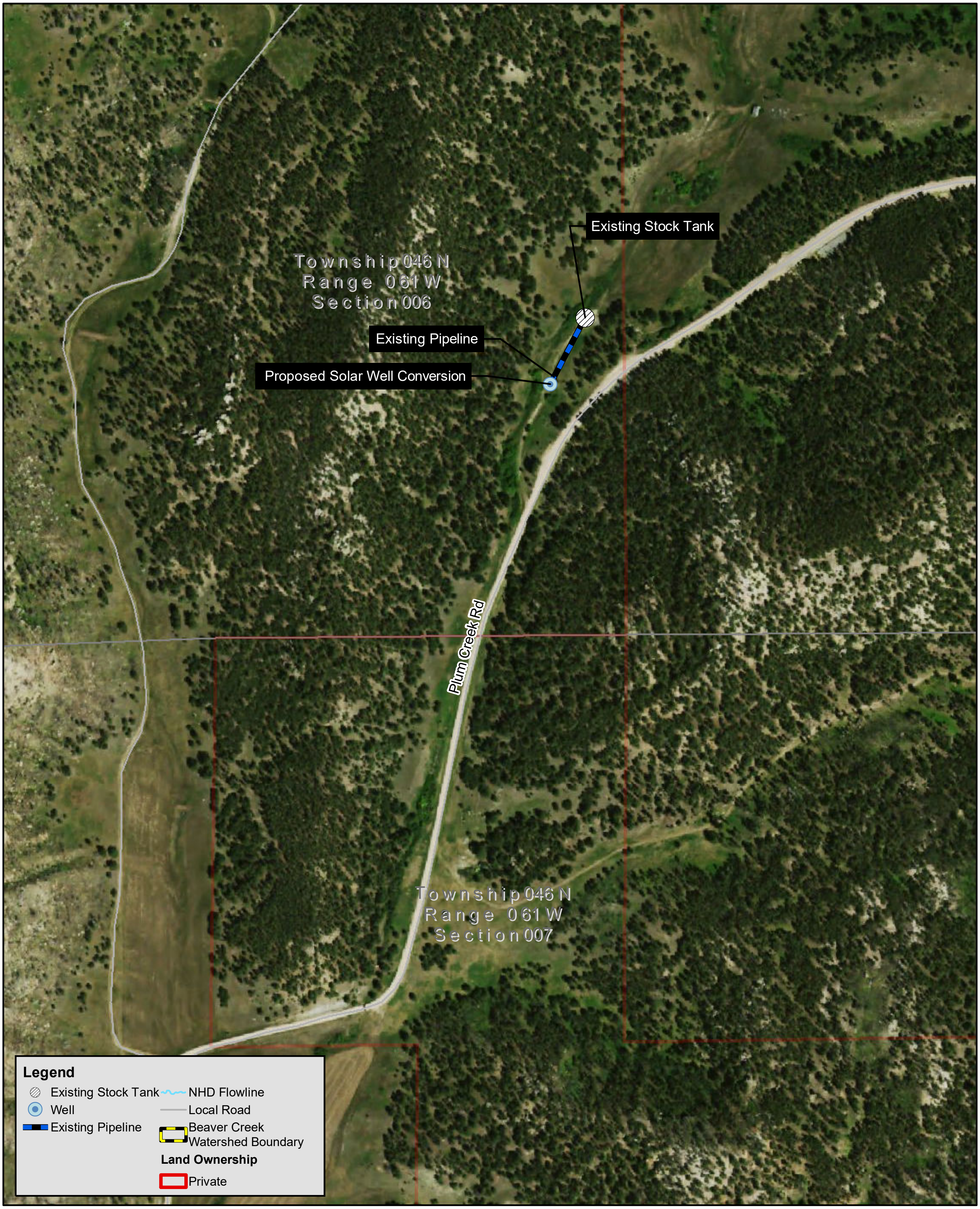

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OLSSON ASSOCIATES

1:5,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Rossman Ranch

MAP
22.4

OLSSON ASSOCIATES

N

0 45 90 feet

1:1,200
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Rossman Ranch

MAP
22.5

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OLSSON ASSOCIATES

N

0 45 90 feet

1:1,200
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Merrill Ranch

MAP
23.1

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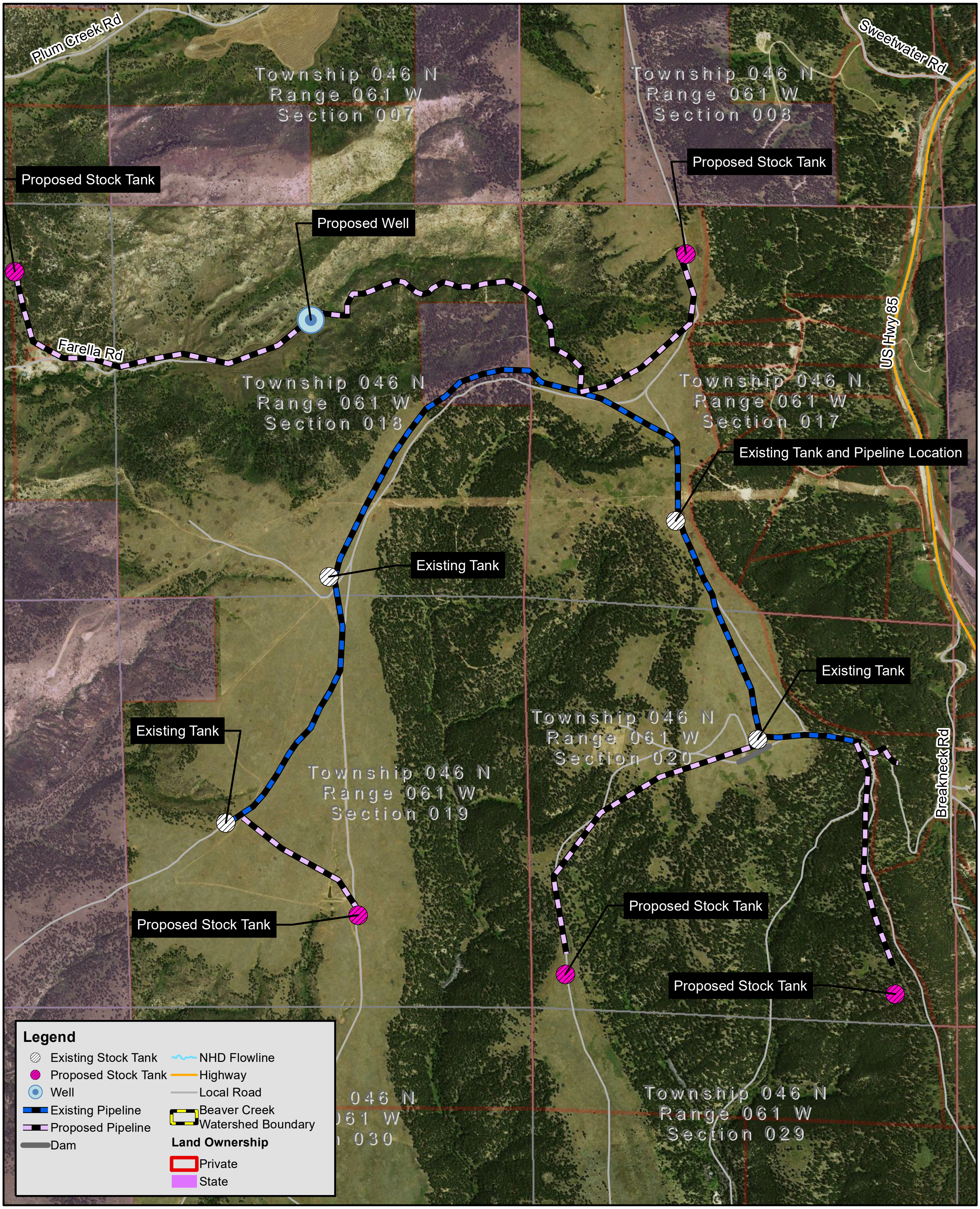

OLSSON ASSOCIATES

N

0 400 800 1,600 feet

1:20,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Merrill Ranch

MAP
23.2

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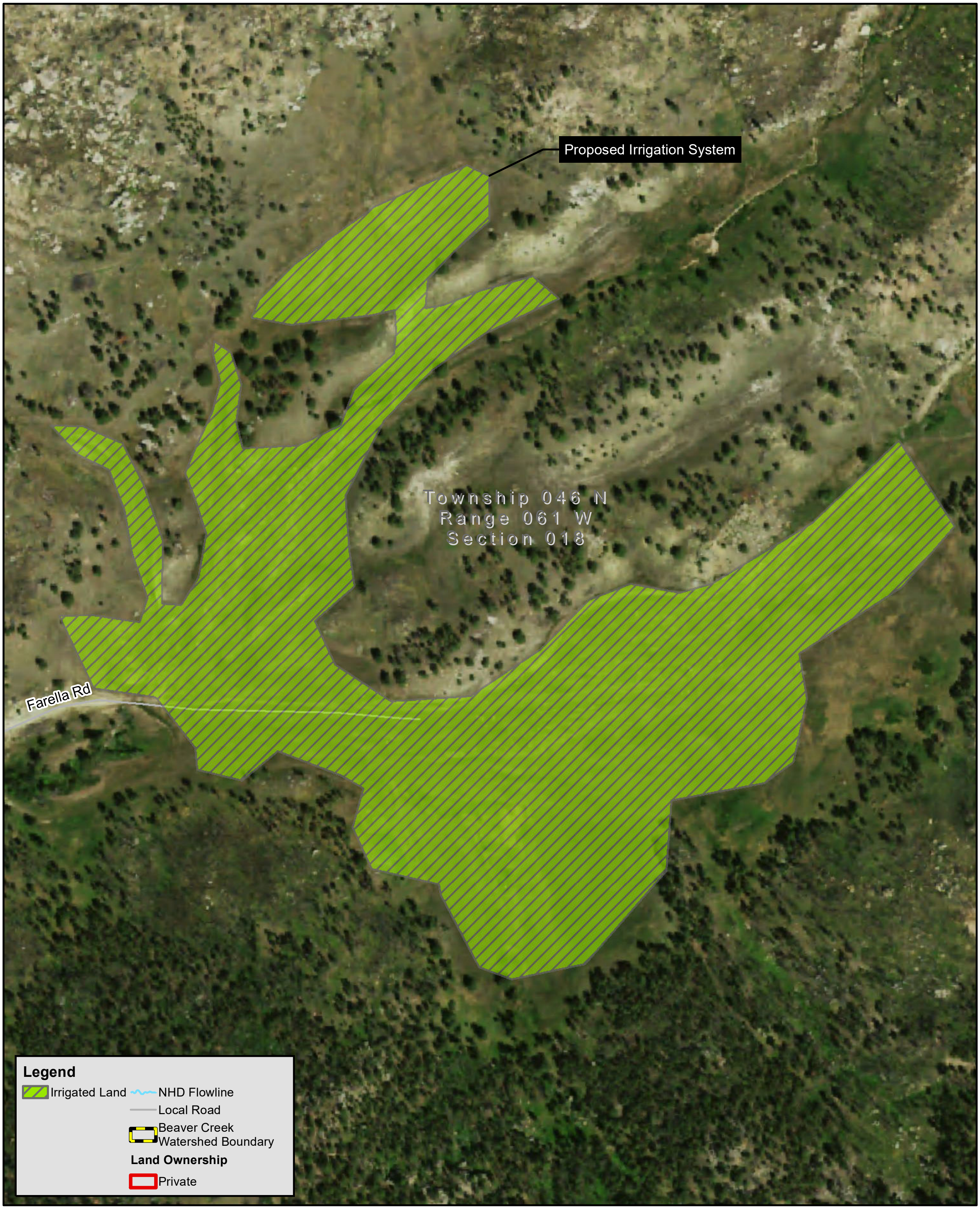

OLSSON ASSOCIATES

N

0 100 200 feet

1:3,200
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Merrill Ranch

MAP 23.3

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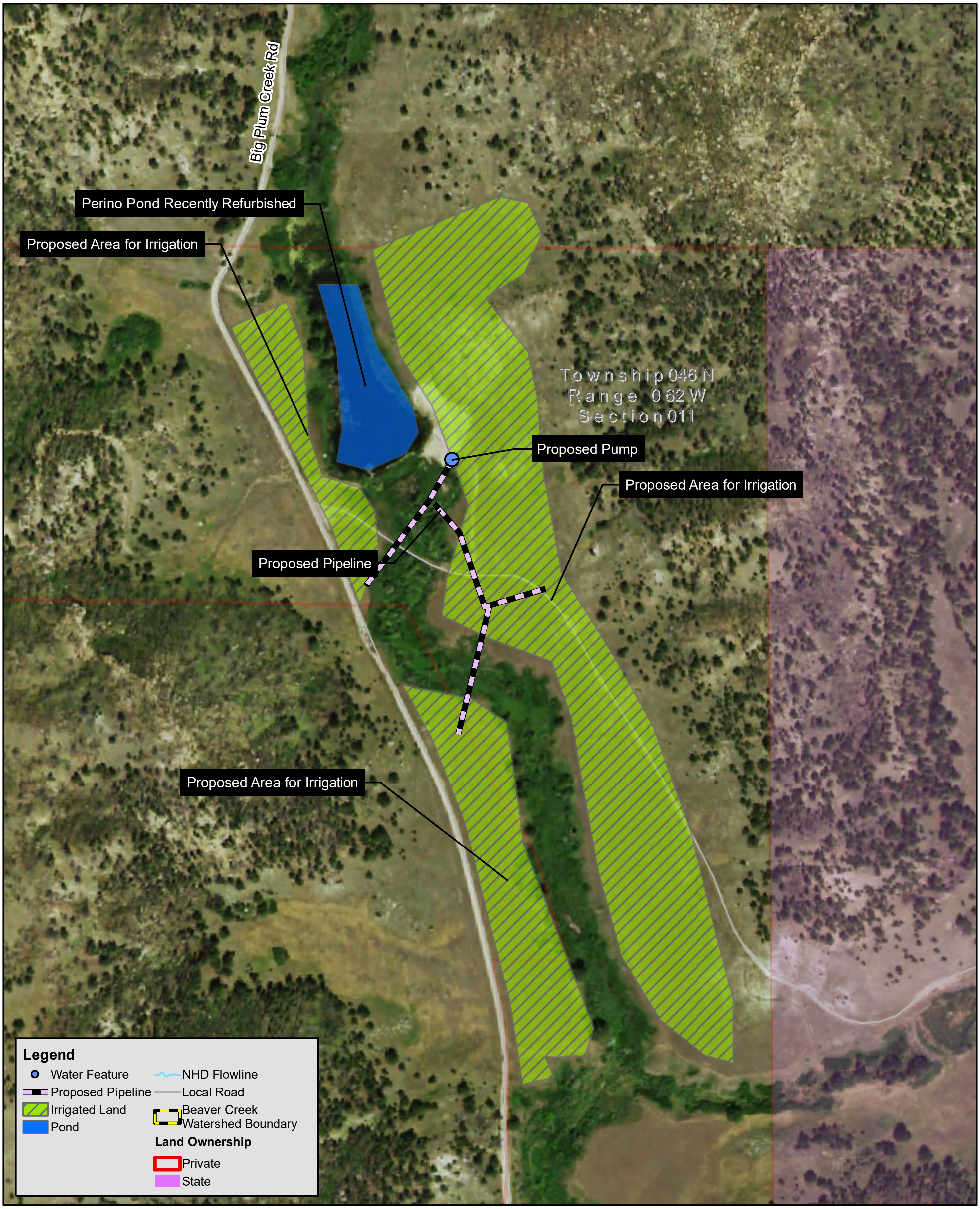

OLSSON ASSOCIATES

N

0 100 200 feet

1:4,000

Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Perino Ranch

MAP
24.1

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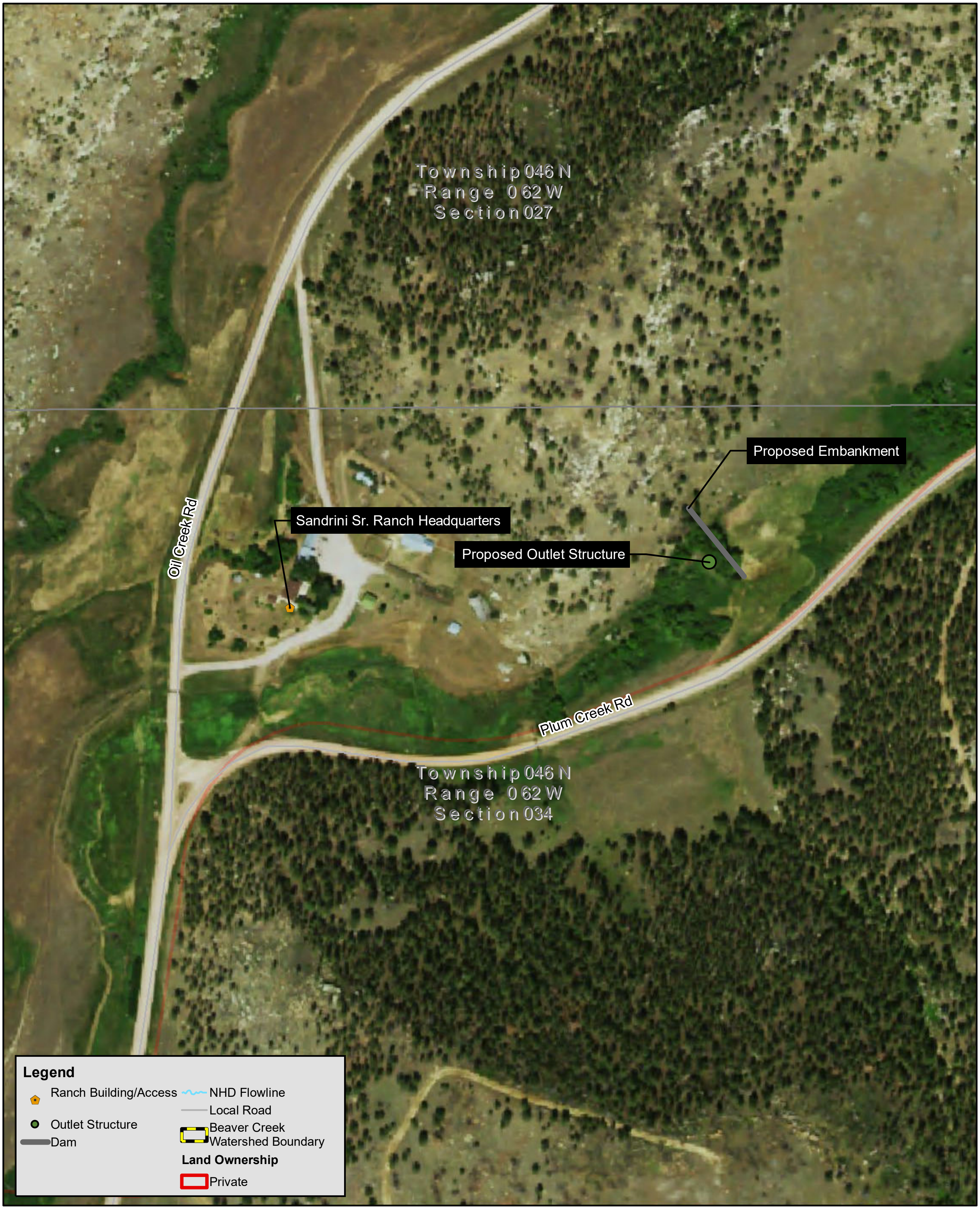

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OLSSON ASSOCIATES

N

0 100 200 feet

1:3,000

Original Published Resolution

NAD 1983 UTM Zone 13N

USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study

Small Water Project

Weston County, Wyoming

Sandrini Ranch

MAP

25.1

OLSSON ASSOCIATES

N

0 80 160 feet

1:2,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Sandrini Ranch

MAP
25.2

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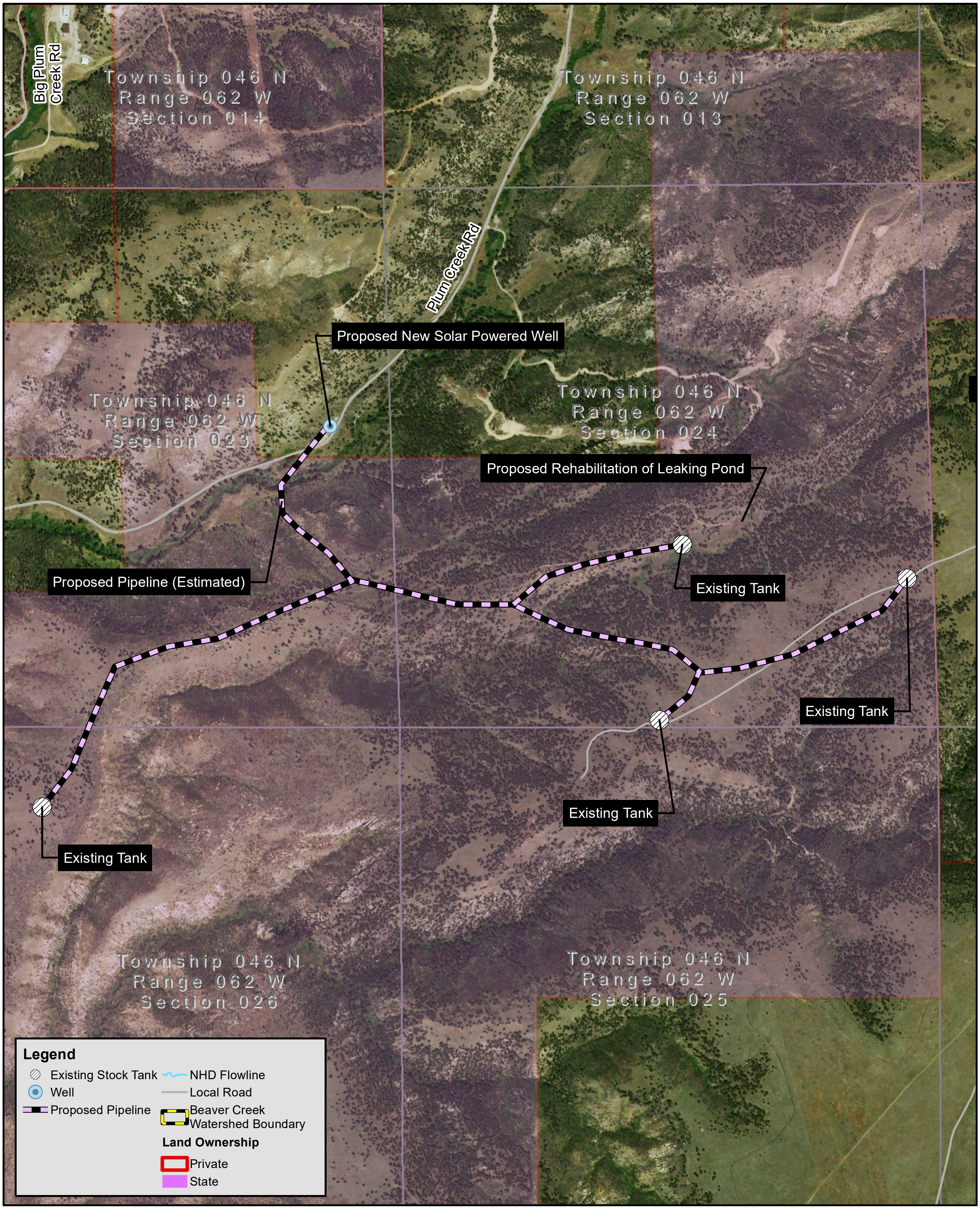

OLSSON ASSOCIATES

N

0 300 600 1,200 feet

1:15,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Sandrini Ranch

MAP
25.3

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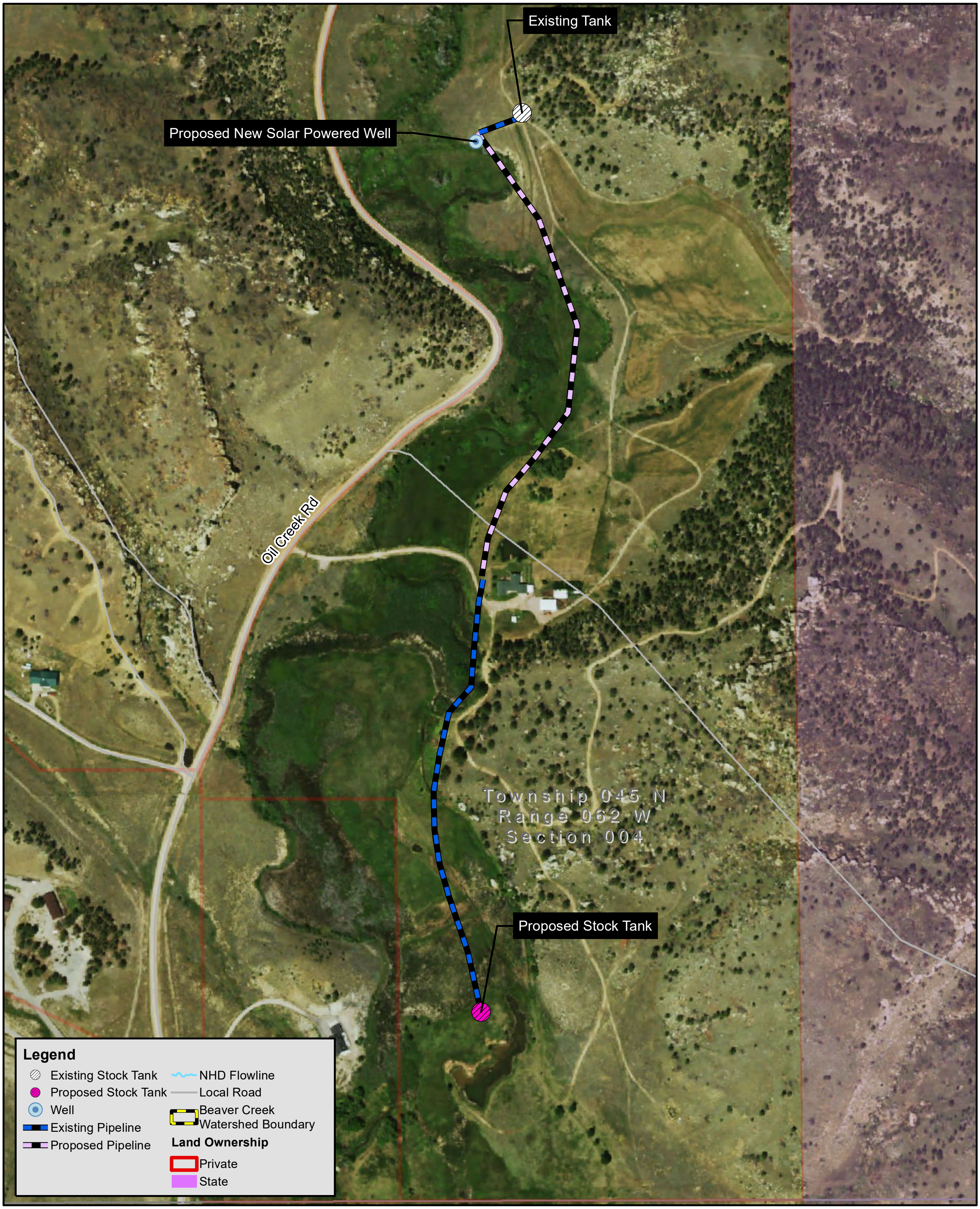

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OLSSON ASSOCIATES

N

0 100 200 400 feet

1:5,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Culver Ranch

MAP
26.1

OLSSON ASSOCIATES

N

0 60 120 feet

1:1,500
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Culver Ranch

MAP
26.2

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OLSSON ASSOCIATES

N

0 60 120 feet

1:1,500
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Hiser Ranch

MAP
28.1

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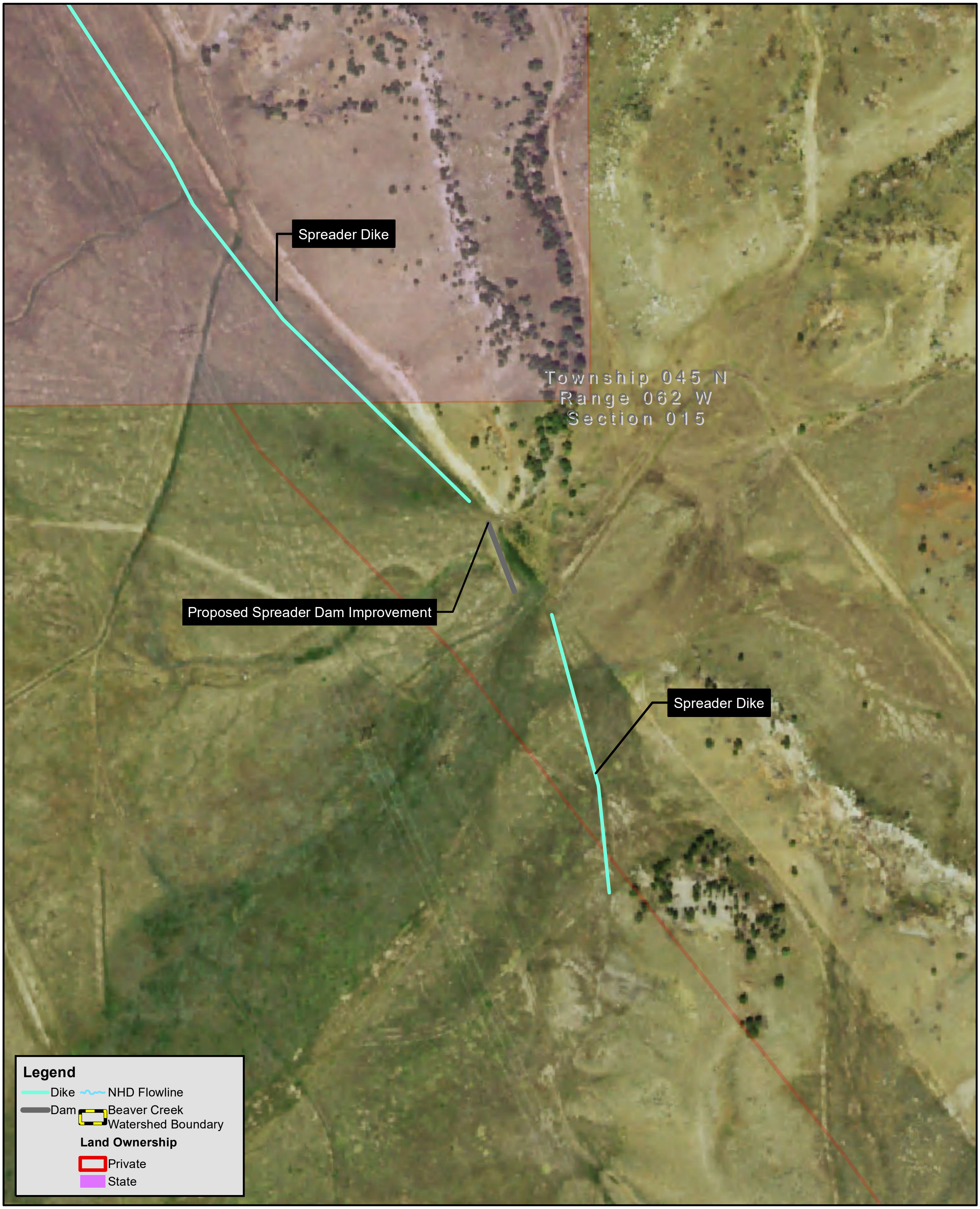

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OLSSON ASSOCIATES

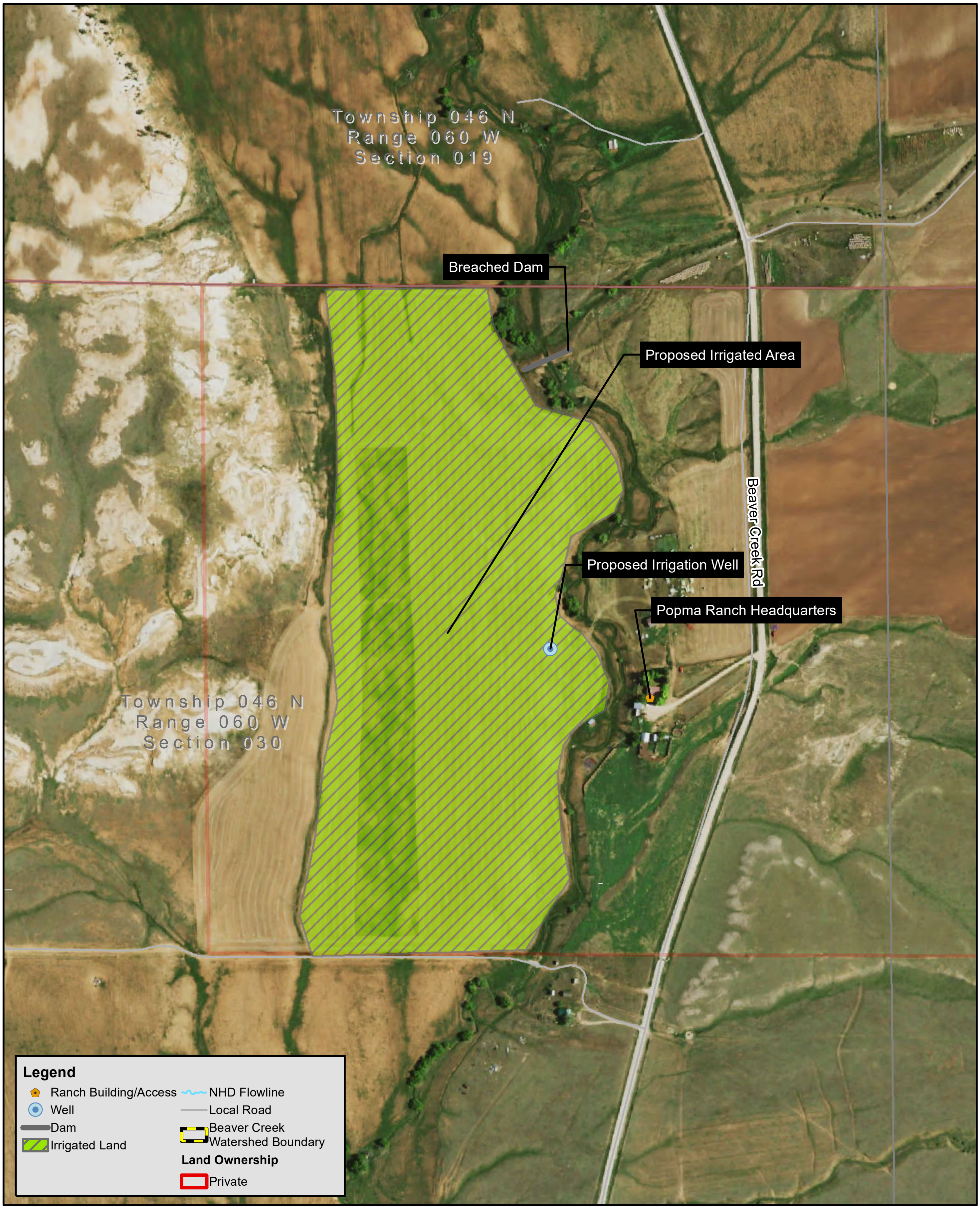
N

0 100 200 feet

1:3,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Engle Ranch

MAP
29.1



OLSSON ASSOCIATES

N

0 100 200 400 feet

1:6,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Pompa Ranch

MAP 30.1

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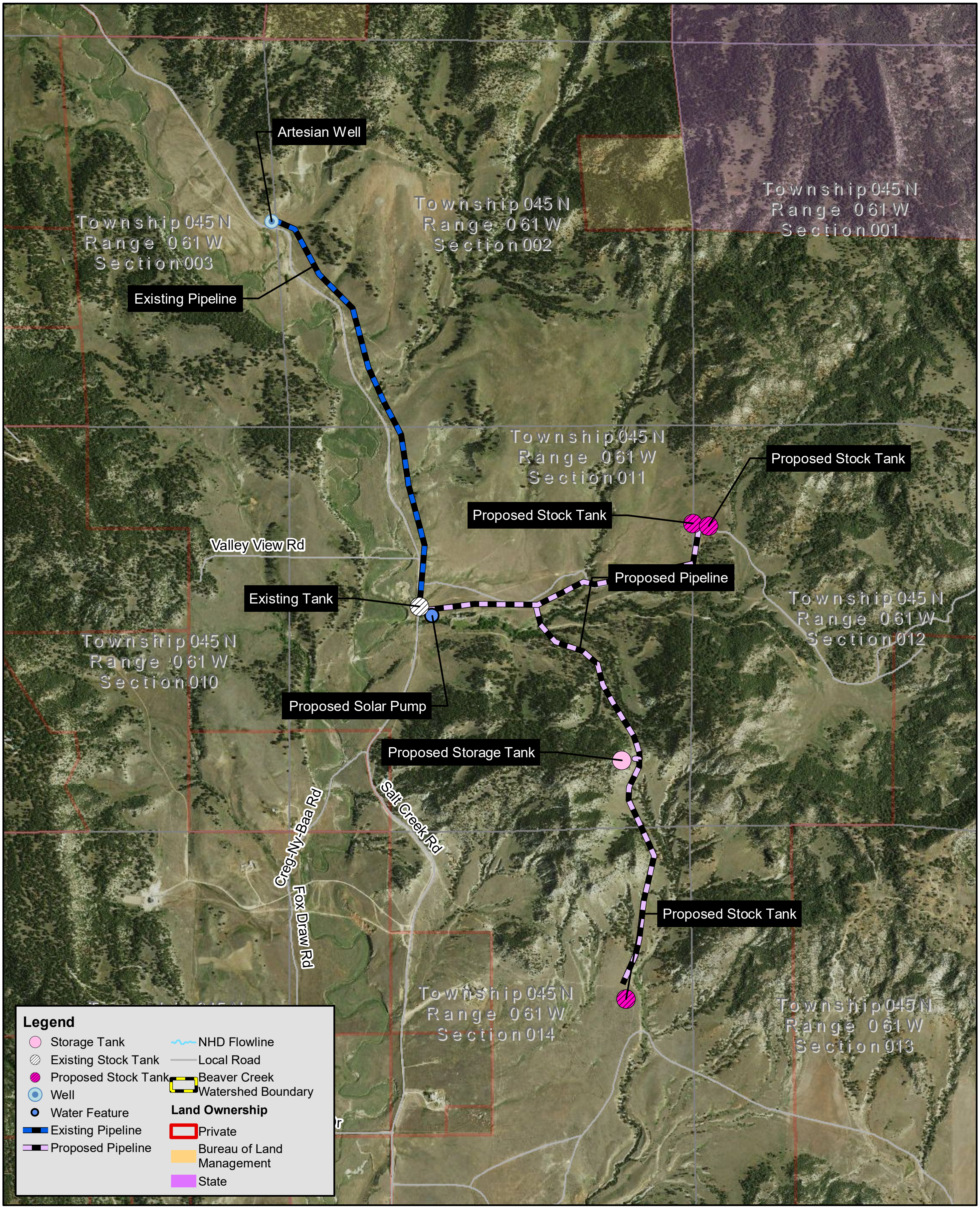

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OLSSON ASSOCIATES

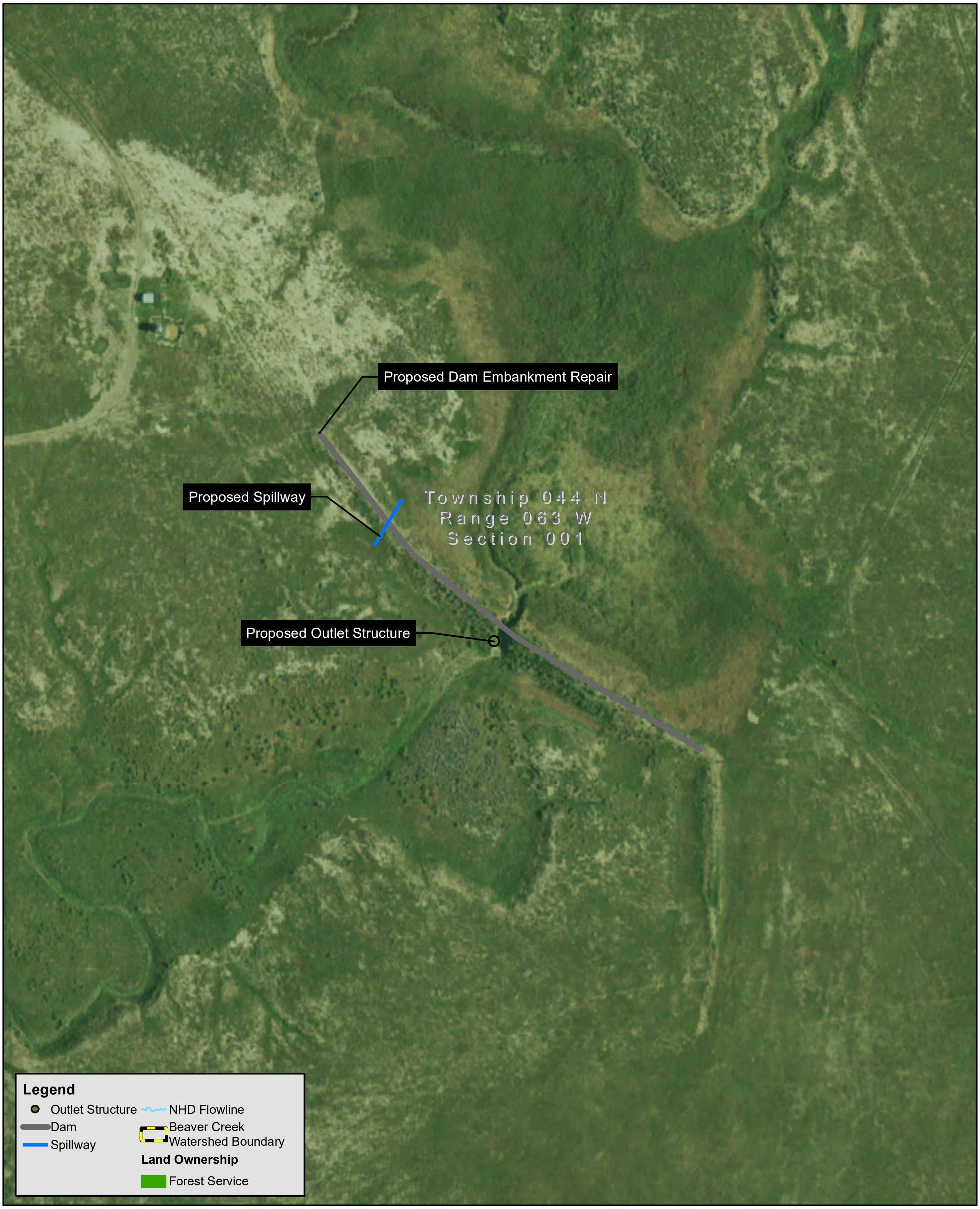
N

0 400 800 1,600 feet

1:20,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Vore Ranch

MAP
31.1



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OLSSON ASSOCIATES

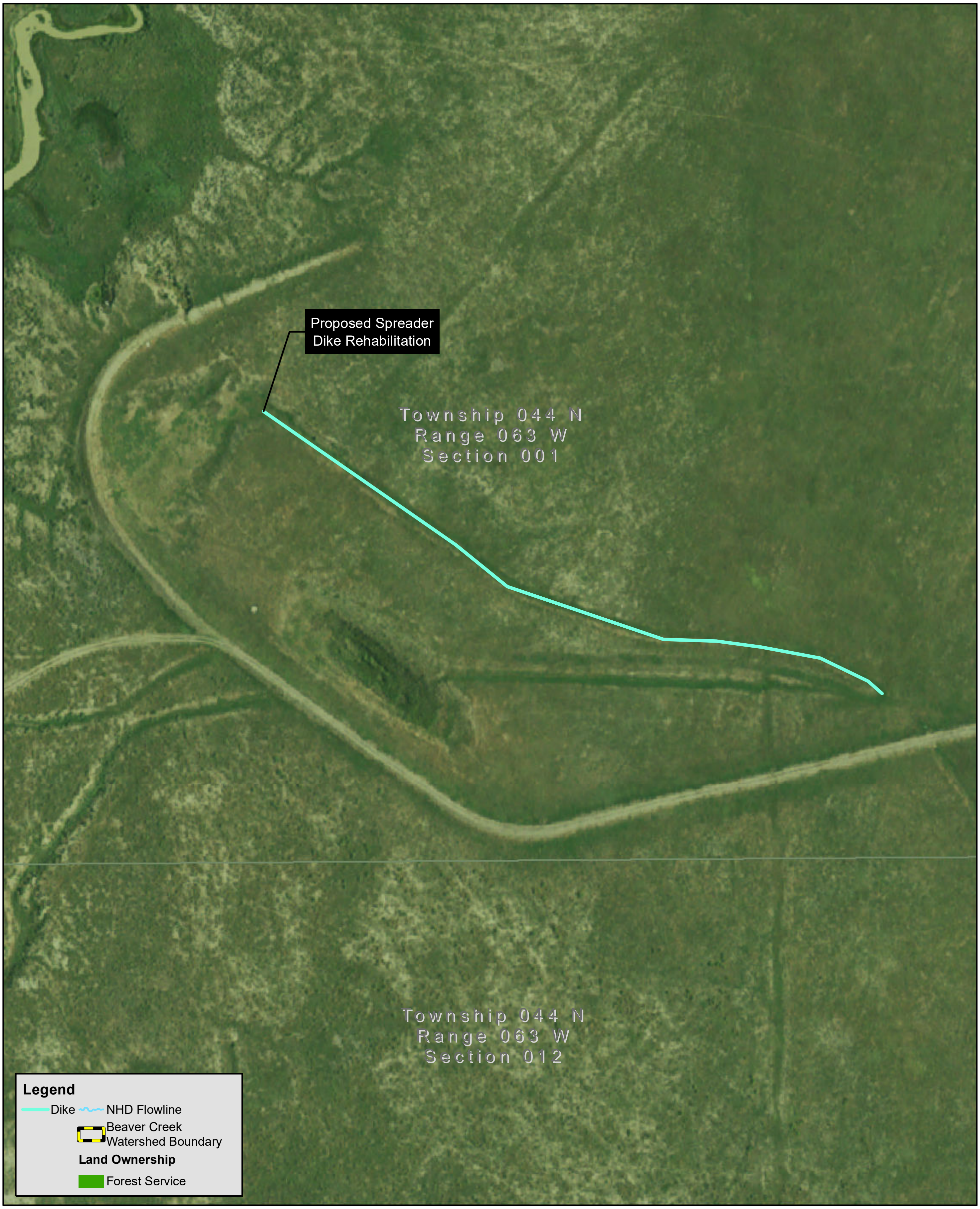
N

0 80 160 feet

1:2,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Millett Ranch

MAP
32.1



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OLSSON ASSOCIATES

N

0 80 160 feet

1:2,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Millett Ranch

MAP
32.2

OLSSON ASSOCIATES

N

0 45 90 feet

1:1,200
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Livingston Ranch

MAP
33.1

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OLSSON ASSOCIATES

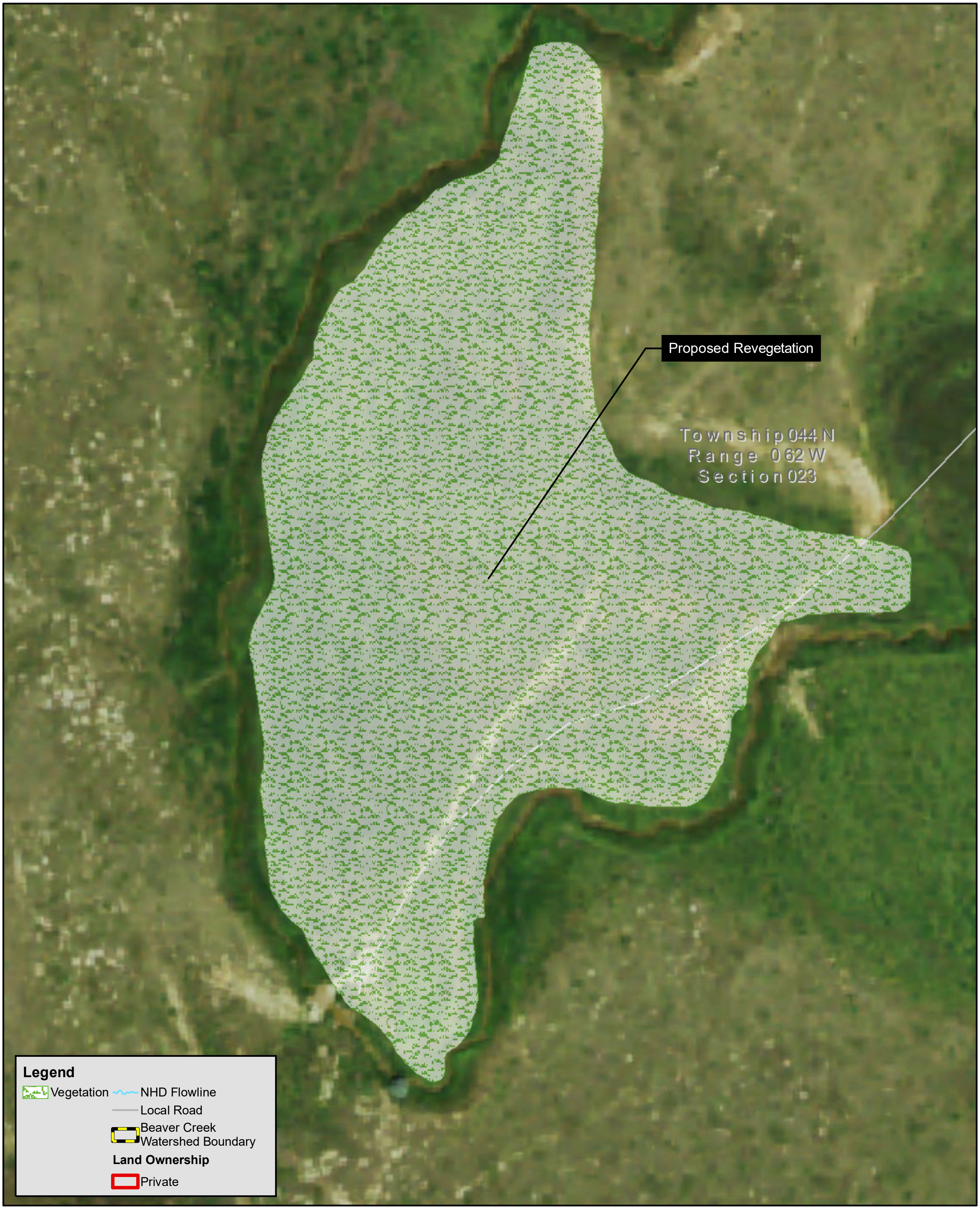
N

0 45 90 feet

1:1,200
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Livingston Ranch

MAP
33.2



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OLSSON ASSOCIATES

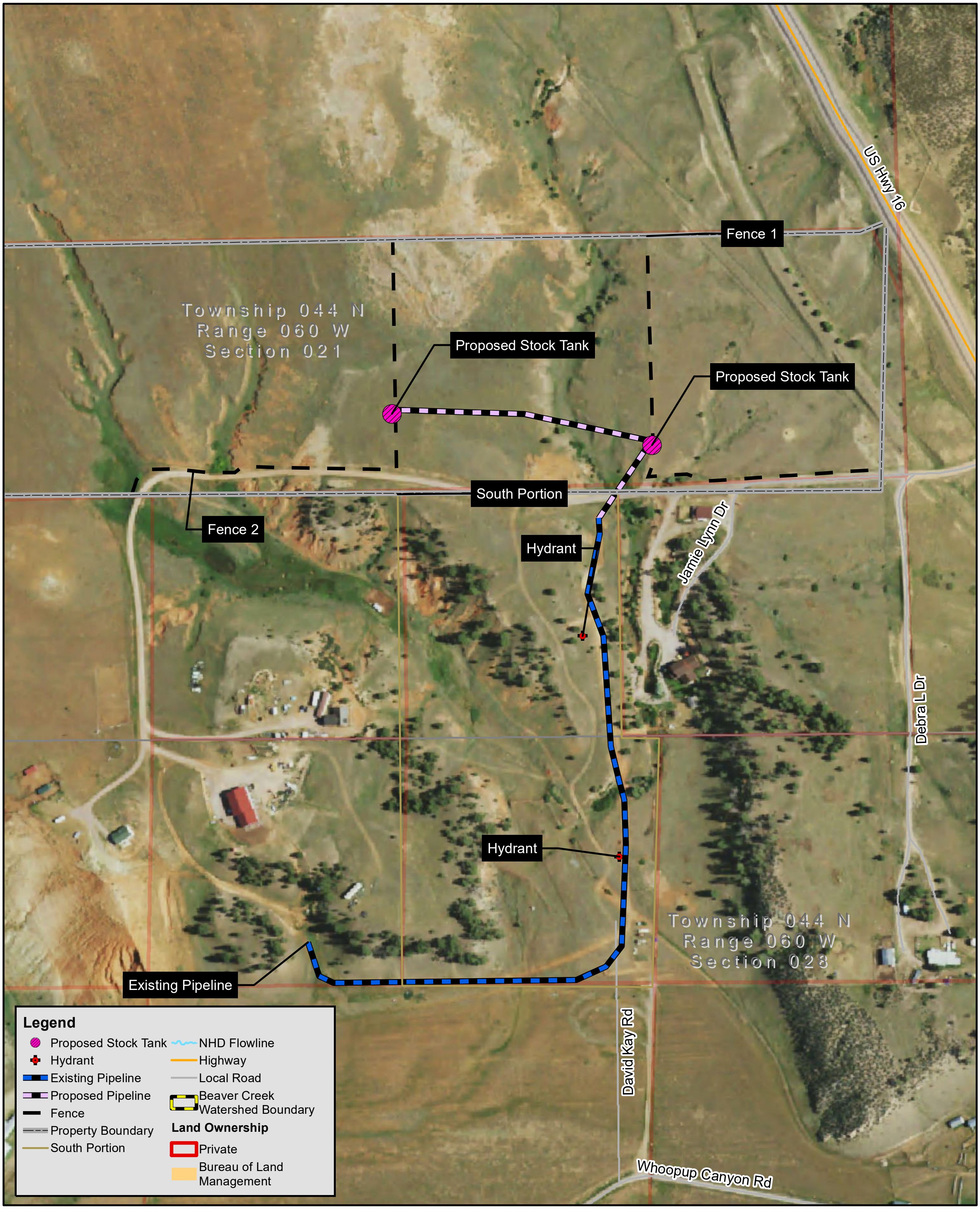
N

0 60 120 feet

1:1,500
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Livingston Ranch

MAP
33.3



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OLSSON ASSOCIATES

N

0 100 200 feet

1:4,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Sudbrink Ranch

MAP
34.1

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OLSSON ASSOCIATES

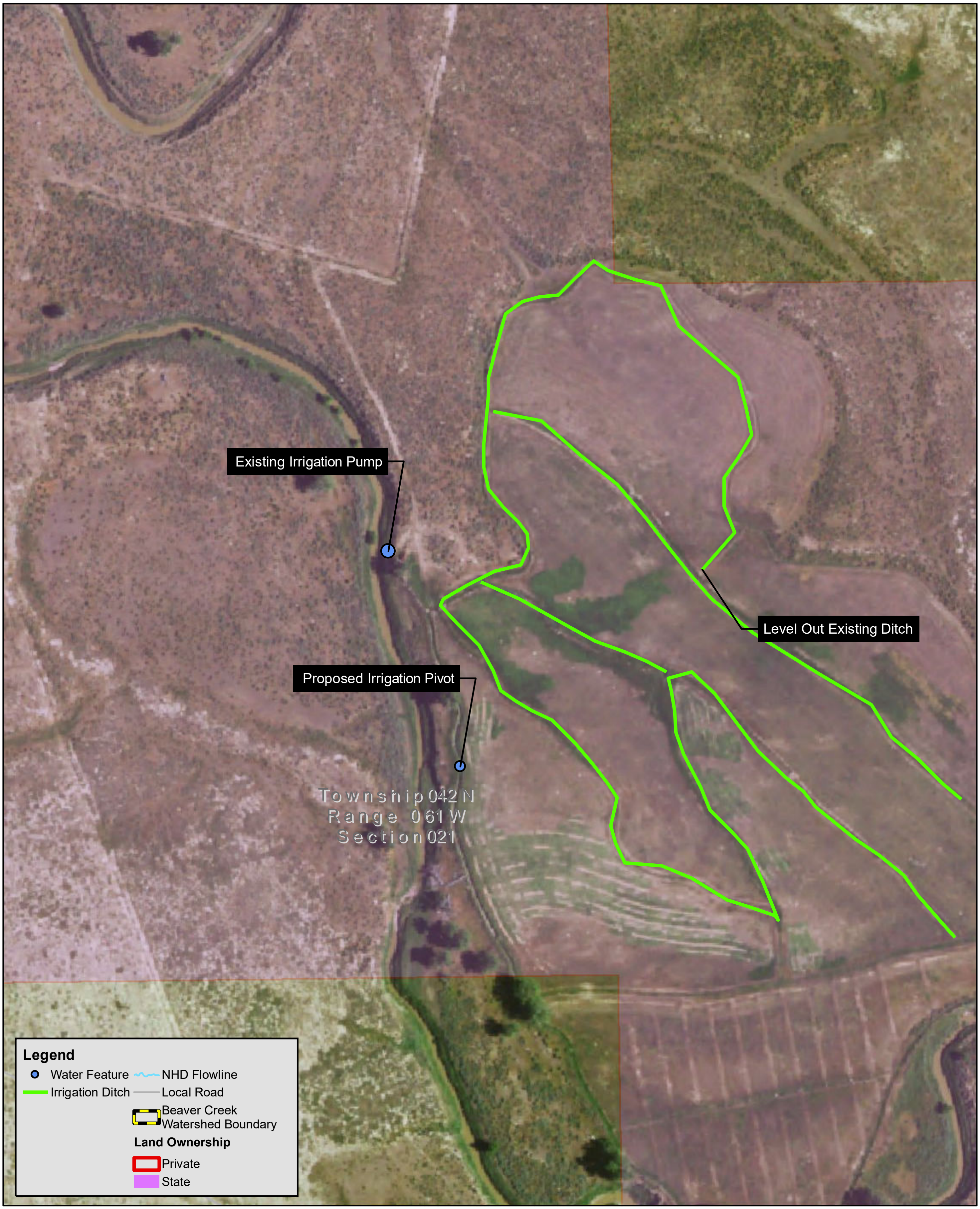
N

0 80 160 feet

1:2,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Sudbrink Ranch

MAP
34.2



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OLSSON ASSOCIATES

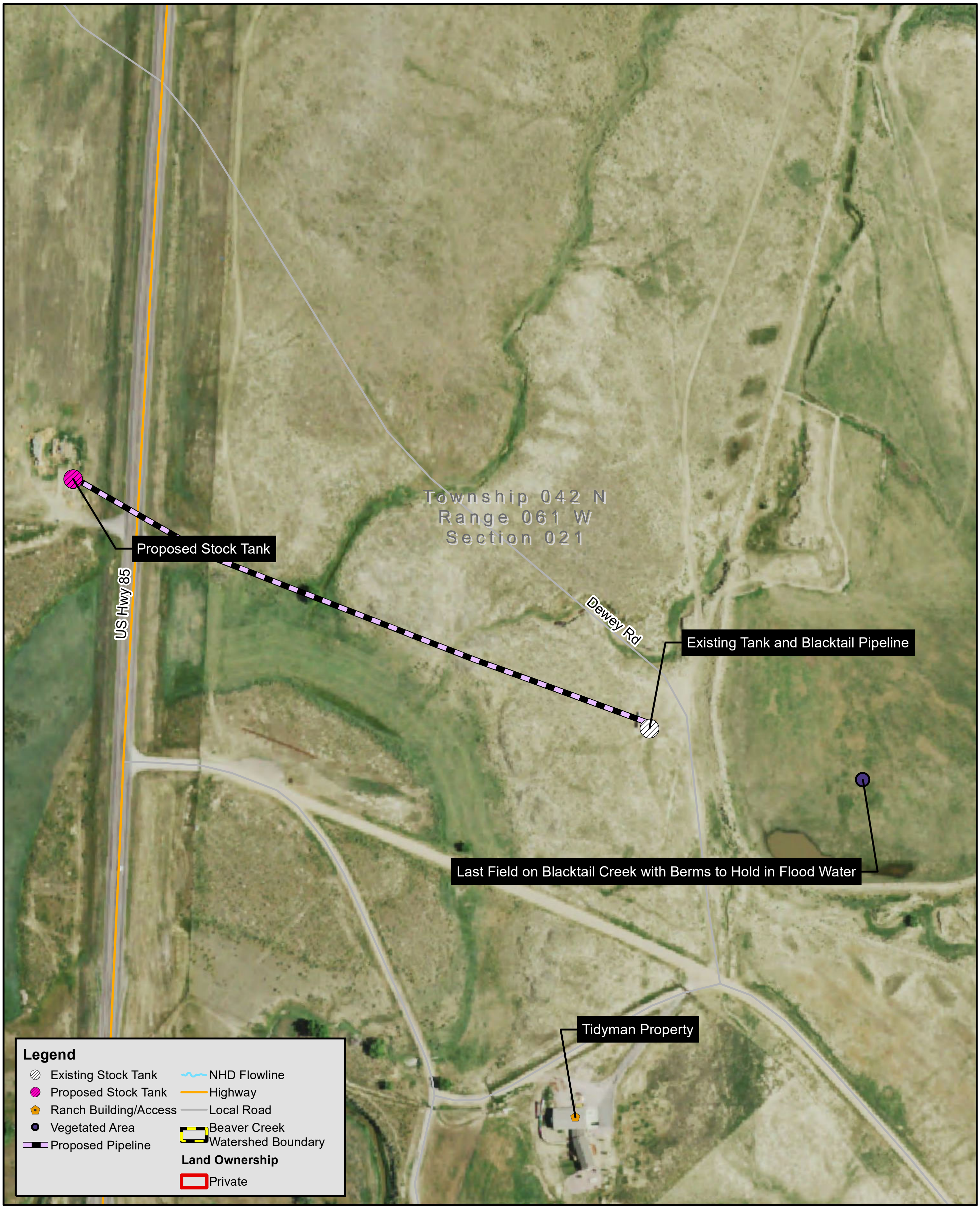
N

0 100 200 feet

1:3,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Tidyman Ranch

MAP
35.1



OLSSON ASSOCIATES

N

0 100 200 feet

1:3,500
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Tidyman Ranch

MAP
35.2

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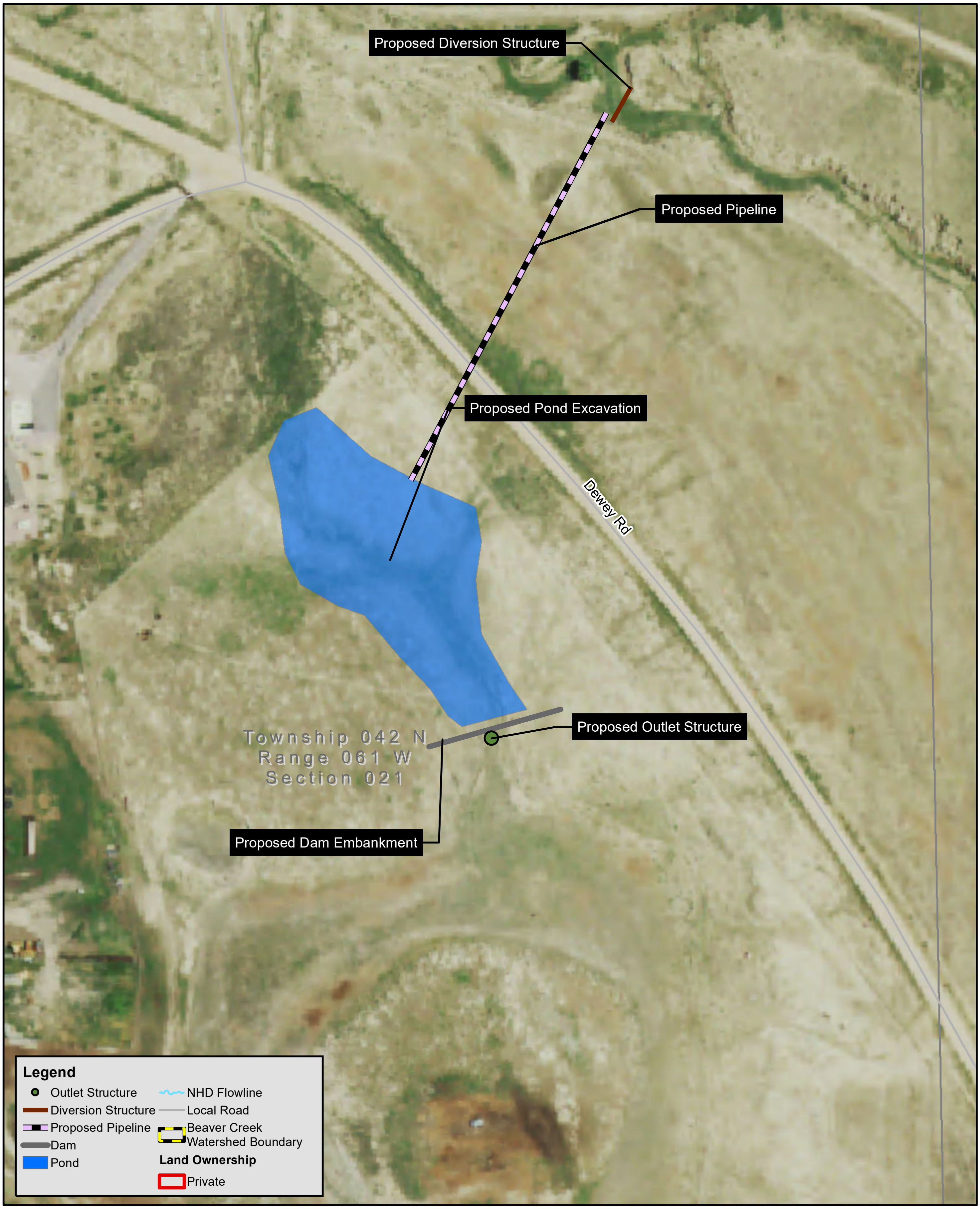

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OLSSON ASSOCIATES

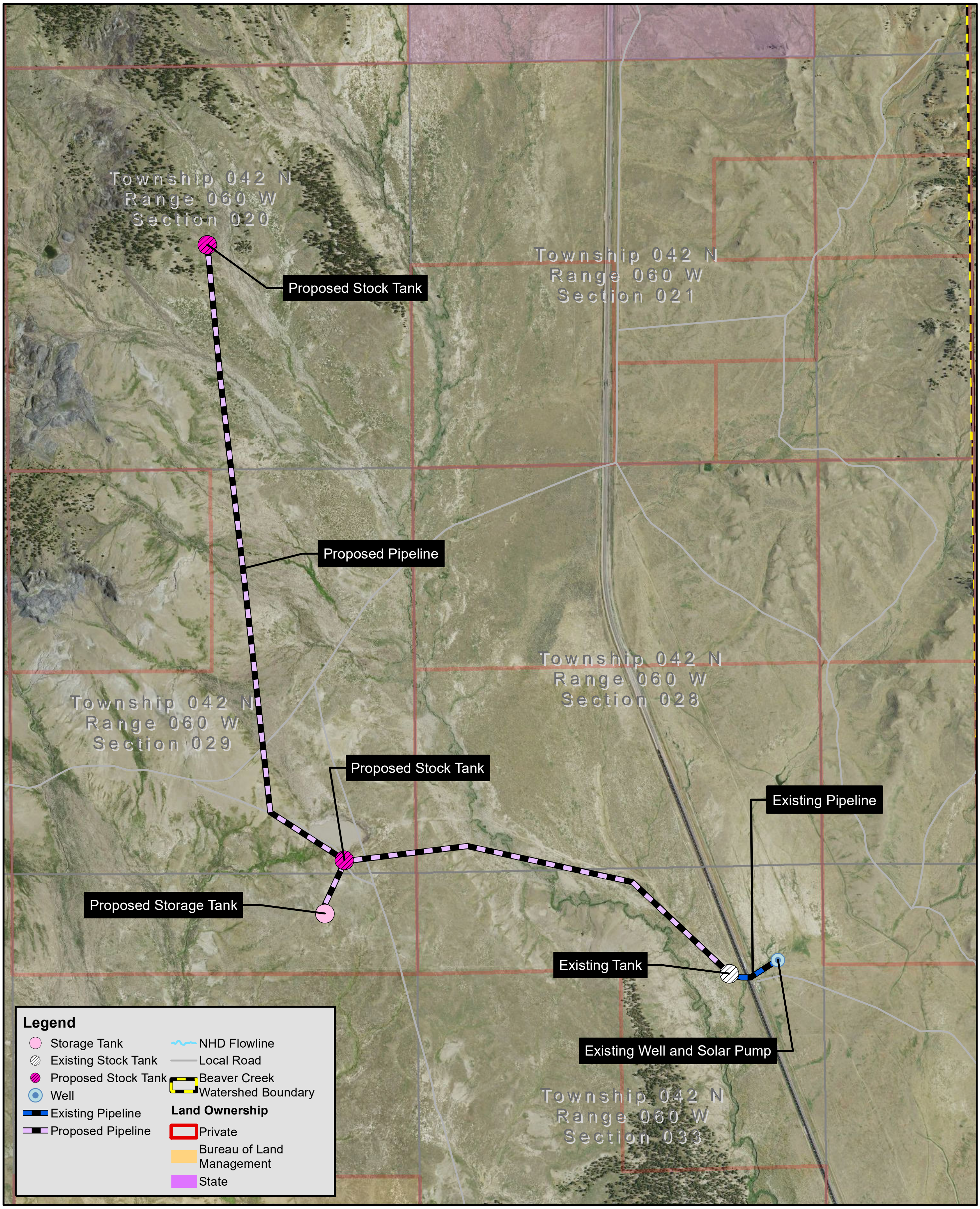
N

0 80 160 feet

1:2,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Tidyman Ranch

MAP
35.3



OLSSON ASSOCIATES

N

0 400 800 1,600 feet

1:20,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Hollenbeck Ranch

MAP
36.1

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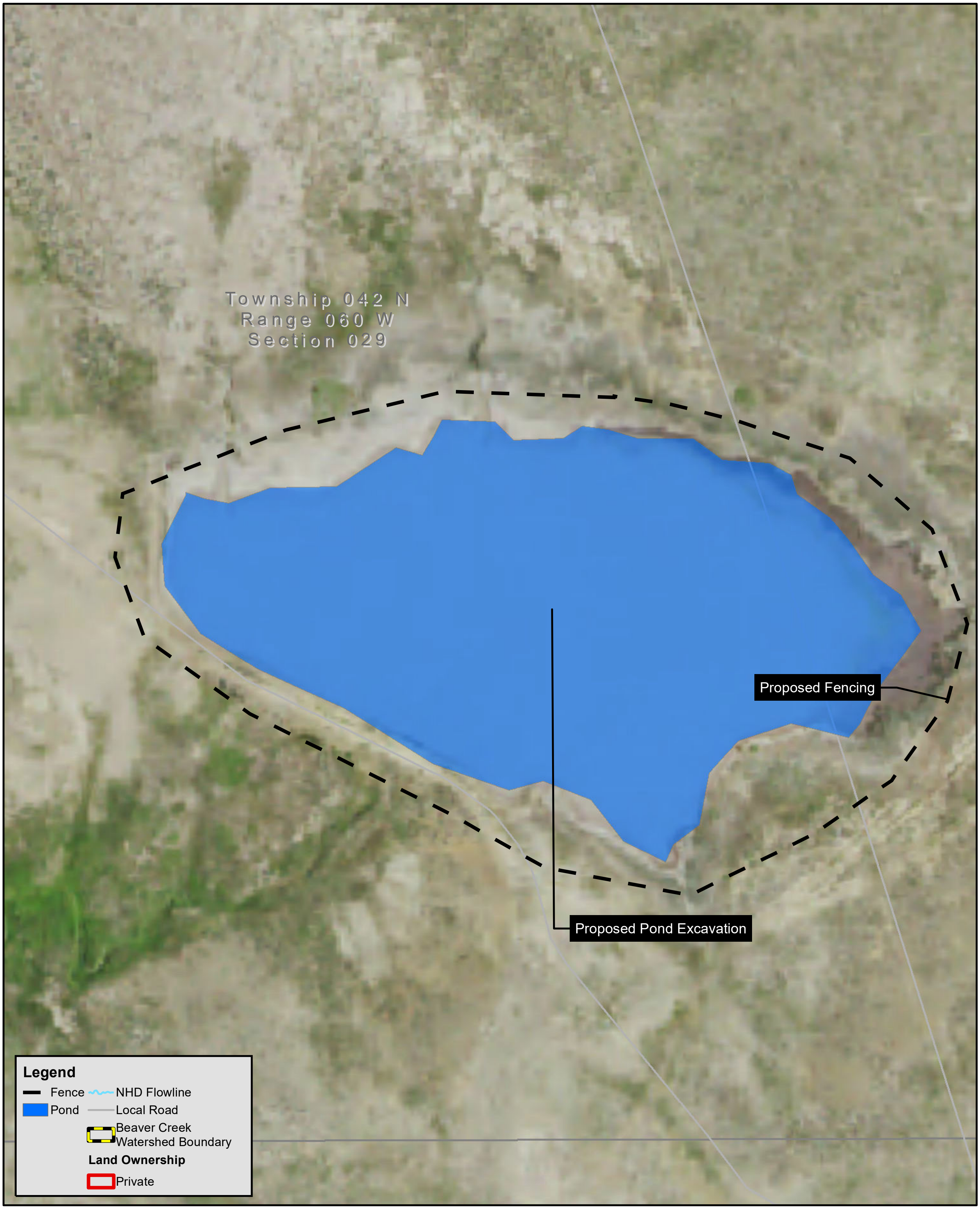

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OLSSON ASSOCIATES

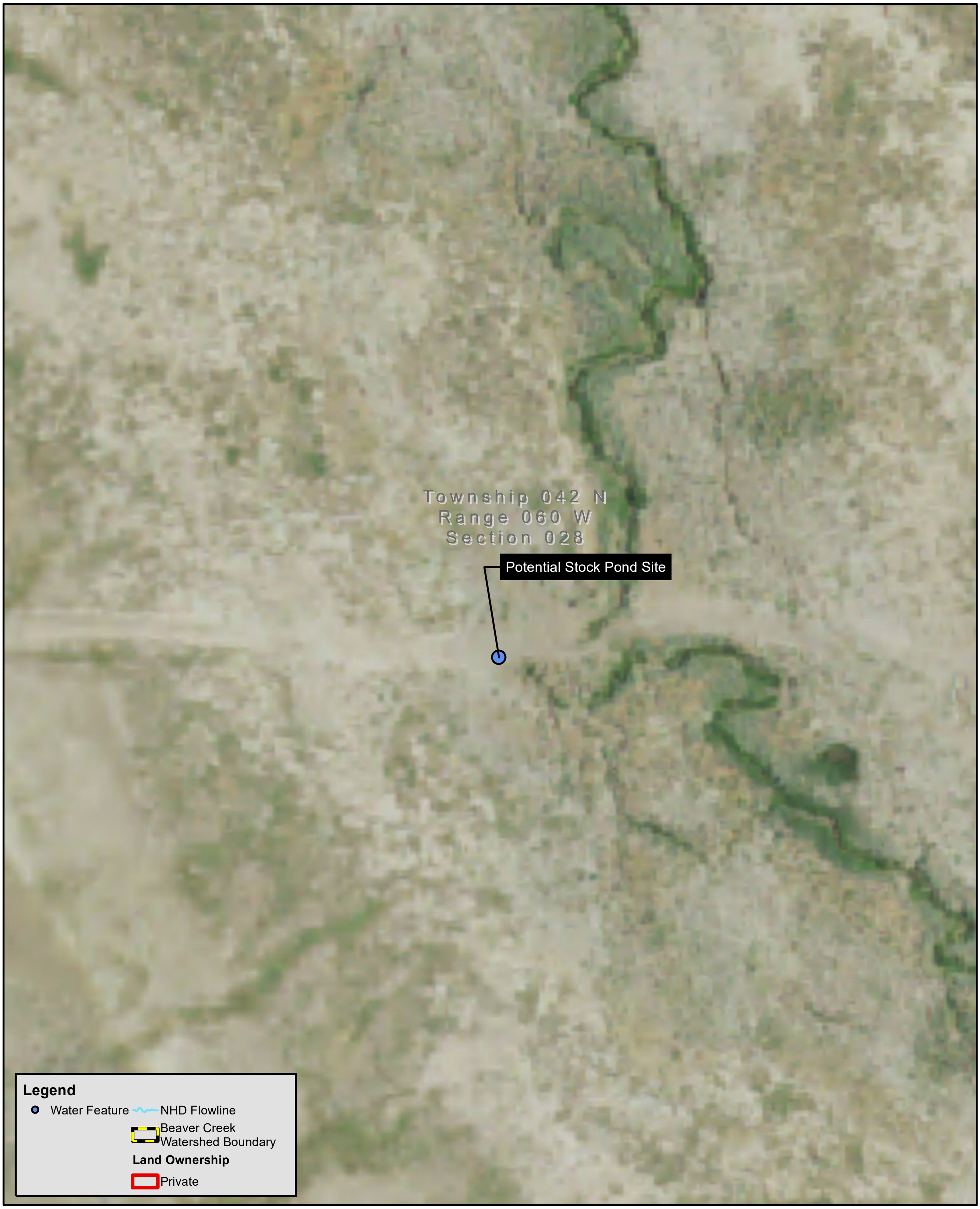
N

0 60 120 feet

1:1,500
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Hollenbeck Ranch

MAP
36.2



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OLSSON ASSOCIATES

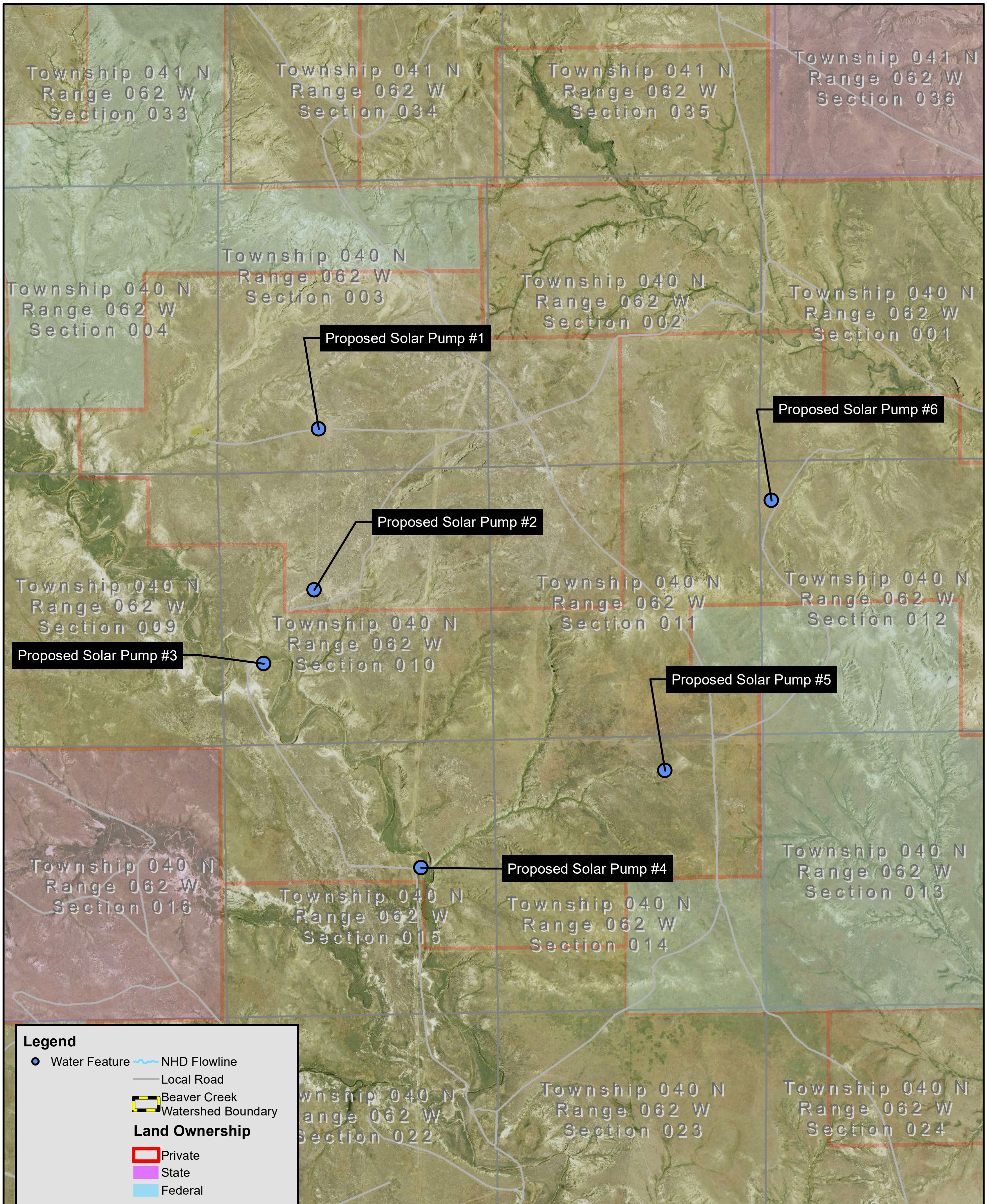
N

0 45 90 feet

1:1,200
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Hollenbeck Ranch

MAP
36.3



OLSSON ASSOCIATES

N

0 600 1,200 2,400 feet

1:30,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Niobrara and Weston County, Wyoming
Simon Ranch

MAP
37.1

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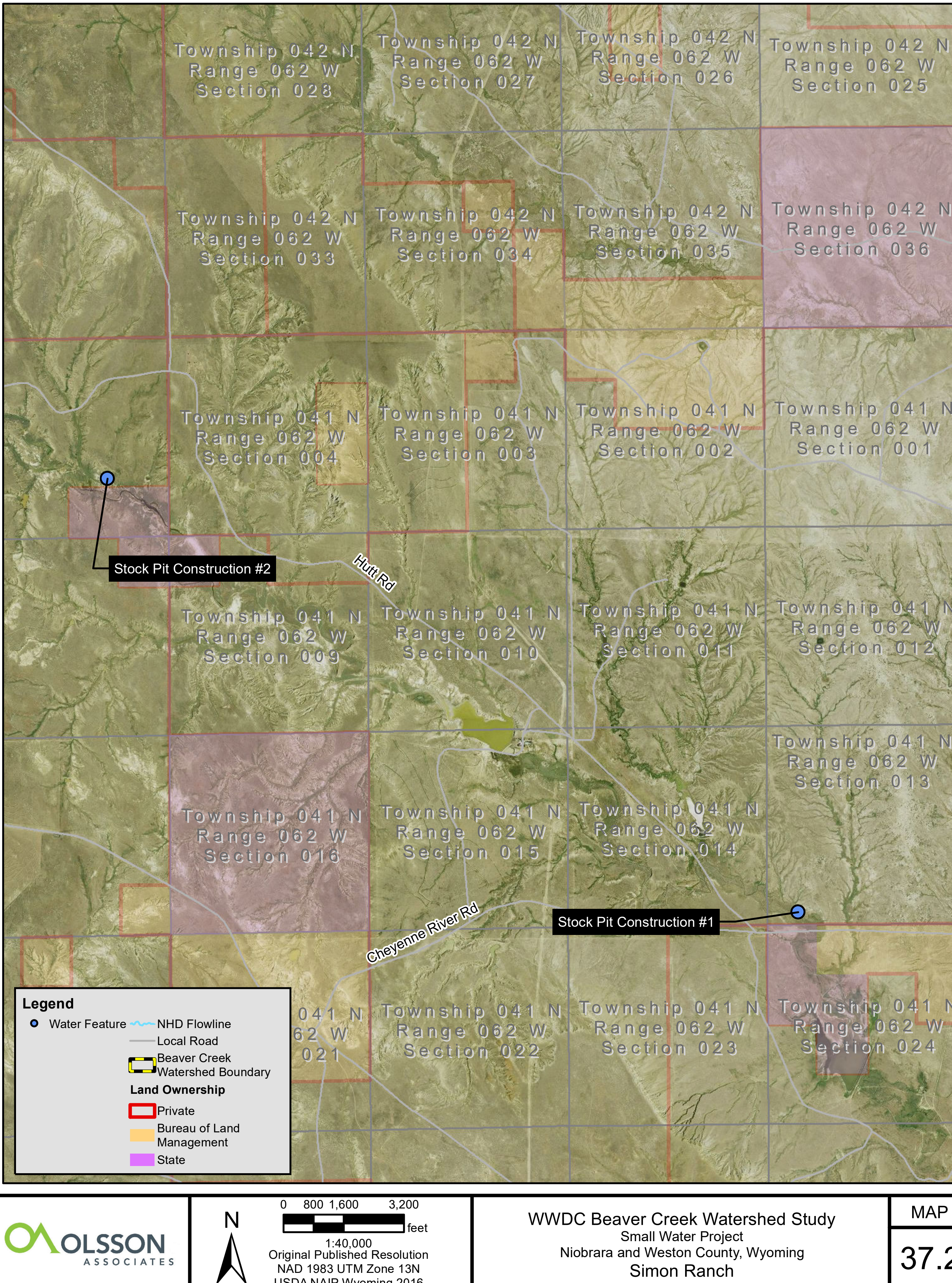

OLSSON ASSOCIATES

1:40,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Niobrara and Weston County, Wyoming
Simon Ranch

MAP
37.2

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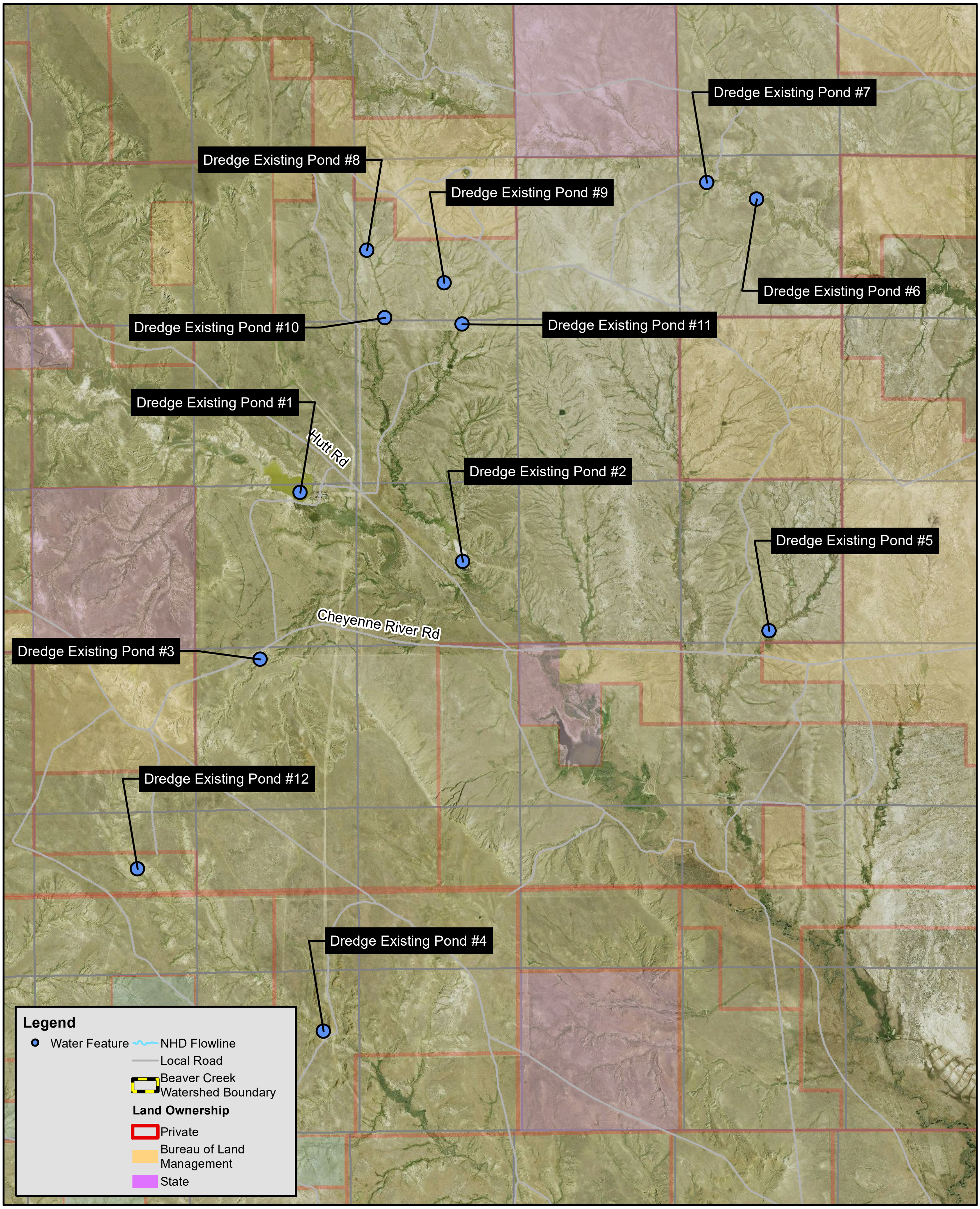

N

0 1,000 2,000 4,000 feet

1:50,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

OLSSON ASSOCIATES

WWDC Beaver Creek Watershed Study
Small Water Project
Niobrara and Weston County, Wyoming
Simon Ranch

MAP
37.3

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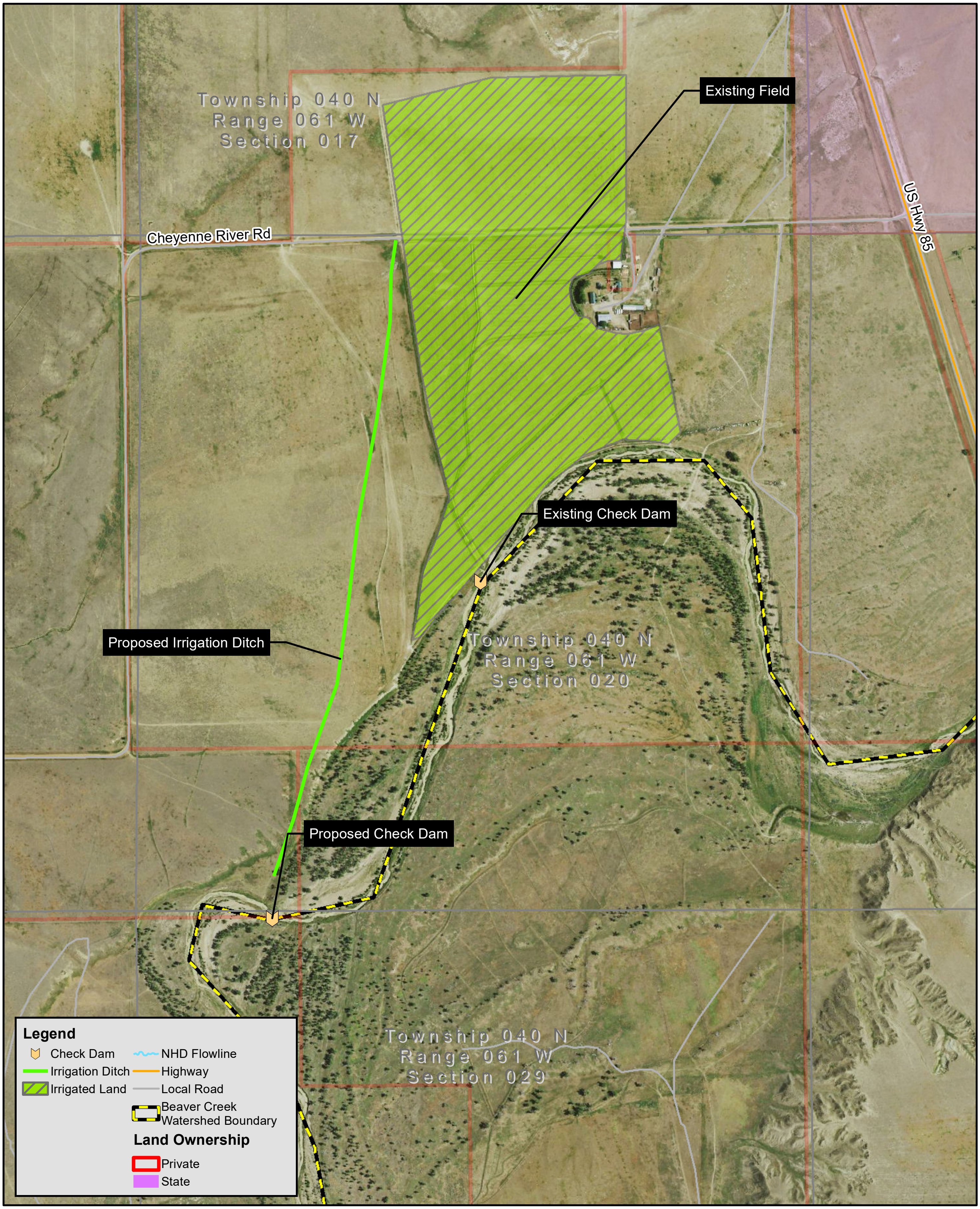

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OLSSON ASSOCIATES

N

0 200 400 800 feet

1:12,000

Original Published Resolution

NAD 1983 UTM Zone 13N

USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study

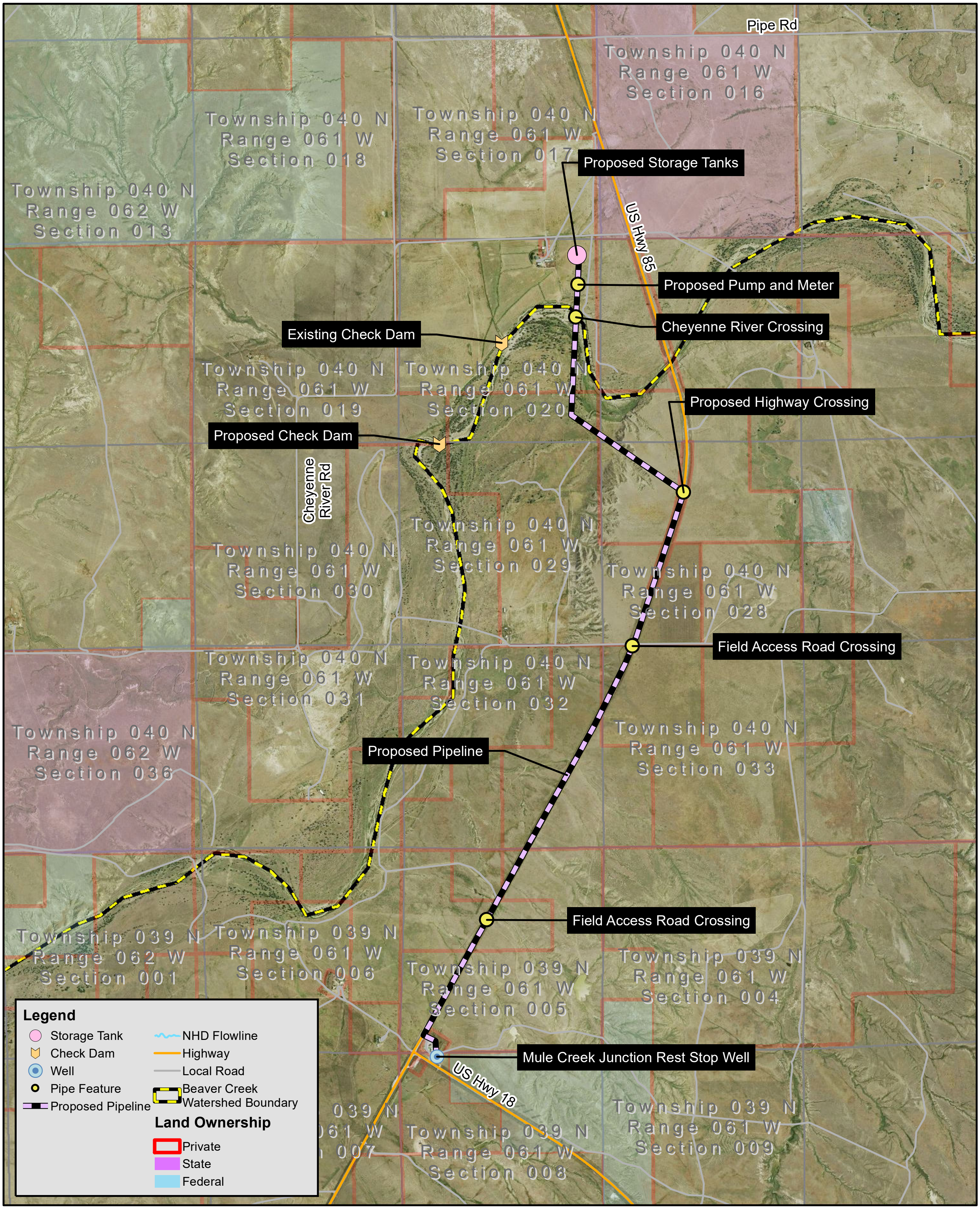
Small Water Project

Niobrara County, Wyoming

Bayne Ranch

MAP

38.1



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OLSSON ASSOCIATES

N

0 800 1,600 3,200 feet

1:40,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Niobrara County, Wyoming
Tysdal Ranch

MAP
39.1

N

0 80 160 feet

1:2,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

OLSSON ASSOCIATES

WWDC Beaver Creek Watershed Study
Small Water Project
Niobrara County, Wyoming
Tysdal Ranch

MAP
39.2

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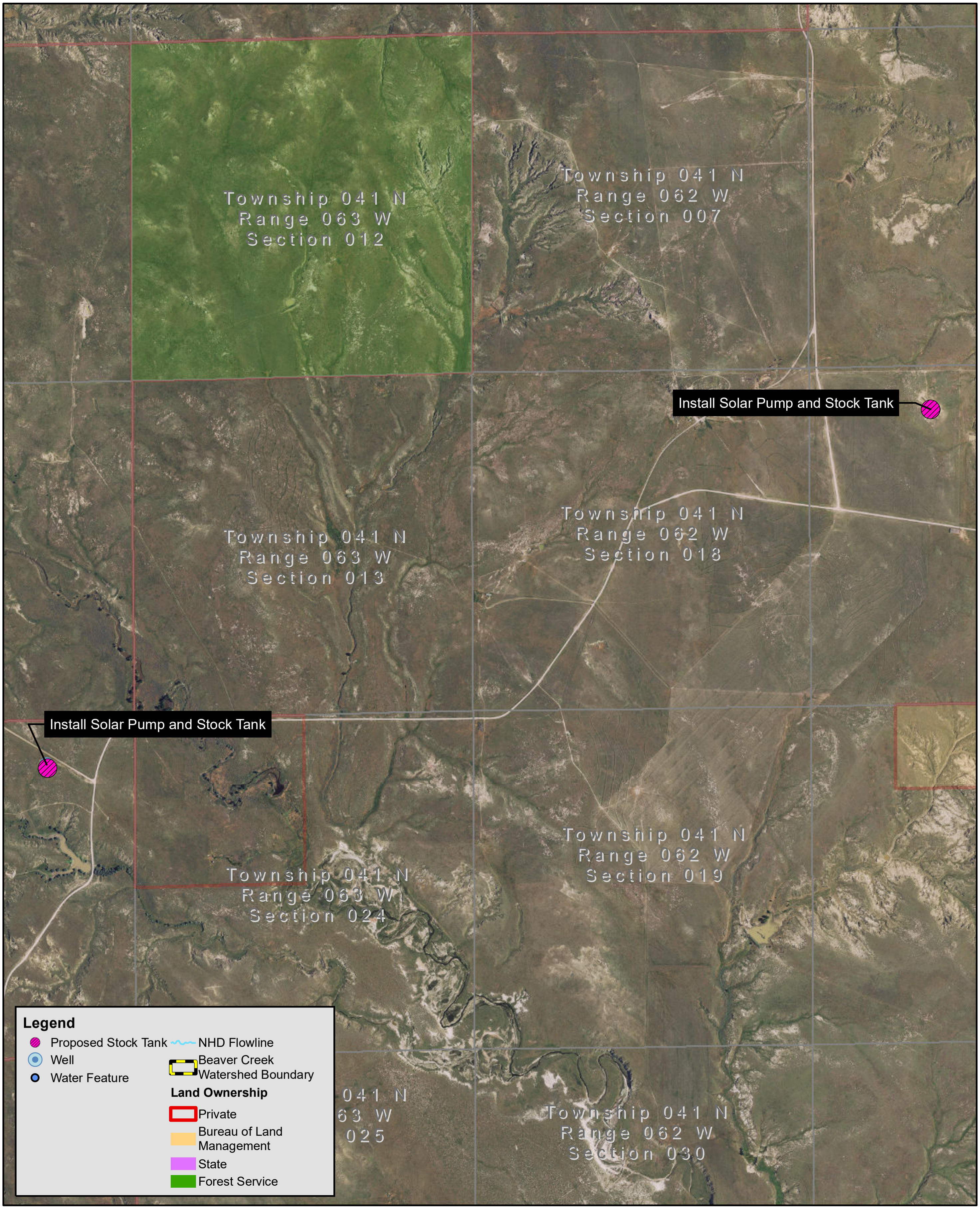


OLSSON ASSOCIATES

N

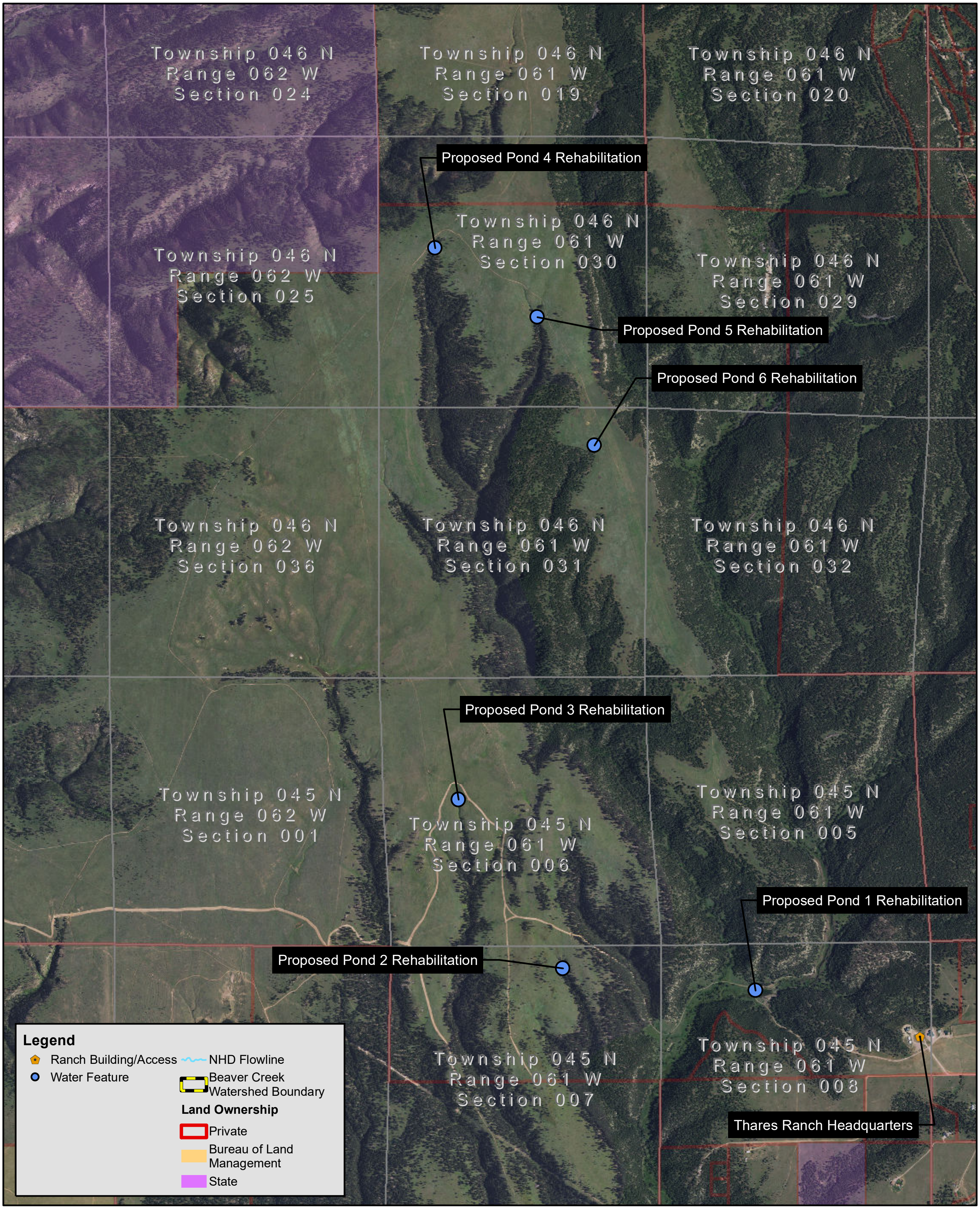
0 400 800 1,600 feet

1:24,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Harris Ranch

MAP
40.1

F:\2017\1501-2000\017-1637\40-Design\Reports\WTRS\Project Requests\Project Specific Folders\BeaverCreekAnnotation.mxd PUBLISHED BY: gmalek-madani DATE: October 29, 2018



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OLSSON ASSOCIATES

N

0 600 1,200 2,400 feet

1:30,000
Original Published Resolution
NAD 1983 UTM Zone 13N
USDA NAIP Wyoming 2016

WWDC Beaver Creek Watershed Study
Small Water Project
Weston County, Wyoming
Thares Ranch

MAP
41.1